society of dyers and colourists

Study Guide:

6th Edition

Diploma Examinations for the Associateship and Licentiateship of the Society of Dyers and Colourists

A Chartered Society since 1963

Contents

Preface to the 6th Edition

The aims of the 6th Edition are:

1. To bring the Study Guide up to date by ensuring that it covers the requirements of all candidates irrespective of the sector of the colour industry in which they are employed,
2. Incorporation of advances in technology and science that the examiners have chosen to bring forward, and
3. To incorporate and explain the changes in the method of assessing the abilities of candidates.

Reading lists have been closely scrutinised, amended and much reduced so as to make them more realistic. For each of the lists given, other texts may be available that may be more conveniently obtained by the candidates. Textbooks published by the Society under the auspices of the Dyers' Company Publications Trust are recommended to candidates. Valuable sources of information covering a wide range of coloration topics have appeared in the volumes of the Society's publication *Review of Progress in Coloration*, which is available on-line via the Society's website.

Distance learning packages have been listed. This form of learning supplements the traditional pattern of lectures, tutorials and textbooks. As educational establishments rationalise their courses, and industrial centres move geographically, candidates have increasing difficulties in attending formally structured lectures. The text-based self-study modules will assist candidates to overcome such difficulties. Further, tutorial support may be provided by the Society.

The Examinations, Qualifications and Accreditation Board emphasises that candidates aspiring to Society awards should have a good underpinning knowledge of mathematics, physics and chemistry. To assist, the Society has available a text-based programme of self-study consisting of modules relating to physics, mathematics and organic chemistry required to support coloration technology. Likewise candidates should have a working knowledge of the application of computer skills.

Diploma Examinations of the Society of Dyers and Colourists

Introduction

The award of the diplomas of Associateship (ASDC) and Licentiateship (LSDC) provides evidence that the holder is well qualified as a professional practitioner in the science and technology of coloration. The awards are recognised as an indication of a high standard of knowledge, competence, experience and judgement in the recipient. It is the strong desire and intention of the Society to maintain and even improve the high reputation that the qualifications have already secured and to promote further their widespread recognition through all coloration industries.

Examination Scheme

Ever since the inception of the Associateship award in 1954 it has been traditional for candidates aspiring to achieve the qualification to sit time-restricted unseen examination papers. Many awarding organisations have gradually changed this form of assessment such that group projects, open-book examinations, and dissertations have been used to replace unseen written papers. To maintain parity with current educational practice, the Education, Qualification and Accreditation Board of the Society has agreed that candidates may submit a dissertation as part of the overall assessment for Associateship and Licentiateship. The examinations will be held in May each year.

Conduct of Studies

The Society wishes to emphasise that at this advanced stage in the education of candidates, it does not consider the presentation of rigid syllabi to which they must adhere is either helpful or desirable. Further, the Society does not regard formal courses of instruction or short residential courses as complete and self-sufficient preparation for the examination. Both diplomas signify professional distinction, the hallmarks of which are the ability to use technical knowledge constructively, a readiness to assume responsibility, and the faculty of independent analysis and judgement.

The following pages are intended to be used as a guide, directing attention to what are considered to be important topics in a particular field of study and to give some indication of useful literature that can be expected to deal with them. They are not intended to be exhaustive or to absolve candidates from the necessity of exercising their own initiative.

Candidates should keep abreast of recent and current developments. Textbooks by themselves are inadequate for this purpose. The Society's own journal, *Coloration Technology* (and the previous *Journal*), and the *Review of Progress in Coloration and Related Topics* should be consulted frequently. The industry is well served by a number of technical periodicals and trade publications. Their reviews and digests can often be a source of relevant information. The habit of regular consultation of the wide range of literature should be cultivated. At this stage of their careers, many candidates hold exacting and responsible jobs, liable at times to interfere with their regular studies. All may consider success in the examinations as evidence not merely of scholastic achievement, but also of initiative, patience and determination. In many cases, prospective candidates may be well advised to minimise the prospect of failure by avoiding premature entrance to the examinations and delaying until they are reasonably assured of success.

The Written Examinations

Candidates are advised to pay attention to the following comments on examination technique.

1. Read each question carefully before commencing to write, making sure that the intentions and requirements of the examiner have been understood.
2. Do not attempt to gain marks by giving related information because you cannot provide that demanded by the question.
3. Many questions at this level call for discussion and critical comment. Recapitulation of memorised notes is not likely to impress the examiner.
4. Plan the answer before committing it to paper.
5. Write legibly. There are limits to the patience of all examiners, who may have many scripts to read. Examiners welcome clear and grammatical English, concise presentation and, where appropriate, tabulation.
6. Leave a little time for checking mathematical calculations.
7. If diagrams are needed, take care over them and be sure that they are sufficiently accurate to illustrate your point.
8. An essay demands an introduction, a main theme and a conclusion. Practice for this type of question is very important. At the same time you can train yourself to write legibly.

Examination requirements for admission to the Associateship

Candidates for the Associateship must:

(a) pass examinations in the following four core subject areas:

Paper 1: Colour Physics
Paper 2: Chemistry (Structural and Physical) of Dyes, Pigments and Auxiliary Chemicals used in Technological Processes
Paper 3: Chemistry (Structural and Physical) of Polymers
Paper 4: Industrial Organisation and Management.

and

(b) Either:

(i) pass examinations in:

Paper 5: Wet Processing of Natural Fibres and Regenerated Cellulosic Fibres
Paper 6: Wet Processing of Synthetic Fibres and Fibre Blends

or

(ii) submit a dissertation on an approved topic

Examination requirements for admission to the Licentiateship

Candidates for the Licentiateship must:

(a) pass the examinations in any three of the Papers 1 – 6,

or

(b) pass the examination in any one of the Papers 1 -4 and submit a dissertation on an approved topic.

Further requirements for admission as a Chartered Colourist

A Chartered Colourist shall:

(a) be an Associate or Fellow of the Society at the time of application.
(b) have established themselves in an approved occupation in one or more branches of colour science or technology for a minimum period of two years subsequent to attaining one of the qualifications above.
(c) have submitted his/her application on the official form obtainable from the Society.
(d) have paid the prescribed fees.
(e) have satisfied the Trustee Board that he/she has the required status.
(f) have demonstrated at interview his/her professional competence in applying his/her knowledge of colour.

Members in possession of Chartered Colourist status shall be required to maintain their status by undertaking a minimum of 30 hours per annum of Continuing Professional Development (CPD) per annum. Failure to submit a completed CPD record on an annual basis when renewing membership will result in the status of Chartered Colourist being removed. More details of the requirements of CPD are available on the Society's website www.sdc.org.uk

Paper 1: Colour Physics

Colour Vision and the Perception of Colour Appearance

1. Physiology of colour vision with particular reference to visual colour-matching ability and the assessment of colour difference; the nature, cause and diagnosis of defective colour vision.
2. Visual perception of whiteness, visual effects of fluorescent materials.
3. Nature and explanation of chromatic adaptation and the effect of colour constancy.
4. Nature and explanation of the simultaneous contrast between neighbouring colours and the assimilation of the colours within a design.
5. Nature and explanation of metamerism.

