For exams January, May and November onwards
For teaching from September 2021 onwards

SPECIFICATION

Learning Resource Network

INTERNATIONAL AS AND A-LEVEL CHEMISTRY (6014)

THE QUEEN'S AWARDS FOR ENTERPRISE: INTERNATIONAL TRADE 2020

Contents

BACKGROUND TO LRN

Learning Resource Network (LRN) is a recognised Awarding Organisation that offers a range of qualifications to candidates, educational institutes, training providers, schools and employers.

LRN is recognised for its high quality qualifications that enable candidates to progress to other areas of study and employment in their designated fields.

In producing its qualifications, LRN uses the experience and expertise of academics, professionals working in the pertinent industries and assessment practitioners with a wealth of best practice and knowledge of validation, verification, delivery and assessment.

ACCOLADES

Queen's Award

In April 2020, LRN received the Queen's Award for Enterprise for International Trade. LRN is one of 220 organisations in the UK to be recognised with this prestigious accolade. This was in recognition of the expansion LRN brought to the overseas qualification market.

MANAGEMENT SYSTEMS

LRN has been awarded international accreditation as part of its quality controls, policies, systems and overall approach to its management systems. These awards are externally validated by the British Assessment Bureau. LRN has achieved accreditation in the form of ISO 9001: Quality Management Systems, ISO 14001: Environment Management Systems and ISO 27001: Information Security Management Systems.

CUSTOMER SERVICE EXCELLENCE

LRN has achieved the prestigious award of Customer Service Excellence. This is in recognition of its customer service practices, approach to managing and dealing with UK and Overseas customer needs, including the diverse needs of its centres.

LRN was the first UK Awarding Organisation to achieve Customer Service Excellence.
Following reaccreditation in 2019, LRN received an award for Customer Service Excellence: Compliance Plus, demonstrating that LRN went above and beyond the delivery of its customer service principles.

INTRODUCTION

This specification provides an overview to the LRN International AS & A Level Chemistry[1]. This document is suitable for various users, including candidates, centres, administrators, employers, parents/guardians, teachers (and other educational based staff) and examiners. The specification outlines the key features and administrative procedures required for this international qualification.

OBJECTIVE

The LRN International AS & A Level Chemistry is designed to enable international candidates to demonstrate their ability, in both practical and theoretical terms across a range of: Atomic Structure, Mole Calculations, Bonding, Acids and Bases, Metals, Elements, Organic Chemistry Alkanes, Alkenes, Halogenoalkanes, Nitrogen Compounds, Condensation Polymers and Organic Synthesis.

MODE OF DELIVERY

This qualification has been constructed to be delivered within centres. Centres will need to demonstrate to LRN, through the centre recognition processes, that they have the resources, facilities and competence to deliver. However, centres must be able to demonstrate, in line with LRN's criteria, that they have the means, capability, capacity and resources (including suitably qualified centre staff) to deliver by the method chosen by the centre.

PROGRESSION

The LRN International AS & A Level Chemistry has been designed to reflect the wide variation in candidates' origins, levels of education and career aims. Progression opportunities may, therefore, take a variety of paths. Depending on the level of qualification achieved, it may be appropriate for the candidate to progress to:

1. Similar level 3 qualification in Chemistry;
2. LRN Level 3 Diploma in Pre-U Foundation Studies;
3. A higher level of any qualification – e.g.; HNC/HND or Degree'
4. Vocationally Related Qualifications

[1] LRN International AS/A Level are globally recognised qualifications designed specifically for international candidates and are available outside the United Kingdom. Candidates based in England refer to the Ofqual register.

QUALIFICATION OVERVIEW

Number	Subject Content	LRN International AS Level	LRN International A Level	AO	Exam
1	Atomic Structure	√	√	1, 2 and 3	Combination of written exam papers (externally set and marked) and a practical demonstration of skills. **AS Level** **Paper 1:** Short and long answer questions. Duration: 2 hours Weighting: 50% **Paper 2:** Short and long answer questions. Duration: 2 hours Weighting: 50% **A Level** **Paper 1:** Short and long answer questions. Duration: 2 hours Weighting: 25% **Paper 2:** Short and long answer questions. Duration: 2 hours Weighting: 25%
2	Mole Calculations	√	√	1, 2 and 3	
3	Bonding	√	√	1, 2 and 3	
4	Enthalpy and Entropy	√	√	1, 2 and 3	
5	Redox	√	√	1, 2 and 3	
6	Equilibria	√	√	1, 2 and 3	
7	Rate of reaction	√	√	1, 2 and 3	
8	Acids and Bases	√	√	1, 2 and 3	
9	Group 2 Metals	√	√	1, 2 and 3	
10	Group 7 Elements	√	√	1, 2 and 3	
11	Period 3 Elements and Oxides	√	√	1, 2 and 3	
12	Transition Metals	-	√	1, 2 and 3	
13	Introduction to Organic Chemistry	√	√	1, 2 and 3	
14	Alkanes	√	√	1, 2 and 3	
15	Alkenes	√	√	1, 2 and 3	
16	Halogenoalkanes	√	√	1, 2 and 3	
17	Alcohols	√	√	1, 2 and 3	
18	Aromatic Chemistry	√	√	1, 2 and 3	

19	Carbonyl Compounds	√	√	1, 2 and 3	**Paper 3:** Multiple choice questions, practical based skills and short and long answer questions. Duration: 2 hours Weighting: 50%
20	Chiral Compounds	√	√	1, 2 and 3	
21	Nitrogen Compounds	-	√	1, 2 and 3	
22	Condensation Polymers	-	√	1, 2 and 3	
23	Organic Synthesis	-	√	1, 2 and 3	
24	Analytical Techniques (mass spectroscopy, infra-red spectroscopy, NMR spectroscopy and chromatography)	-	√	1,2 and 3	

BREAKDOWN OF ASSESSMENT OBJECTIVES

AO1 - demonstrate knowledge and understanding of:

- scientific ideas
- scientific techniques and procedures

AO2 – apply knowledge and understanding of:

- scientific ideas
- scientific enquiry, techniques and procedures I

AO3 – analyse information and ideas to:

- interpret and evaluate
- make judgements and draw conclusions
- develop and improve experimental procedures

ASSESSMENT

The assessment for this qualification consists of (i) written exam papers, and (ii) practical demonstration of skills, set and marked by the LRN.

Assessment objectives (AOs)	Weighting		
	Paper 1	Paper 2	Paper 3
AO1	30%	30%	30%
AO2	40%	40%	50%
AO3	30%	30%	20%

GUIDED LEARNING HOURS (GLH)

The LRN International AS Level guided learning hours (GLH) are 180 and 360 guided learning hours for LRN International A Level. Please note the hours stated are indicative.

ENTRIES CODES

One entry per qualification is sufficient and will cover all the question papers including certification.

