UNIVERSITY ENTRANCE EXAMINATION BIOLOGY SYLLABUS

*** Actual practical work will not be tested, however, candidates should have knowledge of practical work as they might have to draw on this knowledge to answer certain questions in the exam.**

A. CORE SYLLABUS

1 Cellular Functions

Content

- Detailed structure of typical animal and plant cells, as seen under the electron microscope
- Outline functions of organelles in plant and animal cells
- The structure of carbohydrates, lipids and proteins and their roles in living organisms
- Mode of action of enzymes
- Replication and division of nuclei and cells
- Understanding of chromosome number and variation
- Effect of meiosis on chromosome number and variation

Learning Outcomes

Candidates should be able to:

(a) Describe and interpret drawings and photographs of typical animal and plant cells as seen under the electron microscope, recognising the following membrane systems and organelles: rough and smooth endoplasmic reticulum, Golgi body, mitochondria, ribosomes, lysosomes, chloroplasts, cell surface membrane, nuclear envelope, centrioles, nucleus and nucleolus.

(b) Outline the functions of the membrane systems and organelles listed in (a).

(c) Describe the formation and breakage of a glycosidic bond.

(d) Analyse the molecular structure of a triglyceride and a phospholipid, and relate these structures to their functions in living organisms.

(e) Describe the structure of an amino acid and the formation and breakage of a peptide bond.

(f) Explain the meaning of the terms *primary structure*, *secondary structure*, *tertiary structure* and *quaternary structure* of proteins, and describe the types of bonding (hydrogen, ionic, disulphide and hydrophobic interactions) which hold the molecule in shape.

(g) Analyse the molecular structure of a dimeric enzyme with a quaternary structure e.g. viral/HIV protease, as an example of a globular protein, and of collagen as an example of a fibrous protein, and relate these structures to their functions.

(h) Explain the mode of action of enzymes in terms of an active site, enzyme/substrate complex, lowering of activation energy and enzyme specificity.

(i) Follow the time course of an enzyme-catalysed reaction by measuring rates of formation of products (e.g. using catalase) or rate of disappearance of substrate (e.g. using amylase).

(j) Investigate and explain the effects of temperature, pH, enzyme concentration and substrate concentration on the rate of enzyme catalysed reactions, and explain these effects.

(k) Explain the effects of competitive and non-competitive inhibitors on the rate of enzyme activity.

(l) Explain the importance of mitosis in growth, repair and asexual reproduction.

(m) Explain the need for the production of genetically identical cells and fine control of replication.

(n) Explain how uncontrolled cell division can result in cancer, and identify factors which can increase the chances of cancerous growth.

(o) Describe with the aid of diagrams, the behaviour of chromosomes during the mitotic cell cycle and the associated behaviour of the nuclear envelope, cell membrane and centrioles. (Names of the main stages are expected)

(p) Explain what is meant by *homologous pairs* of chromosomes.

(q) Describe, with the aid of diagrams, the behaviour of chromosomes during meiosis, and the associated behaviour of the nuclear envelope, cell membrane and centrioles. (Names of the main stages are expected, but not the sub-divisions of prophase)

Use the knowledge gained in this section in new situations or to solve related problems.

2 DNA and Genomics

Content

- DNA – structure and function
- Central Dogma – DNA to RNA, RNA to protein

Learning Outcomes

Candidates should be able to:

(a) Describe the structure and roles of DNA and RNA (tRNA, rRNA and mRNA).

(b) Describe the process of DNA replication and the experimental evidence for semi-conservative replication.

(c) Describe how the information on DNA is used to synthesise functional polypeptides.

(d) Explain how a change in the sequence of the DNA nucleotide (gene mutation) may affect the amino acid sequence in a protein, and hence the phenotype of the organism e.g. sickle cell anaemia.

Use the knowledge gained in this section in new situations or to solve related problems.

3 Genetics of Viruses and Bacteria

Content

- The Genetics of Viruses
- The Genetics of Bacteria

Learning outcomes

Candidates should be able to:

(a) Discuss whether viruses are living or non-living organisms and explain why viruses are obligate parasites.

