SPECIFICATION

For exams January, May and November onwards
For teaching from September 2024 onwards.

Learning Resource Network

LRN INTERNATIONAL GCSE

COMBINED SCIENCE (6101)

THE QUEEN'S AWARDS FOR ENTERPRISE: INTERNATIONAL TRADE

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 GCSE Combined Science[1]. This document is suitable for various users, including candidates, centres, administrators, employers, parents/guardians, teachers (and other related staff) and examiners. The specification outlines the key features and administrative procedures required for this international qualification.

OBJECTIVE

The LRN International GCSE in Combined Science aims to provide international candidates with a comprehensive understanding of key scientific principles across Biology, Chemistry, and Physics. This qualification is designed to develop candidates' abilities to apply scientific knowledge, conduct practical experiments, and analyse scientific data. It covers a wide range of topics including cell biology, chemical reactions, and physical forces, ensuring a well-rounded education in the sciences. The qualification also prepares candidates for further studies and careers in scientific fields by fostering critical thinking, problem-solving skills, and a deep appreciation for scientific inquiry.

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 GCSE Combined Science 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 2 qualification in Combined Science;
2. LRN Level 2 Certificate or Diploma in Pre-A Foundation Studies;
3. LRN Level 3 Diploma in Pre-U Foundation Studies;
4. A higher level of any qualification – e.g. A-Level, Diploma
5. Vocationally Related Qualifications

[1] LRN International GCSEs 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

All candidates study all sections and must take all three papers.
All sections are covered in each paper.

Number	Subject Content	AO	Exam
	Biology		
1	Cell formation, structure and functions.	1, 2 and 3	Combination of written exam papers (externally set and marked) and a practical demonstration of skills. **Paper 1 (35%):** Multiple Choice questions, Duration: 1 hour **Paper 2 (45 %):** Short answer response, extended response questions and practical based skills. Duration: 2 hours **Paper 3 (20%):** Experimental skills (theoretical questions only) Duration: 1 hour 30 minutes
2	Movement in and out of cells.	1, 2 and 3	
3	Biological molecules and human digestion	1, 2 and 3	
4	Respiratory system	1, 2 and 3	
5	Transport in animals	1, 2 and 3	
6	Disease, immunity and drugs	1, 2 and 3	
7	Plants	1, 2 and 3	
8	Coordination, response and excretion	1, 2 and 3	
9	Reproduction	1, 2 and 3	
10	Genetics, inheritance, classification, variation and selection	1, 2 and 3	

Number	Subject Content	AO	Exam
	Chemistry		
1	The nature of matter	1, 2 and 3	**Paper 1 (35%):** Multiple Choice questions, Duration: 1 hour **Paper 2 (45 %):** Short answer response, extended response questions and practical based skills. Duration: 2 hours **Paper 3 (20%):** Experimental skills (theoretical questions only) Duration: 1 hour 30 minutes
2	Atoms and the Periodic Table	1, 2 and 3	
3	Chemical Bonding	1, 2 and 3	
4	Quantitative Chemistry	1, 2 and 3	
5	Chemical Changes	1, 2 and 3	
6	Reversible reactions and rate of reactions	1, 2 and 3	
7	Organic Chemistry	1, 2 and 3	

Number	Subject Content	AO	Exam
	Physics		
1	General Skills	1, 2 and 3	**Paper 1 (35%):** Multiple Choice questions, Duration: 1 hour **Paper 2 (45 %):** Short answer response, extended response questions and practical based skills. Duration: 2 hours **Paper 3 (20%):** Experimental skills (theoretical questions only) Duration: 1 hour 30 minutes
2	Motion	1, 2 and 3	
3	Forces	1, 2 and 3	
4	Energy	1, 2 and 3	
5	Waves	1, 2 and 3	
6	Electricity	1, 2 and 3	
7	Magnetism	1, 2 and 3	
8	Thermal Physics	1, 2 and 3	
9	Nuclear	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 l

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 written exam papers, set and marked by the LRN.

Assessment objectives (AOs)	Weighting		
	Paper 1	Paper 2	Paper 3
AO1	50%	40%	50%
AO2	30%	35%	30%
AO3	20%	25%	20%

GUIDED LEARNING HOURS

The guided learning hours (GLH) for this qualification are 130. 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

Results are reported, as 9 to 1.

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 the whole qualification as often as they wish, individual components cannot be re-taken as it is a traditional linear specification.

Please remember, one entry per qualification is sufficient and will cover all the question papers including certification.

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.

BIOLOGY

1	Cell formation, structure, and functions

Aim

Biology is the study of living organisms. The aim of this subject content is to enhance understanding of how cells are created, developed, and used within living organisms. Candidates will learn about cell development, including their components, functions, and structures.

Learning Outcomes - The learner will:		Assessment Criteria - The learner can:	
1	Understand the characteristics of living organisms.	1.1	**Identify** examples of (i) living cells, and (ii) non-living cells.
		1.2	**Define** the main characteristics of living organisms.
		1.3	**Outline** methods used in scientific research, including noting observations and capturing results.
		1.4	**Describe** the seven characteristics of life, specifically (i) movement, (ii) respiration, (iii) sensitivity, (iv) growth, (v) reproduction, (vi) excretion, and (vii) nutrition.
		1.6	**Define** photosynthesis.
		1.7	**Outline** the process of aerobic respiration.
		1.8	**Describe** the process of anaerobic respiration in muscle cells and yeast.
2	Be able to demonstrate a practical awareness of the characteristics of living organisms.	2.1	**Carry** out a series of tests for carbon dioxide (CO2) by use of limewater and hydrogen carbonate indicator.
		2.2	**Review** observations of initial and final colour tests to determine positive and negative results.
		2.3	**Discuss** findings of differences in colour change on rate reaction.
		2.4	**Discuss** findings of differences in colour change on hydrogen carbonate indicator related to CO2 concentration from (i) photosynthesis, and (ii) respiration.
3	Understand the basic structures and functions ofcells.	3.1	**Define** the term unicellular, and multi-cellular.

		3.4	**Define** the term eukaryote and prokaryote.
		3.5	**Outline** the process of mitosis and meiosis.
		3.7	**Describe** the organelles and their functions in cells.
		3.8	**State** examples of: (i) specialised animal cells, and (ii) specialised plant cells.
		3.9	**Explain** how specialised animal cells **and** specialised plant cells are structurally adapted in line with their specialised function.
4.	Be able to demonstrate a practical awareness ofbasic structures and functions of cells.	4.1	**Draw** a typical animal cell, along with accurate labelling, and to a significant degree of accuracy, the following: (i) nucleus, (ii) cytoplasm, (iii) cell membrane, (iv) ribosomes, and (v) mitochondria.
		4.2	**Draw** a typical plant cell, along with accurate labelling, and to a significant degree of accuracy, the following: (i) large permanent vacuole, (ii) cellulose cell wall, (iii) chloroplast, and (iv) amyloplast.
		4.3	**Draw** a Venn diagram (or table) in which similarities and differences, between animal and plant cells, are shown.
5	Understand the working functions of a light microscope.	5.1	**Summarise** the size and structure of cells and their ability to be seen with a light microscope.
		5.2	**Describe** the process of slide preparation and operation of the light microscope in order to make careful observations of cells.
		5.3	**Explain** the importance of the following when using a light microscope: (i) cover slip, (ii) methods of prevention, and (iii) correction on practical application.
6	Be able to demonstrate a practical awareness of the working functions basic structures and functions of cells.	6.1	**Label** all parts of a light microscope.
		6.2	**Use** correct chemicals when observing animal cells under a light microscope.
		6.3	**Use** correct chemicals when observing plant cells under a light microscope.
		6.4	**Draw** observed cells from sample slides.
		6.5	**Manipulate** the formula for magnification.

		6.6	**Calculate** (by use of a scale bar) magnification, image size and actual size from micrographs and images.
7	Understand levels of human organisation.	7.1	**Define** the following terms: (i) cells, (ii) tissues, (iii) organs, and (iv) organ systems.
		7.2	**Explain** how tissues, organs and organ system contribute to organisms.
		7.3	**State** the main organ connecting vessels in each main organ system.
8	Be able to demonstrate a practical awareness oflevels of human organisation.	8.1	**Label** positions of main organ systems in the human body.
		8.2	**Label** main organ systems in the human body.
9	Understand levels of plant organisation.	9.1	**Identify** positions of main organ systems of a flowering plant.
		9.2	**List** the main organ systems of a flowering plant.
		9.3	**Outline** the position of the main organs of flowering plants
		9.4	**Explain** the functions of the main organs of flowering plants.

2	**Movement in and out of cells**		
Aim Movement in and out of cells is fundamental to the entire Biology and is intertwined into nearly every topic. The aim of this subject content is to ensure clear understanding of the three main processes diffusion, osmosis and active transport by which substances enter and exit cells.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the characteristics of living organisms.	1.1	**Explain** the term diffusion.
		1.2	**Describe** the importance of diffusion of gases and solutes.
		1.3	**Describe** the importance of water as a solvent.

		1.4	**Explain** the factors which affect the rate of diffusion.
		1.5	**Explain** how the rate of diffusion is calculated.
2	Be able to demonstrate a practical awareness of the characteristics of living organisms.	2.1	**Carry** out technical processes involving the observation of diffusion in given circumstances, specifically: (i) different temperatures, (ii) use of starch, (iii) use of chemicals.
3	Understand the basic structures and functions ofcells.	3.1	**Explain** the term osmosis.
		3.2	**Define** the following terms: (i) hypertonic, (ii) hypotonic, and (iii) isotonic solutions
		3.3	**Outline** the term 'turgor pressure'.
		3.4	**Explain** how plant cells become (i) turgid, (ii) flaccid, (iii) plasmolysed, (iv) lysed, (v) crenated, and (vi) where no changes occur.
		3.5	**Outline** the function of the plant cellulose cell wall.
		3.6	**Explain** how comparisons can be made in percentage mass in potato cores.
4.	Be able to demonstrate a practical awareness ofbasic structures and functions of cells.	4.1	**Use** graphs/tables to show data, specifically (i) percentage change in mass, (ii)plot data, and (iii) identifying water potential within cells.
5	Understand the working functions of a light microscope.	5.1	**Define** the term active transport.
		5.2	**Describe** how active transport consumes energy through respiration
		5.3	**List** ions and molecules that move by active transport in animals and plants.

3	**Biological molecules and human digestion**		
Aim The aim of this subject content is to enhance understanding of biological molecules and the human digestion system, its key purpose and functions, the wayin which nutrients are processed by the body.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the structure of biological molecules.	1.1	**State** the elements found in biological molecules.
		1.2	**Outline** the basic shape of each biological molecules carbohydrates, proteins andfats.
		1.3	**Describe** the properties of the following carbohydrates: (i) antibodies, (ii)enzymes, and (iii) hormones.
		1.4	**Describe** the properties of the following carbohydrates: (i) glucose, (ii) sucrose, (iii) starch, (iv) glycogen, and (v) cellulose.
		1.5	**Describe** suitable food tests for (i) carbohydrates, (ii) proteins, and (iii) fats.
2	Understand the properties of Deoxyribonucleic Acid (DNA).	2.1	**Outline** the characteristics of DNA.
		2.2	**Describe** how complimentary base pairing works.
		2.3	**Describe** the helix-based structure and basic shape of DNA.
3	Be able to demonstrate a practical awareness as to the properties of DNA.	3.1	**Draw** and **label** a nucleotide that is composed of a phosphate group, pentosesugar and nitrogenous base.
4	Understand the function of enzymes.	4.1	**Define** the effect which enzymes have in terms of metabolic reactions.
		4.2	**Describe** the three core functions of enzymes.
		4.3	**Describe** the process of an enzyme catalysed reaction in terms of substrate,active site, complimentary, enzyme-substrate complex and products
		4.4	**Explain** how enzymes are specific and catalyse a reaction in order to replicate.
		4.5	**Outline** specific conditions in which different enzymes function.

