

# STANDARD LEVEL IB CHEMISTRY OPTIONS

## SYLLABUS DETAILS

### OPTION A - Higher Organic Chemistry

#### Obj. A.1 Multiple Bonds (1h)

A.1.1 Describe the relationship between the number of bonds and bond length/strength.

#### Obj. A.2 Shapes of Molecules and Ions (1h)

A.2.1 Predict the molecular/ionic shape and bond angles using the Valence Shell Electron Pair Repulsion (VSEPR) theory for 2 and 3 negative charge centres.

A.2.2 Predict the molecular/ionic shape and bond angles using the PR theory for 5 and 6 negative charge centres.

#### Obj. A.3 Determination of Structure (4h)

A.3.1 Explain how the structure of a compound can be determined by using information from a variety of spectroscopic and chemical techniques.

A.3.2 Describe and explain how information from an infrared spectrum can be used to identify functional groups in a compound.

A.3.3 Describe and explain how information from an infrared spectrum can be used to determine the structure of a compound.

A.3.4 Describe and explain how information from a  $^1\text{H}$  NMR spectrum can be used to determine the structure of a compound.

#### Obj. A.4 Hydrocarbons (4h)

A.4.1 Explain poor reactivity of alkanes in terms of C-H and C-C bonds.

A.4.2 Explain that alkanes can react with halogens and explain the difference between homolytic and heterolytic fission.

A.4.3 Explain the structure of benzene, using chemical and physical evidence.

A.4.4 Describe how the components of a hydrocarbon fuel relate to its 'octane rating'.

#### Obj. A.5 Halogenoalkanes (2h)

A.5.1 Describe and explain the  $\text{S}_{\text{N}}1$  and  $\text{S}_{\text{N}}2$  mechanisms in nucleophilic substitution.

A.5.2 Describe and explain for the  $\text{S}_{\text{N}}1$  and  $\text{S}_{\text{N}}2$  mechanisms.

A.5.3 Describe how the relative rate of nucleophilic substitution is affected by the halogenoalkane.

#### Obj. A.6 Alkanols (1h)

- A.6.1 Describe the dehydration reactions to form alkenes and alkoxyalkanes.
- A.6.2 Predict the products of the oxidation of primary, secondary and tertiary alkanols using acidified dichromate (VI) solution.

**Obj. A.7      Alkanals and alkanones (1h)**

- A.7.1 Explain how the reactivity of the carbonyl group relates to its structure.
- A.7.2 State the product of oxidation of alkanals with acidified dichromate (VI) solution.
- A.7.3 State the product of reduction of alkanals and alkanones with  $\text{LiAlH}_4$ .

**Obj. A.8      Alkanoic acids (1h)**

- A.8.1 Describe how alkanoic acids can be formed from primary alkanols.
- A.8.2 Discuss and explain the acidity of alkanols and alkanoic acids.
- A.8.3 Describe the structure and action of soaps.

## OPTION B - HIGHER PHYSICAL CHEMISTRY

### Obj. B.1 Entropy (2h)

- B.1.1 State and recognise factors which increase disorder in a system.
- B.1.2 Predict whether the entropy change for a given reaction or process would be positive or negative.
- B.1.3 Calculate the standard entropy change for a reaction using values of absolute entropies.

### Obj. B.2 Spontaneity of a reaction (2h)

- B.2.1 Explain that the tendency of a reaction to occur depends upon the total entropy change of the universe.
- B.2.2 Predict whether a reaction or process will be spontaneous by using the sign of  $\Delta G^\theta$ .
- B.2.3 State  $\Delta G^\theta = \Delta H^\theta - T\Delta S^\theta$
- B.2.4 Calculate  $\Delta G^\theta$  for a reaction using the equation  $\Delta G^\theta = \Delta H^\theta - T\Delta S^\theta$  or by using values of the standard Gibbs free energy change of formation.
- B.2.5 Predict the effect of a change in temperature on the spontaneity of a reaction, given standard entropy and enthalpy changes.

