



CHEMISTRY (International Advanced Subsidiary in Chemistry)

CHEMISTRY CONTENT		IAS	IAL
Unit 1	Structure, Bonding and Introduction to Organic Chemistry	40%	20%
Unit 2	Energetics, Group Chemistry, Halogenoalkanes and Alcohols	40%	20%
Unit 3	Practical Skills in Chemistry I	20%	10%

IAS Unit 1: Structure, Bonding and Introduction to Organic Chemistry

Externally assessed (Availability: January & June)

(40%) of the total IAS (80 marks)

Written examination: 1 hour and 30 minutes

Content overview

- Formulae, Equations and Amount of Substance
- Atomic Structure and the Periodic Table
- Bonding and Structure
- Introductory Organic Chemistry and Alkanes
- Alkenes

Assessment overview

This paper has two sections:

(Section A: multiple choice questions) (Section B: mixture of short-open, open-response and calculation questions.)

IAS Unit 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

Externally assessed (Availability: January & June)

(40%) of the total IAS (80 marks)

Written examination: 1 hour and 30 minutes

Content overview

- Energetics
- Intermolecular Forces
- Redox Chemistry and Groups 1, 2 and 7
- Introduction to Kinetics and Equilibria
- Organic Chemistry: Alcohols, Halogenoalkanes and Spectra

Assessment overview

This paper has three sections:

Section A: multiple choice questions

Section B: mixture of short-open, open-response, calculations and extended-writing questions

Section C: contemporary context question.

- This paper will contain questions that require information from the Data Booklet

IAS Unit 3: Practical Skills in Chemistry I

Externally assessed (Availability: January & June)

(20%) of the total IAS (50 marks)

Written examination: 1 hour and 20 minutes

Content overview

Students are expected to develop experimental skills, and a knowledge and understanding of experimental techniques, by carrying out a range of practical experiments and investigations while they study Units 1 and 2. This unit will assess students' knowledge and understanding of experimental procedures and techniques that were developed in Units 1 and 2.

Assessment overview

- This paper may include short-open, open-response and calculation questions.
- Students will be expected to apply their knowledge and understanding of practical skills to familiar and unfamiliar situations.



Unit 1: Structure, Bonding and Introduction to Organic Chemistry

UNIT 1 - Topic 1: Formulae, Equations and Amount of Substance

Students will be assessed on their ability to:

1.1	know the terms 'atom', 'element', 'ion', 'molecule', 'compound', 'empirical formula' and 'molecular formula'
1.2	know that the mole (mol) is the unit for the amount of a substance and be able to perform calculations using the Avogadro constant L ($6.02 \times 10^{23} \text{ mol}^{-1}$)
1.3	write balanced full and ionic equations, including state symbols, for chemical reactions
1.4	understand the terms: (i) 'relative atomic mass' based on the ^{12}C scale (ii) 'relative molecular mass' and 'relative formula mass', including calculating these values from relative atomic masses (<i>The term 'relative formula mass' should be used for compounds with giant Structures</i>) (iii) 'molar mass' as the mass per mole of a substance in g mol^{-1} (iv) parts per million (ppm), including gases in the atmosphere
1.5	calculate the concentration of a solution in mol dm^{-3} and g dm^{-3} (<i>Titration calculations are not required at this stage</i>).
1.6	be able to use experimental data to calculate empirical and molecular formulae
1.7	be able to use chemical equations to calculate reacting masses and vice versa, using the concepts of amount of substance and molar mass
1.8	be able to use chemical equations to calculate volumes of gases and vice versa, using: (i) the concepts of amount of substance (ii) the molar volume of gases (iii) the expression $pV = nRT$ for gases and volatile liquids
1.9	be able to calculate percentage yields and percentage atom economies (by mass) in laboratory and industrial processes, using chemical equations and experimental results $\text{Atom economy} = \frac{\text{molar mass of the desired product}}{\text{sum of the molar masses of all products}} \times 100\%$
1.10	be able to determine a formula or confirm an equation by experiment, including evaluation of the data
1.11	CORE PRACTICAL 1: Measurement of the molar volume of a gas.
1.12	be able to relate ionic and full equations, with state symbols, to observations from simple test-tube experiments, to include: (i) displacement reactions (ii) typical reactions of acids (iii) precipitation reactions Further suggested practicals: (i) preparation of a salt and calculating the percentage yield of product, including the preparation of a double salt, such as ammonium iron(II) sulfate from iron, ammonia and sulfuric acid (ii) determine a chemical formula by experiment, such as the formula of copper(II) oxide by reduction (iii) determine a chemical equation by experiment, such as the reaction between lithium and water, or the reaction between magnesium and an acid (iv) carry out and interpret the results of simple test-tube reactions



