

GCSE (9-1)

***GATEWAY SCIENCE COMBINED SCIENCE A***

**J250**

For first teach in 2016

**Student revision checklist**

Version 1



**[www.ocr.org.uk/science](http://www.ocr.org.uk/science)**

## Revision checklists

The tables below can be used as a revision checklist.

For more information please see:

[OCR GCSE Gateway Combined Science A specification J250](https://www.ocr.org.uk/Images/234596-specification-accredited-gcse-gateway-science-suite-combined-science-a-j250.pdf)

The table headings are explained below:

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| **Assessable learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| Here is a list of the learning outcomes for this qualification and the content you need to cover and work on.  **Please note the learning outcomes in bold are for Higher tier only.** | You can use the tick boxes to show when you have revised an item and how confident you feel about it.  R = **RED** means you are really unsure and lack confidence; you might want to focus your revision here and possibly talk to your teacher for help.  A = **AMBER** means you are reasonably confident but need some extra practice.  G = **GREEN** means you are very confident.  As your revision progresses, you can concentrate on the **RED** and **AMBER** items in order to turn them into **GREEN** items.  You might find it helpful to highlight each topic in red, orange or green to help you prioritise. | | | You can use the comments column to:   * add more information about the details for each point * add formulae or notes * include a reference to a useful resource * highlight areas of difficulty or things that you need to talk to your teacher about or look up in a textbook. |

**Biology**

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| **B1 Cell level systems** | | | | |
| **B1.1 Cell structures** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B1.1a describe how light microscopes and staining can be used to view cells  *To include* – lenses, stage, lamp, use of slides and cover slips, and the use of stains to view colourless specimens or to highlight different structures/tissues and calculation of the magnification used |  |  |  |  |
| B1.1b explain how the main sub-cellular structures of eukaryotic cells (plants and animals) and prokaryotic cells are related to their functions  *To include* - nucleus, genetic material, chromosomes, plasmids, mitochondria (contain enzymes for cellular respiration), chloroplasts (contain chlorophyll), cell membranes (contain receptor molecules, provides a selective barrier to molecules) and ribosomes (site of protein synthesis) |  |  |  |  |

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| **B1.1 Cell structures** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B1.1c explain how electron microscopy has increased our understanding of sub-cellular structures  *To include –* increased resolution in a transmission electron microscope |  |  |  |  |
| **B1.2 What happens in cells (and what do cells need)?** | | | | |
| B1.2a describe DNA as a polymer |  |  |  |  |
| B1.2b describe DNA as being made up of two strands forming a double helix |  |  |  |  |
| B1.2c describe experiments that can be used to investigate enzymatic reactions |  |  |  |  |
| B1.2d explain the mechanism of enzyme action  *To include* – the role of enzymes in metabolism, the role of the active site, enzyme specificity (lock and key hypothesis) and factors affecting the rate of enzyme controlled reactions (pH, temperature, substrate and enzyme concentration) |  |  |  |  |
| **B1.3 Respiration** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B1.3a describe cellular respiration as a universal chemical process, continuously occurring in all living cells that supply ATP |  |  |  |  |
| B1.3b describe cellular respiration as an exothermic reaction |  |  |  |  |
| B1.3c compare the processes of aerobic and anaerobic respiration  *To include* – in plants/fungi and animals the different conditions, substrates, products and relative yields of ATP |  |  |  |  |
| B1.3d explain the importance of sugars in the synthesis and breakdown of carbohydrates  *To include* – the use of the terms monomer and polymer |  |  |  |  |
| B1.3e explain the importance of amino acids in the synthesis and breakdown of proteins  *To include* – the use of the terms monomer and polymer |  |  |  |  |
| **B1.3 Respiration** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B1.3f explain the importance of fatty acids and glycerol in the synthesis and breakdown of lipids |  |  |  |  |
| **B1.4 Photosynthesis** | | | | |
| B1.4a describe photosynthetic organisms as the main producers of food and therefore biomass for life on Earth |  |  |  |  |
| B1.4b describe the process of photosynthesis  *To include* – reactants and products, two-stage process, location of the reaction (in the chloroplasts) |  |  |  |  |
| B1.4c describe photosynthesis as an endothermic reaction |  |  |  |  |
| B1.4d describe experiments to investigate photosynthesis |  |  |  |  |
| B1.4e explain the effect of temperature, light intensity and carbon dioxide concentration on the rate of photosynthesis |  |  |  |  |
| **B1.4 Photosynthesis** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B1.4f **explain the interaction of temperature, light intensity and carbon dioxide, concentration in limiting the rate of photosynthesis**  ***To include* – using graphs depicting the effects of the limiting factors** |  |  |  |  |

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| **B2 Scaling up** | | | | |
| **B2.1 Supplying the cell** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B2.1a explain how substances are transported into and out of cells through diffusion, osmosis and active transport  *To include* - examples of substances moved, direction of movement, concentration gradients and use of the term water potential (no mathematical use of water potential required) |  |  |  |  |
| B2.1b describe the process of mitosis in growth, including the cell cycle  *To include* – the stages of the cell cycle as cell growth, DNA replication, more cell growth, movement of chromosomes |  |  |  |  |
| B2.1c explain the importance of cell differentiation  *To include* – the production of specialised cells allowing organisms to become more efficient and examples of specialised cells |  |  |  |  |
| B2.1d recall that stem cells are present in embryonic and adult animals, and meristems in plants |  |  |  |  |
| **B2.1 Supplying the cell** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B2.1e describe the functions of stem cells in embryonic and adult animals, and meristems in plants  *To include* – division to produce a range of different cell types for development, growth and repair |  |  |  |  |
| B2.1f describe the difference between embryonic and adult stem cells in animals |  |  |  |  |
| **B2.2 The challenges of size** | | | | |
| B2.2a explain the need for exchange surfaces and a transport system in multicellular organisms in terms of surface area : volume ratio  *To include* – calculation of surface area, volume and surface area : volume ratio, and reference to diffusion distances |  |  |  |  |
| B2.2b describe some of the substances transported into and out of a range of organisms in terms of the requirements of those organisms  *To include* – oxygen, carbon dioxide, water, dissolved food molecules, mineral ions and urea |  |  |  |  |
| **B2.2 The challenges of size** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B2.2c describe the human circulatory system  *To include* – to include the relationship with the gaseous exchange system, the need for a double circulatory system in mammals and the arrangement of vessels |  |  |  |  |
| B2.2d explain how the structure of the heart and the blood vessels are adapted to their functions  *To include* – the structure of the mammalian heart with reference to the cardiac muscle, the names of the valves, chambers, and blood vessels into and out of the heart, the structure of the blood vessels with reference to thickness of walls, diameter of lumen, presence of valves |  |  |  |  |
| B2.2e explain how red blood cells and plasma are adapted to their transport functions in the blood |  |  |  |  |
| B2.2f explain how water and mineral ions are taken up by plants, relating the structure of the root hair cells to their function |  |  |  |  |
| **B2.2 The challenges of size** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B2.2g describe the processes of transpiration and translocation  *To include* – the structure and function of the stomata |  |  |  |  |
| B2.2h explain how the structure of the xylem and phloem are adapted to their functions in the plant |  |  |  |  |
| B2.2i explain the effect of a variety of environmental factors on the rate of water uptake by a plant  *To include* – light intensity, air movement and temperature |  |  |  |  |
| B2.2j describe how a simple potometer can be used to investigate factors that affect the rate of water uptake  *To include* – calculation of rate and percentage gain/loss of mass |  |  |  |  |

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| **B3 Organism level systems** | | | | |
| **B3.1 Coordination and control – the nervous system** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.1a describe the structure of the nervous system  *To include* – Central Nervous System, sensory, motor and relay neurones, sensory receptors, synapse and effectors, details of the structure of sensory and motor neurones required |  |  |  |  |
| B3.1b explain how the components of the nervous system can produce a coordinated response  *To include* – it goes to all parts of the body, has many links, has different sensory receptors and is able to coordinate responses |  |  |  |  |
| B3.1c explain how the structure of a reflex arc is related to its function |  |  |  |  |

