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GCSE (9-1)

***TWENTY FIRST CENTURY SCIENCE –   
COMBINED SCIENCE B***

**J260**

For first teach in 2016

**Student revision checklist**

Version 1



## Revision checklists

The tables below can be used as a revision checklist.

For more information please see:

[OCR GCSE Twenty First Century Combined Science B specification J260](https://www.ocr.org.uk/Images/234597-specification-accredited-gcse-twenty-first-century-science-suite-combined-science-b-j260.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 You and your genes** | | | | |
| **B1.1 What is the genome and what does it do?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B1.1.1 a) explain how the nucleus and genetic material of eukaryotic cells (plants and animals) and the genetic material, including plasmids, of prokaryotic cells are related to cell functions |  |  |  |  |
| B1.1.1 b) describe how to use a light microscope to observe a variety of plant and animal cells |  |  |  |  |
| B1.1.2 describe the genome as the entire genetic material of an organism |  |  |  |  |
| B1.1.3 describe DNA as a polymer made up of nucleotides, forming two strands in a double helix |  |  |  |  |

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| **B1.1 What is the genome and what does it do?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B1.1.4 describe simply how the genome and its interaction with the environment influence the development of the phenotype of an organism, including the idea that most characteristics depend on instructions in the genome and are modified by interaction of the organism with its environment  Information *Learners are not expected to describe epigenetic effects* |  |  |  |  |
| B1.1.5 explain the terms chromosome, gene, allele, variant, genotype and phenotype |  |  |  |  |
| B1.1.6 explain the importance of amino acids in the synthesis of proteins, including the genome as instructions for the polymerisation of amino acids to make proteins |  |  |  |  |

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| **B1.2 How is genetic information inherited?** |

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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B1.2.1 explain the terms gamete, homozygous, heterozygous, dominant and recessive |  |  |  |  |
| B1.2.2 explain single gene inheritance, including dominant and recessive alleles and use of genetic diagrams |  |  |  |  |
| B1.2.3 predict the results of single gene crosses |  |  |  |  |
| B1.2.4 use direct proportions and simple ratios in genetic crosses |  |  |  |  |

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| **B1.2 How is genetic information inherited?** |

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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B1.2.5 use the concept of probability in predicting the outcome of genetic crosses |  |  |  |  |
| B1.2.6 recall that most phenotypic features are the result of multiple genes rather than single gene inheritance  Information *Learners are not expected to describe epistasis and its effects* |  |  |  |  |
| B1.2.7 describe sex determination in humans |  |  |  |  |

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| **B1.3 How can and should gene technology be used?** |

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| B1.3.1 discuss the potential importance for medicine of our increasing understanding of the human genome, including the discovery of alleles associated with diseases and the genetic testing of individuals to inform family planning and healthcare |  |  |  |  |
| B1.3.2 describe genetic engineering as a process which involves modifying the genome of an organism to introduce desirable characteristics |  |  |  |  |

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| **B1.3 How can and should gene technology be used?** |

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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **B1.3.3 describe the main steps in the process of genetic engineering including:**   * **isolating and replicating the required gene(s)** * **putting the gene(s) into a vector (e.g. a plasmid)** * **using the vector to insert the gene(s) into cells** * **selecting modified cells** |  |  |  |  |
| B1.3.4 explain some of the possible benefits and risks, including practical and ethical considerations, of using gene technology in modern agriculture and medicine |  |  |  |  |

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| **B2 Keeping healthy** | | | | |
| **B2.1 What are the causes of disease?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B2.1.1 describe the relationship between health and disease |  |  |  |  |
| B2.1.2 describe different types of disease (including communicable and non-communicable diseases) |  |  |  |  |
| B2.1.3 explain how communicable diseases (caused by viruses, bacteria, protists and fungi) are spread in animals and plants |  |  |  |  |
| B2.1.4 describe common human infections including influenza (viral), Salmonella (bacterial), Athlete’s foot (fungal) and malaria (protist) and sexually transmitted infections in humans including HIV/AIDS (viral) |  |  |  |  |
| B2.1.5 describe plant diseases including tobacco mosaic virus (viral), ash dieback (fungal) and crown gall disease (bacterial) |  |  |  |  |

| **B2.2 How do organisms protect themselves against pathogens?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B2.2.1 describe non-specific defence systems of the human body against pathogens, including examples of physical, chemical and microbial defences |  |  |  |  |
| B2.2.2 explain how platelets are adapted to their function in the blood |  |  |  |  |
| B2.2.3 explain the role of the immune system of the human body in defence against disease |  |  |  |  |
| B2.2.4 explain how white blood cells are adapted to their functions in the blood, including what they do and how it helps protect against disease |  |  |  |  |

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| **B2.3 How can we prevent the spread of infection?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B2.3.1 explain how the spread of communicable diseases may be reduced or prevented in animals and plants, to include a minimum of one common human infection, one plant disease and sexually transmitted infections in humans including HIV/AIDS |  |  |  |  |
| B2.3.2 explain the use of vaccines in the prevention of disease, including the use of safe forms of pathogens and the need to vaccinate a large proportion of the population |  |  |  |  |
| **B2.4 How can lifestyle, genes and the environment affect health?** | | | | |
| B2.4.1 a) describe how the interaction of genetic and lifestyle factors can increase or decrease the risk of developing non- communicable human diseases, including cardiovascular diseases, many forms of cancer, some lung and liver diseases and diseases influenced by nutrition, including type 2 diabetes |  |  |  |  |
| B2.4.1 b) describe how to practically investigate the effect of exercise on pulse rate and recovery rate |  |  |  |  |

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| **B2.4 How can lifestyle, genes and the environment affect health?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B2.4.2 use given data to explain the incidence of non-communicable diseases at local, national and global levels with reference to lifestyle factors, including exercise, diet, alcohol and smoking |  |  |  |  |
| B2.4.3 in the context of data related to the causes, spread, effects and treatment of disease:   1. translate information between graphical and numerical forms |  |  |  |  |
| B2.4.3 b) construct and interpret frequency tables and diagrams, bar charts and histograms |  |  |  |  |
| B2.4.3 c) understand the principles of sampling as applied to scientific data |  |  |  |  |
| B2.4.3 d) use a scatter diagram to identify a correlation between two variables |  |  |  |  |
| B2.4.4 describe interactions between different types of disease |  |  |  |  |

| **B2.5 How can we treat disease?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B2.5.1 explain the use of medicines, in the treatment of disease |  |  |  |  |
| B2.5.2 calculate cross-sectional areas of bacterial cultures and of clear zones around antibiotic discs on agar jelly using |  |  |  |  |
| B2.5.3 evaluate different strategies for lowering the risk of cardiovascular disease and treating it, including lifestyle changes, medicines and surgery |  |  |  |  |
| B2.5.4 describe the process of discovery and development of potential new medicines including preclinical and clinical testing |  |  |  |  |

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| **B3 Living together – food and ecosystems** | | | | |
| **B3.1 What happens during photosynthesis?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.1.1 a) describe the process of photosynthesis, including the inputs and outputs of the two main stages and the requirement of light in the first stage, and describe photosynthesis as an endothermic process |  |  |  |  |
| B3.1.1 b) describe practical investigations into the requirements and products of photosynthesis |  |  |  |  |
| B3.1.2 explain how chloroplasts in plant cells are related to photosynthesis |  |  |  |  |
| B3.1.3 a) explain the mechanism of enzyme action including the active site, enzyme specificity and factors affecting the rate of enzyme-catalysed reactions, including substrate concentration, temperature and pH |  |  |  |  |
| B3.1.3 b) describe practical investigations into the effect of substrate concentration, temperature and pH on the rate of enzyme controlled reactions |  |  |  |  |
| **B3.1 What happens during photosynthesis?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.1.4 a) explain the effect of temperature, light intensity and carbon dioxide concentration on the rate of photosynthesis |  |  |  |  |
| B3.1.4 b) describe practical investigations into the effect of environmental factors on the rate of photosynthesis |  |  |  |  |
| **B3.1.5** **use the inverse square law to explain why the rate of photosynthesis changes with distance from a light source** |  |  |  |  |
| **B3.1.6 explain the interaction of temperature, light intensity and carbon dioxide, concentration in limiting the rate of photosynthesis, and use graphs depicting the effects** |  |  |  |  |
| B3.1.7 in the context of the rate of photosynthesis:  a) understand and use simple compound measures such as the rate of a reaction |  |  |  |  |
| B3.1.7 b) translate information between graphical and numerical form |  |  |  |  |

| **B3.1 What happens during photosynthesis?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.1.7 c) plot and draw appropriate graphs selecting appropriate scales for axes |  |  |  |  |
| B3.1.7 d) extract and interpret information from graphs, charts and tables |  |  |  |  |
| **B3.2 How do producers get the substances they need?** | | | | |
| B3.2.1 describe some of the substances transported into and out of photosynthetic organisms in terms of the requirements of those organisms, including oxygen, carbon dioxide, water and mineral ions |  |  |  |  |
| B3.2.2 a) explain how substances are transported into and out of cells through diffusion, osmosis and active transport  Information *Learners are not expected to explain osmosis in terms of water potential* |  |  |  |  |