(b) Describe the structural components of viruses.

(c) Describe the reproductive cycles of the following virus types:

i. bacteriophages, using T4 and lambda phages to illustrate the lytic and lysogenic cycles respectively;

ii. an enveloped virus e.g. influenza;

iii. retroviruses e.g. HIV.

(d) Explain how viral infections cause disease in animals e.g. mammals.

(e) Describe the structure of a bacterial chromosome including the arrangement of DNA within bacterial cells.

(f) Describe the process of binary fission, transformation, transduction and conjugation in bacteria and explain the role of F plasmids in bacterial conjugation.

(g) Distinguish between structural and regulatory genes, and between repressible and inducible enzymes.

(h) Describe the concept of a simple operon (using *lac* operon as an example).

Use the knowledge gained in this section in new situations or to solve related problems.

4 Organisation and Control of Prokaryotic and Eukaryotic Genome

Content

- The Structure of Eukaryotic Chromatin
- Genome Organisation at the DNA level
- The Control of Gene Expression
- The Molecular Biology of Cancer

Learning Outcomes

Candidates should be able to:

(a) Compare the structure and organisation of prokaryotic and eukaryotic genomes.

(b) Describe the structure and function of the portions of eukaryotic DNA that do not encode for protein or RNA.

(c) Describe the role of telomeres and centromeres.

(d) Describe the process and significance of gene amplification.

(e) Describe the eukaryotic processing of pre-mRNA.

(f) Define control elements and explain how they influence transcription.

(g) State the various ways in which gene expression may be controlled at translational and post translational level.

(h) Outline the differences between prokaryotic control of gene expression with the eukaryotic model.

(i) Describe how proto-oncogenes are converted into oncogenes including gain of function mutations in proto-oncogenes and loss of function mutations in tumour suppressor genes.

(j) Explain how mutations in tumour suppressor genes can contribute to cancer and describe the development of cancer as a multi-step process.

Use the knowledge gained in this section in new situations or to solve related problems.

5 Genetic Basis for Variation

Content

- The passage of information from parent to offspring
- Genotypes and phenotypes
- Dihybrid crosses
- Mutations
- The effect of genotype and environment on phenotype
- Interaction between loci
- Linkage and crossing-over

Learning Outcomes

Candidates should be able to:

(a) Explain the terms, *locus*, *allele*, *dominant*, *recessive*, *codominant*, *homozygous*, *heterozygous*, *phenotype* and *genotype*.

(b) Explain how genotype is linked to phenotype and how genes are inherited from one generation to the next via the germ cells or gametes.

(c) Explain, with examples, how the environment may affect the phenotype.

(d) Use genetic diagrams to solve problems in dihybrid crosses, including those involving sex linkages, codominance and multiple alleles (involving autosomal linkage or epistasis).

(e) Use genetic diagrams to solve problems involving test crosses.

(f) Explain the meaning of the terms *linkage* and *crossing-over* and explain the effect of linkage and crossing-over on the phenotypic ratios from dihybrid crosses.

(g) Explain, with examples, what is meant by the terms *gene mutation* and *chromosome aberration*.

(h) Describe the differences between *continuous* and *discontinuous variation* and explain the genetic basis of continuous (many, additive, genes control a characteristic) and discontinuous variation (one or few genes control a characteristic).

(i) Describe the causes of genetic variation in a population.

(j) Describe the interaction between loci (epistasis) and predict phenotypic ratios in problems involving epistasis.

(k) Use the chi square test to test the significance of differences between observed and expected results.

Use the knowledge gained in this section in new situations or to solve related problems.

6 Cellular Physiology and Biochemistry

Content

- The need for energy in living organisms
- Photosynthesis as an energy-trapping process
- Respiration as an energy-releasing process
- Aerobic respiration
- Anaerobic respiration
- The fluid mosaic model of membrane structure
- Homeostasis
- Electrical and chemical signalling
- Nervous and hormonal control
- An overview of cell signalling and communication

- Signal reception and the initiation of transduction
- Signal transduction pathways
- Cellular responses to signals

Learning Outcomes

Candidates should be able to:

(a) With reference to the chloroplast structure, explain the light dependent reactions of photosynthesis (no biochemical details are needed but will include the outline of cyclic and non-cyclic light dependent reactions, and the transfer of energy for the subsequent manufacturing of carbohydrates from carbon dioxide).