PRIVATE CANDIDATES

Centres are advised that private candidates are only to be enrolled with prior agreement and confirmation from LRN.

GRADING

The LRN International A Level will be graded on a six-point scale: A*, A, B, C, D and E and LRN International AS Level will be graded on a five-point scale: A, B, C, D and E Candidates who fail to reach the minimum standard for grade E will be recorded as U (unclassified) and will not receive a qualification certificate.

RESULTS

Exam series are in:

- January (results released in March)
- June (results released in August)
- November (results released in January)

RE-TAKES

Whereas candidates can re-take each paper as often as they wish, within the shelf-life of the specification.

CUSTOMER SERVICE STATEMENT

Learning Resource Network (LRN) is committed to ensuring all customers are dealt with promptly and in a professional and helpful manner. In order to guarantee this, we commit to ensuring the following in our day-to-day interactions with candidates, assessment centres and our stakeholder network:

- All customers will be treated equally and with respect.
- All customer information will only be used in a way which has been agreed in advance, unless we are informed of something that places them or others at risk of harm.
- All customers will be treated by staff in a professional manner.

LRN has arrangements in place to provide a telephone and e-mail helpdesk which will be staffed from 09:00 to 17:00 from Monday to Friday. Furthermore, it will respond to each e-mail, letter, or telephone message it receives regarding feedback on its qualifications, centre approvals process or other matters relating to its products and/or services. The timetable for responding is as follows:

- E-mail: 5 working days
- Letter: 5 working days
- Telephone message: 5 working days

DIVERSITY AND EQUALITY

Learning Resource Network (LRN) is committed to ensuring fair and equal access to its qualifications, examinations and support materials. Our Diversity and Equality policy seeks to eliminate unjustifiable discrimination, harassment and/or victimisation and to advance equality of opportunity, thereby ensuring all candidates are treated fairly, in accordance with the protected characteristics of the Equality Act 2010. Specifically, we comply fully with the requirements laid out in the Equality Act 2010. In addition, and within the constraints of this policy, LRN will have due regard for the General data Protection Regulations (GDPR) in the retention of information which is unnecessary.

1	**Atomic Structure**		
Aim The aim of this subject content is to give an understanding of the structure of the atom			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the structure of an atom in terms of sub atomic mass and particles.	1.1	**Compare** protons, neutrons and electrons in terms of their relative charges and relative masses.
		1.2	**Explain** the distribution of mass and charge within an atom.
		1.3	**Identify** the atomic number and mass number for any given element.
		1.4	**Determine** the numbers of protons, neutrons and electrons in atoms and ions given the atomic numbers, mass numbers and charge.
		1.5	**Define** the terms relative atomic mass, relative isotopic mass, molecular mass and formula mass.
		1.6	**Define** the term orbital.
		1.7	**Subdivide** the electronic structure of an atom of an element into shells, sub-shells and orbitals.
		1.8	**Devise** the electronic configuration of atoms or ions using s, p and d notation up to 36 electrons (up to the 4p sub-shell).
		1.9	**Construct** orbital diagrams for an element to show all the electrons.
		1.10	**Draw** s and p orbitals.
		1.11	**Define** the term ionisation energy.
		1.12	**Devise** equations for 1^{st}, 2^{nd}, 3^{rd} etc. ionisation energies of elements including state symbols.
		1.13	**Explain** the trends in 1^{st} ionisation energies across a period and down a group of the Periodic Table.
		1.14	**Explain** 'dips' in the trends of 1^{st} ionisation energies between elements in groups 2 and 3 and groups 5 and 6 in the Periodic Table.

		1.15	**Interpret** plots of ionisation energy versus number of electrons to identify elements in a period.
		1.16	**Use** successive ionisation energy data of an element to determine its group number in the periodic table.
2	Understand the role and function of isotopes.	2.1	**Define** the term isotope.
		2.2	**Explain** what is meant by the term ‘chemical properties’ in relation to isotopes.
		2.3	**Use** symbols such as $^{x}_{y}A$ for isotopes, where x is the mass number and y is the atomic number.
3	Understand the function of a mass spectrometer.	3.1	**Explain** how a mass spectrometer works in terms of the detector and ionisation of the sample.
		3.2	**Calculate** the relative atomic mass of an element given the relative abundances or mass spectrum of its isotopes.
		3.3	**Calculate** the abundance(s) of isotopes of an element given the relative atomic mass and mass number of each isotope.
		3.4	**Analyse** mass spectra of elements, including diatomic elements, focussing on isotopic abundances and m/z values.

2	**Mole Calculations**		
Aim The aim of this subject content is to explore the scope of mole calculations and carry out titration experiments.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand a variety of mole calculations using chemical equations.	1.1	**Define** the terms empirical formula and molecular formula.
		1.2	**Calculate** empirical formulae using combustion data or composition by mass.
		1.3	**Calculate** molecular formulae from empirical formulae and M_r values.
		1.4	**Construct** balanced chemical equations.
		1.5	**Construct** ionic equations from chemical equations.
		1.6	**Carry out** mole calculations using chemical equations and: i.) reacting masses ii.) volumes of gases (using the molar volume of a gas) iii.) volumes and concentrations of solutions
		1.7	**Calculate** percentage atom economy and percentage yields from chemical equations and experimental results.
		1.8	**Define** Avogadro's constant.
		1.9	**Use** Avogadro's constant to calculate the mass of individual atoms/molecules, or to calculate the number of particles in a given mass.
		1.10	**Use** pV = nRT (the ideal gas equation) in calculations.
2	Be able to demonstrate a practical application in titration experiments.	2.1	**Prepare** a solution of accurate concentration of an acid or base with use of the following equipment: (i) pipette, (ii) volumetric flask, and (iii) balance.
		2.2	**Devise** experiments to establish the end point of an acid-base reaction

		2.3	**Use** a burette to measure an accurate volume.
		2.4	**Calculate** an unknown quantity such as concentration of an acid or base using data from the titration experiment.

