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APPENDICES

Appendix I

METALLURGICAL EDUCATION AND THE WHITE PAPER

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During the four years that have elapsed since the author was appointed Principal of the new Cleveland Technical College at Redcar, on Tees-side, he has been disturbed by the trends in the relative quality of the entrants to Ordinary National Certificate courses in chemistry and metallurgy. Of the chemistry entrants, 75% had G.C.E. "0" level passes in four or more subjects, as compared with 30% of the metallurgy entrants. At the other end of the scale, only 20% of chemistry entrants had no "0" level passes, in contrast to the 64% in the case of metallurgy. In the light of these figures and the recent White Paper on technical education, the author comments on the metallurgical aspects of the problem in this article and presents details of a course suitable for a technician qualification.

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August, 1961.

At the beginning of this year, the White Paper "Better Opportunities in Technical Education" was presented to Parliament by the Minister of Education. Many of his ten proposals are operating already in technical colleges throughout the country. Nevertheless the White Paper was opportune if it awakened in the country as a whole a realisation of the changing pattern of technical education and the need to meet the economic challenge of our age. What is to be our next step? We have had time to examine the points made by the Minister and it is obvious that a number of his recommendations ought to apply to the training of young people in the metallurgical industry.

Comparison with Engineering

It has been said of the engineering field that the technical college has not kept pace with the development of the industry. If this is true, it is equally so of the metallurgical sphere. So far, apart from the low-level operatives course, the only route open for the young entrants has been the National Certificate type of course. The distressing hall-mark of this system lies in the increased failure rates. This, to some extent, can be appreciated when due regard is paid to the fact that there is not only a marked increase in the number of students staying on in the grammar school sixth forms (something over 60% of the 1948 figures), but also an increase in the proportion of science students seeking University entrance. It is also conceivable that immediately after the war students pursuing a National Certificate course were older and, therefore, more purposeful in their desire to achieve a qualification. In effect, the calibre of students coming forward for a metallurgical course is not as strong academically as that of their older brothers. Let us, therefore, examine the problem and compare the position with that in the engineering field, as set out in Table I.

There are two significant omissions on the metallurgical side,

(1) The Ordinary National Diploma.

(2) The Technician Course.

Ordinary National Diploma

At a time when the Minister is recommending a shift

Table I - Courses available to students of Engineering and Metallurgy.

Engineering	Metallurgy
Higher National Diploma	Higher National Diploma
Higher National Certificate	Higher National Certificate
Ordinary National Diploma	-
Technician	No equivalent course
Mechanical Craft Practice	Operatives' Course

of emphasis to sandwich and block release courses, surely there is a case for the "Joint Committee" to exercise its powers in providing an Ordinary National Diploma of two years duration on a six months sandwich basis. This would give the not-so-academically strong student twice the time spent on a three year part-time day release National Certificate course. Such a scheme would have the advantage of sustained study and time for consolidation. If, because of Ministry thought on non-specialisation at this level, the Joint Committee for Metallurgy is not prepared "to go it alone," then why not unite with the chemists and physicists to make a common Ordinary National Diploma scheme in science - a scheme embracing the fundamentals of chemistry, physics and mathematics, but with an emphasis on the practical and the opportunity for industrial training.

Technician Qualification

If educationalists and industry are prepared to sponsor this type of course, then two groups of students are to be considered: (1) the grammar school students who cannot measure up to four "0" level subjects; and (2) the "A" stream boy from a modern school.

The course would be of four years duration and ultimately the students could pursue, at the age of sixteen, a joint course of part-time day or block release study after the modern school boy had passed through a one year full-time course at the technical college - a course designed in consultation with industry, a course for which industry and the College Advisory Committee could help in student selection. This could be achieved with success in much the same way as pre-engineering courses are operated in many colleges. Why continue to be hidebound by a National Certificate scheme that in many instances is "untouchable" and psychologically unsuitable?

Is it necessary to gain a Higher National Certificate to be a shift chemist analysing for carbon, silicon, phosphorus, sulphur and manganese? Is it necessary to hold such a certificate to work in a routine mechanical testing laboratory or on pyrometric control? There will be many who will argue that the student will be a better employee for having gained his qualification - and this is probably true if the student is able to pass through to his Higher National Certificate in four or five years. If he cannot, then frustration will set in and he will be poorer for an incomplete course. How much more sensible to introduce a new course - a course that will examine practically and qualitatively. The following scheme is put forward if only to engender in industry a realisation of the value of an alternative course and to invite comment.

The course, as outlined in Table II, is planned for part-time day release with attendance on one day and one evening per week for the first two years, and one

Table II - Outline of Course for Technician Qualification

Year	Subject	Hours per week in a 30 week session
First	English	1
	Mathematics/Drawing I	2½
	Science I : Theory	2
	Science I : Practical	4
Second	English	1
	Mathematics/Drawing II	2½
	Science II : Theory	2
	Science II : Practical	4½
Third	Mathematics III	2½
	Physics III	2½
	Analytical Chemistry I	3
	Metallurgy I	3
Fourth	Project	2½
	Physics IV	2½
	Analytical Chemistry II	3
	Metallurgy II	3

day and two evenings per week in the third and fourth years. There would be no difficulty in re-arranging the timetable to operate as a block-release scheme. The first and second years could serve two useful purposes: (1) as a common course for metallurgists and chemists; and (2) as a selection course for transfer to the Ordinary National Certificate or the technician final stage.

Syllabus

The details of the topics to be dealt with in the various sections of the course are presented below.

Science I

Chemistry

Theory - Structure of matter; physical and chemical change; elements, compounds and mixtures; atoms and molecules; solid, liquid and gaseous states in terms of elementary kinetic theory . Use of symbols and equations to represent chemical change. Methods of separating mixtures; solution and solubility; solubility curves; crystallisation; filtration; distillation; sublimation.

Air and oxygen: formation of oxides; combustion and heat of combustion; acids, bases and neutralisation; simple acidimetric-alkimetric titrations. Equivalent weight and normality. Water and hydrogen: formation of water; formation of hydrates; reactions with metals and "activity series" of metals; preparation and production of hydrogen from (1) acids (2) water. Oxidation and reduction as illustrated by synthesis of oxides and reduction of oxides by coal gas. Law of simple proportions and percentage composition of compounds; empirical formulae. Classification of elements as metals and non-metals; brief survey of preparation and/or production, properties and reactions of the following elements and their oxides to illustrate metallic and non-metallic characteristics: carbon, sulphur, nitrogen, calcium, iron and copper. (Treatment of carbon to include (a) fuel gases, (b) carbonates and hardness of water.)

Practical - Separation of mixtures into pure components; types of chemical change; combustion and rusting in air; purification of compounds by recrystallisation, distillation and sublimation; solubility of air in water; solubility curve for potassium chlorate; water of crystallisation in hydrates; hardness of water; law of simple proportions; equivalents of magnesium and copper; preparation and properties of oxygen, hydrogen, carbon dioxide, nitric oxide, nitrogen dioxide; volumetric analysis (to include simple acid-alkali titrations only).

Physics

Theory - Units of measurement: length, mass, time. Accurate measurement of length: vernier, micrometer. Energy and energy transformations; work and energy. Mechanical energy: force as a push/pull producing change in state of motion; momentum; mass and weight; moments; centre of gravity. Measurement of mass: chemical balance; Measurement of weight; Hooke's law and spring balance. Measurement of density: direct measurement; Archimedes' principle and flotation; relative density; hydrometers. Fluid pressure: manometer and diaphragm type gauges; atmospheric pressure, mercury and aneroid barometers; Boyle's law; Charles' law. Heat energy: temperature and temperature scale; thermometers; transmission of heat applied to furnaces and vacuum-jacketed vessels; units of heat. Electrical energy: conductors and insulators; nature of electrical charge; resistance and Ohm's law; units of resistance, current and potential difference. Magnetic effect of electrical current: simple properties of magnetic substances; magnetic fields; lines of force; electro-magnets and uses in bells; relays and motors. Chemical effect of current: simple cell; Leclanche cells, accumulators. Heating effect of current; furnaces. Units of electrical power and energy.

Practical - Determination of density and relative density of solids and liquids; verification of Hooke's law; principle of moments; centre of gravity; verification of Boyle's law; constant volume gas thermometer; preparation and calibration of liquid in glass thermometers; comparison of heat conductance by various materials; radiation from different surfaces; verification of Ohm's law; field of force for bar magnet; field of force for straight conductor; solenoid.

calorific value of fuels and food. Vapour pressure and hygrometry. Electrical equivalent of heat; resistance - series and parallel groupings; shunts and series resistance in measuring instruments. Measurement of e.m.f. and resistance; potentiometer; Wheatstone bridge circuit; Post Office box; variation of resistance with temperature; platinum resistance thermometer. Disappearing filament pyrometer. Capacitance and capacitors. Thermocouple and applications in pyrometers. Rectilinear propagation of light; shadows; reflection of sound and light at plane and curved surfaces; refraction; critical angle; refraction through prisms; thin lenses; principles and use of Abbe refractometer, camera, microscope and telescope.

Practical - parallelogram of forces; pulley systems; inclined plane; mechanical equivalent of heat; specific heat and latent heat determinations; calorific value of coal; comparison of vapour pressures; electrical equivalent of heat; measurement of e.m.f. and resistance; effect of temperature on resistance; platinum resistance thermometer; thermocouples and temperature measurement; position of images with plane and curved mirrors; focal length of convex lens; use of Abbe refractometer; disappearing filament pyrometer.

Physics III

Theory - Wave nature of light; diffraction grating, visible spectrum and colour; ultra-violet, visible and infra-red radiations; emission and absorption spectra; spectrometer; flame photometer and colorimeters; applications in analysis; photometers and photometry; polarised light. Electromagnetic induction; dynamo; transformer; induction coil; telephone; induction furnace. Simple harmonic motion; sine curve. Capillarity; surface tension; viscosity.

Practical - Spectrometer; photometry; colorimetric analysis; use of flame photometer in chemical analysis; simple harmonic motion from vibration of springs and simple pendulum; capillary rise and surface tension; viscosity; diffraction phenomena; use of polarimeter.

Physics IV

Theory - A.C. theory: waveform; frequency; standard waveform-vector representation; inductance and capacitance in A.C. circuits; resistance, impedance and phase displacement; power and power factor; single-phase transformer; hysteresis and eddy currents. Thermionic emission and simple applications; diode; triode; photo-electric effect. Cathode ray tube. X-rays and X-ray diffraction; simple crystallography. Practical - A.C. circuits; hysteresis; simple circuits involving diodes and triodes; cathode ray tube and applications; microscopic examination of crystals; photo-electric cells.

Mathematics I

British and metric systems of weights and measures. Fractions; decimal fractions; significant figures; decimal places. Percentages; percentage error. Ratio and proportion: (examples from laws of chemical combination, density, concentration of solution). Squares and square roots. Simple equations and simultaneous simple equations; build-up and transposition of symbolical equations (to include areas of rectilinear figures, surface areas and volumes of simple solids); change in value of function for given change in variable; changing the subject of a formula (involving simple fractions). Graphs: position of a point; rectangular co-ordinates; representation of pairs of variables from experiment and equations; interpolation and reading graphs; straight line graph and simple variation. Geometry and drawing: division of straight line into equal proportional parts; construction of scales; construction of perpendiculars and parallels to lines; the circle; division of circle; measurement of angles; construction of regular polygons; loci.

Mathematics II

Indices: positive integral indices; law of indices; roots as indices; logarithms to base 10; use of logarithms (four rules); the slide rule. Solution of equations, (i) simple factorisation of quadratics, (ii) general case for $ax^2 + bx + c = 0$. Approximate formulae for squares, cubes, square roots and cube roots of a binomial with one term small. Slope and intercept of linear graph; determination of laws by reducing to linear form and testing straight line; area under graph by mid-ordinate rule; graphs of quadratic and cubic functions; elementary ideas on slope of a curve at a point;

approximate arithmetical determination of slope. Sine, cosine and tangent for angles not greater than 90°; solution of right-angled triangles by scale drawing and by trigonometrical ratios. Similarity of triangles and applications in optics. Areas: enlargement and reduction of areas by radial projection; construction of triangle, square and rectangle equal in area to square, rectangle and polygon; isometric and oblique projection; free-hand sketching.

<u>Mathematics III</u>

Collection of statistical data; their adequacy and reliability; presentation of data; simple classification and tabulation; mean, variance and standard deviation by calculations from a set of observations; permutations and combinations; probability; sampling. Logarithmic equations (i.e. index unknown). Introduction to calculus: gradients, graphical differentiation, first and second order differentials; maximum and minimum values; differentiation of (i) sums and differences, (ii) products, (iii) quotients; differentiation of x^n, sin x and cos x; integration as the inverse process to differentiation. Circular measure of an angle; ratios of angles greater than right angles; ratios of compound angles; graphs of sin x, cos x and tan x ($0<x<360$).

Analytical Chemistry I

Theory - Methods of sampling solids, liquids and gases. Reactions in solution; ionisation in solution; conductance of solutions and factors affecting it; strong and weak electrolytes; Kohlrausch's law of the independent migration of ions; the law of mass action and application to solutions of electrolytes. Acid-alkali titrations; strengths of acids and bases; common ion effect; ionic product of water; pH and its determination; titration curves and choice of indicator; conductometric and electrometric titrations. Redox titrations: redox potential; choice of internal indicator. Solubility product; applications in gravimetric analysis; washing precipitate; fractional precipitation; applications in qualitative analysis. Theory of classical group scheme of qualitative inorgan ic analysis; preparation of solution; separation into groups; separation tables for main groups; (ions in the scheme: Pb^{2+}, Ag^{+}, Hg_2^{2+}, Hg^{2+}, Bi^{3+}, Cu^{2+},

Cd^{2+}, As^{3+}, Sb^{3+}, Sn^{2+}, Sn^{4+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Co^{2+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, NH_4^{+}, CO_3^{2-}, HCO_3^{-}, S^{2-}, SO_3^{2-}, NO_2^{-}, CN^{-}, F^{-}, Cl^{-}, Br^{-}, I^{-}, NO_3^{-}, SO_4^{2-}, PO_4^{3-}, SiO_3^{2-}, AsO_3^{3-}, AsO_4^{3-}, CrO_4^{2-}. No interference between radicals at this stage).

Practical - Measurement of conductance of a solution; measurement of pH using (a) capillator; (b) pH meter; variation of pH during acid-alkali titrations; conductometric titration for acid-alkali; volumetric analysis, comprising advanced acid-alkali determinations; potassium permanganate, potassium dichromate and iodine titrations; gravimetric determination of sulphate, iron, phosphate, and silica; qualitative analysis of mixtures of above ions without complications due to interference between ions.

Analytical Chemistry II

Theory - Volumetric analysis; theory of precipitation reactions; use of silver nitrate and potassium thiocyanate solutions; internal indicators; simple theory of colloids; adsorption indicators. Transition metals and complex ions; properties of complex ions; co-ordination number;

importance of complex formation in analysis. Theory of the use of E.D.T.A. in volumetric analysis. Theory of the use of spot tests in qualitative analysis; selectivity and sensitivity of reactions; desirable properties of reagents for spot tests. Use of organic reagents in gravimetric determination of metals. Use of colorimetric methods in analysis; distribution law and extraction of coloured materials from aqueous solutions. Gas analysis; revision of the gas laws, Avogadro's hypothesis; Henry's law, absorption coefficient; equipment and technique. Qualitative analysis; separation of metals in same group; modification of group procedure for interfering acids.

Practical - Volumetric analysis; use of silver nitrate, potassium thiocyanate and E.D.T.A. solutions; investigation of complex ion formation using ion-exchange resins; gravimetric determination of aluminium, nickel, copper, manganese; colorimetric determination of copper and iron; analysis of flue gas.

Metallurgy I & II

Extraction Metallurgy

Metallurgy I & II

Extraction Metallurgy

This will be a two years' course. Candidates will be required to show a reasonable knowledge of fuels, refractories and the fundamentals underlying the extraction and refining of the non-ferrous metals -magnesium, aluminium, zinc, tin, lead and copper - and of iron and steel.

Fuels - Classification, uses and properties of solid, liquid and natural and prepared gaseous fuels. Heat transfer, regeneration and recuperation. Conduction, convection and radiation. Heat exchanges and heat losses. Calculations in connection with combustion, gasification and heat balance. Elementary principles of electric heating.

Refractories - Requirements of a refractory material. Classification and manufacture. Chemical and mineralogical composition and physical properties. Selection of a refractory for a particular metallurgical operation, including insulators. Testing of refractory materials.

Extraction - Ores and their location. Mineral dressing: crushing, classification and concentration methods;

calcination; roasting and sintering; flow sheets. Smelting: fundamental principles in hydro-, pyro- and electrometallurgical extraction. Furnace products; handling of dust and fumes. Refining: principles of fire and electrolytic refining; retreatment and recovery of by-products. Secondary metals: recovery and purification.

Physical Metallurgy

Solidification of metals and alloys. Lattice structure; crystalline nature and properties of metals and alloys. The metallurgical microscope - theoretical and practical considerations in the preparation and examination of metallurgical specimens. Equilibrium in binary sytems: construction of equilibrium diagrams, thermal analysis, dilatometry, microscopic methods and X-ray methods. Effects of nonequilibrium conditions. Representation of simple ternary diagrams. Principles of heat treatment: diffusion, recrystallisation and grain growth; precipitation; phase transformations. Plastic deformation. Destructive and non-destructive testing. Constitution, structure and properties of principal non-ferrous alloys. The iron-carbon equilibrium diagram. Corrosion: protection against corrosion; anti-corrosion alloys.

Project

The content of this syllabus will depend largely upon the type of industry in which the student is employed. It is desirable that there should be close liaison with industry to ensure that the content of the course is closely linked with an evaluation of the processes and practises of the firm in question, and that the practical work will be translated into a thesis covering the whole of the year's work.

Throughout the four years, emphasis will be placed on the practical side of all subjects.

Conclusion

These suggestions are the outcome of a local condition. It is conceivable that other parts of the country are experiencing the same problems. If this is so, the advent of the White Paper provides the stimulus for new thought and development. Let us not miss the opportunity while it lies in our grasp.

Note: Since this article was written the scheme has been accepted by the largest iron and steel concern in the author's "catchment area," and students will receive instruction on this course as from September, 1961.

Appendix II

To Local Education	Administrative
Authorities for	Memorandum No 106
Higher Education	(3rd May, 1933).

BOARD OF EDUCATION

Intermediate Examinations of the City and Guilds of London Institute

The Board have been for some time in consultation with the City and Guilds of London Institute, and with the Union of Lancashire and Cheshire Institutes, the Northern Counties Technical Examinations Council, the East Midland Educational Union, and the Union of Educational Institutions as to the principles which should govern the establishment in England and Wales of examinations of intermediate grade by the City and Guilds of London Institute. As a result of the discussions which have taken place a scheme for dealing with this matter in future has been adopted and is attached as an Appendix to this memorandum. While this scheme is of special importance to Local

Education Authorities who are members of Examining Unions, it appears to the Board desirable to bring it to the notice of Local Education Authorities for Higher Education generally.

Attention is particularly directed to Paragraph 5(c) of the scheme and to the provision that the Institute will accept from Authorities who are members of Examining Unions candidates for certain Intermediate Examinations of the Institute only on a request from the Chief Education Officer in specific terms. It is intended that such a request shall be conveyed to the Institute in a letter signed by the Chief Education Officer of the Authority for Higher Education, and that this letter shall give particulars of the Colleges or Schools concerned and of the subjects in which it is desired to present candidates for Intermediate Examinations to be held by the Institute. The Institute will transmit these particulars to the Union concerned as soon as practicable after the last date for the acceptance of candidates for the Examinations.

The scheme will be regarded by the Board as coming into force as from the date of this memorandum.

APPENDIX

INTERMEDIATE EXAMINATIONS
CONDUCTED BY THE CITY AND GUILDS OF LONDON INSTITUTE

NOTE: The examinations and certificates of the City and Guilds to which reference is made in this Scheme are the examinations and certificates of intermediate grade only.

1. The City and Guilds will submit to the Board any proposal which they may wish to make for the establishment of an examination in a particular subject.

2. In considering any such application, the Board will require to be satisfied:-

(a) That a properly constituted Advisory Committee for the subject has been set up, or recognised, by the City and Guilds (an exception would only be made to this requirement in rare cases, for example, Alkali, or Soap Manufacture, where the number of students is very small and the Board are satisfied that the formation of an Advisory Committee is impracticable);

(b) That the Advisory Committee has considered the course of instruction as a whole and not merely the examination requirements of the students;

(c) That the Advisory Committee in the course of its deliberation has come to the conclusion that an examination at the intermediate stage is desirable, and that this conclusion has been confirmed by the Examinations Board.

3. Before coming to a decision the Board will investigate the need for the examination on educational grounds.

4. Any approval which may be given will be for a limited period and will be subject to review from time to time.

5. In addition to the conditions set out above, the following further conditions will operate in all cases where an application is approved:-

(a) It will be open to the City and Guilds to conduct an examination in the area of any Local

Education Authority which is not a member of an Examining Union, whether situated outside or inside the geographical area of a Union;

(b) It will be open to the City and Guilds to conduct an examination in the area of a Local Education Authority which is a member of a Union in a subject or stage of a subject in which the Union does not itself examine. If and when the Union establishes an examination in the subject or stage of the subject, the position will be governed by the provisions contained in (c);

(c) As regards a subject or stage of a subject in which the Union examines, the normal arrangement will be for a Local Education Authority which is a member of a Union to take the examination of the Union. This will be made clear in the programme of the City and Guilds and in other appropriate ways. In such cases the City and Guilds will accept candidates for an intermediate examination from a Local Education Authority which is a member of a Union only on a specific request, duly signed by the Chief Education Officer of the Local Education Authority, making it clear that the Local Education Authority, having considered the matter, desire to take the examination of the City and Guilds in a particular institution or institutions. On receipt of such an application, the City and Guilds will notify the Examining Union concerned;

(d) In cases where a Professional Institution or Trade Organisation endorses or recognises the Certificates of the City and Guilds, it will be a condition of the Board's approval of the holding of an intermediate examination by the City and Guilds that the Institution or Organisation concerned will extend the same treatment to the appropriate examinations of the Unions after satisfying themselves that the Certificate connote the attainment of a standard satisfactory to the Institution or Organisation.

Appendix III

INTERMEDIATE GRADE METALLURGY

(Common to all branches of the subject). 1933-34

Syllabus:-

1. Properties of Metals - Physical - Lustre, transparency (thin films), colour, odour, density, fluid density, crystalline nature (examples), types of fracture, microstructure, macrostructure. Volume and polymorphic changes.

Specific and latent heat, electrical and thermal conductivity (practical examples), conditions affecting conductivity. Resistivity, fusibility, volatility, occlusion, diffusion. Magnetic properties, hysteresis, permeability, retentivity, coercive force.

Mechanical - Tenacity. The tensile test. Load strain, stress and elasticity. Load-strain diagram, plasticity, elongation and contraction of area. Tensile testing machines. Torsion, compression and transverse tests. Toughness. Bend tests. Impact tests. Fatigue tests. Hardness and hardness tests (abrasion and indentation). Machineability (drill-tests).

Malleability. Ductility.

Chemical - Properties of metallic surfaces, adsorption. Metals and oxygen, sulphur, etc. Metals and acids. Action of air, water and furnace gases. Oxide films.

2. Metallurgical Terms - Mineral, ore, gangue. Concentration, briquetting, sintering, nodulizing.

Leaching, chloridizing, cyanidizing, precipitation, amalgamation, scorification, distillation, sublimation. Oxidation, reduction. Oxidising and reducing agents. Calcining, roasting, smelting. Bessemerizing, refining, melting, liquation, granulation. Welding, brazing, soldering. Regulus, matte, speiss, slag, flux. Cementation, carburization. Alloys, methods of preparation.

3. Composition and Properties of Slags and Fluxes - Slags - Silicate slags; composition and classification, fusibility, fluidity, and other properties. Non-silicate slags. Economic use of waste slags.

Fluxes - Principal fluxes used in Metallurgy and their chief uses.

4. Fuels - Combustion. Calorific power, calorific

intensity and their determination. Heating effect of fuels. Evaporative power.

Classification of Fuels - Solid Fuels - Wood, peat, lignite, bituminous coal, anthracite. Pulverized fuel. Briquettes. Preparation of charcoal. Methods of coking. Types of coking oven. Recovery of by-products. Liquid Fuels. Gaseous Fuels - Natural gas. Coal-gas. Coke-oven gas. Producer gas. Blast furnace gas. Water-gas. Oil-gas.

Gas Producers - Representative types.

5. Refractories - General requirements in acid, basic and neutral refractories. Fireclay and its properties. Influence of impurities. Shaping, drying and burning. Manufacture of fire-brick; properties and tests. Other uses of fireclay. Silica and silica brick. Ganister bauxite, lime, magnesia. Dolomite, chromite, zirconia, carbon bricks, brasque. Crucibles, retorts, muffles.

6. Furnaces - Principles of design. Principles of recuperation and regeneration. Classification of furnaces (one example of each of the following types):

Calcining and Roasting - Kiln, shaft, reverberatory, muffle, blast roasting, sintering. Smelting - Hearth, blast furnaces, reverberatory, retort. Melting (closed vessel) - Crucible furnace (solid fuel, oil and gas-fired). Convertors. Annealing and heat-treatment. Electric-Arc, resistance induction.

7. Pyrometry - Principles underlying the use of the following types of pyrometer; expansion, fusion, optical, electric resistance, thermo-electric, radiation.

8. Smelting, Melting and Casting Processes - Pig Iron - Ores of iron. Preparation of ores for smelting. The blast furnace. Hot-blast stoves. Constitution of charge. Nature of the products. Grading of pig iron. Effect of impurities on cast-iron. Wrought Iron - Production from pig iron. Dry-puddling, pig-boiling. Steel - Outline of methods for making steel by cementation, in the crucible furnace, in the converter and in the open hearth. Cast iron - The cupola; the air-furnace. Green sand, dry sand and loam moulding. Grey iron castings. Malleable castings.

Copper - Ores. Outline of the principles of the

Welsh process. Modern smelting in the reverberatory and blast furnace. Bessemerizing and refining.

Gold - Ores. The stamp battery. Amalgamation. The cyanide process. Refining and parting. Gold Coinage.

Silver - Ores. Pan amalgamation. Outline of the wet processes of extraction. Silver coinage.

Lead - Ores. Outline of the modern methods of extraction and refining.

Zinc - Distillation process.

Melting and Casting Processes - Crucible furnace. The casting shop. Casting apparatus and appliances. Ingots and ingot moulds. Utilization of scrap. Die-casting machines.

9. Mechanical Treatment - General effects of working. Hammering. Influence of temperature on working. Influence of impurities. Rolling; construction of a stand of rolls. Drawing. Draw benches for wire and tubes. Extrusion. Stamping. Pressing. Drop-forging. Annealing. Pickling. Sand-blasting. Finishing.

FINAL GRADE

The Final Examination may include more advanced questions founded on the subjects of the Intermediate Grade Syllabus relating to the Metallurgy of Iron and Steel, and the candidate will also be required to show a knowledge of subjects set forth below.

1. Manufacture of Iron

Geological character and geographical distribution of available iron ore deposits: their formation, position, extent and economic value. Iron ore sampling.

Preparation of ores for smelting; calcining, sintering, nodulizing: changes in composition thereby produced. Mechanical preparation; magnetic concentration.

Arrangements of stock-yards. Handling and transportation of raw materials in blast furnace smelting. Hoists and charging appliances.

Physical properties and compositions of various classes of fuels used in smelting.

The blast furnace; recent developments in construction and design. Lay-out of blast furnace plant.

The smelting process. Distribution of materials. Fluxes. Subsidiary ferrous materials in the burden.

Air-blast production and functions; results of heating the blast; effects of moisture, and of drying the blast; methods of heating and equalising; various types of tuyère.

Influence of variations of blast temperature and pressure, and of physical properties of ore, fuel and flux, on the production and properties of iron and slag.

Details of working, charging and tapping.

Properties and utilization of blast furnace gas. Cleaning of gas.

Properties of slags and their utilization.

Pig casting methods; breakers, etc.

Chemistry of the smelting process. Furnace reactions. Chemical balance sheet.

Zones of combustion and reduction.

Factors governing slag constitution.

Thermal conditions, efficiency and balance sheet.

Effects on iron of carbon, silicon, phosphorus, sulphur and manganese, and their inter-actions.

Classification of irons.

Relationship of composition and fracture.

Influence of furnace conditions and rate of cooling.

Production of ferro-alloys in blast furnaces.

Applications of electricity in the production of iron and ferro-alloys.

Wrought Iron. - Compositions of pig irons used. Refining. Puddling. Fettling and making up the hearth. Effect of composition on yield. Slags produced.

Various qualities of wrought iron; best Yorkshire iron; Swedish bar iron; production, composition, properties.

Uses of wrought iron. Mechanical tests.

Chemistry of the puddling process. Machine puddling. Direct production of wrought iron.

Furnaces, hammers and rolls used in the manufacture of wrought iron.

Ironfounding. - Compositions of pig irons used. The cupola and other melting furnaces; ladles, moulds and foundry appliances. Influence of re-melting; desulphurizing. Volume changes: properties and chief uses of cast-iron with appropriate compositions. "Growth" of cast-iron and its prevention.

Special cast-irons - e.g., "pearlite" iron; semi-steel, low carbon iron; properties and uses.

Addition of special elements - e.g., nickel and chromium.

Malleable Cast-Iron. - Whiteheart and blackheart. Compositions of pig irons used.

Melting in crucibles, cupolas, air and electric furnaces.

Practice and theory of annealing. Conditions favourable for precipitation of carbon. Other changes in the annealing operation.

Properties and uses of malleable cast-iron.

2. Manufacture of Steel.

The relative position of the steel-trade in the chief steel-making countries. Conditions governing choice of method or process in particular districts or countries.

The Bessemer Process - Description of the acid and basic processes; chemistry of the processes.

Construction of converters; materials used therein.

Composition and methods of supplying the hot metal. Working detail of each process.

The functions of carbon, silicon, manganese and phosphorus; influence of variations.

Lay-out of a Bessemer plant.

The Open Hearth Process - Description of the acid and basic processes; chemistry of the processes.

Compositions of pig irons, ore and scrap used. Elimination of impurities.

Details of construction of the open hearth furnace; materials used therein; lining and repairing the hearth. Lay-out of an open hearth furnace plant. Regenerators and valves.

The charge; charging methods and charging machines.

Tapping and other working details. Yield of metal. Comparison of acid and basic steel. Composition of slags and steels produced.

Modifications of the open hearth process. Tilting furnaces. Metal mixers.

Methods of dealing with emergencies - e.g. hot and cold "heats" etc.

Shear and Crucible Steels. Blister, shear and double shear steel.

Manufacture and composition of crucibles. Annealing crucibles. Clay and plumbago crucibles compared.

Crucible furnaces. Constitution of the charge. Composition of materials used. Melting and casting problems.

Varieties of steel produced.

Applications of Electricity in the production of steel.

Casting of Steel - The Production of castings dealt with as a subject in general rather than in detail.

The Tropenas and Stock converters. Moulds used. Annealing of castings.

The Production of Ingots - Ladles, cranes, and ingot-moulds; ingot-stripping. Reheating furnaces, soaking-pits. Shrinkage, liquation and segregation in ingots; blowholes; methods of producing sound and uniform metal including fluid compression of ingots.

Mechanical Treatment. - Effects of working on physical properties. A general knowledge of the processes of rolling, forging, pressing, tube-making, wire-drawing and welding.

Re-heating and re-heating furnaces.

Protection of Iron and Steel. - Galvanizing, tinning, spraying, calorizing, electrodeposition, painting and other methods.

Commercial Varieties of Steel. - Special attention should be given to the specifications adopted by the British Standards Institution.

Alloy Steels. - Influence of nickel, chromium, manganese, tungsten, cobalt, silicon, vanadium and molybdenum. Stainless irons and steels, including the austenitic varieties; heat-resisting irons and steels.

3. Physical Metallurgy.

General. - Phase-changes in iron and steel. Conditions of carbon in iron.

Iron-cementite and iron-graphite equilibria. Stable and metastable states.

Influence of mechanical treatment on microstructure.

Influence of carbon and impurities on the physical, mechanical and chemical properties of iron.

Macrostructure of steel ingots, castings and forgings.

Non-metallic inclusions. Heterogeneity of structure.

Effects of annealing; grain-growth, grain refining, "burning", spheroidizing, etc.

Heat Treatment. - Influence of heat treatment on microstructure and properties; nomenclature of structural constituents, influence of shape and mass, rates of heating and cooling, quenching media, temperature and time of heating and furnace atmosphere.

The scope and technique of heat treatment. Normalizing,annealing, quenching, tempering, case-hardening.

Application of heat treatment to grey cast-iron, carbon steels, carburized steels, alloy steels, self-hardening and high speed steels. Nitrided steels.

Physical Testing. - Stress, strain and elasticity. Strength and ductility. Load-strain diagram. Tensile-testing machines. The test-piece.

Impact tests. Hardness-tests. Bending and fatigue-tests. Tests for welding and hot and cold working properties. Testing rails, axles, tyres and springs.

Microscopic Examination - Candidates will be required to be familiar with the microstructure of cast-iron, wrought iron, malleable cast-iron, and of steels in the unworked, worked and heat-treated condition.

Pyrometers. - Principles of thermo-electric, electrical resistance, radiation and optical pyrometers. Potentiometers, indicators and recorders. Methods of calibrating pyrometers. Industrial pyrometric installations.

The Final Examination of the Institute will comprise two question papers, each of three hours' duration, requiring written answers, drawings or sketches. The First Paper (common to Subject 14, Iron and Steel, and to Subject 15, Non-Ferrous Metals and Alloys) will be upon Physical Metallurgy with questions set upon Section 3 of the above syllabus; and the Second Paper will be set on Sections 1 and 2 of the above syllabus.

Failure in one paper will carry with it failure in the examination as a whole.

A candidate who has passed the Final Examination in either Section of Subject 15, Non-Ferrous Metals and Alloys, if entering for Subject 14 will not be required to take the Final General Paper on Physical Metallurgy a second time. A candidate who has been informed that in his previous examination in Subject 15 he only obtained Second Class marks in the General Paper on Physical Metallurgy must re-enter for the General Paper on Physical Metallurgy if he wishes it to be possible for him to secure a Certificate of the First Class in Subject 14.

Appendix IV

Syllabus: 1939-40

INTERMEDIATE GRADE

1. Properties of Metals:- Physical - Lustre, colour, density, crystalline nature, types of fracture, specific and latent heat, electrical and thermal conductivity, fusibility, volatility. Elasticity, tenacity, ductility, toughness, hardness, malleability.

Chemical - Metals and their compounds: oxidation and reduction. Action of furnace gases on metals.

2. Metallurgical Terms - Mineral, ore, gangue, ore dressing, concentrates, middlings, tailings. Regulus, matte, speiss, flux, slag.

3. Sampling - Principles of the hand-sampling of ores, metallurgical products, fuels, metals and alloys.

4. Fuels - Combustion, calorific value, evaporative power. Classification of Fuels - Solid Fuels - Wood, peat, lignite, bituminous coal, anthracite. Pulverised Fuel, Briquettes. Charcoal. Coke.

Liquid Fuel - Fuel Oil.

Gaseous Fuels - Producer gas, blast furnace gas, coke oven gas, coal gas.

5. Refractories - General requirements in acid, basic, and neutral refractories. Fireclay and firebrick. Silica and silica brick. Ganister, bauxite, lime, magnesia, dolomite, chromite, carborundum.

6. Furnaces - Principles of design. Classification of furnaces on basis of fuel utilisation. Principles of regeneration and recuperation. Classification of electric furnaces - arc, resistance and induction.

7. Principles Underlying Chief Metallurgical Processes - Oxidation, reduction, leaching. Precipitation, distillation, sublimation, calcination, roasting, scorification, sintering, smelting, the Thermit process, melting, refining, liquation, crusting, Bessemerisation.

8. Principles Underlying Physical Examination of Metals and Alloys - Mechanical tests. Crystalline structures.

9. The Chief Groups of Industrial Metals and Alloys - Wrought iron; grey cast iron; white iron; malleable iron; carbon steels; copper; spelter; tin; lead; aluminium; nickel; the brasses; bronze; bearing metals; light alloys.

Principles of Physical Metallurgy

1. Properties of Metals. The physical and mechanical properties of metals and alloys. Lustre; colour, density, crystalline nature; fracture; specific and latent heat; electrical and thermal conductivity; fusibility volatility; occlusion; diffusion; malleability; ductility; hardness. Allotropy.

2. Thermal Analysis - Heating and cooling curves; physico-chemical changes occurring during and after solidification. Under cooling phenomena.

3. Other Physical Determination - Dilatometric determinations. Electrical conductivity and resistivity measurements. Electrical conductivity and hardness in relation to consitution.

4. The Constitution of Alloys - Diagrams of thermal equilibrium; the phase rule and its application to metallic systems. The constitution of binary alloys. Method of representing the constitution of ternary alloys.

5. Macrography and Metallography - Apparatus and methods used in selecting, preparing and examining specimens. Macrographic examination. Micro-structural constituents and inclusions. Types of

structure.

6. Physical Testing - Definition of stress, strain and elasticity. Proof stress. Ductility. The tensile test. Tensile testing machines. Load-strain diagram. Torsion tests, "creep-tests", impact tests, hardness tests (abrasion and indentation), bending and fatigue tests. Ductility tests - e.g. Erichson.

7. Pyrometry - Principles of thermo-electric, electrical resistance, radiation and optical pyrometers. Potentiometers, indicators and recorders. Methods of calibration.

8. Constitutional Diagrams of Typical Alloy Series - Binary systems.

9. Physical constitution and micro-structure in relation to mechanical treatment, heat-treatment. Ageing.

<u>Production of Iron and Steel</u>

<u>Pig Iron.</u> 1. Distribution and economic value of iron ore and deposits.

2. Iron ore sampling; preparation of ores for smelting; changes in composition thereby produced.

3. Physical properties, compositions and preparation of various classes of fuels, fluxes and subsidiary ferrous materials used in smelting.

4. Storage, handling and transportation of raw materials. Hoists and charging appliances.

5. The blast furnace; recent developments in construction and design.

6. The smelting process. Distribution of materials in the furnace. Subsidiary ferrous materials in the burden.

7. Function of the air-blast; methods and results of heating and drying the blast; effects of moisture and of drying the blast; temperature equalization; tuyeres.

8. Chemistry of the smelting process. Furnace reactions. Chemical balance sheet. Principles of burdening. Zones of combustion and reduction. Thermal balance sheet.

Influence of variation of blast temperature and pressure, and of physical properties of ore, fuel and flux on the production and properties of iron and slag.

9. Details of tapping. Transference of hot metal. Pig casting.

10. Pig iron: Effects of carbon, silicon, phosphorus, sulphur, manganese. Classification. Relationship of composition and fracture. Influence of furnace conditions and rate of cooling.

11. Utilization of slags.

12. Properties, cleaning and utilization of blast-furnace gas.

13. Layout of complete blast-furnace plant.

Wrought Iron - 14. Compositions of pig irons used. Fettling, Refining, puddling. Effect of composition on product. Slags produced. Various qualities of wrought iron; production, composition, properties and uses. Hot and cold mechanical tests. Chemistry of the puddling process.

Steel - 15. Brief historical survey of steel-making processes and consideration of modern developments. Conditions governing choice of method or process in particular districts or countries.

Bessemer Steel - 16. Description of the acid and basic processes; chemistry of the processes. Construction of converters; materials used therein. Composition of, and methods of supplying, the hot metal. Working of acid and basic charges. Composition of slags.

The function of carbon, silicon, manganese and phosphorus.

Lay-out of a Bessemer plant.

Open-hearth Steel - 17. Description of the acid and basic processes: chemistry of the processes.

Details of construction of fixed and tilting open-hearth furnaces; materials used therein; composition and properties of fuels; principles of regeneration.

Composition of the materials of the charge. Metal mixers; charging methods. Working of acid and basic charges. Composition of slags.

Lay-out of plant.

Modification of the open-hearth process.

Electric Furnace Steel - 18. Types of arc furnace construction, acid and basic linings, conducting hearths, melting and refining processes, action of slag, sulphur elimination, working of charges, production of carbon and alloy steels. Steel making in modern induction furnaces.

Ingots - 19. Methods of production. Shrinkage and segregation. Types of ingot. Ingot yields by various processes.

20. Comparison of steels made by foregoing processes.

Appendix V

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Rules 111
April 1945

MINISTRY OF EDUCATION

Arrangements and Conditions for the Award of National Certificates in Metallurgy to Students at Colleges or Schools for Further Education in England and Wales

1. The Iron and Steel Institute, the Institution of Mining and Metallurgy, and the Institute of Metals, in conjunction with the Ministry of Education, are prepared to approve schemes submitted by Technical Colleges or Schools working under the Ministry's Administration, for the award under approved conditions of National Certificates in respect of the successful pursuit of part-time grouped courses in Metallurgy.

For the purpose of administering the award of these Certificates a Joint Committee for National Certificates in Metallurgy (hereinafter referred to as "the Committee") has been formed consisting of representatives of The Iron and Steel Institute, the Institution of Mining and Metallurgy, the Institute of Metals and the Ministry of

Education.

Courses of Instruction

2. (a) Courses for the purpose of a certificate under these Rules must be carried on for at least 180 hours in each year. If the instruction is given exclusively in evening classes the course should, as a rule, be carried on for three evenings a week during the school session.

(b) Courses are classified as follows:-

(i) Senior Courses, adapted to the needs of students, who have had full-time continuous education up to the age of 15 or 16, or have completed satisfactorily an appropriate preliminary part-time course. Senior courses must extend over at least three years; in addition to Metallurgy at appropriate stages they must include suitable Chemistry, Physics and Mathematics, and may, where desired, include Engineering Drawing. Certificates relating to senior courses will be termed "Ordinary National Certificates in Metallurgy".