UNIT 1 - Topic 2: Atomic Structure and the Periodic Table

Students will be assessed on their ability to:

2.1	know the structure of an atom in terms of electrons, protons and neutrons
2.2	know the relative mass and charge of protons, neutrons and electrons
2.3	know what is meant by the terms 'atomic (proton) number' and 'mass number'
2.4	be able to use the atomic number and the mass number to determine the number of each type of subatomic particle in an atom or ion
2.5	understand the term 'isotope'
2.6	understand the basic principles of a mass spectrometer and be able to analyse and interpret mass spectra to: (i) deduce the isotopic composition of a sample of an element (ii) calculate the relative atomic mass of an element from relative abundances of isotopes and vice versa (iii) determine the relative molecular mass of a molecule, and hence identify molecules in a sample (iv) understand that ions in a mass spectrometer may have a 2+ charge
2.7	be able to predict mass spectra, including relative peak heights, for diatomic molecules, including chlorine, given the isotopic abundances
2.8	be able to define first, second and third ionisation energies and understand that all ionisation energies are endothermic
2.9	know that an orbital is a region within an atom that can hold up to two electrons with opposite spins
2.10	understand how ionisation energies are influenced by the number of protons in the nucleus, the electron shielding and the sub-shell from which the electron is removed
2.11	know that ideas about electronic structure developed from: (i) an understanding that successive ionisation energies provide evidence for the existence of quantum shells and the group to which the element belongs (ii) an understanding that the first ionisation energy of successive elements provides evidence for electron sub-shells
2.12	be able to describe the shapes of <i>s</i> and <i>p</i> orbitals
2.13	know that orbitals in sub-shells: (i) each take a single electron before pairing up (ii) pair up with two electrons of opposite spin
2.14	be able to predict the electronic configuration of atoms of the elements from hydrogen to krypton inclusive and their ions, using <i>s</i> , <i>p</i> , <i>d</i> notation and electron-inboxes notation
2.15	understand that electronic configuration determines the chemical properties of an element
2.16	know that the Periodic Table is divided into blocks, such as <i>s</i> , <i>p</i> and <i>d</i> , and know the number of electrons that can occupy <i>s</i> , <i>p</i> and <i>d</i> sub-shells in the first four quantum shells
2.17	be able to represent data, in a graphical form (including the use of logarithms of first ionisation energies on a graph) for elements 1 to 36 and hence explain the meaning of the term 'periodic property'
2.18	be able to explain: (i) the trends in melting and boiling temperatures of the elements of Periods 2 and 3 of the Periodic Table in terms of the structure of the element and the bonding between its atoms or molecules (ii) the general increase and the specific trends in ionisation energy of the elements across Periods 2 and 3 of the Periodic Table (iii) the decrease in first ionisation energy down a group



UNIT 1 - Topic 3: Bonding and Structure

Students will be assessed on their ability to:

3A: Ionic bonding

3.1	know and be able to interpret evidence for the existence of ions, limited to physical properties of ionic compounds, electron density maps and the migration of ions
3.2	be able to describe the formation of ions in terms of loss or gain of electrons
3.3	be able to draw dot-and-cross diagrams to show electrons in cations and anions
3.4	be able to describe ionic crystals as giant lattices of ions
3.5	know that ionic bonding is the result of strong net electrostatic attraction between ions
3.6	understand the effects of ionic radius and ionic charge on the strength of ionic bonding
3.7	understand reasons for the trends in ionic radii down a group in the Periodic Table, and for a set of isoelectronic ions, including N^{3-} to Al^{3+}
3.8	understand the meaning of the term 'polarisation' as applied to ions
3.9	understand that the polarising power of a cation depends on its radius and charge, and the polarisability of an anion also depends on its radius and charge
	Further suggested practical The migration of ions in a U-tube using copper(II) chromate solution or on a microscope slide using potassium manganate(VII) crystals