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| **B3.2 Coordination and control – the endocrine system** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.2a describe the principles of hormonal coordination and control by the human endocrine system  *To include* – use of chemical messengers, transport in blood, endocrine glands and receptors |  |  |  |  |
| B3.2b **explain the roles of thyroxine and adrenaline in the body**  ***To include* – thyroxine as an example of a negative feedback system** |  |  |  |  |
| B3.2c describe the role of hormones in human reproduction including the control of the menstrual cycle  *To include* – oestrogen, progesterone, FSH and testosterone |  |  |  |  |
| B3.2d **explain the interactions of FSH, LH, oestrogen and progesterone in the control of the menstrual cycle** |  |  |  |  |

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| **B3.2 Coordination and control – the endocrine system** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.2e explain the use of hormones in contraception and evaluate hormonal and non-hormonal methods of contraception  *To include* – the relative effectiveness of the different forms of contraception |  |  |  |  |
| B3.2f **explain the use of hormones in modern reproductive technologies to treat infertility** |  |  |  |  |
| **B3.3 Maintaining internal environments** | | | | |
| B3.3a explain the importance of maintaining a constant internal environment in response to internal and external change  *To include* – allowing metabolic reactions to proceed at appropriate rates |  |  |  |  |
| B3.3b explain how insulin controls blood sugar levels in the body |  |  |  |  |

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| **B3.3 Maintaining internal environments** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.3c **explain how glucagon interacts with insulin to control blood sugar levels in the body** |  |  |  |  |
| B3.3d compare type 1 and type 2 diabetes and explain how they can be treated |  |  |  |  |

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| **B4 Community level systems** | | | | |
| **B4.1 Ecosystems** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B4.1a recall that many different materials cycle through the abiotic and biotic components of an ecosystem  *To include* – examples of cycled materials e.g. nitrogen and carbon |  |  |  |  |
| B4.1b explain the role of microorganisms in the cycling of materials through an ecosystem  *To include* – the role of microorganisms in decomposition |  |  |  |  |
| B4.1c explain the importance of the carbon cycle and the water cycle to living organisms  *To include* – maintaining habitats, fresh water flow of nutrients and the stages of the carbon and water cycles |  |  |  |  |
| B4.1d describe different levels of organisation in an ecosystem from individual organisms to the whole ecosystem |  |  |  |  |

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| **B4.1 Ecosystems** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B4.1e explain how abiotic and biotic factors an affect communities  *To include –* temperature, light intensity, moisture level, pH of soil, predators, food |  |  |  |  |
| B4.1f describe the importance of interdependence and competition in a community  *To include –* interdependence relating to predation, mutualism and parasitism |  |  |  |  |

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| **B5 Genes, inheritance and selection** | | | | |
| **B5.1 Inheritance** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B5.1a explain the following terms: gamete, chromosome, gene, allele/variant, dominant, recessive, homozygous, heterozygous, genotype and phenotype |  |  |  |  |
| B5.1b describe the genome as the entire genetic material of an organism |  |  |  |  |
| B5.1c describe that the genome, and its interaction with the environment, influence the development of the phenotype of an organism  *To include* – use of examples of discontinuous (e.g. eye colour) and continuous variation (e.g. weight and height) |  |  |  |  |
| B5.1d recall that all variants arise from mutations, and that most have no effect on the phenotype, some influence phenotype and a very few determine phenotype |  |  |  |  |

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| **B5.1 Inheritance** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B5.1e explain the terms haploid and diploid |  |  |  |  |
| B5.1f explain the role of meiotic cell division in halving the chromosome number to form gametes  *To include* – that this maintains diploid cells when gametes combine and is a source of genetic variation |  |  |  |  |
| B5.1g explain single gene inheritance  *To include* – in the context of homozygous and heterozygous crosses involving dominant and recessive genes |  |  |  |  |
| B5.1h predict the results of single gene crosses  *To include* – the use of Punnett squares |  |  |  |  |
| B5.1i describe sex determination in humans using a genetic cross  *To include* – the use of Punnett squares |  |  |  |  |

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| **B5.1 Inheritance** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B5.1j recall that most phenotypic features are the result of multiple genes rather than single gene inheritance |  |  |  |  |
| **B5.2 Natural selection and evolution** | | | | |
| B5.2a state that there is usually extensive genetic variation within a population of a species |  |  |  |  |
| B5.2b describe the impact of developments in biology on classification systems  *To include* – natural and artificial classification systems and use of molecular phylogenetics based on DNA sequencing |  |  |  |  |
| B5.2c explain how evolution occurs through the natural selection of variants that have given rise to phenotypes best suited to their environment  *To include* – the concept of mutation |  |  |  |  |

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| **B5.2 Natural selection and evolution** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B5.2d describe evolution as a change in the inherited characteristics of a population over time, through a process of natural selection, which may result in the formation of new species |  |  |  |  |
| B5.2e describe the evidence for evolution  *To include* – fossils and antibiotic resistance in bacteria |  |  |  |  |

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| **B6 Global challenges** | | | | |
| **B6.1 Monitoring and maintaining the environment** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B6.1a explain how to carry out a field investigation into the distribution and abundance of organisms in a habitat and how to determine their numbers in a given area  *To include* - sampling techniques (random and transects, capture- recapture), use of quadrats, pooters, nets, keys and scaling up methods |  |  |  |  |
| B6.1b describe both positive and negative human interactions within ecosystems and explain their impact on biodiversity  *To include* – the conservation of individual species and selected habitats and threats from land use and hunting |  |  |  |  |
| B6.1c explain some of the benefits and challenges of maintaining local and global biodiversity  *To include* – the difficulty in gaining agreements for and the monitoring of conservation schemes along with the benefits of ecotourism |  |  |  |  |

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| **B6.2 Feeding the human race** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B6.2a explain the impact of the selective breeding of food plants and domesticated animals |  |  |  |  |
| B6.2b describe genetic engineering as a process which involves modifying the genome of an organism to introduce desirable characteristics |  |  |  |  |
| B6.2c **describe the main steps in the process of genetic engineering**  ***To include* – restriction enzymes, sticky ends, ligase, host bacteria and selection using antibiotic resistance markers, vectors e.g. plasmids** |  |  |  |  |
| B6.2d explain some of the possible benefits and risks of using gene technology in modern agriculture  *To include* – practical and ethical considerations |  |  |  |  |

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| **B6.3 Monitoring and maintaining health** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B6.3a describe the relationship between health and disease |  |  |  |  |
| B6.3b describe different types of disease  *To include –* communicable and non-communicable diseases |  |  |  |  |
| B6.3c describe the interactions between different types of disease  *To include* – HIV and tuberculosis, and HPV and cervical cancer |  |  |  |  |
| B6.3d explain how communicable diseases (caused by viruses, bacteria, protists and fungi) are spread in animals and plants    *To include* – scientific quantities, number of pathogens, number of infected cases, estimating number of cases |  |  |  |  |