(ii) Advanced Courses, adapted to the needs of students who have completed satisfactorily a senior course or are otherwise suitably qualified (see paragraph 4.). These courses aim at reaching, within the limits of the subjects covered by them, the standard of University work. Advanced courses must extend over at least two years. Certificates relating to advanced courses will be termed "Higher National Certificates in Metallurgy".

(c) As a rule the whole of the course must be taken by the student at one school, but, subject to previous approval by the Committee, different years of the course may be assigned under a scheme to different schools with suitably co-ordinated curricula and the course of instruction previously taken by a student who has migrated from one area to another, or by a student who has received satisfactory instruction at a Secondary School or Junior Technical School, may be accepted in lieu of such portion of a senior course, other than the final year, as may be previously approved by the Committee.

(d) Where the equivalent of any part, other than the final year, of a course at an approved school is also provided at another school this latter may, under a supplementary scheme, be approved as a "contributory school".

(e) The Certificates (Ordinary and Higher) will record the subjects constituting the course.

(f) Higher Certificates awarded in respect of advanced courses approved as including specialised instruction in Foundry Work subjects will be countersigned on behalf of the Institute of British Foundrymen.

(g) The titles of any approved subjects of study appropriate to an approved course and of a standard not beyond that reached in a senior part-time course, which are successfully taken as an extension of that course, will be added as a supplementary endorsement on the "Ordinary" Certificate. Similarly, the titles of any additional approved subjects of study appropriate to an approved course which are successfully taken as an extension of an advanced part-time course will be added as a supplementary endorsement on the "Higher" Certificate. The counter-signature arrangements detailed in paragraph (f) preceding will apply to such supplementary endorsements.

Approval of Schemes

3. Schemes for approval under these Rules must be

submitted in accordance with the instruction laid down in paragraph 13. Before approving a scheme the Committee will require to be satisfied, for the purpose of the courses under these Rules, as to the equipment of the school, the qualifications of the staff, the curriculum and syllabuses of instruction in the several subjects. Recognition of a school for grant under the Regulations of the Ministry of Education will not necessarily imply that the conditions in regard to equipment, staffing, etc., are such as the Committee can accept for the purposes of the award of National Certificates.

4. Steps must be taken to secure that students are not admitted to the courses unless they are qualified to profit by them. For the present, evidence of having passed an approved preliminary examination prior to admission to a senior course will not be required. For students desiring to enter an advanced course who have not completed a senior course, evidence satisfactory to the Committee as to the attainment of the standard of the Ordinary National Certificate in Metallurgy must be produced.

5. The conditions of a scheme with respect to home work, laboratory work and records, drawings, if any, and examinations (see paragraph 10) prior to the final year of the course, must be submitted for the approval of the Committee.

6. Examinations, including practical tests in appropriate subjects, upon the courses of study detailed in the syllabuses constituting part of the approved scheme must be held in each year of the course. These examinations must be held by the teachers or by an examining body duly approved for the purpose by the Committee. For the examination in the final year of the courses and examinations in subjects for supplementary endorsement the examiners must be associated with assessors in accordance with paragraph 9.

7. It will be a condition of approval of a scheme that certificates shall be issued only to those candidates who pass the prescribed examinations, and that no candidate shall be awarded any certificate or diploma by a college, school or regional examining union on the result of a common examination in which he has

failed to obtain a National Certificate. The award of a National Certificate may be withheld if this condition is not satisfied.

Examinations

8. A memorandum prepared by the Committee as to the conduct and supervision of the final examinations under these Rules may be obtained from the Ministry of Education and arrangements in conformity therewith must be made by the college or school authorities. The examinations will be open to inspection by His Majesty's Inspectors.

The final practical examinations should be conducted, so far as possible, under such conditions as to time allowance, library and laboratory facilities as would obtain in ordinary metallurgical practice.

9. In order that the Committee may be satisfied in respect both of the standard of the questions set and of the marking of the examination scripts, The Iron and Steel Institute, the Institution of Mining and Metallurgy and the Institute of Metals will appoint assessors to act under the Committee's control.

The assessors will review the examination papers set at the end of the final year of the course, and will have the option of substituting questions up to 40 per sent of the total number of questions set. They may make any questions compulsory provided that the number so made compulsory shall not exceed 40 per cent of the number to be answered.

The marking by the examiners of the scripts worked in the final examination will be subject to revision by the assessors, and the marks as accepted or revised by them will be taken into account as explained below for the purpose of awarding certificates and distinctions in accordance with the conditions of paragraphs 10 and 11. The assessors may also satisfy themselves with regard to the amount and standard of the laboratory work done by each student throughout the course, as recorded in the laboratory notebooks (see paragraph 18).

<u>Conditions of Award Certificates</u>

10. To qualify for the award of a certificate a candidate must have:-

(i) made not less than 60 per cent of the possible attendances in each year of the course;

(ii) fulfilled the conditions of the approved scheme with respect to examinations, home work, laboratory work and records, and drawings, if any, in each year of a course prior to the final year;

(iii) obtained not less than 40 per cent of the possible marks in each subject in the final examination;

(iv) obtained in the final year not less than 40 per cent of the possible marks for home work and for laboratory work and records respectively in each subject for which such marks are to be awarded under the approved scheme;

(v) obtained in the final year not less than 50 per cent of the grand total of possible marks. Of this total of possible marks those allocated to the final examination should constitute 70 per cent, and the remaining 30 per cent should be the possible marks for home work and for laboratory work and records for the final year. Where the final examination in any subject includes a practical test, the possible marks in the practical examination should constitute 40 per cent of the total possible marks for the final examination in that subject.

To qualify for the supplementary endorsement of an additional subject of study on a certificate, a candidate must satisfy the conditions under (i), (iii), (iv) and (v) preceding, and, where appropriate, the conditions under (ii).

The Committee may require the submission of the college or school records of attendance, the testimonies of studies, and the laboratory notebooks of any candidate to whom the issue of a certificate is desired.

11. A distinction may be awarded to any candidate qualified to receive a certificate who gains not less than 80 per cent of the possible marks in the final examination in any subject, and his certificate may be specially endorsed to show the subject or subjects in which he

has thus distinguished himself.

12. For a limited period after a scheme has been approved the Committee may decide to issue certificates in respect of a senior course taken by students who have not fulfilled the prescribed conditions in earlier years provided that the conditions applicable to the final year of the course have been completely satisfied.

Submission of Schemes

13. Applications for the approval by the Committee of new and revised schemes must be submitted by the correspondent of the college or school in the first instance to the Ministry of Education, from whom the necessary forms of application and all other forms required under these Rules may be obtained. Applications should be made on Form 325 T, or if they are in respect of courses of contributory schools (see paragraph 2 (d), on form 325a T., in triplicate, not later than 30th September in the school year for which approval is desired. In subsequent years, unless alterations of an approved scheme are proposed by the college or school or are required by

the Committee, a renewed application for approval need not be submitted. An approved scheme, however, may not be altered in any way without the previous approval of the Committee.

Duties of Examinations Officers

14. Each college or school must appoint an examinations officer to conduct on behalf of the College or school the necessary correspondence with the Committee or with the Ministry of Education in connection with the examinations. The Name and address of this officer must be notified to the Committee and to the Ministry of Education.

15. Not less than two months before the date of the beginning of the examinations, the examinations officer must submit to the Committee for transmission to the assessors, draft examination papers, in duplicate, for the examinations in the final years of the courses, together with a copy of the approved syllabuses.

If it is not found possible to complete the whole of the approved syllabuses during the year, a clear indication must be given of those parts which are being omitted in that year.

16. At least one month before the date of the commencement of the examinations, the examinations officer must inform the Committee on Form 328 T, of the number of candidates entered for the examinations to be held in the final years of the courses, and at the same time forward the fees (see paragraphs 20 and 21).

17. The examinations officer will be responsible for the conduct and supervision of the final examinations in conformity with these Rules and with the memorandum mentioned in paragraph 8, and for the safe custody of the examination papers as revised by the assessors and of the worked examination scripts.

As soon as possible after the scripts of the examination of the final year have been marked by the examiners, and in any case not later than 1st July in any year, the examinations officer must forward them to the Committee together with schedules of marks on Form 330 T. After scripts and schedules of marks have been returned to the College or school, the examinations officer will forward Forms 329 T. and

330 T. to the Committee.

Forms 329 T will exhibit the records of the candidates for the several years of their courses in respect of:-

(i) attendance;

(ii) marks for home work, for laboratory work and records, and for drawings, if any;

(iii) examination marks.

The number of marks awarded in connection with each paper set, and in respect of home work, laboratory work and records and of drawings, if any, will be stated on the forms in each instance as a percentage of the maximum marks severally obtainable. Provision will be made on the forms for any recommendations or remarks the teachers may wish to make.

18. If required, the examinations officer must transmit immediately to the Committee, at any time within three months from the last day of the final examination, any candidate's attendance record, testimonies of study

and laboratory notebooks for each year of the course, such notebooks to be attested duly by the teacher of each subject. During the same period he must be prepared to produce for the information of His Majesty's Inspectors any such laboratory notebooks not in the custody of the Committee. In due course, the records, etc., requisitioned by the Committee will be returned to the examinations officer.

19. The Committee will issue to the examinations officer a list of the results showing the names of the successful candidates and any awards of distinction; and as soon as possible thereafter the certificates will be sent to the examinations officer. The college or school authorities must keep a register containing the names of the students to whom certificates have been awarded. The Committee and the Ministry of Education will keep registers of all certificates awarded by them under these Rules.

Fees and Correspondence

20. For the present the following scale of fees has been adopted:-

Fee to be paid by the college or school authorities in respect of each group of candidates entered for a final examination of a senior or advanced course:-

Senior	- In respect of the first group	5 gns.
	In respect of each additional group, for each subject which is not taken by the first or a subsequent group.	$1\frac{1}{2}$ gns.
Advanced	- In respect of the first group	5 gns.
	In respect of each additional group for each subject which is not taken by the first or a subsequent group	$1\frac{1}{2}$ gns.

Fee to be paid by the college or school authorities in respect of each additional subject for supplementary endorsement $1\frac{1}{2}$ gns.

Fee to be paid in respect of each candidate entering for a final examination or an examination for supplementary endorsement 5s.0d.

21. All cheques or postal orders should be made payable to the National Provincial Bank Ltd - Metallurgical Institutes Account, and crossed National Provincial Bank Ltd., and all correspondence with the Committee in connection with any matters arising out of these Rules should be prepaid, and should be addressed to:-

The Secretary,
The Joint Committee for National
Certificates in Metallurgy,
4 Grosvenor Gardens,
London, S.W.1.

Correspondence relating to the submission of schemes (see paragraph 13) should be addressed to:-

The Secretary,
Ministry of Education,
Belgrave Square,
London, S.W.1.

by whom all forms will be supplied.

Appendix VI

To Local Education Authorities for Higher Education, to the Principals of Colleges and Schools providing National Certificate Courses, or Courses in Metallurgy and (for information) to Local Education Authorities for Elementary Education.

Administrative Memorandum No 2
31st August, 1944

MINISTRY OF EDUCATION

National Certificate Courses in Metallurgy

1. A scheme for the award of Ordinary and Higher National Certificates in Metallurgy is being arranged by the Ministry with the Iron and Steel Institute, the Institution of Mining and Metallurgy, and the Institute of Metals.

2. The scheme will operate with effect from the beginning of the School Year 1945-46, and a final examination for the Ordinary Certificate will be held in 1946 for any qualified candidates desiring to present themselves. Under the scheme a course for the award of the Certificate must include, in addition to

Metallurgy at appropriate stages, suitable Chemistry, Physics and Mathematics, and may if desired, include Engineering Drawing.

3. Certain questions relating to the scheme are still under discussion but it is hoped that these questions will be settled at an early date and that the Rules setting out the agreed arrangements and conditions for the award of the Certificates will be issued before the end of the present calendar year. This preliminary notification is issued in order to allow Colleges and Schools providing instruction in Metallurgy ample time for the formulation of courses suitable for acceptance under the scheme.

To Local Authorities and for information to the Principals of Colleges and Schools providing National Certificate Courses.	Administrative Memorandum No 57 15th May, 1945

MINISTRY OF EDUCATION

National Certificate Courses in Metallurgy

In accordance with the announcement made in

Administrative Memorandum No 2 which issued on 31st August, 1944 a copy of Rules 111 showing the arrangements and conditions agreed upon between the Iron and Steel Institute, the Institution of Mining and Metallurgy, the Institute of Metals and the Ministry for the award of Ordinary and Higher National Certificates in Metallurgy is enclosed.

The Institute of British Foundrymen has agreed to co-operate in the scheme by countersigning Higher Certificates awarded in respect of approved Advanced Courses including specialised instruction in Foundry Work subjects, and provision for this countersignature is accordingly made in the Rules.

As already announced in Administrative Memorandum No 2 the scheme will operate with effect from the beginning of the School Year 1945-46 and a final examination for the Ordinary Certificates will be held in 1946 for any qualified candidates desiring to present themselves. In the Colleges and Schools having such candidates, the application for the approval of a scheme under these Rules should be made on Form 325 T as soon as possible and in any case before 30th September, 1945. Copies of this Form may be obtained on application to the Ministry.

Appendix VII

Syllabuses

INTERMEDIATE GRADE

Chemistry

I. General Chemistry - Introductory lecture outlining the scope of chemistry and emphasising the importance of a knowledge of the subject to the Metallurgist. Elements, mixtures and compounds. Laws of Chemical Combination by weight. Valency and atomic structure; equivalents. Use of symbols, formulae and equations. Avogadro's law. Simple calculations based on equations. Elementary study of air and water - natural water, hard and soft water. Experimental study of oxygen and hydrogen. Oxidation. Reduction. Acids; bases and salts. Methods of production and properties of the common mineral acids and of caustic soda. Carbon - carbon monoxide - carbon dioxide. Simple hydrocarbons. Combustion and flame. Sulphur - oxides of sulphur. Sulphuretted hydrogen - use in qualitative analysis. Nitrogen - ammonia and ammonium salts. Halogens and halogen hydracids. Quantitative interaction of acids with metals and bases. Use of standard solutions of acids and alkalis, permanganates and dichromates.

Silicon - silica - glass. Refractories. Slags. Phosphorus - oxides and oxyacids. Introduction to the study of the chemistry of the following metals and their more important compounds:- magnesium, zinc, cadmium, mercury, copper, silver, gold, iron, cobalt, nickel, manganese, chromium, aluminium, tin, lead.

2. Physical Chemistry - The elements of physical chemistry including the following:-

(a) Crystals and the crystalline state - characteristics of solids - process of crystallisation - crystal systems and structure of crystals. Melting points and transition points. Metastable and stable forms. Isomorphism.

(b) Phase rule - one, two and three component systems. Graphical representation.

(c) Solutions - solids in liquids, gases in liquids, gases in solids, solids in solids.

(d) Simple account of Ionic hypothesis. The meaning and importance of pH. Indicators - simple theory and use.

(e) Electrical conduction in solutions and metals. Types of conductors; electrolytic dissociation; Faraday's laws. General principles of Electro-deposition of metals and factors which influence the structure and properties of the deposits.

(f) Thermo-chemistry. Heats of reaction, formation and combustion. Hess's law. Heat of Neutralisation.

3. Practical work - The practical test of three hours duration will be directed towards determining a candidate's familiarity with qualitative and quantitative (both volumetric and gravimetric) analysis.

In physical chemistry the following experiments, which will not constitute a part of the syllabus for the practical examination, are offered as examples of useful practical work:-

Determination of equivalents - e.g. Copper by displacement, tin by action of nitric acid, zinc by replacement of hydrogen in acid. Proof of law of multiple proportion by reduction of oxides by means of coal gas. F.p. curves for lead-tin alloys. Construction of solubility curves. Determination of conductivity, transport numbers etc. Variation of conductivity with temperature. Electrometric titration of alkali with acid. Determination of heat of neutralisation of alkali by acid.

PHYSICS

1. Mechanics - Newton's Laws of Motion - moments of forces - centre of gravity. Mass-momentum, force, impulse, work, energy, power, their units and dimensions. Simple harmonic motion. Wave-motion.

2. Heat - Heat as a form of energy. Temperature - thermometers. Heat units; expansion of solids, liquids and gases. Thermal capacity; specific heat; calorimetry; Boyle's Law; Charles' Law; the properties of vapours; Dalton's Law. Sensible heat; latent heat; the formation of steam. The transfer of heat by conduction, convection and radiation with applications. Mechanical equivalent of heat. The conversion of heat into work.

Vapour pressure, Dalton's Law, Dewpoint, Laws of transmission of heat by conduction and radiation. Emissivity. Black body conditions. Stefan Boltzmann Law. Pyrometry.

3. Electricity and Magnetism - Magnets, magnetic properties, induction. Magnetic force, magnetic field, lines of force. Simple voltaic cell, electro-motive force, electrolysis. Magnetic field due to current, electro-magnets, measurement of current, moving-coil galvanometers, simple forms of ammeters and volt-meters. Ohm's Law, resistance and its measurement. Heating effects of currents.

Measurement of low and high resistances. Specific resistance, series and parallel circuits. Electromagnetism, magnetic fields of permanent magnet and of an electric circuit. Force of a conductor carrying a current in a magnetic field. Force between coils carrying an electric current. Electromagnetic induction. Lenz's Law. Calculation of Ampere Turns, Magnetic properties of materials, magnetic fields and field strengths. B/H curves, hysteresis.

Thermo-electric effects and their application to pyrometry. Introductory treatment of A.C. theory; waveform, frequency. Instantaneous and R.M.S. values. Standard waveform, vector representation. Effect of Inductance and capacitance in A.C. circuits. Reactance, impedance, phase displacement. Calculations for simple series and parallel circuits. Power and power-factor. Elementary treatment of the single-phase transformer. Hysteresis; eddy currents. Thermionic emission and its simple application. Elementary description of cathode ray tube.

4. <u>Light</u> - Rectilinear propagation - Reflection from plane surfaces:- Images and parallax, Inclined Mirrors, Reflection from spherical mirrors:- Principal focus, conjugate points, Relative positions of image and object - magnification. Laws of refraction, measurement of refractive index. Total reflection. Passage of light through a prism. Lenses:- Types, focal lengths, graphical construction of images, magnification. Simple optical instruments, the eye,

Photometry.

Dispersion. Production of pure spectrum. Spectroscope. Interference. Measurement of wave length. Diffraction grating. Polarisation.

5. Practical Work - The Institute will not hold a practical test but each candidate should carry out during the course experiments related directly to the principles enumerated in the preceding sections 1 to 4.

MATHEMATICS

1. Arithmetic and Calculations - Facility in the use of common arithmetical processes. Significant figures, degrees of accuracy, Use of logarithms in simple calculations.

Laws of indices. Logarithms, including numbers raised to negative index. Evaluation of more involved formulae. Simple approximations. Use of slide rule.

2. Mensuration - Right angled triangles. Surface and volume of cylinders and prisms. Density and weights of solids. Similar figures.

Surface and volume of cone; sphere. Simpson's rule. The rectangular solid.

3. <u>Algebra</u> - Symbolic expression. Manipulation of simple expressions. Evaluation of formulae. Fractions. Changing the subject of simple formulae. Simple equations.

Simultaneous equations. Quadratic equations. Simple Algebraic series.

4. <u>Graphs</u> - Plotting from tables. Interpolation. Plotting from simple formulae. Solution of equations by plotting. Determination of linear laws. Areas.

Illustration and solution of more difficult algebraic and trigonometrical equations. Determination of laws from experimental data.

5. <u>Geometry</u> - Elementary geometry of triangles, including similar triangles and ratios of corresponding sides. Areas of similar triangles and polygons. Elementary geometry of angles subtended by chords of a circle.

Theorem of Pythagoras: application to general solution of triangles. Use of geometrical methods in mensuration.

6. <u>Trigonometry</u> - The measurement of angles of

rotation; radian measure. The trigonometrical ratios up to one complete revolution and their graphs. Relation of the ratios derived from the right angled triangle. Solution of acute angled triangles by the sine rule. Simpler relations between the ratios. Solution of simple trigonometrical equations. Simple problems in heights and distances.

Trigonometrical ratios for any angle. Further relations between the ratios - Sin $A \pm B$ and cos $A \pm B$ formulae and simple extension. Solution of triangles and application to simple problems in surveying.

7. <u>Calculus</u> - Graphical differentiation; rates of change; derivatives of simple functions including x^n, cos x, sin x. Integration as the reverse of differentiation.

ENGINEERING DRAWING

The aim of this branch of work should be to develop the student's ability to read and understand a drawing rather than to train a prospective draughtsman.

BSI Engineering Drawing Office Practice to be followed in the making of drawings, tracings in ink and reproduction of drawings.

General - Use of instruments. Use of scales.

Geometry - Construction of angles, triangles, quadrilaterals, hexagons, octagons. Problems on circles and tangents. Construction of ellipse. Principles of orthographic projection. Simple sections. Isometric or oblique projection.

Machine Drawing - Freehand sketching of machine parts. Production of drawings to scale from dimensioned sketches, from freehand sketches and from measurements of machine parts. Clear and systematic dimensioning. Standard screw threads and conventional way of showing threads. Sketching of fastenings such as screw threads, bolts, studs, rivets, keys, pins, cotters, and of simple rivetted joints. Production of drawings to scale of machine parts, engine details, transmission details and boiler fittings. Suitable typical examples may be taken from the following:- Details of bearings, couplings, fast and loose pulleys, brackets, flanged joints. Simple parts of steam and

and internal combustion engines such as pistons, piston rods, eccentrics, valves. Simple boiler parts including boiler-stays, man holes, valves. Stop valves for steam, water and gas pipe lines. Sketching of simple electrical details such as switches, terminal blocks, brush holders. Teachers are recommended to include in the course excercises on copying dimensional drawings of metallurgical plant.

METALLURGY

The syllabuses for this subject are the same as those set out in paragraphs 1 - 9 of Appendix III pages 33-37 but with gold and silver added to the chief groups of industrial metals and alloys paragraph 9 page 37.

10. Practical Work - The practical test of four hours duration will be based on the following metallurgical experiments conducted as far as possible on a quantitative basis:- Calcining of ores, roasting of sulphides, reaction of sulphides and oxides, reduction of oxides, reduction of sulphides, cupellation of argentiferous lead, scorification of argentiferous lead containing antimony or tin, determination of the coking

quality of coal.

Preparation of the following alloys:- Cartridge metal, Muntz metal, Gun metal, Bell metal, Admiralty metal (88/10/2), Cupro-nickel (70/30), Lead-tin solders, Type metals, Babbitt metal, Copper-aluminium (95/5 and 90/10), Aluminium copper (92/8 and 88/12).

Teachers are recommended to include in the course other exercises which will demonstrate the principles taught in the lecture room. These exercises as set forth below will not constitute a part of the syllabus for the practical examination.

Properties of Metals and Alloys.

Relative work-hardening capacities; effects of annealing; influence of temperature on working properties; oxidation at high temperatures and atmospheric temperatures; solubility of oxides; diffusion between solid and molten metals; immiscibility of lead and zinc; ductility; tensile properties; stamping quality; impact value.

Metallurgical Terms: Slags - production of single and multiple base silicates.

Sampling: Hand sampling of ores and fuels; sampling of metals and alloys.

Refractories: Effect of impurities; shrinkage; resistance to attack by metallic oxides.

Industrial Metals and Alloys: Influence of carbon and of phosphorus on melting point of iron; carburising; hardening and tempering carbon steels.

Preparation and Elementary micrographic examination of metals and alloys as cast, as rolled and as annealed.

Appendix VIII

NORTHERN COUNTIES

TECHNICAL EXAMINATIONS COUNCIL

METALLURGICAL COURSES S1, S2, S3, S4.

To obtain a grouped course certificate in any year,

(a) a candidate must pass in the subjects of the course.

(b) The Local Authority concerned must certify that the candidate has made satisfactory progress in the laboratory in the appropriate stages of Chemistry, Physics and Metallurgy.

1st Year S1

Chemistry	Physics	Mathematics

2nd Year S2

Chemistry	Physics	Mathematics

3rd Year S3

Inorganic Chemistry	Eng. Drawing and Mathematics	General Metallurgy

4th Year S4.

Physical Chemistry	Analytical Chemistry	Physical Metallurgy

Note: The Ministry of Education and the Professional Institutions concerned have agreed that the courses and syllabuses are such as can be approved when submitted by individual schools as part of a scheme for the Ordinary National Certificate in Metallurgy under Rules 111.

This approval applies to the session 1946-47 only.

SYLLABUSES

Inorganic Chemistry (S1).

Lecture and Demonstration

The scope of chemistry. Chemical and physical change. Elements, compounds and mixtures. Air as a mixture, rusting and combustion. Oxygen and hydrogen; water as a compound. Solution, solubility and crystallisation. Carbon, carbon monoxide, carbon dioxide, and the common carbonates. Simple treatment of flame and combustion. Nitrogen, nitrous oxide, nitric oxide, nitrogen dioxide, nitric acid and the common nitrates. Ammonia and ammonium salts. Sulphur, sulphuretted hydrogen, sulphur dioxide, sulphur trioxide and sulphuric acid. Chlorine, hydrochloric acid and the common chlorides.

Fundamental chemical theories: laws of chemical combination by weight leading to the Atomic Theory.

Equivalents. The laws of Boyle, Charles and Graham. Symbols, formulae and equations.

Practical Work

The study of chemical materials and processes based on the foregoing syllabus.

Inorganic Chemistry (S2)

Lecture and Demonstration

The gravimetric and volumetric composition of water. Natural waters, hardness of water. The manufacture and properties of oxygen; hydrogen peroxide and ozone. Classification of the oxides. Oxidising and reducing agents.

The halogens as a family, the halogen hydracids. Bleaching powder, hypochlorites and chlorates. Phosphorus, phosphine, phosphoric oxide, phosphoric acids. Silicon, silica, action of silica upon bases, the nature of glass.

General characteristics of the metals. An introductory study of the following metals and their more common compounds: sodium, calcium, copper, magnesium, aluminium, iron and lead. Revision and extension of the fundamental laws. Avogadro's Hypothesis. Determination of atomic and molecular weights. Valency. Reversible reactions. A simple treatment of the ionic theory and electrolysis.

Practical Work

Experiments illustrative of the foregoing subject matter. Simple acidimetry and alkalimetry. Characteristic reactions of the following acid radicals: carbonate, bicarbonate, sulphate, sulphite, sulphide, chloride, bromide, iodide and nitrate.

The detection of not more than two of the following metallic radicals in the presence of one another: lead, copper, iron, calcium, zinc, sodium and ammonium.

Inorganic Chemistry (S3)

Lecture and Demonstration - An outline of the periodic system and atomic structure.

A study of the following:- oxygen, oxides, sulphur, sulphides, carbon, carbon dioxide, carbon monoxide, producer gas, water gas, carbonates, water treatment.

The chemistry of the following metals and their metallurgically important compounds:- sodium, copper, silver, gold, magnesium, zinc, cadmium, mercury, aluminium, tin, lead, chromium, manganese, iron, cobalt, nickel.

Practical Work - Preparation of typical inorganic compounds. Simple volumetric estimations involving the use of potassium permanganate, potassium dichromate, and silver nitrate in neutral solution, and adsorption indicators.

The detection of metals in alloys and in mixtures of their salts or oxides.

Physical Chemistry (S4)

Lecture and Demonstration - Properties of gases, laws associated with the names of Boyle, Charles, Gay-Lussac, Avogadro, Graham, Dalton and Henry and calculations involving their use; kinetic theory of gases; specific heats of gases at constant pressure and constant volume; van der Waal's equation, isothermal and adiabatic expansion, liquefaction of gases.

Determination of equivalent, atomic and molecular weights. Osmosis and related phenomena. Thermo-Chemistry. The Law of Mass Action, solubility products. Electrical conductivity. The Phase Rule and its application to systems with one, two or three components, transition points. Measurement of pH, the theory of indicators, Measurement of E.M.F., electrode potentials. Catalysis. The Colloidal state of matter. The elements of crystallography. The application of the spectrograph.

Practical Work - Typical physicochemical determinations such as:- determination of vapour densities, depression of freezing point, determination of melting and transition points by cooling curves, construction of solubility curves, heat of neutralisation of acids and bases, heat of combustion, determination of electrical conductivity, determination of pH by indicators and by electrometric methods.

Physics (S1)

Energy - forms of energy - transmutation of energy.

Heat and Temperature; thermometry; the expansion of solids, liquids and gases; Charles' Law. Specific and latent heat, with simple calculations; transmission of heat.

Mechanical Force, work, energy and power; units. Principle of Moments; centre of gravity. Transmission of pressure in fluids; barometer; Boyle's Law.

Elementary properties of the electric current. Ohm's Law, electrical power and energy; practical units. Simple treatment of the heating, chemical and magnetic effects of the current.

The simple cell, polarisation, Leclanche cell. Lead-acid secondary cell.

Rectilinear propagation of light; intensity of illumination; inverse square law. Reflection from plane surfaces.

Physics (S2)

Heat - Calorimetry. Change of state. Mechanical equivalent of Heat. Radiation.

Light - Laws of Reflection. Mirrors. Laws of Refraction. Prisms and lenses. Simple Microscope. Spectra.

Magnetism and Electricity - Magnetic fields. Magnetic properties of materials. Magnetic effect of a current.

Resistance and its measurement.

Specific resistance and temperature coefficient of resistance. The potentiometer.

Magnetic behaviour of a coil carrying a current. Moving coil instruments. Heating effect of a current. Joule's Law.

Electromagnetic induction. Induction coil. Transformer. D.C. Dynamo and motor. Introduction to A.C.

Engineering Drawing (S3)

The aim of the course is to enable the student to understand a drawing and to produce clear sketches of plant details. Examples should be taken from metallurgical plant e.g. moulds; dies; patterns; furnaces; forging; rolling and drawing equipment; gas producers; testing machines etc.

Syllabus Use of instruments and scales. Geometrical drawing - plane figures, orthographic, isometric and oblique projections, simple sections. Freehand sketching. Production of dimensioned drawings to scale from sketches. Common engineering details such as screw threads; bolts; rivets and rivetted joints; keys; pins; cotters; simple machine parts and transmission details; bearings; couplings; fast and loose pulleys; flanged joints; valves.

Mathematics (S3)

In this course, an elementary treatment of the calculus only is expected.

The straight line graph and its slope. Graphs of simple functions. Slope of a curve at a point. Graphical differentiation. Differential coefficients of x^n, sin x, cos x, and at the same time the integrals of these functions, (excluding log x) - integration being treated as the inverse process to differentiation.

Function of a function rule.

Product and quotient rules for differentiation.

Rates of change.

Maxima and minima.

Simple substitutions for reducing an integral to one of the above forms (excluding $\int \log x \, dx$.)

Definite Integrals.

Evaluation of simple areas enclosed by curves.

Analytical Chemistry (S4)

Lecture - Scope and types of analysis. Volumetric

analysis - principles and manipulation. Acid-alkali titrations. Volumetric methods depending on oxidation and reduction - use of permanganate, dichromate, iodine, thiosulphate, titanous salts, etc.
Precipitation methods - use of silver nitrate. Gravimetric analysis - principles and manipulation.
Chemical considerations underlying the chief methods for determining lead, copper, tin, antimony, iron, aluminium, chromium, zinc, manganese, nickel, calcium, magnesium, silicon, sulphur, phosphorus, carbon.

Elementary consideration of physicochemical principles underlying analytical processes.

Laboratory - preparation and standardisation of solutions of acids and alkalis. Determination of insoluble bases. Further exercises in the use of silver nitrate in acid solution and of standard permanganate and dichromate. Determination of ferrous and ferric iron. Use of titanous salts. Preparation of standard iodine and thiosulphate and determination of arsenious acid and copper. Gravimetric determinations illustrating principles dealt with in lectures.

Mathematics (SI)

Arithmetic - Degree of accuracy; significant figures in a result calculated from measured values (with illustration from mensuration and experimental work); fractional and percentage errors, rough checks. Averages with negative terms. British and Metric Systems.

Algebra - How to read and evaluate formulae. Simple equations and simultaneous simple equations, with much practice in the solution of easy problems involving negative numbers. Building up formulae and expressing given conditions by means of symbols (application to areas of rectilinear figures, including quadrilateral and trapezium; circle; annulus; surfaces and volumes of simple solids). Simple cases of change in value of a function for given change in the variable. Changing the subject of formulae in simple cases, such as occur in the mensuration and mechanics of the course.

$$\left(cy = ax + b;\ \frac{a}{x} = \frac{b}{c};\ \frac{1}{y} = ax + b;\ \text{etc.}\right).$$

Very easy fractions with +, -, x, $\div$:

(not more difficult than $a + \frac{b}{c}$; $\frac{2}{x + 0 \cdot 5} + \frac{3}{x - 1}$; etc.).

Simple problems involving fractions. Product of binomials; simple cases of approximations, such as $(1 + x)^2 = 1 + 2x$ approx. when x is small. Percentage error in using such approximations.

<u>Factors</u> - Taking out a common factor; differences of two squares, with extensions; easy cases of factors of quadratic expressions. Use of factors in simplifying formulae for the purpose of numerical computation. Frequent use of numerical verification of identities.

<u>Indices</u> - Positive integral indices; laws of indices; roots as indices. Simplification of expressions involving indices in simple cases. Expressing a number in terms of a power of 10; such as $4321 = 4 \cdot 321 \times 10^3$, etc. Illustrations of indices from Log. Tables: expressing a number as a power of 10; leading up to the use of tables for calculations involving multiplication, division, and simple powers and roots: (preferably set out by first expressing

the given numbers as powers of 10 and using the laws of indices).

Remark - Algebra should be restricted to the simplest manipulation, and as much time as possible given to practice and easy problems. It is suggested that this is the better way to arouse real interest in the subject.

Graphs - Position of a point. Rectangular co-ordinates. Representation of pairs of numbers from experiment and equations. Plotting statistics and experimental results:- interpolation: practice in reading graphs - "point" and general slope properties. Importance of choice of scales. Graphs of simple functions such as $ax + b$; ax^2; a/x.

Ideas of a smooth curve associated with a mathematical function. Experiments on sketching a curve through a number of calculated points. Reading intermediate values and comparing with those obtained by calculation.

More particular study of the straight line graph; simple variation; interpretation of the constants in the equation. Slope applied to uniform speed; simple interest, law of machine, etc. Intersections of the graph with axes of co-ordinates. Intersection of two straight line graphs; simultaneous equations. Area under a graph by mid-ordinate rule.

To obtain the equation of a given straight line is not included as an item, though there is no objection to this being done if not at the expense of the more fundamental work outlined in the syllabus.

Trigonometry - How an angle is determined by the ratio of two sides of a right angled triangle. Definition of sine, cosine, and tangent, for angles not greater than 90 deg.; determination of these ratios by drawing and measurement. Given one ratio to determine the others. Use of tables. Solution of right angled triangle with applications to easy problems, by scale drawing and by use of trigonometrical ratios.

Mathematics (S2)

Throughout the whole of the course the idea of functionality should be emphasised.

Algebra - Factors of $ax^2 + bx + c$ with given numerical co-efficients; cube of a binomial; difference of two cubes with simple extensions; remaining factors of a cubic function where one linear factor is given; relation between linear factors and the zero values of a function (quadratic or cubic); approximate formulae for squares, cubes, square roots, cube roots of a binomial when one term is small; quadratic equations with applications to problems; equations (simple or quadratic) involving fractions.

Variation - Application to areas of similar figures and volumes of similar solids.

Indices - Laws for negative and fractional indices; manipulation of simple expressions involving indices; proofs of the rules for logs. of products, quotients and powers; evaluations from formulae to find the subject, and also when the subject is given to find some other factor; e.g., $y = x^n$ to find n; the slide rule.

Graphs - Slope and intercept of linear graph; linear laws with simple extensions; determination of laws from given data by reducing to the linear form and testing with a straight edge; graphs of quadratic and cubic functions; $\frac{a}{x - b}$ and ax^n with fractional and negative values of n; properties of simple functions from their graphs; maxima and minima values. Graphical solution of quadratic and cubic equations. Elementary notions of the slope of a curve at any point with applications to velocity; approximate arithmetical determination of the slope at any point of a curve; use of increment symbol δx.

Interpretation of the area under a graph, with applications to work and volumes of solids.

Trigonometry - Circular measure of an angle; application to problems in angular velocity; ratios of angles greater than a right angle; graphs of Sin θ and of Cos θ

Note - There should be free use of symbols other than x and y as the two principal variables.

General Metallurgy (S3)

Lecture - An introductory course dealing in an elementary way with:- Scope of metallurgy. Physical properties of metals, e.g. density, fusibility, tenacity, ductility, toughness, elasticity, malleability, hardness, fracture, conductivity. Methods of determining chief physical properties. Alloys in general. Impurities in metals. Chief physical properties of common metals and a few representative alloys. Chemical properties of metals in general and of compounds of metallurgical interest, e.g. oxides, sulphides, carbonates, etc. Occurrence of metals in nature, chief types of ore. Extraction of metals by various methods - smelting, hydro-metallurgical and electrolytic extraction. Preparation of ores for smelting. Reduction of metallic compounds. Fluxes and slags. Properties of silica and of basic oxides occurring in slags and refractories. Chief types of furnaces and their applications. Refractory materials. The casting and solidification of metals. Fire refining and electrolytic refining. Types of fuels. Combustion. Calorific Value. Evaporative power.

Working of metals - hot and cold rolling, drawing, hammering etc.

Laboratory - Experiments on:- The melting and casting and the chief physical properties of metals illustrated by tin, lead, magnesium, zinc, aluminium, silver, copper, iron, nickel. Effect of impurities on metals. Preparation and properties of alloys. Effects of cold and hot working. Formation and reduction of oxides and sulphides. Refining e.g. hard lead by scorification. Properties of silicates and refractory materials.

Physical Metallurgy (S4)

Lecture - Physical and mechanical properties of metals and alloys, and the chief mechanical tests. Structure of metals as revealed by macro-examination, micro-examination and X-ray spectroscopy.

Solidification of metals and alloys. Principles of phase diagrams illustrated by a few simple cases. Effects of hot and cold working, and of impurities and non-metallic inclusions. Heat treatment illustrated by annealing of cold worked metals and simple heat treatments of steel.

Pyrometry. Optical, radiation, thermo-electric and resistance pyrometers.

Laboratory - Macro and Micro-examination of metals. Preparation and examination of micro specimens of chief industrial alloys. Thermal analysis and micro structure of simple alloy systems. Effect of mechanical treatment and simple heat treatment on structure and properties. Mechanical testing - tensile, Brinell, izod and Erichson tests.

Appendix IX

Constantine College of Technology, Middlesbrough

National Certificate in Metallurgy

Number of Certificates Awarded

	O.N.C.	H.N.C.
1947 - 48	-	6
1948 - 49	1	5
1949 - 50	6	-
1950 - 51	5	1
1951 - 52	5	5
1952 - 53	6	-
1953 - 54	8	6
1954 - 55	10	1
1955 - 56	10	7
1956 - 57	5	6

Appendix X

14. PRINCIPLES AND PRACTICE OF METALLURGICAL OPERATIONS

NOTE IN REGARD TO THE INTERMEDIATE EXAMINATION IN ENGLAND AND WALES.

When an examination in this subject at a stage corresponding to the Institute's Intermediate Examination is held by an Examining Union recognised by the Ministry of Education, a Local Education Authority which is a member of the Union will normally arrange that its students at that stage will take the corresponding examination of the Union. The City and Guilds of London Institute will accept for its Intermediate Examination a candidate or candidates from such a Local Education Authority only upon the specific request of the Chief Education Officer of the Authority, confirming that the Authority, having considered the matter, desires the City and Guilds of London Institute to accept the candidate or candidates for the Intermediate Examination.

THE SCHEME of examinations in the Principles and Practice of Metallurgical Operations adopted by the

Institute on the recommendation of the Advisory Committee, is designed primarily for students who are actively engaged in or associated with the metallurgical and allied industries. A suggested curriculum for the guidance of colleges holding part-time grouped courses in Metallurgy has been drawn up by the Advisory Committee.

CURRICULUM:

The curriculum comprises courses extending in general over five years, and it will be seen from the scheme, as set forth below, that it is arranged to cover two stages, Intermediate Grade and Advanced Grade, extending over three years and two years respectively.

The course, as arranged, is expected to entail attendance during three periods (evening, morning or afternoon) weekly, and each year's course to comprise not less than 200 hours' instruction. The suggested curriculum is as follows:

INTERMEDIATE GRADE

*First Year	Chemistry
	Physics
	Mathematics

*The Principal of a Technical College may, at his discretion, admit to the second year of the course a student who has attained School Certificate credit standard, or its equivalent, in each of these subjects. Similar consideration may also be given to ex-pupils of Junior Technical Schools (or Secondary Technical Schools) who can produce evidence of having completed satisfactorily an appropriate course of instruction in these subjects.

Second Year	Physics
	Mathematics and Engineering Drawing
	Chemistry and General Metallurgy
Third Year	Chemistry
	Physics
	General Metallurgy

The syllabuses for the basic ancillary subjects of Mathematics, Physics, Chemistry and Engineering Drawing have not been divided into years, nor has the syllabus in General Metallurgy, since technical colleges may desire to vary the order of teaching in the manner best suited to local conditions and circumstances.

ADVANCED GRADE

Students will doubtless desire, in the first instance, to concentrate their studies on Ferrous Metallurgy or on Non-Ferrous Metallurgy, according to the branch of the industry in which they are interested, and in order to meet their requirements alternative schemes have been formulated.

In the fourth and fifth year students in either the Ferrous or the Non-Ferrous branch of the subject are expected to pursue a graded course of study, which must include as an essential part an adequate amount of practical work in the laboratory. Attention is drawn to the advisability of such students pursuing more advanced courses in Chemistry and in certain branches of Physics.