3	**Bonding**		
Aim The aim of this subject content is to understand the various types of chemical bonds and to introduce the concepts of electronegativity and intermolecular forces.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand various forms of bonding, electronegativity and polarity.	1.1	**Describe** what is meant by an ionic bond.
		1.2	**Produce** dot-and-cross diagrams for ionic compounds e.g. NaCl, $MgCl_2$.
		1.3	**Devise** formulae of ionic compounds, including those containing the group ions: NH_4^+, CO_3^{2-}, OH^-, NO_3^- and SO_4^{2-}.
		1.4	**Describe** what is meant by a covalent bond.
		1.5	**Produce** dot-and-cross diagrams for covalent compounds such as CH_4, NH_3, H_2O, O_2, N_2, CO_2, ethane etc.
		1.6	**Describe** what is meant by a dative covalent bond.
		1.7	**Produce** dot-and-cross diagrams for covalent compounds that have dative covalent bonds such as $NH_4^+$and H_3O^+.
		1.8	**Explain** why some molecules can react by forming a dative covalent bond e.g., the formation of Al_2Cl_6 and NH_3BF_3.
		1.9	**Explain** how covalent bond strength and length are related.
		1.10	**Use** the terms ‘non-polar’ and ‘polar’ bonds for any given covalent bond.
		1.11	**Use** the term ‘dipole’ for any given covalent bond and assign partial charges to the atoms in a covalent molecule.
		1.12	**Define** the term *electronegativity*.
		1.13	**Explain** the trend in electronegativity in the periodic table.
2	Understand basic shapes of simple molecular compounds.	2.1	**Predict** the shapes and bond angles of unfamiliar molecules and ions and **sketch** each shapes using the wedged and dashed bonds notation where appropriate.

3	Understand the concept and function of intermolecular forces	3.1	**Explain** why some molecules are non-polar in terms of molecular shape and dipoles.
		3.2	**Compare and contrast** the following intermolecular forces: van der Waals, permanent dipole-dipole and hydrogen bonding.
		3.3	**Explain** the origin of van der Waals forces in terms of the random movement of electrons.
		3.4	**Sketch** diagrams showing hydrogen bonding in molecules such as NH_3 and H_2O.
		3.5	**Explain** why molecules such as CH_4 and Br_2 have low boiling points.
		3.6	**Explain** the trend in boiling point of group 6 hydrides and group 7 hydrogen halides.
		3.7	**Explain** the solubility of simple covalent compounds in different solvents.
4	Understand metallic bonding and properties of metals.	4.1	**Explain** the unusual properties of water, including its boiling point in relation to other Group 6 hydrides and it being less dense in the solid state.
		4.2	**Define** what is meant by metallic bonding.
		4.3	**Sketch** simple diagrams to represent metallic bonding.
		4.4	**Explain** why metals are good conductors of heat and electricity.
		4.5	**Explain** the trend in melting point of metals across period 3 (group 1 to 3).
		4.6	**Identify** ionic, metallic and covalent compounds from chemical formulae.
		4.7	**Classify** ionic, metallic and macromolecular (giant covalent) molecules/compounds as giant lattice structures.
		4.8	**Compare and contrast** the macromolecular structures of graphite, diamond, silicon (IV) oxide and graphene.
		4.9	**Explain** the melting point, conductivities and uses of macromolecular structures.

4	**Enthalpy and Entropy**		
Aim The aim of this subject content is to look at various ways to calculate enthalpy and entropy changes.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the purposes and functions of enthalpy and entropy.	1.1	**Define** the term enthalpy change.
		1.2	**State** standard conditions of 298K and 1 atm (100 kPa).
		1.3	**Use** the terms exothermic and endothermic in relation to bond breaking and bond making.
		1.4	**Construct** reaction profile diagrams labelling ΔH, E_a, reactants and products for exothermic and endothermic reactions.
		1.5	**State** what is meant by the term mean (average) bond enthalpy.
		1.6	**Calculate** the enthalpy change of a reaction using mean bond enthalpy data.
		1.7	**Calculate** a mean bond enthalpy using mean bond enthalpy data and the enthalpy change of a reaction.
		1.8	**Propose** reasons for differences in enthalpy changes of calculated and literature values when using mean bond enthalpies.
		1.9	**Define** the following terms: *i.) enthalpy of combustion* *ii.) enthalpy of formation* *iii.) enthalpy of neutralisation*
		1.10	**Construct** enthalpy cycles using Hess's law based on enthalpies of combustion and formation.

		1.11	**Calculate** enthalpy changes using Hess cycles.
		1.12	**Define** the following terms: *i.) lattice enthalpy* *ii.) atomisation enthalpy* *iii.) electron affinity*
		1.13	**Identify** enthalpy changes in Born-Haber cycles of ionic compounds.
		1.14	**Construct** Born-Haber cycles of ionic compounds.
		1.15	**Use** Born-Haber cycles to calculate various enthalpy changes.
		1.16	**Predict** relative lattice enthalpy values from chemical formulae of ionic compounds.
		1.17	**Explain** the concept of polarisation in relation to lattice enthalpies.
		1.18	**Compare and contrast** differences in experimental and theoretical lattice enthalpies.
		1.19	**Define** the following terms: *i.) enthalpy of solution* *ii.) enthalpy of hydration*
		1.20	**Predict** relative enthalpy of hydration values from chemical formulae of ionic compounds.
		1.21	**Construct** Hess cycles and Born Haber cycles that show enthalpy of solution, enthalpy of hydration and lattice enthalpy,
		1.22	**Calculate** enthalpy of solution, enthalpy of hydration or lattice enthalpy from a Hess or Born Haber cycle.

		1.23	**Conclude** what the enthalpy of solution value indicates about the solubility of an ionic compound.
		1.24	**Explain** what is meant by the term entropy.
		1.25	**Explain** how entropy can influence the solubility of an ionic compound.
		1.26	**Predict** the sign of the entropy change, ΔS, from chemical equations.
		1.27	**Calculate** entropy changes for reactions given standard entropy values.
		1.28	**State** that Gibbs free energy, ΔG, is shown by the equation $\Delta G = \Delta H - T\Delta S$.
		1.29	**Calculate** ΔG using $\Delta G = \Delta H - T\Delta S$.
		1.30	**State** whether a reaction is feasible or not from the value of ΔG.
		1.31	**Predict** the effect of temperature on the feasibility of a reaction given enthalpy and entropy values.
		1.32	**Explain** the role of kinetics in determining the feasibility of a reaction.
		1.33	**Devise** experiments to measure the heat change for reactions such as neutralisation and combustion.
		1.34	**Construct** plots of temperature versus time.
		1.35	**Use** plots of temperature versus time to calculate accurate values for ΔT.
		1.36	**Calculate** enthalpy changes using $q = mc\Delta T$ using data from experiments.
		1.37	**Propose** reasons for differences between a calculated value and a literature value.

5 Redox

Aim

The aim of this subject content is to look at redox reactions in terms of oxidation numbers, oxidising/reducing agents and half-equations.