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| **B6.3 Monitoring and maintaining health** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B6.3e explain how the spread of communicable diseases may be reduced or prevented in animals and plants  *To include* – detection of the antigen, DNA testing, visual identification of the disease |  |  |  |  |
| B6.3f describe a minimum of one common human infection, one plant disease and sexually transmitted infections in humans including HIV/AIDS  *To include* – human infections: one example of each viral, fungal, bacterial  plant diseases: virus tobacco mosaic virus (TMV), fungal *Erysiphe graminis* (barley powdery mildew), bacterial *Agrobacterium tumefaciens (*crown gall disease) |  |  |  |  |
| B6.3g explain how white blood cells and platelets are adapted to their defence functions in the blood |  |  |  |  |
| B6.3h describe the non-specific defence systems of the human body against pathogens |  |  |  |  |
| **B6.3 Monitoring and maintaining health** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B6.3i explain the role of the immune system of human body in defence against disease |  |  |  |  |
| B6.3j explain the use of vaccines and medicines in the prevention and treatment  *To include* – antibiotics, antivirals and antiseptics |  |  |  |  |
| B6.3k describe the processes of discovery and development of potential new medicines  *To include* – preclinical and clinical testing |  |  |  |  |
| B6.3l recall that many non-communicable human diseases are caused by the interaction of a number of factors  *To include* – cardiovascular diseases, many forms of cancer, some lung (bronchitis) and liver (cirrhosis) diseases and diseases influenced by nutrition, including type 2 diabetes |  |  |  |  |

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| **B6.3 Monitoring and maintaining health** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B6.3m evaluate some different treatments for cardiovascular disease  *To include* – lifestyle, medical and surgical |  |  |  |  |
| B6.3n analyse the effect of lifestyle factors on the incidence of non-communicable diseases at local, national and global levels  *To include* – lifestyle factors to include exercise, diet, alcohol and smoking |  |  |  |  |
| B6.3o describe cancer as the result of changes in cells that lead to controlled growth and division |  |  |  |  |
| B6.3p discuss potential benefits and risks associated with the use of stem in medicine  *To include* – tissue transplantation and rejection |  |  |  |  |

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| **B6.3 Monitoring and maintaining health** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B6.3q explain some of the possible benefits and risks of using technology in medicine  *To include* – practical and ethical considerations |  |  |  |  |
| B6.3r discuss the potential importance for medicine of our increasing understanding of the human genome  *To include* – the ideas of predicting the likelihood of diseases occurring and their treatment by drugs which are targeted to genomes |  |  |  |  |

**CHEMISTRY**

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| **C1 Particles** | | | | |
| **C1.1 The particle model** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C1.1a describe the main features of the particle model in terms of states of matter and change of state |  |  |  |  |
| C1.1b explain in terms of the particle model the distinction between physical changes and chemical changes |  |  |  |  |
| C1.1c **explain the limitations of the particle model in relation to changes of state when particles are represented by inelastic spheres (e.g. like bowling balls)**  ***To include* – that it does not take into account the forces of attraction between particles, the size of particles and the space between them** |  |  |  |  |

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| **C1.2 Atomic structure** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C1.2a describe how and why the atomic model has changed over time  *To include –* the models of Dalton, Thomson, Rutherford, Bohr, Geiger and Marsden |  |  |  |  |
| C1.2b describe the atom as a positively charged nucleus surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with most of the mass in the nucleus |  |  |  |  |
| C1.2c recall the typical size (order of magnitude) of atoms and small molecules  *To include* – the concept that typical atomic radii and bond length are in the order of 10-10m |  |  |  |  |
| C1.2d recall relative charges and approximate relative masses of protons, neutrons and electrons |  |  |  |  |

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| **C1.2 Atomic structure** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C1.2e calculate numbers of protons, neutrons and electrons in atoms and ions, given atomic number and mass number of isotopes  *To include* – definitions of an ion, atomic number, mass number and an isotope, also the standard notation to represent these |  |  |  |  |

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| **C2 Elements, compounds and mixtures** | | | | |
| **C2.1 Purity and separating mixtures** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.1a explain what is meant by the purity of a substance, distinguishing between the scientific and everyday use of the term ‘pure’ |  |  |  |  |
| C2.1b use melting point data to distinguish pure from impure substances |  |  |  |  |
| C2.1c calculate relative formula masses of species separately and in a balanced chemical equation  *To include* – the definition of relative atomic mass, relative molecular mass and relative formula mass |  |  |  |  |
| C2.1d deduce the empirical formula of a compound from the relative numbers of atoms present or from a model or diagram and vice versa |  |  |  |  |
| C2.1e explain that many useful materials are formulations of mixtures  *To include* – alloys |  |  |  |  |
| **C2.1 Purity and separating mixtures** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.1f describe, explain and exemplify the processes of filtration, crystallisation, simple distillation, and fractional distillation  *To include* - knowledge of the techniques of filtration, crystallisation, simple distillation and fractional distillation |  |  |  |  |
| C2.1g describe the techniques of paper and thin layer chromatography  *To include -* using aqueous and non-aqueous solvents and locating agents |  |  |  |  |
| C2.1h recall that chromatography involves a stationary and a mobile phase and that separation depends on the distribution between the phases  *To include* – identification of the mobile and stationary phases |  |  |  |  |
| C2.1i interpret chromatograms, including measuring Rf values  *To include* – the recall and the use of the formula |  |  |  |  |
| **C2.1 Purity and separating mixtures** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.1j suggest suitable purification techniques given information about the substances involved |  |  |  |  |
| C2.1k suggest chromatographic methods for distinguishing pure from impure substances  *To include* – paper, thin layer (TLC) and gas chromatography |  |  |  |  |
| **C2.2 Bonding** | | | | |
| C2.2a describe metals and non-metals and explain the differences between them on the basis of their characteristic physical and chemical properties  *To include* - physical properties, formation of ions and common reactions, e.g. with oxygen to form oxides |  |  |  |  |
| C2.2b explain how the atomic structure of metals and non-metals relates to their position in the Periodic Table |  |  |  |  |

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| **C2.2 Bonding** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.2c explain how the position of an element in the periodic table is related to the arrangement of electrons in its atoms and hence to its atomic number  *To include* – group number and period number |  |  |  |  |
| C2.2d describe and compare the nature and arrangement of chemical bonds in:   1. ionic compounds 2. simple molecules 3. giant covalent structures 4. polymers 5. metals |  |  |  |  |
| C2.2e explain chemical bonding in terms of electrostatic forces and the transfer or sharing of electrons |  |  |  |  |
| C2.2f construct dot and cross diagrams for simple covalent and binary ionic substances |  |  |  |  |

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| **C2.2 Bonding** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.2g describe the limitations of particular representations and models  *To include* – dot and cross diagrams, ball and stick models and two- and three- dimensional representations |  |  |  |  |
| C2.2h explain how the reactions of elements are related to the arrangement of electrons in their atoms and hence to their atomic number |  |  |  |  |
| C2.2i explain in terms of atomic number how Mendeleev’s arrangement was refined into the modern Periodic Table |  |  |  |  |
| **C2.3 Properties of materials** | | | | |
| C2.3a recall that carbon can form four covalent bonds |  |  |  |  |
| C2.3b explain that the vast array of natural and synthetic organic compounds occur due to the ability of carbon to form families of similar compounds, chains and rings |  |  |  |  |

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| **C2.3 Properties of materials** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.3c explain the properties of diamond, graphite, fullerenes and graphene in terms of their structures and bonding |  |  |  |  |
| C2.3d use ideas about energy transfers and the relative strength of chemical bonds and intermolecular forces to explain the different temperatures at which changes of state occur |  |  |  |  |
| C2.3e use data to predict states of substances under given conditions  *To include* – data such as temperature and how this may be linked to changes of state |  |  |  |  |
| C2.3f explain how the bulk properties of materials (ionic compounds; simple molecules; giant covalent structures; polymers and metals) are related to the different types of bonds they contain, their bond strengths in relation to intermolecular forces and the ways in which their bonds are arranged    *To include -* recognition that the atoms themselves do not have the bulk properties of these materials |  |  |  |  |
| **C3 Chemical reactions** | | | | |
| **C3.1 Introducing chemical reactions** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C3.1a use chemical symbols to write the formulae of elements and simple covalent and ionic compounds |  |  |  |  |
| C3.1b use the names and symbols of common elements and compounds and the principle of conservation of mass to write formulae and balanced chemical equations **and half equations** |  |  |  |  |
| C3.1c use the names and symbols of common elements from a supplied periodic table to write formulae and balanced chemical equations where appropriate  *To include* – the first 20 elements, Groups 1, 7 and 0 and other common elements included within the specification |  |  |  |  |
| C3.1d use the formula of common ions to deduce the formula of a compound |  |  |  |  |