Creation of Colour

1. Relationships between the light emission spectra, light absorption spectra and the light reflection spectra of a material and its colour.
2. Additive colour mixing by the use of coloured lights; subtractive colour mixing of dye solutions and pigmented materials.

Methods of Colour Specification

1. Systems of colour description and specification; colour atlases; e.g. the Munsell system and the NCS system.
2. Principles of the CIE XYZ tristimulus system, including definitions of the standard observer, illuminating and viewing conditions, chromaticity diagram.
3. Calculation of CIE tristimulus values from reflectance data.
4. The CIE $L^*a^*b^*$ and colour space and its transformation into CIE $L^*C^*h^\circ$ coordinates.
5. One-dimensional colour scales, grey scales, yellowness index, whiteness indices, metamerism index and colour rendering index.

Spectrophotometry and Reflectometry

1. Principles of construction and operation of absorptiometers and transmission spectrophotometers for use in the visible regions of the electromagnetic spectrum.
2. Reflection spectrophotometry, diffuse and specular reflection, optical layout of reflection devices, gloss traps.
3. Other instrumental methods of colour measurement, e.g. tristimulus colorimeters.
4. Instruments for measuring fluorescent materials.
5. Checking the performance of colour measuring instruments.

Colour Measurement and its Application

1. Instrumental methods of colour-difference assessment using the CIE $D E^*$ equation and colour difference splitting.
2. Use of instrumental methods for colour passing and for colour sorting.
3. Use of colour measurement for assessing the degree of fastness.
4. Optimised colour-difference equations using CMC, CIE94 and CIEDE2000 as examples.

Interaction of Light with Materials

1. Laws of light absorption in solutions (Beer–Lambert); deviation from Beer's Law due to instrumental and solution factors. Analysis of mixtures.
2. Laws of light absorption and scattering in opaque materials (Kubelka–Munk); deviations due to instrumental and other factors; dyed materials, pigmented materials and fibre blends.
3. Fluorescence theory with particular reference to the use of fluorescent brighteners in textiles, paper and plastics.
4. Use of the Kubelka–Munk relation in the quantitative analysis of the tinting strength of dyes and of pigmented colorant materials.
5. Principles of instrumental or computer colour matching, recipe prediction including correction equations.

Reproduction of Coloured Designs and Coloured Images

1. Analysis of coloured images by scanners and digital cameras.
2. Reproduction of coloured images by visual display systems.
3. Reproduction of coloured images by printing.

Candidates may be asked to carry out simple numerical and/or graphical exercises based on the above study guide. Some practice in exercises of this kind should therefore be sought whenever possible.

Distance Learning

The Society of Dyers and Colourists has available a range of 6 SDC e-Learning Modules. Module 1 covers the subject matter of this paper and is entitled 'Colour Physics'. It can be obtained from the Society's office either individually or as a complete set of 6 modules.

Reading List

- R W G Hunt and M R Pointer, *Measuring colour*, 4th Edn, (Chichester, John Wiley & Sons, 2011) ISBN 978 1 119 97537 3
- R S Berns, *Billmeyer and Saltzman's principles of colour technology*, 3rd Edn (New York: Wiley, 2000) ISBN 0 471 19459 X.
- *Colour physics for industry*, 2nd Edn, Ed. R McDonald (Bradford: SDC, 1997) ISBN 0 901956 70 8.
- R G Kuehni, *Color: an introduction to practice and principles* (New York: Wiley, 1997) ISBN 0 471 114566 1.
- R H Wardman, *An update on numerical problems in colour physics*, Review of Progress in Coloration, Vol 24 p55 1994

Paper 2: Chemistry (Structural and Physical) of Dyes, Pigments, and Auxiliary Chemicals Used in Technological Processes

Classification of Colorants

1. Classification of colorants according to the *Colour Index* (3rd Edition in book form, 4th Edition in electronic form).
2. Sources, chemistry and structure of the major classes of colorant.
3. Colour gamut associated with each structural class and with each application class based upon it (i.e. acid, metal-complex, direct, basic, disperse, vat, sulphur, azoic, chrome, reactive dyes, and pigments).
4. Commercial importance and technical characteristics of each sub-group (e.g. azo, anthraquinone, etc.).

Note: Some azo colorants are more strictly described as 'hydrazone', which is the tautomeric form of the azo structure.

Properties and Structure

1. Molecular structure of the major chemical and application classes of colorants in relation to their colour, substantivity, application behaviour and end-use properties (e.g. fastness properties, blooming of pigments in certain substrates, etc.).
2. Physical characteristics, with particular reference to dissolving and dispersing; the stability and other (e.g. rheological) characteristics of solutions and dispersions in storage and use, according to the particular technology involved (e.g. textile coloration, paper coloration and paint technology).

Diazotisation and Coupling

1. Chemistry of diazotisation and coupling.
2. Influence of the chemical structures of the components on the diazotisation and coupling conditions and processes.
3. Tautomerism.
4. The particular importance of azo colorants.
5. Essential chemistry of the formation of anthraquinone and polycyclic colorants.

Metal-complexes

1. Chemistry and properties of organometallic coordination compounds (metal chelates) with particular reference to colorants.

Reactive Systems

1. Substrate-reactive dyes: chemistry, structure and properties of the different types.
2. Behaviour of typical reactive systems in application.
3. Properties of substrates coloured by reactive dyes, e.g. fastness, stability of the dye-substrate bond.

Pigments

1. Organic and inorganic pigments suitable for various end uses.
2. Relationship of chemical structure and physical form to optical properties and to application, including, for example, mass pigmentation and resin-bonded systems.

Surface-Active Agents

1. Chemistry and physics of surface activity and surface-active agents.
2. Molecular design of typical surface-active agents in relation to function (e.g. wetting, dispersing, complexing, levelling, detergency) with particular reference to hydrophobic–hydrophilic balance.

Other Auxiliary Chemicals

1. Chemistry and properties of other auxiliary chemicals (e.g. pH agents, complexing agents, electrolytes, protective agents, softeners, water/oil repellents, etc.).
2. Foam generation and defoaming agents.

Fluorescent Brightening Agents (FBAs)

1. Fluorescent brightening agents: chemical structure in relation to their absorption and emission characteristics, substantivity and application properties.

Oxidising and Reducing Agents

1. Oxidising and reducing agents: chemistry and properties, with particular reference to their use in coloration and associated processes.

Distance Learning

The Society of Dyers and Colourists has available a range of 6 SDC e-Learning Modules. Module 2 covers the subject matter of this paper and is entitled 'Chemistry of Colorants'. It can be obtained from the Society's office either individually or as a complete set of 6 modules.