Learning Outcomes - The learner will:		Assessment Criteria - The learner can:	
1	Understand how redox can be used in writing chemical equations and in electrochemistry.	1.1	**Calculate** oxidation numbers of elements in compounds and ions.
		1.2	**Use** changes in oxidation numbers to help balance chemical equations.
		1.3	**Define** the terms *oxidising agent* and *reducing agent*.
		1.4	**Identify** oxidising and reducing agents from chemical equations and changes in oxidation number.
		1.5	**Construct** half-equations for a variety of oxidation and reduction reactions.
		1.6	**Construct** ionic/redox equations by combining half-equations.
		1.7	**Define** the term *standard electrode potential,* E^{θ}.
		1.8	**State** standard conditions for pressure, temperature and concentration.
		1.9	**Discuss** the use and features of the standard hydrogen electrode.
		1.10	**Sketch** diagrams of the equipment used to measure standard electrode potentials, E^{θ}, and cell potentials, E_{cell}, of metals or non-metals in contact with their ions in aqueous solution, as well as for half-cells containing ions of the same element in different oxidation states.
		1.11	**Deduce** the strength of oxidising and reducing agents from standard electrode potential, E^{θ}.
		1.12	**Calculate** cell potentials, E_{cell}, from two standard electrode potential values.
		1.13	**Predict** the feasibility of a reaction from E_{cell} values.

		1.14	**Predict** changes in standard electrode potentials and subsequently, E_{cell} values, when non-standard conditions are used.
		1.15	**Discuss** the use of redox reactions in commercial storage cells with reference to the hydrogen-oxygen fuel cell.
		1.16	**Construct** half-equations under acidic and alkaline conditions for the reactions in the hydrogen-oxygen fuel cell.
		1.17	**Devise** experiments to light a bulb or measure the E_{cell} value of a redox reaction.
		1.18	**Devise** experiments to establish the end point of common redox titrations such as Fe^{2+}/MnO_4^- and $I_2/S_2O_3^{2-}$.
		1.19	**Calculate** quantities such as concentration, % by mass and M_r values from the results of the titration.

6	Equilibria		
Aim The aim of this subject content is to look at the concept of reversible equations and applying Le Chatelier's principle.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the concept and meaning of equilibrium.	1.1	**Explain** what is meant by dynamic equilibrium in terms of the rates of forwards and backwards reactions and the concentrations of reactants and products.
		1.2	**Use** Le Chatelier's principle to predict the qualitative effect of a change in temperature, pressure or concentration on the position of equilibrium.
		1.3	**Explain** the effect of a catalyst on the position of equilibrium.
		1.4	**Compare and contrast** the conditions used in given industrial processes.
		1.5	**Deduce** expressions for K_c from chemical equations.
		1.6	**Calculate** the value of K_c: (i) given the concentrations of the reactants and products for a reaction at equilibrium, or (ii) given the moles of the reactants and products for a reaction at equilibrium.
		1.7	**Deduce** expressions for K_p from chemical equations.
		1.8	**Calculate** the value of K_p given the partial pressure of the reactants and products for a reaction at equilibrium.
		1.9	**Deduce** the units of K_c and K_p for a given equilibrium.
		1.10	**Explain** the effect of changes in pressure, concentration, temperature or the addition of a catalyst on K_c and K_p values.

7	Rate of reaction		
Aim The aim of this subject content is to further knowledge of rate of reaction and how it can calculate experimentally and also to introduce Maxwell-Boltzmann distributions.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the concept, functions, purpose and meaning of reactions in chemistry.	1.1	**Explain** what is meant by the following terms: i.) rate of reaction ii.) activation energy
		1.2	**Use** collision theory to explain the rate of reactions with reference to changes in concentration, pressure, temperature and surface area.
		1.3	**Explain** how a catalyst increases the rate of reaction.
		1.4	**State** what is meant by the term 'initial rate'. **Calculate** initial rate from concentration and time data.
		1.5	**Explain** what a Maxwell-Boltzmann distribution (curve) shows in terms of molecular energies.
		1.6	**Identify** significant points in a Maxwell-Boltzmann distribution e.g., the most probable energy, the mean energy and the area under the curve.
		1.7	**Sketch** Maxwell-Boltzmann distributions at different temperatures. **Use** the distributions to account for changes in rate of reaction with temperature.
		1.8	**Amend** the activation energy on the distribution to show the effect of the catalyst. **Use** the distribution to explain the effect of a catalyst on rate of reaction.
		1.9	**Discuss** the differences between homogeneous and heterogeneous catalysts.

		1.10	**Explain** how a heterogeneous catalyst works in terms of providing a surface for a reaction to take place on.
		1.11	**Assess** the economic benefits of catalysts in industry.
		1.12	**Construct** rate equations of the form rate = $k[A]^x[B]^y$ where x and y are the orders of each reactant.
		1.13	**Deduce** the order of a reactant from: i.) concentration versus time curves ii.) rate versus concentration curves
		1.14	**Deduce** the overall order of a reaction from the orders of the reactants.
		1.15	**Deduce** the order of a reactant from a concentration versus time curve using a half-life method.
		1.16	**Calculate:** i.) the rate constant, k, from the rate equation and initial rates data. ii.) the order of a reactant from concentrations and initial rates data.
		1.17	**Deduce** the rate determining step in a multistep reaction from the rate equation and vice-versa.
		1.18	**Predict** the reaction mechanism for a multistep reaction from the rate equation and chemical equation.
		1.19	**Use** a graphical method and the Arrhenius equation to calculate the activation energy when given rate constant (k) and temperature (T) data.
		1.20	**Devise** experiments to calculate the rate of a reaction e.g. measuring a gas volume over time.

		1.21	**Use** the data from experiments to: i.) **Construct** plots from the experiments e.g. volume versus time. ii.) **Draw** tangents on plots to obtain the gradient specified points. **Calculate** the rate of reaction.
		1.22	**Devise** experiments using 'clock reactions', with the aim to calculate the order of a reactant e.g., propanone and I_2.
		1.23	**Use** the data to calculate the initial rate and hence the orders.
		1.24	**Devise** experiments using 'clock reactions' at different temperatures to find the rate.

8	Acids and Bases		
Aim The aim of this subject content is to further knowledge of acids and bases and their reactions.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the functions of acids and bases. .	1.1	**Define** the terms: *i.) Bronsted-Lowry acid* *ii.) Bronsted-Lowry base*
		1.2	**Construct** equations to show Bronsted-Lowry conjugate acid-base pairs.
		1.3	**Compare and contrast** the differences between strong and weak acids and bases.
		1.4	**Define** the term *pH.*
		1.5	**Calculate:** i.) the pH of a solution of a strong monoprotic and diprotic acids ii.) $[H^+]$ for strong monoprotic and diprotic acids.
		1.6	**Explain** what is meant by the term K_w.
		1.7	**Calculate** the following using the K_w expression: i.) pH of water at different temperatures ii.) pH of a basic solution iii.) K_w value at different temperatures

		1.8	**Explain:** i.) why the pH of water changes with temperature ii.) why water is 'neutral' at any pH
		1.9	**Define** the term pK_a.
		1.10	**Calculate:** i.) the pK_a of an acid. ii.) the K_a of an acid
		1.11	**Deduce** the K_a expression for any given weak acid.
		1.12	**Calculate** the following using the K_a expression: i.) pH of a weak acid ii.) concentration of a weak acid iii.) K_a
		1.13	**Explain** any assumptions used in weak acid calculations.
		1.14	**Interpret** pH/titration curves for any given combination of weak and strong acids and bases.
		1.15	**Draw** pH curves for various combinations of weak and strong acids and bases.
		1.16	**Select** suitable indicators from a given list for a titration based on the pH curve.
		1.17	**Calculate** the following using pH curves and given data: i.) the equivalence point ii.) the concentration of an acid or base

		1.18	**Define** the term *buffer solution.*
		1.19	**Explain** the following: i.) how a buffer solution can be made ii.) how a buffer solution resists changes in pH
		1.20	**Explain** how H_2CO_3/HCO_3^- buffers blood.
		1.21	**Calculate:** i.) the pH of a buffer solution ii.) the mass of salt required to give a desired pH in a buffer solution.