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| **C3.1 Introducing chemical reactions** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C3.1e **construct balanced ionic equations** |  |  |  |  |
| C3.1f describe the physical states of products and reactants using state symbols (s, l, g and aq) |  |  |  |  |
| C3.1g describe tests to identify selected gases  *To include* – oxygen, hydrogen, carbon dioxide and chlorine |  |  |  |  |
| **C3.1h** **recall and use the definitions of the Avogadro constant (in standard form) and of the mole**  *To include* – **the calculation of the mass of one atom/molecule.** In recognition of IUPAC’s review, we will accept both the classical (carbon-12 based) and revised (Avogadro constant based) definitions of the mole in examinations from June 2018 onwards  (see <https://iupac.org/new-definition-mole-arrived/>) |  |  |  |  |

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| **C3.1 Introducing chemical reactions** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **C3.1i** **explain how the mass of a given substance is related to the amount of that substance in moles and vice versa** |  |  |  |  |
| **C3.1j** **explain how the mass of a solute and the volume of the solution is related to the concentration of the solution** |  |  |  |  |
| C3.1k recall and use the law of conservation of mass |  |  |  |  |
| C3.1l explain any observed changes in mass in non-enclosed systems during a chemical reaction and explain them using the particle model |  |  |  |  |
| **C3.1m** **deduce the stoichiometry of an equation from the masses of reactants and products and explain the effect of a limiting quantity of a reactant** |  |  |  |  |
| **C3.1n** **use a balanced equation to calculate masses of reactants or products** |  |  |  |  |

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| **C3.2 Energetics** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C3.2a distinguish between endothermic and exothermic reactions on the basis of the temperature change of the surroundings |  |  |  |  |
| C3.2b draw and label a reaction profile for an exothermic and an endothermic reaction.  *To include* – activation energy, energy change, reactants and products |  |  |  |  |
| C3.2c explain activation energy as the energy needed for a reaction to occur |  |  |  |  |
| **C3.2d** **calculate energy changes in a chemical reaction by considering bond making and bond breaking energies** |  |  |  |  |

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| **C3.3 Types of chemical reactions** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C3.3a explain reduction and oxidation in terms of loss or gain of oxygen, identifying which species are oxidised and which are reduced  *To include* – the concept of oxidising agent and reducing agent |  |  |  |  |
| **C3.3b** **explain reduction and oxidation in terms of gain or loss of electrons, identifying which species are oxidised and which are reduced** |  |  |  |  |
| C3.3c recall that acids form hydrogen ions when they dissolve in water and solutions of alkalis contain hydroxide ions |  |  |  |  |
| C3.3d describe neutralisation as acid reacting with alkali or a base to form a salt plus water |  |  |  |  |
| C3.3e recognise that aqueous neutralisation reactions can be generalised to hydrogen ions reacting with hydroxide ions to form water |  |  |  |  |

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| **C3.3 Types of chemical reactions** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C3.3f recall that carbonates and some metals react with acids and write balanced equations predicting products from given reactants |  |  |  |  |
| **C3.3g** **use and explain the terms dilute and concentrated (amount of substance) and weak and strong (degree of ionisation) in relation to acids**  ***To include* – ratio of amount of acid to volume of solution** |  |  |  |  |
| C3.3h recall that relative acidity and alkalinity are measured by pH |  |  |  |  |
| **C3.3i** **describe neutrality and relative acidity and alkalinity in terms of the effect of the concentration of hydrogen ions on the numerical value of pH (whole numbers only)**  ***To include* – pH of titration curves** |  |  |  |  |

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| **C3.3 Types of chemical reactions** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **C3.3j** **recall that as hydrogen ion concentration increases by a factor of ten the pH value of a solution decreases by a factor of one** |  |  |  |  |
| C3.3k describe techniques and apparatus used to measure pH  *To include -* the use of universal indicator and pH meters |  |  |  |  |
| **C3.4 Electrolysis** | | | | |
| C3.4a recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes  *To include* – the terms cations and anions |  |  |  |  |
| C3.4b predict the products of electrolysis of binary ionic compounds in the molten state  *To include* – compounds such as NaC𝑙 |  |  |  |  |

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| **C3.4 Electrolysis** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C3.4c describe competing reactions in the electrolysis of aqueous solutions of ionic compounds in terms of the different species present  *To include* – the electrolysis of aqueous NaC𝑙 and CuSO4 using inert electrodes |  |  |  |  |
| C3.4d describe electrolysis in terms of the ions present and reactions at the electrodes  *To include -* the equations and **half equations** of the reactions at the electrodes |  |  |  |  |
| C3.4e describe the technique of electrolysis using inert and non-inert electrodes |  |  |  |  |

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| **C4 Predicting and identifying reactions and products** | | | | |
| **C4.1 Predicting chemical reactions** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C4.1a recall the simple properties of Groups 1, 7 and 0  *To include* – physical and chemical properties |  |  |  |  |
| C4.1b explain how observed simple properties of Groups 1, 7 and 0 depend on the outer shell of electrons of the atoms and predict properties from given trends down the groups  *To include* – ease of electron gain or loss, physical and chemical properties |  |  |  |  |
| C4.1c predict possible reactions and probable reactivity of elements from their positions in the Periodic Table |  |  |  |  |
| C4.1d explain how the reactivity of metals with water or dilute acids is related to the tendency of the metal to form its positive ion |  |  |  |  |
| C4.1e deduce an order of reactivity of metals based on experimental results |  |  |  |  |

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| **C5 Monitoring and controlling chemical reactions** | | | | |
| **C5.1 Controlling reactions** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C5.1a suggest practical methods for determining the rate of a given reaction |  |  |  |  |
| C5.1b interpret rate of reaction graphs  *To include* – 1/*t* is proportional to rate and gradients of graphs (not order of reaction) |  |  |  |  |
| C5.1c describe the effect of changes in temperature, concentration, pressure, and surface area on rate of reaction |  |  |  |  |
| C5.1d explain the effects on rates of reaction of changes in temperature, concentration and pressure in terms of frequency and energy of collision between particles |  |  |  |  |
| C5.1e explain the effects on rates of reaction of changes in the size of the pieces of a reacting solid in terms of surface area to volume ratio |  |  |  |  |

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| **C5.1 Monitoring chemical reactions** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C5.1f describe the characteristics of catalysts and their effect on rates of reaction |  |  |  |  |
| C5.1g identify catalysts in reactions |  |  |  |  |
| C5.1h explain catalytic action in terms of activation energy  *To include - reaction* profiles |  |  |  |  |
| C5.1i recall that enzymes act as catalysts in biological systems |  |  |  |  |
| **C5.2 Equilibria** | | | | |
| C5.2a recall that some reactions may be reversed by altering the reaction conditions |  |  |  |  |
| C5.2b recall that dynamic equilibrium occurs in a closed system when the rates of forward and reverse reactions are equal |  |  |  |  |

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| **C5.2 Equilibria** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **C5.3c** **predict the effect of changing reaction conditions on equilibrium position and suggest appropriate conditions to produce as much of a particular product as possible**  ***To include* - Le Chatelier’s principle concerning concentration, temperature and pressure** |  |  |  |  |

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| **C6 Global challenges** | | | | |
| **C6.1 Improving processes and products** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C6.1a explain, using the position of carbon in the reactivity series, the principles of industrial processes used to extract metals, including extraction of a non-ferrous metal  *To include:* the principles of using carbon to extract iron and other metals from their ores |  |  |  |  |
| C6.1b explain why and how electrolysis is used to extract some metals from their ores |  |  |  |  |
| **C6.1c** **evaluate alternative biological methods of metal extraction**  ***To include* – bacterial and phytoextraction** |  |  |  |  |