Reading List

- *Colorants and Auxiliaries, 2nd Edition, Volume 1: Colorants* Ed. J Shore (Bradford SDC, 2002) ISBN 0 90156 77 5.
- *Colorants and Auxiliaries, 2nd Edition, Volume 2: Auxiliaries* Ed. J Shore (Bradford SDC, 2002) ISBN 0 90156 78 3.
- R M Christie, R R Mather and R H Wardman, *The chemistry of colour application* (Oxford: Blackwell, 2000)
- ISBN 0 632 04782 8.
- A T Peters and H S Freeman, *Physico-chemical principles of colour chemistry*, Vol. 4 (Dordrecht, Netherlands: Kluwer Academic, 1996) ISBN 0 7514 0210 9.
- W Herbst and K Hunger, *Industrial organic pigments* (New York: Wiley, 2004) ISBN 3 527 30576 9.
- *Industrial inorganic pigments*, 2nd Edn, Ed. G Buxbaum (New York: Wiley, 1999) ISBN 3 527 28878 3.
- A Reife and H S Freeman, *Environmental chemistry of dyes and pigments* (New York: Wiley, 1995) ISBN 0 471 58927 6.
- R F Conley, *Practical dispersion: a guide to understanding and formulating slurries* (New York: Wiley, 1996) ISBN 0 471 18640 6.
- H N Stein, *The preparation of dispersions in liquids* (New York: Marcel Dekker, 1995) ISBN 0 8247 9674 8.
- R B McKay, *Technological applications of dispersions* (New York: Marcel Dekker, 1994) ISBN 0 8247 9180 0.
- S D Christian and J F Scamehorn, *Solubilization in surfactant aggregates* (New York: Marcel Dekker, 1995) ISBN 0 8247 9099 5.
- D Stoye and W Freitag, *Paints, coatings and solvents*, 2nd Edn (New York: Marcel Dekker, 1999) ISBN 3 527 28863 5.
- S Paul, *Surface coatings: science and technology*, 2nd Edn (New York: Wiley, 1996) ISBN 0 471 95818 2.
- M Sainsbury, *Aromatic chemistry* (Oxford: OUP, 1992) ISBN 0 19 855674 8.
- P Sykes, *A guidebook to mechanism in organic chemistry*. 6th Edn (Upper Saddle River, NJ: Pearson, 1995) ISBN 0 582 44695 3.
- P Bamfield, *Chromic phenomena: technological applications of colour chemistry* (Cambridge: RSC, 2001) ISBN 0 85404 474 4.
- P Gregory, *High-technology applications of organic colorants* (Dordrecht, Netherlands: Kluwer Academic, 1991) ISBN 0 306 43637 X.
- *Chemistry and technology of the cosmetics and toiletries industry*, 2nd Edn, Ed. C Williams and W H Schmitt (Dordrecht, Netherlands: Kluwer Academic, 1996) ISBN 0 7514 0334 2.

In addition, some of the reading matter listed for polymer chemistry is relevant to coloration technology. Journals, particularly those pertaining to a particular discipline, are also a very useful source of information.

Paper 3: Chemistry (Structural and Physical) of Polymers

Basic Concepts of Polymer Science

1. Monomer, co-reactants, functionality.
2. Linearity, branching, crosslinking.
3. Interchain forces, crystallinity and orientation.
4. Chain length, end-groups, molecular mass.
5. Phase-transitions (T_g and T_m), segmental mobility.
6. Addition and condensation polymerisation.
7. Homo- and co-polymerisation.
8. Block, graft and alternating co-polymers.
9. Atactic, isotactic and syndiotactic polymers.
10. Thermoplastic, thermosetting, hydroplastic and elastomeric polymers.

Structure and Properties of Polymers

1. Polymer morphology; influence of chemical structure on interchain forces, crystallinity and phase transitions.
2. Structure-property relationships (e.g. effects of chain structure, inter-and intra-chain forces, crystallinity, crosslinking, molecular mass) on properties of polymers; distribution of molecular mass and related measurements.
3. Solution and dispersion properties of polymers (e.g. concepts of solubility parameters, flexibility of polymer chains in solutions, rheological properties of polymer solutions and dispersions, intrinsic viscosity as a measure of molecular mass); drying/curing properties of polymer solutions and dispersions.
4. Polymer degradation by thermal, chemical, photochemical, bacterial and mechanical agencies; influence of catalysts on chemical degradation; use of additives to protect polymers against degradation.

Industrial Polymers

1. Structural features, properties and applications of industrially important polymers, with special reference to their use in various technologies (e.g. fibres, plastics, elastomers, processing aids, finishes, surface-coatings)
2. Natural polymers (e.g. cellulose, proteins, rubber, starch, alginic acid, gums).
3. Modifications of natural polymers (e.g. regenerated celluloses, cellulose esters and ethers).
4. Synthetic polymers, including polyalkylenes, polydienes, polystyrene, polyvinyl, polyvinylidene and polyacrylic acid types; polyesters, polyamides, polyurethanes, aminoplasts, phenoplasts, epoxides, silicones and fluoropolymers.
5. Applications of the above polymers with reference to a particular technology. e.g. textiles, surface coatings.

Distance Learning

The Society of Dyers and Colourists has available a range of 6 SDC e-Learning Modules. Module 3 covers the subject matter of this paper and is entitled 'Polymers: Properties and Production'. It can be obtained from the Society's office either individually or as a complete set of 6 modules.

Reading List

- J W Nicholson, *The chemistry of polymers* (Cambridge: RSC, 1997) ISBN 0 85404 558 9.
- M P Stevens, *Polymer chemistry: an introduction*, 3rd Edn (Oxford: OUP, 1999) ISBN 0 19 512444 8.
- H-G Elias, *An introduction to polymer science* (New York: Wiley, 1999) ISBN 3 527 28790 6.
- R O Ebewele, *Polymer science and technology* (New York: CRC Press, 2000) ISBN 0 8493 8939 9.
- R J Young and P A Lovell, *Introduction to polymers*, 2nd Edn (Cheltenham: Nelson Thornes, 1991) ISBN 0 7487 5740 6.
- J M G Cowie, *Polymers: chemistry and physics of modern materials*, 2nd Edn (Cheltenham: Nelson Thornes, 1991) ISBN 0 7487 4073 2.
- J A Brydson, *Plastics materials* (Oxford: Butterworth-Heinemann, 1999) ISBN 0 750 64132 0.
- G Scott, *Polymers and the environment* (Cambridge: RSC, 1999) ISBN 0 85404 578 3.
- D J Walton and J P Lorimer, *Polymers* in Oxford Chemistry Primers (Oxford: OUP, 2000) ISBN 0 19 850389 X.
- R R Mather and R H Wardman, *The Chemistry of Textile Fibres*, (Cambridge: RSC Publishing, 2011) ISBN 978 1 84755 876 1.

In addition, some of the reading matter listed for colorant chemistry is relevant to polymer chemistry, particularly that dealing with surface chemistry, dispersants and other auxiliaries. Journals, particularly those pertaining to a particular discipline, are also very useful sources of information.

Paper 4: Industrial Organisation and Management

Candidates are encouraged to examine managerial problems in the light of their own experiences. However, there are dangers of relying exclusively on common sense in approaching and attempting to resolve those problems: decisions tend to be based on an individual's developing experience, which in turn depends on his/ her implicit theories of how to respond to a particular situation; these theories are also informed by personal values and beliefs.