		4.6	**Describe** the effects of temperature on enzyme activity.
		4.7	**Explain** the effects of pH on enzymatic activity.
		4.8	**Describe** substrate concentration and enzyme concentration on enzymatic activity
5	Be able to demonstrate a practical awareness as to the function of enzymes.	5.1	**Carry** out technical processes involving the observation for chemical tests forstarch using iodine.
		5.2	**Carry** out technical processes involving the observation for chemical tests forreducing sugars using Benedict's solution.
		5.3	**Carry** out technical processes involving the observation for chemical tests forproteins using biuret solution.
		5.4	**Carry** out technical processes involving the observation for chemical tests for fats.
		5.5	**Carry** out technical processes involving the observation for chemical tests forVitamin C
6	Understand animal nutrition and the digestive system.	6.1	**Define** the term nutrition.
		6.2	**Explain** the importance of nutrition.
		6.3	**Describe** the importance of a balanced diet, specifically the need for: (i) carbohydrates, (ii) proteins, (iii) fats / lipids, (iv) water, (v) vitamins, (vi) minerals,and (vii) fibre.
		6.6	**Describe** the impact of the following on a diet: (i) excess fat, (ii) not enough fibre, (iii) lack of vitamin C, (iv) lack of vitamin D, (v) lack or iron, and (vi) lack of calcium.
		6.7	**Outline** the effects of a higher energy intake to energy output.
		6.8	**Define** the following terms: (i) ingestion, (ii) digestion, (iii) absorption, (iv)assimilation, and (v) egestion.
		6.9	**Define** the terms mechanical and chemical digestion.
		6.10	**State** the function of (i) amylase, (ii) protease, and (iii) lipase including substratesand products.

		6.11	**Describe** the structure of human teeth and their functions.
		6.13	**Describe** the passage of food along the alimentary canal from mouth to anus
		6.14	**Describe** the events that take place during the chewing and swallowing process.
		6.15	**Outline** the function of saliva
		6.16	**Describe** the movement of food through the oesophagus by way of peristalsis.
		6.17	**Describe** the processes of chemical digestion and mechanical digestion.
		6.21	**Describe** the role of bile and villi in the digestive process.
		6.22	**Describe** the importance of the absorption process in digesting food molecules.
		6.23	**Describe** the passage of undigested food through the intestines by peristalsis.
		6.24	**Outline** the function of the large intestine.
		6.25	**Explain** why the body retains faeces in the rectum prior to it egestion from thebody.
		6.27	**Describe** the role of the gall bladder.
7	Be able to demonstrate a practical awareness as to the processes of animal nutrition and the digestive system.	7.1	**Carry** out technical processes involving the observation of practical food tests, including (i) calorimetry of various foods, and (ii) calculate the energy content of food.

4	**Respiratory system**		
Aim The aim of this is to enhance understanding of the respiratory system and understand the mechanisms involved in the process of breathing.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the role of gaseous exchange in humanbeings.	1.1	**Describe** how the bell jar model can be used to demonstrate ventilation and explain limitations of this experiment.
		1.4	**Outline** how the bronchiole network is visualised as a tree / branch.
		1.5	**Define** the term ventilation and be able to describe how it is different from the termrespiration.
		1.6	**Describe** the process of ventilation both inhalation and exhalation in the lungs interms of pressure changes.
		1.7	**Describe** the pathway of air from atmosphere into a body cell.
		1.8	**Describe** the composition of atmospheric air compared exhaled air.
		1.9	**Describe** the process of gas exchange in the alveoli by diffusion.
		1.11	**Explain** the adaptations of alveoli in terms of: (i) large surface area, (ii) good bloodsupply / capillary network, (iii) moist surfaces, (iv) thin cell walls, and (v) ventilationof the lungs.
		1.12	**Describe** gaseous exchange surfaces in the gills of fish.
		1.13	**Describe** how to measure breathing rate by counting breaths per minute.
		1.14	**Define** the term vital capacity.
		1.15	**Explain** changes in breathing rate and depth before, during and after exercise.
		1.16	**Explain** the relationship between aerobic and anaerobic respiration before, duringand after exercise.
		1.17	**Explain** the role of the liver in breaking down lactic acid.
		1.19	**Describe** the importance of carbon dioxide changes in the blood to regulatebreathing rate.

5	Transport in animals		
Aim The aim of this is to enhance understanding of the human circulatory system, its key purpose and functions, the importance of the lungs on the human circulatory system and how poor diet impacts on the function of the heart.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the function of the human heart and thecirculatory system.	1.1	**Describe** the one-way flow of blood around the body.
		1.2	**Define** the term single and double circulatory system.
		1.3	**Describe** the advantages of a double circulatory system compared to a single circulatory system.
		1.4	**Describe** the role of the coronary artery.
		1.7	**Describe** differences in structure between the left and right side of the heart
		1.13	**Explain** the function of (i) arteries, (ii) veins, and (iii) capillaries.
		1.14	**Describe** differences in blood pressure in each blood vessel.
		1.15	**Describe** the role of red blood cells.
		1.16	**Outline** the structural adaptations of red blood cells
		1.18	**Describe** the role of plasma in the transport of named nutrients: (i) wastes, (ii) blood proteins, and (iii) hormones.
		1.19	**Describe** the function of white blood cells.
		1.20	**Describe** the process of phagocytosis.
		1.21	**Describe** how antibodies can defend the body against pathogens.
		1.22	**Explain** the relationship between antibodies and pathogens

		1.23	**Describe** the role of platelets in the clotting process
2	Be able to demonstrate a practical awareness as to therole of the human heart and the circulatory system.	2.1	**Label** the structure of the heart, specifically: (i) left atrium, (ii) right atrium, (iii) left ventricle, (iv) right ventricle, (v) septum, (vi) bicuspid and tricuspid valves, (vi) aortic, and (vii) pulmonary valves.
		2.2	**Label** the main blood vessels in the body, specifically: (i) vena cava and aorta, (ii) hepatic artery and vein, (iii) hepatic portal vein, and (iv) renal artery and vein.
		2.3	**Carry** out a dissection of the heart.
		2.4	**Identify** blood components from micro pictographs.

6	**Disease, immunity and drugs**		
Aim The aim of this is to enhance understanding of the human body and how lifestyle factors, genetics and behaviours can have a detrimental impact on the body. The subject content will also cover communicable and non-communicable diseases, as well as enhance understanding of medicinal and recreational drugs, their effect on the body and risks associated with drug abuse.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the impact on the human body and plants fromdiseases and immunity.	1.1	**Define** communicable and non-communicable diseases.
		1.2	**State** examples of communicable and non-communicable diseases.
		1.3	**Define** the term pathogen.
		1.4	**Describe** how certain communicable diseases can be transmitted from a host toother non-infected individuals.
		1.5	**Outline** symptoms of the following diseases: (i) influenza, (ii)tuberculosis, (iii)cholera / typhoid, (iv) athletes' foot, (v) HIV/AIDS, (vi) hepatitis, and (vii) chlamydia.
		1.7	**Define** the role of vaccinations.

		1.8	**Outline** the body's primary defenses against disease.
		1.9	**Outline** the role undertaken by phagocytes within the human immune system.
		1.10	**Explain** the role undertaken by lymphocytes and antibodies within the humanimmune system.
		1.11	**Define** the term 'activity immunity'.
		1.12	**Explain** how activity immunity is acquired.
		1.13	**Describe** how mutation of pathogens could lead to a primary response aftervaccination.
		1.14	**Explain** the importance of vaccination for infants and individuals travelling to othercountries.
		1.15	**Explain** the need for regular vaccinations of specific pathogens.
		1.16	**Describe** the terms primary immune response and secondary immune responsein terms of: (i) antibody concentration before and after exposure to pathogen, (ii)presence of memory cells, and (iii) duration of patient sickness / symptoms expressed.
		1.17	**Define** the term passive immunity.
		1.18	**Explain** the importance of breast feeding for infants and passive immunity.
2	Be able to demonstrate a practical awareness as to therole of the impact on the human body and plants from diseases and immunity	2.1	**Draw and label** typical structures, specifically: (i) fungi, (ii) bacteria, (iii)protoctists, and viruses.
		2.2	**Identify** each type of pathogen, specifically: (i) fungi, (ii) bacteria, (iii) protoctists,and viruses.
		2.3	**Identify** from information provided (e.g., graph/comprehension) whether a primaryversus secondary immune response is being observed.
3	Understand the impact of medicinal and recreational drugson the human body.	3.1	**Define** the term drug as a substance ingested into the body that influenceschemical reactions in the body
		3.4	**Describe** and explain the use of antibiotics against bacterial diseases.

		3.6	**Explain** why antibiotics cannot be used to treat viral infections.
		3.7	**Explain** antibiotic resistance in terms of natural selection.
		3.8	**Explain** the importance of correct use of antibiotics and drugs in the fight againstdisease.

7	**Plants**		
Aim The aim of this subject content is to enhance understanding of plant tissues and their key functions.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the role of photosynthesis in plants.	1.1	**State** the chemical and balanced chemical equation for photosynthesis.
		1.2	**Describe** the method to test for starch on a green leaf.
		1.3	**Describe** the role of chlorophyll in photosynthesis.
		1.4	**Describe** experiments that prove that light, chlorophyll, water and carbon dioxide are required for photosynthesis to occur.
		1.5	**Describe** how each of the following factors effects the rate of photosynthesis: (i) light, (ii) temperature, (iii) carbon dioxide concentration, (iv) humidity, (v) presence of wind / air flow.
		1.6	**State** the products of photosynthesis and how they are used in plant.
		1.7	**Describe** how to investigate how each of the following variables effects the rateof photosynthesis: (i) carbon dioxide concentration, (ii) temperature, and (iii) light intensity.
		1.8	**Explain** the results of each of the variables stated above
		1.9	**Define** the term limiting factor.