(b) Outline the three phases of the Calvin cycle: (i) CO_2 uptake (ii) carbon reduction and (iii) ribulose bisphosphate (RuBP) regeneration and indicate the roles of ATP and NADP in the process.

(c) Discuss limiting factors in photosynthesis and carry out investigations on the effects of limiting factors, such as light intensity, CO_2 concentration and temperature, on the rate of photosynthesis.

(d) List and give an overview of the 4 stages of aerobic respiration and indicate where each stage takes place in an eukaryotic cell and mitochondria, and add up the energy captured (as ATP, reduced NAD and FAD) in each stage.

(e) Explain the production of a small yield of ATP from anaerobic respiration and the formation of ethanol in yeast and lactate in mammals.

(f) Compare the storage and structural forms of starch, glycogen and cellulose and their roles in plants/animals with reference to the starting and end points of photosynthesis/cellular respiration.

(g) Describe and explain the fluid mosaic model of membrane structure, including an outline of the roles of phospholipids, cholesterol, glycolipids, proteins and glycoproteins.

(h) Outline the roles and functions of membranes within cells and at the surface of cells.

(i) Recognise the need for control in organised systems and explain the principles of homeostasis in terms of receptors, effectors, and negative feedback.

(j) Recognise the need for communication systems within organisms.

(k) Describe and explain the transmission of an action potential along a myelinated neurone. (The importance of Na^+ and K^+ ions in the impulse transmission should be emphasised.)

(l) Describe the structure of a cholinergic synapse and explain how it functions, including the role of Ca^{2+} ions.

(m) Explain what is meant by an endocrine gland, with reference to the islets of Langerhans in the pancreas.

(n) Explain how the blood glucose concentration is regulated by insulin and glucagon.

(o) Describe the three main stages of cell signalling - ligand-receptor interaction, phosphorylation and signal transduction and signal amplification.

Use the knowledge gained in this section in new situations or to solve related problems.

7 Diversity and Evolution

Content

- Classification
- The concept of the species
- Variation, natural selection and evolution
- The neo-Darwinian revolution
- Evidence of evolution

Learning Outcomes

Candidates should be able to:

(a) Explain the binomial nomenclature of a species and hierarchical classification.

(b) Describe the classification of species into taxonomic groups (genus, family, order, class, phylum, kingdom) and appreciate the significance of the various concepts of the species.

(c) Explain the relationship between classification and phylogeny.

(d) Explain why variation is important in selection.

(e) Explain, with examples, how environmental factors act as forces of natural selection.

(f) Explain how natural selection may bring about evolution.

(g) Explain why the population is the smallest unit that can evolve.

(h) Explain how homology (anatomical, embryological and molecular) supports Darwin's theory of natural selection.

(i) Explain how biogeography and the fossil record support the evolutionary deductions based on homologies.

(j) State the advantages of molecular (nucleotide and amino acid sequences) methods in classifying organisms.

(k) Explain how genetic variation e.g. recessive alleles may be preserved in a natural population.

(l) Briefly describe the neutral theory of molecular evolution.

Use the knowledge gained in this section in new situations or to solve related problems.

B. APPLICATIONS SYLLABUS

8 Isolating, Cloning and Sequencing DNA

Content

- DNA Cloning (Genetic Engineering)
- DNA Analysis and Genomics
- Human genome project

Learning Outcomes

Candidates should be able to:

(a) Describe the natural function of restriction enzymes.

(b) Explain the formation of recombinant DNA molecule.

(c) Outline the procedures for cloning an eukaryotic gene in a bacterial plasmid and describe the properties of plasmids that allow them to be used as DNA cloning vectors.

(d) Explain how eukaryotic genes are cloned using *E. coli* cells to produce eukaryotic proteins to avoid the problems associated with introns.

(e) Distinguish between a genomic DNA and cDNA library.