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| **C6.1 Improving processes and products** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C6.1d describe the basic principles in carrying out a life-cycle assessment of a material or product  *To include* – the use of resources and impact on the environment of all stages of a life-cycle assessment:   * making materials for a product from raw materials through to the process used to make the product * the use of the product * transport of the product * the method used for its disposal at the end of its life |  |  |  |  |
| C6.1e interpret data from a life-cycle assessment of a material or product |  |  |  |  |
| C6.1f describe a process where a material or product is recycled for a different use, and explain why this is viable |  |  |  |  |
| C6.1g evaluate factors that affect decisions on recycling |  |  |  |  |

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| **C6.1 Improving processes and products** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C6.1h describe the separation of crude oil by fractional distillation  *To include* – the name of the fractions |  |  |  |  |
| C6.1i explain the separation of crude oil by fractional distillation  *To include* – molecular size and intermolecular forces |  |  |  |  |
| C6.1j describe the fractions as largely a mixture of compounds of formula CnH2n+2 which are members of the alkane homologous series |  |  |  |  |
| C6.1k recall that crude oil is a main source of hydrocarbons and is a feedstock for the petrochemical industry |  |  |  |  |
| C6.1l explain how modern life is crucially dependent upon hydrocarbons and recognise that crude oil is a finite resource |  |  |  |  |

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| **C6.1 Improving processes and products** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C6.1m describe the production of materials that are more useful by cracking  *To include* – conditions and reasons for cracking and some of the useful materials produced |  |  |  |  |
| **C6.2 Interpreting and interacting with earth systems** | | | | |
| C6.2a interpret evidence for how it is thought the atmosphere was originally formed  *To include* - knowledge of how the composition of the atmosphere has changed over time |  |  |  |  |
| C6.2b describe how it is thought an oxygen-rich atmosphere developed over time |  |  |  |  |
| C6.2c describe the greenhouse effect in terms of the interaction of radiation with matter within the atmosphere |  |  |  |  |

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| **C6.2 Interpreting and interacting with earth systems** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C6.2d evaluate the evidence for additional anthropogenic (human activity) causes of climate change and describe the uncertainties in the evidence base  *To include* - the correlation between change in atmospheric carbon dioxide concentration and the consumption of fossil fuels |  |  |  |  |
| C6.2e describe the potential effects of increased levels of carbon dioxide and methane on the Earth’s climate and how these effects may be mitigated  *To include* – consideration of scale, risk and environmental implications |  |  |  |  |
| C6.2f describe the major sources of carbon monoxide, sulfur dioxide, oxides of nitrogen and particulates in the atmosphere and explain the problems caused by increased amounts of these substances |  |  |  |  |

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| **C6.2 Interpreting and interacting with earth systems** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C6.2g describe the principal methods for increasing the availability of potable water in terms of the separation techniques used  *To include* – ease of treatment of waste, ground and salt water |  |  |  |  |

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| **P1 Matter** | | | | |
| **P1.1 The particle model** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.1a describe how and why the atomic model has changed over time  *To include* – the Thomson, Rutherford (alongside Geiger and Marsden) and Bohr models |  |  |  |  |
| P1.1b describe the atom as a positively charged nucleus surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with almost all of the mass in the nucleus |  |  |  |  |
| P1.1c recall the typical size (order of magnitude) of atoms and small molecules  *To include* – knowledge that it is typically 1 × 10–10m |  |  |  |  |
| P1.1d define density |  |  |  |  |

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| **P1.1 The particle model** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.1e explain the differences in density between the different states of matter in terms of the arrangements of the atoms and molecules |  |  |  |  |
| P1.1f apply the relationship between density, mass and volume to changes where mass is conserved |  |  |  |  |
| **P1.2 Changes of state** | | | | |
| P1.2a describe how mass is conserved when substances melt, freeze, evaporate, condense or sublimate |  |  |  |  |
| P1.2b describe that physical changes differ from chemical changes because the material recovers its original properties if the change is reversed |  |  |  |  |
| P1.2c describe how heating a system will change the energy stored within the system and raise its temperature or produce changes of state |  |  |  |  |

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| **P1.2 Changes of state** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.2d define the term specific heat capacity and distinguish between it and the term specific latent heat  *To include* – specific latent heat of fusion and specific latent heat of vaporisation |  |  |  |  |
| P1.2e apply the relationship between change in internal energy of a material and its mass, specific heat capacity and temperature change to calculate the energy change involved |  |  |  |  |
| P1.2f apply the relationship between specific latent heat and mass to calculate the energy change involved in a change of state |  |  |  |  |
| P1.2g explain how the motion of the molecules in a gas is related both to its temperature and its pressure  *To include* – application to closed systems only |  |  |  |  |
| P1.2h explain the relationship between the temperature of a gas and its pressure at constant volume (qualitative only) |  |  |  |  |
| **P2 Forces** | | | | |
| **P2.1 Motion** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P2.1a describe how to measure distance and time in a range of scenarios |  |  |  |  |
| P2.1b describe how to measure distance and time and use these to calculate speed  *To include* – from graphs |  |  |  |  |
| P2.1c make calculations using ratios and proportional reasoning to convert units and to compute rates  *To include* – conversion from non-Sl to Sl units |  |  |  |  |
| P2.1d explain the vector–scalar distinction as it applies to displacement and distance, velocity and speed |  |  |  |  |
| P2.1e relate changes and differences in motion to appropriate distance–time, and velocity–time graphs; interpret lines and slopes |  |  |  |  |

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| **P2.1 Motion** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P2.1f interpret enclosed area in velocity-time graphs** |  |  |  |  |
| P2.1g calculate average speed for non-uniform motion |  |  |  |  |
| P2.1h apply formulae relating distance, time and speed, for uniform motion, and for motion with uniform acceleration |  |  |  |  |
| **P2.2 Newton’s laws** | | | | |
| P2.2a recall examples of ways in which objects interact  *To include* - electrostatics, gravity, magnetism and by contact (including normal contact force and friction) |  |  |  |  |
| P2.2b describe how such examples involve interactions between pairs of objects which produce a force on each object |  |  |  |  |

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| **P2.2 Newton’s laws** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P2.2c represent forces as vectors  *To include* - drawing free body force diagrams to demonstrate understanding of forces acting as vectors |  |  |  |  |
| P2.2d apply Newton’s First Law to explain the motion of an object moving with uniform velocity and also an object where the speed and/or direction change  *To include* - looking at forces on one body and resultant forces and their effects (qualitative only) |  |  |  |  |
| **P2.2e use vector diagrams to illustrate resolution of forces, a net force (resultant force), and equilibrium situations**  ***To include* – scale drawings limited to parallel and perpendicular vectors only** |  |  |  |  |

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| **P2.2 Newton’s laws** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P2.2f describe examples of the forces acting on an isolated solid object or system**  ***To include* – examples of objects that reach terminal velocity for example skydivers and applying similar ideas to vehicles** |  |  |  |  |
| **P2.2g describe, using free body diagrams, examples where two or more forces lead to a resultant force on an object** |  |  |  |  |
| **P2.2h describe, using free body diagrams, examples of the special case where forces balance to produce a resultant force of zero (qualitative only)** |  |  |  |  |
| P2.2i apply Newton’s second law in calculations relating forces, masses and accelerations |  |  |  |  |
| **P2.2j explain that inertia is a measure of how difficult it is to change the velocity of an object and that the inertial mass is defined as the ratio of force over acceleration** |  |  |  |  |