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| **B3.2 How do produces get the substances they need?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.2.2 b) describe practical investigations into the processes of diffusion and osmosis |  |  |  |  |
| B3.2.3 explain how the partially permeable cell membranes of plant cells and prokaryotic cells are related to diffusion, osmosis and active transport |  |  |  |  |
| B3.2.4 explain how water and mineral ions are taken up by plants, relating to the structure of the root hair cells to their function |  |  |  |  |
| B3.2.5 a) explain how the structure of xylem and phloem are adapted to their functions in the plant |  |  |  |  |
| B3.2.5 b) describe how to use a light microscope to observe the structure of the xylem and phloem |  |  |  |  |

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| **B3.2 How do producers get the substances they need?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.2.6 a) describe the processes of transpiration and translocation, including the structure and function of the stomata  Information *Learners are not expected to describe transpiration in terms of tension or pressure, and are not expected to describe translocation in terms of water potential or hydrostatic pressure* |  |  |  |  |
| B3.2.6 b) describe how to use a light microscope to observe the structure of stomata |  |  |  |  |
| B3.2.6 c) describe how to use a simple potometer |  |  |  |  |
| B3.2.7 a) 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 |  |  |  |  |
| B3.2.7 b) describe practical investigations into the effect of environmental factors on the rate of water uptake by a plant |  |  |  |  |

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| **B3.2 How do producers get the substances they need?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.2.8 in the context of water uptake by plants:  a) use simple compound measures such as rate |  |  |  |  |
| B3.2.8 b) carry out rate calculations |  |  |  |  |
| B3.2.8 c) plot, draw and interpret appropriate graphs |  |  |  |  |
| B3.2.8 d) calculate percentage gain and loss of mass |  |  |  |  |
| **B3.3 How are organisms in an ecosystem interdependent?** | | | | |
| B3.3.1 a) explain the importance of sugars, fatty acids and glycerol, and amino acids in the synthesis and breakdown of carbohydrates, lipids and proteins |  |  |  |  |

| **B3.3 How are organisms in an ecosystem interdependent?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.3.1 b) describe the use of qualitative tests for biological molecules |  |  |  |  |
| B3.3.2 describe photosynthetic organisms as the main producers of food and therefore biomass for life on Earth |  |  |  |  |
| B3.3.3 describe some of the substances transported into organisms in terms of the requirements of those organisms, including dissolved food molecules |  |  |  |  |
| B3.3.4 describe different levels of organisation in an ecosystem from individual organisms to the whole ecosystem |  |  |  |  |
| B3.3.5 explain the importance of interdependence and competition in a community |  |  |  |  |
| B3.3.6 recall that many different substances cycle through the abiotic and biotic components of an ecosystem |  |  |  |  |

| **B3.3 How are organisms in an ecosystem interdependent?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.3.7 explain the importance of the carbon cycle and the water cycle to living organisms |  |  |  |  |
| B3.3.8 explain the role of microorganisms in the cycling of substances through an ecosystem |  |  |  |  |
| B3.3.9 calculate the percentage of mass, in the context of the use and cycling of substances in ecosystems |  |  |  |  |
| **B3.4 How are populations affected by conditions in an ecosystem?** | | | | |
| B3.4.1 explain how some abiotic and biotic factors affect communities, including environmental conditions, toxic chemicals, availability of food and other resources, and the presence of predators and pathogens |  |  |  |  |
| B3.4.2 describe how to carry out a field investigation into the distribution and abundance of organisms in an ecosystem and explain how to determine their numbers in a given area |  |  |  |  |

| **B3.4 How are populations affected by conditions in an ecosystem?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B3.4.3 in the context of data related to organisms within a population:  a) calculate arithmetic means |  |  |  |  |
| B3.4.3 b) use fractions and percentages |  |  |  |  |
| B3.4.3 c) plot and draw appropriate graphs selecting appropriate scales for the axes |  |  |  |  |
| B3.4.3 d) extract and interpret information from charts, graphs and tables |  |  |  |  |

| **B4 Using food and controlling growth** | | | | |
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| **B4.1 What happens during cellular respiration?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B4.1.1 compare the processes of aerobic and anaerobic respiration, including conditions under which they occur, the inputs and outputs, and comparative yields of ATP |  |  |  |  |
| B4.1.2 explain why cellular respiration occurs continuously in all living cells |  |  |  |  |
| B4.1.3 explain how mitochondria in eukaryotic cells (plants and animals) are related to cellular respiration |  |  |  |  |
| B4.1.4 describe cellular respiration as an exothermic process |  |  |  |  |
| B4.1.5 a) describe practical investigations into the effect of different substances on the rate of respiration in yeast |  |  |  |  |
| B4.1.5 b) carry out rate calculations for chemical reactions in the context of cellular respiration |  |  |  |  |

| **B4.2 How do we know about mitochondria and other cell structures?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B4.2.1 explain how electron microscopy has increased our understanding of sub-cellular structures |  |  |  |  |
| B4.2.2 in the context of cells and sub-cellar structures:  a) demonstrate an understanding of number, size and scale and the quantitative relationship between units |  |  |  |  |
| B4.2.2 b) use estimations and explain when they should be used |  |  |  |  |
| B4.2.2 c) **calculate with numbers written in standard form** |  |  |  |  |

| **B4.3 How do organisms grow and develop?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B4.3.1 a) describe the role of the cell cycle in growth, including interphase and mitosis  Information *Learners are not expected to recall intermediate phases* |  |  |  |  |
| B4.3.1 b) describe how to use a light microscope to observe stages of mitosis |  |  |  |  |
| B4.3.2 describe cancer as the result of changes in cells that lead to uncontrolled growth and division |  |  |  |  |
| B4.3.3 explain the role of meiotic cell division in halving the chromosome number to form gametes, including the stages of interphase and two meiotic divisions  Information *Learners are not expected to recall intermediate phases* |  |  |  |  |
| B4.3.4 describe the function of stem cells in embryonic and adult animals and meristems in plants |  |  |  |  |

| **B4.3 How do organisms grow and develop?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B4.3.5 explain the importance of cell differentiation, in which cells become specialised by switching genes off and on to form tissues with particular functions |  |  |  |  |
| **B4.4 Should we use stem cells to treat damage and disease?** | | | | |
| B4.4.1 discuss potential benefits, risks and ethical issues associated with the use of stem cells in medicine |  |  |  |  |

| **B5 The human body – staying alive** | | | | |
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| **B5.1 How do substances get into, out of and around our bodies?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B5.1.1 describe some of the substances transported into and out of the human body in terms of the requirements of cells, including oxygen, carbon dioxide, water, dissolved food molecules and urea |  |  |  |  |
| B5.1.2 explain how the partially permeable cell membranes of animal cells are related to diffusion, osmosis and active transport |  |  |  |  |
| B5.1.3 describe the human circulatory system, including its relationships with the gaseous exchange system, the digestive system and the excretory system |  |  |  |  |
| B5.1.4 explain how the structure of the heart is adapted to its function, including cardiac muscle, chambers and valves |  |  |  |  |
| B5.1.5 explain how the structure of arteries, veins and capillaries are adapted to their functions, including differences in the vessel walls and the presence of valves |  |  |  |  |

| **B5.1 How do substances get into, out of and around our bodies?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B5.1.6 explain how red blood cells and plasma are adapted to their functions in the blood |  |  |  |  |
| B5.1.7 explain the need for exchanges surfaces and a transport system in multicellular organisms in terms of surface area:volume ratio |  |  |  |  |
| B5.1.8 calculate surface area:volume ratios |  |  |  |  |
| **B5.2 How does the nervous system help us respond to changes?** | | | | |
| B5.2.1 explain how the components of the nervous system work together to enable it to function, including sensory receptors, sensory neurons, the CNS, motor neurons and effectors |  |  |  |  |
| B5.2.2 explain how the structure of nerve cells and synapses relate to their functions  Information *Learners are not expected to explain nerve impulse transmission in terms of membrane potentials* |  |  |  |  |

| **B5.2 How does the nervous system help us respond to changes?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B5.2.3 a) explain how the structure of a reflex arc, including the relay neuron, is related to its function |  |  |  |  |
| B5.2.3 b) describe practical investigations into reflex actions |  |  |  |  |
| **B5.3 How do hormones control responses in the human body?** | | | | |
| B5.3.1 describe the principles of hormonal coordination and control by the human endocrine system |  |  |  |  |
| **B5.3.2 explain the roles of thyroxine and adrenaline in the body, including thyroxine as an example of a negative feedback system** |  |  |  |  |
| **B5.4 Why do we need to maintain a constant internal environment?** | | | | |
| B5.4.1 explain the importance of maintaining a constant internal environment in response to internal and external change |  |  |  |  |

| **B5.4 Why do we need to maintain a constant internal environment?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B5.4.2 in the context of maintaining a constant internal environment:   1. extract and interpret data from graphs, charts and tables |  |  |  |  |
| B5.4.2 b) translate information between numerical and graphical forms |  |  |  |  |
| **B5.5 What role do hormones play in human reproduction?** | | | | |
| B5.5.1 describe the role of hormones in human reproduction, including the control of the menstrual cycle |  |  |  |  |
| B5.5.2 **explain the interactions of FSH, LH, oestrogen and progesterone in the control of the menstrual cycle** |  |  |  |  |
| B5.5.3 explain the use of hormones in contraception and evaluate hormonal and non-hormonal methods of contraception |  |  |  |  |
| B5.5.4 **explain the use of hormones in modern reproductive technologies to treat infertility** |  |  |  |  |