(f) Outline 2 important proteins and other products that can be produced by genetic engineering technique (e.g. human growth hormone, anti-thrombin, etc).

(g) Describe the polymerase chain reaction (PCR) and explain the advantages and limitations of this procedure.

(h) Explain how gel electrophoresis is used to analyse nucleic acids and proteins and to distinguish between two alleles of a gene.

(i) Outline the process of nucleic acid hybridisation and explain how it can be used to detect and analyse restriction fragment length polymorphism (RFLP).

(j) Explain how RFLP analysis facilitated the process of genomic mapping, diseases detection, DNA fingerprinting, etc.

(k) Discuss the goals and implications of the human genome project, including the benefits and difficult ethical concerns.

Use the knowledge gained in this section in new situations or to solve related problems.

9 Applications of Molecular and Cell Biology

Content

- Stem cells
- The treatment of genetic diseases in human
- Gene therapy
- Cloning
- Genetic engineering and genetically modified organisms (GMOs)

Learning Outcomes

Candidates should be able to:

(a) Explain the unique features of stem cells.

(b) Explain the normal functions of stem cells in a living organism, using appropriate examples to illustrate.

(c) Describe two types of genetic diseases e.g. SCID (severe combined immunodeficiency) and cystic fibrosis, using viral and non-viral gene delivery systems, that can be treated with gene therapy.

(d) Explain what are the factors that keep gene therapy from becoming an effective treatment for genetic diseases.

(e) Discuss the social and ethical considerations for the use of gene therapy.

(f) Discuss cloning in plants.

(g) Explain the significance of genetic engineering in improving the quality and yield of crop plants and animals in solving the demand for food in the world.

(h) Discuss the ethical and social implications of genetically modified organisms.

Use the knowledge gained in this section in new situation or to solve related problems.

TEXTBOOKS AND REFERENCES

Teachers may find reference to the following books helpful.

CORE SYLLABUS

1. Arms, Karen and Camp, P S (1995) *Biology* (Fourth Edition) (Harcourt Brace & Co.,www.harcourtcollege.com)
2. Barret, D and Spencer, P (1992) *Genetics and Evolution Biology Advanced Studies* (Nelson)
3. Burnet, L (1986) *Essentials Genetics* – a course book (CUP)
4. Burnet, L (1988) *Exercises in Applied Genetics* (CUP)
5. Boyle, M and Senior, K (2002) *Biology Collins Advanced Science* (Collins Educational, www.collinseducational.com) ISBN 0 00713600 5
6. Calladine, C R and Drew, H R (1997) *Understanding DNA* (Second edition) (Academic Press www.apcatalog.com) ISBN 0121550885
7. Campbell, Neil A and Reece, J B (2005) *Biology* (Seventh Edition) (Addison Wesley-Benjamin Cummings, www.aw-bc.com) ISBN 0 8053 7146 X
8. Campbell, Neil A and Reece, J B (2003) *Biology: Concepts and Connections* (Fourth Edition)(Benjamin Cummings)
9. Carr, M and Cordell, R (1993) *Biochemistry Biology Advanced Studies* (Nelson Thornes) ISBN 0 17 448196 9
10. Clegg, C J with MacKean, D J (2000) *Advanced Biology, principles and applications* (Second Edition) (John Murray) ISBN 0 71 957670 9
11. Cummings, Shelly (Ed) (1998) *Current Perspectives in Biology* (Wadsworth Pub. Co, Belmont, CA)
12. Drlica, K (2003) *Understanding DNA and Gene Cloning* (Wiley and Sons) ISBN 0471434167
13. Gould, James L and Keeton, W T (1996) *Biological Science* (Sixth edition) (New York: W. W.Norton, www.wwnorton.com)
14. Gregory, J (2000) *Applications of Genetics* (Second edition) Cambridge Advanced Sciences (CUP, www.cambridge.org) ISBN 0521787254
15. Hayward, G (1990) *Applied Genetics* (Bath Science 16-19) (Nelson Thornes, www.nelsonthornes.com) ISBN 0 17 438511 0
16. Jones, M, Fosbery, R and Taylor, D (2000) *Biology 1 Cambridge Advanced Sciences* (CUP, www.cambridge.org) ISBN 052178719X
17. Jones, M and Gregory, J (2001) *Biology 2 Cambridge Advanced Sciences* (CUP, www.cambridge.org) ISBN 0521797144
18. Jones, M and Jones, G (1997) *Advanced Biology* (CUP) ISBN 0 52 148473 1
19. Kent, M (2000) *Advanced Biology* (Oxford University Press, www.oup.co.uk) ISBN 0199141959
20. Kreuzer, H and Massey, A (2001) *Recombinant DNA and Biotechnology: A guide for Teachers* (American Society Microbiology) ISBN 1555811752
21. Kreuzer, H and Massey, A (2001) *Recombinant DNA and Biotechnology: A guide for Students* (American Society for Microbiology) ISBN 1555811760
22. Lowrie, P and Wells, S (2000) *Microbiology and Biotechnology* Cambridge Modular Sciences(CUP) ISBN 0 52 178723 8
23. Mader, S S (2001) *Biology* (Seventh edition) (Dubuque, IA: McGraw Hill. www.mhhe.com)
24. Marrieb, E N (2001) *Human Anatomy and Physiology* (Fifth edition) (Benjamin/ Cummings) ISBN 0 80 534989 8