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| **P2.2 Newton’s laws** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P2.2k define momentum and describe examples of momentum in collisions**  ***To include* – an idea of the law of conservation of momentum in collisions** |  |  |  |  |
| P2.2l use the relationship between work done, force, and distance moved along the line of action of the force and describe the energy transfer involved |  |  |  |  |
| P2.2m calculate relevant values of stored energy and energy transfers; convert between newton- metres and joules |  |  |  |  |
| P2.2n explain, with reference to examples, the definition of power as the rate at which energy is transferred |  |  |  |  |
| P2.2o recall and apply Newton’s third law  *To include* – application to situations of equilibrium and non-equilibrium |  |  |  |  |

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| **P2.2 Newton’s laws** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P2.2p explain why an object moving in a circle with a constant speed has a changing velocity (qualitative only)** |  |  |  |  |
| **P2.3 Forces in action** | | | | |
| P2.3a explain that to stretch, bend or compress an object, more than one force has to be applied  *To include* – applications to real life situations |  |  |  |  |
| P2.3b describe the difference between elastic and plastic deformation (distortions) caused by stretching forces |  |  |  |  |
| P2.3c describe the relationship between force and extension for a spring and other simple systems  *To include* – graphical representation of the extension of a spring |  |  |  |  |

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| **P2.2 Newton’s laws** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P2.3d describe the difference between linear and non-linear relationships between force and extension |  |  |  |  |
| P2.3e calculate a spring constant in linear cases |  |  |  |  |
| P2.3f calculate the work done in stretching |  |  |  |  |
| P2.3g describe that all matter has a gravitational field that causes attraction, and the field strength is much greater for massive objects |  |  |  |  |
| P2.3h define weight, describe how it is measured and describe the relationship between the weight of an object and the gravitational field strength, *g*  *To include* - knowledge that the gravitational field strength is known as g and has a value of 10N/kg at the Earth’s surface |  |  |  |  |
| P2.3i recall the acceleration in free fall |  |  |  |  |

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| **P3 Electricity and magnetism** | | | | |
| **P3.1 Static and charge** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.1a describe that charge is a property of all matter and that there are positive and negative charges  *To include* – the understanding that in most bodies there are an equal number of positive and negative charges resulting in the body having zero net charge |  |  |  |  |
| P3.1b describe the production of static electricity, and sparking, by rubbing surfaces, and evidence that charged objects exert forces of attraction or repulsion on one another when not in contact  *To include* – the understanding that static charge only builds up on insulators |  |  |  |  |
| P3.1c explain how transfer of electrons between objects can explain the phenomena of static electricity |  |  |  |  |

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| **P3.1 Static and charge** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.1d recall that current is a rate of flow of charge (electrons) and the conditions needed for charge to flow  *To include* – conditions for charge to flow: source of potential difference in a closed circuit |  |  |  |  |
| P3.1e recall that current has the same value as any point in a single closed loop |  |  |  |  |
| P3.1f recall and use the relationship between quantity of charge, current and time |  |  |  |  |
| **P3.2 Simple circuits** | | | | |
| P3.2a describe the differences between series and parallel circuits  *To include* – positioning of measuring instruments in circuits and descriptions of the behaviour of energy, current and potential difference |  |  |  |  |

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| **P3.2 Simple circuits** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.2b represent d.c. circuits with the conventions of positive and negative terminals, and the symbols that represent common circuit elements    *To include* – cells, power supply, diodes, LDRs, NTC thermistors, filament lamps, ammeter, voltmeter, fixed and variable resistors and switch |  |  |  |  |
| P3.2c recall that current (*I*)depends on both resistance (*R*) and potential difference (*V*) and the units in which these are measured  *To include* – the definition of potential difference |  |  |  |  |
| P3.2d recall and apply the relationship between *I*, *R* and *V*, and that for some resistors the value of *R* remains constant but that in others it can change as the current changes |  |  |  |  |
| P3.2e explain that for some resistors the value of *R* remains constant but that in others it can change as the current changes |  |  |  |  |

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| **P3.2 Simple circuits** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.2f explain the design and use of circuits to explore such effects  *To include* – components such as wire of varying resistance, filament lamps, diodes, NTC thermistors and LDRs |  |  |  |  |
| P3.2g use graphs to explore whether circuit elements are linear or non-linear |  |  |  |  |
| P3.2h use graphs and relate the curves produced to the function and properties of circuit elements  *To include* – components such as wire of varying resistance, filament lamps, diodes, NTC thermistors and LDRs |  |  |  |  |
| P3.2i explain why, if two resistors are in series the net resistance is increased, whereas with two in parallel the net resistance is decreased (qualitative explanation only) |  |  |  |  |

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| **P3.2 Simple circuits** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.2j calculate the currents, potential differences and resistances in d.c. series and parallel circuits  *To include* – components such as wire of varying resistance, filament lamps, diodes, NTC thermistors and LDRs |  |  |  |  |
| P3.2k explain the design and use of d.c. circuits for measurement and testing purposes |  |  |  |  |
| P3.2l explain how the power transfer in any circuit device is related to the potential difference across it and the current, and to the energy changes over a given time |  |  |  |  |
| P3.2m apply the equations relating potential difference, current, quantity of charge, resistance, power, energy, and time, and solve problems for circuits which include resistors in series, using the concept of equivalent resistance |  |  |  |  |

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| **P3.3 Magnets and magnetic fields** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.3a describe the attraction and repulsion between unlike and like poles for permanent magnets  *To include* – diagrams of magnetic field patterns around bar magnets to show attraction and repulsion |  |  |  |  |
| P3.3b describe the difference between permanent and induced magnets |  |  |  |  |
| P3.3c describe the characteristics of the magnetic field of a magnet, showing how strength and direction change from one point to another  *To include* – diagrams to show how the strength of the field varies around them and ways of investigating this |  |  |  |  |
| P3.3d explain how the behaviour of a magnetic (dipping) compass is related to evidence that the core of the Earth must be magnetic |  |  |  |  |

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| **P3.3 Magnets and magnetic fields** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.3e describe how to show that a current can create a magnetic effect and describe the directions of the magnetic field around a conducting wire |  |  |  |  |
| P3.3f recall that the strength of the field depends on the current and the distance from the conductor |  |  |  |  |
| P3.3g explain how solenoid arrangements can enhance the magnetic effect |  |  |  |  |
| **P3.3h describe how a magnet and a current- carrying conductor exert a force on one another** |  |  |  |  |
| **P3.3i show that Fleming’s left-hand rule represents the relative orientations of the force, the current and the magnetic field** |  |  |  |  |
| **P3.3j apply the equation that links the force on a conductor to the magnetic flux density, the current and the length of conductor to calculate the forces involved** |  |  |  |  |

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| **P3.3 Magnets and magnetic fields** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P3.3k explain how the force exerted from a magnet and a current-carrying conductor is used to cause rotation in electric motors**  ***To include* – an understanding of how electric motors work but knowledge of the structure of a motor is not expected** |  |  |  |  |

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| **P4 Waves and radioactivity** | | | | |
| **P4.1 Wave behaviour** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.1a describe wave motion in terms of amplitude, wavelength, frequency and period |  |  |  |  |
| P4.1b define wavelength and frequency |  |  |  |  |
| P4.1c describe and apply the relationship between wavelength, frequency and wave velocity |  |  |  |  |
| P4.1d apply formulae relating velocity, frequency and wavelength |  |  |  |  |
| P4.1e describe differences between transverse and longitudinal waves  *To include* – direction of travel and direction of vibration |  |  |  |  |
| P4.1f describe how ripples on water surfaces are used to model transverse waves whilst sound waves in air are longitudinal waves, and how the speed of each may be measured |  |  |  |  |