3B: Covalent bonding

3.10	understand that covalent bonding is the strong electrostatic attraction between two nuclei and the shared pair of electrons between them, based on the evidence: (i) the physical properties of giant atomic structures (ii) electron density maps for simple molecules
3.11	be able to draw dot-and-cross diagrams to show electrons in covalent substances, including: i molecules with single, double and triple bonds ii species with dative covalent (coordinate) bonds, including Al_2Cl_6 and the ammonium ion
3.12	be able to describe the different structures formed by giant lattices of carbon atoms, including graphite, diamond and graphene, and discuss the applications of each
3.13	understand the meaning of the term 'electronegativity' as applied to atoms in a covalent bond
3.14	know that ionic and covalent bonding are the extremes of a continuum of bonding type and be able to explain this in terms of electronegativity differences, leading to bond polarity in bonds and molecules, and to ionic bonding if the electronegativity is large enough
3.15	be able to distinguish between polar bonds and polar molecules and predict whether or not a given molecule is likely to be polar
	Further suggested practical Determine the effect of an electrostatic force on jets of liquids (water, ethanol and cyclohexane) and use the results to determine whether the molecules are polar or non-polar

3C: Shapes of molecules

3.16	understand the principles of the electron-pair repulsion theory, used to interpret and predict the shapes of simple molecules and ions
3.17	understand the terms 'bond length' and 'bond angle'
3.18	know and be able to explain the shapes of, and bond angles in, $BeCl_2$, BCl_3 , CH_4 , NH_3 , NH_4^+ , H_2O , CO_2 , gaseous PCl_5 , SF_6 and C_2H_4
3.19	be able to apply the electron-pair repulsion theory to predict the shapes of, and bond angles in, molecules and ions analogous to those in 3.18

3D: Metallic bonding

3.20	understand that metals consist of giant lattices of metal ions in a sea of delocalised electrons
3.21	know that metallic bonding is the strong electrostatic attraction between metal ions and the delocalised electrons
3.22	be able to use the models in 3.20 and 3.21 to interpret simple properties of metals, including electrical conductivity and high melting temperature



UNIT 1 - Topic 4: Introductory Organic Chemistry and Alkanes

Students will be assessed on their ability to:

4A: Introduction

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| 4.1 | understand the difference between hazard and risk |
| 4.2 | understand the hazards associated with organic compounds and why it is necessary to carry out risk assessments when dealing with potentially hazardous materials |
| 4.3 | be able to suggest ways in which risks can be reduced and reactions carried out safely, for example:
(i) working on a smaller scale
ii taking precautions specific to the hazard
iii using an alternative method that involves less hazardous substances |
| 4.4 | understand the concepts of homologous series and functional group |
| 4.5 | be able to apply the rules of International Union of Pure and Applied Chemistry (IUPAC) nomenclature to:
i name compounds relevant to this specification
ii draw these compounds, as they are encountered in the specification, using structural, displayed and skeletal formulae
(Students will be expected to know prefixes for compounds up to C ₁₀) |
| 4.6 | be able to classify reactions as addition, substitution, oxidation, reduction or polymerisation |
| 4.7 | understand that bond breaking can be:
(i) homolytic, to produce free radicals (ii) heterolytic, to produce ions |
| 4.8 | know definitions of the terms 'free radical' and 'electrophile' |

4B: Alkanes

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| 4.9 | know the general formula of alkanes and cycloalkanes, and understand that they are hydrocarbons (compounds of carbon and hydrogen only) which are saturated (contain single bonds only) |
| 4.10 | understand the term 'structural isomerism' and be able to draw the structural isomers of organic molecules, given their molecular formula |
| 4.11 | be able to draw and name the structural isomers of alkanes and cycloalkanes with up to six carbon atoms |
| 4.12 | know that alkanes are used as fuels and obtained from the fractional distillation, cracking and reforming of crude oil, and be able to write equations for these reactions |
| 4.13 | know that pollutants, including carbon monoxide, oxides of nitrogen and sulfur, carbon particulates and unburned hydrocarbons, are emitted during the combustion of alkane fuels |
| 4.14 | understand the problems arising from pollutants from the combustion of alkane fuels, limited to the toxicity of carbon monoxide and why it is toxic, and the acidity of oxides of nitrogen and sulfur |
| 4.15 | be able to discuss the reasons for developing alternative fuels in terms of sustainability and reducing emissions, including the emission of CO ₂ and its relationship to climate change |
| 4.16 | be able to apply the concept of carbon neutrality to different fuels, such as petrol, bioethanol and hydrogen |
| 4.17 | understand the reactions of alkanes with:
(i) oxygen in the air (combustion) (ii) halogens |
| 4.18 | understand the mechanism of the free radical substitution reaction between an alkane and a halogen:
i using free radicals, which are species with an unpaired electron, represented by a single dot
ii showing the initiation step of the mechanism, with curly half-arrows for free radical formation
iii showing the propagation and termination steps of the mechanism
iv having limited use in synthesis because of further substitution reactions |