FERROUS METALLURGY

Fourth Year	Section A	Metallurgical Analysis
	Section B	Physical Metallurgy
Either	Section C	Production of Iron and Steel
or	Section D	Treatment of Ferrous Metals and Alloys

Fifth Year	Section A	Metallurgical Analysis
	Section B	Physical Metallurgy
Either	Section C or Section D. whichever has not been taken in the previous year.	

NON-FERROUS METALLURGY

Fourth Year	Section A	Metallurgical Analysis
	Section B	Physical Metallurgy
Either	Section E	Extraction and Refining of Common Non-Ferrous Metals.
or	Section F	Manufacture and Treatment of Non-Ferrous Metals and Alloys.
Fifth Year	Section A	Metallurgical Analysis
	Section B	Physical Metallurgy
Either	Section E or Section F, whichever has not been taken in the previous year.	

SCHEME OF EXAMINATIONS

Examinations in the principal metallurgical subjects and in the basic ancillary subjects will be held by the City and Guilds of London Institute, and, whilst the scheme has been devised on a grouped course basis, a candidate will not be debarred from presenting himself for examination in any of the metallurgical subjects alone.

A record of success (not a certificate) will be issued to a candidate passing an Intermediate examination in a basic ancillary subject or the Intermediate examination in General Metallurgy.

A certificate will be issued to a candidate passing the examination in any of the metallurgical subjects A, B, C, D, E and F of the Advanced Grade.

INTERMEDIATE GRADE EXAMINATIONS

Candidates for the Institute's Grouped Course Certificate in Metallurgy (Intermediate Grade) are expected to take in the same year either examinations in Chemistry and Physics, held upon approved syllabuses by or on behalf of the Governing Authority of the Technical College or the Intermediate examinations in Chemistry and Physics held by the City and Guilds of London Institute and the Institute's Intermediate examination in General Metallurgy. It is also expected that examinations at the end of the first and second years will have been held by or on behalf of the Governing

Authority of the Technical College concerned, but the City and Guilds of London Institute has also made provision to hold appropriate Examinations in Mathematics and Engineering Drawing.

The Examinations of the City and Guilds of London Institute in General Metallurgy will consist of a written question paper and a practical test, which must be passed in the same year; that in Mathematics will consist of a written question paper; and the Examination in Engineering Drawing will comprise a question paper to be answered by drawings or sketches.

The examinations in Physics will consist of two written question papers each of three hours' duration. One paper will be confined to (i) Properties of Matter and Mechanics and (ii) Heat, and the other to (iii) Light and (iv) Electricity and Magnetism. A candidate will be required to satisfy the examiners in each paper, but he will not be required to take both papers in the same year.

The examination in Chemistry will consist of two written question papers, each divided into three sections:

(i) General and Inorganic Chemistry; (ii) Physical Chemistry: and (iii) Organic Chemistry: and each paper will be of three hours' duration. Candidates will be expected to attempt questions from all sections in each paper. The examination will also include a practical test of four hours' duration. Candidates will be required to take both written papers and the practical test in the same year and to satisfy the examiners in each case.

The Institute will not hold practical tests in Physics; but every candidate offering Physics will be required to produce with his entry form a certificate from the Principal of the Technical College or other acceptable authority that he has satisfactorily completed appropriate courses of practical work.

ADVANCED GRADE EXAMINATIONS

Provision is made by the City and Guilds of London Institute for Advanced Grade examinations in each of the metallurgical subjects comprising sections A, B, C, D, E and F included in the fourth and fifth years of the course.

Candidates are expected at the end of the fourth year to take the examination in Section C or D, or in Section E or F, according to the branch of Metallurgy selected, and at the end of the fifth year the examinations in Section A and in Section B, and also in the appropriate section not taken at the end of the fourth year.

The Advanced Grade examinations in Section A and in Section B will consist of a written question paper and a practical test, which must be passed in the same year. The examination in each of the remaining Sections C to F will consist of a written question paper.

The City and Guilds of London Institute reserves the right in all subjects and at all stages at which its examinations are taken to call for a candidate's laboratory notebooks and also his college record or records.

AWARD OF GROUPED COURSE CERTIFICATE IN METALLURGY (INTERMEDIATE GRADE)*

(i) A candidate who passes the Institute's Intermediate

* The award of certificates will also be governed by General Regulations 33,34,35 and 36.

examinations in Chemistry, Physics, Mathematics and Engineering Drawing in the same year as, or in a year previous to, that in which he passes the Institute's Intermediate examination in General Metallurgy will be awarded a Grouped Course Certificate in Metallurgy (Intermediate Grade).

(ii) A candidate who passes the Institute's Intermediate examination in General Metallurgy, and who in the same year, or in the previous year, passes appropriate examinations of an approved standard in Chemistry, Physics, Mathematics and Engineering Drawing, held by or on behalf of the governing authority of a technical college, will be awarded a Grouped Course Certificate in Metallurgy (Intermediate Grade).

AWARD OF GROUPED COURSE CERTIFICATE IN METALLURGY (ADVANCED GRADE)*

(iii) A candidate who holds a Grouped Course Certificate in Metallurgy (Intermediate Grade) issued by the Institute, and who passes the Institute's examinations

* The award of certificates will also be governed by General Regulations 33, 34, 35 and 36.

in Sections A, B, C and D, will be awarded a Grouped Course Certificate in Ferrous Metallurgy (Advanced Grade).

(iv) A candidate who holds a Grouped Course Certificate in Metallurgy (Intermediate Grade) issued by the Institute, and who passes the Institute's examinations in Sections A, B, E, and F, will be awarded a Grouped Course Certificate in Non-Ferrous Metallurgy (Advanced Grade).

(v) A candidate who passes the Institute's Intermediate examination in General Metallurgy, and who submits to the Institute satisfactory evidence of an adequate knowledge of the basic ancillary subjects,* and who in addition passes the Institute's examinations in Sections A, B, C and D, will be awarded a Grouped Course Certificate in Ferrous Metallurgy (Advanced Grade). The same conditions will also apply to the award of a Grouped Course Certificate in Non-Ferrous Metallurgy (Advanced

* Any of the qualifications mentioned in clauses (1) to (6) of General Regulation 37 will be accepted for this purpose, provided that the appropriate basic ancillary subjects are covered by the qualification submitted.

Grade), except that a candidate must pass the Institute's examinations in Sections E and F instead of C and D.

AWARD OF FULL TECHNOLOGICAL CERTIFICATE

(vi) A Full Technological Certificate in Metallurgy will be awarded to a candidate who holds a Grouped Course Certificate in Ferrous Metallurgy (Advanced Grade) and who passes the Institute's examination in Section E, or to a candidate who holds a Grouped Course Certificate in Non-Ferrous Metallurgy (Advanced Grade) and who passes the Institute's examination in Section C. The candidate must have attained the age of 21 years at the time of application for the Full Technological Certificate and have appropriate experience in the application of his technology.

NATIONAL CERTIFICATE IN METALLURGY. The Joint Committee for National Certificates in Metallurgy representing the Ministry of Education and the Iron and Steel Institute, the Institute of Mining and Metallurgy and the Institute of Metals has agreed that courses of study based on the content of the scheme in the Principles and Practices of Metallurgical Operations as submitted by the City and Guilds of London Institute are suitable for submission to the Ministry under the arrangements and conditions governing the award of National Certificates in Metallurgy. Applications for approval of schemes from individual colleges and schools should be made on Form 325 T (to be obtained from the Ministry of Education) giving details of each year's curriculum and the corresponding syllabuses for each subject in each year. Examinations must be held at the end of each year of a course, and where appropriate those provided by the City and Guilds of London Institute will be acceptable.

PRIZES. Prizes are offered by the Ironmongers' Company on the results of Sections B, C, E and F of the Advanced Grade examination, and by the Cutlers' Company on the results of the Intermediate examination in General Metallurgy and Sections A and D of the Advanced Grade examination. No single prize will exceed £2 for the Intermediate examination or £3 for any section of the Advanced Grade examination.

SYLLABUSES:

INTERMEDIATE GRADE

Chemistry

The whole syllabus should be treated in an experimental manner, emphasis being placed on a sound understanding of fundamental principles rather than on advanced theoretical ideas.

1. GENERAL AND INORGANIC CHEMISTRY.

The laws of chemical combination. Atomic and molecular theories. Equivalent, atomic and molecular weights and methods for determining them. Atomic structure in so far as it is necessary to explain (a) the different types of valency, (b) the classification of the elements, and (c) isotopes. The treatment of descriptive chemistry should include the preparation and properties of the following elements and of their more important compounds: H, B, C, N, O, F, Na, Mg, Al, Si, P, S, Cl, K, Ca, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Br, Ag, Sn, I, Ba, Hg, Pb. Detailed knowledge of industrial processes is not required at this stage.

2. PHYSICAL CHEMISTRY - The properties of gases, including Graham's law and the law of partial

pressures. Difference of specific heats of gases at constant pressure and at constant volume. Ratio of the specific heats and its connection with atomicity treated empirically.

<u>THE PROPERTIES OF SOLUTIONS</u>. Distribution law. Henry's law. Fractional distillation, azeotropic distillation and steam distillation.

Phase rule applied to systems of not more than two components. Molecular weight, lowering of vapour pressure, raising of boiling point and lowering of freezing point.

Colloidal and true solutions.

Electrolysis and electrolytic dissociation.

<u>CHEMICAL EQUILIBRIUM</u>. Simple applications of the law of mass action. Thermal dissociation. Le Chatelier's principle. Solubility product. The strength of acids and bases, indicators, pH values, hydrolysis of salts, buffer solutions. Effect of concentration, temperature and catalysts on rate of reaction.

<u>THERMOCHEMISTRY</u>. Exothermic and endothermic

reactions. Hess's law.

Elements of crystal structure.

3. Organic Chemistry. Nomenclature. Structural formulae. Isomerism.

Saturated and unsaturated compounds, substitution and addition derivatives as exemplified by a study of the following compounds:

Straight and branch-chain paraffins (up to C_8H_{18}). Olefins (up to C_4H_8) including isomers; acetylene, butadiene, cyclohexane, benzene, naphthalene, alcohols, acids, aldehydes, ketones, ethers, esters.

4. Practical Work. The practical test will be directed towards determining a candidate's familiarity with inorganic qualitative and quantitative (both volumetric and gravimetric) analysis.

In physical chemistry the following experiments, which will not constitute a part of the syllabus for the practical examination, are offered as examples of useful practical work:

Determination of equivalents - e.g., copper by displacement, tin by action of nitric acid, zinc by replacement of hydrogen in acid. Proof of law of multiple proportion by reduction of oxides by means of coal gas. Determination of m.p. and transition points by cooling curve methods: f.p. curves for lead-tin alloys. Construction of solubility curves. Determination of conductivity, transport numbers. Variation of conductivity with temperature. Electrometric titration of alkali with acid. Determination of heat of neutralisation of alkali by acid.

PHYSICS

1. Properties of Matter and Mechanics. Velocity, acceleration, mass, impulse, momentum, work, energy, power, friction, simple mechanisms, moments of inertia. Resultant of two or more forces at a point. Vector representation. Parallel forces, couples, moments. Simple treatment of general conditions for equilibrium of coplanar forces.

Elasticity. Hooke's law.

Density and specific gravity. Surface energy; capillary phenomena; viscosity; diffusion.

Intensity of pressure at a point.

2. Heat. Temperature; scales of temperature including the absolute and International scale.

Instruments for the determination of temperature.

Changes in volume of solids, liquids and gases. Isothermal and adiabatic changes. Relation between volume, temperature and pressure in gases. Quantity of heat. Specific heat. Principles of calorimetry.

Change of state. Latent heat.

The properties of vapours. Hygrometry.

Heat transfer-conduction, convection, radiation.

Conservation of energy.

Mechanical equivalent of heat and methods of determination.

3. Light. Reflection and refraction at plane and spherical surfaces.

Lenses. Magnification.

Measurement of refractive indices of liquids and solids. Refraction through a prism.

Dispersion; qualitative treatment of achromatic lenses.

Production of pure spectrum.

Chromatic dispersion.

The electro-magnetic spectrum. General laws of radiation - visible ultra-violet, infra-red.

Emission and absorption spectra.

Phosphorescence and fluorescence.

Principles of the following instruments: Microscope, spectroscope, refractometer. Basic principles of interference, diffraction, polarisation.

Photometry and simple photometers.

4. Electricity and Magnetism. Magnets, magnetic properties, induction. Magnetic force, magnetic field, lines of force. Static electricity - electrification by friction and induction; potential. Simple voltaic cell, electromotive force, electrolysis. Magnetic field due to current, electromagnets, measurement of current, moving-coil galvanometers, simple forms of ammeters and voltmeters. Ohm's law, resistance and its measurement. Heating effects of currents.

Measurement of low and high resistance. Resistivity. Series and parallel circuits. Electromagnetism, magnetic fields of a permanent magnet and of an electric circuit.

Force on a conductor carrying a current in a magnetic field. Force between coils carrying an electric current. Electromagnetic induction. Lenz's law. Calculation of ampere turns. Magnetic properties of materials, magnetic fields and field strengths. B/H curves, hysteresis.

Thermo-electric effects and their application to pyrometry. Introductory treatment of A.C. theory; waveform, frequency. Instantaneous and R.M.S. values. Standard waveform, vector representation. Effect of inductance and capacitance in A.C. circuits. Reactance, impedance, phase displacement. Calculations for simple series and parallel circuits. Power and power-factor. Elementary treatment of the single-phase transformer. Hysteresis; eddy currents. Thermionic emission and its simple application. Elementary description of cathode ray tube, and X-ray.

MATHEMATICS

Mensuration, including the value of significant figures and decimal places in measurement. Areas and volumes of standard plane figures, common regular solids and frustra. Areas and volumes by Guldinus' Theorem.

Ratio and variation; similar areas and volumes. Areas of irregular figures using trapezoidal and Simpson's rules.

Algebra. Law of indices. Common logarithms, including numbers raised to negative index. Principles of the slide rule and its uses. Napierian logarithms.

Linear and quadratic equations. Simultaneous linear and quadratic equations. Graphical solution of equations. Irrational equations. Binomial Theorem for positive integral index and its use in expansions for any index.

Simple arithmetic and geometric progressions. Determination of linear law from experimental data.

Trigonometry. Radian measure of an angle. Relationships between trigonometrical ratios of any magnitude. Compound angle formulae and their applications.

Sine and cosine rules and applications to solution of triangles and to simple problems in heights and distances.

Calculus. Ratio of change. Differentiation of

x^n, sin x, cos x, log x. Products, quotients, simple cases of functions of a function. Maxima and minima. Errors and approximations.

Integration as reverse of differentiation. Simple integration and determination of areas, volumes, centroids and moments of inertia.

Application of calculus to linear and circular motion.

ENGINEERING DRAWING

The aim of this branch of work should be (1) to develop the student's ability to read and understand engineering drawings rather than to train a prospective draughtsman, and (2) to enable him to express his ideas in freehand sketches or in finished drawings or tracings.

B.S.I. Engineering Drawing Office Practice should be followed in the making of drawings, tracings in ink and reproduction of drawings.

General. Use of instruments. Use of British and Metric scales.

Geometry. Construction of scales. Construction of common geometrical figures, including ellipse, parabola and hyperbola. Construction of simple loci. Principles of orthographic projection and of isometric or oblique projection. Simple sections. Interpenetration of solids; lines of intersection; development of surfaces.

Machine Drawing. Application of method of orthographic projection to the representation of common types of engineering components and the use of clear and systematic dimensioning. Freehand sketching of machine parts. Production of drawings to scale from dimensioned sketches, from freehand sketches and from measurement of machine parts.

Sketching of fastenings such as screw threads, bolts, studs, rivets, keys, pins and cotters, and of simple riveted and welded joints.

Sketching of standard rolled sections, compound girders and simple framed girders.

Production of drawings to scale of machine parts, engine details, transmission details and boiler fittings and plant auxiliaries and accessories. Suitable typical examples may be taken from the following:

Details of bearings, couplings, fast and loose pulleys, brackets, flanged joints. Simple parts of steam and internal combustion engines such as pistons, piston rods, connecting rods, cranks, eccentrics, valves. Simple boiler parts, including boilerstays, manholes, valves. Valves for steam, water, oil and gas.

Sketching of simple electrical details such as switches, terminal blocks, brush-holders.

Teachers are recommended to include in the course exercises on appropriate dimensioned drawings of plant used in the production and utilization of fuel.

GENERAL METALLURGY

This syllabus is to be treated in such a manner as to introduce the general principles of metallurgy, to provide an outline of the subject as a whole, and to illustrate the relationship existing between the various subjects detailed in later syllabuses.

1. General Properties of Metals - Physical. Lustre, colour, density, crystalline nature, types of fracture, specific and latent heat, electrical and thermal conductivity, fusibility, fluidity, volatility. Elasticity, tenacity,

ductility, toughness, hardness, malleability. Chemical. Distinction between metals and non-metals. Metals and their compounds: oxidation and reduction. Action of furnace gases and furnace products on the metals.

2. Definitions. (a) Mineral, ore, gangue, ore dressing, concentrates, middlings, tailings. (b) Roasting, calcining, sintering. (c) Smelting, cupellation, scorification, Bessemerization, refining, liquation. (d) Regulus, matte, speiss, flux, slag, dross, swarf.

3. Sampling. The general principles of the sampling of metallic materials, crushable materials, liquids and gases.

4. Fuels. Combustion, calorific value, evaporative value. Classification of solid, liquid and gaseous fuels. Properties and uses. Manufacture of prepared fuels. Elementary calculations on the combustion of fuels - air required, volume of combustion products. Elementary principles of heat exchange and fuel conservation.

5. Refractories. General requirements of a refractory. Properties of acid, basic and neutral.

refractory materials. Application of refractory materials in metallurgical practice.

6. Chief Metallurgical Processes. Elementary principles and description of the processes listed in para. 2 (b) and (c), together with leaching, distillation, elctrolysis, thermit process.

7. Shaping of Metals and Alloys. Elementary principles underlying casting, forging, rolling, pressing, extruding, spinning, drawing.

8. Physical Examination of Metals and Alloys. Elementary principles underlying the examination of metals by mechanical and microscopical methods and by non-destructive tests.

9. Properties and uses of aluminium, copper, iron, lead, nickel, silver, tin, zinc and their chief alloys, treated in an elementary manner.

10. Practical Work. The practical test of four hours' duration will be based on the following metallurgical experiments conducted as far as possible on a quantitative basis: Calcining of ores, roasting of sulphides, reaction of sulphides and oxides,

reduction of oxides, reduction of sulphides, cupellation of argentiferous lead, scorification of argentiferous lead containing antimony or tin, determination of the coking quality of coal.

Preparation of the following alloys: Cartridge metal, Muntz metal, gun metal, bell metal, Admiralty metal (88/10/2), cupro-nickel (70/30), lead-tin solders, type metals, Babbitt metal, copper-aluminium (95/5 and 90/10), aluminium copper (92/8 and 88/12).

Preparation and elementary micrographic examination of metals and alloys as cast, as rolled and as annealed.

Teachers are recommended to include in the course other exercises which will demonstrate the principles taught in the lecture room. These exercises as set forth below will not constitute a part of the syllabus for the practical examination.

Properties of metals and alloys.

Relative work-hardening capacities; effects of annealing; influence of temperature on working properties; oxidation at high temperatures and atmospheric temperatures;

solubility of oxides; diffusion between solid and molten metals; immiscibility of lead and zinc; ductility; tensile properties; stamping quality; impact value.

Metallurgical terms. Slags-production of single and multiple base silicates.

Sampling: hand sampling of ores and fuels; sampling of metals and alloys.

Refractories: effect of impurities; shrinkage, resistance to attack by metallic oxides.

Industrial metals and alloys: influence of carbon and of phosphorus on melting point of iron; carburizing; hardening and tempering carbon steels.

Appendix XI

14. METALLURGY

NOTE IN REGARD TO THE INTERMEDIATE EXAMINATION IN ENGLAND AND WALES. When an examination in this subject at a stage corresponding to the Institute's Intermediate Examination is held by an Examining Union recognised by the Ministry of Education, a Local Education Authority which is a member of the Union will normally arrange that its students at that stage will take the corresponding examination of the Union. The City and Guilds of London Institute will accept for its Intermediate Examination a candidate or candidates from such a Local Education Authority only upon the specific request of the Chief Education Officer of the Authority, confirming that the Authority, having considered the matter, desires the City and Guilds of London Institute to accept the candidate or candidates for the Intermediate Examination.

THE SCHEME of examinations in Metallurgy, adopted by the Institute on the recommendation of the Advisory

Committee, is designed primarily for students who are actively engaged in or associated with the metallurgical and allied industries. A suggested curriculum for the guidance of Colleges holding part-time grouped courses in Metallurgy has been drawn up by the Advisory Committee.

CURRICULUM:

It will be seen from the scheme, as set forth below, that the curriculum is arranged to cover two stages, the Intermediate Grade, extending over three, or possibly four years, and the Advanced Grade, extending over three years.

Intermediate Grade

The course is expected to entail attendance during four periods weekly in a three-year part-time day course, or three periods weekly for a four-year evening course, each year's course comprising not less than 200 hours' instruction. The suggested curriculum for a three-year part-time day course is as follows:

First Year	Chemistry
	Physics
	Mathematics
Second Year	Chemistry
	Physics
	Mathematics
	Engineering Drawing
Third Year	Chemistry
	Physics
	General Metallurgy

A shorter period of attendance would be sufficient if the standard of the General Certificate of Education at Ordinary Level in these subjects had been attained by the student. The syllabuses on page 152 have not been divided into years, since colleges may desire to vary the order of teaching in the manner best suited to local conditions and circumstances.

Advanced Grade

Examinations will be held in the following subjects:

Section A	Metallurgical Analysis
Section B	Physical Metallurgy
Section C	Production of Iron and Steel

Section D	Treatment of Ferrous Metals and Alloys
Section E	Extraction and Refining of Common Non-Ferrous Metals
Section F	Manufacture and Treatment of Non-Ferrous Metals and Alloys
Section G	Physical Chemistry,

but students will doubtless desire, in the first instance, to concentrate their studies on ferrous or non-ferrous subjects, according to the branch of the industry in which they are chiefly interested. In order to meet their requirements alternative schemes have been formulated (see page 147, paragraph xiv). There are also additional subjects (Section H - Engineering for Metallurgists, and Section J - Fuels and Refractories) for students wishing to carry their studies further.

SCHEME OF EXAMINATIONS:

(i) Examinations in all subjects will be held by the City and Guilds of London Institute. Whilst the scheme has been devised on a grouped course basis, a candidate will not be debarred from presenting himself for examination in a single subject, except the examinations in Section H and J, which may be taken only by the holder of a Grouped Course Certificate (Advanced Grade).

(ii) A record of success (not a certificate) will be issued to a candidate passing the Intermediate examination in any subject.

(iii) A certificate will be issued to a candidate passing the examination in any of the subjects A, B, C, D, E, F, and G of the Advanced Grade.

(iv) Students are advised to include in their course an adequate amount of practical laboratory work. The City and Guilds of London Institute reserves the right, in all subjects and at all stages at which its examinations are taken, to call for a candidate's laboratory notebooks and also his college record or records.

Intermediate Grade Examinations

(v) Candidates for the Institute's Grouped Course Certificate in Metallurgy (Intermediate Grade) are expected to take:

either examinations in Chemistry and Physics, held
upon approved syllabuses by or on behalf of
the governing authority of a technical college,

or the Intermediate examinations in Chemistry and Physics held by the City and Guilds of London Institute,

and the Institute's Intermediate examination in General Metallurgy.

(vi) It is also expected that examinations at the end of the previous years of the course will have been held by or on behalf of the Governing Authority of the Technical College concerned, but the City and Guilds of London Institute has also made provision to hold appropriate examinations in Mathematics and Engineering Drawing. The examination in Mathematics will consist of a written question paper and that in Engineering Drawing will comprise a question paper to be answered by drawings or sketches.

(vii) The examination in Physics will consist of two written question papers, each of three hours' duration. One paper will be confined to (1) Properties of Matter and Mechanics and (2) Heat, and the other to (3) Light and (4) Electricity and Magnetism. A candidate will be required to satisfy the examiners in each paper, but he need not take both papers in the same year.

(viii) The Institute will NOT hold practical tests in Physics; but every candidate offering Physics will be required to produce at the time of entry a certificate from the Principal of the Technical College or other acceptable authority that he has satisfactorily completed appropriate courses of practical work.

(ix) The examination in Chemistry will consist of two written question papers, each divided into two sections: (1) General and Inorganic Chemistry and (2) Physical Chemistry; each paper will be of two hours' duration. Candidates will be expected to attempt questions from both sections in each paper. The examination will also include a practical test of four hours' duration. Candidates will be required to take both written papers and the practical test in the same year and to satisfy the examiners in each case.

(x) The examinations of the City and Guilds of London Institute in General Metallurgy will consist of a written question paper of three hours' duration and a practical test of four hours' duration, which must be passed in the same year.

Award of Grouped Course Certificate in Metallurgy (Intermediate Grade)*

(xi) A candidate who passes the Institute's Intermediate examinations in Chemistry, Physics, Mathematics and Engineering Drawing not later than the year in which he passes the Institute's Intermediate examination in General Metallurgy will be eligible for a Grouped Course Certificate in Metallurgy (Intermediate Grade).

(xii) A candidate who passes appropriate examinations of an approved standard in Chemistry, Physics, Mathematics and Engineering Drawing, held by or on behalf of the governing authority of a technical college not later than the year in which he passes the Institute's examination in General Metallurgy will be eligible for a Grouped Course

* The award of certificates will also be governed by General Regulations 33, 34, 35 and 36.

Certificate in Metallurgy (Intermediate Grade).

(xiii) A candidate who qualifies for the award of a Grouped Course Certificate (Intermediate Grade) should make application for it to the Director, Department of Technology, supporting the application with documentary evidence of examination successes.

Advanced Grade Examinations

(xiv) Provision is made by the City and Guilds of London Institute for Advanced Grade examinations in each of the metallurgical subjects comprising sections A, B, C, D, E, F, and G. Candidates are expected to take examinations as under, according to the branch of Metallurgy selected:

Ferrous Subjects

Four sections, selected from Sections A, B, C, D and G.

Non-ferrous Subjects

Four sections, selected from Sections A, B, E, F and G.

(xv) The Advanced Grade examinations in Section A and in Section B will each consist of a written question paper and a practical test. The written and practical examinations in Section A or Section B must be passed in the same year. The examinations in each of the remaining Sections C to G will each consist of a written question paper only.

Award of Grouped Course Certificate in Metallurgy (Advanced Grade)*

(xvi) A candidate who holds a Grouped Course Certificate in Metallurgy (Intermediate Grade) issued by the Institute and who passes the Institute's examinations in any four of the Sections A, B, C, D and G will be eligible for a Grouped Course Certificate in Metallurgy (Advanced Grade) - ferrous subjects.

(xvii) A candidate who holds a Grouped Course Certificate in Metallurgy (Intermediate Grade) issued by the Institute and who passes the Institute's examinations in any four of the Sections A, B, E, F and G will be eligible for a Grouped Course Certificate in Metallurgy (Advanced Grade) - non-ferrous subjects.

* The award of certificates will also be governed by General Regulations 33, 34, 35 and 36.

(xviii) A candidate who, having passed the Institute's Intermediate examination in General Metallurgy, submits to the Institute satisfactory evidence of an adequate knowledge of the other Intermediate subjects, ≠ and who in addition passes the Institute's examinations in any four of the Sections A, B, C, D and G will be eligible for a G rouped Course Certificate in Metallurgy (Advanced Grade) - ferrous subjects. The same conditions will also apply to the award of a Grouped Course Certificate in non-ferrous subjects, except that a candidate must pass the Institute's examinations in any four of Sections A, B, E, F and G .

(xix) A candidate who qualifies for the award of a Grouped Course Certificate (Advanced Grade) should make application to the Director, Department of Technology, supporting the application with documentary evidence of examination successes.

≠ Any of the qualifications mentioned in clauses (1) to (6) of the General Regulation 37 will be accepted for this purpose, provided that the appropriate subjects are covered by the qualification submitted.

Additional Subjects (Advanced Grade)

(xx) Provision is made for additional examinations in:

Section H	Engineering for Metallurgists
Section J	Fuels and Refractories

The examination in Section H will consist of two written papers, each of three hours' duration and each divided into Mechanical and Electrical Engineering sections The examination in Section J will comprise two three-hour written papers, one on Fuels and one on Refractories.

A candidate who holds a Grouped Course Certificate (Advanced Grade) may take either or both of these subjects. These examinations do not form part of the Grouped Course and are not obligatory on candidates for the advanced Grade examinations. Candidates may also take any of the Sections A to G not previously taken. Candidates who are successful in these additional examinations will receive separate certificates for each subject.

Award of Full Technological Certificate

(xxi) A Full Technological Certificate in Metallurgy will be awarded to a candidate who holds a Grouped Course Certificate (Advanced Grade) and has passed in the following Advanced Grade Sections:

Section B

Section C

Section E

Sections D or F

Any two of Sections A, G, H and J.

The candidate must pass in SIX sections in all, as shown above, of which he will already have passed in four by virtue of his Grouped Course Certificate (Advanced Grade).

The candidate must have attained the age of 21 years at the time of application for the Full Technological Certificate and have had appropriate experience in the application of his technology. Application for the award of a Full Technological Certificate should be made to the Director, Department of Technology, with documentary evidence of examination successes.

(xxii) Prizes Prizes are offered by the Cutlers' Company on the results of the Intermediate examination in General Metallurgy and Sections A and D of the Advanced Grade examination. No single prize will exceed £2 for the Intermediate examination or £3 for any section of the Advanced Grade examination.

SYLLABUSES:

Intermediate Grade

Chemistry

The whole syllabus should be treated in an experimental manner, emphasis being placed on a sound understanding of fundamental principles rather than on advanced theoretical ideas.

1. General and Inorganic Chemistry. The laws of chemical combination. Atomic and molecular theories. Equivalent, atomic and molecular weights and methods for determining them. Atomic structure in so far as it is necessary to explain (a) the different types of valency, (b) the classification of the elements, and (c) isotopes. The treatment of descriptive chemistry should include the preparation and properties

of the following elements and of their more important compounds: H, B, C, N, O, F, Na, Mg, Al, Si, P, S, Cl, K, Ca, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Br, Ag, Sn, I, Ba, Hg, Pb. Detailed knowledge of industrial processes is not required at this stage.

2. Physical Chemistry. The properties of gases, including Graham's law and the law of partial pressures. Difference of specific heats of gases at constant pressure and at constant volume. Ratio of the specific heats and its connection with atomicity treated empirically.

The properties of solutions. Distribution law. Henry's law. Fractional distillation, azeotropic distillation and steam distillation.

Phase rule applied to systems of not more than two components. Molecular weight, lowering of vapour pressure, raising of boiling point and lowering of freezing point.

Colloidal and true solutions.

Electrolysis and electrolytic dissociation.

Chemical equilibrium. Simple applications of the law of mass action. Thermal dissociation. Le Chatelier's principle. Solubility product. The strength of acids and bases, indicators, pH values, hydrolysis of salts, buffer solutions. Effect of concentration, temperature and catalysts on rate of reaction.

Thermochemistry.. Exothermic and endothermic reactions. Hess's law.

Elements of crystal structure.

3. Practical Work. The practical test will be directed towards determining a candidate's familiarity with inorganic qualitative and quantitative (both volumetric and gravimetric) analysis.

In physical chemistry the following experiments, which will not constitute a part of the syllabus for the practical examination, are offered as examples of useful practical work:

Determination of equivalents - e.g., copper by displacement, tin by action of nitric acid, zinc by replacement of hydrogen in acid. Proof of law of multiple proportion by reduction of oxides by means of coal gas. Determination of m.p. and transition points by cooling curve methods: f.p. curves for lead-in alloys. Construction of solubility curves. Determination of conductivity, transport numbers. Variation of conductivity with temperature. Electrometric titration of alkali with acid. Determination of heat neutralization of alkali by acid.

Physics

1. Properties of Matter and Mechanics. Velocity, acceleration, mass, impulse, momentum, work, energy, power, friction, simple mechanisms, moments of inertia. Resultant of two or more forces at a point. Vector representation. Parallel forces, couples, moments. Simple treatment of general conditions for equilibrium of coplanar forces.

Elasticity. Hooke's law.

Density and specific gravity. Surface energy; capillary phenomena; viscosity; diffusion.

Intensity of pressure at a point.

2. Heat. Temperature; scales of temperature including the absolute and International scale.

Instruments for the determination of temperature.

Changes in volume of solids, liquids and gases. Isothermal and adiabatic changes. Relation between volume, temperature and pressure in gases. Quantity of heat. Specific heat. Principles of calorimetry.

Change of state. Latent heat.

The properties of vapours. Hygrometry.

Heat transfer - conduction, convection, radiation.

Conservation of energy.

Mechanical equivalent of heat and methods of determination.

3. Light. Reflection and refraction at plane and spherical surfaces. Lenses. Magnification.

Measurement of refractive indices of liquids and solids. Refraction through a prism.

Dispersion; qualitative treatment of achromatic lenses.

Production of pure spectrum.

Chromatic dispersion.

The electro-magnetic spectrum. General laws of radiation-visible ultra-violet, infra-red.

Emission and absorption spectra.

Phosphorescence and fluorescence.

Principles of the following instruments: microscope, spectroscope, refractometer. Basic principles of interference, diffraction, polarisation.

Photometry and simple photometers.

4. Electricity and Magnetism. Magnets, magnetic properties, induction. Magnetic force, magnetic field, lines of force. Static electricity - electrification by friction and induction; potential. Simple voltaic cell, electro-motive force, electrolysis. Magnetic field due to current, electromagnets, measurement of current, moving-coil galvanometers, simple forms of ammeters and voltmeters. Ohm's law, resistance and its measurement. Heating effects of currents.

Measurement of low and high resistance. Resistivity. Series and parallel circuits. Electromagnetism, magnetic fields of a permanent magnet and of an electric circuit. Force on a conductor carrying a current in a magnetic field. Force between coils carrying an electric current. Electromagnetic induction. Lenz's law. Calculation of ampere turns. Magnetic properties of materials, magnetic fields and field strengths. B/H curves, hysteresis.

Thermo-electric effects and their application to pyrometry. Introductory treatment of A.C. theory; waveform, frequency. Instantaneous and R.M.S. values. Standard waveform, vector representation. Effect of inductance and capacitance in A.C. circuits. Reactance, impedance, phase displacement. Calculations for simple series and parallel circuits. Power and power-factor. Elementary treatment of the single-phase transformer. Hysteresis; eddy currents. Thermionic emission and its simple application. Elementary description of cathode ray tube, and X-ray.

Mathematics

Mensuration, including the value of significant figures and decimal places in measurement. Areas and volumes of standard plane figures, common regular solids and frustra. Areas and volumes by Guldinus' Theorem.

Ratio and variation; similar areas and volumes. Areas of irregular figures using trapezoidal and Simpson's rules.

Algebra. Law of indices. Common logarithms, including numbers raised to negative index. Principles of the slide rule and its uses. Napierian logarithms.

Linear and quadratic equations. Simultaneous linear and quadratic equations. Graphical solution of equations. Irrational equations. Binomial Theorem for positive integral index and its use in expansionsfor any index.

Simple arithmetic and geometric progressions. Determination of linear law from experimental data.

Trigonometry. Radian measure of an angle. Relationships between trigonometrical ratios of any magnitude. Compound angle formulae and their applications.

Sine and cosine rules and applications to solution of triangles and to simple problems in heights and distances.

Calculus. Ratio of change. Differentiation of x^n, sin x, cos x, log x. Products, quotients, simple cases of functions of a function. Maxima and minima. Errors and approximations.

Integration as reverse of differentiation. Simple integration and determination of areas, volumes, centroids and moments of inertia.

Application of calculus to linear and circular motion.

Engineering Drawing

The aim of this branch of work should be (1) to develop the student's ability to read and understand engineering drawings rather than to train a prospective draughtsman, and (2) to enable him to express his ideas in freehand sketches or in finished drawings or tracings.

B.S.I. Engineering Drawing Office Practice should be followed in the making of drawings, tracings in ink and reproduction of drawings.

General. Use of instruments. Use of British and Metric scales.

Geometry. Construction of scales. Construction of common geometrical figures, including ellipse, parabola and hyperbola. Construction of simple loci. Principles of orthographic projection and isometric or oblique projection. Simple sections. Interpenetration of solids; lines of intersection; development of surfaces.

Machine Drawing. Application of method of orthographic projection to the representation of common types of engineering components and the use of clear and systematic dimensioning. Freehand sketching of machine parts. Production of drawings to scale from dimensioned sketches, from freehand sketches and from measurement of machine parts.

Sketching of fastenings such as screw threads, bolts, studs, rivets, keys, pins, and cotters, and of simple riveted and welded joints.

Sketching of standard rolled sections, compound girders and simple framed girders.

Production of drawings to scale of machine parts, engine details, transmission details and boiler fittings and plant auxiliaries and accessories. Suitable typical examples may be taken from the following: Details of bearings, couplings, fast and loose pulleys, brackets, flanged joints. Simple parts of steam and internal combustion engines such as pistons, piston rods,

connecting rods, cranks, eccentrics, valves. Simple boiler parts including, boiler-stays, manholes, valves. Valves for steam, water, oil and gas.

Sketching of simple electrical details such as switches, terminal blocks, brush-holders.

Teachers are recommended to include in the course exercises on appropriate dimensioned drawings of plant used in the production and utilisation of fuel.

General Metallurgy

This syllabus is to be treated in such a manner as to introduce the general principles of metallurgy, to provide an outline of the subject as a whole, and to illustrate the relationship existing between the various subjects detailed in later syllabuses.

1. General Properties of Metals - Physical.

Lustre, colour, density, crystalline nature, types of fracture, specific and latent heat, electrical and thermal conductivity, fusibility, fluidity, volatility. Elasticity, tenacity, ductility, toughness, hardness, malleability.

Chemical. Distinction between metals and non-metals. Metals and their compounds: oxidation and reduction.

Action of furnace gases and furnace products on the metals.

2. Definitions. (a) Mineral, ore, gangue, ore dressing, concentrates, middlings, tailings, (b) Roasting, calcining, sintering. (c) Smelting, cupellation, scorification, Bessemerization, refining, liquation. (d) Regulus, matte, speiss, flux, slag, dross, swarf.

3. Sampling. The general principles of the sampling of metallic materials, crushable materials, liquids and gases.

4. Fuels. Combustion, calorific value, evaporative value. Classification of solid, liquid and gaseous fuels. Properties and uses. Manufacture of prepared fuels. Elementary calculations on the combustion of fuels - air required, volume of combustion products. Elementary principles of heat exchange and fuel conservation.

5. Refractories. General requirements of a refractory. Properties of acid, basic and neutral refractory materials. Application of refractory materials

in metallurgical practice.

6. Chief Metallurgical Processes. Elementary principles and description of the processes listed in para. 2 (b) and (c), together with leaching, distillation, electrolysis, thermit process.

7. Shaping of Metals and Alloys. Elementary principles underlying casting, forging, rolling, pressing, extruding, spinning, drawing.

8. Physical Examination of Metals and Alloys. Elementary principles underlying the examination of metals by macro- and microscopical methods and by mechanical and non-destructive tests.

9. An elementary survey of the properties and uses of aluminium, copper, iron, lead, nickel, silver, tin, zinc and their chief alloys.

10. Practical Work. The practical test of four hours' duration will be based on the following metallurgical experiments conducted as far as possible on a quantitative basis: calcining of ores, roasting of sulphides, reduction of sulphides, cupellation of argentiferous lead, scorification of argentiferous lead

containing antimony, tin or copper, determination of the coking quality of coal.

Preparation of the following alloys: Cartridge metal, Muntz metal, gun metal, bell metal, Admiralty metal (88/10/2), cupro-nickel, lead-tin, solder, type metals, Babbitt metal, copper-aluminium (95/5 and 90/10), aluminium-copper (92/8 and 88/12).

Preparation and elementary macro- and micro-graphic examination of metals and alloys as cast, as rolled and as annealed.

Teachers are recommended to include in the course other exercises which will demonstrate the principles taught in the lecture room. These exercises as set forth below will not constitute a part of the syllabus for the practical examination.

Relative work-handling capacities; effects of annealing; influence of temperature on working properties; oxidation at high temperatures and atmospheric temperatures; solubility of oxides; diffusion between solid and molten metals; immiscibility of lead and zinc; ductility; tensile properties; stamping quality; impact value.

Slags: production of single and multiple base silicates.

Sampling: hand sampling of ores and fuels; sampling of metals and alloys.

Refractories: effect of impurities; shrinkage, resistance to attack by metallic oxides.

Iron and steel; influence of carbon and of phosphorus on melting point of iron; carburizing; hardening and tempering carbon steels.