### Obj. B.3 Rate expression (3h)

- B.3.1 Predict the rate expression for a reaction given data showing how reaction rates vary with concentration of reactants.
- B.3.2 Define the terms 'order of a reaction' and 'rate constant'.
- B.3.3 Describe the qualitative effect of temperature changes on the rate constant.
- B.3.4 Interpret graphical representation for zero, first and second order reactions.
- B.3.5 Determine the order of a reaction from given data.
- B.3.6 Calculate half-life for first order reaction only.

### Obj. B.4 Reaction mechanism (1h)

- B.4.1 Define the terms 'rate determining step', 'molecularity' and 'activated complex'.
- B.4.2 Describe the relationship between mechanism, order, rate determining step and activated complex.

### Obj. B.5 Calculations involving acids and bases (4h)

- B.5.1 State the expression for the ionic product constant of water.
- B.5.2 Define pH, pOH, and  $PK_w$ .
- B.5.3 Calculate pH, pOH,  $[H^+(aq)]$  and  $[OH^-(aq)]$  from specified concentrations.
- B.5.4 State the equation for the reaction of any acid or base with water and hence derive the ionisation constant expression for any weak acid or base in water.

- B.5.5 Define  $K_a$ ,  $K_b$ ,  $pK_a$  and  $pK_b$ .
- B.5.6 Describe and explain the relationship between  $K_a$  and  $pK_a$ ; and between  $K_b$  and  $pK_b$ .
- B.5.7 Discuss the relative strengths of acids or their conjugate bases from  $K_a$  or  $pK_a$  values.
- B.5.8 Use  $K_a$  or  $pK_a$  in calculations.

Obj. B.6      **Buffer solutions (2h)**

- B.6.1 Describe a buffer solution in terms of its composition and behaviour.
- B.6.2 Calculate the pH of a specified buffer system.

Obj. B.7      **Acid-base titration (1h)**

- B.7.1 Sketch and explain the general shapes of graphs showing pH vs volume of titrant for titrations involving monoprotic acids and bases.

## **OPTION C - HUMAN BIOCHEMISTRY**

### **Obj. C.1      Diet (1h)**

- C.1.1 Describe the requirements of the human body for a healthy diet.
- C.1.2 Explain how the calorific value of a food is related to its enthalpy of combustion.

### **Obj. C.2      Proteins (3h)**

- C.2.1 State the basic structure of 2-amino acids.
- C.2.2 Describe the condensation reaction of amino acids to form polypeptides.
- C.2.3 Explain how proteins can be analysed by chromatography and electrophoresis.
- C.2.4 Describe and explain the primary, secondary, tertiary and quaternary structure of proteins.
- C.2.5 Describe the major functions of proteins in the body.

### **Obj. C.3      Carbohydrates (2.5h)**

- C.3.1 Explain the term 'monosaccharide'.
- C.3.2 Describe a straight-chain formula of glucose and the structural difference between  $\alpha$ -glucose and  $\beta$ -glucose.
- C.3.3 Describe the condensation of monosaccharides to form polysaccharides.
- C.3.4 describe the major functions of polysaccharides in the body.

### **Obj. C.4      Fats(2.5h)**

- C.4.1 Describe the composition of fats and oils.
- C.4.2 Explain the difference between saturated and unsaturated fats.
- C.4.3 Calculate the number of C=C double bonds in a fat from addition reactions.
- C.4.4 Describe the hydrolysis of fats to form soap.
- C.4.5 Describe the major functions of fats in the body.

### **Obj. C.5      Vitamins (2.5h)**

- C.5.1 Describe the role of vitamins in metabolism.
- C.5.2 Classify vitamins as water or fat soluble.
- C.5.3 Describe the structure and major functions of retinol (vitamin A), calciferol (vitamin D) and ascorbic acid (vitamin C).
- C.5.4 Discuss the effects of food processing on the vitamin content of food.

### **Obj. C.6.1      Hormones (3.5h)**

- C.6.1 Describe the production and roles of hormones in the body.
- C.6.2 Recognise the similarities and differences between the structures of cholesterol and the sex hormones.

C.6.3 Describe the mode of action of oral contraceptives.