Therefore, a systematic appreciation of the accepted principles of sound management, learned from the study of a distillation of other managers' experiences, broadens the conceptual base and enables the individual to select and apply the most appropriate perspective in approaching and attempting to resolve a problem. However, it may often be found that the root cause of the problem lies in the structure of the particular industry and the political and economic environment in which it operates; thus, the individual may not be in a position where he/she can apply sound management principles immediately.

Industrial Organisation

1. Types of industrial organisation.
2. Developments of organisations; horizontal and vertical integration.
3. Financing of industry and industrial development.
4. Structure of the bleaching, dyeing, printing and finishing sectors within the textile industry.

Principles and Practice of Management

1. Types of management organisation and their relative merits and disadvantages.
2. Responsibilities of managers at various levels.
3. Principles and practice of supervision.
4. The planning function in management.
5. Budgetary control and standard costing.
6. Planning and control of production.
7. Work study and work measurement.
8. Stock planning and control.
9. Quality control and quality assurance.
10. Cost control and cost accounting methods; management ratios.
11. Wages and salaries; incentive schemes.

Mathematics in Management

1. Use of statistical methods.
2. Applications of computers.
3. Forecasting techniques.

Marketing, Sales and Purchasing Aspects

1. Market research; relating products and prices.
2. Customer relations; creditors and debtors.
3. Organisation of selling activities; exporting aspects.
4. Purchasing policy; relationship with suppliers.

Personnel Management

1. Industrial relations and joint consultation.
2. Trade unions, employers' federations, trade organisations; legislation affecting these bodies.
3. Effects of working conditions on industrial relations (e.g. shift-working, pay and other incentives, automation).
4. Motivation and behaviour; management by objectives (MBO).
5. Legislation in relation to factories and other workplaces.
6. Safety aspects and precautions in workplaces.
7. Recruitment and training of staff and employees; staff appraisal and career development.

Layout and Maintenance of Plant and Buildings

1. Factors affecting layout of plant, buildings and services.
2. Environmental factors (e.g. Lighting, ventilation, noise, etc.).
3. Maintenance, including planned maintenance.

Economic and Legal Aspects of Essential Services

1. Generation and use of steam, power and heat.
2. Water supply and effluent disposal; atmospheric pollution and other environmental considerations.
3. Effective and efficient use of resources; recycling.

Financial Management

1. Accounting systems and types of accounts.
2. Factors affecting profitability (e.g. scale of operations, buying and marketing strategies, effects of depreciation and obsolescence).
3. Evaluation of capital projects, utilisation of capital, rate of return on investment, time value of money, discounted cash flow, present value comparison.
4. Research and development, relevant policies, financial control.

Distance Learning

The Society of Dyers and Colourists has available a range of 6 SDC e-Learning Modules. Module 4 covers the subject matter of this paper and is entitled 'Industrial Organisation and Management'. It can be obtained from the Society's office either individually or as a complete set of 6 modules

Reading List

- D Lock, *The Gower handbook of management*, 4th Edn (London: Gower, 1998) ISBN 0 566 07938 0.
- H Johansen and G T Page, *International dictionary of management* (London: Kogan Page, 1995) ISBN 0 749 41316 6.
- S Crouch and M Houseden, *Marketing research for managers* (Oxford: Butterworth-Heinemann, 2003) ISBN 0 750 65453 8.

Paper 5: Wet-processing of Natural Fibres and Regenerated Cellulosic Fibres.
&
Paper 6: Wet-processing of Synthetic Fibres and Fibres Blends.

The general content on Papers 5 and 6

Paper 5: Wet-processing of Natural and Regenerated Cellulosic Fibres.
Relates to the processing of wool, silk, cotton and all regenerated cellulosic fibres of the viscose type but excluding the cellulose acetates.

Paper 6: Wet-processing of Synthetic Fibres and Fibre Blends.
Includes the cellulose acetates as well synthetic fibres such as nylon, polyesters, acrylics, modacrylics and polypropylene

In both papers, candidates are expected to have knowledge of the processing of these fibres in all forms, e.g. slubbing and loose stock, yarn, fabric and garments.

Whilst the main emphasis of the questions will be on the practical aspects of wet-processing, some questions will relate to **theoretical** aspects, especially in so far as they affect the practice of wet-processing. However, the emphasis in the theoretical questions will be on **qualitative** rather than **quantitative** aspects.

It is of particular importance that candidates should have knowledge of the machinery used in wet-processing and should be able to provide schematic diagrams of typical machines where appropriate. Candidates will need to be able to specify appropriate machinery for use with textile substrates in a particular form, such as slubbing, loose stock, yarn, fabric or garments, and in batchwise (discontinuous) or continuous modes. Some basic understanding of engineering aspects is required.

Environmental aspects may also be included in both papers.

Preparatory Processes

1. Singeing, desizing, scouring, cleansing and bleaching processes for all types of fibres and blends, yarns, fabrics and garments, particular attention being paid to the details and sequences of handling and processing machinery.
2. Carbonising and shrink-resist processes for wool.
3. Mercerisation and other swelling processes for cellulosic materials applied before and after dyeing.
4. Bulking and setting of various textile materials.

Equipment, Materials and Processes for Textile Dyeing

Detailed consideration of equipment, materials, colorants, processes and process controls used in dyeing the principal natural and synthetic fibres and their mixtures and blends in the normal textile forms, including historical development. Specific aspects include:

1. Nature, important features and functions of the equipment used in dyeing of loose fibre, slubbing, tow, yarn, fabric, carpet, hosiery and garments, and the criteria for their technical efficiency; for example:
   - hank-dyeing machines for yarn
   - machines with liquor circulation for fibre, tow, yarn etc.
   - jig- and beam-dyeing machines for open-width fabric
   - winch, jet and overflow machines for rope-form fabric
   - paddle-, jet- and rotary-dyeing machines for hosiery and garments
   - winch and continuous carpet piece-dyeing machines
   - padding mangles and associated equipment
   - steamers, bakers etc for continuous fixation
   - arrangements of machinery for continuous and semi-continuous processing

Candidates should be able to demonstrate an understanding of the nature and performance of pumps, impellers and other devices for moving or controlling fabrics, "pressure-dyeing" machines and relevant laboratory equipment.

2. Structure: winding and backwinding of yarn hanks, packages and beams; comparison of yarn dyeing methods in relation to yarn type, product uniformity, process cost and end-use requirements.
3. Nature and properties of different types of fabric or garment in relation to selection of dyeing equipment or process; product appearance and quality.
4. Selection of dyes including fluorescent brightening agents, dye combinations, auxiliary products and processes for batch, semi-continuous and continuous application methods; uses of pigments for "dyeing".