Appendix XII

CITY AND GUILDS OF LONDON INSTITUTE

Department of Technology

Paper GAC/1

14 - METALLURGY

The General Advisory Committee for Metallurgical Subjects

Name and Address	Representing
Sir Arthur Smout, FRIC, CGIA, (Chairman) 154 Wake Green Road, Moseley, Birmingham	Additional Adviser nominated by the City and Guilds of London Institute
Dr A. M. Ward, FRIC, (Deputy Chairman) Sir John Cass College, Jewry Street, London, E.C.3.	Association of Technical Institutions
Dr J. W. Jenkin, Department of Development and Research, Tube Investments Ltd., Plume Street, Aston, Birmingham, 6.	Iron and Steel Institute
Dr I. Jenkins, FIM, Research Laboratories, General Electric Co Ltd., Wembley, Middlesex	Institute of Metals

Name and Address	Representing
Mr. R.S. Brown, MBE, FIM, Ryland Brothers Ltd., Warrington, Lancs.	Institution of Metallurgists
Mr. W.A.C. Newman, CBE, The Royal Mint London, E.C.3.	Institution of Mining and Metallurgy
Mr. T. Makemson, MBE, St. John Street Chambers, Deansgate, Manchester, 3.	Institute of British Foundrymen
Mr. A.L. Johnson, MA, Johnson, Clapham & Morris Ltd., Haywood House, Stewkley, Leighton Buzzard, Bedfordshire.	British Non-Ferrous Metals Federation
Mr. R.W. Blount, HMI, Ministry of Education, Curzon Street, London, W.1.	Ministry of Education
Mr. H.V. Field, B.Sc., Wh.Sch., MIEE., Technical College, Coventry	Association of Principals of Technical Institutions
Mr. R. Smith, B.Sc., Clyro, Snatchwood Road, Abersychan, Monmouthshire.	Association of Teachers in Technical Institutions

Name and Address	Representing
Mr. H.A.MacColl, B.Sc.FIM., County Technical College, Wednesbury, Staffordshire.	Joint Representative of the Regional Examining Unions, nominated by the Union of Education Institutions
Mr. T. Bamford, M.Sc., Fronfelen Hall, Corris, Machynlleth, Mont.	
Mr. A. Jackson, CGIA, Cliff Gardens, Scunthorpe, Lincolnshire.	
Mr. G. Patchin, ARSM, MIMM, 84 Chase Way, London, N. 14.	Additional Advisers nominated by the City and Guilds of London Institute
Mr. G. Thompson, M.I.Mech.E., M.I.Mar.E., M.Eng. Municipal Technical College, Swansea.	
Dr. M.B. Thompson, College of Technology and Art, Rotherham.	

Appendix XII

CITY AND GUILDS OF LONDON INSTITUTE

Department of Technology

15 - Iron and Steel Operatives' Course

Advisory Committee

Name and Address	Representing
Mr T. G. Bamford, MSc, Fronfelen Hall, Corris, Machynlleth, Mont.	Additional Adviser nominated by the City and Guilds of London Institute
Mr R. W. Blount, HMI, Ministry of Education, Curzon Street, House, Curzon Street, London, W.1.	Ministry of Education
Mr H. V. Field, BSc, WhSch, MIEE, The Technical College, The Butts, Coventry	Association of Principals of Technical Institutions
Mr A. Jackson, CGIA, 5 Cliff Gardens, Scunthorp, Lincs.	Additional Adviser nominated by the CGLI (Chairman).
Dr J. W. Jenkin, Research Department. Tube Investments Ltd., Plume Street, Aston, Birmingham, 6.	Iron and Steel Institute

Name and Address	Representing
Mr W. A. C. Newman, CBE, The Royal Mint, London, E.C.3.	Institution of Mining and Metallurgy
Mr G. Patchin, ARSM, MIMM, 84 Chase Way, London, N.14.	Additional Adviser nominated by the CGLI
Dr M. B. Thompson, College of Technology and Art, Rotherham	Additional Adviser nominated by the CGLI
Dr A. M. Ward, FRIC, Sir John Cass College, Jewry Street, London, E.C.3.	Association of Technical Institutions
Mr A. W. W. Watson, Training Department, British Iron and Steel Federation, Windsor House, Victoria Street, London, S.W.1.	British Iron and Steel Federation
Mr D. R. O. Thomas, Chief Education Officer, United Steel Companies Ltd., 17 Westbourne Road, Sheffield	British Iron and Steel Federation
Mr R. S. Brown, MBE, FIM, Ryland Brothers Ltd., Warrington, Lancs.	British Iron and Steel Federation
Mr E. W. Colbeck, Hadfields Ltd., East Hecla Works, Sheffield	British Iron and Steel Federation

Name and Address	Representing
Capt. O. F. Atkins, Education and Training Officer, Richard Thomas & Baldwins Ltd., Cookley Works, Brierley Hill, Staffs.	Additional Adviser nominated by the City and Guilds of London Institute
Mr H. Douglas, Swinton House, 324 Grays Inn Road, London, W.C.1.	The Iron and Steel Trades Federation
Mr J. O'Hagan, 93 Brough Road West, Middlesbrough, Yorks.	The National Union of Blastfurnacemen, Ore Miners, Coke Workers and Kindred Trades.

Documents also to be sent for information to

Sir Arthur Smout, FRIC, CGIA,
154 Wake Green Road,
Moseley,
Birmingham

Appendix XII

CITY AND GUILDS OF LONDON INSTITUTE

Department of Technology

16 - Non-Ferrous Metals Operatives' Course

Advisory Committee

Name and Address	Representing
Mr A. L. Johnson, MA, Johnson, Clapham & Morris, Ltd., Haywood House, Stewkley, Leighton Buzzard, Bedfordshire	British Non-Ferrous Metals Federation (Chairman).
Mr J. Crosbie, I.C.I. Ltd., Metals Division, Kynoch Works, Witton, Birmingham, 6.	British Non-Ferrous Metals Federation
Mr G. S. Somerset, 132 Hagley Road, Birmingham, 16.	British Non-Ferrous Metals Federation
Mr A. F. Rayner, Anti-Attrition Metal Co Ltd., Woodlands Park Works, Maidenhead, Berks.	Association of Bronze and Brass Founders
Mr C. H. M. Holden, Hall Street Metal Rolling Co Ltd., Western Road, Birmingham, 18.	Brass Wire Association

Name and Address	Representing
Mr W. W. Kee and Mr V. L. James, Enfield Rolling Mills Ltd., Millmarsh Lane, Brimsdown, Enfield, Middlesex	Cold Rolled Brass and Copper Association
Mr H. W. Blake, Tylors of London Ltd., Belle Isle, York Way, London, N.7.	National Brass Foundry Association
Dr E. Voce, MSc, FIM, Copper Development Association, Kendalls Hall, Radlett, Herts	Copper Development Association
Mr R. W. Bailey, MA, BSc, FIM, Zinc Development Association, Lincoln House, Turl Street, Oxford	Zinc Development Association
Mr H. C. Harris, MRSanI., Lead Industries Development Council, Eagle House, Jerym Street, London, S.W.1.	Lead Industry Council
Mr S. A. E. Wells, J. Stone & Co Ltd., Woolwich Road, Charlton, London, S.E.7.	Light Metals Founders' Association

Name and Address	Representing
Dr E. G. West, BSc, FIM, Technical Director, Aluminium Development Association, 33 Grosvenor Street, London, W.1.	Aluminium Development Association
Professor C. W. Dannatt, ARSM, DIC, Royal School of Mines, London, S.W.7.	Institute of Metals
Dr W. O. Alexander, FIM, I.C.I. Ltd., Metals Division, Kynoch Works, Witton, Birmingham, 6.	Institution of Metallurgists
Mr W. A. C. Newman, CBE, Royal Mint, London, E.C.3.	Institution of Mining and Metallurgy
Mr W. G. Mochrie, The Tyseley Metal Co Ltd., Balfour House, Finsbury Pavement, London, E.C.2.	Institute of British Foundrymen
Mr H. A. MacColl, BSc., Principal, County Technical College, Wednesbury, Staffs.	Association of Principals of Technical Institutions
Mr R. Smith, BSc, Clyro, Snatchwood Road, Abersychan, Mon.	Association of Teachers in Technical Institutions

Name and Address	Representing
Mr R. W. Blount, HMI, Ministry of Education, Curzon Street, London, W,1.	Ministry of Education
Mr F. W. Cooper, BSc, Principal, Chance Technical College, Crocketts Lane, Smethwick	Joint Representative of the Regional Examining Unions, nominated by the Union of Educational Institutions
Dr A. M. Ward, DSc, FRIC, Principal, Sir John Cass College, Jewry Street, London, E.C.3.	Association of Technical Institutions
Professor A. J. Murphy, MSc, FIM, Birmingham University, Edgbaston, Birmingham, 15. Mr J. W. Berry, Birmingham Aluminium Casting, (1903) Co Ltd, Dartmouth Road, Birmingham, 40.	Additional Advisers nominated by the City and Guilds of London Istitute

Documents also to be sent to Sir Arthur Smout, FRIC, CGIA,
154 Wake Green Road,
Moseley,
Birmingham

Appendix XIII

CITY AND GUILDS OF LONDON INSTITUTE

Department of Technology

Paper GAC/2
18th January 1954

COMMITTEES AND TERMS OF REFERENCE

14. METALLURGY

The General Advisory Committee on Metallurgical Subjects, and the Advisory Committee on Subject 14 - Metallurgy, of the City and Guilds of London Institute.

1. To consider matters relating to metallurgical education and report thereon to the City and Guilds of London Institute.

2. To ensure co-ordination between the various schemes of examinations of the Institute intended for these engaged in the production and treatment of metals.

3. To act as the Institute's Advisory Committee in Subject 14 - Metallurgy.

4. To receive reports from the Advisory Committees for the Operatives' Courses (Subjects 15 and 16).

15. IRON AND STEEL OPERATIVES' COURSE

The Advisory Committee of the City and Guilds of London Institute.

To consider matters affecting the education of operatives employed in the production and treatment of iron and steel and to report thereon to the General Advisory Committee on Metallurgical Subjects of the City and Guilds of London Institute.

16. NON-FERROUS METALS OPERATIVES' COURSE

The Advisory Committee of the City and Guilds of London Institute.

To consider matters affecting the education of operatives employed in the production and treatment of non-ferrous metals and to report thereon to the General Advisory Committee on Metallurgical Subjects of the City and Guilds of London Institute.

Appendix XIV

CITY AND GUILDS OF LONDON INSTITUTE

Gresham College,
Basinghall Street,
London, E.C.2.
4th March, 1958.

T/14/12/B1

Dear Sir,

Metallurgical Technicians

The Minutes of the General Advisory Committee for Metallurgical Subjects held on 4th February are now enclosed.

With reference to Minute 49, particularly the last paragraph, I should be glad to receive comments from members as a basis for discussion at the next meeting.

We would ask you to consider particularly the type of person for whom it is intended to cater and the occupations concerned, as applied specifically to your section of the Industry.

Some indication of the following matters would be useful, and we should, of course, be very glad of comments on any additional points which may be relevant.

(i) The numbers likely to be involved, (with reference to existing categories rather than to people whom it is hoped to recruit at a future date).

(ii) Whether the demand is anticipated to be (a) steady or intermittent,

(b) increasing or decreasing.

(iii) The geographical areas likely to be involved.

(iv) Any further information about the kind of work on which people who could be defined as "metallurgical technicians" might be engaged in the particular section of the Industry with which you are associated.

(v) The occupations, ages and approximate numbers of students failing, or not completing the course for, the

Ordinary National Certificate, but
who are thought to be suitable for
a metallurgical technicians' course.
The identity of colleges to which
information given under this
heading refers will not be disclosed.

If members would be good enough to give their comments on these matters in the order in which they are set out above, it would simplify the consolidated document, containing these comments, which will be circulated before the next meeting of the General Advisory Committee.

In view of the decision to hold another meeting in the fairly near future, it would be appreciated if members could let me have their replies by <u>Friday, 11th April</u>. In view of the time factor, it is thought that reasonable estimates by that date would be of more value than detailed information obtained as the result of prolonged and meticulous inquiries.

Yours faithfully,

(Mary K. Brade-Birks)
for Director.

To: Members of the General Advisory Committee on Metallurgical Subjects and additional representatives.

Appendix XV

25th July 1958

PRIVATE AND CONFIDENTIAL

AC 14/Paper 10

CITY AND GUILDS OF LONDON INSTITUTE

Gresham College, Basinghall Street, London, E.C.2.

Metallurgical Technicians

Replies to Miss Brade-Birks' letter of 4th March, 1958, related to the headings under which information was requested. (Members were asked to consider particularly the type of person for whom it was intended to cater and the occupations concerned).

General observations

Mr F. C. Hayes (representing British Iron and Steel Federation)

"We have approached a selection of our member companies about their attitude to possible courses for metallurgical technicians. The sample included large and medium sized works and should, I think, give a fairly representative picture of the Industry's views."

Mr S. I. Bull (representing British Iron & Steel Federation)

"The following information as requested in your letter of 4th March, applies to these Works (Messrs Stewarts and Lloyds Ltd) only. There are two other steel producing works in the area who have similar requirements, but the British Iron and Steel Federation will probably be able to supply you with information relating to those works."

"Although a considerable amount of metallurgical laboratory work is done, the laboratory is staffed by trained metallurgists assisted by apprentice metallurgists, since it is felt that since the latter require such training, they should be offered the facilities rather than using metallurgical technicians to do the routine work."

Mr R. S. Brown (representing Institution of Metallurgists)

"I doubt whether there would be sufficient support in a number of areas for such a restricted subject and I, therefore, suggest for consideration that the course be for Metallurgical and General Laboratory Technicians."

<u>Mr H. A. MacColl</u> (representing Regional Examining Unions)

"With regard to the subject content of such a course, I would agree with Dr Williams' comments that the metallurgy portions should differ markedly from the conventional O.N.C. syllabus. I should envisage a substantial section on the manufacturing technologies rather on the lines of the present operatives syllabuses, coupled with some elementary physical metallurgy and mechanical testing. As regards the ancillary subjects suggested, I am again in agreement but feel strongly that these should be fitted into the course after the syllabus in metallurgy proper has been decided, and they can then be adjusted in the light of any time remaining."

<u>Mr A. Jackson</u> (Additional Adviser)

"The answers apply in particular to this Company (Appleby-Frodingham Steel Company). Some of them will not be particularly significant because we may not represent a complete cross-section of the industry. I think, however, you will probably get the overall figures from the B.I.S.F."

Dr M. B. Thompson (Additional Adviser)

"As far as we are concerned in this College (College of Technology, Rotherham) our main interest in the proposed course for Metallurgical Technicians would be to cater for those who fail to obtain satisfactory standard in the Ordinary National Certificate in Metallurgy, and for whom at present there is no satisfactory alternative."

Mr T. Bamford (Additional Adviser)

"I am afraid I have been unable to gather any new information of significance and therefore reply briefly:-

Type of person (1) Those who now start for O.N.C. and now fail mainly at S1 and S2.

(2) Laboratory Technicians who now are non-entrants for any course.

(3) Young men to train as Supervisors not only in the process but also and perhaps chiefly in the user industries."

Mr. J. Crosbie (Non-Ferrous interests)

"I have written to I.C.I. Metals Division and with the help of Mr. S.G. Temple, (examiner for the Non-Ferrous Metals Operatives' Course) have drawn up the following ideas.

"We both feel that there is a need to close the gap between the general operative and the professional metallurgist in the non-ferrous metal industry. Equally, we believe that this will not be done merely be setting up another examination. First the tradition needs to be developed in the industry that the study of metallurgy is worthwhile for the ordinary operative before details of a course for the intermediate level are worked out. Mr. Temple feels, and has always felt, that such a tradition can only be built up by giving some tangible recognition or reward to show that it is worthwhile; for example, some supplement of wages to all who pass the operatives' course. Passing of this examination would then become a stepping stone for those who wish to get the sort of jobs which might be included in the term 'technicians' - namely, inspectors and senior operators in rolling, annealing, tube and wire drawing, etc., routine analysis, test house staffs and even charge hands and foremen. These people would probably constitute up to 10% of the working population of a non-ferrous metal manufacturing concern.

"Any attempt to set up a graded system of courses and examinations for non-ferrous metal employees must run parallel with a promotion policy within the industry which would clearly establish the value of such studies to those other than the professional grades for whom plenty of facilities are already in existence. At the present moment no encouragement is given to the man who is keen to undertake systematic study, and shift work in the industry actually discourages it. The jobs listed above under the term 'technician' are at present usually filled by seniority and selection of the more intelligent or adaptable types from the shop floor. As has been pointed out often enough recently, this is a source of recruitment which may well cease as a result of the creaming of the secondary modern school population."

"It would appear, therefore, that there is a place for an examination for this technician group but that it will need a considerable change in the attitude of management to the recruitment, training and promotion of these people in industry before they are likely to see the value of an external course."

Dr E.G. West (Non-Ferrous interests)

"I am enclosing a Memo based on replies to a questionnaire which I sent to members of the aluminium industry, and which has been discussed on at least two occasions since the last special meeting which I attended in connection with the Metallurgical Technicians' proposed courses."

"As you will see from the Memorandum, the aluminium industry does not feel that such courses would be of any value to it with the exception of one or two small firms in certain districts. This may well be because the aluminium industry selects its trainees with particular care and normally they go through O.N.C. without undue trouble or difficulty. Many of them then proceed to H.N.C. and some to the L.I.M. examinations."

Mr I.H. Hogg (representing United Kingdom Atomic Energy Authority)

"In reply to your letter of the 4th March we have considered this matter and have come to the conclusion that "Metallurgical Technicians", as defined at the meeting on the 4th February, are of little interest to us."

"Our main interest at this level is in "Laboratory Technicians" and as these are not included and are in any case adequately catered for in existing courses we feel that we should drop out of this particular discussion."

Answers under specific headings

1. The numbers likely to be involved (with reference to existing categories rather than to people whom it is hoped to recruit at a future date)

Mr F.C. Hayes

"It appears that the numbers would be small, certainly insufficient to justify the establishment of courses for the iron and steel industry. Support would, however, be forthcoming for any courses established in steelmaking areas patronised mainly by other industries.

"As an example, one large group of companies, employing about 27,000 workers on steel making processes, thought that in their case about 70 people suitable for the course would be available in the first instance. Not all of these would necessarily wish to take the course."

Mr S. I. Bull

"Of the twenty or so people employed by the Metallurgical Department on what is generally called "Quality Control" approximately half could be classed as metallurgical technicians, who would be suited to the proposed course. The remaining half are employed on jobs of the inspection type which require little actual metallurgical knowledge."

"Based on past experience an annual turnover of up to 25% is to be expected. Initially then, we would have about 10 people who would benefit from such a course and subsequently 2 or 3 per annum".

"It must be pointed out that there are considerable difficulties involved in allowing people who work shifts and who are in addition employed on the same job, to attend courses. Replacements have to be found in order to cover each job on a continuous basis."

Mr H. A. MacColl

"It would appear at this College (Wednesbury) that there are already some 25-30 bodies per year who are definitely out of place in the O.N.C. and C. & G. Group Course, and who might well be diverted to the proposed new course."

Mr A. Jackson

"The total number we would expect to benefit directly in the metallurgical department and laboratory would be 30/40."

Dr M. B. Thompson

"I am going to assume that entry to this course would take place at the S3 level and would consist of those who had not reached the satisfactory standard in S2 in order to proceed to S3 National Certificate Course along with students who have already taken and failed in Ordinary National Certificate

Course. The numbers, therefore, that we might expect to go into such a course could be say 20/30. This figure might not be reached, however, since it is possible that a student not being accepted for an Ordinary National Certificate Course might decide to throw up attendances at this College and seek to gain admission to a National Certificate Course at a neighbouring one."

<u>Mr T. Bamford</u>

"Small at first but one to two hundred as soon as it becomes known that employers are behind the scheme."

<u>Dr E. G. West</u>

"The numbers appear to be extremely small, either at present or in the future. In the Birmingham area there might be five or six: in Enfield, two or three; and in Warrington possibly two or three."

<u>Mr D. W. Hopkins</u> (Additional Adviser)

"10 per year." (Swansea Technical College)

2. <u>Whether demand is anticipated to be (a) steady or intermittent, (b) increasing or decreasing</u>

<u>Mr F. C. Hayes</u>

"The demand would probably decrease to about one-third of the initial total, and would, in most cases, be intermittent."

<u>Mr S. I. Bull</u>

"It has been found that the demand is of an intermittent nature but it is probable that with present economic trends requiring higher standards of quality an increasing demand can be anticipated."

<u>Mr R. S. Brown</u>

"Slowly increasing."

<u>Mr H. A. MacColl</u>

"I should anticipate a steady demand with an increasing tendency."

<u>Mr A. Jackson</u>

"This would give rise to a steady annual demand of three to five per year after an original influx which might be expected from those already in these departments.

"In this connection I think there will be an expanding field of people requiring training in steelmaking by oxygen processes, though I would not like to forecast the extent without knowing the rate of development to be expected for these new methods."

Dr M. B. Thompson

"Probably steady".

Dr E. G. West

"Any demand there might be would be intermittent and would probably decline in the course of time, although the possibility of some increase is suggested in the North London or Enfield areas in the next few years."

Mr D. W. Hopkins

"The formal answer is steady, but I anticipate a slight fall during the next two years and then a more than compensating increase."

3. The geographical areas likely to be involved

Mr F. C. Hayes

"The main steelmaking areas, i.e.:-

Lancashire and the North-West Coast.

The Midlands, near Birmingham.

The North-East Coast.

North Lincolnshire.

West Coast of Scotland.

South Wales and Monmouthshire.

Sheffield and North Derbyshire."

Mr R. S. Brown

"Manchester, serving a radius of 20 miles. No knowledge of other areas."

Mr H. A. MacColl

"I find this rather difficult to answer since I draw students from areas within the ambit of other Colleges, but certainly the Walsall, Wednesbury, Darlaston, Bilston and Tipton areas in particular."

Mr A. Jackson

"The geographical areas likely to be involved are no doubt the same as the Federation's training areas. If there is also to be a non-ferrous section, then probably such areas as Birmingham, Wolverhampton, Coventry, Bristol etc., can be included."

Dr. M.B. Thompson

"As stated above, the figures I am giving are for Rotherham district only. I should imagine that all areas submitting candidates for National Certificate in Metallurgy or for City and Guilds examinations would become involved."

Mr. T. Bamford

"All the large Metallurgical, Engineering and also the new Atomic Research Stations."

Dr. E.G. West

"These are the Birmingham conurbation (excluding Coventry and Wolverhampton); North London, particularly Enfield area; and possibly the Warrington area."

Mr. D.W. Hopkins

"West Wales from Port Talbot to Llanelly."

4. Any further information about the kind of work on

which people who could be defined as "metallurgical technicians" might be engaged in the particular section of the Industry with which you are associated.

Mr F. C. Hayes

"The following categories of employee were among those mentioned:-

Inspectors of various kinds, e.g. inspectors of finished products.

Melting shop and other process observers.

Test House Operatives.

Heat treatment personnel.

Radiography assistants.

Those employed on slag control, steel stock records, routine chemical analysis.

"Most of these categories are employed on some form of routine quality control, which requires only a limited amount of metallurgical and chemical knowledge, e.g. the reaction involved in the steel-making process, or the causes of defects.

"One company pointed out that routine metallurgical duties are frequently used as training grounds for young people before they take on more responsible metallurgical work."

Mr S. I. Bull

"Metallurgical technicians are employed on a variety of jobs in these works, such as examination of end products, examination of casting pit conditions and obtaining rectification of any unsatisfactory conditions by production people, slag control work on open hearth furnaces, checking the heating and rolling temperatures of ingots, blooms, billets etc., collection of data in trials and ensuring that requirements of trial conditions are met throughout."

Mr R. S. Brown

"Works testers, plant process foremen, works and central laboratory staffs."

Mr H. A. MacColl

"The majority of the students whom I envisage as more suited to a Technicians' Course are those engaged in routine operations such as elementary metallurgical analysis, mechanical testing, pyrometry, polishing and etching of metallurgical specimens (for examination by a superior) and general work of a routine character."

Mr A. Jackson

"One could visualise metallurgical technicians being engaged on such work as teeming observers in a casting pit, temperature observers and carbometer men on the melting shop, steel observers (defectives etc.) in mills, melters using more advanced processes such as oxygen steelmaking and electric furnace practice, and possibly even routine chemists in laboratories doing semi-mechanical analyses."

Dr M. B. Thompson

"I think the type of students who might take this course would be the same as those already taking National Certificate Courses, e.g. those employed in works' laboratories, metallurgical laboratories, research establishments, etc. I do not think, as far as this area is concerned, that there is likely to be any specific group of workers that one could label 'Metallurgical Technicians', who would be likely to take the course under discussion initially rather than a National Certificate Course."

Mr T. Bamford

"Technicians (Test House) Laboratory workers. Heat treatment staff - in late teenages."

Dr E. G. West

"Laboratory assistants in mechanical testing laboratories, technical assistants in works experimental departments, and possibly certain junior supervisory grades. It is doubtful whether this class of worker is sufficiently well defined, or likely to be so defined, in the aluminium industry. In Research Departments in the industry encouragement is already given to juniors to undertake further metallurgical education to a higher level than technicians, in particular O.N.C., H.N.C., and L.I.M. In the lower grades of routine test work the preparation of specimens, etc., employees are usually juniors who may have taken G.C.E. at ordinary level but are unsuitable to proceed to any real metallurgical courses."

Mr D. W. Hopkins

"Routine anlaysis, physical testing, plant checks and records, collection and preparation of samples, metallographic specimen preparation."

5. The occupations, ages and approximate numbers of students failing, or not completing the course for, the Ordinary National Certificate, but who are thought to be suitable for a metallurgical technicians' course. The identity of colleges to which information given under this heading refers will not be disclosed.

Mr F. C. Hayes

"Most of the companies approached stated that the type of employee taking the O.N.C. in Metallurgy was usually of a high enough calibre to pass the examination, and would not be interested in a course of the kind proposed. One company enclosed a breakdown of all students taking the O.N.C. course in metallurgy over the past seven years and I enclose a copy for your information. This should, however, be regarded as confidential.

"The company, which has highly developed and progressive training schemes, offered the following observations on the breakdown:-

'Of the 43 students who have had time to obtain the Ordinary National Certificate, 25 have been successful, 15 have discontinued their studies and 3 are stili studying. A further 6 employees have ceased to study during this period, although they would not yet have had time to obtain their Ordinary National Certificate had they continued.

'Of the 21 students who have discontinued their studies, 8 are engaged as Laboratory Assistants on routine chemical analysis. We feel that many of the 21 students discontinued their studies through lack of effort and determination rather than lack of ability. Many of the students who discontinued studying were of mature years and had difficulty in maintaining their attendances at the Technical College due to their domestic responsibilities.'"

Dr E. G. West

"In general, it is felt that the percentage of failures in the O.N.C. courses among employees in the aluminium industry is so small as to be entirely neglected. This is attributable to careful selection of employees as candidates for the National Certificate Courses and there is considerable doubt as to whether there is any merit in providing Metallurgical Technicians' Courses of a lower standard than O.N.C. This can be taken as the general opinion throughout the industry with the exception of one or two rather small companies in particular areas where there are already adequate training facilities for National Certificate candidates.

"In general, the aluminium industry consists of large companies which have encouraged their junior employees to undertake technical college courses commencing with O.N.C., and providing facilities to go forward in all appropriate cases, to a professional qualification.

Information relating to Colleges - (identity not disclosed)

(a) "The occupations of the students failing to obtain O.N.C. level come within the categories listed in paragraph 4 although, on their enrolment forms, such students usually describe themselves as metallurgists or laboratory assistant. With regard to age, all the failures are normally in the 17+ to 18+ age group. Currently we are experiencing a 50% wastage between S1 and S3, and this represents in our case some 25-35 students."

(b) "The number of people failing to complete the National Certificate SIII level is upwards of 12 per year in this district. Whether these would be suitable candidates for the metallurgical technicians course or not I would not like to say. Numerically, however, there does appear to be a field for a grade of examination between operative and SIII."

(c) "Approximately 20-30. The occupations mostly as listed under section 4. Ages: approximately 17-20."

(d) "Probably 60% of present total enrolments for O.N.C. and City and Guilds Inter Courses."

(e) "Over the last three years there have been 33 failures, of whom 17 were described as Chemists, 14 as Metallurgists and 2 as Fuel Technologists, but "Chemist" and "Metallurgist" are almost synonymous in the smaller firms. The age range was from 18 years to 26 years and virtually all of them were far more suited to the technicians course than to the O.N.C. course which they took. The estimate of 10 per year is based on this finding."

<u>Appendix XVI</u>

TUBE INVESTMENTS LIMITED

Department of Technical Information

Plume Street, Aston

Birmingham, 6.

Our Ref: 10/19.5(2) August 27th 1958

<u>METALLURGICAL TECHNICIANS</u>

(1) In connection with the enquiry by the General Advisory Committee for Metallurgical Subjects of the City and Guilds of London Institute, some fifteen organisations within Tube Investments Ltd. have been consulted, and thirteen have replied, namely, two establishments within the Research and Development Organisation, and eleven manufacturing concerns. They are about equally divided between those who see little or no need for a metallurgical technicians' course (seven), and those who appreciate the need, but regard the potential demand as small and intermittent (six). There is no sharp line of demarcation between the two categories. The seven who see virtually no

need for such courses are all operating companies. Their general view is that most of their routine work can be well taken care of by trainee metallurgists on their way towards full qualifications. As it is common to enrol new students each year, there is never any real shortage of this type of labour, and those who fall by the wayside generally leave.

(2) At least two of the companies (one in each category) stress the point made by Mr Crosbie and Mr Temple and recorded on page 187 of the Memorandum AC 14/Paper 10. circulated with Miss Brade-Birks' letter of the 14th August 1958, namely that there should be some encouragement, presumably economic, to persuade the technician to attend such a course, i.e., some incentive in the way of a wage increase if he gets the certificate concerned. This prompts one company to suggest that there is no advantage to industry in having a grade intermediate between the present unqualified level and the lower graduates. It is thought that if in fact some firms are using graduates to do work that could equally

well be done by lower grades, there should be a better answer than a new intermediate qualification.

(3) Another company sees no need for an "in-between" course, in that the metallurgical technicians they use are those who have passed ONC; those who fail at ONC should in their view be classed as operatives. They fear that one result of the introduction of such a course might well be that fewer people will take the National course, and the company might have to accept operatives as technicians.

(4) Some of the companies in both categories stressed the point made by Mr Heselwood and Mr Kirkland at the meeting of 4th February 1958, that there should be some machinery for transfer from the proposed metallurgical technicians' course to the National course, and vice versa. The common practice in T.I. is to select good G.C.E. types and train them for the specific jobs required in each company; this is in line with the views expressed by Dr E.G. West in the Memorandum AC 14/Paper 10 referred to above.

(5) Of the six who realised that there may be a need, although the demand will be small and intermittent, two do not support their views with hard facts, being content merely to say that they believe there will be a demand. Two others are more constructive: one suggests a course of a standard similar to that held for welders, and says that while they have had most useful recruits of about thirty years of age, that would create a precedent in allowing them one day per week off for training; the other says that their day-to-day routine work can quite will be taken care of by their existing laboratory staff, but outlines the sort of duties that metallurgical technicians could suitably undertake. These are included in paragraph 9(iv), in answer to a specific question in Miss Brade-Birks' letter of the 4th March.

(6) The two establishments within the T.I. Research and Development Organisation have rather specialised requirements, so that their views are not strictly comparable with those of the operating companies. In both cases their demands are likely to be very small.

One of them, the T.I. Research Laboratories, is not favourably placed geographically, being in rural surroundings some eleven miles from Cambridge; it considers that any multiplication of such courses would not find favour with local technical colleges, especially those remote from industrial centres. The other, the T.I. Technological Centre at Walsall Airport, expects the majority of its staff to be of H.N.C. standard, but agrees that metallurgical technicians are always required where an appreciable body of routine work is to be carried out.

(7) An interesting suggestion comes from the T. I. Technological Centre. They are generally in favour, especially as the O.N.C. in metallurgy is regarded as stiffer than some other O.N.C. examinations. They feel, however, that there is a need for simpler and less thorough coverage of the basic sciences than is given in O.N.C., plus much of the metallurgy that is given to H.N.C. students (with less theory), such as heat treatment, simple equilibrium diagrams and S-curves, working, casting, cast structures, and steel making.

The view is held that useful instruction of a practical character can be given without the need for so much of the basic sciences, lack of which contributes so largely to wastage. They also stress the importance, noted in paragraph 4 of this memorandum, of easy transfer in both directions between the proposed metallurgical technicians' course and the National Certificate courses. They further make the psychological point that at the commencement a student might feel confident of getting the O.N.C. and may be unwilling to start on something of a lower order, until he had failed a time or two.

(8) On this question of wastage, it might not be inappropriate for the writer, as Chairman of the Joint Committee for National Certificates, to provide figures of entries and passes since the inception of the scheme. For the past five years the number of colleges entering students for the O.N.C. has been between thirty and forty, and for the H.N.C. (over the past three years) between twenty and twenty-five. As will be seen from the following table, the percentage

of passes over the past twelve years is of the order of 50% for the Ordinary National Certificate, and 78% for the Higher National Certificate. This, of course, ignores examinations for endorsement subjects, and the assessed examination in mathematics, S2.

	ORDINARY NATIONAL		HIGHER NATIONAL	
Years	Entries	Passes	Entries	Passes
1946	28	23	-	-
1947	102	69	22	18
1948	123	74	38	22
1949	222	107	74	59
1950	281	142	62	42
1951	314	138	110	54
1952	334	186	132	120
1953	390	184	140	116
1954	522	258	173	144
1955	523	275	183	138
1956	571	296	247	205
1957	600	288	275	222
	4010	2040	1456	1140

Clearly, therefore, the facts being as they are, there is some wastage, which is much more serious at the Ordinary level than at the Higher.

(9) The answers, as best they can be given, to the questions set out in Miss Brade-Birks' letter of the 4th March, are as follows:-

(i) The numbers likely to be involved from Tube Investments Ltd. will be very small, if any.

(ii) The demand, (again, if any) is expected to be intermittent, and may possibly show a gradual increase.

(iii) There is more likely to be a demand in the Midlands than anywhere else, although enquiries have extended also to South Wales, Sheffield, and the North East coast.

(iv) The sort of work that it is envisaged that metallurgical technicians might undertake includes: control of temperature and atmosphere of furnaces, control of temperature and strength of pickling and lubricating media, mechanical testing, spark and spectrographic testing, specimen preparation, non-destructive testing, process control, and assistance in the dark room.

(v) Unfortunately, the information sought under this heading is not available.

(10) The author's own view, based on this evidence and on that set out in Memorandum AC 14/Paper 10, is that a good case for a metallurgical technicians' course has not been established.

J.W. JENKINS

Director of Technical Information

Tube Investments Ltd.

Appendix XVII

CITY AND GUILDS OF LONDON INSTITUTE

February 1962 Confidential

AC14/P(17)

METALLURGICAL TECHNICIANS

Draft Regulations and Syllabuses

Suggested timing of introduction of new scheme of examinations for Metallurgical Technicians:

Year	Metallurgical Technicians. Examinations to be offered
1963	-
1964	Metallurgical Technician's Certificate only
1965	Metallurgical Technician's Certificate and Metallurgical Technician's Advanced Certificate +
1966 and thereafter	Metallurgical Technician's Certificate and Metallurgical Technician's Advanced Certificate

\+ In 1965 an examination for the Metallurgical Technician's Advanced Certificate will only be held if the Institute receives written requests from the authorities of colleges providing courses, not later than 1st January, 1964.

METALLURGICAL TECHNICIANS

This scheme of study and examinations for Metallurgical Technicians has been prepared by the Institute's General Advisory Committee for Metallurgical Subjects. Its purpose is to provide for those employed in the metallurgical industries (or in related departments of other industries) who are, or wish to become, technicians.

The scheme is especially suited to the needs of those employed on analysis, inspection and testing, and process and quality control, in works, in laboratories, and in research and development departments.

It is intended that the scheme of study and examinations should be complementary to organised practical training given within individual companies.

The scheme comprises:

Metallurgical Technician's Certificate

Metallurgical Technician's Advanced Certificate.

METALLURGICAL TECHNICIAN'S CERTIFICATE

The Metallurgical Technician's Certificate is intended to have two main functions. It aims to provide a suitable, self-contained qualification for those who need an understanding of the principles underlying their work and the techniques of application of these principles. It will also provide a foundation for the continued studies of those going on to the Metallurgical Technician's Advanced Certificate.

1. COURSE OF STUDY

1.1 The scheme is designed for adaptation to various forms of part-time study in technical colleges. It is envisaged that students will attend part-time day or block release courses, and that they will not have to rely wholly on evening study. Exceptionally, the provision of evening-only classes may be necessary but such an arrangement will usually involve spending one additional year on the course.

1.2 It is assumed that there will be close co-operation between local industry and technical colleges, with particular reference to links with industrial training.

1.3 It is considered essential to the success of the scheme that colleges providing the courses will have ensured that the necessary specialized accommodation and equipment are available, and in adequate quantity for the number of students in attendance.

1.4 The course of study leading to the examination for the Metallurgical Technician's Certificate should comprise a minimum of 900 hours' instruction, normally extending over not less than three years of study organised on a part-time day or block release basis. If, exceptionally, it is necessary to organise the course on an evening-only basis, its extension to four years is considered desirable.

1.5 It is hoped that the division of the syllabuses into years, and the following suggested allocation of time to the various subjects of the course, will assist teachers, who should nevertheless feel entirely free to vary the suggested arrangements, in accordance with the needs and abilities of their students. It is suggested that at least 50 per cent of the total course time should be devoted to practical work.

1.6	Subject	Suggested allocation of time, in hours per week (related to part-time day courses)
First Year		
1.	Metallurgical Science I	5
2.	Engineering Drawing and Equipment Construction	2
3.	General Metallurgy	3
Second Year		
4.	Metallurgical Science II	5
5.	Physical and Industrial Metallurgy I	4
6.	Industrial Practice	1 (for 1 term)
7.	(a) Presentation of Information) (b) Liberal Studies)	1 (for 2 terms)

Third Year

8.	Metallurgical Science III	4
9.	Physical and Industrial Metallurgy II	5
10.	(a) Presentation of Information (b) Liberal Studies	1

1.7 Although separate syllabuses are given for the various subjects, it is essential that there should be close co-ordination in the teaching of them throughout the course, and it will be evident that some topics studied during the first and second years should again receive attention at a later stage in the course.

1.8 The attention of teachers is drawn to the Notes for the Guidance of Teachers (Section 11).

2. APPROVAL OF COURSES

2.1 College courses in this subject, in the United Kingdom, do not require special approval by the Institute. The attention of college authorities is however drawn to the fact that the provision of suitable equipment is considered essential to the success of the scheme (see Section 1.3).

2.2 Courses in colleges outside the United Kingdom require prior approval by the Institute. Applications for approval should be made on Form F 2045, not later than six months before the start of the course.

3. SELECTION OF STUDENTS FOR COURSES

3.1. Although the selection of students for courses is within the discretion of the Principal of the technical college, the following is suggested as a possible basis for assessing the suitability of students for entry to the course for the Metallurgical Technician's Certificate.

3.2. Qualification	Minimum Age	Year of entry to course
(a) a five-year secondary school course (or four-year in Scotland) which, in the final year, has included a suitable science subject and mathematics	16	First Year

3.2 Qualification	Minimum Age	Year of entry to course
(b) completion of the first year of a general course in science* or engineering	16	First Year
(c) satisfactory completion of a general course in science*	17	Second Year
(d) Three or more passes at Ordinary Level in the G.C.E. or S.C.E. examination, including appropriate science subjects	16	Second Year
(e) a pass in the Ordinary examination in Foundry Practice of the City and Guilds of London Institute	17	First Year

* NOTE These references to a general course in science are intended to cover a national general course (if and when one is introduced) or, until then, a suitable college course. It therefore follows that suggestions (b) and (c) above are necessarily provisional. In the Principal's choice of a student's most suitable point of entry to the course, much will

depend on the content of the general course taken by the student, particularly as regards (c).

4. ELIGIBILITY FOR ENTRY TO THE EXAMINATION

The Principal of the college will be required to certify, on Form MTC, that all candidates for entry to the examination for the Metallurgical Technician's Certificate have:

(a) satisfactorily completed the course of study, including Liberal Studies.

(b) satisfactorily performed the experiments listed in the scheme of practical work.

and

(c) kept satisfactory individual written records of the practical work and demonstrations in separate notebooks that are available for inspection by the Institute.

5. EXTERNAL CANDIDATES

The entry to the examination of external candidates (i.e. those who have not satisfactorily completed the appropriate course of study at a college, as indicated in these regulations) is not permitted.

6. OVERSEAS CANDIDATES

The conditions of eligibility for entry to the examination for overseas candidates are the same as for those from the United Kingdom, except that the college course taken by them must have been specially approved by the Institute (see Section 2.2).

7. EXAMINATION

7.1 The Institute will set an examination for the Metallurgical Technician's Certificate, to be taken at the end of the course. This examination will comprise three written papers, each of 3 hours' duration, as follows:-

1st paper (Metallurgy)

2nd paper (Metallurgy)

3rd paper (Metallurgical Science)

Questions from any section of the syllabuses for the Metallurgical Technician's Certificate may be included in any paper and candidates may be required to draw on their knowledge of items listed in the scheme of practical work. The Metallurgy papers may include a compulsory question on Presentation of Information.

Candidates must take all three papers in the same year and will normally be expected to pass all three together. In borderline cases, however, and where the results in the other paper or papers are sufficiently good, a candidate may be referred in either Metallurgy (both papers together) or Metallurgical Science. Such a candidate may make one attempt only to make good the failure in the referred part, without repeating the whole examination. There can be no question of referment in Liberal Studies, which is the subject of a college examination. A candidate who has not taken the college examination in Liberal Studies will be regarded as ineligible.

7.2. At the end of the course, colleges are required to examine in Liberal Studies and to submit evidence to the Institute that each candidate has taken the examination. Results in the Institute's examination will be withheld in the absence of evidence that a candidate has taken the Liberal Studies examination The form of the Liberal Studies examination is left entirely to the college to devise, but one copy of each examination paper must be sent to the Institute for record purposes.

7.3 The Institute will not hold a practical examination for the Metallurgical Technician's Certificate but, during the course, each candidate is required to perform experiments listed in the scheme of practical work and to keep satisfactory written records, in a separate notebook, of the practical work done by him and demonstrated to him. <u>A selection of these notebooks will be called for by the Institute each year and may be taken into account in determining the results of the examination</u>.