25. Micklos, D, Freyer, G A and Crotty, D A (2003) *DNA Science – A first course* (Second edition) (CSHL) ISBN 0 87969 632 2
26. Minkoff, C, Eli & Baker, Pamela J (2001) *Biology Today: An issues approach* (Second edition) (Garland Publishing, New York, London)
27. Nicholl, D S T (2002) *An Introduction to Genetic Engineering* (Second edition) Studies in Biology (CUP) ISBN 0521004713
28. Purves, W K, Gordon H O, and Heller C H (2000) *Life: The Science of Biology* (Sixth edition) (W. H. Freeman, www.whfreeman.com)
29. Raven, P H and Johnson, G B (1999) *Biology* (Fifth edition) (William C Brown/McGraw-Hill Publishers, www.mhhe.com)
30. Roberts, M B V, Monger G and Reiss M (2000) *Advanced Biology* (Nelson Thornes) ISBN 0 17 4887326
31. Rowland, M *Biology* (Bath Science 16-19) (Nelson Thornes) ISBN 0 17 438425 4
32. Salters – Nuffield Advanced Biology A2 Student Book (2005) (Heinemann UK) ISBN 0435628585
33. Salters – Nuffield *Advanced Biology AS Student Book* (2005) (Heinemann UK) ISBN 0435628585
34. Smith, J G (1996) *Biotechnology* (Third edition) (CUP) ISBN 0 52 144911 1
35. Solomon, Eldra, Berg, L R and Martin, D W (1999) *Biology* (Fifth edition) (Harcourt College Publishers. www.harcourtcollege.com)
36. Starr, Cecie and Taggart, R (2001) *Biology: The Diversity of Life* (Ninth edition) (Wadsworth Publishing. www.wadsworth.com)
37. Taylor, D (2001) *Growth, Development and Reproduction* Cambridge Modular Sciences (Second edition) (CUP) ISBN 0 52 178721 1
38. Taylor, D J, Green, N P O, Stout, G W and Soper R (1997) *Biological Science 1 and 2* (Third edition) (CUP, www.cambridge.org) ISBN 0521561787
39. Taylor, J (2001) *Microorganisms and Biotechnology* (Bath Science 16-19) (CUP) ISBN 0 17 448255 8
40. Tomkins, S (1989) *Hereditary and Human Diversity* (CUP)
41. Tobin, Allan J. and Dusheck, J (2001) *Asking About Life* (Second Edition) Harcourt College Publishers. www.harcourtcollege.com
42. Vardy, P (1999) *The Puzzle of Ethics* (Fount) ISBN 0006281443
43. Wallace, R A, Sanders, G P, and Ferl, R J. (1996) *Biology: The Science of Life* (Fourth edition) (New York: Addison-Wesley Publishing Co. www.awlonline.com)
44. Wood, E J and Myers, A (1994*) Essential Chemistry for Biochemistry BASC I* (The Biochemical Society) Available free online

The following may also be useful.