Further suggested practical

Cracking alkanes by thermal decomposition, including liquid paraffin using aluminium oxide as a catalyst



UNIT 1 - Topic 5: Alkenes

Students will be assessed on their ability to:

5.1	know the general formula of alkenes and understand that alkenes and cycloalkenes are hydrocarbons which are unsaturated (have a carbon-carbon double bond which consists of a σ bond and a π bond)
5.2	be able to explain geometric isomerism in terms of restricted rotation around a C=C double bond and the nature of the substituents on the carbon atoms
5.3	understand the <i>E-Z</i> naming system for geometric isomers and why it is necessary to use this when the <i>cis-</i> and <i>trans-</i> naming system breaks down
5.4	be able to describe the reactions of alkenes, limited to: (i) the addition of hydrogen, using a nickel catalyst, to form an alkane (ii) the addition of halogens to produce a di-substituted halogenoalkane (iii) the addition of hydrogen halides to produce mono-substituted halogenoalkanes (iv) the addition of steam, in the presence of an acid catalyst, to produce alcohols (v) oxidation of the double bond by acidified potassium manganate(VII) to produce a diol
5.5	know the qualitative test for a C=C double bond using bromine or bromine water
5.6	be able to describe the mechanism (including diagrams), giving evidence where possible, of: i the electrophilic addition of bromine and hydrogen bromide to ethene ii the electrophilic addition of hydrogen bromide to propene <i>Use of the curly arrow notation is expected – the curly arrows should start from either a bond or from a lone pair of electrons.</i> <i>Knowledge of the relative stability of primary, secondary and tertiary carbocation intermediates is expected.</i>
5.7	be able to describe the addition polymerisation of alkenes and draw the repeat unit given the monomer, and vice versa
5.8	understand how chemists limit the problems caused by polymer disposal by: i developing biodegradable polymers ii removing toxic waste gases produced by the incineration of polymers
	Further suggested practicals: (i) investigating the difference in reactivity of alkanes and alkenes, including combustion, reaction with bromine water, reaction with acidified potassium manganate(VII) (ii) preparation of cyclohexene from cyclohexanol (iii) preparation of limonene from orange peel by steam distillation (iv) preparation of Perspex® from methyl 2-methylpropenoate



Unit 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

UNIT 2 - Topic 6: Energetics

Students will be assessed on their ability to:

6.1	know that the enthalpy change, ΔH , is the heat energy change measured at constant pressure and that standard conditions are 100 kPa and a specified temperature, usually 298 K
6.2	know that, by convention, exothermic reactions have a negative enthalpy change and endothermic reactions have a positive enthalpy change
6.3	be able to construct and interpret enthalpy level diagrams, showing exothermic and endothermic enthalpy changes
6.4	know the definition of standard enthalpy change of: (i) reaction, $\Delta_r H$ (ii) formation, $\Delta_f H$ (iii) combustion, $\Delta_c H$ (iv) neutralisation, $\Delta_{neut} H$ (v) atomisation, $\Delta_{at} H$
6.5	be able to use experimental data to calculate: (i) energy transferred in a reaction recalling and using the expression: energy transferred (J) = mass (g) \times specific heat capacity ($J g^{-1} ^\circ C^{-1}$) \times temperature change ($^\circ C$) ii enthalpy change of the reaction in $kJ mol^{-1}$ <i>This will be limited to experiments where substances are mixed in an insulated container and combustion experiments using a suitable calorimeter.</i>
6.6	know Hess's Law and be able to apply it to: i constructing enthalpy cycles ii calculating enthalpy changes of reaction using data provided, or data selected from a table or obtained from experiments
6.7	CORE PRACTICAL 2: Determination of the enthalpy change of a reaction using Hess's Law.
6.8	be able to evaluate the results obtained from experiments and comment on sources of error and uncertainty and any assumptions made in the experiments <i>Students will need to consider experiments where substances are mixed in an insulated container and combustion experiments using, for example, a spirit burner and be able to draw suitable graphs and use cooling curve corrections.</i>
6.9	understand the terms 'bond enthalpy' and 'mean bond enthalpy', and be able to use bond enthalpies to calculate enthalpy changes, understanding the limitations of this method
6.10	be able to calculate mean bond enthalpies from enthalpy changes of reaction
6.11	understand that bond enthalpy data gives some indication about which bond will break first in a reaction, how easy or difficult it is and therefore how rapidly a reaction will take place at room temperature
	Further suggested practicals: i the enthalpy change for the decomposition of calcium carbonate using the enthalpy changes of reaction of calcium carbonate and calcium oxide with hydrochloric acid ii the enthalpy change of combustion of an alcohol iii the enthalpy change of the reaction between zinc and copper(II) sulfate solution iv the enthalpy of hydration of anhydrous copper(II) sulfate