5. Discussion of factors affecting dye and process selection in relation to uniformity, reproducibility, fastness, cost etc. Also in specific cases, effects on fibres, environmental issues.
6. Control of dyeing processes by use of pH, temperature, electrolytes or other auxiliary products.
7. Faults arising with particular dyeing methods, their investigation and eradication; precision and reproducibility of laboratory dyeing
8. Comparison of alternative application or control techniques, e.g. the advantages and disadvantages of:
   - batch, semi-continuous or continuous dyeing of tow or fabric
   - hank- or package-dyeing of yarns
   - paddle- or rotary-dyeing of hosiery or garments
   - subjective or instrumental methods of matching
   - "blind-dyeing" or traditional "sampling" techniques of batch dyeing
   - radio-frequency heating for dye fixation
   - low liquor-ratio techniques, including the use of foam, etc.

Equipment, Materials and Procedures for Textile Printing

Detailed consideration of equipment, materials, processes and process control used in printing the principal natural and synthetic fibres and their blends, including:

1. Nature: important features and functions of the equipment used in hand- and mechanised-printing processes.
2. Structure of flat and rotary printing screens, choice of screen mesh to meet the requirements of various designs, fabrics and processes.
3. Nature, properties and functions of print-paste thickeners.
4. Practical significance of paste rheology in printing.
5. Application of dyes and pigments by common printing techniques including direct, discharge and resist.
6. Comparison with dyeing processes.
7. Space dyeing and printing of yarns and similar processes.
8. Functions of steaming and thermofixation; modern developments in these stages of processing.
9. Faults arising with particular printing systems and their methods of Investigation.
10. Relative merits of various printing techniques; the effect of design on the choice of a suitable technique.
11. Transfer printing: (i) production of the printed paper and (ii) transfer and fixation methods and associated equipment.
12. Ink-jet printing of textiles: print-head technology (drop-on-demand and continuous ink jet), fabric pre-treatments, ink formulation. Advantages and disadvantages of ink-jet printing in relation to screen printing.
13. Carpet and carpet tile printing

Procedures Following Dyeing or Printing

1. Washing: a general consideration of machinery and procedures used in washing; factors affecting efficiency of washing; special requirements in the washing of printed substrates.
2. Drying: removal of water by mechanical and evaporative methods.
3. Drying combined with other finishing processes.
4. Finishes: with emphasis on those finishing methods which affect coloration, e.g. setting treatments, conventional wool finishes, coating treatments, resin and other chemical finishes; the specific effect of such treatments on dyed and printed materials.

The broader problems encountered in dyeing and printing, including:

5. Advantages and disadvantages of continuous, semi-continuous and batch Processing.
6. Special problems arising from handling different types of textile material.
7. Mechanical principles of plant operation with special reference to liquor circulation, maintenance of high pressure, regulation of temperature and progression of materials.
8. Automatic control of plant and automation of plant assemblies.

Essential Services

Consideration of the following topics in so far as they affect the technical aspects of the processes referred to in the preceding sections:

1. Generation, supply and use of steam.
2. Supply, treatment and use of water.
3. Disposal and on-site treatment of effluent.
4. Sources of heat for textile processing.
5. Lighting and ventilation of the working area.
6. Equipment and layout of dispensaries for dyes and chemicals.
7. Health and safety aspects.

Theoretical Aspects

Papers 5 and 6 require only a **qualitative** understanding of the physical chemistry underlying textile wet processing. However, it is of considerable benefit to candidates if they also have a good understanding of many aspects of general physical chemistry, in particular the following:

1. Surface chemistry
   - contact angles and wetting;
   - absorption and adsorption, including isotherms;
   - electrical double layer and zeta potential.
2. Acids and bases
   - ionisation;
   - pH;
   - buffer systems.
3. The general principles of thermodynamics of dyeing.
4. The general principles of kinetics of dyeing.

With specific reference to textile wet processing candidates should be able to explain:

1. the nature and course of chemical reactions involved in the processes.
2. the relationships between the chemical structure of dyes and fibres in so far as they influence sorption, retention of dye and colour fastness.
3. diffusion of colorants in relation to processing conditions.
4. aggregation and stability of dyes in the dyebath, effects of electrolytes, dispersing and surface active agents and temperature.
5. the influence of ionic groups in the dye , in the fibre and in accompanying electrolytes on dyeing, printing and dye fixation.
6. dielectric, microwave and radio-frequency heating techniques.

Examples of specific coloration systems and processes and associated processes:

1. sorption of acids and anionic dyes by protein and nylon fibres, cationic dyes by acrylic fibres and direct and other anionic dyes by cellulosic fibres.
2. influence of electrolytes and pH on ionic dye-fibre systems.
3. control of pH.
4. sorption of disperse dyes by hydrophobic fibres in dyeing and printing.
5. reactive dyes: their reactions with textile fibres and with water; stability of reactive-dyed and printed fibres.
6. chelation and mordanting processes.
7. the reactions involved in azoic dyeing and printing.
8. the reactions involved in dyeing and printing with vat and sulphur dyes and the significance of reduction and oxidation potentials.
9. classifications of dyes within their application groups according to their dyeing Properties.
10. wetting, detergency, heating and drying as they affect textile wet processes and colour fastness.
11. printing and continuous dyeing: e.g. chemistry and physics of thickeners, migration-inhibitors and film-forming systems, and the fixation of colorants. Special considerations of dye solubility, control of pH, swelling of fibres.

Engineering Aspects

Candidates should be able to produce schematic diagrams of the machines commonly used in textile wet processing. They should be able to specify the types of machine suitable for the processing of textiles in particular forms, e.g. loose fibre, yarn, fabric or garment, and to discuss the advantages and disadvantages of them.

More specialised knowledge includes the following:

1. the characteristics of valves and pumps and their suitability for particular purposes.
2. transfer of heat by conduction, convection and radiation.
3. the principles of automatic control of processes:
   - types of controller action (on-off, proportional, proportional + integral, proportional + integral + derivative)
   - specification of controller mechanisms (pneumatic, electro-magnetic, electronic)
4. industrial measurement of temperature, pressure. liquid level, flow.
5. civil engineering: the construction of buildings for textile wet processing; heating and ventilation of buildings; steam generation and distribution; factors influencing choice of fuel.
6. the transport of fabric in rope form and in open width (tubular and flat) within a single machine, or from machine to machine in sequence.
7. fabric-delay units including pad-batch, pad-roll, twin batch, roller steamers, J- and U-boxes etc.