| **B5.6 What can happen when organs and control systems stop working?** | | | | |
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| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B5.6.1 explain how insulin controls the blood sugar level in the body |  |  |  |  |
| B5.6.2 **explain how glucagon and insulin work together to control the blood sugar level in the body** |  |  |  |  |
| B5.6.3 compare type 1 and type 2 diabetes and explain how they can be treated |  |  |  |  |

| **B6 Life on Earth – past, present and future** | | | | |
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| **B6.1 How was the theory of evolution developed?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B6.1.1 state that there is usually extensive genetic variation within a population of a species |  |  |  |  |
| B6.1.2 recall that genetic variants arise from mutations, and that most have no effect on the phenotype, some influence on phenotype and a very few determine phenotype |  |  |  |  |
| B6.1.3 explain how evolution occurs through natural selection of variants that give rise to phenotypes better suited to their environment |  |  |  |  |
| B6.1.4 explain the importance of competition in a community, with regard to natural selection |  |  |  |  |
| B6.1.5 describe evolution as a change in the inherited characteristics of a population over a number of generations through a process of natural selection which may result in the formation of new species |  |  |  |  |

| **B6.1 How was the theory of evolution developed?** | | | | |
| --- | --- | --- | --- | --- |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B6.1.6 explain the impact of the selective breeding of food plants and domesticated animals |  |  |  |  |
| B6.1.7 describe how fossils provide evidence for evolution |  |  |  |  |
| B6.1.8 describe modern examples of evidence for evolution including antibiotic resistance in bacteria |  |  |  |  |
| **B6.2 How does our understanding of biology help us classify the diversity of organisms on Earth?** | | | | |
| B6.2.1 describe the impact of developments in biology on classification systems, including the use of DNA analysis to classify organisms |  |  |  |  |
| **B6.3 Why is biodiversity threatened and how can we protect it?** | | | | |
| B6.3.1 describe both positive and negative human interactions within ecosystems and explain their impact on biodiversity |  |  |  |  |
| B6.3.2 explain some of the benefits and challenges of maintaining local and global biodiversity |  |  |  |  |

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| **B6.3 Why is biodiversity threatened and how can we protect it?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| B6.3.3 extract and interpret information related to biodiversity from charts, graphs and tables |  |  |  |  |

**Chemistry**

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| **C1 Air and water** | | | | |
| **C1.1 How has the Earth’s atmosphere changed over time, and why?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C1.1.1 recall and explain the main features of the particle model in terms of the states of matter and change of state, distinguishing between physical and chemical changes and recognise that the particles themselves do not have the same properties as the bulk substances |  |  |  |  |
| C1.1.2 **explain the limitations of the particle model in relation to changes of state when particles are represented by inelastic spheres** |  |  |  |  |
| C1.1.3 use ideas about energy transfers and the relative strength of forces between particles to explain the different temperatures at which changes of state occur |  |  |  |  |
| C1.1.4 use data to predict states of substances under given conditions |  |  |  |  |

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| **C1.1 How has the Earth’s atmosphere changed over time, and why?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C1.1.5 interpret evidence for how it is thought the atmosphere was originally formed |  |  |  |  |
| C1.1.6 describe how it is thought an oxygen-rich atmosphere developed over time |  |  |  |  |
| C1.1.7 describe the major sources of carbon monoxide and particulates (incomplete combustion), sulfur dioxide (combustion of sulfur impurities in fuels), oxides of nitrogen (oxidation of nitrogen at high temperatures and further oxidation in the air) |  |  |  |  |
| C1.1.8 explain the problems caused by increased amounts of these substances and describe approaches to decreasing the emissions of these substances into the atmosphere including the use of catalytic converters, low sulfur petrol and gas scrubbers to decrease emissions |  |  |  |  |
| C1.1.9 use chemical symbols to write the formulae of elements and simple covalent compounds |  |  |  |  |

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| **C1.1 How has the Earth’s atmosphere changed over time, and why?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C1.1.10 use the names and symbols of common elements and compounds and the principle of conservation of mass to write formulae and balanced chemical equations |  |  |  |  |
| C1.1.11 use arithmetic computations and ratios when balancing equations |  |  |  |  |
| C1.1.12 describe tests to identify oxygen, hydrogen and carbon dioxide |  |  |  |  |
| C1.1.13 explain oxidation in terms of gain of oxygen |  |  |  |  |
| **C1.2 Why are there temperature changes in chemical reactions?** | | | | |
| C1.2.1 distinguish between endothermic and exothermic reactions on the basis of the temperature change of the surroundings |  |  |  |  |

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| **C1.2 Why are there temperature changes in chemical reactions?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C1.2.2 draw and label a reaction profile for an exothermic and an endothermic reaction, identifying activation energy |  |  |  |  |
| C1.2.3 explain activation energy as the energy needed for a reaction to occur |  |  |  |  |
| C1.2.4 interpret charts and graphs when dealing with reaction profiles |  |  |  |  |
| C1.2.5 **calculate energy changes in a chemical reaction by considering bond breaking and bond making energies** |  |  |  |  |
| C1.2.6 carry out arithmetic computations when calculating energy changes |  |  |  |  |

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| **C1.3 What is the evidence for climate change, why is it occurring?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C1.3.1 describe the greenhouse effect in terms of the interaction of radiation with matter |  |  |  |  |
| C1.3.2 evaluate the evidence for additional anthropogenic causes of climate change, including the correlation between change in atmospheric carbon dioxide concentration and the consumption of fossil fuels, and describe the uncertainties in the evidence base |  |  |  |  |
| C1.3.3 describe the potential effects of increased levels of carbon dioxide and methane on the Earth’s climate, including where crops can be grown, extreme weather patterns, melting of polar ice and flooding of low land |  |  |  |  |
| C1.3.4 describe how the effects of increased levels of carbon dioxide and methane may be mitigated, including consideration of scale, risk and environmental implications |  |  |  |  |
| C1.3.5 extract and interpret information from charts, graphs and tables |  |  |  |  |

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| **C1.3 What is the evidence for climate change, why is it occurring?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C1.3.6 use orders of magnitude to evaluate the significance of data |  |  |  |  |
| **C1.4 How can scientists help improve the supply of potable water?** | | | | |
| C1.4.1 describe the principal methods for increasing the availability of potable water, in terms of the separation techniques used, including the ease of treating waste, ground and salt water including filtration and membrane filtration; aeration, use of bacteria; chlorination and distillation (for salt water) |  |  |  |  |
| C1.4.2 describe a test to identify chlorine (using blue litmus paper) |  |  |  |  |

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| **C2 Chemical patterns** | | | | |
| **C2.1 How have our ideas about atoms developed over time?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.1.1 describe how and why the atomic model has changed over time to include the main ideas of Dalton, Thomson, Rutherford and Bohr |  |  |  |  |
| C2.1.2 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 |  |  |  |  |
| C2.1.3 recall relative charges and approximate relative masses of protons, neutrons and electrons |  |  |  |  |
| C2.1.4 estimate the size and scale of atoms relative to other particles |  |  |  |  |
| C2.1.5 recall the typical size (order of magnitude) of atoms and small molecules |  |  |  |  |
| C2.1.6 relate size and scale of atoms to objects in the physical world |  |  |  |  |

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| **C2.1 How have our ideas about atoms developed over time?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.1.7 calculate numbers of protons, neutrons and electrons in atoms, given atomic number and mass number of isotopes or by extracting data from the Periodic Table |  |  |  |  |
| **C2.2 What does the Periodic Table tell us about the elements?** | | | | |
| C2.2.1 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 |  |  |  |  |
| C2.2.2 describe how Mendeleev organised the elements based on their properties and relative atomic masses |  |  |  |  |
| C2.2.3 describe how discovery of new elements and the ordering elements by atomic number supports Mendeleev’s decisions to leave gaps and reorder some elements |  |  |  |  |

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| **C2.2 What does the Periodic Table tell us about the elements?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.2.4 describe metals and non-metals and explain the differences between them on the basis of their characteristic physical and chemical properties, including melting point, boiling point, state and appearance, density, formulae of compounds, relative reactivity and electrical conductivity |  |  |  |  |
| C2.2.5 recall the simple properties of Group 1 elements including their reaction with moist air, water and chlorine |  |  |  |  |
| C2.2.6 recall the simple properties of Group 7 elements including their states and colours at room temperature and pressure, their colours as gases, their reactions with Group 1 elements and their displacement reactions with other metal halides |  |  |  |  |
| C2.2.7 predict possible reactions and probable reactivity of elements from their positions in the Periodic Table |  |  |  |  |

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| **C2.2 What does the Periodic Table tell us about the elements?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.2.8 describe experiments to identify the reactivity pattern of Group 7 elements including displacement reactions |  |  |  |  |
| C2.2.9 describe experiments to identify the reactivity pattern of Group 1 elements |  |  |  |  |
| **C2.3 How do metals and non-metals combine to form compounds?** | | | | |
| C2.3.1 recall the simple properties of Group 0 including their low melting and boiling points, their state at room temperature and pressure and their lack of chemical reactivity |  |  |  |  |
| C2.3.2 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 |  |  |  |  |
| C2.3.3 explain how the reactions of elements are related to the arrangement of electrons in their atoms and hence to their atomic number |  |  |  |  |