9	Group 2 Metals		
Aim The aim of this subject content is to look at the reactions and properties of group 2 elements.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the forms. Functions and reactions of group 2 metals,	1.1	For the reactions of group 2 metals (Mg to Ba) with oxygen, chlorine and water: i.) **Construct** equations ii.) **Identify** any observations
		1.2	For the reactions of group 2 oxides, hydroxides and carbonates with water and dilute acids. i.) **Construct** equations ii.) **Identify** any observations
		1.3	**State** the trends in solubilities of group 2 hydroxides and sulfates in water.
		1.4	**State** the uses of magnesium and calcium hydroxides and barium sulfate.
		1.5	**State** what is meant by the term thermal decomposition.
		1.6	**Explain**: i.) the trend in the thermal decompositions of group 2 nitrates and carbonates. ii.) the difference in trends between group 1 and group 2 carbonates and nitrates.
		1.7	**Explain** how the trends in decomposition could be established in a laboratory
		1.8	**Construct** equations for the thermal decomposition of group 1 and 2 nitrates and carbonates.

10	Group 7 Elements		
Aim The aim of this subject content is to look at the reactions and properties of group 7 elements.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the properties, reactivity limits and reactions of group 7 elements	1.1	**State** the physical states and colours of chlorine, bromine and iodine.
		1.2	**Explain** the trend in boiling point of the group 7 elements.
		1.3	**Explain** the trend in reactivity of the group 7 elements with reference to the halogens as oxidising agents.
		1.4	**Use** the observations of the redox reactions of groups 7 elements with halide ions to show the order of reactivity of the halogens.
		1.5	**Construct** chemical and ionic equations for the redox reactions of group 7 elements with halide ions.
		1.6	**Define** the term *disproportionation*.
		1.7	**Construct** equations for the reactions of chlorine with cold and hot NaOH and water.
		1.8	**Use** oxidation numbers to show that these reactions are disproportionation reactions.
		1.9	**Explain** why chlorine is used in water purification.
		1.10	**Explain** how the reactions of halide ions with concentrated sulfuric acid demonstrate the reducing power of halide ions.
		1.11	**Construct** equations for the reactions of halide ions with sulfuric acid.

		1.12	**Devise** chemical tests to identify the following inorganic ions: i.) carbonate, CO_3^{2-} ii.) sulfate, SO_4^{2-} iii.) ammonium, NH_4^+ iv.) halide ions, Cl^-, Br^-, I^-

11	Period 3 Elements and Oxides		
Aim The aim of this subject content is to look at the reactions and properties of period 3 elements and oxides.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the properties and reaction rates of period 3 elements and oxides.	1.1	**Explain** the variation in atomic radius and ionic radius.
		1.2	**Explain** the variation in melting point and electrical conductivity of the period 3 elements with reference to their structure and bonding.
		1.3	**State** the colours observed when Na, Mg, Al, Si, S and P are burned in a flame.
		1.4	**Construct** equations for the reactions of the period 3 elements with oxygen, chlorine and water (water with Na and Mg only).
		1.5	**State** any observations of these reactions.
		1.6	**Construct** equations for reactions of the acidic and basic period 3 oxides with water and acid or base.
		1.7	**State** any observations of these reactions.
		1.8	**Explain** the amphoteric behaviour of Al_2O_3.

12	Transition Metals		
Aim The aim of this subject content is to explore the properties and reactions of the transition metals and d-block elements.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the forms, functions and properties of transition metals.	1.1	**Explain** what is meant by the terms: i.) transition element. ii.) d-block element
		1.2	**Deduce** the electronic configuration of atoms and ions of elements from Sc to Zn.
		1.3	**Explain** why transition metals have varying oxidation numbers.
		1.4	**Define** the following terms: i.) *ligand* ii.) *complex ion* iii.) *coordination number*
		1.5	**Use** the terms monodentate**,** bidentate and multidentate in reference to ligands.
		1.6	**Explain** how a complex ion is formed.
		1.7	**Use** the terms linear, square planar, tetrahedral and octahedral in reference to the geometry of complex ions.
		1.8	**Provide** common examples of complex ions with each shape e.g., cis-platin (square planar), Ag^+ complexes (linear).
		1.9	**Sketch** diagrams showing linear, square planar, tetrahedral and octahedral complex ions.
		1.10	**Explain** why ligands such as chloride ions might not form octahedral complexes.

		1.11	**Predict:** i.) the charge on a complex ion from the metal ion and ligands ii.) the charge on the metal ion from the complex ion formula
		1.12	**Compare and contrast** the following types of complex ion isomers that have monodentate or/and bidentate ligands: i.) cis-trans ii.) optical
		1.13	**Explain** how cis-platin acts as an anticancer drug by reference to its interaction with DNA.
		1.14	**Explain** how haemoglobin acts as a complex ion and transports oxygen around the body.
		1.15	**Explain** the origin of colour in transition metal complexes with reference to d-orbitals.
		1.16	**Predict** which complexes are coloured and not coloured from electronic configurations.
		1.17	**State** the factors that cause complex ions to have different colours.
		1.18	**Explain** what is meant by ligand exchange reactions.
		1.19	**Compare and contrast** ligand exchange reactions of complex ions that contain monodentate ligands with bidentate and multidentate ligands in terms of changes in entropy.
		1.20	**Construct equations** for the reactions of Cu^{2+} and Co^{2+} complex ions with chloride ions.
		1.21	**State** any observations for these reactions.
		1.22	**Explain** why transition metals are often used as catalysts.

		1.23	**Construct** equations showing the role of the transition metal as a catalyst in the following reactions: i.) $SO_2(g) + ½O_2(g) \rightarrow SO_3(g)$ using V_2O_5 as the catalyst ii.) $2I^- + S_2O_8^{2-} \rightarrow I_2 + 2SO_4^{2-}$ using Fe^{2+} or Fe^{3+} ions as the catalyst
		12.24	**Compare and contrast** the observations for the reactions of Cr^{3+}, Cu^{2+}, Fe^{2+} and Fe^{3+} ions with dilute NaOH and dilute NH_3 solutions, including in excess.
		12.25	**Construct** ionic equations for these reactions.