		1.10	**Explain** how greenhouses arterially control abiotic factors to promote optimum conditions for growth of plants such as temperature, light intensity, CO2 and water.
2	Understand the structure of plant tissues and their keyfunctions.	2.1	**List** the main plant organs.
		2.2	**Outline** the role of the following organs: (i) flower, (i) root, (iii) stem, and (iv) leaves.
		2.3	**Describe** the features of a root hair cell and how it is adapted to function.
		2.4	**Describe** the role of plant roots for absorption of substances by (i) diffusion, (ii) osmosis, and (iii) active transport.
		2.5	**Explain** structural differences in xylem and phloem transport vessels.
		2.6	**Explain** how the following structures promote photosynthesis in leaves/plants: (i) upper epidermis, (ii) palisade layer, (iii) spongy mesophyll layer, (iv) vascular bundle/vein including xylem and phloem, (v) lower epidermis, (vi) guard cells, and, and (vii) stomata.
		2.7	**Describe** the processes involved that allow guard cells to open and close.
		2.8	**Describe** environmental factors that can affect the rate at which stomata opensand closes.
		2.9	**Explain** how diffusion affects the concentration levels in stomata.
3	Understand the plant transport function.	3.1	**Define** the term transpiration and translocation
		3.2	**Compare** differences between the processes of transpiration and translocation
		3.4	**Describe** movement of water and mineral ions from root to leaf in the xylem.
		3.5	**Outline** the chemical properties of water.
		3.6	**Explain** movement of substances from source to sink.
		3.7	**Explain** how substances are transported in xylem and phloem.
		3.8	**Describe** how changes in humidity, temperature and light intensity can affectthe rate of transpiration.
		3.9	**State** that minerals can be absorbed by diffusion and active transport

		3.10	**State** the importance of the following minerals for plant nutrition: (i) nitrates, (ii) phosphates, and (iii) magnesium.
		3.11	**Describe** the impact of mineral deficiency and diseases in plants.
4	Be able to demonstrate a practical awareness as to the roleof transpiration, photosynthesis and plant tissue.	4.1	**Calculate** surface area of a leaf using grid paper.
		4.2	**Calculate** the number of stomata from a micro pictograph.
		4.3	**Deduce** from a diagram which method of absorption is occurring based on concentration gradient.
		4.4	**Test** a leaf for starch.
		4.5	**Investigate** the need for chlorophyll for photosynthesis
		4.6	**Investigate** the need for carbon dioxide for photosynthesis.
		4.7	**Investigate** how light is needed for photosynthesis
		4.8	**Measure** the rate of photosynthesis by measuring volume of oxygen produced over a period of time.
		4.9	**Investigate** the effect of light intensity and rate of photosynthesis
		4.10	**Investigate** the effect of temperature on the rate photosynthesis
		4.11	**Investigate** the effect of carbon dioxide on the rate of photosynthesis.
		4.12	**List** the balanced chemical equation for photosynthesis (including light and chlorophyll on the arrow).
		4.13	**Investigate** the results of the following variables on the rate of effect on photosynthesis: (i) carbon dioxide concentration, (ii) temperature, and (iii) light intensity.
		4.15	**Label** the following parts on a leaf: (i) upper epidermis, (ii) palisade layer, (iii) spongy mesophyll layer, (iv) vascular bundle/vein, (v) xylem and phloem, (vi)lower epidermis, (vii) guard cells, and (viii) stomata.

8	Coordination, response and excretion

Aim

The aim of this subject content is to enhance understanding of nervous and chemical coordination system in humans alongside understanding chemicalcoordination in plants. Learners will also enhance their understanding as to the excretory system and the role of the kidneys.

Learning Outcomes - The learner will:		Assessment Criteria - The learner can:	
1	Understand the nervous system in the human body.	1.1	**State** the meaning of the term sensitivity.
		1.2	**Explain** the difference between central nervous and peripheral nervous system.
		1.3	**Describe** the structure of the human nervous system in terms of: (i) brain, (ii) spine, (iii) cranial, and (iv) spinal nerves.
		1.4	**Explain** receptors as specialised cells that can detect a range of stimulus.
		1.5	**Describe** the purpose of the following sense organs and the stimuli they detect: (i) eye, (ii) ear, (iii) skin, (iv) nose, (iv) tongue.
		1.6	**Describe** the purpose of effectors within muscles / glands.
		1.7	**Describe** how electrical impulses pass along neurones.
		1.8	**Outline** the sequences of events that take place between stimulus and responses.
		1.9	**Compare** differences between voluntary and involuntary actions.
		1.10	**Describe** the adaptations of neurones to increase impulse transmission.
		1.11	**Explain** the difference between white and grey matter in the spinal cord.
		1.12	**Describe** how neurones are involved in coordination for nervous responses and reflex arcs.
		1.13	**Explain** the importance of reflex arcs as a process that prevents damage to the human body.

		1.14	**Describe** the reflex arc in terms of: Stimulus > sensory neurone > relay neurone > motor neurone > effector > response.
		1.15	**Define** the term synapse.
		1.16	**Describe** the processes involved of how impulses are pass across a synapse.
		1.17	**Describe** the function of structures found in the eye, specifically: (i) sclera, (ii) cornea, (iii) iris, (iv) pupil, (v) lens, (vi) ciliary muscles, (vii) ligaments, (viii) vitreous humor, (ix) retina, (x) yellow spot/fovea, (xi) blind spot,and (xii) optic nerve.
		1.18	**Explain** the pupil reflex in terms of changes of light intensity and reflex arc involved including the muscles involved.
		1.19	**Describe** the process of accommodation including actions carried out by the (i) ciliary muscles, (ii) suspensory ligaments, and (iii) change in lens shape for near and far objects.
		1.20	**Explain** functions carried out by rod and cone cells in the retina and relative distribution.
2	Understand chemical coordination in humans.	2.1	**State** the hormones released by each gland.
		2.2	**Describe** the effects of adrenaline on the heart, lungs, liver, and pupils
		2.3	**Explain** the effects of adrenaline for muscle contractions and for increasing blood flow.
		2.4	**Compare** differences of nervous system and endocrine system in terms of: (i) structures involved, (ii) method of transmission, (iii) pathway taken, (iii) rate of transmission, (iv) duration of effect, (v) target organs / tissues, and (vi) responses.
		2.5	**Define** the term homeostasis
		2.6	**Define** the term ‘negative feedback’ in the context of chemical coordination in humans.

		2.7	**Outline** the process of feedback loops for the following scenarios: (i) controlling blood glucose, and (ii) controlling body temperature.
		2.8	**Outline** the functions of the skin.
		2.9	**Define** the terms (i) vasodilation, and (ii) vasoconstriction.
		2.10	**Explain** the importance of conditions such as (i) blood glucose, (ii) temperature, and (iii) water regulation on the survival of the human body.
3	Be able to demonstrate a practical awareness as to the roleof the nervous system and chemical coordination in humans.	3.1	**Label** structures of the following neurones: (i) sensory, (ii) relay, and (iii) motor neurone.
		3.2	**Label** the following parts of the human eye: (i) sclera, (ii) cornea, (iii) iris, (iv) pupil, (v) lens, (vi) ciliary muscles, (vii) suspensory ligaments, (viii) vitreous humor, (ix) retina, (x) yellow spot/fovea, (xi) blind spot, and (xii) optic nerve.
		3.3	**Identify** from a diagram the following endocrine glands: (i) adrenal glands, (ii) the pancreas, (iii) pituitary gland, (iv) thyroid, (v) the testes, and (vi) ovaries.
		3.4	**Identify** and **label** substructures from a diagram of human skin
		3.5	**Carry** out an eye dissection.
		3.6	**Carry** out a ruler dropping experiment to measure reaction time.
4	Understand the role of excretion in human beings	4.1	**Define** the term ‘excretion’.
		4.2	**Outline** the functions carried out by the following excretory organs: (i) lungs, (ii) kidneys, and (iii) skin.
		4.3	**Describe** roles of the liver in detail.
		4.4	**Describe** the structure of the urinary system in terms of: (i) renal artery, (ii) renal vein, (iii) ureters, (iv) bladder, and (v) urethra.
		4.5	**Explain** differences in blood composition between renal artery and veins.
		4.6	**Describe** the role of kidneys in excretion.

		4.7	**Describe** the structure of a nephron.
		4.8	**Explain** the role performed by (i) nephrons in filtration, (ii) blood, (iii) selective reabsorption of substances.
		4.9	**Describe** structural features of an epithelial cell in a kidney tubule.
		4.10	**Describe** functions of the kidneys.
5	Be able to demonstrate a practical awareness as to the roleof role of excretion in human beings.	5.1	**Identify** from a diagram internal structures of the kidney.
		5.2	**Carry** out a kidney dissection.
		5.11	**Explain** the role performed by (i) nephrons in filtration, (ii) blood, (iii) selective reabsorption of substances.
		5.17	**Describe** functions of the kidneys.
6	Be able to demonstrate a practical awareness as to the roleof role of excretion in human beings.	6.1	**Identify** from a diagram internal structures of the kidney.
		6.2	**Carry** out a kidney dissection.

9	**Reproduction**		
Aim The aim of this subject content to gain an enhancing understanding of the reproductive system of both animals and plants.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand reproductive cell division.	1.1	**Define** the term ‘sexual reproduction’ and ‘asexual reproduction’.
		1.2	**Describe** the process of mitosis in detail.

		1.4	**Outline** the importance of mitosis for growth and repair, and importance as a form of asexual reproduction
		1.5	**Explain** the importance of mitosis as a form of asexual reproduction.
		1.7	**Describe** the process of meiosis and formation of gametes
		1.8	**Compare** the process of mitosis and meiosis.
2	Understand plant reproduction.	2.1	**Describe** the functions of internal reproductive structures within flowering plants.
		2.2	**Define** the term pollination
		2.3	**Explain** adaptations of different pollen types to increase chance of pollination.
		2.4	**Describe** the differences between self-pollination and cross-pollination.
		2.5	**Outline** the steps involved from pollination to seed formation.
		2.6	**Explain** conditions needed for germination.
		2.7	**Discuss** advantages and disadvantages of both sexual and asexual reproduction in plants.
		2.8	**Describe** the functions of the male and female reproductive system.
		2.9	**Compare** structural differences of male and female gametes.
		2.10	**Explain** methods of cell division through meiosis.
		2.11	**Describe** roles of sex hormones in terms of primary and secondary sexual characteristics in men and women.
		2.13	**Describe** the process of menstruation.
		2.14	**Explain** the process of fertilisation in humans.

10	Genetics, inheritance, classification, variation and selection.		
Aim The aim of this subject content is to enhance understanding of genetics and inheritance, to enhance understanding of the history of classification and how various organisms are grouped together based on observed features and to enhance understanding of variation in organisms and the various processes ofselection that occur in the environment.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the concept of genetics and inheritance.	1.1	**Describe** the term inheritance and hereditary.
		1.2	**Outline** the terms: (i) DNA, (ii) genes, and (iii) chromosomes.
		1.3	**State** the diploid and haploid number of chromosomes in humans.
		1.4	**Outline** the structure of DNA.
		1.6	**Define** the terms (i) alleles, (iii) dominant, and (iii) recessive.
		1.7	**Explain** the terms (i) genotype, (ii) heterozygous, and (iii) homozygous.
		1.8	**Define** the term phenotype.
		1.9	**Interpret** pedigree diagrams to determine if alleles are dominant or recessive.
		1.10	**Define** the term monohybrid inheritance
		1.11	**Describe** and explain the term codominance of allele.
		1.12	**Define** the term ‘sex linkage’.
2	Be able to demonstrate a practical awareness as to the roleof genetics and inheritance.	2.1	**Correctly** calculate probability of genotypes and phenotypes of offspring using a punnet square / test cross.
		2.2	**Draw** punnet squares / test cross to successfully predict probabilities based on information provided from (i) pedigree diagrams, and (ii) comprehension of offspring or parents.
		2.3	**Determine** probability using a punnet square of the following scenarios: (i)gender determination, and (ii) inheriting recessive or dominant diseases.

		2.4	**Use** pedigree diagrams to determine if a genetic condition is linked.