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| **C2.3 How do metals and non-metals combine to form compounds?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.3.4 explain how the atomic structure of metals and non-metals relates to their position in the Periodic Table |  |  |  |  |
| C2.3.5 describe the nature and arrangement of chemical bonds in ionic compounds |  |  |  |  |
| C2.3.6 explain ionic bonding in terms of electrostatic forces and transfer of electrons |  |  |  |  |
| C2.3.7 calculate numbers of protons, neutrons and electrons in atoms and ions, given atomic number and mass number or by using the Periodic Table |  |  |  |  |
| C2.3.8 construct dot and cross diagrams for simple ionic substances |  |  |  |  |
| C2.3.9 explain how the bulk properties of ionic materials are related to the type of bonds they contain |  |  |  |  |

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| **C2.3 How do metals and non-metals combine to form compounds?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.3.10 use ideas about energy transfers and the relative strength of attraction between ions to explain the melting points of ionic compounds compared to substances with other types of bonding |  |  |  |  |
| C2.3.11 describe the limitations of particular representations and models of ions and ionically bonded compounds, including dot and cross diagrams, and 3-D representations |  |  |  |  |
| C2.3.12 translate information between diagrammatic and numerical forms and represent three dimensional shapes in two dimensions and vice versa when looking at chemical structures for ionic compounds |  |  |  |  |
| **C2.4 How are equations used to represent chemical reactions?** | | | | |
| C2.4.1 use chemical symbols to write the formulae of elements and simple covalent and ionic compounds |  |  |  |  |

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| **C2.4 How are equations used to represent chemical reactions?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C2.4.2 use the formulae of common ions to deduce the formula of Group 1 and Group 7 compounds |  |  |  |  |
| C2.4.3 use the names and symbols of the first 20 elements, Groups 1, 7 and 0 and other common elements from a supplied Periodic Table to write formulae and balanced chemical equations where appropriate |  |  |  |  |
| C2.4.4 describe the physical states of products and reactants using state symbols (s, l, g and aq) |  |  |  |  |

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| **C3 Chemical of the natural environment** | | | | |
| **C3.1 How are the atoms held together in a metal?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C3.1.1 describe the nature and arrangement of chemical bonds in metals |  |  |  |  |
| C3.1.2 explain how the bulk properties of metals are related to the type of bonds they contain |  |  |  |  |
| **C3.2 How are metals with different reactivities extracted?** | | | | |
| C3.2.1 deduce an order of reactivity of metals based on experimental results including reactions with water, dilute acid and displacement reactions with other metals |  |  |  |  |
| C3.2.2 explain how the reactivity of metals with water or dilute acids is related to the tendency of the metal to form its positive ion to include potassium, sodium, calcium, aluminium, magnesium, zinc, iron, lead, [hydrogen], copper, silver |  |  |  |  |

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| **C3.2 How are metals with different reactivities extracted?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C3.2.3 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 ionic equations** |  |  |  |  |
| C3.2.4 explain, using the position of carbon in the reactivity series, the principles of industrial processes used to extract metals, including the extraction of zinc |  |  |  |  |
| C3.2.5 explain why electrolysis is used to extract some metals from their ores |  |  |  |  |
| C3.2.6 **evaluate alternative biological methods of metal extraction (bacterial and phytoextraction)** |  |  |  |  |
| **C3.3 What are electrolytes and what happens during electrolysis?** | | | | |
| C3.3.1 describe electrolysis in terms of the ions present and reactions at the electrodes |  |  |  |  |
| C3.3.2 predict the products of electrolysis of binary ionic compounds in the molten state |  |  |  |  |
| **C3.3 What are electrolytes and what happens during electrolysis?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C3.3.3 recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes |  |  |  |  |
| C3.3.4 **use the names and symbols of common elements and compounds and the principle of conservation of mass to write half equations** |  |  |  |  |
| C3.3.5 **explain reduction and oxidation in terms of gain or loss of electrons, identifying which species are oxidised and which are reduced** |  |  |  |  |
| C3.3.6 explain how electrolysis is used to extract some metals from their ores including the extraction of aluminium |  |  |  |  |
| C3.3.7 describe competing reactions in the electrolysis of aqueous solutions of ionic compounds in terms of the different species present, including the formation of oxygen, chlorine and the discharge of metals or hydrogen linked to their relative reactivity |  |  |  |  |

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| **C3.3 What are electrolytes and what happens during electrolysis?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C3.3.8 describe the technique of electrolysis of an aqueous solution of a salt |  |  |  |  |
| **C3.4 Why is crude oil important as a source of new materials?** | | | | |
| C3.4.1 recall that crude oil is a main source of hydrocarbons and is a feedstock for the petrochemical industry |  |  |  |  |
| C3.4.2 explain how modern life is crucially dependent upon hydrocarbons and recognise that crude oil is a finite resource |  |  |  |  |
| C3.4.3 describe and explain the separation of crude oil by fractional distillation |  |  |  |  |
| C3.4.4 describe the fractions of crude oil as largely a mixture of compounds of formula  which are members of the alkane homologous series |  |  |  |  |

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| **C3.4 Why is crude oil important as a source of new materials?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C3.4.5 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 |  |  |  |  |
| C3.4.6 deduce the empirical formula of a compound from the relative numbers of atoms present or from a model or diagram and vice versa |  |  |  |  |
| C3.4.7 use arithmetic computation and ratio when determining empirical formulae |  |  |  |  |
| C3.4.8 describe the arrangement of chemical bonds in simple molecules |  |  |  |  |
| C3.4.9 explain covalent bonding in terms of the sharing of electrons |  |  |  |  |
| C3.4.10 construct dot and cross diagrams for simple covalent substances |  |  |  |  |

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| **C3.4 Why is crude oil important as a source of new materials?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C3.4.11 represent three dimensional shapes in two dimensions and vice versa when looking at chemical structures for simple molecules |  |  |  |  |
| C3.4.12 describe the limitations of dot and cross diagrams, ball and stick models and two and three dimensional representations when used to represent simple molecules |  |  |  |  |
| C3.4.13 translate information between diagrammatic and numerical forms |  |  |  |  |
| C3.4.14 explain how the bulk properties of simple molecules are related to the covalent bonds they contain and their bond strengths in relation to intermolecular forces |  |  |  |  |
| C3.4.15 describe the production of materials that are more useful by cracking |  |  |  |  |
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| **C4 Material choices** | | | | |
| **C4.1 How is data used to choose a material for a particular use?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C4.1.1 compare quantitatively the physical properties of glass and clay ceramics, polymers, composites and metals, including melting point, softening temperature (for polymers), electrical conductivity, strength (in tension or compression), stiffness, flexibility, brittleness, hardness, density, ease of reshaping |  |  |  |  |
| C4.1.2 explain how the properties of materials are related to their uses and select appropriate materials given details of the usage required |  |  |  |  |
| **C4.2 How do bonding and structure affect properties of materials?** | | | | |
| C4.2.1 explain how the bulk properties of materials (including strength, melting point, electrical and thermal conductivity, brittleness, flexibility, hardness and ease of reshaping) 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, recognising that the atoms themselves do not have these properties |  |  |  |  |

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| **C4.2 How do bonding and structure affect properties of materials?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C4.2.2 recall that carbon can form four covalent bonds |  |  |  |  |
| C4.2.3 explain that the vast array of natural and synthetic organic compounds occurs due to the ability of carbon to form families of similar compounds, chains and rings |  |  |  |  |
| C4.2.4 describe the nature and arrangement of chemical bonds in polymers with reference to their properties including strength, flexibility or stiffness, hardness and melting point of the solid |  |  |  |  |
| C4.2.5 describe the nature and arrangement of chemical bonds in giant covalent structures |  |  |  |  |
| C4.2.6 explain the properties of diamond and graphite in terms of their structures and bonding, include melting point, hardness and (for graphite) conductivity and lubricating action |  |  |  |  |

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| **C4.2 How do bonding and structure affect properties of materials?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C4.2.7 represent three dimensional shapes in two dimensions and vice versa when looking at chemical structures e.g. allotropes of carbon |  |  |  |  |
| C4.2.8 describe and compare the nature and arrangement of chemical bonds in ionic compounds, simple molecules, giant covalent structures, polymers and metals |  |  |  |  |
| **C4.3 Why are nanoparticles so useful?** | | | | |
| C4.3.1 compare ‘nano’ dimensions to typical dimensions of atoms and molecules |  |  |  |  |
| C4.3.2 describe the surface area to volume relationship for different-sized particles and describe how this affects properties |  |  |  |  |
| C4.3.3 describe how the properties of nanoparticulate materials are related to their uses including properties which arise from their size, surface area and arrangement of atoms in tubes or rings |  |  |  |  |
| C4.3.4 explain the properties fullerenes and graphene in terms of their structures |  |  |  |  |
| **C4.3 Why are nanoparticles so useful?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C4.3.5 explain the possible risks associated with some nanoparticulate materials including:  a) possible effects on health due to their size and surface area  b) reasons that there is more data about uses of nanoparticles than about possible health effects  c) the relative risks and benefits of using nanoparticles for different purposes |  |  |  |  |
| C4.3.6 estimate size and scale of atoms and nanoparticles including the ideas that:   1. nanotechnology is the use and control of structures that are very small (1 to 100 nanometres in size) 2. data expressed in nanometres is used to compare the sizes of nanoparticles, atoms and molecules |  |  |  |  |
| C4.3.7 interpret, order and calculate with numbers written in standard form when dealing with nanoparticles |  |  |  |  |