Distance Learning

The Society of Dyers and Colourists has available a range of 6 SDC e-Learning Modules. Modules 5 and 6 cover the subject matter of these papers and are entitled 'Preparation, Dyeing and Finishing' and 'Textile Printing Technology'. They can be obtained from the Society's office either individually or as a complete set of 6 modules

Reading List

- *Textile printing*, 2nd Revised Edn, Ed. L W C Miles (Bradford; SDC, 2003) ISBN 0 901956 79 1.
- J Shore, *Blends dyeing* (Bradford; SDC, 1998) ISBN 0 901956 74 0.
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- *Engineering in textile coloration*, Ed. C Duckworth, (Bradford; SDC, 1983) ISBN 0 901956 31 7.
- A D Broadbent, *Basic principles of textile coloration* (Bradford: SDC, 2001) ISBN 0 901956 76 7.
- G W Madaras, G J Parish and J Shore, *Batchwise Dyeing of Woven Cellulosic Fabrics* (Bradford SDC, 1993) ISBN 0 90156 55 4.
- *Colorants and Auxiliaries, 2nd Edition, Volume 1: Colorants* Ed. J Shore (Bradford SDC, 2002) ISBN 0 90156 77 5.
- *Colorants and Auxiliaries, 2nd Edition, Volume 2: Auxiliaries* Ed. J Shore (Bradford SDC, 2002) ISBN 0 90156 78 3.
- *Colour in Dyehouse Effluent* Ed. P Cooper (Bradford; SDC, 2003) ISBN 0 901956 69 4.
- *Textile Finishing* Ed. D Heywood (Bradford; SDC, 2003) ISBN 0 901956 81 3.
- *Water Recycling in Textile Wet Processing* Ed. JK Skelly (Bradford; SDC, 2003) ISBN 0 901956 80 5.
- B Thompson, *Printing materials: science and technology* (Leatherhead, UK: Pira, 1998) ISBN 1 85802 168 5.
- *Chemistry and technology of printing and imaging systems*, Ed. P Gregory (Dordrecht, Netherlands: Kluwer Academic, 1995) ISBN 0 7514 0238 9.
- H Speirs, *Introduction to printing and finishing* (Leatherhead, UK: Pira, 2003) ISBN 1 85802 2906 6.
- R W G Hunt, *The reproduction of colour*, 5th Edn (Fountain Press, 1995) ISBN 0 86343 381 2.
- W S Perkins, *Textile coloration and finishing* (Durham, NC: Carolina Academic Press, 1996) ISBN 0 89089 885 5.
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- *Infrared absorbing dyes*, Ed. M Matsuoka (Dordrecht, Netherlands: Kluwer Academic, 1990) ISBN 0 306 43478 4.
- H K Rouette and G Kittan, *Wool Fabric Finishing, English translation* (Wool Development International Ltd., 1991)
- P Schomakers, G Seiler, S Sutcliffe and R Tindall, *A Handbook for the Fabric Piece Dyer* (Thies GmbH & Co. KG, 2002)
- J H Heetjans, P Schomakers, G Seiler and R Tindall, *A Handbook for the Yarn Dyer* (Thies GmbH & Co. KG, 2002)

Dissertation

Introduction

These notes are to assist you to choose, organise, write and present your dissertation. You will choose the subject of your dissertation. You may seek advice and guidance from the Examinations, Qualifications and Accreditation Board and from your Manager. Choose a subject relevant to your interests and strengths. Irrespective of your choice of subject, the dissertation must be based on:

1. The technology and engineering of the colorant application processes and related processes associated with your subject, and
2. The theories and mechanisms of the colorant application processes and related processes associated with your subject.

Guidelines related to these two areas are set out below.

The Examinations, Qualifications and Accreditation Board must approve the subject of the dissertation before your work commences. The proposal for your dissertation, together with the name of a proposed mentor, should be submitted on the approved form available from the Society. The dissertation, of between 7500 and 10 000 words (excluding appendices and references), is to be presented in bound form. Successful candidates will be invited to present their dissertation to the members of the Examinations, Qualifications and Accreditation Board as part of the interview.

It is recommended that you commence work on the dissertation early in the summer prior to the year in which you will be submitting. It is never too early to start background reading on the technology, engineering and physical chemistry associated with your subject. If you are a part-time student, basing the subject of your dissertation on the type of work carried out at your place of employment will be useful to your employers and to yourself, particularly if the topic requires investigation. Your experience at work will enable you to focus on a suitable topic.

The work on preparing the dissertation will develop your ability to analyse a particular problem, compile a logical presentation of information, and to give a verbal summary.

Aims of the Dissertation

1. To give candidates the opportunity to demonstrate their ability to think critically and logically, and communicate effectively.
2. To provide an opportunity to carry out an independent investigation in an area of technological relevance.
3. To allow candidates to demonstrate their technical skills and initiative in explaining, in terms of an appropriate level of knowledge, a past, current or predicted problem.

Assessment

Two examiners, who will work independently of each other, will assess your dissertation Marking will be as follows:

Assessment	Allocated marks, %
Planning and presentation	20
Content and depth	30
Results and conclusions	50

Moderation of the marking will be the responsibility of the Examinations, Qualifications and Accreditation Board. From past experience, strictly comparable standards of marking are obtained for dissertations differing widely in character and content. Candidates who obtain the pass mark of 40% or more will be asked to discuss their dissertation at an interview.

Timetable and Submission Date

In the opinion of the Examinations, Qualifications and Accreditation Board, it is preferable for you to have completed the four written papers (Papers 1–4) **before** embarking on work for the dissertation.

The dissertation is considered to be equivalent to two written examination papers. Therefore, at least the equivalent time should be given to the work on the dissertation. This is time that would have been spent in lectures, learning, writing essays and revising.

You may submit to the Examinations, Qualifications and Accreditation Board for approval your choice of title, along with an explanatory paragraph and suggestions for the person who could act as your mentor (local advisor) at any time. Six months prior to your final submission date you should provide a draft introduction and summary of not more than 500 words. Two copies of your final dissertation should be submitted to the Examinations, Qualifications and Accreditation Board. If relevant, you will be invited to attend a *viva voce* examination and interview.

Subject of the Dissertation

A major role of the dissertation is to demonstrate the candidate's knowledge and expertise in two aspects of coloration science and technology:

- The technology and engineering of the colorant application processes and related processes associated with your subject.
- The theories and mechanisms of the colorant application processes and related processes associated with your subject.

It is important that the choice of subject should give you the opportunity to use your knowledge in these two areas, and others if necessary. It follows that there is an obligation to study topics within these areas as part of the work on the dissertation.

A more detailed description of topics included in the two areas may be found later. In addition to the areas described, you may wish to include in the dissertation material from the core areas of study. For example, you may find it necessary to include aspects of colour physics in your dissertation.

Examples of dissertation titles and explanatory paragraphs are as follows.

1. **The Dyeing of Polyester in a Jet Dyeing Machine**

The significant features of the dissertation would cover the technology of disperse dye application to polyester, together with the relevant engineering aspects of the design and use of jet machines. Liquor flow may be important, as well as the physical chemistry and theories of the use of disperse dyes. Colour tolerances and shade matching may be significant.

2. **The Implications of the use of High-Substantivity Dyes for the Manufacture of Fine Papers**

Significant features would include advances in application techniques, particularly the design and use of continuous processes, together with online closed-loop colour control. Liquor flow and the physical chemistry of surfaces would form part of the assignment.

3. **Colour Control in the Manufacture and Application of PVC Plastisols**

A review should be presented of the science and technology involved in the production and use of PVC plastisols as surface-active materials. The factors that need to be controlled in order to achieve accurate colour matching at the laboratory level should be identified and described. The results of a study into the reasons why the colour obtained from the coating applied by full-scale production machinery may be different to that of a coating applied by laboratory-scale methods would be required.