13	Introduction to Organic Chemistry		
Aim The aim of this subject content is to introduce basic organic chemistry concepts, rules and molecules.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand types of formulae, terminology and structures of organic chemistry.	1.1	**Use** the following terms to represent simple organic compounds: structural, displayed, general, molecular, empirical and skeletal formulae.
		1.2	**Use** IUPAC nomenclature to name alkanes, alkenes and halogenoalkanes molecules up to eight carbons.
		1.3	**Define** the term *hydrocarbon.*
		1.4	**Explain** what is meant by the following terms: i.) aliphatic ii.) functional group iii.) saturated iv.) unsaturated
		1.5	**Define** the term *homologous series.*
		1.6	**Identify** key features of a homologous series.
		1.7	**Define** the term *structural isomerism*.
		1.8	**Draw** isomers using the various types of structural isomerism (chain, positional and functional group).
		1.9	**Define** the term *stereoisomerism*.

		1.10	**Explain** why stereoisomerism occurs for some alkenes and not others.
		1.11	**Sketch** cis/trans isomers.
		1.12	**Differentiate** between the use of the terms cis/trans and E/Z.
		1.13	**Draw** E/Z isomers by applying priority rules.

14	Alkanes		
Aim The aim of this subject content is to look at the properties and reactions of alkanes.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand forms, functions and properties of alkanes.	1.1	**Explain** why alkanes are not reactive.
		1.2	**Construct** equations for the combustion reactions of alkanes.
		1.3	**Point out** the consequences of incomplete combustion in an internal combustion engine by referring to the formation and environmental effects of carbon monoxide, oxides of nitrogen and unburnt hydrocarbons.
		1.4	**Explain** how gases produced by combustion contribute to the enhanced greenhouse effect
		1.5	**Construct** equations to show how catalytic convertors help reduce pollution.
		1.6	**Outline** the following processes related to crude oil: i.) fractional distillation ii.) cracking iii.) reforming
		1.7	**Construct** equations showing the cracking for any given alkane.
		1.8	**Construct** equations showing the reforming of any given alkane.
		1.9	**Define** the term *free radical.*
		1.10	**Differentiate** between homolytic and heterolytic bond fission.
		1.11	**Construct** equations for the initiation, propagation and termination steps of free radical substitution of alkanes (and halogenoalkanes) with halogens.

		1.12	**Identify** reasons why free radical substitution leads to a low yield of product.

15	Alkenes		
Aim The aim of this subject content is to look at the properties and reactions of alkenes.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand forms, functions and properties of alkenes.	1.1	**Explain** what is meant by the terms sigma and pi bonds by discussing the differences of orbitals used and resulting bond strength.
		1.2	**Describe** a chemical test for an alkene.
		1.3	**Describe** the following reactions of alkenes, including conditions and products: i.) addition of hydrogen ii.) reaction with steam iii.) reaction with hydrogen halides or halogens iv.) oxidation with cold $KMnO_4$
		1.4	**Construct** equations for the reactions of alkenes. [O] can be used to represent an oxidising agent.
		1.5	**Define** the term *electrophile*.
		1.6	**Draw** the electrophilic addition mechanism of alkenes e.g. ethene with HCl or Cl_2.
		1.7	**Predict** major and minor products of electrophilic addition between unsymmetrical alkenes and hydrogen halides by using Markovinkov's rule.
		1.8	**Explain** why major and minor products are obtained in terms of the stability of carbocations.
		1.9	**State** that alkenes form addition polymers.
		1.10	**Use** the terms, monomer, polymer and repeat unit in relation to addition polymerisation reactions.

		1.11	**Draw** the repeating unit of a polymer from a monomer.
		1.12	**Construct** equations to show the formation of an addition polymer from a monomer.
		1.13	**Identify** monomers from a section of a polymer.
		1.14	**Explain** the difference in properties of different addition polymers e.g., polyethene and PVC.
		1.15	**Evaluate** the problems associated with the disposal of addition polymers.
		1.16	**Explain** how alternative fuels are used as solutions to the disposal problem.

16	Halogenoalkanes		
Aim The aim of this subject content is to look at the properties and reactions of halogenoalkanes.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand forms, functions and properties of halogenoalkanes.	1.1	**Classify** halogenoalkanes as primary, secondary and tertiary.
		1.2	**Define** the term *nucleophile*.
		1.3	**Draw** the nucleophilic substitution mechanism of halogenoalkanes with KOH, KCN and NH_3.
		1.4	**Contrast** the different products formed when NH_3 or the halogenoalkane is used in excess.
		1.5	**State** the trend in reactivity of primary, secondary and tertiary halogenoalkanes.
		1.6	**Explain** the trend in reactivity of chloro, bromo and iodo halogenoalkanes in terms of bond enthalpies.
		1.7	**Compare and contrast** the S_N1 and S_N2 mechanisms with reference to transition state, intermediate and racemic mixture.
		1.8	**Predict** the alkene product(s) of elimination reactions of symmetrical and asymmetrical halogenoalkanes with ethanolic KOH.
		1.9	**Understand** why chlorofluoroalkanes were considered harmful to the ozone layer and the measures taken to counter this problem.
		1.10	**Construct** equations showing how Cl radicals decompose ozone.
		1.11	**Devise** experiments to show the reactivity of different halogenoalkanes using aqueous silver nitrate in ethanol.

17	Alcohols		
Aim The aim of this subject content is to look at the properties and reactions of alcohols.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand forms, functions and properties of alcohols. .	1.1	**Classify** alcohols as primary, secondary and tertiary.
		1.2	**Describe** the following reactions of alkanes, including conditions and products: i.) combustion ii.) substitution with PCl_5, $NaBr/H_2SO_4$ or red P/I_2 iii.) with sodium iv.) dehydration using concentrated H_3PO_4
		1.3	**Construct** equations for the reactions of alcohols.
		1.4	**Identify** the different oxidation products of primary and secondary alcohols with acidified $K_2Cr_2O_7$.
		1.5	**State** any observations of these oxidation reactions.
		1.6	**Explain** how different conditions influence the products formed.
		1.7	**Construct** chemical equations using [O] to represent the oxidising agent.
		1.8	**Devise** experiments to oxidise primary and secondary alcohols.
		1.9	**Sketch** labelled diagrams for heating under reflux and distillation.
		1.10	**Explain** the purpose of heating under reflux and distillation.