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| **P4.1 Wave behaviour** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.1g describe evidence for the cases of ripples on water surfaces and for sound waves in air that it is the wave that travels and not the water or the air |  |  |  |  |
| **P4.2 The electromagnetic spectrum** | | | | |
| P4.2a recall that electromagnetic waves are transverse and are transmitted through space where all have the same velocity |  |  |  |  |
| P4.2b explain that electromagnetic waves transfer energy from source to absorber  *To include* – examples from a range of electromagnetic waves |  |  |  |  |
| P4.2c apply the relationships between frequency and wavelength across the electromagnetic spectrum |  |  |  |  |

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| **P4.2 The electromagnetic spectrum** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.2d describe the main groupings of the electromagnetic spectrum and that these groupings range from long to short wavelengths and from low to high frequencies  *To include* – radio, microwave, infrared, visible (red to violet), ultraviolet, X-rays and gamma rays |  |  |  |  |
| P4.2e describe that our eyes can only detect a limited range of the electromagnetic spectrum |  |  |  |  |
| P4.2f recall that light is an electromagnetic wave |  |  |  |  |
| P4.2g give examples of some practical uses of electromagnetic waves in the radio, microwave, infrared, visible, ultraviolet, X-ray and gamma ray regions |  |  |  |  |
| P4.2h describe how ultraviolet waves, X-rays and gamma rays can have hazardous effects, notably on human bodily tissues |  |  |  |  |
| **P4.2 The electromagnetic spectrum** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P4.2i recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits** |  |  |  |  |
| **P4.2j recall that different substances may absorb, transmit, refract, or reflect electromagnetic waves in ways that vary with wavelength** |  |  |  |  |
| **P4.2k explain how some effects are related to differences in the velocity of electromagnetic waves in different substances** |  |  |  |  |

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| **P4.3 Radioactivity** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.3a recall that atomic nuclei are composed of both protons and neutrons, that the nucleus of each element has a characteristic positive charge |  |  |  |  |
| P4.3b recall that atoms of the same elements can differ in nuclear mass by having different numbers of neutrons |  |  |  |  |
| P4.3c Use the conventional representation for nuclei to relate the differences between isotopes  *To include* – identities, charges and masses |  |  |  |  |
| P4.3d recall that some nuclei are unstable and may emit alpha particles, beta particles, or neutrons, and electromagnetic radiation as gamma rays |  |  |  |  |
| P4.3e relate the emission of alpha particles, beta particles, gamma radiation and neutrons to possible changes in the mass or the charge of the nucleus, or both |  |  |  |  |

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| **P4.3 Radioactivity** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.3f use names and symbols of common nuclei and particles to write balanced equations that represent radioactive decay |  |  |  |  |
| P4.3g balance equations representing the emission of alpha, beta or gamma radiation in terms of the masses, and charges of the atoms involved |  |  |  |  |
| P4.3h recall that in each atom its electrons are arranged at different distances from the nucleus, that such arrangements may change with absorption or emission of electromagnetic radiation and that atoms can become ions by loss of outer electrons  *To include* - knowledge that inner electrons can be ‘excited’ when they absorb energy from radiation and rise to a higher energy level. When this energy is lost by the electron it is emitted as radiation. When outer electrons are lost this is called ionisation |  |  |  |  |

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| **P4.3 Radioactivity** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.3i recall that changes in atoms and nuclei can also generate and absorb radiations over a wide frequency range  *To include* – an understanding that these types of radiation may be from any part of the electromagnetic spectrum which includes gamma rays |  |  |  |  |
| P4.3j explain the concept of half-life and how this is related to the random nature of radioactive decay |  |  |  |  |
| **P4.3k calculate the net decline, expressed as a ratio, during radioactive emission after a given (integral) number of half-lives**  ***To include* – half-life graphs** |  |  |  |  |
| P4.3l recall the differences in the penetration properties of alpha particles, beta particles and gamma rays |  |  |  |  |
| P4.3m recall the differences between contamination and irradiation effects and compare the hazards associated with these two |  |  |  |  |
| **P5 Energy** | | | | |
| **P5.1 Work done** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P5.1a describe for situations where there are energy transfers in a system, that there is no net change to the total energy of a closed system (qualitative only)  *To include* – the law of conservation of energy |  |  |  |  |
| P5.1b describe all the changes involved in the way energy is stored when a system changes for common situations    *To include* - an object projected upwards or up a slope, a moving object hitting an obstacle, an object being accelerated by a constant force, a vehicle slowing down, bringing water to a boil in an electric kettle |  |  |  |  |
| P5.1c describe the changes in energy involved when a system is changed by heating (in terms of temperature change and specific heat capacity), by work done by forces, and by work done when a current flows |  |  |  |  |

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| **P5.1 Work done** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P5.1d make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system  *To include* – work done by forces, current flow, through heating and the use of kWh to measure energy use in electrical appliances in the home |  |  |  |  |
| P5.1e calculate the amounts of energy associated with a moving body, a stretched spring and an object raised above ground level |  |  |  |  |
| **P5.2 Power and efficiency** | | | | |
| P5.2a describe, with examples, the process by which energy is dissipated, so that it is stored in less useful ways |  |  |  |  |

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| **P5.2 Power and efficiency** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P5.2b describe how, in different domestic devices, energy is transferred from batteries or the a.c. from the mains  *To include* – how energy may be wasted in the transfer to and within motors and heating devices |  |  |  |  |
| P5.2c describe, with examples, the relationship between the power ratings for domestic electrical appliances and how this is linked to the changes in stored energy when they are in use |  |  |  |  |
| P5.2d calculate energy efficiency for any energy transfer |  |  |  |  |
| **P5.2e describe ways to increase efficiency** |  |  |  |  |
| P5.2f explain ways of reducing unwanted energy transfer  *To include* – through lubrication and thermal insulation |  |  |  |  |
| **P5.2 Power and efficiency** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P5.2g describe how the rate of cooling of a building is affected by the thickness and thermal conductivity of its walls (qualitative only) |  |  |  |  |

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| **P6 Global challenges** | | | | |
| **P6.1 Physics on the move** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.1a recall typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems |  |  |  |  |
| P6.1b estimate the magnitudes of everyday accelerations |  |  |  |  |
| P6.1c make calculations using ratios and proportional reasoning to convert units and to compute rates  *To include* – conversion from non-Sl to Sl units |  |  |  |  |
| P6.1d explain methods of measuring human reaction times and recall typical results |  |  |  |  |

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| **P6.1 Physics on the move** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.1e explain the factors which affect the distance required for road transport vehicles to come to rest in emergencies and the implications for safety  *To include* - factors that affect thinking and braking distance and overall stopping distance |  |  |  |  |
| P6.1f explain the dangers caused by large decelerations |  |  |  |  |
| **P6.2 Powering Earth** | | | | |
| P6.2a describe the main energy sources available for use on Earth, compare the ways in which they are used and distinguish between renewable and non-renewable sources  *To include* - fossil fuels, nuclear fuel, biofuel, wind, hydroelectricity, tides and the Sun |  |  |  |  |

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| **P6.2 Powering Earth** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.2b explain patterns and trends in the use of energy resources    *To include* – the changing use of different resources over time |  |  |  |  |
| P6.2c recall that, in the national grid, electrical power is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic use |  |  |  |  |
| P6.2d recall that step-up and step-down transformers are used to change the potential difference as power is transferred from power stations |  |  |  |  |
| P6.2e explain how the national grid is an efficient way to transfer energy |  |  |  |  |
| P6.2f recall that the domestic supply in the UK is a.c. at 50Hz and about 230 volts |  |  |  |  |

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| **P6.2 Powering Earth** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.2g explain the difference between direct and alternating voltage |  |  |  |  |
| P6.2h recall the differences in function between the live, neutral and earth mains wires, and the potential differences between these wires |  |  |  |  |
| P6.2i explain that a live wire may be dangerous even when a switch in a mains circuit is open and explain the dangers of providing any connection between the live wire and earth  *To include* – the protection offered by insulation of devices |  |  |  |  |