4. **The Influence of Storage Conditions on the Properties of a Pigment Product**

A review should be presented of those physical and chemical properties of pigment powders that have an influence on colouring properties, with particular emphasis on stability during long-term storage. For example, a product manufactured in one country could be stored and dispersed into a paint formulation in another where climatic conditions are hugely different. The standard test methods used to establish the technical properties of pigments should be described. The results of a study into the ways in which the conditions of storage influence the results of the tests should be presented.

5. Decolorisation of Pigmented Inks and Paints

A review should be presented of the potential environmental hazards associated with the disposal of surplus ink and paint materials. The technology of various disposal methods should be described, and the commercial and environmental advantages and drawbacks of each should be identified and reported. In particular, a comparison should be made between formulations that use water and those that use an organic solvent as the carrier liquid.

Remember that the aim of your work is to produce an account of a technological process, thereby demonstrating your technical knowledge, and your ability to plan and to think critically and logically.

Writing and Presentation

The presentation of the dissertation is as important as the work itself. Sufficient time should be given to planning the structure of the dissertation and the writing up. The work should be written in English, together with correct English grammar, spelling and abbreviations. If units are used, they should be expressed in the SI System. The dissertation should be typed on A4 size paper using double line spacing on one side of the paper. All pages within the chapters should be numbered consecutively. Diagrams and samples may be included; if many samples are to be submitted, it may be desirable to fasten them into a separate folder.

Occasionally a dissertation may contain confidential information. In such cases the Society should be informed in writing by the candidate's employer. Examiners will be asked to sign a confidentiality agreement, and the Examinations, Qualifications and Accreditation Board will give a written guarantee that information will not be divulged by any employee, agent or representative of the Society.

A typical plan for the dissertation would be as follows:

1. Title page
2. Abstract
3. Acknowledgements
4. Contents
5. Introduction, subject of work, previous work
6. Background technology/engineering/chemistry, etc.
7. Review of current knowledge
8. Description of relevant practical work undertaken
9. Discussion
10. Conclusions
11. Appendices
12. References: The list of references should be numbered and presented at the end of the assignment script. The format should be that used by the SDC:
    - For papers: Author(s), *Publication*, Volume, Year, Page number. For example: J G Roberts, *J.S.D.C.*, **103** (1987) 251.
    - For books, etc.: Author(s), *Publication*, Edition, Editor (if any), Publisher, Year, Page number. For example: D H Wyles in *Engineering in Textile Coloration*, Ed. C Duckworth (Bradford: Dyers' Company Publication Trust, 1983) 1.

    This scheme is intended as guide only: other topics may call for a departure from these chapter headings.

Technology and Engineering of the Appropriate Colorant Application, and Related Processes

This is an important part of the dissertation since it is the candidate's opportunity to demonstrate his/ her in-depth knowledge of the practical aspects of coloration processes and to relate it to theoretical and engineering aspects. It should be noted that a critical account is required, demonstrating the candidate's ability to assimilate, analyse and adjudge.

Knowledge of current technology is obviously of primary importance, but it may help to demonstrate wider knowledge and insight by making historical comparisons and/or predictions for future trends arising, for example, out of current research. The impact of economic and environmental factors may also be of some importance and, once again, the candidate can demonstrate critical awareness by, for example, saying why it is better in environmental terms.

Knowledge of certain engineering aspects, such as fluid flow, heat transfer and mass transfer, will enable candidates to appreciate how systems operate and how equipment may be optimised. Many processes involve fluid flow, whether gas, vapour or solute, together with heat transfer and mass transfer. For example, drying and dyeing are two such

processes.

In controlling these processes, instrumentation and computer control systems are of the utmost importance.

Certain aspects are generally common to all coloration processes, irrespective of whether the actual topic is textile, plastic, ceramic or surface-coatings based. Hence, the following should certainly be considered.

Technology of Colorant Application

1. The importance and nature of any process preparatory to the actual coloration process. Indeed a great many coloration processes critically depend for their quality and reliability on correctly carried out preparation processes.
2. The important features and functions of materials and equipment used in the various processes. An obviously important aspect is the compatibility (or otherwise) of ingredients used. Explain why they are (or are not) compatible: it may also be appropriate to discuss any tolerance margins. The nature, or varied natures, of the substrate to be coloured may also call for discussion, e.g. in relation to the products and machinery used.
3. Health and safety aspects of materials, processes and equipment.
4. Selection of colorants and other chemicals. In some cases, it could be advantageous to discuss, e.g. how and why selection varies depending on whether a batchwise, semi-continuous or continuous process is used. Important considerations in the selection are likely to include:
   - Machinery and processing conditions, e.g. temperature and pH
   - End-use performance requirements, e.g. fastness to light or other agencies, including further processing.
5. Characterisation and limitations of dispersion equipment.
6. Factors affecting uniformity or otherwise of coloration. Reproducibility from process to process may also need to be discussed. Faults that may arise; their investigation and eradication or correction.
7. Formulation of paints and inks for various end uses.
8. Quality control, both in relation to the coloration process itself and as regards the subsequent performance of the coloured product.
9. It will almost certainly be worthwhile discussing any physico-chemical aspects pertinent to any of the above-listed factors, especially if it can be shown how these relate to processing parameters.

The inclusion and weighting given to the above items will obviously vary with the precise nature of the candidate's topic and should be used only as a guide. Indeed, the candidate may well include an aspect, which is not mentioned above if it is pertinent to the topic. The aim should always be to arrive at an overall balanced presentation according to the information given in the general guidelines for your assignment.

Engineering of Colorant Application

1. Fluid flow; laminar and turbulent flow; Reynolds number; mass/volumetric flow rate; streamlining; liquid momentum.
2. Energy of a fluid in motion; potential and kinetic energy of fluids; potential, kinetic and velocity head; total mechanical energy of a fluid in motion; Bernoulli's equation; losses in energy.
3. Flow through orifices; discharge velocity; vena contra; coefficients of contraction; velocity and discharge; actual and theoretical values of velocity and discharge; loss in head and discharge.
4. Flow in pipes and ducts; flow patterns; fully developed flow; entry length; Reynolds number for straight and coiled pipes; Reynolds number for circular pipes and ducts.
5. Energy losses in piping systems; fanning friction factor, relative roughness; Colebrook graph; variation of Reynolds number; equivalent diameters and length; Fanning friction factor of coiled pipes.
6. Measurement of fluid flow; inferential and direct measuring flow meters; Pitot tube; orifice meter; Venturi meter; nozzle meter; magnetic flowmeter; direct meter; stop, regulating, non-return and pressure control valves.
7. Pumping of liquids; suction and discharge heads; vapour pressure; net positive suction head; cavitation; rotodynamic and positive displacement pumps; centrifugal, reciprocating, rotary and peristaltic pumps; propellers; turbines and impellers; mixers and baffles.
8. Properties of heat; transient and steady state conditions; specific heat; heat content and enthalpy; rate of heat transfer; heat flux; thermal conductivity; overall heat transfer coefficients.
9. Conduction in simple and multi-layer plane slabs and circular pipes; thermal insulation; mean and critical radius.
10. Fundamentals of convection; boundary layer film concept; overall heat transfer coefficients for flat surfaces and pipes; logarithmic mean temperature difference
11. Dimensionless groups in convection; Nusselt, Reynolds, Prandtl and Grashof groups; Dittus–Boelter, Sieder–Tate and Colburn j-factor equations