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| **C4.3 Why are nanoparticles so useful?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C4.3.8 use ratios when considering relative sizes and surface area to volume comparisons |  |  |  |  |
| C4.3.9 calculate surface areas and volumes of cubes |  |  |  |  |
| **C4.4 What happens to products at the end of their useful life?** | | | | |
| C4.4.1 explain reduction and oxidation in terms of loss or gain of oxygen, identifying which species are oxidised and which are reduced |  |  |  |  |
| C4.4.2 **explain reduction and oxidation in terms of gain or loss of electrons, identifying which species are oxidised and which are reduced** |  |  |  |  |

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| **C4.4 What happens to products at the end of their useful life?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C4.4.3 describe the basic principles in carrying out a life-cycle assessment of a material or product including:   1. the use of water, energy and the environmental impact of each stage in a life cycle, including its manufacture, transport and disposal 2. incineration, landfill and electricity generation schemes 3. biodegradable and non-biodegradable materials |  |  |  |  |
| C4.4.4 interpret data from a life-cycle assessment of a material or product |  |  |  |  |
| C4.4.5 describe the process where PET drinks bottles are reused and recycled for different uses and explain why this is viable |  |  |  |  |
| C4.4.6 evaluate factors that affect decisions on recycling with reference to products made from crude oil and metal ores |  |  |  |  |

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| **C5 Chemical analysis** | | | | |
| **C5.1 How are chemicals separated and tested for purity?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C5.1.1 explain that many useful materials are formulations of mixtures |  |  |  |  |
| C5.1.2 explain what is meant by the purity of a substance, distinguishing between the scientific and everyday use of the term ‘pure’ |  |  |  |  |
| C5.1.3 use melting point data to distinguish pure from impure substances |  |  |  |  |
| C5.1.4 recall that chromatography involves a stationary and a mobile phase and that separation depends on the distribution between the phases |  |  |  |  |
| C5.1.5 interpret chromatograms, including calculating Rf values |  |  |  |  |

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| **C5.1 How are chemicals separated and tested for purity?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C5.1.6 suggest chromatographic methods for distinguishing pure from impure substances including the use of:   1. paper chromatography 2. aqueous and non-aqueous solvents 3. locating agents |  |  |  |  |
| C5.1.7 describe, explain and exemplify the processes of filtration, crystallisation, simple distillation, and fractional distillation |  |  |  |  |
| C5.1.8 suggest suitable purification techniques given information about the substances involved |  |  |  |  |
| **C5.2 How are the amounts of substances in reactions calculated?** | | | | |
| C5.2.1 recall and use the law of conservation of mass |  |  |  |  |
| C5.2.2 explain any observed changes in mass in non-enclosed systems during a chemical reaction and explain them using the particle model |  |  |  |  |

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| **C5.2 How are the amounts of substances in reactions calculated?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C5.2.3 calculate relative formula masses of species separately and in a balance chemical equation |  |  |  |  |
| C5.2.4 **recall and use the definitions of the Avogadro constant (in standard form) and of the mole** |  |  |  |  |
| **C5.2.5 explain how the mass of a given substance is related to the amount of that substance in moles and vice versa and use the relationship:**  **number of moles = mass of substance (g)**  **relative formula mass (g** |  |  |  |  |
| **C5.2.6 deduce the stoichiometry of an equation from the masses of reactants and products and explain the effect of a limiting quantity of a reactant** |  |  |  |  |
| **C5.2.7 use a balanced equation to calculate masses of reactants or products** |  |  |  |  |

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| **C5.2 How are the amounts of substances in reactions calculated?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C5.2.8 use arithmetic computation, ratio, percentage and multistep calculations throughout quantitative chemistry |  |  |  |  |
| **C5.2.9 carry out calculations with numbers written in standard form when using the Avogadro constant** |  |  |  |  |
| C5.2.10 change the subject of a mathematical equation |  |  |  |  |
| **C5.3 How are the amounts of chemicals in solution measured?** | | | | |
| **C5.3.1** **explain how the mass of a solute and the volume of the solution is related to the concentration of the solution and calculate concentration using the formula: concentration (g/dm3) = mass of solute (g) volume (dm3)** |  |  |  |  |

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| **C5.3 How are the amounts of chemicals in solution measured?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **C5.3.2 explain how the concentration of a solution in mol/dm3 is related to the mass of the solute and the volume of the solution and calculate the molar concentration using the formula: concentration (mol/dm3) =**  **numbers of moles of solute volume (dm3)** |  |  |  |  |
| C5.3.3 describe neutralisation as acid reacting with alkali to form a salt plus water including the common laboratory acids hydrochloric acid, nitric acid and sulfuric acid and the common alkalis, the hydroxides of sodium, potassium and calcium |  |  |  |  |
| C5.3.4 recall that acids form hydrogen ions when they dissolve in water and solutions of alkalis contain hydroxide ions |  |  |  |  |

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| **C5.3 How are the amounts of chemicals in solution measured?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C5.3.5 recognise that aqueous neutralisation reactions can be generalised to hydrogen ions reacting with hydroxide ions to form water |  |  |  |  |
| C5.3.6 describe and explain the procedure for a titration to give precise, accurate, valid and repeatable results |  |  |  |  |
| C5.3.7 evaluate the quality of data from titrations |  |  |  |  |

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| **C6 Making useful chemicals** | | | | |
| **C6.1 What useful products can be made from acids?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C6.1.1 recall that acids react with some metals and with carbonates and write equations predicting products from given reactants |  |  |  |  |
| C6.1.2 describe practical procedures to make salts to include appropriate use of filtration, evaporation, crystallisation and drying |  |  |  |  |
| C6.1.3 use the formulae of common ions to deduce the formula of a compound |  |  |  |  |
| C6.1.4 recall that relative acidity and alkalinity are measured by pH including the use of universal indicator and pH meters |  |  |  |  |
| **C6.1.5 use and explain the terms dilute and concentrated (amount of substance) and weak and strong (degree of ionisation) in relation to acids including differences in reactivity with metals and carbonates** |  |  |  |  |

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| **C6.1 What useful products can be made from acids?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **C6.1.6 use the idea that as hydrogen ion concentration increases by a factor of ten the pH value of a solution decreases by one** |  |  |  |  |
| **C6.1.7 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)** |  |  |  |  |
| **C6.2 How do chemists control the rate of reactions?** | | | | |
| C6.2.1 describe the effect on rate of reaction of changes in temperature, concentration, pressure, and surface area |  |  |  |  |
| C6.2.2 explain the effects on rates of reaction of changes in temperature, concentration and pressure in terms of frequency and energy of collision between particles |  |  |  |  |
| C6.2.3 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 |  |  |  |  |
| **C6.2 How do chemists control the rate of reactions?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C6.2.4 describe the characteristics of catalysts and their effect on rates of reaction |  |  |  |  |
| C6.2.5 identify catalysts in reactions |  |  |  |  |
| C6.2.6 explain catalytic action in terms of activation energy |  |  |  |  |
| C6.2.7 suggest practical methods for determining the rate of a given reaction including:  for reactions that produce gases:   1. gas syringes or collection over water can be used to measure the volume of gas produced 2. mass change can be followed using a balance   **measurement of physical factors:**   1. **colour change** 2. **formation of a precipitate** |  |  |  |  |
| C6.2.8 interpret rate of reaction graphs |  |  |  |  |
| C6.2.9 use arithmetic computation and ratios when measuring rates of reaction |  |  |  |  |
| **C6.2 How do chemists control the rate of reactions?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C6.2.10 draw and interpret appropriate graphs from data to determine rate of reaction |  |  |  |  |
| C6.2.11 determine gradients of graphs as a measure of rate of change to determine rate |  |  |  |  |
| C6.2.12 use proportionality when comparing factors affecting rate of reaction |  |  |  |  |
| C6.2.13 describe the use of enzymes as catalysts in biological systems and some industrial processes |  |  |  |  |
| **C6.3 What factors affect the yield of chemical reactions?** | | | | |
| C6.3.1 recall that some reactions may be reversed by altering the reaction conditions including:   1. reversible reactions are shown by the **⇌** symbol 2. reversible reactions (in closed systems) do not reach 100% yield |  |  |  |  |

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| **C6.3 What factors affect the yield of chemical reactions?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| C6.3.2 recall that dynamic equilibrium occurs when the rates of forward and reverse reactions are equal |  |  |  |  |
| **C6.3.3 predict the effect of changing reaction conditions (concentration, temperature and pressure) on equilibrium position and suggest appropriate conditions to produce a particular product, including:**   1. **catalysts increase rate but do not affect yield** 2. **the disadvantages of using very high temperatures or pressures** |  |  |  |  |

**PHYSICS**

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| **P1 Radiation and waves** | | | | |
| **P1.1 What are the risks and benefits of using radiations?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.1.1 describe the main groupings of the electromagnetic spectrum – radio, microwave, infrared, visible (red to violet), ultraviolet, X- rays and gamma rays, that these range from long to short wavelengths, from low to high frequencies, and from low to high energies |  |  |  |  |
| P1.1.2 recall that our eyes can only detect a very limited range of frequencies in the electromagnetic spectrum |  |  |  |  |
| P1.1.3 recall that all electromagnetic radiation is transmitted through space with the same very high (but finite) speed |  |  |  |  |
| P1.1.4 explain, with examples, that electromagnetic radiation transfers energy from source to absorber |  |  |  |  |
| P1.1.5 recall that different substances may absorb, transmit, or reflect electromagnetic radiation in ways that depend on wavelength |  |  |  |  |