UNIT 2 - Topic 7: Intermolecular Forces

Students will be assessed on their ability to:

7.1	understand the nature of the following intermolecular forces: (i) London forces (instantaneous dipole-induced dipole) (ii) permanent dipole-permanent dipole interactions (iii) hydrogen bonds
7.2	understand the interactions in molecules, such as H ₂ O, liquid NH ₃ and liquid HF, which give rise to hydrogen bonding
7.3	understand the following anomalous properties of water resulting from hydrogen bonding: (i) its high melting and boiling temperature when compared with similar molecules (ii) the density of ice compared to that of water
7.4	be able to predict the presence of hydrogen bonding in molecules analogous to those mentioned in 7.2
7.5	understand, in terms of intermolecular forces, physical properties shown by substances, including: (i) the trends in boiling temperatures of alkanes with increasing chain length (ii) the effect of branching in the carbon chain on the boiling temperatures of alkanes (iii) the relatively low volatility (higher boiling temperatures) of alcohols compared to alkanes with a similar number of electrons (iv) the trends in boiling temperatures of the hydrogen halides HF to HI
7.6	understand factors that influence the choice of solvents, including: (i) water, to dissolve some ionic compounds, in terms of the hydration of the ions (ii) water, to dissolve simple alcohols, in terms of hydrogen bonding (iii) water, as a poor solvent for compounds (to include polar molecules such as halogenoalkane), in terms of inability to form hydrogen bonds (iv) non-aqueous solvents, for compounds that have similar intermolecular forces to those in the solvent
	Further suggested practicals: (i) the solubility of simple molecules in different solvents (ii) measuring the enthalpy change of vaporisation of water (iii) measuring temperature changes when substances dissolve



UNIT 2 - Topic 8: Redox Chemistry and Groups 1, 2 and 7

Students will be assessed on their ability to:

8A: Redox chemistry

8.1	know what is meant by the term 'oxidation number' and understand the rules for assigning oxidation numbers
8.2	be able to calculate the oxidation number of elements in compounds and ions, including in peroxides and metal hydrides
8.3	be able to indicate the oxidation number of an element in a compound or an ion, using a Roman numeral
8.4	be able to write formulae given oxidation numbers
8.5	understand oxidation and reduction in terms of electron transfer and changes in oxidation number, and the application of these ideas to reactions of s-block and p-block elements
8.6	know that oxidising agents gain electrons and reducing agents lose electrons
8.7	understand that a disproportionation reaction involves an element in a single species being simultaneously oxidised and reduced
8.8	know that oxidation number is a useful concept in terms of the classification of reactions as redox and as disproportionation
8.9	understand that metals, in general, form positive ions by loss of electrons with an increase in oxidation number whereas non-metals, in general, form negative ions by gain of electrons with a decrease in oxidation number
8.10	be able to write ionic half-equations and use them to construct full ionic equations