8. LIBERAL STUDIES

8.1 At the end of the course for the Metallurgical Technician's Certificate, colleges are required to examine in Liberal Studies and to submit evidence to the Institute that each candidate has taken the examination. Results in the Institute's examination will be withheld in the absence of evidence that a candidate has taken the Liberal Studies examination. The form of the Liberal Studies examination is left entirely to the college to devise, but one copy of each examination question paper must be sent to the Institute for record purposes.

8.2 Some suggestions concerning Liberal Studies are given in the Notes for the Guidance of Teachers (Section 11).

9. AWARD OF CERTIFICATES

A certificate of the first or second class will be awarded to a candidate who is successful in the Institute's examination for the Metallurgical Technician's Certificate, and complies with the requirements concerning Liberal Studies.

10. TRANSITIONAL REGULATIONS (linking with old scheme for Subject 14 - Metallurgy)

10.1 Students who have passed the Institute's Intermediate General Metallurgy examination may, at the discretion of the Principal of the college, be admitted to the second year of the course for the Metallurgical Technician's Certificate. Such students must comply with the eligibility requirements for entry to the examination, including those concerning Liberal Studies.

11. NOTES FOR THE GUIDANCE OF TEACHERS

11.1 This scheme for courses and examinations is primarily intended for those employed in the metallurgical industries (or related departments of other industries) who are, or wish to become, technicians.

11.2 It is considered essential that the theoretical and practical course work should be closely linked with practical industrial training and supported by works visits.

11.3 It is stressed that co-operation between local industry and technical colleges is considered essential to the success of the scheme. Such co-operation is of particular importance in relation to specialized equipment that may not be readily available in colleges.

11.4 The syllabuses are for examination purposes and it is for each teacher to arrange his own teaching programme. It is hoped that the division of the syllabuses into years, and the suggested allocation of time to the various topics, will assist teachers, who should nevertheless feel entirely free to vary the suggested arrangements in accordance with the needs and abilities of their students. It will be evident that some of the topics covered in the first and second years should again receive attention at a later stage in the course.

11.5 It is considered very important that there should be a practical approach throughout the course. During the course, each student is required to perform experiments listed in the scheme of practical work, and to keep individual records, in a separate notebook, of the practical work done by him and demonstrated to him. <u>A selection of these notebooks will be called for by the Institute each year and may be taken into account in determining the results of the examination.</u>

11.6 It is not intended, nor will it always be desirable, that the theoretical principles should necessarily be studied in the lecture room, and it is important that many items be supported and illustrated by practical work and demonstration.

11.7 The examination for the Metallurgical Technician's Certificate will be set on the syllabuses for all years of the course.

11.8 It is hoped that the following, more detailed comments on Presentation of Information (to be examined by the Institute) and Liberal Studies (to be examined by the college) will be of interest to teachers.

PRESENTATION OF INFORMATION

It is hoped that this subject will not be treated in a formal manner but rather that the student may be taught the importance and convenience of speaking and writing clearly and adequately, i.e. using language as a " tool ". It should aim at developing:

(i) skill in effective oral and written communication

and

(ii) understanding of the relationship involved in communicating.

Exercises and examples should be taken from the students' working and personal background, and should include, inter alia:

(a) oral work (making use of tape-recorders, etc.)

(b) sources of information, including abstracting and summarising

(c) practice in such written work as reports of experiments and plant trials.

It is suggested that questions of grammar, punctuation, and correct English generally, may well be dealt with as they arise without separate formal instruction.

LIBERAL STUDIES

The Institute is anxious that the outlook of technicians who pass through this course should not be restricted to the confines of their technical studies. For this reason, Liberal Studies have been included in the scheme.

It is recognised that colleges and individual teachers will necessarily vary in their methods of treating the subjects; examinations will therefore not be conducted by the Institute. Many colleges already provide courses in Liberal Studies that may be suitable for metallurgical technicians. The suggestion that follows is therefore in no sense obligatory.

The scheme of study given below, which

relates the students' occupation - metallurgy - to the development of society, might provide opportunities for a liberal broadening of outlook and its relevance would be easily apparent to students.

The Stone Age and the Bronze Age; metals as ornament, currency and weapons in prehistoric times and classical antiquity.

The Iron Age; the Romans and the barbarians.

The Middle Ages; armour and feudalism.

The end of the Middle Ages; cannon and castles.

The Renaissance; development of metallurgical arts and crafts.

The Industrial Revolution as the age of iron and steel.

The "Second Industrial Revolution" - aluminium, light alloys, the "rare" metals, new materials, e.g. plastics.

SYLLABUSES

Safety and safe working methods should form an integral part of all instruction. Matters relating to safety may enter into examination questions.

FIRST YEAR

1. Metallurgical Science I

Use, care, and maintenance of laboratory apparatus and facilities.

Principles of sampling, elementary statistical basis of error. Methods of sampling e.g. ores, concentrates, coal, oil, gas, molten and solid metals. Reduction of bulk samples to laboratory samples.

Chemical reaction, illustrated especially by the cycle: formation of ores - metal extraction - corrosion. The chemistry of simple qualitative and quantitative analysis. Combustion: fuels; products; efficiency; proportion of air and fuel.

Physical properties of metals and non-metals. Thermometry, quantity of heat, specific heat, latent heat, expansion of solids, liquids, and gases, gas laws; liquid, gaseous and bimetallic thermometers. Thermal and electrical conductivity.

Electromotive force, potential difference; voltmeters, ammeters, Ohm's law, simple series and parallel circuits, heating and magnetic effects of current flow. Primary and secondary cells, electrical power and energy.

Reflection and refraction of light; lenses and mirrors, principles of the telescope and the microscope.

Averages, percentages, ratios. Significant figures and approximations, indices. Logarithms, including simple fractions and negative powers. Use of mathematical tables and slide rule. Construction, evaluation, and transposition of simple formulae, simple equations. Simple and simultaneous linear equations in two unknowns. Graphs, plotting from data and from tabulated values, graphic solutions of equations. Surface areas and volumes of regular figures and solids. Simple geometry of the circle, angles subtended by an arc, angle in a semi-circle, angle between tangent and chord.

2. <u>Engineering Drawing and Equipment Construction</u>

The Engineering Drawing course is intended to teach the student to read simple drawings, and to prepare dimensioned sketches from which working drawings may be produced.

It will be evident that students should spend a large proportion of the time devoted to Equipment Construction in carrying out a series of practical exercises. These exercises need not be recorded in the students' notebooks for practical work.

Use of drawing instruments, British and metric scales. Construction of scales and common geometrical figures. Sketches and interpretation of drawings made therefrom. (The conventions of British Standard 308 should be applied.)

The use of hand tools for work on metals, wood, and plastics. Soft and hard soldering, brazing and welding. Forming and joining of plastics by heat and cements.

Simple hand forging; hardening and tempering. The use of the lathe, drilling machine, plain milling machine, and shaper in simple exercise on metals and plastics, Preparation of test pieces for mechanical tests. Drilling and tapping, die cutting of threads on rod and tube. Safety precautions and the care of tools.

The elements of glass blowing: simple bends and joints, including joining of tubing of different sizes.

Electrical conductors: materials used, current carrying capacities, joining, coil winding. Types of fuses and their uses.

Construction of simple laboratory furnaces.

3. General Metallurgy

Sources of metals. Concentration; extraction of iron, copper, zinc, and aluminium. Refining by oxidation, liquation, electrolysis, and distillation. Melting and casting, solidification in sand and chill moulds, grains, formation of dendrites, occurrence of segregation. Hot and cold working of metals, properties of cast and worked metals.

Introduction to mechanical testing: tensile and compressive strength, load-extension graphs, proof stress, Young's Modulus, ductility, impact resistance, and hardness. British Standard forms of test pieces.

SECOND YEAR

4. Metallurgical Science II

Introduction to atomic and molecular structure of elements; periodic classification and its relation to differences in properties between metals and non-metals.

The chemistry of copper, lead, iron, nickel, and aluminium as applied to their extraction, refining, and analysis: utilisation of that chemistry as the theoretical basis of analytical methods.

Simple ionic theory and electro-chemistry, Faraday's Laws, electro-chemical series, potentials, pH, buffer solutions, electrolysis, electro-refining, and electro-plating. Use of electrolytic, potentiometric, and calorimetric methods of analysis; pH measurement.

Principles of calorimetry with reference to solid, liquid, and gaseous fuels. Physical properties of fuel oils. Proximate analysis of coal. Simple gas analysis.

Introduction to refractory materials and their application in metallurgical practice.

Theory and use of the simple potentiometer, galvanometers, shunts; sensitivity. Post-office box.

Pyrometry: an elementary treatment of the principles of temperature measurement by thermoelectric, resistance, optical, and radiation pyrometers.

Refraction through a prism. Simple account of dispersion and the production of a pure spectrum, line spectra, and metallurgical applications of spectroscopy and spectrography.

Degrees of accuracy, errors from multiplication. Comparison of the areas of similar figures and volumes of geometrical solids.

Elements of statistics. Ratio and proportion, variation, including joint variation. Determination of straight line law from experimental data in simple cases. Histograms.

5. Physical and Industrial Metallurgy I

Crystalline nature of metals. Grains and grain boundaries. Purposes and methods of alloying. Simple phase diagrams - solid solutions and eutectics. Solidification shrinkage, dendritic structure, segregation, non-metallic and gaseous inclusions in cast metals and alloys.

The purpose and principles of hot-working by rolling, forging, and extrusion, and of cold-working by rolling and drawing. Common defects arising from these processes.

The elements of heat-treatment. Definitions of the following terms: annealing, normalising, inter-stage annealing, quenching, tempering, solution treatment, precipitation treatment. Reheating for working - over-heating and burning.

Principles underlying the selection and preparation of samples of metals and alloys for macro and micro-examination. Metallographic techniques: mounting, grinding, polishing, and etching. Ink and sulphur printing. Use of the optical microscope and photographic apparatus. Processing of negatives and prints. Comparison of the structure and properties of cast and worked metals and alloys. (The subject matter of this paragraph should be illustrated by reference to materials such as cast iron, wrought iron, plain carbon steels, common brasses and bronzes, solders, a cast aluminium - copper alloy and a wrought heat-treatable aluminium alloy.)

6. <u>Industrial Practice</u>

Safety in workshops and factories. Introduction to general factory regulations. Mechanical, electrical, and chemical hazards encountered in the melting, casting, working, and heat-treatment of metals. Introduction to plant layout, material and product flow. storage and handling, scrap segregation and disposal.

Planning of labour; supply of services and materials.

7. Presentation of Information

The need for communication, with examples from everyday life and from the laboratory and workshop.

Language as most important form of communication. Speech, telephone, letters, reports, memoranda, sketches, and drawings - their advantages and disadvantages, with examples and exercises from students' working and personal background aimed at securing accuracy, clarity, brevity, and coherence.

The preparation and compiling of information, and communicating it in reports or other forms.

Recognition of relationships as the basis for effective communication; the need to consider the people with whom one communicates and the reason for the communication.

THIRD YEAR

8. Metallurgical Science III

Revision and extension of atomic theory and periodic classification.

Corrosion: direct oxidation, electrolytic action, passivity, and protective films.

Protection: use of inhibitors and protective coatings.

Magnetic fields of magnets and solenoids. Properties of hard and soft magnetic materials; permeability and hysteresis curves. Permanent magnets. Electromagnetic induction - eddy currents. Introductory treatment of a.c. theory, waveform, frequency, instantaneous and R.M.S. values. Principles of the electric motor and generator. The use of single-phase, two-phase, and three-phase supplied. Elementary treatment of the single-phase transformer. The differential transformer. Rectification.

Electronics: valves, transistors, condensers, electron gun.

Electrostriction.

Simple switching and control circuits. Relays. The precise measurement and control of temperature in the laboratory.

9. Physical and Industrial Metallurgy II

Further study of phase diagrams, peritectics, intermediate phases, and solid state transformations with particular reference to the formation of eutectoids. Use of phase diagrams in the study of common industrial alloys, e.g. cast iron, plain carbon steel, alpha and alpha-beta brasses, tin bronzes, aluminium bronzes, binary alloys of aluminium, including modified alloys. Techniques of phase diagram determinations, including X-ray crystallographic methods.

More detailed study of heat-treatment - annealing, normalising, spheroidizing, quenching, tempering, solution treatment and precipitation hardening.

Case hardening of steel by carburising methods.

Recrystallisation, grain growth, and directional properties with reference to heat-treatment and working processes.

Metallurgical aspects of welding, soldering, and brazing.

Elementary description of the effects of nickel, chromium, and molybdenum on steel.

Metallurgical testing. The mechanical properties of the common metals and alloys used for engineering purposes. Elements of quality control. The need for inspection and control at all stages from raw material to finished product. Limitations of destructive testing in continuous plant operation. Simple account of the principles and methods of non-destructive testing, e.g. radiography, crack detection by magnetic and penetrant methods, ultrasonic examination.

10. Presentation of Information.

The syllabus in paragraph 7 above applies.

Metallurgical Technician's Certificate

Scheme of Practical Work

The scheme of practical work has been devised on the assumption that a student taking the whole course will perform all the experiments listed and see all the demonstrations. A student entering the course at the beginning of the second year will be expected to complete at least 66% of the practical work, doing those parts of it that are appropriate to his course of study, in relation to the theoretical studies for the second and third years.

Students should be taught how to clean and maintain standard items of laboratory equipment (e.g. glassware: taps, joints, filters), and also how to dismantle, clean, and re-assemble a simple piece of apparatus (e.g. balance, calorimeter, simple dilatometer). The correct techniques of care and maintenance should be applied in respect of the experiments that follow.

List of Experiments.

(To be performed by each student)

Metallurgical Science

(It is assumed that students will already be familiar with practical work in elementary physics and chemistry).

1. The comparison of the characteristics of a laboratory sample properly prepared from a bulk supply with those of one obtained by incorrect

methods.

2. The preparation and titration of a standard solution of one of the following:

   (a) sulphuric acid

   (b) sodium carbonate

   (c) sodium thiosulphate

   (d) potassium permanganate

   (e) iodine

3,4 & 5. The qualitative analysis of three different mixtures of salts containing two of the metals and two of the acid radicles from the following list:

lead	sulphate
silver	chloride
copper	nitrate
cadmium	nitrite
tin	carbonate
iron	sulphide
aluminium	sulphite
nickel	
zinc	

6,7 & 8. The qualitative analysis by means of spot tests of three different alloys containing two or more of the following metals:

lead	aluminium
silver	chromium
copper	nickel
cadmium	zinc
tin	manganese
iron	cobalt

9. The quantitative determination of one of the following:

(a) sulphur in iron pyrites

(b) lead in red lead

(c) iron in haematite.

10,11 & 12. The gravimetric determination of three of the following elements in alloys:

(a) lead	(d) silicon
(b) iron	(e) nickel
(c) aluminium	(f) sulphur

13,14 & 15. The volumetric determination of three of the following elements in alloys:

(a) copper

(b) manganese

(c) chromium

(d) zinc

(e) iron

(f) phosphorus

16. The quantitative determination of carbon in either a steel or in a cast iron.

17. The calibration of a pH meter and its use in comparison with that of a colorimeter in the determination of the pH value of solutions.

18. The colorimetric determination by absorptiometry of e.g. manganese in steel, or copper in aluminium alloys.

19. The systematic recording of the change in weight and appearance of the following metals on exposure to the atmosphere: mild steel, aluminium, copper tinplate, galvanised steel, and stainless steel.

20. The measurement of the electromotive force between the following pairs of metals when immersed in a normal sodium chloride solution: copper and zinc,

copper and iron, annealed and hard rolled mild steel, aerated and unaerated annealed mild steel.

21. The systematic recording of the change in weight and appearance of annealed mild steel on exposure to the atmosphere in the following conditions:

    (a) bare

    (b) painted with red lead

    (c) painted with epoxy resin

    (d) electroplated with about 0.001" of copper

    (e) electroplated with about 0.001" of zinc.

22. The determination of changes in weight of mild steel on immersion in:

    (a) normal sulphuric acid solution

    (b) the same plus 5% quinoline

    (c) the same plus 5% ferric sulphate.

23. The measurement of the electromotive force of a Daniell cell with (a) zero current, (b) 50 milliamps, (c) 100 milliamps.

24. The measurement of breakdown potential of copper

sulphate and of passivating current density using copper electrodes.

25. The verification of Faraday's laws.

26. The determination of carbon dioxide, carbon monoxide, hydrocarbones, hydrogen, and nitrogen in town's gas.

27. The proximate analysis of coal for volatile matter, ash, coke, and sulphur.

28. The determination of the calorific value of coal or oil or gas.

29. The determination of the following characteristics of a fuel oil:

(a) viscosity	(c) pouring point
(b) flash point	(d) solid residue

30. The determination of the relationship between electromotive force, current, and resistance in a circuit containing resistances (a) in series and (b) in parallel. The use of shunts to extend instrument ranges.

31. The determination of the heating effect of a current.

32. The construction of a simple transformer and the

determination of its characteristics.

33. The determination of the frequency and wave form of the mains supply, using an oscilloscope.

34. The determination of the characteristics of a valve diode or a transistor diode.

35. The determination of the voltage/current relationship for (a) a condenser and (b) an inductance.

36. The construction of a temperature control relay operating from a bimetallic strip.

37. The measurement of resistance by a Wheatstone bridge or a Post Office box.

38. The comparison of electromotive forces by means of a simple potentiometer.

39. The construction and calibration (at a boiling point and a freezing point) of a thermocouple.

40. The measurement of temperature by thermo-electric, optical and radiation pyrometers.

41. The simple comparison of thermal conductivities of selected metals and alloys.

42. The determination of the refraction of light by a prism.

43. The measurement of typical wave lengths in a line spectrum.

Metallurgy

1. The preparation and metallographic examination of samples using typical metals and alloys to illustrate the following techniques:

   (a) selection and separation of the sample

   (b) rough and fine grinding

   (c) mechanical polishing

   (d) electro-polishing

   (e) mounting

   (f) chemical and electrolytic etching.

2. The examination of the microstructures, including any porosity and non-metallic content, of the following cast materials:

   (a) copper

   (b) aluminium

   (c) zinc

   (d) α - brass

   (e) cast iron

   (f) a copper-nickel alloy

   (g) eutectic lead-antimony alloy

   (h) eutectic lead-tin alloy

   (i) " aluminium-zinc "

3. The preparation of a selected specimen and the production of a photomicrograph from it.

4. The examination of representative alloys to illustrate typical microstructural constituents in the following systems:

   (a) copper-zinc
   (b) copper-tin
   (c) copper aluminium
   (d) copper-nickel
   (e) aluminium-silicon.
   (f) plain carbon steels
   (g) white cast iron
   (h) grey cast iron

5. The production, in sand and chill moulds, of small ingots of the following, to show the effect of the impurities and the type of mould upon microstructure and macrostructure respectively:

   aluminium containing iron
   brass containing lead
   copper containing bismuth.

6. The preparation and macrographic examination of samples of typical metals and alloys to illustrate:

   (a) the use of etching to reveal the gross crystal structure

(b) sulphur printing

(c) ink printing.

7. The preparation of a selected specimen and the production of a photomacrograph from it.

8. The use of standard methods for the determination of the hardness of typical metals and alloys.

9. The use of a tensile testing machine for the determination of the load-extension curve for a mild steel, and the proof stress of a wrought aluminium alloy.

10. The study of changes in hardness of aluminium, copper, and steel caused by hot and cold working by simple methods, e.g. hammering on an anvil, hand rolling.

11. The determination of the recrystallisation temperature of heavily cold-worked copper by means of the construction of a hardness/annealing temperature graph and a comparison of the microstructures in the cold-worked and in the subsequently annealed conditions.

12. The determination of the influence of the amount of cold work upon the recrystallisation temperature of alpha-brass.

13. The determination of the hardness gradient and the examination of the change in microstructure in a medium carbon steel bar, quenched at one end from the austenitic range.

14. The comparison by micro-examination of samples of steel in the following conditions:

    (a) cast

    (b) hot-worked

    (c) normalised

    (d) spheroidised

    (e) overheated

    (f) burnt

15. The study of the changes in microstructure and hardness of a quenched medium carbon steel, tempered at a series of temperatures up to 650°C.

16. The determination of the cooling curves, during solidification of: (a) lead or tin
    (b) the lead-tin eutectic
    (c) a 50/50 lead-tin alloy.

17. The determination of the transformation range in a medium carbon steel by a dilatometric method.

18. The use of penetrants and magnetising methods to reveal surface defects in metals and alloys.

LIST OF DEMONSTRATIONS

(To be demonstrated to all students)

Metallurgical Science

1. Comparison of the physical and mechanical properties of copper, zinc, magnesium, aluminium, glass, wool, concrete, polythene, perspex.

2. The use of a universal shunt to control galvanometer sensitivity; critical damping.

3. Production of spectra by refraction through a prism.

4. Physical methods of chemical analysis, other than those included in the list of experiments, e.g. spectrography, polarography (as and when facilities can be made available).

5. The determination of the voltage and amperage characteristics and wave form of half and full-wave rectifiers

6. The use of a differential transformer for dilatometry.

7. The use of a photo-transistor for control of temperature, flow, and pressure.

Metallurgy

When facilities can be made available, such exercises as those set forth below should be included among the demonstrations:

1. Mechanical tests, other than those included in the list of experiments, e.g. compression, impact, fatigue, shear, torsion, cupping.

2. Demonstration of X-ray diffraction techniques for the examination of alloy systems and the effects of working and heat treatment.

3. Non-destructive testing by ultrasonic and radiographic methods.

Metallurgical Technician's Advanced Certificate

The Metallurgical Technician's Advanced Certificate is intended for those who have already obtained the Metallurgical Technician's Certificate. It makes provision for further study, which is partly of a general character and partly concerned with the more specialized aspects of certain important techniques, and is designed for technicians employed at a responsible level.

The sub-committee makes the following general recommendations as regards the structure and content of the Metallurgical Technician's Advanced Certificate:

1. Course of Study

Two years, part-time day or block release. Minimum of 600 hours instruction for course as a whole.

2. Approval of Courses.

As for Metallurgical Technician's Certificate.

3. Selection of Students for Courses

Within the discretion of the Principal of the technical college, but entrants to the course should normally be at least 19 years of age and have passed the examination for the Metallurgical Technician's Certificate (or the equivalent examination of a Regional Examining Union).

4. Eligibility for Entry to the Examination

All candidates must have:

(a)passed the Institute's examination for the

Metallurgical Technician's Certificate (or the equivalent examination of a Regional Examining Union)

(b) completed the course of study for the Metallurgical Technician's Advanced Certificate, including Liberal Studies

(c) carried out, or seen demonstrated, experiments listed in the scheme of practical work

and

(d) kept records of the practical work (available for inspection by the Institute).

5. <u>External Candidates</u>

As for Metallurgical Technician's Certificate.

6. <u>Overseas Candidates</u>

As for Metallurgical Technician's Certificate.

7. <u>Examinations</u>

The Institute will hold written and practical examinations.

Colleges will be required to examine in Liberal Studies.

Referment will be permitted under similar conditions to those suggested for the Metallurgical

Technician's Certificate.

8. Liberal Studies

As for Metallurgical Technician's Certificate.

9. Award of Certificates

As for Metallurgical Technician's Certificate.

10. Notes for the Guidance of Teachers

To be completed - similar in approach to those for Metallurgical Technician's Certificate.

SYLLABUSES

The sub-committee suggests that there should be two main fields of study:

(i) Industrial Metallurgy

(ii) Metallurgical Techniques

All students would study Industrial Metallurgy (which would cover such topics as the making, shaping, heat-treatment, properties, and uses of metals and alloys, from an industrial aspect). It is envisaged that Industrial Metallurgy will occupy about one-third of the time available for the course as a whole.

It is proposed that there should be at least four Metallurgical Techniques and that the necessary supporting science should be included in each syllabus. So far, the following techniques have been suggested.

(a) metallography

(b) analysis

(c) testing

(d) production control.

Practical examinations would be held in appropriate techniques.

The sub-committee is still considering:

(i) how many techniques any one student should be required to study,

(ii) whether more techniques should be added to the list in the first instance.

Appendix XIX

Student Analysis Data Sheet

Column	Data		Punch	
1 - 3	Student Number	3N	101	___
4	Firm	IA	D	Sp
5	College	IN	3	Sp
6	School	IN	3	Sp
7 - 8	Age on Entry	2N	16	Sp Sp
9	'0' level passes	IN	1	Sp
10	'A' level passes	IN		Sp
11	SI passes	IN		Sp
12	S2 passes	IN		Sp
13	S3 passes	IN		Sp
14	Other qualifications	IN		Sp
15	Present Job	IN	2	Sp
16				Sp
17				Sp

NOTES: Transferred from Stockton to Constantine in session 1962-63 and shown as data sheet 073 in the Constantine records.

ALL DATA 1 2 3 4 5 6
EXCEPT P or F 1 or 2

MULTI PUNCH	18	Course 57/8		2	Course 58/59	8	Skip
		Physics for all courses					
	19	Homework	IN	3	IN	9	Sp
	20	Classwork	IN	-	IN	-	Sp
	21	Lab.	IN	5	IN	9	Sp
	22	Theory	IN	3	IN	9	Sp
	23	Practical	IN	1	IN	9	Sp
	24	P or F	IN	2	IN	7	Sp
		Chemistry for S1 - S4 Metallurgy for A1 and A2					
	25	Hw	IN	3	IN	9	Sp
	26	Cw	IN	-	IN	-	Sp
	27	Lab	IN	3	IN	10	Sp
	28	Th.	IN	3	IN	7	Sp
	29	Pract.	IN	2	IN	8	Sp
	30	P or F.	IN	2	IN	8	Sp
		Maths for S1 - S4 Production A1 and A2					
	31	Hw	IN	3	IN	9	Sp
	32	Cw	IN	1	IN	9	Sp
	33	Theory	IN	1	IN	9	Sp
	34	P or F	IN	2	IN	7	Sp
		Eng. Drawing A1 or A2					
	35	Hw	IN		IN		Sp
	36	Cw	IN		IN		Sp
	37	Theory	IN		IN		Sp
	38	P or F	IN		IN		Sp

39	Course 59/60		2	Course 60/61	9	Skip
	Physics for all courses					
40	Hw	IN	5	IN	11	Sp
41	Cw	IN	-	IN	-	Sp
42	Lab.	IN	4	IN	9	Sp
43	Theory	IN	4	IN	8	Sp
44	Pract.	IN	6	IN	10	Sp
45	P or F	IN	1	IN	8	Sp
	Chemistry for S1 - S4 Metallurgy for A1 and A2					
46	Hw	IN	5	IN	10	Sp
47	Cw	IN	-	IN	-	Sp
48	Lab.	IN	5	IN	0	Sp
49	Theory	IN	5	IN	8	Sp
50	Pract.	IN	5	IN	11	Sp
51	P or F	IN	1	IN	8	Sp
	Maths for S1 - S4 Production for A1 and A2					
52	Hw	IN	3	IN	9	Sp
53	Cw	IN	3	IN	10	Sp
54	Theory	IN	4	IN	10	Sp
55	P or F	IN	1	IN	7	Sp
	Eng. Drawing A1 or A2					
56	Hw	IN		IN		Sp
57	Cw	IN		IN		Sp
58	Theory	IN		IN		Sp
59	P or F	IN		IN		Sp

Column	Course 61/62		3	Course 62/63	10	Skip
	Physics for all courses					
61	Hw	IN	4	IN	11	Sp
62	Cw	IN	-	IN	-	Sp
63	Lab	IN	4	IN	11	Sp
64	Th	IN	3	IN	9	Sp
65	Pract.	IN	5	IN	11	Sp
66	P or F	IN	1	IN	7	Sp
	Chemistry S1 - S4 Metallurgy for A1 and A2					
67	Hw	IN	5	IN	10	Sp
68	Cw	IN	-	IN	-	Sp
69	Lab	IN	5	IN	11	Sp
70	Th	IN	4	IN	7	Sp
71	Pract.	IN	4	IN	10	Sp
72	P or F	IN	1	IN	8	Sp
	Maths for S1 - S4 Production for A1 and A2					
73	Hw	IN	4	IN	9	Sp
74	Cw	IN	4	IN		Sp
75	Th	IN	5	IN		Sp
76	P or F	IN	1	IN		Sp
	Eng. S4					
77	Hw	IN		IN	11	Sp
78	Cw	IN		IN	10	Sp
79	Th	IN		IN	10	Sp
80	P or F	IN		IN	7	Sp

APPENDIX XVIII

Student	Firm	College	Age on Entry	Qual on Entry	Subjects in course of study	1957/58 Year	1957/58 Attend in hrs Ac	Attend in hrs Pos	Course % HW	Course % C	Course % L	Exam % Th	Exam % Pr	1958/59 Year	1958/59 Attend in hrs Ac	Attend in hrs Pos	Course % HW	Course % C	Course % L	Exam % Th	Exam % Pr
103	D	III	16	Nil		S.2								S.3							
					Mathematics		75	80	40	41		42			72½	80	41				
					Physics		96	99	49		62	50			90	102	62		55	53	
					Chemistry		96	99			46	50			90	102	40		53	40	
104	A	III	16	GCE'O Chem. & Relig. Know.																	
					Mathematics																
					Physics																
					Chemistry																
105	A	III	16	-		S.2								S.2							
					Mathematics								44		72½	97½	47				29
					Physics		1090/ 1140 Full-time						28		105	111	47		75		47
					Chemistry								41		96	111	53		53		46
106	A	III	16	GCE'O 1 subj.		S.2								S.3							
					Mathematics		42½	80	40	33		43			60	80	40			20	
					Physics		72	99	44		63	61	76		99	102	44		49	30	53
					Chemistry		72	99	40		42	47	84		90	102	40		50	28	51
107	B	III	17	-										S.2							
					Mathematics										75	80	57			75	
					Physics										80	80	58		76	63	75
					Chemistry										80	80	66		62	68	45
108	D	III	16	GCE'O 3 subj. Pass S1 1953, Fail S2 1954,55 Fail S3 1956																	
					Mathematics																
					Physics																
					Chemistry																
109	A	III	16	GCE Maths Phys. Chem. Geom. Drg. 1959										S.2							
					Mathematics										72½	80	85			87	
					Physics										99	99	93		95	75	90
					Chemistry										99	99	78		78	91	86
110	D	III	16	GCE 8 subj.										S.3							
					Mathematics										10	40	53				
					Physics										27	51	13				
					Chemistry										24	45	-				40

Student	Subjects in course of study	1959/60 Year	1959/60 Attend in hrs Ac	Attend in hrs Pos	Course % HW	Course % C	Course % L	Exam % Th	Exam % Pr	1960/61 Year	1960/61 Attend in hrs Ac	Attend in hrs Pos	Course % HW	Course % C	Course % L	Exam % Th	Exam % Pr
103		S.3								S.3							
	Mathematics		60	75	25			45			57½	72½	48			40	
	Physics		81	96	24		56	22	61		90	93	64		47	31	40
	Chemistry		81	96	48		67	33	45		93	93	58		77	27	78
104		S.2								S.3							
	Mathematics		65	72½	44			40			72½	72½	49			44	
	Physics		87	90	67		43	62	80		93	93	86		77	61	65
	Chemistry		87	90	76		80	68	62		93	93	73		79	33	75
105		S.2															
	Mathematics		65	72½	53			44			60	72½	44	44		40	
	Physics		90	90	88		73	56	70		84	93	81	89		52	75
	Chemistry		90	90	77		68		71		60	93	93		76	40	73
106		S.3								S.3							
	Mathematics		35	75	25						60	72½	41			40	
	Physics		30	80	33		15				93	96	58		68	55	80
	Chemistry		48	96							87	96	44		79	60	60
107		S.3															
	Mathematics		96%		60			58									
	Physics		97%		50		66	45	46								
	Chemistry		100%		58		81	49	55								
108		S.3															
	Mathematics		69%		44			53									
	Physics		62%		58		79	40	70								
	Chemistry		66%		50		59	49	65								
109		S3															
	Mathematics		67½	72½	92			77									
	Physics		100%		86		89	93	82								
	Chemistry		100%		87		93	85	60								
110		S.3															
	Mathematics		77%		47			79									
	Physics		88%		65		69	73	58								
	Chemistry		90%		73		64	61	43								

Student	Subjects in course of study	1961/62 Year	1961/62 Attend in hrs Ac	Attend in hrs Pos	Course % HW	Course % C	Course % L	Exam % Th	Exam % Pr	1962/63 Year	1962/63 Attend in hrs Ac	Attend in hrs Pos	Course % HW	Course % C	Course % L	Exam % Th	Exam % Pr
103										S 3							
	Mathematics										65	82½	51			16	
	Physics										72½	87½	50		81	29	
	Chemistry										70	82½	47		76	48	
104		S 3															
	Mathematics		75	77½	76			51									
	Physics		90	93	91		89	52	80								
	Chemistry		90	93	80		82	55	68								

APPENDIX XX

Student No.	YEAR 58 P	58 F	59 P	59 F	60 P	60 F	61 P	61 F	62 P	62 F	63 P	63 F
1		1		1								
2		1		1								
3				1								
4					1			2	2			3
5				1		1	1			2		
6	0			1		1		1		1		
7			1		2							
8								2	2			3
9		2		2		2						
10				1								
11		0	0		1		2		3			4
12		1		1								
13	2											
14		2										
15		2	2			3						
16		0		0		0						
17	0		1		2		3		4		5	
18												1
19							0		1			2
20									1			2
21										0		
22										1		1
23									1			
24										1		
25							1			2		2
26								2		2		
27		1		1	1			2		2		
28				0								
29				1	1		2			3		3
30				2								
31		0		0		1						
32	1			2	2							
33						1	1			2		
34	0			1		1						
35		1		1		1						
36		2		2								
37		0		0		1		1				
38								0	0			
39							1					
40							1			2		
41										2		
42												1
43												1
44												1
45								1	1			2
46						0	0			1		
47								1	1			2
48			0		1		2					
49								1		2		
50	3			4	4							
51		1		1								
52					1		2		3			
53		3	3		4			5	5			
54			2		3		4		5			
55		3		3								
56	1		2			3	3			4		4
57		3	3		4		5					

Student No.	S0 1 P	S0 1 F	S0 2 P	S0 2 F	S0 3 P	S0 3 F	S0 W	S1 1 P	S1 1 F	S1 2 P	S1 2 F	S1 3 P	S1 3 F	S1 W
1											X			W
2											X			W
3									X					W
4								✓						
5												✓		
6	✓												X	W
7								✓						
8														
9														
10									X					W
11			✓					✓						
12											X			W
13														
14														
15														
16						X	W							
17	✓							✓						
18									X					
19	✓							✓						
20								✓						
21		X					W							
22											X			
23								✓						
24									X					W
25								✓						
26														
27												✓		
28		X					W							
29										✓				
30														
31				X					X					W
32														
33										✓				
34	✓										X			W
35													X	W
36														
37				X							X			W
38			✓				W							
39								✓						W
40								✓						
41														
42									X					
43									X					
44									X					
45										✓				
46			✓						X					W
47										✓				
48	✓							✓						
49									X					
50														
51											X			W
52														
53														
54														
55														
56														
57														

Student No.	S2 1 P	S2 1 F	S2 2 P	S2 2 F	S2 3 P	S2 3 F	S2 W	S3 1 P	S3 1 F	S3 2 P	S3 2 F	S3 3 P	S3 3 F	S3 W
1														
2														
3														
4			✓						X					
5		X					W							
6														
7	✓						W							
8			✓						X					
9						X	W							
10														
11	✓							✓						
12														
13	✓													
14		X					W							
15			✓						X					W
16														
17	✓							✓						
18														
19		X												
20		X												
21														
22														
23														
24														
25				X										
26				X			W							
27				X			W							
28														
29	✓										X			
30		X					W							
31														
32														
33		X					W							
34														
35														
36				X			W							
37														
38														
39														
40		X					W							
41		X					W							
42														
43														
44														
45		X												
46														
47		X												
48	✓						W							
49		X					W							
50								✓						
51														
52								✓						W
53										✓				
54	✓							✓						
55											X			W
56										✓				
57										✓				

Student No.	A1 1 P	A1 1 F	A1 2 P	A1 2 F	A1 3 P	A1 3 F	A1 W	A2 1 P	A2 1 F	A2 2 P	A2 2 F	A2 3 P	A2 3 F	A2 W	
1															
2															
3															
4															
5															
6															Failed S1 4 times
7															Left to marry (Female)
8															Also 191
9															
10															
11		X													Also 190
12															
13															Transfer to HND Met.
14															
15															Emigrated
16															
17	✓							✓							
18															
19															
20															
21															
22															
23															
24															
25															
26															
27															
28															
29															Also 185
30															
31															Allowed to pass to S1
32															To HND Metallurgy
33															
34															
35															
36															
37															Allowed to pass to S1
38															Changed to Technical Course
39															
40															
41															Changed to Technical Course
42															
43															
44															
45															
46															
47															
48															
49															(Allowed to pass to S2
50			✓				W								(Changed to Technical Course
51															
52															Also 259 from Col.5.
53	✓									✓					
54	✓							✓							
55															
56				X											Also 112 from Col.3
57	✓							✓							

Student No	YEAR												S0							S1							S2							S3							A1							A2							
	58		59		60		61		62		63		1		2		3			1		2		3			1		2		3			1		2		3			1		2		3			1		2		3			
	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	W	P	F	P	F	P	F	W	P	F	P	F	P	F	W	P	F	P	F	P	F	W	P	F	P	F	P	F	W	P	F	P	F	P	F	W	
58	5																																															✓							
59				3																															X					W															Transferred from HND
60						2		2	2			3																							X																				Also 293 from Col. 5
61		3	3		4		5																													✓					✓							✓							
62		3	3			4		4																												✓								X			W								
63		3		3																																	X			W															
64							4		5																																✓							✓							
65		3		3																																	X			W															
66	3		4		5																													✓							✓							✓							
67			2			3	3			4		4															✓									✓						X													
68					4		5																																		✓							✓							
69	5																																															✓							This student spent 11 years on course from 41-58 with time out for War Service
70		3																																	X					W															
71			4		5																																				✓							✓							This student spent 12 years on the course
72		1		1	1			2	2			3																							X																				Also 100
73	5																																															✓							
74			4																																							X					W								
75	1																			✓						W																													
76		2		2		3																						X							X					W															Allowed to go to S3
77				2																								X					W																						Suspended from classes
78	5																																															✓							
79							3																											✓						W															Entry with GCE 'A' levels
80								3																											X					W															" " " " "
81				3	3			4		4																										✓								X			W								
82		3																																	X					W															
83				1																	X					W																													
84				3	3		4		5																											✓					✓							✓							S2 outwith Tees-side Region
85									3			4																						✓								X													Entry with GCE 'A' levels
86	2			3	3		4		5																		✓									✓					✓							✓							
87	1			2	2			3	3																											✓				W															Also 116
88	2			3		3																					✓										X			W															
89								2	2			3																							X																				Also 156
90		3		3		3		3		3		3																												X																Failed S3 4 times
91				2	2		3		4		5																							✓							✓							✓							Also 109
92				3																															X					W															Entry by GCE 'A' level
93	1		2			3	3			4		4																																											Also 135
94	5																																																						10 years to gain HNC
95					1			2	2		3																							✓																					Also 103
96		2																										X					W																						
97		4	4		5																																						✓					✓							
98									4																																✓														
99			1		2															✓							✓						W																						
100		1		1	1			2	2			3												✓					✓						X																				Also 72
101					1		2			3	3									✓							✓									✓																			Also 237
102	1			2		2		2		2		2								✓												X	W																						Failed S2 4 times
103					1			2	2		3									✓									✓					✓																					Also 95
104				1	1		2			3		3																									X																		Also 182
105	1			2		2	2			3		3																									X																		Also 179
106			1		2																																																		
107					2		3		4		5																																												Also 178
108			1		2		3													✓							✓							✓						W															Also 241
109				2	2		3		4		5																																												Also 91
110					2		3																																																Also 161
111		2	2																										✓											W															Transferred to Chemistry
112	1		2			3	3			4		4																																											Also 56

Student No.	YEAR 58		59		60		61		62		63		SO 1		2		3			SI 1		2		3			S2 1		2		3			S3 1		2		3			AI 1		2		3			A2 1		2		3			
	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	W	P	F	P	F	P	F	W	P	F	P	F	P	F	W	P	F	P	F	P	F	W	P	F	P	F	P	F	W	P	F	P	F	P	F	W	
113	1		2		3		4		4																																														Also 197
114	1			2																✓								X					W																						
115	1			2		2														✓										X			W																						
116	1			2	2			3	3											✓									✓							✓				W															Also 87
117		1		2		2															X									X			W																						Allowed to pass to S2
118	2			3																							✓								X					W															Also 240
119		2	2			3	3		4																				✓							✓																			Also 212
120		2																										X					W																						
121	2			3		3																					✓										X			W															Also 183
122		2																										X					W																						
123					1		2													✓							✓						W																						Transfer to HND
124								1	1													✓				W																													
125			1			2	2			3		3								✓									✓								X																		Also 175
126					1		2													✓							✓						W																						Transferred to Chemistry
127					0			1		1		1	✓												X																														
128								1	1													✓				W																													
129									0		1		✓							✓																																			
130												1									X																																		
131										1		1											X																																
132		1		1																			X			W																													
133				1																	X					W																													
134				1																	X					W																													
135	1		2			3	3			4		4								✓							✓									✓								X											Also 93
136	1			2		2														✓										X			W																						
137	2			3	3		4		5																		✓									✓					✓							✓							Also 225
138												1									X																																		
139											1									✓																																			
140											2																✓																												
141					1			2		2		2								✓												X																							
142								2		2		2																				X																							
143												0		X																																									
144						1		1															X			W'																													
145												1									X																																		
146										1		1											X																																
147											1									✓																																			
148												1									X																																		
149				1		1																	X			W																													
150						1															X					W																													
151						1															X					W																													
152						1		1															X			W																													
153							2			3																	✓								X																				Also 213
154								1		1													X			W																													
155								2	2			3																	✓						X																				Also 174
156								2	2			3																	✓						X																				Also 89
157						2		2	2			3																			✓				X																				Also 204
158										1											X					W																													
159			1			2		2		2										✓								X					W																						
160							1			2										✓								X					W																						Changed to Accountancy
161					2		3																																																Also 110
162												3																							X																				ONC Mech. Eng.
163	3			4		4	4		5																									✓							✓							✓							
164												3																							X																				Outwith area for S0, 1 and 2
165				3																															X					W															Began studies in 1950 - 2 Breaks
166		4		4	4			5	5																																				✓					✓					
167			4		6																																				✓							✓							Break from 1952-58
168	5																																															✓							