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| **P1.1 What are the risks and benefits of using radiations?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.1.6 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 |  |  |  |  |
| P1.1.7 recall that changes in molecules, atoms and nuclei can generate and absorb radiations over a wide frequency range, including:   1. gamma rays are emitted from the nuclei of atoms 2. X-rays, ultraviolet and visible light are generated when electrons in atoms lose energy 3. high energy ultraviolet, gamma rays and X-rays have enough energy to cause ionisation when absorbed by some atoms 4. ultraviolet is absorbed by oxygen to produce ozone, which also absorbs ultraviolet, protecting life on Earth 5. infrared is emitted and absorbed by molecules |  |  |  |  |

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| **P1.1 What are the risks and benefits of using radiations?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.1.8 describe how ultra-violet radiation, X-rays and gamma rays can have hazardous effects, notably on human bodily tissues |  |  |  |  |
| P1.1.9 give examples of some practical uses of electromagnetic radiation in the radio, microwave, infrared, visible, ultraviolet, X-ray and gamma ray regions of the spectrum |  |  |  |  |
| **P1.1.10 recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits** |  |  |  |  |
| **P1.2 What is climate change and what is the evidence for it?** | | | | |
| P1.2.1 explain that all bodies emit radiation, and that the intensity and wavelength distribution of any emission depends on their temperatures |  |  |  |  |
| **P1.2.2 explain how the temperature of a body is related to the balance between incoming radiation, absorbed radiation and radiation emitted; illustrate this balance, using everyday examples including examples of factors which determine the temperature of the Earth** |  |  |  |  |
| **P1.3 How do waves behave?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.3.1 describe wave motion in terms of amplitude, wavelength, frequency and period |  |  |  |  |
| P1.3.2 describe evidence that for both ripples on water surfaces and sound waves in air, it is the wave and not the water or air itself that travels |  |  |  |  |
| P1.3.3 describe the difference between transverse and longitudinal waves |  |  |  |  |
| P1.3.4 describe how waves on a rope are an example of transverse waves whilst sound waves in air are longitudinal waves |  |  |  |  |
| P1.3.5 define wavelength and frequency |  |  |  |  |
| P1.3.6 recall and apply the relationship between speed, frequency and wavelength to waves, including waves on water, sound waves and across the electromagnetic spectrum:  wave speed (m/s) = frequency (HZ) × wavelength (m) |  |  |  |  |

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| **P1.3 How do waves behave?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P1.3.7 a) describe how the speed of ripples on water surfaces and the speed of sound waves in air may be measured  b) describe how to use a ripple tank to measure the speed/frequency and wavelength of a wave |  |  |  |  |
| P1.3.8 a) describe the effects of reflection and refraction of waves at material interfaces  b) describe how to measure the refraction of light through a prism  c) describe how to investigate the reflection of light off a plane mirror |  |  |  |  |
| **P1.3.9 recall that waves travel in different substances at different speeds and that these speeds may vary with wavelength** |  |  |  |  |
| **P1.3.10 explain how refraction is related to differences in the speed of the waves in different substances** |  |  |  |  |
| P1.3.11 recall that light is an electromagnetic wave |  |  |  |  |
| P1.3.12 recall that electromagnetic waves are transverse |  |  |  |  |
| **P2 Sustainable energy** | | | | |
| **P2.1 How much energy do we use?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P2.1.1 describe how energy in chemical stores in batteries, or in fuels at the power station, is transferred by an electric current, doing work on domestic devices, such as motors or heaters |  |  |  |  |
| P2.1.2 explain, with reference to examples, the relationship between the power ratings for domestic electrical appliances, the time for which they are in use and the changes in stored energy when they are in use |  |  |  |  |
| P2.1.3 recall and apply the following equation in the context of energy transfers by electrical appliances:  energy transferred (J, kWh) = power (W, kW) × time (s, h) |  |  |  |  |
| P2.1.4 describe, with examples, where there are energy transfers in a system, that there is no net change to the total energy of a closed system  *qualitative only* |  |  |  |  |

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| **P2.1 How much energy do we use?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P2.1.5 describe, with examples, system changes, where energy is dissipated, so that it is stored in less useful ways |  |  |  |  |
| P2.1.6 explain ways of reducing unwanted energy transfer e.g. through lubrication, thermal insulation |  |  |  |  |
| P2.1.7 describe the effects, on the rate of cooling of a building, of thickness and thermal conductivity of its walls  *qualitative only* |  |  |  |  |
| P2.1.8 recall and apply the equation:  efficiency = useful energy transferred ÷ total energy transferred  to calculate energy efficiency for any energy transfer and **describe ways to increase efficiency** |  |  |  |  |
| P2.1.9 interpret and construct Sankey diagrams to show understanding that energy is conserved |  |  |  |  |

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| **P2.2 How can electricity be generated?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P2.2.1 describe the main energy resources available for use on Earth (including fossil fuels, nuclear fuel, biofuel, wind, hydroelectricity, the tides and the Sun) |  |  |  |  |
| P2.2.2 explain the differences between renewable and non-renewable energy resources |  |  |  |  |
| P2.2.3 compare the ways in which the main energy resources are used to generate electricity |  |  |  |  |
| P2.2.4 recall that the domestic supply in the UK is a.c., at 50 Hz and about 230 volts and explain the difference between direct and alternating voltage |  |  |  |  |
| P2.2.5 recall that, in the National Grid, transformers are used to transfer electrical power at high voltages from power stations, to the network and then used again to transfer power at lower voltages in each locality for domestic use |  |  |  |  |

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| **P2.2 How can electricity be generated?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P2.2.6 recall the differences in function between the live, neutral and earth mains wires, and the potential differences between these wires; hence 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 any earthed object |  |  |  |  |
| P2.2.7 explain patterns and trends in the use of energy resources in domestic contexts, workplace contexts, and national contexts |  |  |  |  |

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| **P3 Electric circuits** | | | | |
| **P3.1 What determines the current in an electric circuit?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.1.1 recall that current is a rate of flow of charge, that for a charge to flow, a source of potential difference and a closed circuit are needed and that a current has the same value at any point in a single closed loop |  |  |  |  |
| P3.1.2 recall and use the relationship between quantity of charge, current and time:  charge (C) = current (A) × time (s) |  |  |  |  |
| P3.1.3 recall that current (*I*) depends on both resistance (*R*) and potential difference (*V*) and the units in which these quantities are measured |  |  |  |  |
| P3.1.4 a) recall and apply the relationship between *I*, *R*, and *V*, to calculate the currents, potential differences and resistances in d.c. series circuits:  potential difference (V) = current (A) × resistance (Ω).  b) describe an experiment to investigate the resistance of a wire and be able to draw the circuit diagram of the circuit used |  |  |  |  |
| **P3.1 What determines the current in an electric circuit?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.1.5 recall that for some components the value of *R* remains constant (fixed resistors) but that in others it can change as the current changes (e.g. heating elements, lamp filaments) |  |  |  |  |
| P3.1.6 a) use graphs to explore whether circuit elements are linear or non-linear and relate the curves produced to their function and properties  b) describe experiments to investigate the  *I*-*V* characteristics of circuit elements. To include lamps, diodes, LDRs and thermistors. Be able to draw circuit diagrams for the circuits used |  |  |  |  |
| P3.1.7 represent circuits with the conventions of positive and negative terminals, and the symbols that represent common circuit elements, filament lamps, diodes, LDRs and thermistors, switches and fixed and variable resistors |  |  |  |  |

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| **P3.2 How do series and parallel circuits work?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.2.1 relate the potential difference between two points in the circuit to the work done on, or by, a given amount of charge as it moves between these points  potential difference (V) = work done (energy transferred) (J) ÷ charge (C) |  |  |  |  |
| P3.2.2 a) describe the difference between series and parallel circuits: to include ideas about how the current through each component and the potential difference across each component is affected by a change in resistance of a component.  b) describe how to practically investigate the brightness of bulbs in series and parallel circuits. Be able to draw circuit diagrams for the circuits used |  |  |  |  |
| P3.2.3 explain, why, if two resistors are in series the net resistance is increased, whereas with two in parallel the net resistance is decreased *qualitative only* |  |  |  |  |
| P3.2.4 solve problems for circuits which include resistors in series, using the concept of equivalent resistance |  |  |  |  |
| **P3.2 How do series and parallel circuits work?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.2.5 explain the design and use of d.c. series circuits for measurement and testing purposes including exploring the effect of:   1. changing current in filament lamps, diodes, thermistors and LDRs 2. changing light intensity on an LDR 3. changing temperature of a thermistor (NTC only) |  |  |  |  |
| **P3.3 What determines the rate of energy transfer in a circuit?** | | | | |
| P3.3.1 describe the energy transfers that take place when a system is changed by work done when a current flows through a component |  |  |  |  |
| P3.3.2 explain, with reference to examples, how the power transfer in any circuit device is related to the energy transferred from the power supply to the device and its surroundings over a given time:  power (W) = energy (J) ÷ time (s) |  |  |  |  |