C.6.4 Describe the use and abuse of steroids.

## **OPTION D - ENVIRONMENTAL CHEMISTRY**

### **Obj. D.1 Primary air pollution (3h)**

- D.1.1 Describe the sources of the carbon monoxide, 'nitrogen oxides', 'sulphur oxides', particulates and hydrocarbons in the atmosphere.
- D.1.2 Describe the effects of primary air pollution on health.
- D.1.3 Describe and discuss methods for the control and prevention of primary air pollution.

### **Obj. D.2 Ozone depletion (2h)**

- D.2.1 Discuss the evidence for ozone depletion.
- D.2.2 Describe the formation and depletion of ozone in the ozone layer by natural processes.
- D.2.3 Describe the pollutants, and their sources, that cause rapid ozone depletion.
- D.2.4 Discuss the environmental effects of rapid depletion, and alternatives to CFC's.

### **Obj. D.3 Global warming (2h)**

- D.3.1 Discuss the evidence for global warming.
- D.3.2 Identify the main gases which cause the greenhouse effect, and their sources.
- D.3.3 Discuss the influence of these gases on global warming, and its possible effects.
- D.3.4 Discuss the influence of particulates on the Earth's surface temperature.

### **Obj. D.4 Acid rain (2h)**

- D.4.1 Describe the pollutants, sources and chemical reactions leading to acid rain.
- D.4.2 Discuss the environmental effects of acid rain.
- D.4.3 Discuss and evaluate possible methods of controlling acid rain.

### **Obj. D.5 Demand and supply of fresh water (1.5h)**

- D.5.1 Discuss the reasons for the inadequacy of global fresh water supply to meet demand.
- D.5.2 Discuss ways to 'save' and recycle water.
- D.5.3 Discuss ways to obtain fresh water from sea water using distillation, reverse osmosis or ion exchange.

### **Obj. D.6 Oxygen demanding wastes (1.5h)**

- D.6.1 Explain the importance of dissolved oxygen in water.
- D.6.2 Describe aerobic and anaerobic decomposition of organic material in water.
- D.6.3 Discuss the effects of oxygen demanding wastes on water quality.

D.6.4 Define Biological Oxygen Demand (BOD) and describe how it is a measure for oxygen demanding wastes.

D.6.5 Describe the effect of heat on dissolved oxygen and metabolism.

Obj. D.7      **Water treatment (3h)**

D.7.1 Discuss the reasons for treating drinking water.

D.7.2 Compare the advantages and disadvantages of treating drinking water with chlorine and ozone.

D.7.3 Describe primary, secondary and tertiary stages of sewage treatment.

D.7.4 State the pollutants removed during each stage of treatment in D.7.3.

D.7.5 Discuss the effectiveness of the different treatments and the increasing need for tertiary treatment.

## **OPTION E - CHEMICAL INDUSTRIES**

### **Obj. E.1 Initial overview (2h)**

- E.1.1 Describe the abundance and availability of sources of materials.
- E.1.2 Explain the factors that influence the establishment of a chemical industry in a particular location.
- E.1.3 Explain the division of the industry into bulk chemicals and speciality chemicals.

### **Obj. E.2 Principles of extraction and production (2h)**

- E.2.1 Explain that materials are rarely found free in nature and have to be extracted and processed before they can be used.
- E.2.2 Describe the principles used in the physical separation and purification of materials.
- E.2.3 Discuss the chemical principles used in the physical separation and purification of materials.

### **Obj. E.3 Metals - iron and aluminium (3h)**

- E.3.1 State the main sources of iron.
- E.3.2 Explain the reactions that occur in the blast furnace.
- E.3.3 Describe the conversion of iron into steel in the basic oxygen converter.
- E.3.4 Describe the main properties of common forms of iron and steel.
- E.3.5 Explain the principal uses of iron and steel.
- E.3.6 Describe the production of pure alumina from bauxite.
- E.3.7 Discuss the production of aluminium by electrolysis of alumina ( $\text{Al}_2\text{O}_3$ ) in molten cryolite ( $\text{Na}_3\text{AlF}_6$ ).
- E.3.8 Describe the main properties of aluminium.
- E.3.9 Explain the principal uses of aluminium.
- E.3.10 Discuss the environmental impact of iron and aluminium production.