Student No.	YEAR 58 P	58 F	59 P	59 F	60 P	60 F	61 P	61 F	62 P	62 F	63 P	63 F	S0 1 P	S0 1 F	S0 2 P	S0 2 F	S0 3 P	S0 3 F	S0 W	S1 1 P	S1 1 F	S1 2 P	S1 2 F	S1 3 P	S1 3 F	S1 W	S2 1 P	S2 1 F	S2 2 P	S2 2 F	S2 3 P	S2 3 F	S2 W	S3 1 P	S3 1 F	S3 2 P	S3 2 F	S3 3 P	S3 3 F	S3 W	A1 1 P	A1 1 F	A1 2 P	A1 2 F	A1 3 P	A1 3 F	A1 W	A2 1 P	A2 1 F	A2 2 P	A2 2 F	A2 3 P	A2 3 F	A2 W	
169	1			2																✓								X					W																						
170		3		3	3		4		5																													✓			✓							✓							
171	2			3	3		4		5																		✓									✓					✓							✓							
172	1			2		2		2		2		2								✓												X																							
173												3																							X																				Entry with GCE 'A' levels
174								2	2			3																							X																				Also 155
175			1			2	2			3		3																									X																		Also 125
176					2			3	3		3																									✓					✓														Also 295
177							4		5																																✓							✓							ONC outwith area
178					2		3		4		5																							✓							✓							✓							Also 107
179	1			2		2	2			3		3																									X																		Also 105
180	2			3	3			4																												✓						X					W								
181				2		2	2		3			4																			✓			✓								X													Also 309
182				1	1		2			3		3																									X																		Also 104
183	2			3		3																					✓										X			W															Also 121
184						3																													X					W															Outwith area S0-S2
185				1	1		2			3		3																									X																		Also 29
186					5																																											✓							Outwith area ONC and A1
187									3			4																						✓								X													Outwith area S0-S2
188		1		1		1		1																	X	W																													
189					2		3																																	W															Also 296
190		0	0		1		2		3			4																						✓								X													Also 11
191								2	2			3																							X																				Also 8
192				3		3	3		4		5																											✓			✓							✓							Outwith area S0-S2
193	4		5																																						✓							✓							
194										3																									X					W															Outwith area S0-S2
195			2		3			4	4		5																✓							✓									✓					✓							
196						5																																										✓							Transferred from HND
197	1				3		4		4																									✓									✓					✓							Also 113
198		3	3		4			5	5																											✓					✓									✓					
199	5																																															✓							
200						4	4			5		5																															✓								X				Transferred from Leeds Univ.
201	4		5																																						✓							✓							
202		3	3																																	✓				W															
203						2	2			3		3																									X																		Also 307
204						2		2	2			3																							X																				Also 157
205						3	3																													✓				W															Began in 1951-S1. 2 yrs. Break
206			2			3		3		3		3															✓								X																				Break of 3 years
207					2		3			4		4																						✓										X											Also 318
208				3		3		3		3		3																											X																Break in 1957-58. Failed S3 5 times
209			0		1				2	2		3	✓							✓									✓						X																				Also 269
210		2		2			2	2		3																					✓				X					W															Also 319
211		1		1	1			2		3	3												X				✓									✓																			Allowed to pass S1→ 2 Referred ONC Physics
212		2	2				3	3	4																																														Also 119
213								2		3																																													Also 153
214	4		5																																						✓							✓							
215	1		2				3													✓							✓								X					W															
216				3	3			4	5																											✓					✓							✓							
217				5																																													X					W	A year's break in study 57-58
218		3		3																																	X			W															
219									4		5																														✓							✓							Entry from University
220		3		3	3			4	5																													✓			✓							✓							
221			3				4	4	5																									✓							✓							✓							
222	3		4		5																													✓							✓							✓							
223		2																										X					W																						
224	0		1				2	2			3	3																																											Also 297 and 298

Student No.	YEAR 58 P	58 F	59 P	59 F	60 P	60 F	61 P	61 F	62 P	62 F	63 P	63 F
225	2			3	3		4		5			
226		2	2		3		4		5			
227	2											
228	1			2	2			3		3		
229	2			3		3	3			4		
230		1		1								
231				2								
232		3	3			4	4					
233		3	3		4		5					
234	1			2		2		2		2		
235				3	3		4		5			
236	3			4								
237					1		2			3	3	
238		4	4		5							
239	1			2		2		2				
240	2			3								
241			1		2		3					
242	4			5								
243	2			3		3						
244			5									
245	2											
246			2			3	3		4		5	
247		2										
248	4		5									
249												2
250						1		1		1		
251					1			2	2			
252						1						
253						1	1					
254						1		1				
255						1						
256					1			2	2			
257						1		1				
258						1	1					
259					1		2		3			
260						1		1				
261						1		1				
262						1	1			2		
263					1			2				
264					1		2					
265						1		1				
266					2							
267					0			1		1		
268						1						
269			0		1			2	2			3
270						1		1		1		
271						1		1	1			
272					1		2					
273						1	1			2		
274					1			2				
275						1						
276					1			2				
277						1		1				
278					1			2				
279					1			2				
280					1							
281						1						

Student No.	S0 1 P	S0 1 F	S0 2 P	S0 2 F	S0 3 P	S0 3 F	S0 W	S1 1 P	S1 1 F	S1 2 P	S1 2 F	S1 3 P	S1 3 F	S1 W
225														
226														
227														
228														
229														
230														W
231														
232														
233														
234								✓						
235														
236														
237														
238														
239								✓						
240														
241														
242														
243														
244														
245														
246														
247														
248														
249														
250													X	W
251								✓						
252									X					W
253										✓				W
254											X			W
255									X					W
256								✓						
257											X			W
258										✓				W
259								✓						
260											X			W
261											X			W
262										✓				
263											X			
264								✓						
265											X			W
266														
267	✓										X			W
268									X					W
269	✓													
270	✓													W
271														W
272														
273														
274														
275														W
276														
277														W
278														
279														
280														W
281														W

Student No.	S2 1 P	S2 1 F	S2 2 P	S2 2 F	S2 3 P	S2 3 F	S2 W	S3 1 P	S3 1 F	S3 2 P	S3 2 F	S3 3 P	S3 3 F	S3 W
225														
226			✓					✓						
227							W							
228														W
229	✓			X								✓		
230				X			W							
231		X					W							
232										✓				
233										✓				
234						X	W							
235										✓				
236								✓						
237														
238														
239						X	W							
240														
241														
242														
243	✓										X			W
244														
245		X					W							
246	✓									✓				
247		X					W							
248														
249		X												
250														
251			✓				W							
252														
253														
254														
255														
256			✓				W							
257														
258														
259	✓							✓						W
260														
261														
262		X					W							
263							W							
264	✓						W							
265														
266	✓						W							
267														
268														
269														
270														
271														
272							W							
273							W							
274							W							
275														
276							W							
277														
278							W							
279							W							
280														
281														

Student No.	A1 1 P	A1 1 F	A1 2 P	A1 2 F	A1 3 P	A1 3 F	A1 W	A2 1 P	A2 1 F	A2 2 P	A2 2 F	A2 3 P	A2 3 F	A2 W	
225															Also 137
226	✓							✓							
227															
228															Also 292
229		X					W								
230															
231															
232			✓				W								
233	✓							✓							
234															Also 323 (4 Fails at S2)
235	✓							✓							
236		X													
237															Also 101
238			✓					✓							
239															Also 287
240															Also 118
241															Also 108
242	✓								X					W	
243															
244								✓							
245															
246	✓							✓							
247															
248	✓							✓							
249															
250															
251															
252															
253															
254															
255															
256															
257															
258															
259															Also 52
260															
261															
262															
263															
264															Transferred to Chemistry
265															
266															Transferred to Chemistry
267															
268															
269															Also 209
270															
271															
272															Transferred to Chemistry
273															
274															
275															
276															
277															
278															
279															
280															
281															

Student No.	YEAR												S0							S1							S2							S3							A1							A2							
	58		59		60		61		62		63		1		2		3			1		2		3			1		2		3			1		2		3			1		2		3			1		2		3			
	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	W	P	F	P	F	P	F	W	P	F	P	F	P	F	W	P	F	P	F	P	F	W	P	F	P	F	P	F	W	P	F	P	F	P	F	W	
282					1		2																										W																						Transferred to Chemistry
283						1		1																		W																													
284						2		2																									W																						
285					2																												W																						Transferred to Chemistry
286						2																											W																						
287	1			2		2		2																									W																						Also 239
288						2		2																									W																						
289						2	2																										W																						Transferred to Chemistry
290						2		2																									W																						
291						2	2																										W																						To HND Metallurgy
292	1			2	2			3		3																														W															Also 228
293						2		2	2			3																																											Also 60
294						2		2																									W																						
295					2			3	3		3																																												Also 176
296					2		3																																	W															Also 189
297	0		1			2	2			3		3																																											Also 224
298	0		1			2	2			3		3																																											Also 224
299						1		1																		W																													
300						2		2																									W																						
301						1		1	1																	W																													
302						2	2																										W																						Transferred to Chemistry
303						2	2																										W																						Transferred to Chemistry
304						2	2																										W																						Transferred to Chemistry
305						2																											W																						
306							2																										W																						Transferred to Chemistry
307						2	2			3		3																																											Also 203
308						2		2																									W																						
309				2		2	2		3			4																																											Also 181
310						1		1																		W																													
311						2		2																									W																						
312						2																											W																						
313						2																											W																						
314						2																											W																						
315						2	2																										W																						Transferred to Chemistry
316						2		2																									W																						
317						2		2																									W																						
318					2		3			4		4																																											Also 207
319		2		2		2	2			3																														W															Also 210
320						2																											W																						
321					2																												W																						Transferred to Chemistry
322						2																											W																						
323	1			2		2		2		2																							W																						Also 234

APPENDIX XXI

Number failing in separate subjects and in various combinations of subjects at each stage. (Pooling over the six years of the survey)

S0 — 7 7 4 3 3 1 — Number of candidates sitting examination = 25

No. Failing	All 3						Chemistry						Physics						Maths					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
All 3		1	1	1	1	1																		
Chem.													1	1										
Physics													2	1	1				1	1				
Maths																								
	4	4	2	1	1	1																		
	3	3	2	2	2	0																		

Total No. of failures = 13

Total No. of passes = 12

S1 — 30 31 58 36 21 15 — Number of candidates sitting examination = 191

No. Failing	All 3						Chemistry						Physics						Maths					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
All 3	9	12	17	6	8	8																		
Chem.							1	1	2	3	1		2	6	4	6	1	1			4	3		
Physics														1	2	3	1		1	2	2	1	1	1
Maths																			1		2	3	1	1
	14	22	33	25	12	11																		
	16	9	25	11	9	4																		

Total No. of failures = 116

Total No. of passes = 74

Number failing in separate subjects and in various combinations of subjects at each stage. (Pooling over the six years of the survey)

Number of candidates sitting examination = 207

S2	26	34	53	57	25	12																		
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
No. Failing	All 3						Chemistry						Physics						Mathematics					
All 3	5	10	18	13	7	7																		
Chem.							1	1	1	2		1	4	2	6	6	3	1	1		1	2	1	
Phys.													1	1	4	4				4	3	3	3	1
Maths.																			3	4	4	2		1
	15	22	37	32	14	11																		
	11	12	16	25	11	1																		

Total No. of failures = 131
Total No. of passes = 76

Number of candidates sitting examination = 151

S3	22	34	31	21	20	23																		
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
No. Failing	All 3						Chemistry						Physics						Mathematics					
All 3	3	10	6	2	5	6																		
Chem.							4	3		2	1	6	5	2			6	7	2	5	3			
Phys.													2	1	2	1	2	2		2				
Gen. Met.																			1	3	6			
	17	26	17	5	14	21																		
	5	8	14	16	6	2																		

Total No. of failures = 100
Total No. of passes = 51

Number failing in separate subjects and in various combinations of subjects at each stage. (Pooling over the six years of the survey)

A1

Year	58	59	60	61	62	63
Candidates	7	10	11	21	15	7

Number of candidates sitting examination = 71

No. Failing	All 3						Met. Anal.						Phys. Met.						Iron & Steel					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
All 3	0	2	2	1	3	4																		
Met. Anal.								1	1	1	2			1	1		1	2						
Phys. Met.													1					1	1					
Iron & Steel																								

	58	59	60	61	62	63
Failures	2	3	4	2	6	7
Passes	5	7	7	19	9	0

Total No. of failures 24

Total No. of passes 47

A2

Year	58	59	60	61	62	63
Candidates	7	7	7	7	18	9

Number of candidates sitting examination = 55

No. Failing	All 3						Met. Anal.						Phys. Met.						Iron & Steel					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
All 3		2	1			1																		
Met. Anal.										1	1													
Phys. Met.																1								
Iron & Steel																								

	58	59	60	61	62	63
Failures		2	1	2	1	1
Passes	7	5	6	5	17	8

Total No. of failures 7

Total No. of passes 48

Appendices XXII to XXV

Marks aredistributed between six bands for each subject of the course and for homework, laboratory work, theoretical and practical examinations where appropriate.

1	0	-	29	Fail
2	30	-	39	
3	40	-	49	
4	50	-	59	Pass
5	60	-	84	
6	85	-	100	

THEORY

S.3 General Metallurgy / **A.1 Physical Metallurgy**

Year	1: 58	59	60	61	62	63	2: 58	59	60	61	62	63
S.3 General Metallurgy												
Hw. 6												
5	1	4	3		1	3	1	5	2		2	
4		1	2	1				2	2			
3	1	3					1	1	1		1	
2		1	3								0	
1		2	1	1	1	2						
Totals	2	11	9	2	2	6	2	8	5		3	
Grand Totals				32						18		
A.1 Physical Metallurgy												
Hw. 6				0	0					0	0	
5				0	2	4	1	1		0	0	1
4				0	1	1	1			0	0	0
3		1		2	2	0				0	0	
2	1			0						0		
1		1		0	1	1				0		0
Totals	1	2		2	6	6	2	1		0	0	1
Grand Totals				17						4		

Year	3: 58	59	60	61	62	63	4: 58	59	60	61	62	63
S.3 General Metallurgy												
Hw. 6												2
5	4	6	3	4	4	4	3	2	5	4	7	7
4		4	2	1		1	5		1	3	1	
3	1	1	3			1	1	1	1	2		
2												
1												
Totals	5	11	8	5	4	6	9	3	7	9	8	9
Grand Totals				39						45		
A.1 Physical Metallurgy												
Hw. 6				1	0			1	1	0	0	
5		1	4	3	1	0	1	3	3	10	2	0
4		1	2	0	0	0	1	1		0	1	0
3				1	2					0	0	
2				0						0		
1				0		0				0		0
Totals		2	6	5	3	0	2	5	4	10	3	0
Grand Totals				16						24		

Year	5: 58	59	60	61	62	63	6: 58	59	60	61	62	63	Totals: 58	59	60	61	62	63	Grand Totals
S.3 General Metallurgy																			
Hw. 6				1												1		2	3
5	4	1	1	2	2	2				1			13	18	14	11	16	16	88
4				1	1								5	7	7	6	2	2	29
3			1										4	6	6	2	1	1	20
2														1	3		0		4
1														2	1	1	1	2	7
Totals	4	1	2	4	3	2				1			22	34	31	21	20	23	151
Grand Totals				16						1									151
A.1 Physical Metallurgy																			
Hw. 6				2	0					0	1			1	1	3	1		6
5	2		1	2	2	0				0	0	0	4	5	8	15	7	5	44
4				0	0	0				0	0	0	2	2	2	0	2	1	9
3				0	0					0	0			1		3	4		8
2				0						0			1						1
1				0		0				0		0		1			1	1	3
Totals	2		1	4	2	0				0	1	0	7	10	11	21	15	7	71
Grand Totals				9						1									71

THEORY

S.3

Physics

	1						2						3						4						5						6						Totals						Grand Totals
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
Hw. 6					5	2								2	1	1	2		1	3	1	2		2		1	1	3									1	6	3	6	7	4	27
5	1	2	1	1	5	4		1	1	1		1	1	4	1	2		3	2	3	2	2		4	3	5	7	5							1		7	15	12	11	6	12	63
4		4			1	3		2				1	3	1	2		2		2	1	3		1		2		1										7	8	6		4	4	29
3	1	2	3		1	1	1					1	2		1	3			2		1		1				2										6	2	7	3	2	2	22
2	1																																				1		0		0	0	1
1		3	3	1	1	1																																3	3	1	1	1	9
Totals	3	11	7	2	13	11	1	3	1	1	0	3	6	7	5	6	4	3	7	7	7	4	2	6	5	6	11	8	0	0					1	0	22	34	31	21	20	23	151
Grand Totals				47						9						31						33						30						1									151

S.3

Chemistry

	1						2						3						4						5						6						Totals						Grand Totals
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
Hw 6			2			1								1	2			1			2	0				1	1	2										2	7	2		2	13
5	2	3			5	7	1	5		1	2	1	3	4	5	6	1		1	1	4	2	2	1		6	3									1	7	19	12	9	10	10	67
4	5	2		1	3	5	3	1	1	1	1	1	2	2		5	2	1		1	2	1	2			1	3		1						0		10	7	6	8	9	7	47
3	1	1	1			2	1	1					1	1	1							1					1										3	3	3	1	0	2	12
2	1	1	2																																		1	1	2				4
1	1	2	1	1	1	2																															1	2	1	1	1	2	8
Totals	10	9	6	2	9	17	5	7	1	2	3	2	6	8	8	11	3	2	1	2	8	4	4	1		8	8	2	1	0					0	1	22	34	31	21	20	23	151
Grand Totals				53						20						38						20						19						1									151

THEORY

S.2
Chemistry

		1						2						3					
Year		58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
	6			1	1											1	2		
	5		4	5			2	2	1	3	2		2	2		8	5	4	
Hw.	4	1	1	3	7	2	3	1		1	1			1	2	3	9	2	1
	3	3	5	3	5	1	1	1	2	1				2	5	2	3	4	1
	2			2	0	0	1								1			0	
	1	1	2	5	0	2													
Totals		5	8	18	18	5	7	4	3	5	3	0	2	5	8	14	19	0	2
Grand Totals					61						17						58		
S.2 Maths																			
	6																		
	5		1	5	1	2	2	1	1	3				3	3	1	4		1
Hw.	4		5	6	5	3	3		2	1		1		2	1	3	3	1	
	3	1	5		4	1	2	1	2	1	2			3	1	2	8	1	
	2	1		1		1		1		1	1						1	1	
	1	3	1	6	3	1	1					1		1		1	1		
Totals		5	12	18	13	8	8	3	5	6	3	2	0	9	5	7	17	3	1
Grand Totals					64						19						42		

		4						5						6						Totals						Grand Totals
Year		58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
	6			1	1	1			1							1		1			1	4	4	2	0	11
	5	1	1	5	3	2	1	7	5	4	5	2				1	2	1		12	7	25	22	9	5	80
Hw.	4	1	3						1	3	2	1								4	7	10	19	5	4	49
	3		2	1	2	1		2	2		2	1								8	16	7	12	7	2	52
	2	1																		1	1	2		0	1	5
	1																			1	2	5	0	2	0	10
Totals		3	6	7	6	4	1	9	9	7	9	4	0			2	2	2		26	34	53	57	25	12	207
Grand Totals					27						38						6									207
S.2 Maths																										
	6				1					5						1	1	1		0		6	2	1	0	9
	5	1	4	4	6	4	1	4		4	6					1	1			9	9	18	18	6	4	64
Hw.	4	2	5	1	6	2				2	1	1	2							4	13	13	15	8	5	58
	3	2	3	3	1	4				1										7	11	7	15	6	2	48
	2																			2		2	2	2	0	8
	1																			4	1	7	5	2	1	20
Totals		5	12	8	15	10	1	4		12	7	1	2			2	2	1	0	26	34	53	57	25	12	207
Grand Totals					51						26						5									207

THEORY

S. 1 Maths / **S. 2 Physics**

		1						2					
Year		58	59	60	61	62	63	58	59	60	61	62	63
S. 1 Maths													
Hw.	6			1		0	1					0	0
	5		1	6	1	0	2	1	4			0	0
	4	1		4	2	4	2	1	1	1		0	1
	3	1	5	5	3	0	2	2		2	1	0	0
	2	2	1	5	1	0	0	1				0	0
	1	2	1	1	5	4	2		2	1		1	1
Totals		6	8	22	12	8	9	5	7	4	1	1	2
Grand Totals					65						20		
S. 2 Physics													
Hw.	6								1				
	5		3	3	2	2	3		1	3	3		
	4	2	2	6	6	3	3		1	1	2		0
	3	1	5	9	6	2	2	3	1		2		
	2	1		2	0								
	1	1	2	6	2	1							
Totals		5	12	26	16	8	8	3	4	4	7	0	0
Grand Totals					75						18		

		3						4					
Year		58	59	60	61	62	63	58	59	60	61	62	63
S. 1 Maths													
Hw.	6	2		1		0	0		1	1		1	0
	5	3		10	3	2	1	1	3	1		2	0
	4	4		4	5	1	0	3	1	1	2	1	0
	3	2	3	4	4	1	0		1	1		1	0
	2			1		0	0					0	0
	1		2		1	0	1					0	1
Totals		11	5	20	13	4	2	4	6	4	2	5	1
Grand Totals					55						22		
S. 2 Physics													
Hw.	6		1						1		3	1	
	5	1	4	1	6	2	1	1	2	6	4		
	4		3	3	6	2	2	1	1	3	1	1	1
	3	3	2		3	2		1	1		5	1	
	2	1	1										
	1					1							
Totals		5	11	4	15	7	3	3	5	9	13	3	1
Grand Totals					45						34		

		5						6					
Year		58	59	60	61	62	63	58	59	60	61	62	63
S. 1 Maths													
Hw.	6	2	1	1		0	1		1	1		0	0
	5	1	2	3	1	3	0				1	0	0
	4	1	1	2	1	0	0					0	0
	3			1	4	0	0				1	0	0
	2					0	0					0	0
	1					0	0					0	0
Totals		4	4	7	6	3	1		1	1	2	0	0
Grand Totals					25						4		
S. 2 Physics													
Hw.	6				3					2		1	
	5	6	1	3	3							1	
	4	2	1	2		1				1			
	3	2		2		4							
	2												
	1												
Totals		10	2	7	6	5	0	0	0	3	0	2	0
Grand Totals					30						5		

		Totals						Grand Totals
Year		58	59	60	61	62	63	
S. 1 Maths								
Hw.	6	4	3	5		1	2	15
	5	6	10	20	6	7	3	52
	4	10	3	12	10	6	3	44
	3	5	9	13	13	2	2	44
	2	3	1	6	1	0	0	11
	1	2	5	2	6	5	5	25
Totals		30	31	58	36	21	15	191
Grand Totals								191
S. 2 Physics								
Hw.	6		3	2	6	2		13
	5	8	11	16	18	5	4	62
	4	5	8	16	15	7	6	57
	3	10	9	11	16	9	2	57
	2	2	1	2	0	0		5
	1	1	2	6	2	2		13
Totals		26	34	53	57	25	12	207
Grand Totals								207

APPENDIX XXII

Correlation of Homework with Theory (pooling over six years of each stage S1 to A2)

THEORY

S.1 Physics

	1						2						3						4						5						6						Totals						Grand Totals
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
Hw. 6					1	0		1				0						1	1		1	0	1	0	1	2	3			0						0	2	3	4	0	2	1	12
5	1	2	3	1		6	1		4	4	1	1	1	1	2	5	1	0	2	2	7	2		0	4	1	8	3	2	1				1		0	9	6	24	16	4	8	67
4	2	5	3		2	1		2	2	3	4	0	3		3	4	2	0	1	1	2		1	0	1	1	1	1	2	0						0	7	9	11	8	11	1	47
3	2	2	4	1		1			1	1		0	1	1	3			3	1		2	4	1	0	2			3	1	0						0	6	3	10	9	2	4	34
2		3	6	1	1	1	3	2				0	1					0			1			0		1				0						0	4	6	7	1	1	1	20
1	2	4	1	2	1	0						0						0			1			0						0						0	2	4	2	2	1	0	11
Totals	7	16	17	5	5	9	4	5	7	8	5	1	6	2	8	9	3	4	5	3	14	6	3	0	8	5	12	7	5	1				1		0	30	31	58	36	21	15	191
Grand Totals				59						30						32						31						38						1									191

S.1 Chemistry

	1						2						3						4						5						6						Totals						Grand Totals
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
Hw. 6			2	2	0	1			1		0	0				0	0	0					1	0	1		1		0	0					0	0	1		4	2	1	1	9
5	2	1	2	4	2	4			1		0	0	3		3	2	5	1	1	2	4	4	0	2	5	4	9	2	2	1	1	1			0	0	12	8	19	12	9	8	68
4	3	3	4	3	1	2	1		1		1	1	1	2	1	1	2	0	1	1	2	1	1	0	1		3	1	0	0	1				0	0	8	6	11	6	5	3	39
3	3	8	5	3	0	1		2	1	1	0	0	3	2	3	4	1	1	1		2	3	1	0	1		3	2	0	0					0	0	8	12	14	13	2	2	51
2			3	1	1	0	1	2	1		1	0					0	0					0	0					0	0					0	0	1	2	4	1	2	0	10
1		2	5	2	2	1		1			0	0					0	0			1		0	0					0	0					0	0		3	6	2	2	1	14
Totals	8	14	21	15	6	9	2	5	5	1	2	1	7	4	7	7	8	2	3	3	9	8	3	2	8	4	16	5	2	1	2	1	0	0	0	0	30	31	58	36	21	15	191
Grand Totals				73						16						35						28						36						3									191

THEORY

S.2
Physics

	1						2						3						4						5						6						Totals						Grand Totals
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
Pract. 6	1									1												3	1		1	1	1	1					1		1		2	1	2	5	2	0	12
5		3	4	3		3		2	1	2				4	2	4	2	1	1	2	3	4	1	1	5		2	4	1				2				6	11	14	17	4	5	57
4	1	1	4	3		2		1	2	2			2	4		4	2		1	1	3	2	1		1	1	2	1									5	8	11	12	3	2	41
3	1	3	5	3	1		1			1			2	3	2	6	2	2	1	2	3	4			2		2		1						1		7	8	12	14	5	2	48
2		1	3		1	1	1		1				1																2								2	1	4	0	3	1	11
1	2	4	10	7	6	2	1	1		1						1	1								1				1								4	5	10	9	8	2	38
Totals	5	12	26	16	8	8	3	4	4	7	0	0	5	11	4	15	7	3	3	5	9	13	3	1	10	2	7	6	5	0			3	0	2	0	26	34	53	57	25	12	207
Grand Totals				75						18						45						34						30						5									207

S.2
Chemistry

Laboratory Work

	1						2						3						4						5						6						Totals						Grand Totals
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
Hw. 6																					2					1	1	3	1				1	1	1			1	4	4	2	0	10
5	1												5	2	1	1	2	1	1	2	4	6	3	2	4	3	1	7	9	4	1		3	6		2	12	7	25	22	9	5	80
4				1		1								2	3	7	2		2	3	3	4	2	1	2	2	3	4	1	1			1	3		1	4	7	10	19	5	4	49
3	1						1			2	2		3	6	1	3	1	1	2	7	1	5	4		1	3	4	1		1			1	1			8	16	7	12	7	2	52
2			2					1											1					1													1	1	2	0	0	1	5
1	1	2	5		2																																1	2	5	0	2	0	10
Totals	3	2	7	1	2	1	1	1	0	2	2	0	8	10	5	11	5	2	6	12	10	15	9	4	7	9	25	17	6	2	1		6	11	1	3	26	34	53	57	25	12	207
Grand Totals				16						6						41						56						66						22									207

S.2 Physics

PRACTICAL

		1						2						3						4						5						6						Totals						Grand Totals
Year		58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
	6														1		1										2	1	4					1	1	2			3	2	6	2	0	13
	5			1		2	1			1				3	1	4	3	2	1		3	3	5	1		4	6	7	9		2	1	1		1			8	11	16	18	5	4	62
Hw.	4	1	1		2	2				2			1	2	3	4	5	1	1		2	6	5	2	2	1	2	4	1	2	2	1			2			5	8	16	15	7	6	57
	3	1	2	2	5	2	1	2	1	1	3			1	3	4	5	2		5	3	2	2			1		1	3	2	1			1	1			10	9	11	16	9	2	57
	2	1		2										1													1											2	1	2	0	0	0	5
	1	1	2	5	2	2	0																					1										1	2	6	2	2	0	13
Totals		4	5	10	9	8	2	2	1	4	0	3	1	7	8	12	14	5	2	5	8	11	12	3	2	6	11	14	17	4	5	2	1	2	5	2		26	34	53	57	25	12	207
Grand Totals					38						11						48						41						57						12									207

S.2 Physics

THEORY

		1						2						3						4						5						6						Totals						Grand Totals
Year		58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
	6				1		1		1		1											2	4	1					2					2		1			1	4	8	2	1	16
	5		2	7	3	4	2		1	3	1			1	7	3	5	3	3	1	2	7	3	1		7	1	6	3	1				1				9	13	27	15	9	5	78
Lw.	4	1	2	4	6		2	2	1		3				2		7	1		2	3		5	1	1	2		1	1	2								7	8	5	22	4	3	49
	3	2	5	9	4	3	3	1	1	1	2			2	2	1	3	3					1				1			2						1		5	9	11	10	9	3	47
	2	1	1		0									2																								3	1	0	0	0	0	4
	1	1	2	6	2	1																				1												2	2	6	2	1	0	13
Totals		5	12	26	16	8	8	3	4	4	7	0	0	5	11	4	15	7	3	3	5	9	13	3	1	10	2	7	6	5	0			3		2	0	26	34	53	57	25	12	207
Grand Totals					75						18						45						34						30						5									207

THEORY

A.2
Iron Steel Manufacture

	1						2						3						4						5						6						Totals						Grand Totals
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
6		1		0	0	0				0	0	0				0	1	1			2	1	2	3	1			1	1	1				0	0	0	1	1	2	2	4	5	15
5				0	0	0				0	0	0	2	1	2	1	2	1	4	2	1	1	6	0			1	3	4	2				0	0	0	6	3	4	5	12	3	33
Hw. 4			1	0	0	0					0	1		2			1	0					1	0					0	0					0	0		2	1		2	1	6
3																																											
2																																											
1		1																																				1					1
Totals		2	1	0	0	0				0	0	1	2	3	2	1	4	2	4	2	3	2	9	3	1		1	4	5	3				0	0	0	7	7	7	7	18	9	55
Grand Totals				3						1						14						23						14						0									55

S.2
Physics

Further Correlation Tables between Hw. Lw. Theory and Practical at various stages.

LW

6																				1		1				1		1				1	2	4	2			3	2	6	2	0	13
5														1	1	2	2		1	5		6	2		7	5	13	9	3	2			2	1			8	11	16	18	5	4	62
Hw. 4	1			1									1	2	3	3	1	1	2	1	1	6	1	1	1	5	12	3	5	3				2		1	5	8	16	15	7	6	57
3							1	1					4	6	6	5	5	2	4	1	3	8	3		1	1	2	2	1					1			10	9	11	16	9	2	57
2	1		1				1								1											1											2	1	2	0	0	0	5
1		2	5	1	1		1										1				1	1															1	2	6	2	2	0	13
Totals	2	2	6	2	1	0	3	1	0	0	0	0	5	9	11	10	9	3	7	8	5	22	4	3	9	13	27	15	9	5	0	1	4	8	2	1	26	34	53	57	25	12	207
Grand Totals				13						4						47						49						78						16									207

THEORY

	1						2						3						4						5						6						Totals						Grand Totals
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
A.2 Physical Metallurgy																																											
Hw. 6		1		0	0	0				0	0	0				1	0	1	1			0	1	0				1	1	0				0	0	0	1	1		2	2	1	7
5				0	0	0				0	0	1	4	2	2	3	6	3	1	1	4	1	6	2	1	1		1	2	2				0	0	0	6	4	6	5	14	8	43
4				0	0						1						1						0						0						0						2		2
3																				1																		1					1
2																																											0
1		1	1																																			1	1				2
Totals		2	1	0	0	0				0	1	1	4	2	2	4	7	4	2	2	4	1	7	2	1	1		2	3	2				0	0	0	7	7	7	7	18	9	55
Grand Totals				3						2						23						18						9						0									55
A.2 Metallurgical Analysis																																											
Hw. 6						0						0						1						0	1					0						0	1					1	2
5		1		0	0	0				1	1	0		1	2	2	0	2	4	2	3	3	8	3	1		1	1	6	1				0	0	0	5	4	6	7	15	6	43
4					0	0					0	1					0	1		1			2	0	1	1			0	0					0	0	1	2			2	2	7
3					0						0						1						0						0						0	0					1		
2																																											
1		1	1																																			1	1				2
Totals		2	1	0	0	0				1	1	1		1	2	2	1	4	4	3	3	3	10	3	3	1	1	1	6	1				0	0	0	7	7	7	7	18	9	55
Grand Totals				3						3						10						26						13						0									55

THEORY

A.1 Metallurgical Analysis

	1						2						3						4						5						6						Totals						Grand Totals
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
Hw. 6				0						0						0						0						1						0						1			1
5				0	5	2			1	1	0	0	1	2	5	3	2	1		1	1	3	2	0	3	2		7	1	0				1	0	0	4	5	7	15	10	3	44
4		1			0	2		1	1		0	0			2		2	0	1				0	0	1			2	0	0					0	0	2	2	3	2	2	2	13
3		1		1	1	1			1	1	0	0		1		0	1	0				0	0	0				1	0	0				0	0	0		2	1	3	2	1	9
2																																											
1	1	1		0	1	1						0						0						0						0						0	1	1		0	1	1	4
Totals	1	3		1	7	6		1	3	2	0	0	1	3	7	3	5	1	1	1	1	3	2	0	4	2		11	1	0				1	0	0	7	10	11	21	15	7	71
Grand Totals				18						6						20						8						18						1									71

A.1 Iron Steel Manufacture.

	1						2						3						4						5						6						Totals						Grand Totals
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
Hw. 6				0		0				0		1				0		0				0		0				1	3	0				0		0				1	3	1	5
5				0	0	0	1		1	0	0	0		2	2	2	1	0	1	2	6	3	2	1	2	2	1	3	2	0				0	0	0	4	6	10	8	5	1	34
4				0						0		1	1	1		3	2			1	1	4	0		1			1	1					0	0		2	2	1	8	3	1	17
3				0	0			1		1	1					2	1	1				1	0					0	0					0	0			1		4	2	1	8
2	1			0																																	1						1
1		1		0	2	3					0	0					0	0					0	0					0	0					0	0		1			2	3	6
Totals	1	1		0	2	3	1	1	1	1	1	2	1	3	2	7	4	1	1	3	7	8	2	1	3	2	1	5	6	0				0	0	0	7	10	11	21	15	7	71
Grand Totals				7						7						18						22						17						0									71

PRACTICAL

S.2 Chemistry

		1						2						3						4						5						6						Totals						Grand Totals
Year		58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
Hw.	6				1										1		1					2						2	2	2									1	4	4	2	0	11
	5	2		2		1	1				1		1	3	2	3	3	1	1	4	2	8	6	6		3	3	7	8	1	2			5	4			12	7	25	22	9	5	80
	4		1	0	4	1	1			1		2		2	1	2	3	1	2	1		3	4			1	4	4	6	1	1		1		2			4	7	10	19	5	4	49
	3	1	2	2	4	1		1	1	1		1		2	6	1	1	5	2	4	5	1	1				1	2	4				1		2			8	16	7	12	7	2	52
	2			2															1	1													1					1	1	2	0	0	1	5
	1	1	1	5		2				0					1																							1	2	5	0	2	0	10
Totals		4	4	11	9	5	2	1	1	2	1	3	1	7	11	6	8	7	6	10	7	14	11	6	0	4	8	15	20	4	3		3	5	8	0	0	26	34	53	57	25	12	207
Grand Total					35						9						45						48						54						16									207

THEORY

S.2 Chemistry

		1						2						3						4						5						6						Totals						Grand Totals
Year		58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
L.W.	6			2	4		1				1		1	1		2	1						2	1	1			1	2					1	1			1		6	11	1	3	22
	5		1	4	3	1		1	1	4	2			1	2	8	5	1	2	1	3	6	1	2		4	2	2	5	1				1	1	1		7	9	25	17	6	2	66
	4	2	3	3	4	1	3	1	1	1			1	2	2	3	9	6		1	3	1	2				3	2		1						1		6	12	10	15	9	4	56
	3		2	2	4		2	2	1					1	3	1	4	3		1			1			4	4	2	2	2								8	10	5	11	5	2	41
	2	1			2	1									1									1														1	1		2	2	0	6
	1	2	2	7	1	2	1																			1												3	2	7	1	2	1	16
Totals		5	8	18	18	5	7	4	3	5	3	0	2	5	8	14	19	10	2	3	6	7	6	4	1	9	9	7	9	4	0			2	2	2	0	26	34	53	57	25	12	207
Grand Total					61						17						58						27						38						6									207

THEORY

S.2 Chemistry

	1						2						3						4						5						6						Totals						Grand Totals
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
6								1	2					1	1	3					2	2				1		3										3	5	8	0	0	16
5			2	1	1	1	1	1	1	3		1		2	6	9				2	1	2	1	1	3	3	3	4	1				2	1	1		4	8	15	20	4	3	54
Pract. 4	2	2	1	2			2		2				1	1	5	6	2		3	2	4	1	2		2	2	2	1	1					1	1		10	7	14	11	6	0	48
3	1	3	2	5	1	3						1	4	4	2	1	5	2		1		1			2	3	2	1	1								7	11	6	8	7	6	45
2	1	1	2	1		1											2												1								1	1	2	1	3	1	9
1	1	2	11	9	3	2	1	1									1			1			1		2												4	4	11	9	5	2	35
Totals	5	8	18	18	5	7	4	3	5	3	0	2	5	8	14	19	10	2	3	6	7	6	4	1	9	9	7	9	4	0			2	2	2	0	26	34	53	57	25	12	207
Grand Totals				61						17						58						27						38						6									207
S.2 Theory																			**Chemistry**																								
6																											1						2		2				3	0	2	0	5
Physics 5					1				1	1			3		3	1	2		3		1	1			4	2	2	2	2					1			10	2	7	6	5	0	30
4							1							2	4	7	1			1	4	2	1	1	2	2	1	3	1					1			3	5	9	13	3	1	34
3	1			4			1	1	1			2	1	3	3	7	3	1		3		1	3		2	4		3	1								5	11	4	15	7	3	45
2		3	1	3			1	1	1	2			1		1	1						1			1		1										3	4	4	7	0	0	18
1	4	5	17	11	4	7	1	1	2	0				3	3	3	4	1		2	2	1				1	2	1									5	12	26	16	8	8	75
Totals	5	8	18	18	5	7	4	3	5	3	0	2	5	8	14	19	10	2	3	5	7	6	4	1	9	9	7	9	4	0			2	2	2	0	26	34	53	57	25	12	207
Grand Totals				61						17						58						27						38						6									207

S.2 Theory — Physics

	Year	1						2						3					
	Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
Maths.	6																		
	5			4			1				1						2	1	1
	4			2	3	1			1	1	2			1	7	3	6	5	1
	3	3	2	3	2	1		1		1	4			2	2		2		
	2		3	2	2				1	1				1	1	1	1	1	
	1	2	7	15	9	6	7	2	2	1				1	1		4		1
Totals		5	12	26	16	8	8	3	4	4	7	0	0	5	11	4	15	7	3
Grand Totals					75						18						45		

	Year	4						5						6						Totals						Grand Totals
	Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
Maths.	6			1	1						1					1		1				2	2	1	0	5
	5			3	2			4		4	2					1				4		12	7	1	2	26
	4	2	3	1	3	2		2	1	1	1	1						1		5	12	8	15	10	1	51
	3	1		2	7	1	1	2	1	1	2	1								9	5	7	17	3	1	42
	2							2		1		1				1				3	5	6	3	2	0	19
	1		2	2								2								5	12	18	13	8	8	64
Totals		3	5	9	13	3	1	10	2	7	6	5	0			3	0	2	0	26	34	53	57	25	12	207
Grand Totals					34						30						5									207

S.2 Theory — Mathematics

	Year	1						2						3					
	Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
Chem.	6																		
	5	1	2	2	1	1	0	1		2			0	3	1		4	1	
	4		2	1	1			1	1			1	0		1	2	3		1
	3		3	2	3	4	2	1	1	1				2	1	2	5	2	
	2	2								1				1	2	2	2		
	1	2	5	13	8	3	6		3	2	3	1		3		1	3		0
Totals		5	12	18	13	8	8	3	5	6	3	2	0	9	5	7	17	3	1
Grand Totals					64						19						42		

	Year	4						5						6						Totals						Grand Totals
	Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
Chem.	6				1	1				1						1	1	1				2	2	2	0	6
	5	2	6	1	1	2		2		2	3	0						0		9	9	7	9	4	0	38
	4	1	2	1		2		1		3	2	1								3	6	7	6	4	1	27
	3	1	3	3	8	4	0	1		5	2		0			1	1		0	5	8	14	19	10	2	58
	2	1	1	2	1		1						1							4	3	5	3	0	2	17
	1			1	4	1				1			1							5	8	18	18	5	7	61
Totals		5	12	8	15	10	1	4		12	7	1	2			2	2	1	0	26	34	53	57	25	12	207
Grand Totals					51						26						5									207

Correlation of Laboratory Work with Practical Examination

S1 Physics — Practical

	1						2						3						4						5						6						Total						
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
6													1							2	1		1		2	1		1			1		1				4	3	2	1	1		
5	2		1			1		1	1				1	3	2	2	4		3	1	3	1	2		5	6	13	5	3	5	2	1	3	1		1	13	12	23	9	9	7	
Lab. 4		1	3		2				2	2	1			1	4	3		1	2	1	2	3			1		5	1	1				3	0			3	3	19	9	4	1	
Work 3	1	2		3		3	1	2	1	3		1		1	2	3	1	2	2		2	2	2		2		2	2					1	1			6	5	8	14	3	6	
2		1	2	2			1												1	1																	2	2	2	2			
1	2	2	3	1		1		1			3									2	1					1									1		2	6	4	1	4	1	
Total	5	6	9	6	2	5	2	4	4	5	4	1	2	5	8	8	5	3	8	7	9	6	5		10	8	20	9	4	5	3	1	8	2	1	1	30	31	58	36	21	15	
			33						20						31						35						56						16										191

S1 Chemistry — Practical

	1						2						3						4						5						6						Total						
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
6															2			1				2			2		2	1	1		1		1	1			3	0	5	4	1	1	
5	1		4	1	2	1	1		1		1	1	1	2	4	1	1			3	6		2		5	1	9	2	3	2		2	1	2	1		8	8	25	6	10	4	
Lab. 4		2	2	2		1	1	2	1	3			1	2	1	5		1			1	2	1		8	1	3	1					1		1		10	7	9	13	2	2	
Work 3	2			1		2	1	4	1		1			2	5	3	2	2	2	3	4	2		1	2	1	1	3		2	1	1					8	11	11	9	3	7	
2		1	3			1				1				1							1				1	1											1	3	4	1		1	
1		1	3	3	3									1	1		1												1						0			2	4	3	5		
Total	3	4	12	7	5	5	3	6	3	4	2	1	2	8	13	9	4	4	2	6	12	6	3	1	18	4	15	7	5	4	2	3	3	3	2		30	31	58	36	21	15	
			36						19						40						30						53						13										191

S2 Physics — Practical

	1						2						3						4						5						6						Total						
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
6				1								1				2						1				1	3	3					1	1	2			1	4	8	2	1	
5			2	2	3				1				3	3	7	3	2	2		4	8	3	2	1	5	6	8	4	2	2	1	0	1	3			9	13	27	15	9	5	
Lab. 4		1	1	3		1	1		1		1		3	2		5	1		2	2	1	4			1	3	2	9	2	2		0		1			7	8	5	22	4	3	
Work 3	1	2	1	1	4	1		1	2		2			2	5	4	2		3	2	2	4	1	1		1	1	1		1	1	1					5	9	11	10	9	3	
2	1						1						1	1																							3	1					
1	2	2	6	2	1																																2	2	6	2	1		
Total	4	5	10	9	8	2	2	1	4		3	1	7	8	12	14	5	2	5	8	11	12	3	2	6	11	14	17	4	5	2	1	2	5	2		26	34	53	57	25	12	
			38						11						48						41						57						12										207

2.