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| **P3.3 What determines the rate of energy transfer in a circuit?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.3.3 recall and use the relationship between the potential difference across the component and the total charge to calculate the energy transferred in an electric circuit when a current flows through a component:  energy transferred (work done) (J) =  charge (C) × potential difference (V) |  |  |  |  |
| P3.3.4 recall and apply the relationships between power transferred in any circuit device, the potential difference across it, the current through it, and its resistance:   1. power (W) = potential difference (V)   × current (A)   1. power (W)= (current (A))2 × resistance (Ω) |  |  |  |  |
| P3.3.5 use the idea of conservation of energy to show that when a transformer steps up the voltage, the output current must decrease and vice versa.   1. select and use the equation:   potential difference across primary coil  × current in primary coil = potential difference across secondary coil  × current in secondary coil |  |  |  |  |

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| **P3.3 What determines the rate of energy transfer in a circuit?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.3.6 explain how transmitting power at higher voltages is more efficient way to transfer energy |  |  |  |  |
| **P3.4 What are magnetic fields?** | | | | |
| P3.4.1 describe the attraction and repulsion between unlike and like poles for permanent magnets |  |  |  |  |
| P3.4.2 describe the characteristics of the magnetic field of a magnet, showing how strength and direction change from one point to another |  |  |  |  |
| P3.4.3 explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic |  |  |  |  |
| P3.4.4 describe the difference between permanent and induced magnets |  |  |  |  |
| P3.4.5 describe how to show that a current can create a magnetic effect |  |  |  |  |

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| **P3.4 What are magnetic fields?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P3.4.6 describe the pattern and directions of the magnetic field around a conducting wire |  |  |  |  |
| P3.4.7 recall that the strength of the field depends on the current and the distance from the conductor |  |  |  |  |
| P3.4.8 explain how the magnetic effect of a solenoid can be increased |  |  |  |  |
| **P3.5 How do electric motors work?** | | | | |
| **P3.5.1 describe the interaction forces between a magnet and a current-carrying conductor to include ideas about magnetic fields** |  |  |  |  |
| **P3.5.2 show that Fleming’s left-hand rule represents the relative orientations of the force, the conductor and the magnetic field** |  |  |  |  |

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| **P3.5 How do electric motors work?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P3.5.3 select and apply the equation that links the force (*F)* on a conductor to the strength of the field (*B)*, the size of the current (*I)* and the length of conductor (*l)* to calculate the forces involved:**  **force (N) = magnetic flux density (T)**  **× current (A) × length of conductor (m)** |  |  |  |  |
| **P3.5.4 explain how the force on a conductor in a magnetic field is used to cause rotation in the rectangular coil of a simple electric motor**  **Information**  **detailed knowledge of the construction of motors not required** |  |  |  |  |

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| **P4 Explaining motion** | | | | |
| **P4.1 What are forces?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.1.1 recall and apply Newton’s third law |  |  |  |  |
| P4.1.2 recall examples of ways in which objects interact: by gravity, electrostatics, magnetism and by contact (including normal contact force and friction) |  |  |  |  |
| P4.1.3 describe how examples of gravitational, electrostatic, magnetic and contact forces involve interactions between pairs of objects which produce a force on each object |  |  |  |  |
| P4.1.4 represent interaction forces as vectors |  |  |  |  |
| P4.1.5 define weight |  |  |  |  |
| P4.1.6 describe how weight is measured |  |  |  |  |

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| **P4.1 What are forces?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.1.7 recall and apply the relationship between the weight of an object, its mass and the gravitational field strength:  weight (N) = mass (kg) × gravitational field strength (N/kg) |  |  |  |  |
| **P4.2 How can we describe motion?** | | | | |
| P4.2.1 recall and apply the relationship:  average speed (m/s) = distance (m) ÷ time (s) |  |  |  |  |
| P4.2.2 recall typical speeds encountered in everyday experience for wind, and sound, and for walking, running, cycling and other transportation systems |  |  |  |  |
| P4.2.3 a) make measurements of distances and times and calculate speeds.   1. describe how to use appropriate apparatus and techniques to investigate the speed of a trolley down a ramp |  |  |  |  |
| P4.2.4 make calculations using ratios and proportional reasoning to convert units, to include between m/s and km/h |  |  |  |  |
| **P4.2 How can we describe motion?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.2.5 explain the vector–scalar distinction as it applies to displacement and distance, velocity and speed |  |  |  |  |
| P4.2.6 a) recall and apply the relationship:  acceleration (m/s2) = change in speed (m/s) ÷ time taken (s)  b) explain how to use appropriate apparatus and techniques to investigate acceleration |  |  |  |  |
| P4.2.7 select and apply the relationship:  (final speed (m/s))2 – (initial speed(m/s))2  = 2 × acceleration (m/s2) × distance (m) |  |  |  |  |
| P4.2.8 draw and use graphs of distances and speeds against time to determine the speeds and accelerations involved |  |  |  |  |
| P4.2.9 interpret distance–time and velocity–time graphs, including relating the lines and slopes in such graphs to the motion represented |  |  |  |  |
| **P4.2.10 interpret enclosed areas in velocity – time graphs** |  |  |  |  |

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| **P4.2 How can we describe motion?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.2.11 recall the value of acceleration in free fall and calculate the magnitudes of everyday accelerations using suitable estimates of speeds and times |  |  |  |  |
| **P4.3 What is the connection between forces and motion?** | | | | |
| P4.3.1 describe examples of the forces acting on an isolated solid object or system |  |  |  |  |
| P4.3.2 describe, using free body diagrams, examples where several forces lead to a resultant force on an object and the special case of balanced forces (equilibrium) when the resultant force is zero  *qualitative only* |  |  |  |  |
| **P4.3.3 use scale drawings of vector diagrams to illustrate the addition of two or more forces, in situations when there is a net force, or equilibrium**  **Information**  **Limited to parallel and perpendicular vectors only** |  |  |  |  |

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| **P4.3 What is the connection between forces and motion?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P4.3.4 recall and apply the equation for momentum and describe examples of the conservation of momentum in collisions:**  **momentum (kg m/s) = mass (kg) × velocity (m/s)** |  |  |  |  |
| **P4.3.5 select and apply Newton’s second law in calculations relating force, change in momentum and time:**  **change in momentum (kg m/s) = resultant force (N) × time for which it acts (s)** |  |  |  |  |
| P4.3.6 apply Newton’s first law to explain the motion of objects moving with uniform velocity and also the motion of objects where the speed and/or direction changes |  |  |  |  |
| **P4.3.7 explain with examples that motion in a circular orbit involves constant speed but changing velocity**  ***qualitative only*** |  |  |  |  |
| **P4.3.8 explain that inertial mass is a measure of how difficult it is to change the velocity of an object and that it is defined as the ratio of force over acceleration** |  |  |  |  |
| **P4.3 What is the connection between forces and motion?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.3.9 recall and apply Newton’s second law relating force, mass and acceleration:  force (N) = mass (kg) × acceleration (m/s2) |  |  |  |  |
| P4.3.10 use and apply equations relating force, mass, velocity, acceleration, and **momentum** to explain relationships between the quantities |  |  |  |  |
| P4.3.11 explain methods of measuring human reaction times and recall typical results |  |  |  |  |
| P4.3.12 explain the factors which affect the distance required for road transport vehicles to come to rest in emergencies and the implications for safety |  |  |  |  |
| P4.3.13 explain the dangers caused by large decelerations |  |  |  |  |

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| **P4.4 How can we describe motion in terms of energy transfer?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.4.1 describe the energy transfers involved when a system is changed by work done by forces including:   1. to raise an object above ground level 2. to move an object along the line of action of the force |  |  |  |  |
| P4.4.2 recall and apply the relationship to calculate the work done (energy transferred) by a force:  work done (Nm or J) = force (N) × distance (m) (along the line of action of the force) |  |  |  |  |
| P4.4.3 recall the equation and calculate the amount of energy associated with a moving object: kinetic energy (J) = 0.5 × mass (kg) × (speed (m/s))2 |  |  |  |  |
| P4.4.4 recall the equation and calculate the amount of energy associated with an object raised above ground level:  gravitational potential energy (J) = mass (kg) × gravitational field strength (N/kg) × height (m) |  |  |  |  |

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| **P4.4 How can we describe motion in terms of energy transfer?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P4.4.5 make calculations of the energy transfers associated with changes in a system, recalling relevant equations for mechanical processes |  |  |  |  |
| P4.4.6 calculate relevant values of stored energy and energy transfers; convert between newton- metres and joules |  |  |  |  |
| P4.4.7 describe all the changes involved in the way energy is stored when a system changes, for common situations: including 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 |  |  |  |  |
| P4.4.8 explain, with reference to examples, the definition of power as the rate at which energy is transferred (work done) in a system |  |  |  |  |
| P4.4.9 recall and apply the relationship:  power (W) = energy transferred (J) ÷ time (s) |  |  |  |  |

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| **P5 Radioactive materials** | | | | |
| **P5.1 What is radioactivity?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P5.1.1 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 |  |  |  |  |
| P5.1.2 describe how and why the atomic model has changed over time to include the main ideas of Dalton, Thomson, Rutherford and Bohr |  |  |  |  |
| P5.1.3 recall the typical size (order of magnitude) of atoms and small molecules |  |  |  |  |
| P5.1.4 recall that atomic nuclei are composed of both protons and neutrons, and that the nucleus of each element has a characteristic positive charge |  |  |  |  |
| P5.1.5 recall that nuclei of the same element can differ in nuclear mass by having different numbers of neutrons, these are called isotopes |  |  |  |  |