45. *Biological Nomenclature: Standard terms and expressions used in the teaching of Biology* (Third edition) (2000) Edited by Alan Cadogan ISBN 0 900490 36 5
46. *Biological Sciences Review* Philip Allan Publishers Ltd, Market Place, Deddington, Oxfordshire, OX15 0SE, England (www.philipallan.co.uk)
47. Cadogan, A and Sutton, R *Maths for Advanced Biology* (Thomas Nelson and Sons Waltonon-Thames 1994) ISBN 0 17 448214 0
48. Dyson, T (1994) *The Ethics of in Vitro Fertilization* (Continuum International Publishing – Mowbray) ISBN 0264672836
49. Edmonson, A and Druce, D (1996) *Advanced Biology Statistics* (OUP) ISBN 0199146543
50. Ennos, R (2000) *Statistical and Data Handling Skills in Biology* (Prentice Hall Harlow) ISBN 0 58 231278 7
51. Freeland, P W (1985) *Problems in Practical Advanced Level Biology* (Hodder and Stoughton Sevenoaks 1985) ISBN 0 34 033563 7

52. Garvin, J W (1986) *Skills in Advanced Biology 1: Dealing With Data* (Stanley Thornes, Cheltenham) ISBN 0 85950 588 X
53. Garvin, J W and Boyd, J D (1994) *Skills in Advanced Biology Series: Volume 2 Observing, Recording and Interpreting Student Text and Teacher's Supplement* (Nelson Thornes) ISBN 0 85950 817 X and 0 7487 0043 9
54. Garvin, J W (1995) *Skills in Advanced Biology 3: Investigating* (Stanley Thornes Cheltenham) ISBN 0 7487 2048 0
55. Jones, R and Reed, R and Weyers, J (1999) *Practical Skills in Biology* (Second edition) (Longman Harlow) ISBN 0 582 29885 7
56. King, T J, Reiss, M and Roberts, M (2001) *Practical Advanced Biology* (Nelson Thornes, www.nelsonthornes.com) ISBN 0 17448308 2
57. *LAB NOTES Guide to Research in Genetics* (1995) The Wellcome Trust, 183 Euston Road, London, NW 1 2BE, England (http://library.wellcome.ac.uk)
58. Lewis, O A M Plants and Nitrogen (1991) *Studies in Biology Series* (CUP) ISBN 0 52 142776 2
59. Powell, S (1996*) Statistics for science projects* (Hodder and Stoughton London) ISBN 0 340 66409 6
60. Rockett, B and Sutton, R *Chemistry for Biologists at Advanced Level* (John Murray London 1996) ISBN: 0 7195 7146 4
61. Siddiqui, S A (1999) *Comprehensive Practical Biology for A Levels* (Ferozons, Lahore) ISBN 9690015729
62. Stewart, A (1995-6) *Lab notes: your up-to-date guide to research in genetics* (Wellcome Centre for Medical Science, http://library.wellcome.ac.uk)
63. Webb, N and Blackmore, R (1985) *Statistics for Biologists: A Study Guide* (CUP) ISBN 0 52131712 6

List of readings for enrichment: books, landmark papers, journals

Books e.g.:

1. Francis Crick: *Discoverer of the Genetic Code* (Eminent Lives) (2006) – Matt Ridley
2. *Genome* (2000) - Matt Ridley
3. *The Red Queen: Sex and the Evolution of Human Nature* (1995) - Matt Ridley
4. *Nature via Nurture: Genes, Experience and What makes us Human* (2003) - Matt Ridley
5. *The Best American Science Writing* (2002) - Matt Ridley
6. *DNA the Secret of Life* (2003) - James Watson
7. *Genes, Girls and Gamow* (2001) - James Watson
8. *The Double Helix* (2001) – James Watson
9. *A Passion for DNA* (2000) - James Watson
10. *My Life in Science* (2002) - Sydney Brenner
11. *The Ancestors Tale: A Pilgrimage to the Dawn of Evolution* (2004) – Richard Dawkins
12. *The Blind Watchmaker* (1996) - Richard Dawkins
13. *The Selfish Gene* - Richard Dawkins
14. *The Eighth Day of Creation* – Harold Judson
15. *The Second Creation* – Ian Wilmut
16. *Genethics* – David Suzuki
17. Life on Earth – David Attenborough
18. *Trials of Life* – David Attenborough