Practical

	1						2						3						4						5						6						Total						
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
S2 Chemistry																																											
6			1	3											1	2		1	1		2	2					2	3	1	2				1			1	0	6	11	1	3	
5		1		1	1				1				2	3	4	3	1	2	2	1	9	2	3		3	4	7	10	1	0			4	1			7	9	25	17	6	2	
Lab. 4		1	1	2				0	1	1	2	1	3	3		1	3	2	3	5	2	3	2			2	5	5	2	1		1	1	3			6	12	10	15	9	4	
Work 3	2	1	2	1	1	1		1			1		2	4	1	1	2	1	3	1	1	4	1		1	2	1	2				1		3			8	10	5	11	5	2	
2				1	1		1									1	1															1					1	1		2	2		
1	2	1	7	1	2	1								1					1																		3	2	7	1	2	1	
Total	4	4	11	9	5	2	1	1	2	1	3	1	7	11	6	8	7	6	10	7	14	11	6		4	8	15	20	4	3		3	5	8			26	34	53	57	25	12	
				35						9						45						48						54						16									207
S3 Physics (Practical)																																											
6			1	1	2	1					1		1				1			1	2	2	1	2		2	3	1				1		1		1	1	4	6	5	5	4	
5	1		1		3	1	3	1			2	1	6	4	4	1	4	1		6	4	1		7	5	9	2	10	1	3					1		15	20	11	12	11	13	
Lab. 4	3	3	1		1								1		1		1		2	1	3	1	1				2	2		1						1	6	4	7	3	3	2	
Work 3			2					1							1					1	2			1		2												3	5			2	
2		2																												1								2				1	
1		1	2	1	1	1																																1	2	1	1	1	
Total	4	6	7	2	7	4	3	1			3	1	8	4	6	1	6	1	2	9	11	4	2	10	5	13	7	13	1	5		1		1	1	2	22	34	31	21	20	23	
				30						8						26						38						44						5									151
S3 Chemistry (Practical)																																											
6			3	1		1		1					1		1	1						1	1	1	2		5	3	1	1	2		2	2	1	1	5	1	11	8	3	4	
5						1	1		1		1	1	1	2			4	3	2	5		1	1	3	3	9	5	5	8	5	1	1	4			1	8	17	10	6	14	14	
Lab. 4	1						3	1				1			1				1	3	1	1			2	3	1	2	1	2			1	2			7	7	4	5	1	3	
Work 3																				5							2	1	1									5	2	1	1		
2		1	3																																			1	3				
1	2	3	1	1	1	2																															2	3	1	1	1	2	
Total	3	4	7	2	1	4	4	2	1		1	2	2	2	2	1	4	3	3	13	1	3	2	4	7	12	13	11	11	8	3	1	7	4	1	2	22	34	31	21	20	23	
				21						10						14						26						62						18									151

3.

A1 Physical Metallurgy — Practical

		1						2						3						4						5						6						Total						
Year		58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
	6																		1			1				1	1	3	3	2					2	1		1	1	4	5	3	1	
	5		1	1			4			1				2	1		4	2		1	4	3	3	2	1	1		1	4	3								4	6	6	11	7	5	
Lab.	4				1	3										1	1				1		2																1	1	4	3		
Work	3										1				1									1		1												1	1		1	1		
	2																																											
	1	1	1			1	1																															1	1			1	1	
Total		1	2	1	1	4	5			1	1			2	2	1	5	2	1	1	5	4	5	3	1	3	1	4	7	5					2	1		7	10	11	21	15	7	
					14						2						13						19						20						3									71

A1 Metallurgical Analysis — Practical

		1						2						3						4						5						6						Total						
Year		58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
	6						1									1		1									2	1		2									2	2		3	1	
	5					3	3			1					1	1	1	1	1		1	1	1	2	1	4	3	2	4	2		1		1	4	1		5	5	6	10	9	5	
Lab.	4					1											1	1					2					1	1				1		2				1	1	6	2		
Work	3									1					1								1			1		1	2						1			1	1	2	4			
	2																1																								1			
	1	1	1			1	1																															1	1			1	1	
Total		1	1			5	5			2					2	2	3	3	1		1	1	4	2	1	5	5	5	7	4		1	1	1	7	1		7	10	11	21	15	7	
					12						2						11						9						26						11									71

A2 Physical Metallurgy — Practical

		1						2						3						4						5						6						Total						
Year		58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
	6		1											2			1	1	1	1			1	3	1	2		1	1									5	1	1	3	4	2	
	5										1		1			4		1		1	1	1	3	4	3	1	2			7	2					1		2	3	5	4	13	6	
Lab.	4																				1									1									1			1		
Work	3														1				1																				1				1	
	2																																											
	1		1	1							1		1																										1	1				
Total			2	1							1		1	2	1	4	1	1	2	2	2	1	4	7	4	3	2	1	1	8	2					1		7	7	7	7	18	9	
					3						2						11						20						17						1									55

A2 Metallurgical Analysis

Practical

	1						2						3						4						5						6						Total						
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	
Lab. Work 6				1												1								2	3		1		1				1		4		3		2	2	5	2	
5		1									1		1	1		2		1				1	2	1	2	1			3	1	1	1	3		7	1	4	4	3	3	13	4	
4		1										1				1								1		1							1					2	1	1		2	
3																1		1												1								1		1		1	
2																																											
1			1																																				1				
Total		2	1	1							1	1	1	1		5		2				1	2	4	5	2	1		4	1	1	2	5		11	1	7	7	7	7	18	9	
				4						2						9						7						13						20									55

APPENDIX XXIIIA

S2 supplementary Correlation Tables (Correlation coefficient r)

(Summary over all years)

Physics

Theory

14 30 49 41 45

17 10

		1	2	3	4	5	6	
	6		1	1	5	3	3	13
	5	13	7	15	13	13	1	62
Hw	4	22	4	16	8	6	1	57
	3	25	6	10	8	8		57
	2	3		2				5
	1	12		1				13
		75	18	45	34	30	5	207

r = 0.308

Practical

1 8 9 34 42 67

39 5 2

		1	2	3	4	5	6	
	6	1	1	2	1	7	4	16
	5	7	1	20	18	27	5	78
Lw	4	6	3	11	9	19	1	49
	3	10	5	13	13	4	2	47
	2	1	1	2				4
	1	13						13
		38	11	48	41	57	12	207

r = 0.490

Lw.

2 8 31 98

53 11 4

		1	2	3	4	5	6	
	6				2	2	9	13
	5			6	14	39	3	62
Hw	4	2		11	12	29	3	57
	3		2	28	19	7	1	57
	2	2	1	1		1		5
	1	9	1	1	2			13
		13	4	47	49	78	16	207

r = 0.668

Practical

4 9 30 45 76

28 11 3 1

		1	2	3	4	5	6	
	6			2		7	4	16
	5	4	1	14	12	28	3	78
Hw	4	6	3	16	17	12	3	49
	3	13	7	15	12	8	2	47
	2	3		1		1		4
	1	12				1		13
		38	11	48	41	57	12	207

r = 0.523

Theory

2 20 20 61 33 56

10 3 1 1

		1	2	3	4	5	6	
	6	2	2		7	2	3	16
	5	18	5	22	14	18	1	78
Lw	4	15	6	10	12	6		49
	3	26	5	11	1	3	1	47
	2	2		2				4
	1	12				1		13
		75	18	45	34	30	5	207

r = 0.413

Theory

1 14 16 35 36 72

21 7 3 2

		1	2	3	4	5	6	
	6	1	1		4	4	2	12
	5	13	5	13	12	12	2	57
Pract.	4	11	5	12	8	5		41
	3	13	2	17	10	5	1	48
	2	6	2	1		2		11
	1	31	3	2		2		38
		75	18	45	34	30	5	207

r = 0.445

S2 Supplementary Correlation Tables (Correlation coefficient r)

(Summary over all years)

Chemistry

Theory

				2	11	30	43	39	56
		1	2	3	4	5	6		18
	6	2		3	3	1	2	11	8
	5	11	10	19	13	23	4	80	
Hw	4	17	3	18	4	7		49	
	3	18	4	17	6	7		52	
	2	3		1	1			5	
	1	10						10	
		61	17	58	27	38	6	207	

r = 0.384

Practical

				4	3	9	33	41	67
		1	2	3	4	5	6		32
	6	4		4	5	8	1	22	12
	5	3	1	15	17	25	5	66	5
Lw	4	4	5	12	15	15	5	56	1
	3	8	2	11	10	6	4	41	
	2	2	1	2			1	6	
	1	14		1	1			16	
		35	9	45	46	54	16	207	

r = 0.408

Lw.

					1	2	15	45	81
		1	2	3	4	5	6		44
	6				2	6	3	11	17
	5	1		12	18	37	12	80	2
Hw	4	2		14	15	13	5	49	
	3	1	5	15	19	10	2	52	
	2	2	1		2			5	
	1	10						10	
		16	6	41	56	66	22	207	

r = 0.589

Practical

				1	6	11	28	49	58
		1	2	3	4	5	6		38
	6	1		2	2	6		11	12
	5	6	2	13	26	24	9	80	3
Hw	4	7	3	11	8	17	3	49	1
	3	10	4	17	11	7	3	52	
	2	2		1	1		1	5	
	1	9		1				10	
		35	9	45	48	54	16	207	

r = 0.402

Theory

				7	11	28	37	45	50
		1	2	3	4	5	6		12
	6	7	2	4	4	3	2	22	16
	5	9	8	19	13	14	3	66	0
Lw	4	16	4	22	7	6	1	56	1
	3	10	3	12	2	14		41	
	2	4		1	1			6	
	1	15				1		16	
		61	17	58	27	38	6	207	

r = 0.274

Theory

					8	19	40	33	72
		1	2	3	4	5	6		18
	6		3	5	4	4		16	12
	5	5	7	17	7	14	4	54	3
Pract.	4	7	4	15	12	8	2	48	2
	3	15	1	18	2	9		45	
	2	6		2		1		9	
	1	28	2	1	2	2		35	
		61	17	58	27	38	6	207	

r = 0.468

S2 Supplementary Correlation Tables (Correlation coefficient r)

(Summary over all years)

Chemistry

				1	2	15	32	96
								24
	1	2	3	4	5	6		
6					1	4	5	26
5	1	2	9	5	12	1	30	7
Phys 4		1	14	9	9	1	34	4
3	5	5	18	7	10		45	
2	7	5	3	1	2		18	
1	48	4	14	5	4		75	
	61	17	58	27	38	6	207	

r = 0.624

Physics

				5	7	21	42	78
								28
	1	2	3	4	5	6		
6				2	1	2	5	15
5	5	1	4	5	10	1	26	8
Maths. 4	6	4	23	11	6	1	51	3
3	11	6	6	12	7		42	
2	7	2	5		4	1	19	
1	46	5	7	4	2		64	
	75	18	45	34	30	5	207	

r = 0.513

Mathematics

				7	7	28	25	56
	1	2	3	4	5	6		
6				2	1	3	6	42
5	7	3	9	12	7		38	21
Chem. 4	4	3	7	6	7		27	9
3	14	3	12	19	8	2	58	2
2	2	1	7	6	1		17	
1	37	9	7	6	2		61	
	64	19	42	51	26	5	207	

r = 0.428

Supplementary Correlation Tables (Correlation coefficient r) for both stages of mathematics i.e. S1 and S2 pooling over all years

S1 Maths. Theory

		2	10	21		42	40	50
	1	2	3	4	5	6		15
6	2	0	3	3	5	2	15	9
5	10	5	19	7	10	1	52	2
Hw 4	13	4	14	8	5	0	44	
3	16	5	14	3	5	1	44	
2	9	1	1	0	0	0	11	
1	15	5	4	1	0	0	25	
	65	20	55	22	25	4	191	

r = 0.427

S2 Maths Theory

			11	27		30	44	66
	1	2	3	4	5	6		24
6	0	0	0	1	5	3	9	4
5	11	5	12	20	14	2	64	1
Hw 4	22	4	10	16	6	0	58	
3	13	6	15	13	1	0	48	
2	3	3	2	0	0	0	8	
1	15	1	3	1	0	0	20	
	64	19	42	51	26	5	207	

r = 0.457

Supplementary Correlation Tables (Correlation coefficient r) for all stages of physics i.e. S1, S2 and S3 pooling over all years

S1 — Theory

1 14 25 34 45 47

16 7 2

		1	2	3	4	5	6	
	6	1	1	1	3	6	0	12
	5	13	11	10	13	19	1	67
Hw	4	13	11	12	5	6	0	47
	3	10	2	8	8	6	0	34
	2	12	5	1	1	1	0	20
	1	10	0	0	1	0	0	11
		59	30	32	31	38	1	191

$r = 0.383$

S2 — Theory

24 30 49 41 26

17 10

		1	2	3	4	5	6	
	6	0	1	1	5	3	3	13
	5	13	7	15	13	13	1	62
Hw	4	22	4	16	8	6	1	57
	3	25	6	10	8	8	0	57
	2	3	0	2	0	0	0	5
	1	12	0	1	0	0	0	13
		75	18	45	34	30	5	207

$r = 0.307$

S3 — Theory

7 14 18 31 29 42

8 2

		1	2	3	4	5	6	
	6	7	0	6	9	5	0	27
	5	14	4	11	13	20	1	63
Hw	4	8	3	8	7	3	0	29
	3	8	2	6	4	2	0	22
	2	1	0	0	0	0	0	1
	1	9	0	0	0	0	0	9
		47	9	31	33	30	1	151

$r = 0.351$

Supplementary Correlation Tables (Correlation coefficient r) for all stages of chemistry i.e. S1, S2 and S 3 pooling over all years

S1 — Theory

5 16 17 39 31 60

15 7 1

		1	2	3	4	5	6	
	6	5	1	0	1	2	0	9
	5	15	1	14	13	23	2	68
Hw	4	16	4	7	6	5	1	39
	3	20	4	14	7	6	0	51
	2	5	5	0	0	0	0	10
	1	12	1	0	1	0	0	14
		73	16	35	28	36	3	191

$r = 0.358$

S2 — Theory

2 11 30 43 39 50

18 8

		1	2	3	4	5	6	
	6	2	0	3	3	1	2	11
	5	11	10	19	13	23	4	80
Hw	4	17	3	18	4	7	0	49
	3	18	4	17	6	7	0	52
	2	3	0	1	1	0	0	5
	1	10	0	0	0	0	0	10
		61	17	58	27	38	6	207

$r = 0.383$

S3 — Theory

		1	2	3	4	5	6		
				3	17	30	34	33	26
		1	2	3	4	5	6		7
	6	3	0	4	2	4	0	13	1
	5	17	10	19	11	9	1	67	
Hw	4	16	8	12	6	5	0	47	
	3	5	2	3	1	1	0	12	
	2	4	0	0	0	0	0	4	
	1	8	0	0	0	0	0	8	
		53	20	38	20	19	1		

$r = 0.359$

Supplementary Correlation Tables (Correlation coefficient r) for General Metallurgy S3 pooling over all years

S3 — Theory

					12	15	35	45	35
		1	2	3	4	5	6		8
	6	0	0	0	2	1	0	3	1
	5	12	10	25	28	12	1	88	
Hw	4	5	4	8	10	2	0	29	
	3	4	4	6	5	1	0	20	
	2	4	0	0	0	0	0	4	
	1	7	0	0	0	0	0	7	
		32	18	39	45	16	1	151	

$r = 0.418$

Supplementary Correlation Table (Correlation coefficient r) for Physical Metallurgy A1 and A2 pooling over all years

A1 — Theory

					6	6	17	25	17
		1	2	3	4	5	6		
	6	0	0	1	2	2	1	6	
	5	6	3	9	19	7	0	44	
Hw	4	2	1	3	3	0	0	9	
	3	5	0	3	0	0	0	8	
	2	1	0	0	0	0	0	1	
	1	3	0	0	0	0	0	3	
		17	4	16	24	9	1	71	

$r = 0.580$

A2 — Theory

			1	0	3	23	18	9
	1	2	3	4	5	6		1
6	1	0	2	2	2	0	7	
5	0	1	20	15	7	0	43	
4	0	1	1	0	0	0	2	
3	0	0	0	1	0	0	1	
2	0	0	0	0	0	0	0	
1	2	0	0	0	0	0	2	
	3	2	23	18	9	0	55	

$r = 0.440$

Supplementary Correlation Tables (Correlation coefficient r)

for both stages of metallurgical analysis i.e. A1 and A2

pooling over all years

A1 — Theory

				7	5	20	14		20
		1	2	3	4	5	6		4
	6	0	0	0	0	1	0	1	1
	5	7	2	14	7	13	1	44	
Hw	4	3	2	4	1	3	0	13	
	3	4	2	2	0	1	0	9	
	2	0	0	0	0	0	0	0	
	1	4	0	0	0	0	0	4	
		18	6	20	8	18	1	71	

r =0.457

A2 — Theory

				1	3		8	25	16
		1	2	3	4	5	6		2
	6	0	0	1	0	1	0	2	
	5	1	2	7	23	10	0	43	
Hw	4	0	1	1	3	2	0	7	
	3	0	0	1	0	0	0	1	
	2	0	0	0	0	0	0	0	
	1	2	0	0	0	0	0	2	
		3	3	10	26	13	0	55	

r =0.481

Supplementary Correlation Tables (Correlation coefficient r)

for both stages of Iron and Steel Manufacture i.e. A1 and A2

pooling over all years

A1 — Theory

					1	2	8	30	
									26
		1	2	3	4	5	6		4
	6	0	1	0	0	4	0	5	
	5	0	2	7	15	10	0	34	
Hw	4	0	1	7	6	3	0	17	
	3	0	3	4	1	0	0	8	
	2	1	0	0	0	0	0	1	
	1	6	0	0	0	0	0	6	
		7	7	18	22	17	0	71	

r = 0.724

A2 — Theory

				1	0		3	18	21
		1	2	3	4	5	6		12
	6	1	0	2	8	4	0	15	
	5	0	0	9	14	10	0	33	
Hw	4	1	1	3	1	0	0	6	
	3	0	0	0	0	0	0	0	
	2	0	0	0	0	0	0	0	
	1	1	0	0	0	0	0	1	
		3	1	14	23	14	0	55	

r = 0.439

Supplementary Correlation Tables (Correlation coefficent r)

Summary over all years

S1 Physics — Practical

				4	9	30		36	66
		1	2	3	4	5	6		28
	6			1	4	4	2	11	11
	5	4	2	12	10	37	8	73	5
Lw	4	6	5	9	8	8	3	39	1
	3	9	8	9	8	6	2	42	1
	2	5	1	0	2	0	0	8	
	1	9	4		3	1	1	18	
		33	20	31	35	56	16	191	

r =0.489

S1 Chemistry — Practical

					9	14	23	39	54
		1	2	3	4	5	6		32
	6			3	2	6	3	14	15
	5	9	4	9	11	22	6	61	4
Lw	4	7	7	10	4	13	2	43	1
	3	5	7	14	12	9	2	49	
	2	5	1	1	1	2		10	
	1	10		3		1		14	
		36	19	40	30	53	13	191	

r =0.384

S2 Physics — Practical

			1	8	9	34	42		67
		1	2	3	4	5	6		39
	6	1	1	2	1	7	4	16	5
	5	7	1	20	18	27	5	78	2
Lw	4	6	3	11	9	19	1	49	
	3	10	5	13	13	4	2	47	
	2	1	1	2				4	
	1	13						13	
		38	11	48	41	58	12	207	

r = 0.490

S2 Chemistry — Practical

			4	3	9	33		41	67
		1	2	3	4	5	6		32
	6	4	0	4	5	9	1	22	12
	5	3	1	15	17	25	5	65	5
Lw	4	4	5	12	15	15	5	56	1
	3	8	2	11	10	6	4	41	
	2	2	1	2			1	6	
	1	14	0	1	1			16	
		35	9	45	48	55	16	207	

r = 0.408

S3 Physics — Practical

			5	7	17		31	29	48
		1	2	3	4	5	6		10
	6	5	1	2	8	6	3	25	3
	5	6	7	20	13	30	1	82	1
Lw	4	8		3	9	5	1	25	
	3	3		1	4	2		10	
	2	2				1		3	
	1	6						6	
		30	8	26	38	43	5	151	

r = 0.335

S3 Chemistry — Practical

			5	2	8	18		29	59
		1	2	3	4	5	6		23
	6	5	1	3	3	12	8	32	7
	5	1	4	10	12	35	7	59	
Lw	4	1	5	1	6	11	3	27	
	3	0	0	0	5	4	0	9	
	2	4						4	
	1	10						10	
		21	10	14	26	61	18	151	

r = 0.486

Practical

A1 Physical Metallurgy

						6	6	10	27
		1,	2	3	4	5	6		20
	6			1	1	10	3	15	1
	5	6	1	9	14	9		39	1
Lw	4	4		2	3			9	
	3		1	1	1	1		4	
	2								
	1	4						4	
		15	2	13	19	20	3	71	

r = 0.583

Practical

A1 Met. Analysis

				1	6	4	5	14	22
		1	2	3	4	5	6		11
	6	1		2		5		8	7
	5	6	1	5	6	15	7	40	1
Lw	4	1		2	2	2	3	10	
	3		1	1	1	4	1	8	
	2			1				1	
	1	4						4	
		13	2	11	9	26	11	71	

r = 0.306

Practical

A2 Physical Metallurgy

				1	0	7	11	17	17
		1	2	3	4	5	6		2
	6	1		5	6	4		16	
	5		2	5	13	12	1	33	
Lw	4				1	1		2	
	3			2				2	
	2							0	
	1	2						2	
		3	2	12	20	17	1	55	

r = 0.371

Practical

A2 Met. Analysis

				1	1	3	8	10	16
		1	2	3	4	5	6		14
	6	1	0	1	2	5	5	14	1
	5	1	1	5	4	7	13	31	1
Lw	4	1	1	1	1	1	1	6	
	3			2			1	3	
	2							0	
	1	1						1	
		4	2	9	7	13	20	55	

r = 0.325

1	13	4	47	78	16		-1				
	13	5	57	62	13		-1				
	4	11	53	98	31	8	2	-1			
2	38	11	48	41	57	12	-1				
	13	5	57	57	62	13	-1				
	1	3	11	28	76	45	30	9	4	-1	
3	75	18	45	34	30	5	-1				
	13	4	47	49	78	16	-1				
	1	1	3	10	56	33	61	20	20	2	-1
4	75	18	45	34	30	5	-1				
	38	11	48	41	57	12	-1				
	2	3	7	21	72	36	16	14	1	-1	
5	16	6	41	56	66	22	-1				
	10	5	52	49	80	11	-1				
	2	17	44	81	45	15	2	1	-1		
6	35	9	45	48	54	16	-1				
	10	5	52	49	80	11	-1				
	1	3	12	38	58	49	28	11	6	1	-1
7	61	17	58	27	38	6	-1				
	16	6	41	56	66	22	-1				
	1	0	16	12	50	45	37	28	11	7	-1
8	61	17	58	27	38	6	-1				
	35	9	45	48	54	16	-1				
	2	3	12	18	72	33	40	19	8	-1	
9	61	17	58	27	38	6	-1				
	75	18	45	34	30	5	-1				
	4	7	26	24	96	32	15	2	1	-1	
10	75	18	45	34	30	5	-1				
	64	19	42	51	26	5	-1				
	3	8	15	28	78	42	21	7	5	-1	
11	64	19	42	51	26	5	-1				
	61	17	58	27	38	6	-1				
	2	9	21	42	66	25	28	7	7	-1	
12	65	20	55	22	25	4	-1				
	25	11	44	44	52	15	-1				
	2	9	15	50	40	42	21	10	2	-1	
13	7	7	18	22	17	0	-1				
	6	1	8	17	34	5	-1				
	4	26	30	8	2	1	-1				
14	64	19	42	51	26	5	-1				
	20	8	48	58	64	9	-1				
	1	4	24	66	44	30	27	11	-1		
15	3	1	14	23	14	0	-1				
	1	0	0	6	33	15	-1				
	12	21	18	3	0	1	-1				
16	32	18	39	45	16	1	-1				
	7	4	20	29	88	3	-1				
	1	8	35	45	35	15	12	-1			
17	59	30	32	31	38	1	-1				
	11	20	34	47	67	12	-1				
	2	7	16	47	45	34	25	14	1	-1	
18	3	2	23	18	9	0	-1				
	2	0	1	2	43	7	-1				
	1	9	18	23	3	0	1	-1			
19	75	18	45	34	30	5	-1				
	13	5	57	57	62	13	-1				
	10	17	46	41	49	30	24	-1			
20	47	9	31	33	30	1	-1				
	9	1	22	29	63	27	-1				
	2	8	42	29	31	18	14	7			
21	17	4	16	24	9	1	-1				
	3	1	8	9	44	6	-1				
	17	25	17	6	6	-1					
22	73	16	35	28	36	3	-1				
	14	10	51	39	68	9	-1				
	1	7	15	60	31	39	17	16	5	-1	
23	18	6	20	8	18	1	-1				
	4	0	9	13	44	1	-1				
	1	4	20	14	20	5	7	-1			
24	61	17	58	27	38	6	-1				
	10	5	52	49	80	11	-1				
	8	18	56	39	43	30	11	2	-1		
25	3	3	10	26	13	0	-1				
	2	0	1	7	43	2	-1				
	2	16	25	8	3	1	-1				
26	53	20	38	20	19	1	-1				
	8	4	12	47	67	13	-1				
	1	7	26	33	34	30	17	3	-1		
27	33	20	31	35	56	16	-1				
	18	8	42	39	73	11	-1				
	1	1	5	11	28	66	36	30	9	4	-1
28	36	19	40	30	53	13	-1				
	14	10	49	43	61	14	-1				
	1	4	15	32	54	39	23	14	9	-1	
29	38	11	48	41	58	12	-1				
	13	4	47	49	78	16	-1				
	2	5	39	67	42	34	9	8	1	-1	
30	35	9	45	48	55	16	-1				
	16	6	41	56	66	22	-1				
	1	5	12	32	67	41	33	9	3	4	-1
31	30	8	26	38	43	5	-1				
	6	3	10	25	82	25	-1				
	1	3	10	48	29	31	17	7	5	-1	
32	21	10	14	26	61	18	-1				
	10	4	9	27	69	32	-1				
	7	23	59	29	18	8	2	5	-1		
33	15	2	13	19	20	3	-1				
	4	0	4	9	39	15	-1				
	1	1	20	27	10	6	6	-1			
34	13	2	11	9	26	11	-1				
	4	1	8	10	40	8	-1				
	1	7	11	22	14	5	4	6	1	-1	
35	3	2	12	20	17	1	-1				
	2	0	2	2	33	16	-1				
	2	17	17	11	7	0	1	-1			
36	4	2	9	7	3	20	-1				
	1	0	3	6	31	14	-1				
	1	1	14	16	10	8	3	1	1	-1	

CORRELATIONS

		A1	A2	A3	R
1	S2 Phys. Hw-Lw.	320.763	306.435	208.415	.6679
2	" " Hw-Pr.	487.749	306.435	390.097	.5226
3	" " Lw-Th.	500.184	320.763	489.826	.4133
4	" " Pr- Th .	500.184	487.749	548.647	.4447
5	" Chem. Hw-Lw.	362.609	285.517	268.995	.5891
6	" " Hw-Pr.	481.517	285.517	469.111	.4017
7	" " Lw-Th.	492.435	362.609	623.478	.2740
8	" " Pr -Th.	492.435	481.517	519.213	.4680
9	S2 Phys. Chem.	492.435	500.184	372.879	.6244
10	Theory Maths. Chem.	500.184	470.937	472.357	.5138
11	Between Subjects Chem. Maths.	470.937	550.415	550.415	.4288
12	S1 Maths Hw-Th.	415.194	406.775	470.743	.4273
13	A1 Iron & Steel Hw-Th.	107.746	116.394	61.915	.7243
14	S2 Maths. Hw-Th.	470.937	351.478	450.184	.4575
15	A2 Iron&Steel Hw-Th.	56.800	36.545	53.345	.4390
16	S3 Gen. Met. Hw-Th.	263.974	185.589	264.371	.4183
17	S1 Phys. Hw-Th.	450.440	326.660	479.466	.3880
18	A2 Phys. Hw-Th.	53.745	44.545	55.200	.4403
19	S2 Phys. Hw-Th.	500.184	306.435	565.770	.3706
20	S3 Phys. Hw-Th.	358.675	249.152	397.709	.3514
21	A1 Phys. Met. Hw-Th.	140.310	87.718	99.324	.5801
22	S1 Chem. Hw-Th.	492.293	317.163	526.461	.3581
23	A1 Met. Anal. Hw-Th.	166.648	84.197	142.366	.4579
24	S2 Chem. Hw-Th.	492.435	285.517	490.213	.3837
25	A2 Met. Anal. Hw-Th.	59.382	40.909	52.836	.4814
26	S3 Chem. Hw-Th.	309.020	203.099	331.934	.3596
27	S1 Phys. Lw-Pr.	492.796	351.487	436.880	.4894
28	S1 Chem. Lw-Pr.	485.058	329.466	507.173	.3844
29	S2 Phys. Lw-Pr.	487.749	320.763	420.589	.490
30	S2 Chem. Lw-Pr	481.517	362.609	502.995	.408
31	S3 Phys. Lw-Pr.	349.393	194.397	368.861	.3356
32	S3 Chem. Lw-Pr	376.000	263.020	333.152	.4863
33	A1 Phys. Met. Lw-Pr.	170.000	99.437	117.831	.5830
34	A1 Met. Anal. Lw-Pr.	205.500	103.718	219.718	.3065
35	A2 Phys. Met. Lw-Pr.	67.345	57.927	78.836	.3717
36	A2 Met. Anal. Lw-Pr.	128.800	47.927	125.636	.3251

APPENDIX XXIV

Correlation Tables: Summary over all years.

Correlations between successive years within subjects (theory only).

Physics S2

		1	2	3	4	5	6	Total
	6	-	-	-	-	1	-	1
	5	9	1	8	5	2	1	26
S1	4	4	3	4	4	4	-	19
	3	7	1	1	3	1	-	13
	2	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-
		20	5	13	12	8	1	59

Chemistry S2

	6	0	0	1	0	1	1	3
	5	3	3	8	6	10	0	30
S1	4	6	0	8	0	0	0	14
	3	7	0	2	3	0	0	12
	2	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-
		16	3	19	9	11	1	59

Mathematics S2

	6	1	1	0	0	1	0	3
	5	6	1	3	4	4	0	18
S1	4	4	0	1	5	1	0	11
	3	13	3	6	4	1	0	27
	2	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-
		24	5	10	13	7	0	59

Physics S3

		1	2	3	4	5	6	Total
	6	0	0	1	0	1	0	2
	5	3	1	3	5	1	0	13
S2	4	10	3	2	4	2	0	21
	3	4	0	5	5	2	0	16
	2	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-
		17	4	11	14	6	0	52

Chemistry S3

	6	1	0	0	0	1	0	2
	5	3	1	5	4	3	0	16
S2	4	5	2	1	0	0	1	9
	3	9	2	7	6	1	0	25
	2	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-
		18	5	13	10	5	1	52

Physical Metallurgy A2

	6	-	-	-	-	1	0	1
	5	1	0	1	1	4	0	7
A1	4	0	1	9	9	1	0	20
	3	0	0	6	3	1	0	10
	2	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-
		1	1	16	13	7	0	38

Metallurgical Analysis A2

		1	2	3	4	5	6	Total
	6	-	-	-	1	-	-	1
	5	1	1	3	5	5	-	15
A1	4	-	-	-	6	1	-	7
	3	-	1	5	7	2	-	15
	2	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-
		1	2	6	19	8	-	38

Iron and Steel A2

	6	-	-	-	-	-	-	-
	5	-	-	4	3	5	-	12
A1	4	-	-	2	7	7	-	16
	3	1	-	3	6	-	-	10
	2	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-
		1	-	9	15	11	-	38

Correlations between successive years within subjects (Theory)

S1 to S2

Physics

	S2 Band 1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
S1 Band 6																												1														
5	1		3	3	2		1						4	1	3				1	1	3						2					1					7	3	11	3	2	
4	2		1	1					2				1	1	2				1	1	2					1	1	2									5	3	8	3		
3	3		1	1	2				1						1				1	1	1							1									4	1	4	2	2	
Total	6		5	5	4		2		3				5	2	6				3	3	6					1	3	4				1					16	7	23	9	4	

Chemistry

	S2 Band 1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
S1 Band 6													1												1												2					
5			1	1	1		1		2				2	2	4				3	1	2				1	1	6	2									7	4	15	3	1	
4	1		3	1	1								2	1	1	4																					3	1	4	5	1	
3	2		2	1	2			1							2				2																		4	1	4	1	2	
Total	3		6	3	4		1	1	2				5	3	7	4			5	1	2				2	1	6	2									16	7	23	9	4	

Maths

	S2 Band 1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
S1 Band 6				1					1																	1												1	1	1		
5				4	2					1			1	1	1				1	1	2					1	3										2	3	6	5	2	
4	2	1			1								1						1	1	3					1											4	3	3		1	
3	6		4	2	1		2		1						5	1			2		2						1										10		13	3	1	
Total	8	1	4	7	4		2		2	1			2	1	6	1			4	2	7					3	4										16	7	23	9	4	

2.

Physics — S3 Band

	1						2						3					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
6																	1	
S2 5	1			2			1						1		2			
Band 4	2	1	1	5	1			1	1		1					2		
3	1			1	2								1		1	2	1	
Total	4	1	1	8	3		1	1	1		1		2		3	4	2	
Chemistry																		
6					1													
S2 5	2			1			1						2		2		1	
Band 4	1	1		1	2				1	1				1				
3	2		1	4	2					1	1		1	1	2	2	1	
Total	5	1	1	6	5		1		1	2	1		3	2	4	2	2	
Physical Metallurgy																		
6																		
A1 5	1																1	
Band 4										1			1	1	2	5		
3														1	2	1	2	
Total	1									1			1	2	4	6	3	

	4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
6									1												1		1	
S2 5	1	2	1		1		1												5	2	3	2	1	
Band 4			2	1	1			1	1										2	3	5	8	3	
3		4			1			2											2	6	1	3	4	
Total	1	6	3	1	3		1	3	2										9	11	10	13	9	
Chemistry	S3 Band																							
6									1												1		1	
S2 5		3		1				3											5	6	2	2	1	
Band 4																	1		1	2	1	2	3	
3		2	2	2					1										3	3	6	9	4	
Total		5	2	3				3	2								1		9	11	10	13	9	
Physical Metallurgy	A2 Band																							
6											1											1		
A1 5				1			1		1	2									2		1	3	1	
Band 4	1	3	1	3	1						1								2	4	3	9	2	
3				2	1				1											1	3	3	3	
Total	1	3	1	6	2		1		2	2	2								4	5	7	15	7	

3.

A2 Band

	1						2						3						4						5						6						Total					
Metallurgical Analysis																																										
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
6																						1																		1		
A1 5	1									1			1			1	1		2	2		1						5									4	2		8	1	
Band 4																				1	1	3	1						1									1	1	3	2	
3									1					1	2		2				2	3	2			1	1											2	6	3	4	
Total	1								1	1			1	1	2	1	3		2	3	3	8	3			1	1	5	1								4	5	7	15	7	
Iron & Steel Manufacture																			A2 Band																							
6																																										
A1 5													2	1		1				1		1	1					2	3								2	2		4	4	
Band 4														1	1				1		1	5				1	4	2									1	2	6	7		
3	1															2	1			1	1	2	2														1	1	1	4	3	
Total	1												2	2	1	3	1		1	2	2	8	3			1	4	4	3								4	5	7	15	7	

To investigate improvement (or worsening performance) in respect of re-sit candidates

2nd Attempt

S.1
Physics

	1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
1st Attempt 6																																										
5				1																																				1		
4					1				1																		4	1					1						6	1	1	
3	1			1					1	1			1		2	1				1		2															2	1	3	5		
2	2	2	1		1		2		1	2				1	1						1					1	1	1									4	4	5	3	1	
1	5	1	4				1		1					1	2	1	2			3	1																6	5	8	1	2	
Total	8	3	5	2	2		3		4	3			1	2	5	2	2			4	2	2				1	5	2					1				12	10	22	11	4	

3rd Attempt

	1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
2nd Attempt 6																																										
5			1																																				1			
4																																1						1				
3									1					1					1																		1	1	1			
2	1																								1												2					
1	1															1	1																				1		1	1		
Total	2		1						1					1		1	1		1						1							1					4	2	3	1		

S.1
Chemistry

2nd Attempt

	1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
1st Attempt 6																																										
5																						1																		1		
4			2						1							1					1						1											1	4	1		
3	2			3	1								1		1	1											1	1									3	1	2	4	1	
2	1	1			1		1								1						2							1									2	1	4		1	
1	4	2	8		1		1	1		1			2	2	3	2					1	1	1				2						1				7	7	12	5	2	
Total	7	3	10	3	3		2	1	1	1			3	2	5	4					4	2	1				4	2					1				12	10	22	11	4	

2.

3rd Attempt

	1						2						3					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
2nd Attempt 5																		
4																		
3			2															
2																		
1	2			1														
Total	2		2	1														
S.1 Maths																		
1st Attempt 5													1					
4																		
3		1	2	1	1					1						1		
2							3	1						1	1			
1	3	1	9	2	1		1	1	1		1		1	1	4		1	
Total	3	2	11	3	2		4	2	1	1	1		2	2	5	1	1	
2nd Attempt 5																		
4																		
3																		
2													1	1				
1			2	1														
Total			2	1									1	1				

	4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
2nd Attempt 5																								
4																								
3							1	1											1	1	2			
2								1												1				
1							1		1										3		1	1		
Total							1	1	1										4	2	3	1	0	
2nd Attempt																								
S.1 Maths																								
1st Attempt 5	1							1		1									2	1		1		
4																								
3		2	1	3					2	2										3	5	8	1	
2							1	1	1										4	3	2			
1	1		1																6	3	15	2	3	
Total	2	2	2	3			1	2	3	3									12	10	22	11	4	
3rd Attempt																								
2nd Attempt 5							1												1					
4																								
3	2								1										2		1			
2								1											1	2				
1																					2	1		
Total	2							1	1										4	2	3	1	0	

3.