### **Obj. E.4 Air (1h)**

- E.4.1 Describe how oxygen, nitrogen and argon are obtained from air.
- E.4.2 Describe the main uses of air products.

### **Obj. E.5 Equilibrium processes - The Haber and contact processes (2h)**

- E.5.1 Explain that many industrial processes depend on manipulation of equilibria.
- E.5.2 Describe the uses of ammonia.
- E.5.3 Describe the contact process, and compare its conditions with those used in the Haber process.
- E.5.4 Describe the uses of sulphuric acid.

Obj. E.6      **The oil industry (4h)**

- E.6.1 Describe the importance of oil as a source of chemical feedstock.
- E.6.2 Describe cracking and its products.
- E.6.3 Describe reforming processes and their products.
- E.6.4 Describe the removal of sulphur from crude oil.
- E.6.5 Explain the uses of refinery products as feedstock for the organic chemical industry.
- E.6.6 Describe and compare the properties and uses of polymers.
- E.6.7 Discuss the environmental implications of polymer use.

Obj E.7      **Other chemical industries (1h)**

- E.7.1 State that there are other important material manufactures.
- E.7.2 Describe the role of biotechnology in chemical manufacture.

## **OPTION F - FUELS AND ENERGY**

### **Obj. F.1 Energy sources (1h)**

F.1.1 Discuss the desirable characteristics of energy sources.

F.1.2 State current and potential energy sources.

### **Obj. F.2 Fossil fuels (5h)**

F.2.1 Describe how coal, oil and natural gases are formed.

F.2.2 Describe the characteristics of coal, oil and natural gas.

F.2.3 Calculate the enthalpy of combustion of a compound.

F.2.4 State the main types of pollutants produced by the burning of fossil fuels.

F.2.5 Describe how the burning of fossil fuels produces each type of pollutant.

F.2.6 describe the fractional distillation of oil as part of the refining process.

F.2.7 Describe the composition and characteristics of the oil fractions used for fuel.

F.2.8 Describe the main methods for increasing the yield of the gasoline fraction of petroleum.

F.2.9 Describe the processes of coal gasification and liquefaction,

F.2.10 Describe the functions of the main components of a fossil fuel power plant.

F.2.11 Discuss the advantages and disadvantages of the different fossil fuels.

### **Obj. F.3 Nuclear energy (4h)**

F.3.1 Discuss the differences between nuclear reactions and chemical reactions.

F.3.2 Write balanced nuclear equations.

F.3.3 describe the nature of  $\alpha$ ,  $\beta$  and  $\gamma$  radiation and state how to differentiate between them.

F.3.4 Explain the concept of half-life.

F.3.5 Perform calculations involving whole numbers of half-lives.

F.3.6 Describe the difference between nuclear fission and nuclear fusion.

F.3.7 Describe the functions of the main components of a nuclear power plant.

F.3.8 Discuss why certain fuels are used in nuclear reactors.

F.3.9 Discuss the differences between conventional power reactors and nuclear reactors.

F.3.10 Discuss the concerns about safety in nuclear power plants.

### **Obj. F.4 Solar energy (3h)**

F.4.1 Describe the characteristics of solar energy.

F.4.2 Describe the ways in which solar energy can be converted to other forms of energy.

F.4.3 Describe the role of photosynthesis in converting solar energy to other forms of energy.

F.4.4 Describe and discuss the ways in which biomass can be converted to energy.

F.4.5 Describe the principles of using solar energy for space heating.

F.4.6 Discuss the methods by which solar energy can be converted into electricity.

Obj. F.5      **Electrochemical energy (2h)**

F.5.1 State the materials used as electrodes and the electrolytes in the lead-acid storage battery and dry cell (Leclanchæ and alkaline) batteries.

F.5.2 Explain the factors that affect the voltage and power available from a battery.

**END**