12. Thermal radiation; black body radiation; Stefan–Boltzmann law; rate of heat transfer; radiation heat transfer co-efficient
13. Heat transfer equipment; direct and surface contact exchangers; construction of shell and tube exchangers; area of heat exchangers; single and multi-pass exchangers; co-current and counter-current flow in exchangers
14. Steam as a heat transfer medium; saturated, dry saturated and wet steam; dryness fraction; superheated steam; steam tables; enthalpy of steam; sensible and latent heat of steam; heat content of steam
15. Fundamentals of drying; humidity; dry and wet bulb thermometer; terms used in humidity; moisture content and regain; air recycling; enthalpy balance; essential and non-essential purposes of heat; thermal efficiency; essential specific steam consumption.
16. Moisture-material relationship; unbound and bound moisture; equilibrium moisture content; critical moisture content; free moisture content; commercial moisture content; rate of drying; hot air and dielectric drying.
17. Instrumentation; analogue and digital quantities; measurement systems; thermocouple and platinum resistance thermometers; use of the Wheatstone bridge; pressure measurement using Bourdon Tube and strain gauges; liquid level measurement using floats; conductivity and pneumatics; measurement of pH.
18. Principles of control systems; open and closed-loop systems; error signals; positive and negative feedback; on/off and proportional control; two and three term controllers; pneumatic controllers, analogue electronic controllers.
19. Digital and computer control systems; mainframe; mini and micro computers; programming languages; digital devices; structure of a computer; direct digital controllers; computer supervisory control; electro-magnetic interference.
20. Motive power; electric, pneumatic and hydraulic variable speed drive; AC inverter variable speed drive; variable speed and reduction gearboxes.
21. Functional machine design; fundamental requirements for continuous and batch processing machinery; potentials and limitations of the installed equipment; factors affecting shape, dimensions and performance of machines; choice of components and accessories; web transport and control within machines; fluid and material flow characteristics.
22. Web transport and control; web transport from machine to machine in sequence; width and length tension control; guiding, de-curling, weft straightening and overfeeding systems; principles of batching and plaiting.
23. Choice of energy source; efficient use of energy; moisture removal by mechanical versus evaporative systems.
24. Special considerations for laboratory and pilot scale machinery; understand the problems associated with producing small samples of material; factors affecting how far a machine may be scaled-down and still produce the characteristics of the production machine.

Theories and Mechanisms of the Appropriate Colorant Applications and Related Processes

The theories and mechanisms of dye and pigment application rest firmly on the doctrines of physical chemistry. The latter is concerned with the influence of physical quantities such as temperature, pressure, concentration and electrical potential on interactions and reactions between molecules and surfaces. Coloration of any kind depends on the distribution of molecular species (the majority of which are coloured) by diffusion and mass transport through a medium (be it a fibre or a resin for paint manufacture). The physical chemistry of coloration includes a treatment of adsorption, electrical double-layer and related interfacial behaviour, reaction kinetics and thermodynamics, all of which should be familiar to the candidates.

1. Intermolecular bonds, leading to dye/surface (fibre) interactions.
2. Relationships between structures of dyes, and linear and three-dimensional polymers as they determine sorption, dye retention, affinity, and colour fastness.
3. Aggregation of dyes
4. Diffusion of dyes through substrates, and diffusion models. Boundary layers in diffusion processes. Kinetics of diffusion. Influence of temperature on rates of diffusion and dyeing.
5. Description of physical and chemical adsorption. Classification of surfaces. Processes at equilibrium.
6. Description of adsorption, absorption and sorption.
7. Surface potentials and boundary layers.
8. Equilibrium isotherms of Langmuir, Freundlich and Nernst, including their interpretation.
9. Thermodynamics of coloration processes, including quantitative expression of, and interpretation of, affinity, enthalpy and entropy.

Examples of more specific topics are:

- Surface tension, wetting and detergency; chemistry and physics of thickeners (rheology), film-forming and foam-forming systems.
- Dispersion and its effect on the properties of the colorant, flocculation, floatation.

- Influence of electrolytes (ionic strength) and pH on ionic systems; control of pH.
- Dissociation of cellulose and the interaction with reactive dyes.
- Reduction–oxidation potentials (redox potentials).
- Mechanism of chelation and mordanting processes.
- Aqueous-phase and vapour-phase transfer of disperse dyes to solid surfaces.
- Thermodynamic descriptions of nonionic and ionic dye-substrate systems, including the Donnan equilibrium model.

Distance Learning

The Society of Dyers and Colourists has available a range of 6 SDC e-Learning Modules. Modules 5 and 6 cover some of the above, particularly for candidates in the textile sector. These are entitled: 'Preparation, Dyeing and Finishing' and 'Textile Printing Technology'. They can be obtained from the Society's office either individually or as a complete set of 6 modules

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- A D Broadbent, *Basic principles of textile coloration* (Bradford: SDC, 2001) ISBN 0 901956 76 7.
- *Surfactants in polymers, coatings, inks and adhesives*, Ed. D R Karsa (Oxford: Blackwell, 2003) ISBN 1 841 27336 8.
- *Technological applications of dispersions*, Surfactant Science Series, Vol. 52, Ed. R B McKay (New York: Marcel Dekker, 1994) ISBN 0 8247 9180 0.
- *Paint and surface coatings: theory and practice*, 2nd Edn, Ed. R Lambourne and T A Strivens (Cambridge: Woodhead, 1999) ISBN 1 85573 348 X.
- *Paints, coatings and solvents*, 2nd Edn, Ed. D Stoye and W Freitag (New York: Wiley, 1998) ISBN 3 527 28863 5.
- *Liquid film coating: scientific principles and their technological implications*, Ed. P Schweizer and S Kistler (Dordrecht, Netherlands: Kluwer Academic, 1997) ISBN 0 412 06481 2.
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- *The chemistry and physics of coatings*, Ed. A R Marrion (Cambridge: RSC, 1994) ISBN 0 85186 994 7.
- J Bentley and G P A Turner, *Introduction to paint chemistry and principles of paint technology*, 4th Edn (Cheltenham: Nelson Thornes, 1997) ISBN 0 412 72330 1.
- *Chemistry and technology of water-based inks*, Ed. P Laden (Dordrecht, Netherlands: Kluwer Academic, 1997) ISBN 0 751 40165 X.
- J T Guthrie and L Lin, *Physical chemical aspects of pigment applications* (London: OCCA, 1994) ISBN 0 903809 15 X.
- J C Roberts, *The chemistry of paper* (Cambridge: RSC, 1996) ISBN 0 85404 518 X.
- J R Aspland, *Textile dyeing and coloration* (Research Triangle Park, NC: AATCC, 1997) ISBN 0 961335 01 7.
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