		1.11	**Devise** experiments to prepare and purify an organic liquid using the following techniques and apparatus: i.) heat under reflux ii.) separating funnel with aqueous Na_2CO_3 iii.) drying with an anhydrous salt such as $MgSO_4$ or $CaCl_2$ iv.) distillation
		1.12	**Sketch** a labelled diagram of a separating funnel.
		1.13	**Explain** the purpose of the separating funnel and the use of Na_2CO_3.
		1.14	**Explain** the purpose of the drying agent.
		1.15	**Use** the boiling point as an indicator of purity.
		1.16	**Use** IUPAC nomenclature to name carboxylic acids, esters and acyl chlorides.

18	Aromatic Chemistry		
Aim The aim of this subject content is to look at the structure and reactions of benzene and related compounds.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand forms, functions and properties of aromatic chemistry.	1.1	**Compare and contrast** the Kekule model with the delocalised model of the structure of benzene.
		1.2	**Sketch** a diagram to show the bonding in benzene with particular reference to orbital overlap.
		1.3	**State** the H-C-C bond angle in benzene.
		1.4	**Explain** how the Kekule model was disproven with reference to the following: i.) reaction with Br_2 ii.) bond lengths iii.) hydrogenation of benzene
		1.5	**Compare and contrast** the reactivity of benzene with the reactivity of alkenes.
		1.6	**Construct** equations for the combustion reactions of benzene.
		1.7	**Draw** the electrophilic substitution mechanism for benzene with the following electrophiles: i.) NO_2^+ (nitration) ii.) R^+ (Friedel-Crafts alkylation) iii.) RCO^+ (Friedel-Crafts acylation) iv.) Cl^+ and Br^+ (halogenation)
		1.8	**State** the reagents required to form the electrophiles.

		1.9	**Construct** chemical equations for the formation of the electrophiles.
		1.10	**State** the reagents and conditions required to convert $C_6H_5NO_2$ to $C_6H_5NH_2$.
		1.11	**Construct** an equation for this reaction using [H] to represent the reducing agent.
		1.12	**Compare and contrast** the reactivity of phenol with benzene.
		1.13	**Construct** equations for the reactions between phenol and: i.) aqueous bromine ii.) NaOH iii.) Na
		1.14	**Compare and contrast** the reactions of phenol with weak and strong bases.
		1.15	**Predict** the position of electrophilic substitution reactions for the following directing groups: i.) OH ii.) NH_2 iii.) NO_2

19	Carbonyl Compounds		
Aim The aim of this subject content is to look at the properties and reactions of carbonyl compounds.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand forms, functions and properties of carbonyl compounds.	1.1	**Compare and contrast** the boiling points of aldehydes and ketones with carboxylic acids.
		1.2	**Explain** why short-chain aldehydes, ketones and carboxylic acids are soluble in water.
		1.3	**Draw** the nucleophilic addition mechanisms of aldehydes and ketones: i.) with $NaBH_4$ or $LiAlH_4$ (using H^- to represent the nucleophile) ii.) with KCN and acid
		1.4	**Describe** the reactions of carboxylic acids with: i.) $LiAlH_4$ ii.) bases iii.) PCl_5 or $SOCl_2$
		1.5	**Construct** equations for the reactions of carboxylic acids (using [H] to represent a reducing agent where necessary).
		1.6	**State** the reagents and conditions used to convert a nitrile to a carboxylic acid. **Construct** an equation for this reaction.
		1.7	**Compare and contrast** the formation of esters from carboxylic acids and alcohols with their formation from acyl chlorides and alcohols.

		1.8	**Construct** equations for the formation of esters.
		1.9	**Compare and contrast** the hydrolysis of esters under acidic and alkaline conditions.
		1.10	**Describe** the reactions of acyl chlorides with: i.) primary and secondary amines ii.) water iii.) phenol
		1.11	**Construct** equations for the reactions of acyl chlorides.
		1.12	**Draw** the nucleophilic addition-elimination mechanisms of acyl chlorides with: i.) primary and secondary amines ii.) water iii.) alcohols

20	**Chiral Compounds**		
Aim The aim of this subject content is to give an understanding of chiral compounds and optical isomers.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand forms, functions and properties of chiral compounds.	1.1	**Explain** what is meant by the term chiral carbon or centre.
		1.2	**Explain** what is meant by the following terms: i.) chiral carbon/centre ii.) optical isomers/enantiomers
		1.3	**Identify** chiral carbons in a variety of organic compounds.
		1.4	**Draw** enantiomers using the 3D dashed and wedges style bonds.
		1.5	**Explain** the method of using plane-polarised light to distinguish between two enantiomers.
		1.6	**State** what is meant by the term racemic mixture.
		1.7	**Explain** how a racemic mixture forms with reference to the nucleophilic addition mechanism.

21	Nitrogen Compounds		
Aim The aim of this subject content is to give an understanding of the properties and reactions of amines, amino acids and amides.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand forms, functions and properties of nitrogen compounds.	1.1	**Describe** the following reactions to form amines, including reagents, conditions and equations: i.) reduction of a nitrile ii.) reaction of NH_3 with halogenoalkanes iii.) reduction of $C_6H_5NO_2$ to $C_6H_5NH_2$
		1.2	**Describe** the following reactions of amines, including reagents, conditions and equations: i.) with H_2O ii.) with acids iii.) with acyl chlorides
		1.3	**Compare and contrast** the basicity of various aliphatic and aromatic amines.
		1.4	**Compare and contrast** the hydrolysis of amides under acidic and alkaline conditions.
		1.5	**Use** IUPAC nomenclature to name amines, amides and amino acids.
		1.6	**Draw** the general structure of amino acids.
		1.7	**Explain** why amino acids have high melting points.
		1.8	**Predict** amino acid structures in acidic and alkaline solutions.
		1.9	**Describe** the formation of zwitterions.

		1.10	**Draw** zwitterion structures.
		1.11	**Draw** the structures of the di- and tri-peptides formed from any given amino acids.
		1.12	**Identify** amino acids after peptide hydrolysis using R_f values.
		1.13	**Explain** the purpose of ninhydrin in identifying amino acids in chromatography experiments.

22	Condensation Polymers		
Aim The aim of this subject content is to give an understanding of how polyesters and polyamides can be formed and some commercial uses of each.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand forms, functions and properties of condensation polymers.	1.1	**State** that polyesters and polyamides are condensation polymers.
		1.2	**Draw** repeating units of polymers from the reactions of: i.) dicarboxylic acids and diols ii.) dicarboxylic acids and diamines iii.) amino acids
		1.3	**Draw** repeating units of the following polymers: i.) Kevlar ii.) Nylon 6,6 iii.) Terylene
		1.4	**Draw** repeating units from sections of a polymer.
		1.5	**Identify** the monomer(s) from a section of a polymer.
		1.6	**Explain** how intermolecular forces influence the properties of polyesters and polyamides such as Kevlar.
		1.7	**Explain** why condensation polymers are classed as biodegradable.