UNIT 2 - Topic 8: Redox Chemistry and Groups 1, 2 and 7

8B: The elements of Groups 1 and 2

8.11	understand reasons for the trend in ionisation energy down Groups 1 and 2
8.12	understand reasons for the trend in reactivity of the elements down Group 1 (Li to K) and Group 2 (Mg to Ba)
8.13	know the reactions of the elements of Group 1 (Li to K) and Group 2 (Mg to Ba) with oxygen, chlorine and water
8.14	know the reactions of: (i) oxides of Group 1 and 2 elements with water and dilute acid (ii) hydroxides of Group 1 and 2 elements with dilute acid
8.15	know the trends in solubility of the hydroxides and sulfates of Group 2 elements
8.16	understand the reasons for the trends in thermal stability of the nitrates and the carbonates of the elements in Groups 1 and 2 in terms of the size and charge of the cations involved
8.17	understand the formation of characteristic flame colours by Group 1 and 2 compounds in terms of electron transitions <i>Students will be expected to know the flame colours for Group 1 and 2 compounds.</i>
8.18	know experimental procedures to show: (i) patterns in the thermal decomposition of Group 1 and 2 nitrates and carbonates <i>Students will be expected to know tests for carbon dioxide and oxygen; and to recognise nitrogen dioxide by its colour and acidic pH.</i> (ii) flame colours in compounds of Group 1 and 2 elements
8.19	know reactions, including ionic equations where appropriate, for identifying: (i) carbonate ions, CO_3^{2-} , and hydrogencarbonate ions, HCO_3^- , using an aqueous acid to form carbon dioxide (and testing the gas with limewater) (ii) sulfate ions, SO_4^{2-} , using acidified barium chloride solution (iii) ammonium ions, NH_4^+ , using sodium hydroxide solution and warming to form ammonia (and testing with litmus and HCl fumes)
8.20	be able to calculate solution concentrations, in mol dm^{-3} and g dm^{-3} , including simple acid-base titrations using the indicators methyl orange and phenolphthalein



8.21	CORE PRACTICAL 3: Finding the concentration of a solution of hydrochloric acid.
8.22	understand how to minimise the sources of measurement uncertainty in volumetric analysis and estimate the overall uncertainty in the calculated result
8.23	CORE PRACTICAL 4: Preparation of a standard solution from a solid acid and use it to find the concentration of a solution of sodium hydroxide.
	<p>Further suggested practicals:</p> <ul style="list-style-type: none"> (i) experiments to study the thermal decomposition of Group 1 and 2 nitrates and carbonates (ii) flame tests on compounds of Group 1 and 2 (iii) simple acid-base titrations using the indicators methyl orange and phenolphthalein to calculate solution concentrations in g dm^{-3} and mol dm^{-3} (iv) the solubility of calcium hydroxide by titration (v) determination of moles of water of crystallisation by titration
UNIT 2 - Topic 8: Redox Chemistry and Groups 1, 2 and 7	
8C: Inorganic chemistry of Group 7 (limited to chlorine, bromine and iodine)	
8.24	understand reasons for the trends for Group 7 elements in: <ul style="list-style-type: none"> (i) melting and boiling temperatures and physical state at room temperature (ii) electronegativity (iii) reactivity down the group
8.25	understand the trend in reactivity of Group 7 elements in terms of the redox reactions of Cl_2 , Br_2 and I_2 with halide ions in aqueous solution <i>Students are expected to know the colours of the elements in standard conditions, in aqueous solution and in a non-polar organic solvent.</i>
8.26	understand, in terms of changes in oxidation number, the following reactions of the halogens: <ul style="list-style-type: none"> (i) oxidation reactions with Group 1 and 2 metals (ii) the disproportionation reaction of chlorine with water and the use of chlorine in water treatment (iii) the disproportionation reaction of chlorine with cold, dilute aqueous sodium hydroxide to form bleach (iv) the disproportionation reaction of chlorine with hot alkali (v) reactions analogous to those specified above
8.27	understand the following reactions: <ul style="list-style-type: none"> (i) solid Group 1 halides with concentrated sulfuric acid, to illustrate the trend in reducing ability of the hydrogen halides (ii) precipitation reactions of the aqueous anions Cl^-, Br^- and I^- with aqueous silver nitrate solution and nitric acid, and the solubility of the precipitates in aqueous ammonia solution (iii) hydrogen halides with ammonia gas (to produce ammonium halides) and with water (to produce acids)
8.28	be able to make predictions about fluorine and astatine and their compounds, in terms of knowledge of trends in halogen chemistry
	<p>Further suggested practicals:</p> <ul style="list-style-type: none"> (i) reaction of solid potassium halides with concentrated sulfuric acid (ii) precipitation reaction for halides and other anions



UNIT 2 - Topic 9: Introduction to Kinetics and Equilibria

Students will be assessed on their ability to:

9A: Kinetics

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| 9.1 | understand, in terms of the collision theory, the effect of changes in concentration, temperature, pressure and surface area on the rate of a chemical reaction |
| 9.2 | understand that reactions take place only when collisions have sufficient energy, known as the activation energy |
| 9.3 | be able to calculate the rate of a reaction from:
(i) the time taken for a reaction, using $\text{rate} = 1/\text{time}$
(ii) the gradient of suitable graph, by drawing a tangent, either for initial rate, or at a time, t |
| 9.4 | understand qualitatively, in terms of the Maxwell-Boltzmann distribution of molecular energies, how changes in temperature affect the rate of a reaction |
| 9.5 | understand the role of catalysts in providing alternative reaction routes of lower activation energy |
| 9.6 | be able to draw the reaction profiles for uncatalysed and catalysed reactions, including the energy level of the intermediate formed with the catalyst |
| 9.7 | understand the use of catalysts in industry to make processes more sustainable by using less energy and/or higher atom economy |
| 9.8 | be able to interpret the action of a catalyst in terms of a qualitative understanding of the Maxwell-Boltzmann distribution of molecular energies |
| | Further suggested practical
Experiments to demonstrate the factors that influence the rate of chemical reactions, including the decomposition of hydrogen peroxide, reaction of marble chips with acid, reaction of thiosulfate ions with acid |

9B: Equilibria

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| 9.9 | know that many reactions are readily reversible and that they can reach a state of dynamic equilibrium in which:
(i) the rate of the forward reaction is equal to the rate of the backward reaction
(ii) the concentrations of the reactants and the products remain constant |
| 9.10 | be able to predict and justify the qualitative effects of changes of temperature, pressure and concentration on the position of equilibrium in a homogeneous system |
| 9.11 | evaluate data to explain the necessity, for many industrial processes, to reach a compromise between the yield and the rate of reaction |
| | Further suggested practicals:
Demonstrate the effect of a change of temperature, pressure and concentration on a system at equilibrium:
(i) chlorine reacting with iodine to form iodine(I) chloride, which then reacts with chlorine to form iodine(III) chloride
(ii) the equilibrium system between nitrogen dioxide (NO_2) and dinitrogen tetroxide (N_2O_4) |



UNIT 2 - Topic 10: Organic Chemistry: Halogenoalkanes, Alcohols and Spectra

Students will be assessed on their ability to:

10A: General principles

10.1	be able to classify reactions (including those in Unit 1) as addition, elimination, substitution, oxidation, reduction, hydrolysis or polymerisation
10.2	understand the concept of a reaction mechanism
10.3	understand that heterolytic bond breaking results in species that are electrophiles or nucleophiles
10.4	know the definition of the term 'nucleophile'
10.5	understand the link between bond polarity and the type of reaction mechanism a compound will undergo

UNIT 2 - Topic 10: Organic Chemistry: Halogenoalkanes, Alcohols and Spectra

10B: Halogenoalkanes

10.6	understand the nomenclature of halogenoalkanes and be able to draw their structural, displayed and skeletal formulae
10.7	understand the distinction between primary, secondary and tertiary halogenoalkanes
10.8	understand the reactions of halogenoalkanes with: (i) aqueous alkali, including KOH(aq) to produce alcohols (where the hydroxide ion acts as a nucleophile) (ii) ethanolic potassium hydroxide to produce alkenes by an elimination reaction (where the hydroxide ion acts as a base) (iii) aqueous silver nitrate in ethanol (where water acts as a nucleophile) (iv) alcoholic ammonia under pressure to produce amines (where the ammonia acts as a nucleophile) (v) alcoholic potassium cyanide to produce nitriles (where the cyanide ion acts as a nucleophile) <i>Students should know this is an example of increasing the length of the carbon chain.</i>
10.9	understand the mechanisms of the nucleophilic substitution reactions between primary halogenoalkanes and: (i) aqueous potassium hydroxide (ii) ammonia <i>S_N1 and S_N2 substitution mechanisms will be tested in Unit 4.</i>
10.10	understand that experimental observations and data can be used to compare the relative rates of hydrolysis of: (i) primary, secondary and tertiary structural isomers of a halogenoalkane (ii) primary chloro-, bromo- and iodoalkanes using aqueous silver nitrate in ethanol
10.11	CORE PRACTICAL 5: Investigation of the rates of hydrolysis of some halogenoalkanes.
10.12	know the trend in reactivity of primary, secondary and tertiary halogenoalkanes
10.13	understand, in terms of bond enthalpy, the trend in reactivity of chloro-, bromo and iodoalkanes
10.14	CORE PRACTICAL 6: Chlorination of 2-methylpropan-2-ol with concentrated hydrochloric acid. Further suggested practicals: (i) the use of silver nitrate solution to identify the halogen present in halogenoalkanes (ii) preparation of 1-bromobutane from butan-1-ol, potassium bromide and sulfuric acid