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| **WS1 Working scientifically assessed in written examinations** | | | | |
| **WS1.1 Development of scientific thinking** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |

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| 1.1a understand how scientific methods and theories develop over time  *To include* – new technology allowing new evidence to be collected and changing explanations as new evidence is found |  |  |  |  |
| 1.1b use models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts  *To include* – representational, spatial, descriptive, computational and mathematical models |  |  |  |  |
| 1.1c understand the power and limitations of science  *To include* – how developments in science have led to increased understanding and improved quality of life and questions and problems that science cannot currently answer |  |  |  |  |

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| **WS1.1 Development of scientific thinking** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |

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| 1.1d discuss ethical issues arising from developments in science |  |  |  |  |
| 1.1e explain every day and technological applications of science |  |  |  |  |
| 1.1f evaluate associated personal, social, economic and environmental implications |  |  |  |  |
| 1.1g make decisions based on the evaluation of evidence and arguments |  |  |  |  |
| 1.1h evaluate risks both in practical science and the wider societal context  *To include* – perception of risk in relation to data and consequences |  |  |  |  |
| 1.1i recognise the importance of peer review of results and of communicating results to a range of audiences |  |  |  |  |

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| **WS1.2 Experimental skills and strategies** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |

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| 1.2a use scientific theories and explanations to develop hypotheses |  |  |  |  |
| 1.2b plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena |  |  |  |  |
| 1.2c apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment |  |  |  |  |
| 1.2d recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative |  |  |  |  |
| 1.2e evaluate methods and suggest possible improvements and further investigations |  |  |  |  |

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| **WS1.3 Analysis and evaluation** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| Apply the cycle of collecting, presenting and analysing data, including: |  |  |  |  |

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| 1.3a presenting observations and other data using appropriate methods  *To include –* methods to include descriptive, tabular diagrammatic and graphically |  |  |  |  |
| 1.3b translating data from one form to another |  |  |  |  |
| 1.3c carrying out and representing mathematical and statistical analysis  *To include* – statistical analysis to include arithmetic means, mode, median |  |  |  |  |
| 1.3d representing distributions of results and make estimations of uncertainty |  |  |  |  |

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| **WS1.3 Analysis and evaluation** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |

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| 1.3e interpreting observations and other data  *To include* – data presentations to include verbal, diagrammatic, graphical, symbolic or numerical form interpretations to include identifying patterns and trends, making inferences and drawing conclusions |  |  |  |  |
| 1.3f presenting reasoned explanations  *To include* – relating data to hypotheses |  |  |  |  |
| 1.3g being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility |  |  |  |  |
| 1.3h identifying potential sources of random and systematic error |  |  |  |  |
| 1.3i communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions  *To include* – presentations through paper- based presentations using diagrammatic, graphical, numerical and symbolic forms |  |  |  |  |

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| **WS1.4 Scientific vocabulary, quantities, units, symbols and nomenclature** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |

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| 1.4a use scientific vocabulary, terminology and definitions |  |  |  |  |
| 1.4b recognise the importance of scientific quantities and understand how they are determined |  |  |  |  |
| 1.4c use SI units and IUPAC chemical nomenclature unless inappropriate  *To include* – base units & derived units |  |  |  |  |
| 1.4d use prefixes and powers of ten for orders of magnitude  *To include* – tera, giga, mega, kilo, centi, milli, micro and nano |  |  |  |  |
| 1.4e interconvert units |  |  |  |  |
| 1.4f use an appropriate number of significant figures in calculation |  |  |  |  |

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| **WS2 Working scientifically skills demonstrated** | | | | |
| **Practical skills to be developed** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |

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| 2a carry out experiments  *To include* – due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations, and following written instructions. |  |  |  |  |
| 2b make and record observations and measurements using a range of apparatus and methods  *To include* – keeping appropriate records |  |  |  |  |
| 2c presenting observations using appropriate methods  *To include* – methods to include descriptive, tabular diagrammatic and graphically |  |  |  |  |

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| **WS2 Working scientifically skills demonstrated** | | | | |
| **Practical skills to be developed** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |

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| 2d communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions    *To include* – presentations through paper- based and electronic reports and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms |  |  |  |  |

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| **Equations in Physics** | | | | | |
| ***recall and apply the following relationships using standard SI units (units given in brackets)*** | | **R** | **A** | **G** | **Comments** |
| PM1.1i | density (kg/m3) = mass (kg)/volume (m3) |  |  |  |  |
| PM2.1i | distance travelled (m) = speed (m/s) × time (s) |  |  |  |  |
| PM2.1ii | acceleration (m/s2) = change in velocity (m/s)/time (s) |  |  |  |  |
| PM2.1iv | kinetic energy (J) = 0.5 × mass (kg) × (speed (m/s))2 |  |  |  |  |
| PM2.2i | force (N) = mass (kg) × acceleration (m/s2) |  |  |  |  |
| **PM2.2ii** | **momentum (kg m/s) = mass (kg) × velocity (m/s)** |  |  |  |  |
| PM2.2iii | work done (J) = force (N) × distance (m) (along the line of action of the force) |  |  |  |  |
| PM2.2iv | power (W) = work done (J)/time(s) |  |  |  |  |
| **Equations in Physics** | | | | | |
| ***recall and apply the following relationships using standard SI units (units given in brackets)*** | | **R** | **A** | **G** | **Comments** |
| PM2.3i | force exerted by a spring (N) = extension (m) × spring constant (N/m) |  |  |  |  |
| PM2.3iii | gravitational force (N) = mass (kg) × gravitational field strength, *g* (N/kg) |  |  |  |  |
| PM2.3iv | (in a gravitational field) potential energy (J) = mass (kg) × height (m) × gravitational field strength, *g* (N/kg) |  |  |  |  |
| PM3.1i | charge flow (C) = current (A) × time (s) |  |  |  |  |
| PM3.2i | potential difference (V) = current (A) × resistance (Ω) |  |  |  |  |
| PM3.2ii | energy transferred (J) = charge (C) × potential difference (V) |  |  |  |  |
| PM3.2iii | power (W) = potential difference (V) × current (A) = (current (A))2 × resistance (Ω) |  |  |  |  |

|  |  |  |  |  |  |
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| **Equations in Physics** | | | | | |
| ***recall and apply the following relationships using standard SI units (units given in brackets)*** | | **R** | **A** | **G** | **Comments** |
| PM3.2iv | energy transferred (J, kW h) = power (W, kW) × time (s, h) |  |  |  |  |
| PM5.1i | wave speed (m/s) = frequency (Hz) × wavelength (m) |  |  |  |  |
| PM7.2i | efficiency = useful output energy transfer (J) / input energy transfer (J) |  |  |  |  |

|  |  |  |  |  |  |
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| **Equations in Physics** | | | | | |
| ***select and apply from a list the following relationships using standard SI units:*** | | **R** | **A** | **G** | **Comments** |
| PM1.2i | change in thermal energy (J) = mass (kg) × specific heat capacity (J/kg°C) × change in temperature (°C) |  |  |  |  |
| PM1.2ii | thermal energy for a change in state (J) = mass (kg) × specific latent heat (J/kg) |  |  |  |  |
| PM2.1iii | (final velocity (m/s))2 – (initial velocity (m/s))2 = 2 × acceleration (m/s2) × distance (m) |  |  |  |  |
| PM2.3ii | energy transferred in stretching (J) = 0.5 × spring constant (N/m) × (extension (m))2 |  |  |  |  |
| **PM4.2i** | **force on a conductor (at right angles to a magnetic field) carrying a current (N) = magnetic flux density (T) × current (A) × length (m)** |  |  |  |  |
| PM8.2i | potential difference across primary coil (V) × current in primary coil (A) = potential difference across secondary coil (V) × current in secondary coil (A) |  |  |  |  |

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