3	Understand the history of classification.	3.1	**Outline** how organisms are classified.
		3.2	**Define** the term 'binomial system'.
		3.3	**Explain** the terms 'morphology' and 'anatomy'.
		3.4	**List** features of organisms classified in the five kingdoms.
		3.5	**Describe** the importance of classification to evolution.
		3.6	**Explain** the importance of fossil evidence to support theory of evolution.
4	Understand classification of animals.	4.1	**Define** the terms 'vertebrate' and 'invertebrate'.
		4.2	**Describe** the features of the following five vertebrate groups: (i) fish, (ii)mammals, (iii) amphibians, (iv) reptiles, and (v) birds.
		4.3	**Compare** and **contrast** features of different vertebrate groups.
5	Understand classification of plants.	5.1	**Describe** cellular structures that classify organisms as plants
6	Be able to demonstrate a practical awareness as to theclassification of animals and plants.	6.1	**Draw** and **use** simple dichotomous keys to identify plants and animals.
		6.2	**Classify** unknown species based on visible external features from pictures of descriptions of organisms.
		6.3	**Classify** unknown species based on visible external features from pictures of descriptions of organisms
7	Understand the role of variation in organisms.	7.1	**Define** the term 'variation'.
		7.2	**Describe** differences between genetic and phenotypic variation.
		7.3	**State** the differences between continuous and discontinuous variation.
		7.4	**Describe** continuous variation in terms of genes and environment.
		7.5	**Explain** discontinuous variation in terms of genes only

		7.6	**Describe** the causes of variation of individuals caused by sexual reproduction (meiosis) and mutation.
		7.7	**Define** the term mutation.
		7.8	**State** the causes of mutation such as (i) carcinogens, (ii) harmful chemicals, and (iii) radiation.
		7.9	**Explain** possiblepositive and negative effects on mutation forming new allelesin a population.
8	Understand the role of adaptations in organisms.	8.1	**Define** the term ‘adaptive feature’.
		8.2	**Explain** adaptive features of animals in varying climates.
		8.3	**Describe** various predator and prey adaptations in terms of: (i) camouflage, (ii) teeth shape, and (iii) eye location.
9	Understand selection and evolution in organisms.	9.1	**Describe** the term ‘natural selection’.
		9.2	**Define** the term ‘speciation’.
		9.4	**Explain** how Darwin’s finches demonstrate natural selection.
		9.6	**Describe** how fossil evidence can be used to identify changes
		9.7	**Describe** evolution as a natural selection results in a change of adaptive features over time
		9.8	**Explain** how natural selection maintains adaptive features.

1	**States of matter and methods of separation.**		
Aim The aim of this subject content is to improve understanding of states of matter and methods of separation.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand states of matter.	1.1	**Describe** solids, liquids, and gases in terms of particle arrangement proximity and motion.
		1.2	**Explain** differences of solids, liquids, and gases in terms of (i) volume, (ii) ability to flow, (iii) ability to be compressed, and (iv) relative kinetic energy of particles.
		1.3	**Describe** the physical changes of state of substances as a result in temperature change.
		1.4	**Explain** the kinetic particle model.
		1.7	**Define** diffusion.
		1.8	**Explain** factors that influence diffusion.
		1.9	**Outline** why diffusion is unable to occur within solids.
		1.10	**Describe** the pressure and temperature of gases in terms of motion of particles
		1.11	**Carry out** practicals/simulations involving investigation of rates of diffusion. • Temperature and diffusion e.g., soluble solid added to hot and cold water and record observations and explain results. • Molecular mass and rate of diffusion

2	Understand methods of purification.	2.1	**List** apparatus for the measurement of time, temperature, mass, and volume.
		2.2	**Explain** the processes carried out during paper chromatography.
		2.3	**Carry out** chromatography on the following: 1. A mixture of water-soluble pigments and calculate Rf value and determine thenumber of pure substances in a mixture based on results. 2. A mixture of non-water-soluble pigments and the use of an organic solvent toseparate the mixture. Explain the importance of using a pencil to draw the origin line and solvent front. Explain the chemical nature of substances and reasons for using the difference solvents. E.g., polar substances only dissolve in polar, and non-polar only dissolvein non-polar solvents.
		2.4	**Identify** substances and assess purity of substances based on melting and boilingpoints.
		2.6	**Describe** the effect of impurities on melting and boiling points of substances.
		2.7	**Explain** the term conservation of mass**.**
		2.10	**Perform** and **evaluate** methods of purification including in terms of solubility, density, boilingpoints in the suitability of each method (i)-(iii) i) Process of filtration. ii) Process of crystallisation. iii) Process of simple distillation • Identify all equipment used from diagrams for methods of purification listedabove. • Describe a suitable method of purification from information provided.
		2.11	**Carry out** each method of separation. Examples include: • Sand, salt water to separate to achieve pure sand, pure salt, and pure water

			• Achieved solid copper sulphate from copper sulphate solution
3	Be able to demonstrate a practical awareness ofstates of matter and methods of separation.	3.1	**Investigate** methods of heating and cooling of pure substances and report findings.
		3.2	**Interpret** simple chromatograms.
		3.3	**Interpret** simple chromatograms using Rf values.
		3.4	**Investigate** the effect of impurities on melting and boiling points of substances andreport findings.

2	**Atoms and the periodic table**		
Aim The key aim of this subject content is to develop an understanding of the structure of the atom and how atoms are arranged in the periodic table.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the structure of atoms.	1.1	**State** the relative mass and charge of a proton, neutron, and electron.
		1.2	**Outline** the term proton number and nucleon number.
		1.3	**Describe** the importance of proton number to explain the periodic table.
		1.4	**Define** the term relative atomic mass and relative formula mass.
		1.5	**Define** the term isotope.
		1.6	**State** two types of isotope as being radioactive and non-radioactive.
		1.7	**State** a range of medical and industrial uses of isotopes.
		1.8	**Evaluate** how isotopes have the same chemical properties due to have the same number of electrons in the outer shell.
		1.9	**Explain** the significance of the noble gas electronic structure and outer shell electrons in terms of chemical reactivity.

		1.10	**Describe** the differences between elements, compounds, and mixtures.
		1.11	**Outline** the build-up of electron shells/energy levels
2	Understand the periodic table.	2.1	**Describe** the changes from metallic to non-metallic character across a period.
		2.3	**Define** appearance of various elements in the periodic table
		2.4	**Summarise** the relationship between group number and number of electrons in the outer shell.
		2.5	**Evaluate** the relationship between period and number of electron shells.
		2.6	**Describe** the differences between metals and non-metals.
		2.7	**Identify** trends in the periodic table including: 1. Orders of magnitude of atoms across the period and down the group. 2. Metallic and non-metallic across the period. 3. States of matter across the period and down the group. Specific group trends requirements highlighted in other learning outcomes.
		2.8	**Describe** the trends in physical and chemical properties of group 1 metals in terms of: (i) melting and boiling points, (ii) density, (iii) reactivity and (iv) other properties of metals.
		2.9	**Describe** and explain the importance of appropriate storage of group 1 metals
		2.10	**Explain** changes of reactivity of group 1 in terms of ease of loss of outer electron due to weaker force of attraction between the nuclei and outer electron.
		2.11	**Outline** how halogens are considered as diatomic molecules.
		2.12	**Describe** the trends in physical properties of the group VII elements (Halogens) in terms of: (i) colour of appearance, (ii) melting and boiling points, (iii) states of matter, and (iv) reactivity.
		2.13	**State** the uses of group VII elements.

		2.14	**Predict** properties of other elements in group VII.
		2.15	**Explain** changes of reactivity of group VII in terms of ease of gaining of additional electrons due to stronger force of attraction between the nuclei and outer electrons
		2.16	**Describe** the noble gases as being unreactive, monatomic gases and explain this in terms of electronic structure.
		2.17	**Outline** uses of noble gases and explain appropriateness due to creating an inert atmosphere
		2.18	**Describe** properties of transition elements in terms of: (i) high melting and boiling points, (ii) high densities, (iii) forming coloured compounds, (iv) acting as catalysts, (v) variable oxidation states, and (vi) other metal properties.
3	Be able to demonstrate a practical awareness as tothe structure of atoms.	3.1	**Calculate** the number of protons, neutrons and electrons of an element using the periodic table.
		3.2	**Investigate** how lithium, sodium and potassium reacts with water.
		3.3	**Investigate** and predict properties of other group 1 metals.
		3.4	**Investigate** trends in other groups from specified provided.

3	**Chemical bonding**		
Aim The aim of this subject content is to enhance understanding of bonding between atoms.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand structure and bonding.	1.1	**Explain** that bulk properties of substances are related to the type of bonding present.In terms of: 1. Bond strength of intermolecular forces 2. Bonding arrangement Recall that individual atoms do not have these properties.

		1.2	**Explain** the formation of ions by electrons loss or gain.
		1.3	**Describe** ionic bonding in terms of forces of attraction between positive and negativeions, referred to as an electrostatic force.
		1.4	**Outline** the formation of ionic bonds between metallic and non-metallic elements.
		1.5	**Outline** the formation of ionic bonds between elements groups I and VII.
		1.6	**Outline** the formation of ionic bonds between elements groups II and VI.
		1.7	**Describe** the lattice structure of ionic compounds.
		1.8	**Describe** covalent bonding in terms of sharing of electrons.
		1.9	**Describe** the formation of simple covalent bonds, specifically: (i) hydrogen, (ii)chlorine, (iii) water, (iv) ammonia, (v) hydrogen chloride, and (vi) methane
		1.10	**Define** the term 'lone pair of electrons'
		1.11	**Outline** the idea of bonding leading to a noble gas electron configuration due to bonding.
		1.12	**List** examples of electrons for complex covalent molecules.
		1.13	**Describe** and **list** the term single, double and triple covalent bonds with examples.
		1.15	**Explain** the term valency.
		1.18	**Describe** giant covalent structures with examples such as diamond, graphite,fullerenes, and graphene.
		1.20	**Describe** differences in physical properties of ionic and covalent substances in terms of: (i) volatility, (ii) electrical conductivity, (iii) solubility, and (iv) melting and boiling points.
		1.21	**Define** the term 'metallic bonding' in terms of a lattice of positive ions floating in a sea of delocalized electrons.
		1.22	**Explain** properties of metals.

2	Be able to demonstrate a practical awareness as tothe purpose of chemical bonding.	2.1	**Draw** cross and dot diagrams representing electron transfer for ionically bonded substances.
		2.2	**Draw** chemical diagrams representing a covalent bond with a single line e.g. H – H
		2.3	**Deduce** uses of diamond, graphite, fullerenes, and graphene relating to their structure.
		2.4	**Compare** diamond and silicon (IV) dioxide in terms of structure and properties.

4	**Quantitative Chemistry**		
Aim The aim of this subject content is to enhance understanding of quantitative chemistry.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand chemical formula	1.1	**Differentiate** between metals and non-metals, metal and non-metal compounds, and covalent compounds.
		1.2	**Define** the terms ‘products’ and ‘reactions.
		1.3	**Outline** the following states of matter symbols: (i) s, (ii) l, (iii) g, (iv) aq.
		1.4	**Define** the term ‘spectator ions’.
2	Be able to demonstrate a practical awareness as tochemical formula.	2.1	**Write** chemical formula for elements and simple compounds.
		2.2	**Deduce** formula of ionic compounds using valency of elements present.
		2.3	**Deduce** the formula of compounds from diagrams.
		2.4	**Construct** word, chemical and balanced chemical equations form information provided.

		2.5	**Construct** balanced ionic chemical equations.
3	Understand chemical calculations.	3.1	**Describe** the term mole and the Avogadro constant.
		3.2	**Describe** titrations as methods to identify an unknown concentration of a solution.
		3.3	**Describe** the terms 'percentage yield' and 'percentage purity'.
4	Be able to demonstrate a practical awareness as tochemical calculations.	4.1	**Deduce** relative atomic mass and relative formula mass of various chemical compounds.
		4.2	**Use** moles in calculating stoichiometric reacting masses including the following calculations: 1. Moles (mol) = mass (g) ÷ relative formula molar mass (Ar or Mr) 2. Moles (mol) = concentration (mol/dm^3) x volume (dm^3) 3. Moles (mol) = volume (dm^3) ÷ 24 (dm^3) (volume of gas at room temp.) 4. Concentration (mol/dm^3) = Mass (g) ÷ volume (dm^3)
		4.3	**Calculate** theoretical yield of product from a given amount of reactant.
		4.4	**Deduce** which reactant is limiting or in excess by comparing number of moles of each reactant considering the stoichiometry of the equation.
		4.5	**Calculate** the percentage by mass of an element in a compound
		4.6	**Calculate** (i) percentage yield, (ii) percentage purity', (iii) empirical formulae, and (iv) molecular formulae.
		4.7	**Calculate** the concentration of a given solution.