19. *The Living Planet* – David Attenborough
20. *The Private Life of Plants* – David Attenborough
21. *Origin of Species* – Charles Darwin
22. *The Silent Spring* – Rachel Carson
23. *Inspiring Science* – Jim Watson and *the Age of DNA* (2003) – John R Inglis, Joseph Sambrook, Jan Witkowski
24. *What Mad Pursuit: A Personal View of Scientific Discovery* (1988) – Francis Crick

Landmark Papers e.g.:

1. *The Double Helix*
2. *McClintock's Jumping Genes*
3. *Kary Mullis Thermus aquaticus*
4. *HGP in Nature*
5. *Celera's Genome in Science*

Journals e.g.:

1. Nature's 50th anniversary of the DNA structure

GLOSSARY OF TERMS USED IN SCIENCE PAPERS

It is hoped that the glossary (which is relevant only to science subjects) will prove helpful to candidates as a guide, i.e. it is neither exhaustive nor definitive. The glossary has been deliberately kept brief not only with respect to the number of terms included but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend in part on its context.

1. *Define* (*the term(s)*...) is intended literally. Only a formal statement or equivalent paraphrase being required.

2. *What do you understand by/What is meant by* (*the term(s)*...) normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.

3. *State* implies a concise answer with little or no supporting argument, e.g. a numerical answer that can be obtained 'by inspection'.

4. *List* requires a number of points, generally each of one word, with no elaboration. Where a given number of points is specified, this should not be exceeded.

5. *Explain* may imply reasoning or some reference to theory, depending on the context.

6. *Describe* requires candidates to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena. In other contexts, *describe and give an account of* should be interpreted more generally, i.e. the candidate has greater discretion about the nature and the organisation of the material to be included in the answer. *Describe and explain* may be coupled in a similar way to *state and explain*.

7. *Discuss* requires candidates to give a critical account of the points involved in the topic.

8. *Outline* implies brevity, i.e. restricting the answer to giving essentials.

9. *Predict* implies that the candidate is not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an early part of the question.

10. *Deduce* is used in a similar way as *predict* except that some supporting statement is required, e.g. reference to a law/principle, or the necessary reasoning is to be included in the answer.

11. *Comment* is intended as an open-ended instruction, inviting candidates to recall or infer points of interest relevant to the context of the question, taking account of the number of marks available.

12. *Suggest* is used in two main contexts, i.e. either to imply that there is no unique answer (e.g. in chemistry, two or more substances may satisfy the given conditions describing an 'unknown'), or to imply that candidates are expected to apply their general knowledge to a 'novel' situation, one that may be formally 'not in the syllabus'.

13. *Find* is a general term that may variously be interpreted as calculate, measure, determine etc.

14. *Calculate* is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.

15. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument, e.g. length, using a rule, or angle, using a protractor.

16. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula, e.g. relative molecular mass.

17. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.

18. *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, but candidates should be aware that, depending on the context, some quantitative aspects may be looked for, e.g. passing through the origin, having an intercept, asymptote or discontinuity at a particular value. In diagrams, sketch implies that a simple, freehand drawing is acceptable: nevertheless, care should be taken over proportions and the clear exposition of important details.

19. *Compare* requires candidates to provide both the similarities and differences between things or concepts.

20. *Recognise* is often used to identify facts, characteristics or concepts that are critical (relevant/appropriate) to the understanding of a situation, event, process or phenomenon.

21. *Classify* requires candidates to group things based on common characteristics.

SPECIAL NOTE

Units, significant figures. Candidates should be aware that misuse of units and/or significant figures, i.e. failure to quote units where necessary, the inclusion of units in quantities defined as ratios or quoting answers to an inappropriate number of significant figures, is liable to be penalised.