UNIT 2 - Topic 10: Organic Chemistry: Halogenoalkanes, Alcohols and Spectra

10C: Alcohols

10.15	understand the nomenclature of alcohols and be able to draw their structural, displayed and skeletal formulae
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10.16	understand the distinction between primary, secondary and tertiary alcohols
10.17	understand the reactions of alcohols with: (i) oxygen in air (combustion) (ii) halogenating agents • PCl ₅ to produce chloroalkanes (including its use as a qualitative test for the presence of the –OH group) • 50% concentrated sulfuric acid and potassium bromide to produce bromoalkanes • red phosphorus and iodine to produce iodoalkanes iii concentrated phosphoric acid to form alkenes by elimination <i>Descriptions of the mechanisms of these reactions are not required.</i>
10.18	understand that potassium dichromate(VI) in dilute sulfuric acid can oxidise: (i) primary alcohols to produce aldehydes (which give a positive result with Benedict's or Fehling's solution) if the product is distilled as it forms (ii) primary alcohols to produce carboxylic acids (which give a positive result with sodium carbonate or sodium hydrogencarbonate) if the reagents are heated under reflux (iii) secondary alcohols to produce ketones <i>In equations, the oxidising agent can be represented by [O].</i>
10.19	understand, the following techniques in the preparation and purification of a liquid organic compound: (i) heating under reflux (ii) extraction with a solvent using a separating funnel (iii) distillation (iv) drying with an anhydrous salt (v) boiling temperature determination
10.20	CORE PRACTICAL 7: The oxidation of propan-1-ol to produce propanal and propanoic acid.
	Further suggested practical: Investigation of reactions of primary and secondary alcohols, including propan-1-ol and propan-2-ol
UNIT 2 - Topic 10: Organic Chemistry: Halogenoalkanes, Alcohols and Spectra	
10D: Mass spectra and IR	
10.21	be able to interpret data from mass spectra to suggest possible structures of simple organic compounds using the m/z of the molecular ion and fragmentation patterns
10.22	be able to use infrared spectra, or data from infrared spectra, to deduce functional groups present in organic compounds, and predict infrared absorptions, given wavenumber data, due to familiar functional groups including: (i) C–H stretching absorptions in alkanes, alkenes and aldehydes (ii) C=C stretching absorption in alkenes (iii) O–H stretching absorptions in alcohols and carboxylic acids (iv) C=O stretching absorptions in aldehydes, ketones and carboxylic acids (v) C–X stretching absorption in halogenoalkanes (vi) N–H stretching absorption in amines
10.23	CORE PRACTICAL 8: Analysis of some inorganic and organic unknowns.



Unit 3: Practical Skills in Chemistry I

This unit consists of a written practical examination, covering the skills and techniques developed during practical work in Units 1 and 2.

Although the unit content contains eight core practical activities, the examination will not be limited to recall of these core practicals but may include questions where students are expected to apply their knowledge to new practical situations.

Students should, therefore, develop their practical skills by completing a range of different practicals that require a variety of different techniques.

As students carry out practical activities, they should be encouraged to write laboratory reports using appropriate scientific, technical and mathematical language, conventions and symbols.

Students are expected to develop experimental skills and a knowledge and understanding of the necessary techniques by carrying out a range of practicals while they study Units 1 and 2.

This unit will assess students' knowledge and understanding of the practical procedures and techniques they develop. To prepare for assessment of this unit, centres should give students opportunities to carry out practical activities, collect and analyse data, and draw conclusions.

Students should – at the least

– carry out the eight core practicals in class. By completing these practicals students will be able to: follow and interpret experimental instructions, covering the full range of laboratory exercises set throughout the course, with minimal help from the teacher

- always work with interest and enthusiasm in the laboratory, completing most laboratory exercises in the time allocated
- manipulate apparatus, use chemicals, carry out all common laboratory procedures and use data logging (where appropriate) with the highest level of skill that may be reasonably expected at this level
- work sensibly and safely in the laboratory, paying due regard to health and safety requirements without the need for reminders from the teacher
- gain accurate and consistent results in quantitative exercises, make most of the expected observations in qualitative exercises and obtain products in preparations of high yield and purity.

Assessment information

- First assessment: June 2019.
- The assessment is 1 hour and 20 minutes.
- The assessment is out of 50 marks.
- Students must answer all questions.
- This paper may include short-open, open-response and calculation questions.
- Students will be expected to apply their knowledge and understanding of practical skills to familiar and unfamiliar situations.
- Calculators may be used in the examination

Dr. Raouf Khodabocus, September 2019