5	**Chemical Changes**		
Aim The aim of this subject content is to enhance understanding of chemical changes.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand chemical changes.	1.1	**List** examples of physical and chemical changes.
		1.2	**Explain** what is meant by physical and chemical changes with examples.
		1.3	**Describe** the terms exothermic and endothermic in terms of: 1. Net energy gain and loss from a reaction. 2. Change in surrounding temperature.
		1.4	**State** various finite fuels including coal, oil, gas, hydrogen, and uranium
		1.6	**Evaluate** differences in energy output by fuels per kg of fuel.
2	Be able to demonstrate a practical awareness as tochemical changes.	2.1	**Draw**, label and interpret energy level diagrams.
		2.2	**Calculate** the energy absorbed / released from reactions using bond energy values.
		2.3	**Deduce** a reaction as exothermic or endothermic from given.
		2.4	**Investigate** fuels using calorimetry to measure energy released.
		2.8	**Write** balanced chemical half reactions include: acidic and alkaline solutions
3	Understand acid and bases.	3.1	**Describe** the terms neutral, acid, base, and alkali.
		3.2	**Define** acids and bases in terms of proton transfer.

		3.3	**Evaluate** the differences between strong and weak acids in terms of: **1.** Hydrogen ion concentration and term pH. **2.** Ability of acid substances to dissociate to form hydrogen ions. **3.** Examples of laboratory acids and chemical formula • Hydrochloric acid HCl • Sulphuric acid H_2SO_4 • Nitric acid HNO_3
		3.4	**Describe** indicators used to identify acids and alkalis, specifically: (i) litmus, (ii) methyl orange, (iii) Phenolphthalein, and (iv) universal indicator.
		3.5	**Carry out** a range of chemical tests on variety of substances using the full range of indictors stated in 3.4(i)-(iv). Including the ability to deduce the chemical nature of unknown chemicals based on observations.
		3.6	**Describe** properties of acidic substances
		3.7	**Evaluate** the importance of using bases to assist in regulating pH of soils.
		3.8	**List** examples of oxides as: (i) acidic, (ii) basic, (iii) neutral, and (iv) amphoteric.
		3.9	**Classify** oxides as acidic, basic, neutral, and amphoteric with examples.
4	Be able to demonstrate a practical awareness as toacids and bases.	4.1	**Deduce** the acidity / alkalinity of a substance based on given information.
		4.2	**Apply** the following general equations in given examples: (i) Metal + acid -> salt + hydrogen, (ii) metal oxide + acid -> salt + water, (iii) metal carbonate + acid -> salt + water + carbon dioxide, (iv) metal hydroxides + acid -> salt + water, and (v) aqueous ammonia + acid -> salt.
		4.3	**Write** word, chemical and balanced chemical equations of reactions including states of matter symbols for acid-base reactions.

		4.4	**Write** ionic equations for acid-base reactions.
		4.5	**Carry out** a range of metal, metal oxide, metal carbonate and metal hydroxide reactions using range of laboratory acids.
5	Understand the process for making salts	5.1	**Describe** methods of preparation, separation, and purification of (i) salts from metal, (ii) a soluble base, and (iii) an insoluble base.
		5.2	**Carry out** experiments to make metal salts from metals, metal oxides, metal carbonates and metal hydroxides reacted with laboratory acids e.g., copper oxide + sulphuric acid to make solid copper sulphate.
		5.3	**Describe** the preparation of insoluble salts by precipitation reactions.
		5.4	**Describe** methods and observation for the following chemical tests: (i) test for oxygen, and (ii) test for carbon dioxide, (iii) test for water, and (iv) test for Sulphur dioxide, (v) test for ammonia, and (vi) test for chlorine.
		5.5	**Describe** the tests for cations using the following: (i) precipitation reactions, and (ii) flame tests.
		5.6	**Describe** the test for anions, specifically: (i) testing for halides using precipitation, (ii) reactions, (iii) testing for carbonates by analysis of gas product carbon dioxide, (iii) testing for nitrates by identifying ammonia using litmus, (iv) testing for sulphate by identifying sulphur dioxide using potassium manganate (VII).
6	Be able to demonstrate a practical awareness as theprocess for making salts.	6.1	**Deduce** a suitable method of making a salt from information provided.
		6.3	**Deduce** unknown substances by qualitative analysis based on given information.
		6.4	**Carry** out observations for the following chemical tests: (i) test for oxygen, and (ii) test for carbon dioxide, (iii) test for water, and (iv) test for sulphur dioxide, (v) test for ammonia, and (vi) test for chlorine.
7	Understand metals and reactivity.	7.1	**Define** the term ‘alloy’.
		7.2	**State** metals that determine the following alloys: (i) brass, (ii) bronze, (iii) solder, and (iv) stainless steel.
		7.3	**Describe** the properties and uses of the following alloys (i) brass, (ii) bronze, (iii) solder, and (iv) stainless steel.

		7.4	**Identify** alloys from given information (diagrams).
		7.5	**Describe** metals that are above hydrogen in the reactivity series.
		7.6	**State** metals that react with (i) water, (ii) steam, and (iii) acids.
		7.7	**Describe** metal reactivity in terms of displacement reactions.
		7.8	**Carry out** a range of metal + acid reactions and construct a reactivity series based on observations on vigorousness of reaction.
		7.9	**Describe** reactivity of metals in terms of valency and ability to lose electrons.
		7.10	**Explain** the use of carbon as a reducing agent for some metal oxides.
		7.12	**Define** the term 'thermal decomposition'.
		7.15	**State** the correct word, chemical **and** balanced chemical formula for the thermal decomposition of (i) hydroxides, and (ii) nitrates
8	Be able to demonstrate a practical awareness as tometals and reactivity.	8.1	**Investigate** metals placed in a reactivity series in terms of reactions with water, steam, and acids.
		8.2	**Deduce** reactivity of metals based on given information.
9	Understand electricity and chemistry.	9.1	**Define** the term electrolysis
		9.2	**Define** the term cation and anion.
		9.3	**State** the word, chemical **and** balanced chemical equation for common electrolysis reactions.
		9.5	**Summarise** electrolysis in terms of electron transfer.
		9.6	**Explain** electrolysis in the context of purifying copper, including the type of electrolyte used and electrodes used.
		9.7	**Describe** the process of electrolysis in electroplating.
		9.8	**Outline** the uses of electroplating in terms of: (i) protection against corrosion, and (ii) improving of appearance of metals.

		9.9	**Carry out** an electroplating experiment/simulation on conductive material e.g., using copper sulphate solution and an iron nail.
		9.11	**Define** the term conductor and insulator in terms of energy transfer within a material.
10	Be able to demonstrate a practical awareness as toelectricity and chemistry.	10.1	**Label** components of an electrolysis cell.
		10.2	**Deduce** the products at electrodes of a molten ionic compound and ionic compounds in solution.

6	**Reversible reactions and rate of reactions**		
Aim The aim of this subject content is to enhance understanding reversible reactions and rate of reactions.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the rate of reactions.	1.1	**Describe** suitable methods to calculate rate of reactions based on: (i) calculating mass loss of reactants in a given time, (ii) calculating volume of product in a giventime, and (iii) calculating the time taken in a precipitation reaction.
		1.2	**Outline** suitable methods named equipment to measure: (i) calculating mass lossof reactants in a given time, (ii) calculating volume of product in a given time, and (iii) calculating the time taken in a precipitation reaction.
		1.3	**Evaluate** suitable methods for calculating rate of reactions based on information provided.
		1.4	**Explain** changes from data and graphs regarding rates of reactions.

		1.5	**Describe** how the following factors affect rate of reaction: (i) surface area, (ii)temperature, (iii) catalyst, and (iv) concentration.
		1.6	**Carry out a range of practicals to observe rates of reactions:** Examples include: 1. Measuring volume of carbon dioxide produced over a period of time usingmetal carbonate + acid. 2. Measuring mass decrease over a period of time e.g., metal carbonate +acid. 3. Using difference sizes of reactants e.g., lumps versus powder.
		1.8	**State** the word, chemical **and** balanced chemical equation of photosynthesis.
		1.10	**State** the word, chemical **and** balanced chemical equation for some common redox reactions.
2	Be able to demonstrate a practical awareness as tothe rate of reactions.	2.1	**Investigate** the use of dependent, independent and control variables based on given information.
		2.2	**Interpret** data and graphs when describing rate of reactions, in terms of (i) chanceof successful collisions between reacting particles, and (ii) kinetic energy and activation energy.
		2.3	**Calculate** rate of reaction from data and graphs based on given information.
3	Understand reversible reactions.	3.1	**Evaluate** the conditions which must be present when chemical reactions are reversible.
		3.2	**Identify** a reversible reaction using ⇌ symbol
		3.3	**Describe** common reversible reactions in terms of changing conditions
		3.4	**Define** the term 'water crystallisation'.
		3.5	**Describe** the appearance of hydrous and anhydrous copper sulphate.

		3.6	**Carry out** an experiment to observe the hydrated and anhydrous versions of copper sulphate.
		3.13	**Define** the term oxidation and reduction in terms of: (i) gain or loss of electrons, (ii)gain or loss of oxygen, (iii) gain or loss of hydrogen.
		3.14	**Evaluate** the importance of oxidation states.
		3.15	**Define** the terms oxidising agents and reducing agents.
		3.16	**State** the chemical **and** balanced chemical half reactions for redox reactions.

7	**Organic Chemistry**		
Aim The aim of this subject content is to enhance understanding of organic chemistry.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand organic chemistry and petrochemicals.	1.1	**Describe** the term 'homologous series in terms of a group of similar compounds with similar chemical properties due to the presence of the same functional group.
		1.2	**Describe** the general characteristics of a homologous series.
		1.3	**Explain** the compounds in homologous series have the same general formula.
		1.4	**State** the structures of methane, ethane, ethanol
		1.5	**Define** the term 'hydrocarbon'.
		1.6	**State and draw the structural formulae** the structures of alkanes up to 6 carbon atoms.
		1.7	**Define** the term 'isomers.
		1.8	**Describe** structural isomers from given information.

		1.9	**Outline** the characteristics of the following fuels: (i) coal, (ii) natural gas, and (iii) petroleum (crude oil).
		1.10	**Describe** the fuels obtained from petroleum.
		1.11	**Describe** the properties of molecules within a fraction
		1.12	**Describe** the products of complete combustion of a hydrocarbon fuel as carbon dioxide and water.
		1.13	**Describe** the separation of petroleum into different fractions by fractional distillation.
		1.14	**State** uses of fractions from fractional distillation.
2	Understand alkanes and alkenes.	2.1	**Describe** the properties of alkanes.
		2.2	**Describe** the bonding of alkanes.
		2.3	**Summarise** the reaction of alkanes with chlorine.
		2.4	**Explain** the manufacturing process of: (i) alkenes, and (ii) hydrogen by cracking.
		2.5	**State and draw the structural formulae** of alkenes up to 6 carbon atoms.
		2.6	**Differentiate** between saturated and unsaturated hydrocarbons in terms of: (i) presence of double C bond, and (ii) reactions with aqueous bromine.
		2.7	**Describe** the addition reactions of alkenes with bromine, steam and hydrogen.
		2.8	**Evaluate** the formation of ethanol by fermentation and by the addition of steam to ethane
		2.9	**Describe** the uses of ethanol.
		2.10	**State and draw the structural formulae** of alcohols up to four carbon atoms.
3	Understand polymers.	3.1	**Define** the following terms: (i) macromolecule, (ii) monomer', (iii) polymer, and (iv) polymerisation.
		3.2	**State** some uses of plastics and man-made fibres**.**
		3.3	**Define** the structure of a polymer from a given alkene.