S.2 Physics

2nd Attempt

		1						2						3						4						5						6						Total					
Year		58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
1st Attempt	6																											1												1			
	5					1								1						1									1									2			1	1	
	4		2																			1						1											2	2			
	3	1	1		2											2	2			1	1						1								1			2	3	2	5		
	2		1	3	1									1			2					1																1	1	4	3		
	1	1	3	6		1			1	3				1	0	5	1				1	2	2				2	1	1				0	0	1			2	7	17	5	3	
Total		2	7	9	3	2			1	3				3	0	7	5			2	2	4	2				3	3	2				0	0	1			7	13	26	14	4	
																		3rd Attempt																									
2nd Attempt	6																																										
	5																																										
	4																																										
	3																									1												1					
	2		1																																				1				
	1	1	1		1				1						1	1	1				1	1					1											1	5	2	2		
Total		1	2		1				1						1	1	1				1	1				1	1											2	6	2	2	0	

S.2 Chemistry

		1						2						3						4						5						6						Total					
																		2nd Attempt																									
Year		58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
1st Attempt	6																																										
	5		1	1		1											1				1	1				1		1	1					1				1	2	4	2	1	
	4		2											1	1	2						1																1	3	3			
	3								1					1	1	4		1				1				1	1											2	3	5		1	
	2							1	1	1					1	2						1	2															1	2	4	2		
	1	1	1	6	2	1		1	1			1				2	4						1			1	2	1							2			2	3	10	10	2	
Total		1	4	7	2	2		2	3	1		1		2	3	10	5	1			1	4	3			3	3	2	1					1	2			7	13	26	14	4	

3rd Attempt

	1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
2nd Attempt 6																																										
5																										1	1					0						1	1			
4																																										
3														1		1																						1		1		
2							1	1					1	1																							2	2				
1		1		1																	1					1												2	1	1		
Total		1		1			1	1					1	2		1					1					2	1					0					2	6	2	2	0	
S.2 Mathematics																																										
2nd Attempt																																										
1st Attempt 6																																										
5			1																														1						2			
4					1																1	3					2	1											3	4	1	
3					1		1	1	1						2				1		1	4				2											2	3	4	4	1	
2															2				3		3	1				1								1			3	1	5	2		
1		3	5	1	1			1					2	2	5	2				1	1	1	1			2	1										2	9	12	4	2	
Total		3	6	1	3		1	2	1				2	2	9	2			4	1	6	9	1			5	3	1					1	1			7	13	26	14	4	
3rd Attempt																																										
2nd Attempt 6																																										
5																																1						1				
4				1																	1																		1	1		
3				1			1							2							1				1												2	2	1	1		
2														1																								1				
1		1												1																								2				
Total		1		2			1							4							2				1							1					2	6	2	2	0	

5.

2nd Attempt

S.3 Physics

	1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
1st Attempt 6																																										
5																					1				3	1	2										3	1	3			
4				1															4							2	3										4	2	3	1		
3	1	2		1									2		1								1		2	3											5	5	1	1	1	
2		1					1															1															1	1		1		
1	1	1		1	6		1							4	2					1			2			2											2	8	2	1	8	
Total	2	4		3	6		2						2	4	3				4	1	1	1	3		5	8	5										15	17	9	4	9	
3rd Attempt																																										
2nd Attempt 6																																										
5																										1												1				
4																																										
3	1		1											1											1												2	1	1			
2																																										
1				2									1	1																							1	1		2		
Total	1		1	2									1	2											1	1											3	3	1	2	0	

S.3 Chemistry

2nd Attempt

	1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
1st Attempt 6																																										
5																										1												1				
4									0						3					1	1																	1	4			
3		2							1					1	2					1	1	1			2	1											2	5	4	1		
2				1	2		1			1									1	1					3	2											5	3		2	2	
1		1		1	5		2	1			1		3	4	1				1				1		2	1											8	7	1	1	7	
Total		1		2	7		3	1	1	1	1		3	5	6				2	3	2	1	1		7	5											15	17	9	4	9	

6.

3rd Attempt

	1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
6																																										
5																																										
2nd 4																			1																		1					
Attempt 3	1							1					1	2																							2	3				
2				1					1																														1	1		
1				1																																				1		
Total	1			2				1	1				1	2					1																		3	3	1	2	0	
S.4 General Metallurgy																																										
																			2nd Attempt																							
6																																										
5													1						1						1												3					
1st 4	1				2					1			4		1	1				1	0		1														5	1	1	3	3	
Attempt 3					1								3	1			1		1	1	1		1														4	2	1		3	
2		3			1		1								1					3	2		1			1								1			1	7	4		2	
1		1		1			2	3						3			1				2						1										2	7	3	1	1	
Total	1	4		1	4		3	3		1			8	4	2	1	2		2	5	5		3		1	1	1							1			15	17	9	4	9	
																			3rd Attempt																							
6																																										
5																																										
2nd 4															1																								1			
Attempt 3					1																																			1		
2	1																		1	2		1															2	2	1			
1													1													1											1	1				
Total	1				1								1						1	2		1				1											3	3	1	2	0	

3rd Attempt

	1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
2nd Attempt 6																																										
5																																										
4															1																								1			
3				1																																				1		
2	1																		1	2		1															2	2		1		
1													1													1											1	1				
Total	1			1									1		1				1	2		1				1											3	3	1	2		
A.1 Physical Metallurgy																																										
																			2nd Attempt																							
1st Attempt 6																																										
5																																		1						1		
4																																										
3															1	1					2																		3	1		
2																			2	1																	2	1				
1	1			1	2									1																							1	1		1	2	
Total	1			1	2									1	1	1			2	1	2													1			3	2	3	3	2	
																			3rd Attempt																							
2nd Attempt 6																																										
5																																										
4																																										
3																																										
2																																										
1													1																								1					
Total													1																								1					

A1 Metallurgical Analysis

2nd Attempt

	1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
1st Attempt 6																																										
5																						1																		1		
4																			1																		1					
3					1								1																								1				1	
2				1					1					1													2											1	3	1		
1	1			1	1									1																							1	1		1	1	
Total	1			2	2				1				1	2					1			1					2										3	2	3	3	2	
																			3rd Attempt																							
2nd Attempt 6																																										
5																																										
4																																										
3																																										
2																																										
1													1																								1					
Total													1																								1					

A1 Iron & Steel Production

2nd Attempt

	1						2						3						4						5						6						Total					
Year	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63	58	59	60	61	62	63
1st Attempt 6																																										
5					1																				1			1									1			1	1	
4															1								1					1											1	1	1	
3															1											1												1	1			
2				1									1		1										1												1	1	1	1		
1																																					1					
Total				1	1								1		3								1		2	1		2									3	2	3	3	2	

APPENDIX XXVI

Students studying between S0-S2 stages

		No. of Students	No. who might continue to study	No. of completed records	No. passing S2
College 1		49	10	39	10
	None	22	4	18	3
No. of Science '0' levels gained	MCP	11	1	10	4
	MC	5	1	4	-
	CP	-	-	-	-
	MP	6	2	4	2
	M	1	1	-	-
	C	2	1	1	-
	P	2	-	2	1
College II		28	2	26	13
	None	11	1	10	4
No. of Science '0' levels gained	MCP	10	1	9	7
	MC	2	-	2	1
	CP	1	-	1	1
	MP	-	-	-	-
	M	4	-	4	1
	C	-	-	-	-
	P	-	-	-	-
College III		74	6	68	26
	None	32	1	31	6
No. of Science '0' levels gained	MCP	13	2	11	6
	MC	2	-	2	1
	CP	6	-	6	2
	MP	9	1	8	6
	M	10	2	8	4
	C	2	-	2	1
	P	-	-	-	-

		No. of Students	No. who might continue to study	No. of completed records	No. passing S2
College IV		33	6	27	20
	None	13	3	10	7
No.	MCP	8	1	7	5
of	MC	2	-	2	-
Science	CP	2	1	1	2
'0'	MP	2	-	2	2
levels	M	2	-	2	2
gained	C	4	1	3	2
	P	-	-	-	-
College V		29	10	19	7
	None	18	5	13	4
No.	MCP	2	2	-	2
of	MC	2	2	-	-
Science	CP	3	-	3	1
'0'	MP	2	-	2	-
levels	M	2	1	1	-
gained	C	-	-	-	-
	P	-	-	-	-

Students studying at the A2 stage

		No. of Students	No. who might continue to study	No. of completed records	No. passing S2
College I		1	-	1	1
	None	-	-	-	-
No. of Science '0' levels gained	MCP	-	-	-	-
	MC	-	-	-	-
	CP	-	-	-	-
	MP	-	-	-	-
	M	-	-	-	-
	C	1	-	1	1
	P	-	-	-	-
College II		48	1	47	44
	None	10	1	9	6
No. of Science '0' levels gained	MCP	24	-	24	24
	MC	4	-	4	4
	CP	5	-	5	5
	MP	2	-	2	2
	M	1	-	1	1
	C	1	-	1	1
	P	1	-	1	1
College III	No students reached this stage.				
College IV		3	-	3	3
	None	-	-	-	-
No. of Science '0' levels gained	MCP	2	-	2	2
	MC	-	-	-	-
	CP	1	-	1	1
	MP	-	-	-	-
	M	-	-	-	-
	C	-	-	-	-
	P	-	-	-	-

		No. of Students	No. who might continue to study	No. of completed records	No. passing S2
<u>College V</u>		1	-	1	1
	None	-	-	-	-
No.	MCP	-	-	-	-
of	MC	-	-	-	-
Science	CP	1	-	1	1
'0'	MP	-	-	-	-
levels	M	-	-	-	-
gained	C	-	-	-	-
	P	-	-	-	-

APPENDIX XXVII

QUESTIONNAIRE

NAME:	Melvin Jackson
ADDRESS:	18 Kingsway Avenue, Lowfields Estate, Middlesbrough
Firm: (with dates)	South Durham Steel & Iron Company Limited
1. Technical Colleges: (with dates)	Cleveland 1961-62 Longlands 1962-63-64 Constantine 1964-65-66
2. Type of School: (delete where not applicable)	~~Modern~~ ~~Technical~~ Grammar ~~Comprehensive~~ ~~Public~~
3. Passes in GCE:	'0' Level 'A' Level Maths. Chem. Eng.Lang.Art
4. Nature of Job: (delete where not applicable)	(a) ~~Quality control~~ (b) ~~Engineering application~~ (c) Development ~~and/or Research~~

5. Did you:

(a) select metallurgy as a career whilst at school? ____________________

(b) were you advised by the Youth Employment Officer? ____________________

5. (c) Parents' request? ______

(d) the only job available? Second choice of those available.

---

6. Does the job involve shift working? Yes. Not permanent

If so:

(a) does work interfere with study? No.

(b) does the College make provision to accommodate shift working in your case? No, but it is not necessary

---

7. Would you prefer the course to include metallurgical subjects at an early stage? ______

---

8. Do you feel that the course content is too academic? Yes

---

9. In terms of the course content, do you consider part-time day release gives sufficient time for assimilation? No

---

10. To what extent have you found the following topics essential or unessential in your job? Please mark all subjects listed as follows:

1. Essential
2. Most useful
3. Useful
4. Rarely used
5. Unessential

Mark with an X if the topic has not been studied.

	RATING
	1,2,3,4 or 5
MATHEMATICS	
1. Mensuration	2
2. Algebra	2
3. Geometry	5
4. Trigonometry	5
5. Differential Calculus	5
6. Integral Calculus	5
7. Partial Differential Calculus	5
8. Co-ordinate Geometry	X
INORGANIC	
1. Study of Water	2
2. Study of Halogens	5
3. Phosphorus and its Compounds	2
4. Sulphur and its Compounds	2
5. Nitrogen and its Compounds	2
6. Manufacture of Na_2CO_3	5
$NaHCO_3$	5
NH_3	5
HNO_3	5
HCl	5
H_2SO_4	5
Graphite	5
Glass	5
CS_2	5
PHYSICAL-CHEMISTRY	
1. Factors affecting equilibrium	4
2. Electro Chemistry	4
3. Thermo Chemistry	5
4. Osmosis	5

	RATING
	1,2,3,4 or 5

PHYSICAL CHEMISTRY PRACTICAL

1. Determination of Vapour Densities	5
2. Elevation of B.P.	5
3. Depression of F.P.	5
4. Heat of neutralisation	5
5. Determination of Electrical Conductivity	3
6. Determination of molecular weights	3
7. Transition Points	5
8. Potentiometric Titrations	5

PHYSICS

A. Heat

1. Charles' Law	3
2. Specific and Latent Heat	4
3. Mechanical Equivalent of Heat	3
4. Vapour Pressure	3
5. Dew Point and Relative Humidity	3
6. Liquefaction	2

B. Mechanics

1. Work, Energy, Power	3
2. Levers, Simple machines	5
3. Force	5
4. Pressure in fluids	4
5. Boyle's Law	4
6. Archimedes Principles	1
7. Surface Tension	5
8. Elementary study of Dynamics	5

	RATING
	1,2,3,4 or 5.

ELECTRICITY AND MAGNETISM

1. Magnetic effect	5
2. Electrical power and energy	4
3. Electrolysis	2
4. Static Electricity	5
5. Current Electricity	3
6. Electrical Measurement	2
7. Photoelectric and thermionic effect	1
8. Cathode ray oscilloscope	5

LIGHT

1. Reflection - Mirrors	5
2. Refraction - Prisms and Lenses	3
3. Telescope	5
4. Microscope	2
5. Wave Theory	5
6. Spectrum (Electro magnetic)	X
7. X-rays	5
8. Spectrometer	4
9. Polarimeter	3
10. Phosphorescence and fluorescence	5

SOUND

1. Wave Motion	5
2. Amplitude	5
3. Wave Length	3
4. Velocity	5
5. Reflection	5
6. Frequency	5
7. Sonometers	5
8. Resonance	5

APPENDIX XXVIIIA

Answers to Questionnaire

Sample: Tees-side 111

Coatbridge 80

1. Distribution by College

College	1	2	3	4	5	6	Total
Tees-side	6	49	41	7	8		111
Coatbridge						80	80

2. Distribution by type of School

Type of School	Tees-side	Coatbridge
Modern	14	1
Technical	8	8
Grammar	86	64
Comprehensive	-	2
Public	3	5

NOTE: In the Scottish system the Junior Secondary and Senior Secondary Schools equate to the Modern and Grammar Schools respectively.

3. Number of G.C.E. '0' level subjects gained by each student.

No. of Subjects	Tees-side	Coatbridge
0	28	5
1	5	4
2	11	8
3	12	3
4	11	9
5+	44	51

NOTE: In the Scottish system S.C.E. '0' level equates to G.C.E. '0' level.

Number of G.C.E. 'A' level subjects gained by each student on Tees-side:

No. of Subjects	Tees-side
0	110
1	1

Number of S.C.E. 'Highers' gained by each student at Coatbridge:

No. of Subjects	Coatbridge
0	23
1	13
2	16
3	13
4	9
5+	6

NOTE: S.C.E. 'Highers' are taken one year after the '0' levels and are of a lower standard than G.C.E. 'A' levels.

4. Distribution by Job

Nature of Job	Tees-side	Coatbridge
Quality Control	84	60
Engineering Application	15	14
Development and/or Research	12	6

5. Job Selection

Selection	Tees-side	Coatbridge
While at School	51	55
Through Youth Emp. Officer	11	3
Parents' request	6	4
Only job available	43	18

6. Shift Working

Involvement	Tees-side	Coatbridge
Yes	67	32
No	44	48

Interference with Study

Interference	Tees-side	Coatbridge
Yes	34	13
No	33	19

Provision to accommodate shift-workers

in College

Provision	Tees-side	Coatbridge
Yes	38	0
No	29	32

7. Inclusion of Metallurgy subjects at early stage

Inclusion	Tees-side	Coatbridge
Yes	107	76
No	4	3

8. Course content too Academic (all students)

Content too Academic	Tees-side	Coatbridge
Yes	50	55
No	61	25

Course content too Academic
(S1, S2, S3 students only)

Content too Academic	Tees-side	Coatbridge
Yes	45	9
No	17	1

9. Sufficient time for assimilation of course content by day release

Sufficient	Tees-side	Coatbridge
Yes	38	35
No	73	45

APPENDIX XXVIIIB

Statistical Tests of Significance

6. Shift Working

Δ	Δ^2	O	E	O	E		$\Sigma\Delta^2/E$
9.47	89.68	67	57.53	32	41.47	99	1.559
9.47	89.68	44	53.47	48	38.53	92	2.163
		111		80		191	1.677
							2.328
				df = 1		χ^2 =	7.727

From Fisher's Chi-square table for $\chi^2 > 6.64$, $P < .01$.

i.e. the test is significant at less than 1%.

Shift working interfering with study

Δ	Δ^2	O	E	O	E		$\Sigma\Delta^2/E$
2.19	4.796	34	31.81	13	15.19	47	0.151
2.19	4.796	33	35.19	19	16.81	52	0.136
		67		32		99	0.316
							0.285
				df = 1		χ^2 =	0.908

Again from Fisher's Chi-square tables, since $\chi^2 < 3.84$

the test is not significant.

Provision to accommodate shift workers*

Fisher's exact Probability Test

38	0	38
29	32	61
67	32	99

Prob. of observed frequencies

$$= \frac{67!\ 61!\ 38!\ 32!}{99!\ 38!\ 32!\ 29!} \times \frac{1}{0!}$$

$$= .2243 \times 10^{-8}$$

Highly significant difference.

7. <u>Inclusion of Metallurgy at an early stage</u>*

107	76	183
4	3	7
111	79	190

Prob. of observed frequencies

$$= \frac{183!\ 111!\ 79!\ 7!}{190!\ 107!\ 76!\ 4!\ 3!}$$

$$= 0.299$$

Not significant.

8. <u>Course content too academic</u>

Δ	Δ^2	O	E	O	E		$\Sigma\Delta^2/E$
11.02	121.44	50	61.02	55	43.98	105	1.990
11.02	121.44	61	49.98	25	36.02	86	2.430
		111		80		191	2.761
							3.371

df = 1 $\chi^2 = 10.552$

From Fisher's Chi-square table it can be seen that since $\chi^2 > 6.64$ ($\chi^1 = 10.552$) <u>the test is significant</u>.

(The figures are so clearly above the significance level that there is no point in making Yate's correction.)

<u>Course content too academic - O.N.C. students only</u>*

45	9	54
17	1	18
62	10	72

Prob. of observed frequencies

$$= \frac{62!\ 54!\ 18!\ 10!}{72!\ 45!\ 17!\ 9!}$$

$$= .179$$

Not significant.

9. Sufficient time to study

Δ	Δ^2	O	E	O	E		$\Sigma\Delta^2/E$
4.42	19.536	38	42.42	35	30.58	73	0.4605
4.42	19.536	73	68.58	45	49.42	118	0.6390
		111		80		191	0.2849
							0.3953
				df = 1		χ^2 =	1.7797

From Fisher's Chi-square table it can be seen that since

$\chi^2 < 3.84$ ($\chi^2 = 1.7797$) the test is not significant at 5%.

* Sir Ronald Fisher's statistical methods

for research workers - p.96.

MATHEMATICS

TOPIC	Actual No. of Questionnaires									Answers Expressed as % of Total									Answers Expressed as % of Topics Studied.						
	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5
Tees-side Answers																									
Mensuration	29	17	46	11	14	34	48	6	54	26	15	41	10	13	31	44	5	49	28	15	44	10	13	33	46
Algebra	12	22	34	17	18	42	60	0	60	11	20	31	15	16	38	54	0	54	11	20	31	15	16	38	54
Geometry	11	6	17	16	19	58	77	1	78	10	5	15	14	17	53	70	1	71	10	5	15	14	17	54	71
Trigonometry	11	12	23	13	16	57	73	2	75	10	11	21	12	14	52	66	1	67	10	11	21	12	14	53	67
Differential Calculus	7	8	15	10	12	44	56	30	86	6	7	13	9	11	40	51	27	78	9	10	19	12	15	54	69
Integral Calculus	6	9	15	5	11	45	56	35	91	5	8	13	5	10	41	51	31	82	8	12	20	7	14	59	73
Partial Differentiation	2	5	7	5	11	42	53	46	99	2	5	7	5	10	38	48	40	88	3	8	11	8	16	65	81
Co-ordinate Geometry	3	1	4	2	6	26	32	73	105	3	1	4	2	5	24	29	65	94	8	3	11	5	16	68	84
Coatbridge Answers																									
Mensuration	30	9	39	9	6	9	15	17	32	38	11	48	11	8	11	19	21	40	48	14	62	14	10	14	24
Algebra	16	17	33	18	12	15	27	2	29	20	21	41	22	15	19	34	3	37	20	22	42	23	15	20	35
Geometry	7	17	24	14	17	22	39	3	42	9	21	30	17	21	28	44	4	48	9	22	31	18	22	29	51
Trigonometry	7	18	25	19	13	20	33	3	36	9	22	31	24	16	25	41	4	45	9	23	32	25	17	26	43
Differential Calculus	4	10	14	9	18	33	53	6	59	5	13	18	11	22	41	63	8	71	5	13	18	12	25	45	70
Integral Calculus	4	12	16	8	14	37	51	5	56	5	16	21	10	17	46	63	6	69	5	16	21	11	19	49	68
Partial Differentiation	0	6	6	6	13	42	55	13	68	0	8	8	8	16	52	68	16	84	0	9	9	9	19	63	82
Co-ordinate Geometry	0	3	3	5	9	36	45	27	72	0	4	4	6	11	45	56	34	90	0	6	6	9	17	68	85

INORGANIC CHEMISTRY

Tees-side Answers

TOPIC	Actual No. of Questionnaires									Answers Expressed as % of Total									Answers Expressed as % of Topics Studied						
	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5
Study of Water	13	15	28	14	17	36	53	16	69	12	13	26	13	15	32	47	15	62	14	16	30	15	18	37	55
" " Halogens	9	7	16	15	16	46	62	18	80	8	6	14	13	15	42	57	16	73	10	8	18	16	17	49	66
Phosphorus & Comps.	14	18	32	27	18	20	38	14	52	13	16	29	24	16	18	34	13	47	14	19	33	28	19	20	39
Sulphur & Compounds	15	20	35	32	17	16	33	11	44	14	18	32	28	15	15	30	10	40	15	20	35	32	17	16	33
Nitrogen & Compounds	8	10	18	25	23	32	55	13	68	7	9	16	22	21	29	50	12	62	8	10	18	26	23	33	56
Manufacture of Na_2Co_3	4	7	11	10	12	59	71	19	90	4	6	10	9	11	53	64	17	81	4	8	12	11	13	64	77
$NaHCo_3$	3	5	8	11	14	60	74	18	92	2	4	6	10	13	55	68	16	84	3	5	8	12	15	65	80
NH_3	4	5	9	14	16	56	72	16	88	3	4	7	13	15	50	65	15	80	4	5	9	15	17	59	76
HNo_3	3	6	9	16	16	52	68	18	86	2	4	6	15	15	48	63	16	79	3	6	9	17	17	57	74
HCl	5	8	13	19	17	44	61	18	79	4	7	11	17	15	41	56	16	72	5	9	14	20	18	48	66
H_2So_4	6	6	12	20	21	41	62	17	79	5	5	10	18	19	36	55	15	70	6	6	12	21	22	45	77
Graphite	9	10	19	10	13	44	57	25	82	8	9	17	9	11	40	51	23	74	10	12	22	12	15	51	66
Glass	4	6	10	5	11	60	71	25	96	3	5	8	4	10	55	65	23	88	5	7	12	6	13	69	82
CS_2	2	4	6	8	9	59	68	29	97	2	4	6	7	8	53	61	26	87	2	5	7	10	11	72	83

Coatbridge Answers

TOPIC	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5
Study of Water	11	13	24	16	10	25	35	5	40	14	16	30	20	12	32	44	6	50	15	17	32	21	13	34	47
" " Halogens	4	15	19	17	16	27	43	1	44	5	19	24	21	20	34	54	1	55	5	19	24	21	20	35	55
Phosphorus & Comps.	14	19	33	13	12	15	27	7	34	17	24	41	16	15	20	35	8	43	19	26	45	17	16	22	38
Sulphur & Compounds	17	20	37	14	12	14	26	3	29	21	25	46	17	15	17	32	4	36	22	26	48	18	15	18	33
Nitrogen & Compounds	15	20	35	9	14	20	34	2	36	19	25	44	11	17	25	42	3	45	20	26	46	11	17	26	43
Manufacture of Na_2Co_3	1	9	10	5	21	41	62	3	65	1	11	12	6	26	52	78	4	82	1	11	12	6	27	55	82
$NaHCo_3$	1	8	9	5	23	38	61	5	66	1	10	11	6	29	48	77	6	83	1	11	12	6	31	51	82
NH_3	3	6	9	12	20	37	57	2	59	4	7	11	15	25	46	71	3	74	4	7	11	15	26	48	74
HNo_3	3	11	14	10	21	33	54	2	56	4	14	18	12	26	41	67	3	70	4	14	18	12	27	43	70
HCl	3	12	15	10	20	32	52	3	55	4	15	19	12	25	40	65	4	69	4	16	20	12	26	42	68
H_2So_4	3	12	15	11	19	33	52	2	54	4	15	19	14	24	40	64	3	67	4	15	19	14	25	42	77
Graphite	8	8	16	7	11	32	43	14	57	10	10	20	9	14	40	55	17	72	12	12	24	11	17	48	67
Glass	1	5	6	5	12	38	50	19	69	1	6	7	6	15	48	63	24	87	2	8	10	8	19	63	82
CS_2	0	5	5	3	17	37	54	18	72	0	6	6	4	21	46	77	23	100	0	8	8	5	27	60	87

PHYSICAL CHEMISTRY

TOPIC	Actual No. of Questionnaires									Answers Expressed as % of Total									Answers Expressed as % of Topics Studied						
	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5

Tees-side Answers

TOPIC	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5
<u>THEORY</u>																									
Chemical Equilibrium	14	10	24	12	21	41	62	13	75	13	9	22	11	19	36	55	12	67	14	10	24	12	21	43	64
Electro Chemistry	14	13	27	14	30	33	63	7	70	13	12	25	13	27	29	56	6	62	13	13	26	13	29	32	61
Thermo Chemistry	18	11	29	16	23	26	49	17	66	16	10	26	15	21	23	44	15	49	19	12	31	17	24	28	52
Osmosis	0	3	3	2	6	68	74	32	106	0	3	3	2	5	61	66	29	95	0	4	4	3	8	85	93
<u>PRACTICAL</u>																									
Det. of V.D.	4	5	9	10	11	71	82	10	92	4	5	9	9	10	63	73	9	82	4	5	9	10	11	70	81
Elevation of B.P.	4	9	13	11	18	56	74	13	87	4	8	12	10	16	50	66	12	78	4	9	13	11	18	58	76
Depression of F.P.	5	7	12	10	18	55	73	16	89	5	6	11	9	16	49	65	15	80	5	7	12	10	19	59	78
Heat of Neutralisation	4	7	11	10	14	58	72	18	90	4	6	10	9	13	52	65	16	81	4	8	12	11	15	62	77
Det. of Elect. Cond.	7	14	21	21	20	40	60	9	69	6	13	19	19	18	36	54	8	62	7	14	21	21	20	38	58
" " Molecular Wt.	9	17	26	15	16	49	65	5	70	8	15	23	14	15	41	56	5	61	8	16	24	14	15	47	62
" " Transition Pts.	8	8	16	7	14	39	53	35	88	7	7	14	6	13	35	48	32	80	11	11	22	9	18	51	69
Potentiometric Tit.	10	11	21	6	6	42	48	36	82	9	10	19	5	5	38	43	33	76	13	15	28	8	8	56	64

Coatbridge Answers

TOPIC	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5
<u>THEORY</u>																									
Chemical Equilibrium	24	12	36	11	7	18	25	8	33	30	15	45	14	9	22	31	10	41	34	17	41	15	10	35	45
Electro Chemistry	15	17	32	12	8	14	22	14	36	19	21	40	15	10	17	27	18	45	22	25	47	18	12	21	33
Thermo Chemistry	22	13	35	9	4	10	14	22	36	28	16	43	11	5	12	17	28	45	38	22	60	16	7	17	24
Osmosis	2	10	12	6	8	27	35	27	62	2	12	14	8	10	34	44	34	78	4	19	23	11	15	51	66
<u>PRACTICAL</u>																									
Det. of V.D.	4	14	18	10	16	34	50	2	52	5	18	23	12	20	43	63	2	65	5	18	23	13	21	45	66
Elevation of B.P.	6	9	15	12	13	30	43	10	53	7	11	18	15	16	39	55	12	67	9	13	22	17	19	42	61
Depression of F.P.	6	12	18	9	13	30	43	10	53	7	15	22	11	16	39	55	12	67	9	17	26	13	19	42	61
Heat of Neutralisation	6	15	21	12	6	21	27	20	47	7	19	26	15	7	27	34	25	59	10	25	35	20	10	35	45
Det. of Elect. Cond.	6	11	17	14	14	26	40	9	49	7	14	21	18	18	32	50	11	61	8	16	24	20	20	36	56
" " Molecular Wt.	26	13	39	11	13	16	29	1	30	33	16	49	14	16	20	36	1	37	34	16	50	14	16	20	36
" " Transition Pts	16	10	26	8	8	27	35	11	46	20	12	32	10	10	34	44	14	58	23	14	37	12	12	39	51
Potentiometric Tit.	18	9	17	10	5	17	22	21	43	23	11	34	12	6	21	27	27	54	31	15	46	17	8	29	37

PHYSICS-HEAT

TOPIC	Actual No. of Questionnaires									Answers Expressed as % of Total									Answers Expressed as % of Topics Studied						
	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5
Tees-side Answers																									
Charles' Law	7	5	12	12	25	57	82	5	87	6	5	11	11	23	50	73	5	78	7	5	12	11	23	54	77
Spec. & Latent Heat	8	9	17	21	22	50	72	1	73	7	8	15	19	20	45	65	1	66	7	8	15	19	20	46	66
Mech. Equiv. of Heat	10	5	15	17	18	57	75	4	79	9	5	14	15	16	51	67	4	71	9	5	14	16	17	53	70
Vapour Pressure	6	5	11	10	21	62	83	7	90	5	5	10	9	19	56	75	6	81	6	5	11	10	20	59	79
Dew Pt. & Humidity	4	7	11	5	12	67	79	16	95	4	6	10	5	11	59	70	15	85	4	7	11	5	13	71	84
Liquefaction	5	5	10	11	18	53	71	19	90	5	5	10	10	16	47	63	17	80	5	5	10	12	19	59	78
Coatbridge Answers																									
Charles' Law	13	14	27	12	8	32	40	1	41	16	17	33	15	10	41	51	1	52	16	17	33	15	10	42	52
Spec. & Latent Heat	16	19	35	14	8	23	31	0	31	20	24	44	17	10	29	39	0	39	20	24	44	17	10	29	39
Mech. Equiv. of Heat	14	16	30	11	12	26	38	1	39	17	20	37	14	15	34	49	1	50	17	20	37	14	15	35	50
Vapour Pressure	9	12	21	19	15	24	39	1	40	11	15	26	24	19	30	49	1	50	11	15	26	24	19	31	50
Dew Pt. & Humidity	3	4	7	2	11	36	47	23	70	4	5	9	2	14	46	60	29	89	5	7	12	4	19	65	84
Liquefaction	3	11	14	10	11	33	44	12	56	4	14	18	12	14	41	55	15	70	4	16	20	15	16	49	65

PHYSICS — MECHANICS

TOPIC	Actual No. of Questionnaires									Answers Expressed as % of Total									Answers Expressed as % of Topics Studied						
	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5
Tees-side Answers																									
Work, Energy & Power	12	9	21	25	17	45	62	3	65	11	8	19	23	15	40	55	3	58	11	8	19	24	15	42	57
Levers, Simple machines	12	8	20	17	22	48	70	4	74	11	7	18	15	20	43	63	4	67	11	7	19	15	21	45	66
Force	10	10	20	12	25	51	76	3	79	9	9	18	11	23	45	68	3	71	9	9	18	11	24	47	71
Pressure in fluids	5	13	18	7	27	51	78	8	86	5	12	17	6	25	45	70	7	77	5	14	19	6	26	49	75
Boyle's Law	5	6	11	11	26	60	86	3	89	5	5	10	10	24	53	77	3	80	5	5	10	10	25	55	80
Archimedes' Principle	8	9	17	13	11	62	73	8	81	7	8	15	12	10	56	66	7	73	8	9	17	12	10	61	71
Surface Tension	6	8	14	12	25	54	79	6	85	5	7	12	11	23	49	72	5	75	6	8	14	11	24	51	75
Dynamics	4	10	14	10	15	56	71	16	87	4	9	13	9	14	49	63	15	78	4	10	14	10	16	59	75
Coatbridge Answers																									
Work, Energy & Power	14	16	30	13	12	24	36	1	37	17	20	37	16	15	31	46	1	47	17	20	37	16	15	32	47
Levers, Simple machines	16	13	29	13	12	26	38	-	38	20	16	36	16	15	33	48	-	48	20	16	36	16	15	33	48
Force	16	10	26	16	11	25	36	2	38	20	12	32	20	14	32	46	2	48	20	12	32	20	14	34	48
Pressure in fluids	15	11	26	12	9	30	39	3	41	18	14	32	15	11	39	50	3	53	19	14	33	15	11	41	52
Boyle's Law	13	12	25	11	12	32	41	-	41	16	15	31	14	15	40	55	-	55	16	15	31	14	15	40	55
Archimedes' Principle	10	11	21	7	16	35	51	1	52	12	14	26	9	20	44	64	1	65	12	14	26	9	20	45	65
Surface Tension	7	12	19	10	12	30	42	9	51	9	15	24	12	15	40	55	9	64	10	17	27	14	17	42	59
Dynamics	12	10	22	11	14	30	44	3	47	15	12	27	14	17	39	56	3	59	15	12	27	14	18	41	59

PHYSICS — ELECTRICITY AND MAGNETISM

TOPIC	Actual No. of Questionnaires									Answers Expressed as % of Total									Answers Expressed as % of Topics Studied						
	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5
Tees-side Answers																									
Magnetic Effect	13	10	23	12	23	49	72	4	76	12	9	21	11	21	44	65	3	70	12	9	21	11	21	47	68
Elect. power & energy	15	13	28	17	21	41	62	4	66	14	12	26	15	19	37	56	3	59	14	12	26	15	19	40	59
Electrolysis	12	7	19	22	21	47	68	2	70	11	6	17	20	19	43	52	1	53	11	6	17	20	19	44	53
Static Electricity	6	6	12	5	24	61	70	9	79	5	5	10	4	22	56	78	8	86	6	6	12	5	24	59	83
Current Electricity	12	13	25	18	27	39	66	2	68	11	12	23	16	25	35	60	1	63	11	12	23	16	25	36	61
Electrical Measurement	25	28	53	20	18	18	36	2	38	23	26	49	18	16	16	32	1	33	23	26	49	18	16	17	33
Photoelectric and Thermionic effect	11	9	20	9	11	43	54	28	72	10	8	18	8	10	38	48	26	74	13	11	24	11	13	52	65
Cathode ray oscilloscope	7	7	14	11	9	46	55	31	84	6	6	12	10	8	42	50	28	78	9	9	18	14	11	57	68
Coatbridge Answers																									
Magnetic Effect	17	10	27	14	13	24	37	2	39	21	12	33	18	16	31	47	2	49	22	12	34	18	16	32	48
Elect.power & energy	13	12	25	11	18	22	40	4	44	16	15	31	14	22	28	50	5	55	17	16	33	14	23	30	53
Electrolysis	18	15	33	13	14	18	32	2	34	22	19	41	16	18	23	41	2	43	23	19	42	16	18	24	42
Static Electricity	3	11	14	8	14	35	49	9	58	4	14	18	10	18	43	61	11	72	4	15	19	11	15	55	70
Current Electricity	13	13	26	12	18	21	39	3	42	16	16	32	15	22	27	49	4	53	17	17	34	15	23	28	51
Electrical Measurement	31	18	51	6	11	11	22	3	25	39	22	61	7	14	14	28	4	32	41	24	65	7	14	14	28
Photoelectric and Thermionic effect	12	15	27	10	12	17	39	14	43	15	19	34	12	15	31	46	18	64	18	23	41	15	18	26	44
Cathode ray oscilloscope	13	8	21	10	8	21	29	20	49	16	10	26	12	10	27	37	25	62	22	13	35	13	17	35	52

PHYSICS — LIGHT

TOPIC	Actual No. of Questionnaires									Answers Expressed as % of Total									Answers Expressed as % of Topics Studied						
	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5
Tees-side Answers																									
Reflection	3	2	5	7	15	82	97	2	99	3	2	5	6	14	73	87	2	89	3	2	5	6	14	75	89
Refraction	5	2	7	17	19	66	85	2	87	5	2	6	15	17	60	77	2	79	5	2	6	15	17	62	79
Telescope	2	2	4	8	11	84	95	4	99	2	2	4	7	10	75	85	4	89	2	2	4	7	11	78	89
Microscope	27	26	53	21	12	22	34	3	37	25	24	49	19	11	18	29	3	32	26	25	51	20	11	18	29
Wave Theory	5	6	11	6	12	60	72	22	94	5	5	10	5	11	54	65	20	85	5	7	12	7	13	66	79
Spectra	7	9	16	10	17	58	75	10	85	6	8	15	9	15	52	67	9	76	7	9	16	10	17	57	74
X-rays	14	11	25	14	22	38	60	12	72	13	10	23	13	20	33	53	11	64	14	11	25	14	22	39	61
Spectrometer	15	9	24	16	17	41	58	13	71	14	8	22	15	15	36	51	12	63	15	9	24	16	17	43	60
Polarimeter	7	3	10	10	6	49	53	36	89	6	3	9	9	5	44	49	33	82	9	4	13	13	8	66	74
Phosphorescence and fluorescence	5	3	8	9	7	58	65	29	94	4	3	7	8	6	53	59	26	75	6	4	10	11	9	60	69
Coatbridge Answers																									
Reflection	10	17	27	9	9	26	35	9	44	12	21	33	11	11	34	44	11	55	14	24	28	13	13	56	69
Refraction	13	10	23	12	10	26	36	9	45	16	12	28	15	12	34	46	11	57	18	14	32	17	14	37	51
Telescope	10	7	17	11	7	37	44	8	52	12	9	21	14	9	46	55	10	65	14	10	24	15	10	51	61
Microscope	37	11	48	9	5	10	15	8	23	46	14	60	11	6	13	19	10	29	52	14	66	13	7	12	19
Wave Theory	7	10	17	16	7	25	32	15	47	9	12	21	20	9	32	41	18	59	11	15	26	25	11	38	49
Spectra	20	13	33	12	6	18	24	11	35	25	16	41	15	8	22	30	14	44	29	19	48	17	9	26	34
X-rays	22	8	30	8	5	18	23	19	42	27	10	37	10	6	23	29	24	53	36	13	49	13	8	30	38
Spectrometer	25	9	34	11	5	19	24	11	35	31	11	42	14	6	24	30	14	44	27	13	40	16	6	28	34
Polarimeter	6	9	15	13	11	22	33	19	52	7	11	18	16	14	17	31	24	55	10	15	25	21	18	36	54
Phosphorescence and fluorescence	6	7	13	10	12	20	32	25	57	7	9	16	12	15	26	41	31	72	11	12	23	14	29	34	63

PHYSICS — SOUND

Tees-side Answers

TOPIC	Actual No. of Questionnaires									Answers Expressed as % of Total									Answers Expressed as % of Topics Studied						
	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5
Wave Motion	3	5	8	6	7	74	81	16	97	3	5	8	5	6	66	72	15	87	3	5	8	6	7	79	86
Amplitude	2	4	6	4	6	73	79	22	101	2	4	6	4	5	65	70	20	90	2	5	7	5	7	81	88
Wave Length	3	5	8	5	11	73	84	14	98	3	5	8	5	10	64	74	13	87	3	5	8	5	11	76	87
Velocity	3	5	8	6	12	72	84	13	97	3	5	8	5	11	64	74	12	86	3	5	8	6	12	74	86
Reflection	3	4	7	6	14	72	86	12	98	3	4	7	5	13	64	77	11	88	3	4	7	5	13	75	88
Frequency	3	5	8	6	14	66	80	17	97	3	5	8	5	13	59	72	15	87	3	5	8	5	14	73	87
Sonometers	2	3	5	6	4	69	73	27	100	2	3	5	5	4	61	65	25	90	3	4	7	8	5	80	85
Resonance	1	3	4	5	8	71	79	25	104	1	3	4	4	7	62	69	23	92	1	4	5	6	10	79	89

Coatbridge Answers

TOPIC	Actual No. of Questionnaires									Answers Expressed as % of Total									Answers Expressed as % of Topics Studied						
	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5	X	4+5+X	1	2	1+2	3	4	5	4+5
Wave Motion	7	4	11	3	7	23	30	36	66	9	5	14	4	9	28	37	45	82	16	9	25	7	16	52	68
Amplitude	4	7	11	2	9	22	31	36	67	5	9	14	2	11	28	39	45	84	9	16	25	5	20	50	70
Wave Length	6	6	12	4	7	21	28	36	64	7	7	14	5	9	27	36	45	81	14	14	28	9	16	49	65
Velocity	4	7	11	5	6	22	28	36	64	5	9	14	6	7	28	35	45	80	9	16	25	11	14	50	64
Reflection	6	5	11	4	5	24	29	36	65	7	6	13	5	6	31	37	45	82	14	11	25	9	11	55	66
Frequency	6	7	13	2	6	24	30	35	65	7	9	16	2	7	31	38	44	82	13	16	29	4	13	54	67
Sonometers	2	5	7	3	9	21	30	40	70	2	6	8	4	11	27	38	50	88	5	12	12	7	22	59	81
Resonance	2	5	7	3	7	16	33	47	77	2	6	8	4	8	21	29	59	88	6	15	21	9	21	49	70