23	**Organic Synthesis**		
Aim The aim of this subject content is to give an understanding of the properties and reactions of amines, amino acids and amides.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand forms, functions and properties of organic synthesis.	1.1	**Devise** synthetic routes up to four steps using any combination of reactions in the syllabus.
		1.2	**Explain** why drug synthesis often involves the production of a single optical isomer.
		1.3	**Explain** the steps involved to purify an organic solid by recrystallisation.
		1.4	**Use** the melting point of an organic solid as an indicator of purity.

24	Analytical Techniques (mass spectroscopy, infra-red spectroscopy, NMR spectroscopy and chromatography)		
Aim The aim of this subject content is to give an understanding of infra-red, NMR spectroscopy and mass spectrometry as used in organic chemistry.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand forms, functions and properties of analytical techniques.	1.1	**Identify** the molecular ion peak in a mass spectrum.
		1.2	**Use** the *m/z* values of fragment peaks to identify an organic compound.
		1.3	**Use** infra-red spectra and data from the data book to identify functional groups including: i.) C-H ii.) C=C iii.) C=O iv.) O-H alcohol v.) O-H carboxylic acid
		1.4	**Explain** the use and limitations of the fingerprint region (0-1500 cm-1) in infra-red spectroscopy.
		1.5	**Analyse** ^{13}C NMR spectra to identify: i.) different carbon environments from the chemical shift ii.) possible structures of organic compounds
		1.6	**Use** structures to predict the following in ^{13}C NMR spectra: i.) number of environments ii.) chemical shifts of different carbon environments
		1.7	**Analyse** ^{1}H NMR spectra to identify: i.) different hydrogen environments from the chemical shift

			ii.) number of hydrogens from relative peak areas iii.) number of adjacent hydrogens from splitting patterns and the n+1 rule iv.) possible structures of organic compounds
		1.8	**Use** structures to predict the following in ^1H NMR spectra: i.) number of environments ii.) chemical shifts of different hydrogen environments iii.) relative peak areas iv.) splitting patterns
		1.9	**Explain** the following: i.) the use of TMS (tetramethylsilane) in NMR ii.) the use of deuterated solvents such as $CDCl_3$
		1.10	**Explain** how D_2O can be used to identify O-H and N-H protons in ^1H NMR.
		1.11	**Explain** the basic principle of chromatography in terms of mobile and stationary phases.
		1.12	**Calculate** R_f values from thin layer chromatograms.
		1.13	**Compare and contrast** gas chromatography and HPLC (High Performance Liquid Chromatography) in terms of i.) mobile and stationary phases ii.) limitations and uses
		1.14	**Explain** what is meant by the term 'retention time'.
		1.15	**Interpret** chromatograms to identify the percentage composition of a mixture.
		1.16	**Explain** how mass spectrometry can be used alongside gas chromatography to help identify components in a mixture.

APPENDIX:

CORE PRACTICAL COMPETENCIES:

Candidates will need to carry out and evidenced internally carried out practical's that include a range of the 5 representative competencies.

Competencies:

1. Follows written instructions:

a. Correctly follows written instructions to carry out experimental techniques or procedures.

2. Applies investigative approaches and methods when using instruments and equipment

a. Correctly uses appropriate instrumentation, apparatus, and materials (including ICT) to carry out investigative activities, experimental techniques and procedures with minimal assistance or prompting.

b. Carries out techniques or procedures methodically, in sequence and in combination, identifying practical issues and adjusting when necessary.

c. Identifies and controls significant quantitative variables where applicable, and plans approaches to take account of variables that cannot readily be controlled.

d. Selects appropriate equipment and measurement strategies to ensure suitably accurate results.

3. Safely uses a range of practical equipment and materials

a. Identifies hazards and assesses risks associated with these hazards, making safety adjustments as necessary, when carrying out experimental techniques and procedures in the lab or field.

b. Uses appropriate safety equipment and approaches to minimise risks with minimal prompting.

4. Makes and records observations

a. Makes accurate observations relevant to the experimental or investigative procedure.

b. Obtains accurate, precise, and sufficient data for experimental and investigative procedures and records this methodically using appropriate units and conventions.

5. Research, references, and reports

a. Uses appropriate software and/or tools to process data, carry out research and report findings.

b. Cites sources of information demonstrating that research has taken place, supporting planning and conclusions.

It is expected through time candidates will demonstrate these competencies consistently throughout subsequent practicals. It is not required that each competency be demonstrated in all practicals.

Candidates should have gained experience from at least 10 practicals across the 2-year course.

Representative of the following skills:

Practical techniques to be completed by candidates

- Use appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length, voltage and current)
- Use appropriate instrumentation to record quantitative measurements (such as Vernier callipers for length)
- Correct design of circuits and meters
- Produce appropriate graphs of the collected data

A centre will need to demonstrate candidates have met these competencies, this will be done through regular moderation processes once every 2 years for quality assurance to ensure standards are maintained and assessed accurately.

This will require communication from a LRN moderator, evidence will need to be submitted to gain approval from the moderator to pass the centre and complete the endorsement process.

A video lesson may need to be recorded and submitted also additionally for international centres where visitation is not a viable option.

Additional guidance and training are available.

MATHEMATICAL REQUIREMENTS

Calculators may be used in all parts of the examination.

Candidates should be able to:

1. Complete equations involving addition, subtraction, multiplication, and division
2. Understand and use the symbols: =, <, <<, >>, >, ∝, ~.
3. Calculate percentages
4. Calculate percentage change
5. Translate information between graphical, numerical and algebraic forms
6. Manipulate a range of formula to identify the unknown variable.
7. Deduce and determine uncertainties in measurements.
8. Carry out unit conversions
9. Solve algebraic equations using substitution and appropriate units.
10. Judge appropriate orders of magnitude and scale.
11. Use a calculator to find and use power, exponential and logarithmic functions.
12. Calculate circumferences, surface area and volume of a range of shapes circle, square, rectangle and triangle
13. Calculate rate of change from graphs
14. Apply standard form to data
15. Able to sufficiently round data correctly
16. Provide answers to significant figures
17. Present values in line with equipment measurements

18. Understand that $y = mx + c$ represents a linear relationship
19. Determine the intercept of a graph
20. Rearrange log and exponential formulae
21. Derive useful data from both gradient and area beneath certain graphs

SAFETY IN PRACTICAL INVESTIGATIONS

Candidates should be able to:

1. Identify relevant hazards and associated risks of equipment used
2. Carry out practical procedures carefully and thoroughly applying good practice
3. Identify risks associated with high voltages and currents.

The safety of candidates and staff are the responsibility of the centre involved, full guidance can be found on https://www.cleapss.org.uk/ (Members only).