		3.5	**State** the structure of a monomer from a given addition polymer.
		3.6	**State** the structure of monomers and additional polymers.
		3.9	**Explain** condensation polymerisation.
		3.11	**Differentiate** between addition polymers and condensation polymers.

1	General Skills		
Aim Learners will be expected to use the following skills throughout the course and will be assessed on them across all the units.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand units.	1.1	**State** the correct SI units (name and symbol) for physical quantities.
		1.2	**Recall** and make use of the SI unit prefixes (names and symbols) nano [n], micro [µ], milli [m], kilo [k], mega [M] and giga [G].
		1.3	**Convert** between units as part of a calculation.
		1.4	**State** calculation answers to an appropriate number of significant figures. Usually 2 or 3sf is sufficient. 1sf is usually not enough to gain correct answer marks. A question that states “Show that” requires a value to be seen to at least one more significant figure than the value asked for.
		1.5	**State** the correct symbols for physical quantities.
2	Understand how to plot graphs.	2.1	**Draw** axes using a ruler.
		2.2	**Label** axes with descriptions and units.
		2.3	**Label** axes with correct scales. They should be continuous with equal increments, and the increments should be factors of 1, 2, 5 and 10 (e.g. 0.05, but not 30). The scale does not need to start at zero, but it should be clearly labelled.
		2.4	**Plot** data points using a cross. The centre of the cross should be within half a grid square of the correct point.
		2.5	**Draw** a line of best fit using a ruler. The line should go through the middle of the data, so there should be about the same number of points above and below the line. The line does not need to pass through any of the points and should not simply connect the first and last points.

		2.6	**Label** different data sets clearly if they are plotted on the same axes.
		2.7	**Draw** a triangle at least half the size of one of the graph dimensions when finding a gradient.
		2.8	**Draw** and shade in the area under a graph when using it to calculate a value.
		2.9	**Draw** sketch graph axes with a ruler.
		2.10	**Label** sketch graph axes with descriptions but not units.
		2.11	**Sketch** the general shape of a sketch graph.
3	Understand how to make measurements	3.1	**Calculate** the mean of a data set.
		3.2	**Describe** measurements of length using an appropriate device. <3cm micrometer (or Vernier callipers), 3cm-1m metre rule, 1m-10m tape measure, 10m+ trundle wheel.
		3.3	**Describe** how to measure the volume/diameter of a cylinder. e.g. Measure a wire by measuring its diameter (usually with a micrometer) at different points along it and at different orientations, then take an average.
		3.4	**Describe** how to measure small dimensions by measuring multiple objects. e.g. Measuring the thickness of paper by measuring a large number of identical sheets stacked next to each other and finding the average.
		3.5	**Describe** how to measure vertical distances, including making sure the measurement is actually vertical. Use set-squares or plumb-line to check.
		3.6	**Describe** measurements of time using an appropriate device. Stop-watch/stop- clock, or timer are acceptable. Clocks and watches are not accurate enough for times less that several hours.
		3.7	**Describe** how to measure a small-time interval by measuring multiple consecutive events. e.g., Timing a pendulum swing by timing a large number of repetitions and finding the average.
		3.8	**Describe** measurements of mass using an appropriate device. (Electronic)balance is acceptable. Scales are not accurate enough for masses less that about 100kg.
		3.9	**Describe** how to measure a small mass by measuring a large number of identical objects.

		3.10	**Describe** how to measure volumes using appropriate equipment. A measuring cylinder for liquids, a displacement can and measuring cylinder for oddly shapedobjects, measurements and calculations for regular objects.
		3.11	**Describe** how to measure current and potential difference.
		3.12	**Describe** how to use a thermometer to find the temperature of a solid, liquid or gas. Ensuring thermal contact with the solid, not in contact with a fluids container,ensuring that the fluid is stirred, and waiting for the thermometer to reach the same temperature as the material it is measuring.
		3.13	**Describe** measurements of angle using an appropriate device.
		3.14	**Define** an 'Anomaly' as a measurement result that is significantly far away from the other results (compared to the uncertainty in the measurements).
4	Understand how to conduct an experiment.	4.1	**Identify** the independent, dependent variables and control variables in an experiment.
		4.2	**Describe** how variables are measured and/or controlled.
		4.3	**Draw** a labelled diagram of the apparatus and/or circuit.
		4.4	**State** safety precautions.
		4.5	**Describe** how to conduct the experiment. A student who is just starting International GCSE should be able to follow your description and obtain usable results.
		4.6	**State** which parts are to be repeated for accuracy, which results are ignored as anomalies, and that you will take an average.
		4.7	**State** what changes you would make to the independent variable before repeating the whole process.
		4.8	**State** the equations you would use to calculate the results.
		4.9	**Describe** the graph you would plot and how you would obtain results from it.

2	Motion		
Aim Physics is all about how things move and change. The aim of this subject content is to describe, depict, calculate and predict the motion of objects.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1		1.1	**List** examples of scalar quantities.
		1.2	**List** examples of vector quantities.
		1.3	**State** an appropriate direction along with a magnitude for vector quantities.
		1.4	**Draw** vector diagrams.
		1.5	D**etermine** the sum of two vectors using vector diagrams.
2	Understand displacement, velocity and acceleration.	2.1	**Define** 'Displacement' as the distance travelled in a given direction and use distance and displacement correctly in descriptions.
		2.2	**Define** 'Speed' as the distance travelled per unit time.
		2.3	**Solve** problems using $v = \frac{s}{t}$ and $\text{Average Speed} = \frac{\text{Total Distance}}{\text{Total Time}}$.
		2.4	**Define** 'Velocity' as the speed in a given direction and use speed and velocity correctly in descriptions.
		2.5	**Outline** an experiment to find the average speed of a given object moving in a straight line.
		2.6	**Define** 'Acceleration' as the rate of change of velocity.
		2.7	**State** that acceleration can cause the velocity to increase or decrease, and/or change direction.
		2.8	**Understand** that 'Deceleration' is the 'Rate of decrease of velocity'.
		2.9	**Solve** problems using $a = \frac{\Delta v}{\Delta t}$, and $\text{Average Acceleration} = \frac{\text{Change in Velocity}}{\text{Time Taken}}$.
		2.10	**Outline** an experiment to find the average acceleration of a given object moving in a straight line.

3	Understand motion graphs.	3.1	**Draw** distance-time and velocity-time graphs.
		3.2	**Interpret** distance-time and velocity-time graphs.
		3.3	**Calculate** speed from the gradient of a distance-time graph.
		3.4	**Calculate** acceleration from the gradient of a velocity-time graph.
		3.5	**Calculate** distance travelled from the area under a velocity-time graph.
		3.6	**Identify** key points on a distance-time or velocity-time graph.
4	Understand the equations of motion.	4.1	**State** that the 'SUVAT' equations of motion describe the movement of objects under constant acceleration.
		4.2	**Recognise** situations where velocity or acceleration are constant, or where acceleration is changing (from descriptions, data or graphs).
		4.3	**Solve** problems using $s = ut + \frac{1}{2}at^2$.
		4.4	**Solve** problems using $v = u + at$.
		4.5	**Solve** problems using $s = \frac{u+v}{2}t$.
		4.6	**Solve** problems using $v^2 = u^2 + 2as$ (equation given).
		4.7	**Calculate** the average velocity of an object using $\text{Average Velocity} = \frac{u+v}{2}$.
		4.8	**Estimate** typical speeds and the magnitude of common accelerations.
5.	Understand momentum.	5.1	**Define** 'Momentum' as the product of an objects (inertial) mass and its velocity.
		5.2	**Solve** problems using $p = mv$.
		5.3	**State** that momentum is conserved unless an external force acts.
		5.4	**Explain** how a moving object can lose momentum.
		5.5	**Use** $\text{Total Momentum Before} = \text{Total Momentum After}$ to **solve** problems involving the collision of two objects (assuming no external forces) in one dimension.

		5.6	**Explain** why momentum is conserved during a collision.
		5.7	**Outline** an experiment to test the conservation of momentum.

3	**Forces**		
Aim Forces mediate the interactions between objects. The aim of this subject content is to explain the interaction of objects through forces and how those forces can balance out to produce a system in equilibrium.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand forces.	1.1	**Define** a 'Force' as an interaction that tries to change an objects momentum.
		1.2	**List** examples of forces.
		1.3	**Draw** force vectors as arrows with length proportional to the magnitude of the force.
		1.4	**Describe** how multiple forces can be represented by a single resultant force.
		1.5	**Calculate** the resultant of several parallel forces.
		1.6	**Use** vector diagrams to find the resultant force in an unbalanced (non-equilibrium) system, or to find the unknown force in a balanced (equilibrium) system.
		1.7	**Draw** free-body diagrams for simple systems.
		1.8	**Explain** why stretching, compressing or bending an object requires more than one force to be acting on the object.
		1.9	**Distinguish** between internal (acting between two objects inside the system) forces and external (acting on an object in the system from outside it) forces.
		1.10	**Describe** resistance forces as forces that oppose motion, and give examples.
		1.11	**State** that friction and air resistance increase as the speed of an object increases.

		1.12	**State** that the force due to gravity/gravitational field strength/acceleration due to gravity is constant near the Earth's surface.
		1.13	**Explain** the motion of a body falling in a constant gravitational field in terms of the forces acting on it.
		1.14	**Describe** 'Terminal Velocity' as the velocity reached when the accelerating force is balanced by the resistance forces, so that the resultant force/acceleration is zero, and therefore the velocity does not change.
2	Understand Newton's Laws.	2.1	**State and use** Newton's First Law – An object maintains its state of motion unless acted upon by an external resultant force.
		2.2	**State and use** Newton's Second Law – An object accelerates when acted upon by an external resultant force.
		2.3	**Solve** problems using $F = ma$, where *m* is the inertial mass .
		2.4	**Define** the 'Inertial Mass' as the resistance to changing the velocity of an object, given by $m = \frac{F}{a}$. {The distinction between inertial and gravitational mass will not be examined, and use of the term 'inertial' will not be expected by the student}
		2.5	**Define** 'Weight' as the force exerted on an object (with mass) by gravity.
		2.6	**Recall** that the gravitational field strength, *g*, is 10 m/s at the Earth's surface, and that it will be different on other planets/moons/etc.
		2.7	**Solve** problems using $\text{Weight} = mg$, where *g* is given if the object is not on the Earth's surface.
		2.8	**Explain** why motion in a circle at a constant speed requires a constant force (towards the centre of the circle).
		2.9	**State and use** Newton's Third Law – When an object exerts a force on a second object, the second object exerts an equal and opposite force on the first.

		2.10	**Identify** Newton's Third Law force pairs.
		2.11	**Explain** why two forces are/aren't Third Law pairs.
		2.12	**Outline** an experiment to estimate human reaction times.
		2.14	**Explain** factors that affect the stopping distance [thinking distance + braking distance] of a car in an emergency.
		2.15	**Explain** the dangers of high deceleration and **estimate** the forces involved in normal traffic situations and during crashes.
		2.16	**Explain**, using Newton's Laws and the equations of motion, how car safety systems reduce the force, and therefore the damage, on passengers in a crash. {Answers involving the force being proportional to the rate of change ofmomentum will be accepted, but not expected}
3	Understand forces acting on springs.	3.1	**State** that a force can change the shape of an object.
		3.2	**State** that if an object returns to its original shape when the force deforming it is removed then the change was elastic, otherwise the change is inelastic.
		3.3	**State** Hooke's Law as the extension of a spring is directly proportional to the force causing the extension.
		3.4	**Solve** problems using $F = kx$.
		3.5	**Outline** an experiment to find the spring constant of a metal spring.
		3.9	**Interpret** Force-Extension graphs and use them to calculate a spring constant, and the energy stored, below the limit of proportionality.
4	Understand pressure.	4.1	**Define** 'Pressure' as the force per unit area.
		4.2	**State** that the pressure on a surface is at right angles (normal) to the surface.

		4.3	**Solve** problems using $P = \frac{F}{A}$.
		4.4	**Explain** why pressure in a fluid varies with height or depth.
		4.6	**Define** 'Density' as the mass per unit volume of a material.
		4.7	**Solve** problems using $\rho = \frac{m}{V}$.
		4.8	**Explain** how the difference in pressure above and below a partially submerged object leads to an upwards force (buoyancy) on the object.
		4.9	**Describe** factors that affect whether an object sinks or floats.
		4.10	**Explain** why one object floats while the other sinks even though they have the same mass and are made from the same material.

4	**Energy**		
Aim Energy is the driving force behind changes in the physical world. The Aim of this subject content is to explain what the quantity called 'Energy' is, how it can cause motion, and how it can be moved between different stores in order to produce useful effects.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand energy stores and changes.	1.1	**Define** 'Work' as the energy transferred when a force causes an object to move a distance.
		1.2	**Solve** problems using $W = Fd$.
		1.3	**Define** 'Energy' as the capacity to do Work.
		1.4	**List** examples of 'Energy Stores'.

		1.5	**Describe** the energy transfers that take place in common devices or situations.
		1.6	**Define** 'Power' as the rate at which energy is transferred.
		1.7	**Solve** problems using $P = \frac{W}{t}$.
2	Understand energy conservation and efficiency.	2.1	**State** that energy is conserved.
		2.2	**Define** 'Useful' energy as the energy output in the forms a device was intended to produce, and 'Wasted' energy as the energy output in the forms a device was not intended to produce.
		2.3	**Identify** useful and wasted energies in common devices or situations.
		2.4	**Calculate** an unknown energy using Total Energy In = Total Energy Out.
		2.5	**Explain** how energy tends to dissipate/spread out among objects in a system, and that system's surroundings, so that it is stored in less useful ways.
		2.6	**Draw** Sankey diagrams from information given
		2.7	**Calculate** the efficiency of a system using $\text{Efficiency} = \frac{\text{Useful Energy}}{\text{Total Energy}}$.
		2.8	**Explain** ways of improving the efficiency of a system
3	Understand energy calculations	3.1	**Solve** problems using $\text{K.E.} = \frac{1}{2}mv^2$.
		3.2	**Solve** problems using $\text{G.P.E.} = mgh$.
		3.3	**Solve** problems using $\text{Energy Stored in a Spring (E.P.E.)} = \frac{1}{2}kx^2$ (equation given).
		3.4	**Solve** problems involving the transfer of energy between K.E., G.P.E. and E.P.E.
		3.5	**Outline** an experiment to test the conservation of energy using a falling object.
		3.6	**Solve** problems involving the work done on a system and the K.E., G.P.E. and E.P.E. gained.
		3.7	**Solve** problems involving the power put into a system and the K.E., G.P.E. and E.P.E. gained.

4.	Understand energy resources.	4.1	**Explain** how the main energy sources available on Earth are used to generate electricity.
		4.2	**Define** 'Renewable Energy Sources' as sources which replenish themselves faster than they can be used.
		4.3	**Compare and Contrast** the main energy sources in terms of renewability, reliability, cost to set-up, cost to run, environmental impact and limitations.
		4.4	**Explain** why an energy source would or would not be suitable in a given situation.

5	**Waves**		
Aim Waves are a class of phenomena across many different areas of physics. The aim of this subject content is to understand the similarities and differences of different types of wave, and how wave properties and the way they interact with materials can be used to our advantage.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the characteristics of waves.	1.1	**Describe** waves as oscillations that transfer energy without transferring matter.
		1.2	**Define** the term 'Amplitude' as the difference between the maximum value of the wave and the equilibrium value.
		1.3	**Define** the term 'Wavelength' as the distance between two adjacent maxima (or minima).
		1.4	**Define** the term 'Frequency' as the number of wavelengths passing a point per second.
		1.5	**Define** the term 'Period' as the time taken for one whole wavelength to pass a point.
		1.6	**Label** diagrams of waves with: amplitude, wavelength or period, crest and trough.

		1.7	**Solve** problems using $v = f\lambda$
		1.8	**Compare and Contrast** transverse and longitudinal waves and give examples of each type.
2	Understand the interaction of waves with a boundary.	2.1	**Define** the term 'Reflection' as an abrupt change in direction of a wave when it meets a boundary, such that it remains in the original material.
		2.2	**Define** the term 'Refraction' as an abrupt change in direction of a wave when it meets a boundary, such that it passes into the second material.
		2.3	**Define** the term 'Diffraction' as the spreading out of a wave as it passes through a gap, or travels past an object.
		2.4	**Define** the term 'Transmission' as the passing of all or part of a wave completely through an object or region.
		2.5	**Define** the term 'Absorption' as the transfer of energy from a wave into the medium it is passing through.
		2.6	**Identify** angles of 'Incidence', 'Reflection' and 'Refraction'.
		2.7	**Describe** reflection at a plane surface and relate it the effect of reflections from smooth (specular reflection) and rough surfaces (diffuse reflection).
		2.8	**State and use** the law of reflection *angle of incidence = angle of reflection.*
		2.9	**Outline** an experiment to test the law of reflection.
		2.10	**Explain** refraction at a boundary in terms of the change in wavelength due a change in speed at constant frequency.
		2.14	**State** real world examples of reflection, refraction and diffraction.
3	Understand electromagnetic waves.	3.1	**State** that light is an electromagnetic wave.
		3.2	**Recall** that the speed of light in a vacuum, *c*, is $3x10^8$ m/s, and that it is approximately the same in air.

		3.3	**State** the properties of electromagnetic waves. EM waves: transverse, same velocity, travel through a vacuum, and exhibit wave behaviour (e.g., refraction).
		3.4	**List** the different parts of the electromagnetic spectrum in order of increasing/decreasing wavelength/frequency.
		3.5	**Describe** means of producing and detecting each of the parts of the electromagnetic spectrum.
		3.6	**Describe** uses and dangers for each of the parts of the electromagnetic spectrum.
		3.7	**List** the colours in the visible part of the electromagnetic spectrum in order of increasing/decreasing wavelength/frequency.
4	Understand how to construct ray diagrams.	4.1	**Construct** a ray diagram to show reflection in a plane mirror.
		4.2	**Construct** a ray diagram to show the refraction of light passing through a rectangular glass block.
		4.3	**Sketch** a ray diagram of visible light passing through a prism (dispersion).
		4.4	**Define** the terms ‘Converging’, ‘Diverging’, and ‘Focal point’.
		4.5	**Construct** ray diagrams for convex and concave lenses.
		4.6	**Sketch** and **explain** how refraction of light from glass into air leads to Total Internal Reflection.
5	Understand sound waves.	5.1	**State** that sound is a longitudinal wave.
		5.2	**Define,** and relate to the equivalent wave terms, the terms ‘Loudness’ [Amplitude], ‘Pitch’ [Frequency], and ‘Echo’ [Reflection].
		5.3	**Describe** sound waves as a series of compressions and rarefactions in a medium.
		5.4	**Explain** how sound travels through air and solids.

		5.5	**Explain** why sound travels better and faster through a solid than a gas.

6	**Electricity**		
Aim Electricity is the most diversely used energy source in our modern world. The aim of this subject content is to explain the difference between current and static electricity, how each can be used to produce beneficial effects, and how the dangers of each can be prevented.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand current, potential difference and resistance.	1.1	**Define** 'Current' as the rate of flow of charge (through a point in a circuit).
		1.2	**Solve** problems using $I = \frac{Q}{t}$.
		1.3	**State** that the current in metals is due to the flow of electrons.
		1.4	**Recall** that electrons flow in the opposite direction to 'Conventional Current'.
		1.5	**Define** 'Potential Difference' at the energy transferred per unit charge (moving across a component in a circuit). {use of the term 'e.m.f.' will not be expected}
		1.6	**Solve** problems using $V = \frac{W}{Q}$.
		1.7	**State** that for current to flow a closed circuit and a source of potential difference is required.
		1.8	**Define** 'Resistance' as the ratio of the potential difference across a component and the current through it.
		1.9	**Solve** problems using $R = \frac{V}{I}$.
2	Understand series and parallel circuits.	2.1	**Draw and identify** common component symbols. (wire, cell, battery, switch, fixed resistor, variable resistor, LDR, thermistor, lamp, diode, ammeter, voltmeter)

		2.2	**Describe** the difference between series and parallel circuits.
		2.3	**Draw and interpret** simple circuit diagrams using common component symbols.
		2.4	**Explain** why the resistance of two identical resistors in series is higher than one of the resistors (qualitative only).
		2.5	**Calculate** the total resistance of two resistors in series using $R_T = R_1 + R_2$.
		2.6	**Explain** why the resistance of two identical resistors in parallel is lower than one of the resistors (qualitative only).
		2.7	**Calculate** the total resistance of two resistors in parallel using $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$.
		2.8	**Calculate** currents, potential differences and resistances in series and parallel circuits using the circuit rules.
		2.11	**Describe** advantages and disadvantages of series and parallel circuits.
3	Understand static electricity.	3.1	**State** that charges are either positive or negative.
		3.2	**Describe** the direction of the force between two like charges and between two unlike/opposite charges.
		3.3	**State** that an 'Electric Field' is a region in which an electric charge experiences a force, and that the direction of the field is the direction of the force on a positive charge.
		3.4	**Sketch** the electric field around a point charge, between two-point charges, around a conducting sphere, and between parallel plates. {Edge effects can be ignored}
		3.5	**State** that a body becomes charged if electrons are added or removed.
		3.6	**Describe** 'Static Electricity' as the effects of the electric fields due to separated charges.

		3.7	**Describe** methods of producing charge separation.
		3.8	**Describe** the difference between insulators and conductors in terms of the actions of electrons.
		3.9	**Explain** the effects of static electricity in terms of the actions of electrons in simple situations where a charged insulator is brought close to either a charged insulator, a conductor, or an uncharged insulator.
		3.10	**Explain** why a build-up of charge on an insulator is dangerous.

8	**Thermal Physics**		
Aim The aim of this subject content is to describe the different states of matter, explain how thermal energy is transferred and how we can reduce that transfer, and how the amount of internal energy affects a substance.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the states of matter and the transitions between them.	1.1	**Draw** diagrams of the particle arrangements in solids, liquids, and gases.
		1.2	**Describe** the particle arrangement and motion in solids, liquids, and gases
		1.3	**Define** the term 'Density'.
		1.4	**Solve** problems using $\rho = \frac{m}{v}$.
		1.5	**Outline** an experiment to find the density of an object with a complicated shape.
		1.6	**Explain** the relative densities of solids, liquids, and gases in terms of particle arrangements. {The special case of ice is not needed}
		1.7	**Define** the state change terms 'Melt' [solid->liquid], 'Freeze' [liquid->solid], 'Evaporate' [liquid->gas], 'Condense' [gas->liquid], 'Sublimate' [solid->gas], and 'Deposit' [gas->solid].

		1.8	**Explain** why state changes are physical changes and not chemical changes.
2	Understand the changes in internal energy as a substance is heated or cooled.	2.1	**State** that the energy stored in a chemical bond is negative (you are required to put energy into the bond in order to break it).
		2.2	**State** that 'Internal Energy' is the energy stored in the chemical bonds (P.E.) and motion of the particles (K.E.) in a substance.
		2.3	**Describe** how heating a system increases its internal energy.
		2.4	**State** that the temperature of a gas is proportional to the average kinetic energy of the gas molecules.
		2.5	**Explain** why heating a system either increases its temperature or changes its state.
		2.6	**Define** the term 'Specific Heat Capacity (of a substance in a specific state)' as the energy required to increase the temperature of 1kg of a substance by 1°C.
		2.7	**Define** the term 'Specific Latent Heat (of a substance in a specific state)' as the energy required to change the state of 1kg of a substance.
		2.8	**Solve** problems using $\Delta E = mc\Delta T$, where *c* is the Specific Heat Capacity (equation given).
		2.9	**Solve** problems using $\Delta E = mL$, where *L* is the Specific Latent Heat, (equation given).
		2.10	**Outline** an experiment to calculate the Specific Heat Capacity of a liquid.
3	Understand the relationship between pressure, volume and temperature of an ideal gas.	3.1	**Recall** that an 'Ideal Gas' as a simple model of a gas that allows us to create equations that describe its behaviour, and that most gases behave like an ideal gas.
		3.2	**Explain** how the pressure on the walls of a container is the result of collisions between the gas molecules and the wall.
		3.3	**State** that the force on a surface due to the pressure of the gas is directed at right angles (normal) to the surface.

		3.4	**Explain** the relationship between pressure and temperature at constant volume (qualitative*).
		3.5	**Explain** the relationship between pressure and volume at constant temperature (qualitative*).
		3.6	**Explain** the relationship between volume and temperature at constant pressure (qualitative*). {The derivation of PV=nRT is not necessary. PV=nRT will not be used for calculation, and it is not expected to be known}.
		3.7	**Solve** problems using $PV = \text{constant}$ (equation given)
		3.8	**Explain** how doing work on a gas can increase its temperature.
4	Understand how thermal energy flows from one place to another.	4.1	**Describe** the difference between 'Heat' and 'Temperature'
		4.2	**Explain** the process of heat transfer by Conduction.
		4.3	**Explain** the process of heat transfer by Convention.
		4.4	**Explain** the process of heat transfer by Radiation.
		4.5	**Explain** the process of heat transfer by Evaporation.
		4.6	**Explain** how each type of heat transfer can be prevented or reduced.

9	**Nuclear**		
Aim Nuclear processes power the Sun, create electricity, and have many other uses in our modern world. The aim of this subject content is to describe the internal structure of the atom, explain how energy can be released by nuclear processes, and explain the uses and hazards of radiation.			
Learning Outcomes - The learner will:		**Assessment Criteria - The learner can:**	
1	Understand the composition of the atom.	1.1	**Describe** the structure of an atom.
		1.2	**State** the typical size of atoms, molecules and nuclei (order of magnitude).
		1.3	**Describe** how the accepted model of the atom has changed over time.
		1.4	**Explain** how Rutherford's Gold Foil experiment provides evidence for the nucleus.
		1.5	**State** that electrons inside an atom have specific energy levels they can be in.
		1.6	**Describe** how the electrons move between energy levels as they absorb and emit energy.
		1.7	**State** that electrons that gain enough energy will leave their atoms, and that that loss of electrons changes those atoms into ions.
2	Understand nuclear terms.	2.1	**Define** the term 'Isotopes' as nuclei with the same number of protons but a different number of neutrons.
		2.2	**Define** the term 'Radiation' as energy or particles emitted by a source in all directions.
		2.3	**Define** the term 'Radioactive decay' as a change in the nucleus (of an atom) the causes radiation to be emitted
		2.4	**Define** the term 'Radioactive' (Substance) as (a substance that is) undergoing radioactive decay.
		2.5	**Define** the term 'Half-life' as the time it takes (on average) for half of the nuclei in a radioactive substance to decay.

		2.6	**Define** the term 'Background radiation' as the radiation that is not produced by the source under consideration.
3	Understand radioactive decay.	3.1	**Explain** that radioactive nuclei are unstable and undergo radioactive decay by emitting radiation.
		3.2	**State** that unstable nuclei can emit alpha particles, beta particles, neutrons, or electromagnetic radiation (gamma-rays).
		3.3	**List** the properties of each type of nuclear radiation (what they are, relative charge, relative mass).
		3.4	**List** sources of background radiation.
		3.5	**Outline** an experiment to demonstrate the how the amount of gamma radiation varies with distance from the source, taking background radiation into account.
		3.6	**Explain** the changes in the nucleus when radiation is emitted.
		3.7	**Use** nuclear notation to write balanced equations for radioactive decay.
		3.8	**Explain** how radiation can cause the ionisation of atoms they interact with.
		3.9	**State** the relative penetration and ionisation power of alpha, beta and gamma radiation.
		3.10	**Outline** an experiment to determine the type of radiation emitted from a source, taking background radiation into account.
		3.11	**Calculate** the half-life of a radioactive material using data tables or graphs. {Simple multiples only}
		3.12	**Describe** how to correct for background radiation when measuring the activity of a radioactive source.
		3.13	**Calculate** the activity of a radioactive source by correcting for background radiation.

		3.14	**Calculate** the amount of radioactive material left after a whole number of half-lives.
4	Understand nuclear fission and nuclear fusion.	4.1	**Describe** the process of induced nuclear fission.
		4.2	**Explain** how the release of multiple neutrons during a fission event leads to a chain reaction.
		4.3	**Describe** the function of the moderator and control rods in a nuclear fission reactor.
		4.4	**Describe** the process of nuclear fusion.
		4.5	**Use** nuclear notation to write balanced equations for nuclear fission and nuclear fusion.
		4.6	**Compare and contrast** nuclear fission and nuclear fusion.
5	Understand the hazards and applications associated with nuclear processes.	5.1	**Compare and contrast** the relative danger of ionising radiation and radioactive material.
		5.2	**Describe** the danger associated with ionising radiation.
		5.3	**Explain** the dangers of associated with radioactive material, and how they depend on the half-life of the material.
		5.4	**Describe** uses for each type of ionising radiation.
		5.5	**Explain** what sort of source is best for a given application in terms of the penetrating power of the radiation and the half-life of the source.
		5.6	**Outline** how Carbon-14 can be used to find out how old an object is.

ALTERNATIVE TO PRACTICAL (PAPER 3)

Candidates may be questioned about and are expected to understand the following experimental aspects:

Biology:

- Basic quantitative tests, such as measuring weights, temperatures, time, lengths, and volumes of gases and liquids.
- Diffusion
- Microscopy (Light)
- Osmosis and food tests
- Speeds of processes that are catalysed by enzymes (includes: determining end-points, such as colour changes)
- pH tests – applying litmus, universal indicator, and hydrogen carbonate indicator
- Observing and dissecting seeds and blossoms
- Indicators, limiting variables and rates of photosynthesis
- Respiration, transpiration, heart rate and breathing rate
- Germination
- Continuous and discontinuous variation
- Drawings of biological specimens, calculating magnification scales or actual sizes, adding labels as necessary, observe, record, and measuring images of both familiar and non-familiar biological specimens
- Use basic equipment in situations where a typical method may not be familiar

Chemistry:

- Use basic equipment in situations where a typical method may not be familiar, such as determining the quantities of:
    - gases or liquids or solutions
    - Masses
    - Temperatures
    - Times
    - Lengths

- Rates of reactions
- Salt preparation
- Separation and purification techniques (i.e. filtration, crystallisation, simple distillation, fractional distillation, chromatography)
- Electrolysis
- Identification of metal ions, non-metal ions, and gases

- Chemical tests for water,
- Test-tube reactions of diluted acids
- Tests for oxidizing and reducing agents
- Heating and cooling curves
- Titrations
- Solubility
- Melting and boiling points
- Displacement reactions of metals and halogens
- Temperature changes during reactions
- Conditions under which iron rusts or other metals corrode
- Unknown scientific procedures using basic known equipment

Physics:

- Measuring physical quantities like length, volume, or force; measuring short distances or time intervals;
- Calculating a derived quantity like a spring's extension per unit load,
- The value of a known resistance, or an object's acceleration;
- Testing and determining the relationship between two variables, like the potential difference across a wire and its length;
- Comparing measured quantities, like angles of reflection; comparing derived quantities, like density;
- Cooling and heating, including temperature measurement;
- Experiments with springs and balances; timing motion or oscillations
- Electric circuits, including how they are connected and disconnected, as well as how current and potential difference are measured.
- The use of transparent, translucent, and opaque materials to examine the transmission of light.
- Optics experiments that uses equipment like optics pins, mirrors, prisms, lenses, glass, or Perspex blocks (both rectangular and semicircular).
- Unknown scientific procedures using basic known equipment

In addition, applicants might have to complete the following tasks:

- Exhibit an understanding of how to choose and utilise methods, tools, and supplies properly (including adhering to a set of guidelines where necessary)
- Determine the equipment from descriptions or diagrams; create, fill in, or label biological specimen and equipment diagrams
- Use or explain common methods, tools, and materials; choose the best tool or approach for the job and provide justification for it
- Describe tests (such as food, gas, qualitative, and other tests); identify safety precautions; and describe and explain potential risks.
- Describe and clarify the methods utilised to guarantee the precision of data and observations.
- Arrange for investigations and experiments:

- Determine the independent and dependent variables; identify, explain how and why variables should be controlled;
- Provide a suitable range of values for the independent variable when planning;
- Identify suitable equipment and apparatus for an experiment;
- Plan and describe an appropriate experimental method, which includes a suitable control experiment;
- Identify and describe safety risks, appropriate safety measures and how to minimise or eliminate these risks;
- Describe how to record results of an experiment as well as how to process these results;
- Explain how to analyse experiment data to draw conclusions or assess predictions; and formulate logical predictions about anticipated outcomes.
- make and document observations, measurements, and estimations:
    - obtain accurate readings from analogue and digital equipment or from equipment diagrams
- Take accurate readings, rounding to the closest half-scale division where necessary
- Make observations, measurements, or estimates that match expected outcomes or values;
- Take enough observations or measurements, including repeats when necessary;
- Document qualitative findings from tests (such as chemical, food, and other tests); and;
- Record observations and measurements methodically, for instance in a suitable table, with the proper level of precision and units.
- Interpret and assess experimental observations and data:
    - process data, including for use in additional calculations or graph plotting, using a calculator as necessary
    - present data graphically, including using best-fit lines when appropriate
    - analyse and interpret observations and data, including data presented graphically
    - use interpolation and extrapolation graphically to determine a gradient or intercept
    - form conclusions supported by observations and data and with appropriate justification
    - assess the quality of observations and data, identifying any anomalous results and taking appropriate action
    - comment on and explain whether results are equal within the parameters of experimental accuracy (assumed to be ±10% at this level of study).
- Evaluate methods and suggest possible improvements:
    - evaluate experimental arrangements, methods and techniques, including the control of variables
    - identify sources of error, including measurement error, random error and systematic error
    - identify possible causes of uncertainty in data or in a conclusion
    - suggest possible improvements to the apparatus, experimental arrangements, methods or techniques

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