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| **P5.1 What is radioactivity?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P5.1.6 use the conventional representation to show the differences between isotopes, including their identity, charge and mass |  |  |  |  |
| P5.1.7 recall that some nuclei are unstable and may emit alpha particles, beta particles, or neutrons, and electromagnetic radiation as gamma rays |  |  |  |  |
| P5.1.8 relate emissions of alpha particles, beta particles, or neutrons, and gamma rays to possible changes in the mass or the charge of the nucleus, or both |  |  |  |  |
| P5.1.9 use names and symbols of common nuclei and particles to write balanced equations that represent the emission of alpha, beta, gamma, and neutron radiations during radioactive decay |  |  |  |  |
| P5.1.10 explain the concept of half-life and how this is related to the random nature of radioactive decay |  |  |  |  |

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| **P5.1 What is radioactivity?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| **P5.1.11 calculate the net decline, expressed as a ratio, in a radioactive emission after a given (integral) number of half-lives** |  |  |  |  |
| P5.1.12 interpret activity-time graphs to find the half- life of radioactive materials |  |  |  |  |
| **P5.2 How can radioactive materials be used safely?** | | | | |
| P5.2.1 recall the differences in the penetration properties of alpha particles, beta particles and gamma rays |  |  |  |  |
| P5.2.2 recall the differences between contamination and irradiation effects and compare the hazards associated with each of these |  |  |  |  |
| P5.2.3 describe the different uses of nuclear radiations for exploration of internal organs, and for control or destruction of unwanted tissue |  |  |  |  |
| P5.2.4 explain how ionising radiation can have hazardous effects, notably on human bodily tissues |  |  |  |  |
| **P5.2 How can radioactive materials be used safely?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P5.2.5 explain why the hazards associated with radioactive material differ according to the radiation emitted and the half-life involved |  |  |  |  |

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| **P6 Matter – models and explanations** | | | | |
| **P6.1 How does energy transform matter?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.1.1 a) define density  b) describe how to determine the densities of solid and liquid objects using measurements of length, mass and volume |  |  |  |  |
| P6.1.2 recall and apply the relationship between density, mass and volume to changes where mass is conserved: density (kg/m3) = mass (kg) ÷ volume (m3) |  |  |  |  |
| P6.1.3 describe the energy transfers involved when a system is changed by heating (in terms of temperature change and specific heat capacity) |  |  |  |  |
| P6.1.4 define the term specific heat capacity and distinguish between it and the term specific latent heat |  |  |  |  |

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| **P6.1 How does energy transform matter?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.1.5 a) select and apply the relationship between change in internal energy of a material and its mass, specific heat capacity and temperature:  change in internal energy (J) = mass (kg) × specific heat capacity (J/kg°C) × change in temperature (°C)    b) explain how to safely use apparatus to determine the specific heat capacity of materials |  |  |  |  |
| P6.1.6 select and apply the relationship between energy needed to cause a change in state, specific latent heat and mass:  energy to cause a change of state (J) = mass (kg) × specific latent heat (J/kg) |  |  |  |  |
| P6.1.7 describe all the changes involved in the way energy is stored when a system changes, and the temperature rises, for example: a moving object hitting an obstacle, an object slowing down, water brought to a boil in an electric kettle |  |  |  |  |

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| **P6.1 How does energy transform matter?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.1.8 make calculations of the energy transfers associated with changes in a system when the temperature changes, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes |  |  |  |  |
| **P6.2 How does the particle model explain the effects of heating?** | | | | |
| P6.2.1 explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules |  |  |  |  |
| P6.2.2 use the particle model of matter to describe how mass is conserved, when substances melt, freeze, evaporate, condense or sublimate, but that these physical changes differ from chemical changes and the material recovers its original properties if the change is reversed |  |  |  |  |
| P6.2.3 use the particle model to 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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| **P6.2 How does the particle model explain the effects of heating?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.2.4 explain how the motion of the molecules in a gas is related both to its temperature and its pressure: hence explain the relationship between the temperature of a gas and its pressure at constant volume  *qualitative only* |  |  |  |  |
| **P6.3 How does the particle model relate to materials under stress?** | | | | |
| P6.3.1 explain, with examples, that to stretch, bend or compress an object, more than one force has to be applied |  |  |  |  |
| P6.3.2 describe **and use the particle model to explain** the difference between elastic and plastic deformation caused by stretching forces |  |  |  |  |
| P6.3.3 a) describe the relationship between force and extension for a spring and other simple systems  b) describe how to measure and observe the effect of forces on the extension of a spring |  |  |  |  |

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| **P6.3 How does the particle model relate to material under stress?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P6.3.4 describe the difference between the force- extension relationship for linear systems and for non-linear systems |  |  |  |  |
| P6.3.5 recall and apply the relationship between force, extension and spring constant for systems where the force-extension relationship is linear  force exerted by a spring (N) = extension (m) x spring constant (N/m) |  |  |  |  |
| P6.3.6 a) calculate the work done in stretching a spring or other simple system, by calculating the appropriate area on the force-extension graph  b) describe how to safely use apparatus to determine the work done in stretching a spring |  |  |  |  |
| P6.3.7 select and apply the relationship between energy stored, spring constant and extension for a linear system:  energy stored in a stretched spring (J) = ½ × spring constant (N/m) × (extension (m))2 |  |  |  |  |

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| **P7 Ideas about Science** | | | | |
| **P7.1 What needs to be considered when investigating a phenomenon scientifically?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.1.1 in given contexts use scientific theories and tentative explanations to develop and justify hypotheses and predictions |  |  |  |  |
| P7.1.2 suggest appropriate apparatus, materials and techniques, justifying the choice with reference to the precision, accuracy and validity of the data that will be collected |  |  |  |  |
| P7.1.3 recognise the importance of scientific quantities and understand how they are determined |  |  |  |  |
| P7.1.4 identify factors that need to be controlled, and the ways in which they could be controlled |  |  |  |  |
| P7.1.5 suggest an appropriate sample size and/or range of values to be measured and justify the suggestion |  |  |  |  |

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| **P7.1 What needs to be considered when investigating a phenomenon scientifically?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.1.6 plan experiments or devise procedures by constructing clear and logically sequenced strategies to:   * make observations * produce or characterise a substance * test hypotheses * collect and check data * explore phenomena |  |  |  |  |
| P7.1.7 identify hazards associated with the data collection and suggest ways of minimizing the risk |  |  |  |  |
| P7.1.8 use appropriate scientific vocabulary, terminology and definitions to communicate the rationale for an investigation and the methods used using diagrammatic, graphical, numerical and symbolic forms |  |  |  |  |
| **P7.2 What needs to be considered when investigating a phenomenon scientifically?** | | | | |
| P7.2.1 present observations and other data using appropriate formats |  |  |  |  |

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| **P7.2 What needs to be considered when investigating a phenomenon scientifically?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.2.2 when processing data use SI units where appropriate (e.g. kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate |  |  |  |  |
| P7.2.3 when processing data use prefixes (e.g. tera, giga, mega, kilo, centi, milli, micro and nano) and powers of ten for orders of magnitude |  |  |  |  |
| P7.2.4 be able to translate data from one form to another |  |  |  |  |
| P7.2.5 when processing data interconvert units |  |  |  |  |
| P7.2.6 when processing data use an appropriate number of significant figures |  |  |  |  |
| P7.2.7 when displaying data graphically select an appropriate graphical form, use appropriate axes and scales, plot data points correctly, draw an appropriate line of best fit, and indicate uncertainty (e.g. range bars) |  |  |  |  |

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| **P7.2 What needs to be considered when investigating a phenomenon scientifically?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.2.8 when analysing data identify patterns/trends, use statistics (range and mean) and obtain values from a line on a graph (including gradient, interpolation and extrapolation) |  |  |  |  |
| P7.2.9 in a given context evaluate data in terms of accuracy, precision, repeatability and reproducibility, identify potential sources of random and systematic error, and discuss the decision to discard or retain an outlier |  |  |  |  |
| P7.2.10 evaluate an experimental strategy, suggest improvements and explain why they would increase the quality (accuracy, precision, repeatability and reproducibility) of the data collected, and suggest further investigation |  |  |  |  |
| P7.2.11 in a given context interpret observations and other data (presented in diagrammatic, graphical, symbolic or numerical form) to make inferences and to draw reasoned conclusions, using appropriate scientific vocabulary and terminology to communicate the scientific rationale for findings and conclusions |  |  |  |  |

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| **P7.2 What needs to be considered when investigating a phenomenon scientifically?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.2.12 explain the extent to which data increase or decrease confidence in a prediction or hypothesis |  |  |  |  |
| **P7.3 How are scientific explanations developed?** | | | | |
| P7.3.1 use ideas about correlation and cause to:   * identify a correlation in data presented as text, in a table, or as a graph * distinguish between a correlation and a cause-effect link * suggest factors that might increase the chance of a particular outcome in a given situation, but do not invariably lead to it * explain why individual cases do not provide convincing evidence for or against a correlation * identify the presence (or absence) of a plausible mechanism as reasonable grounds for accepting (or rejecting) a claim that a factor is a cause of an outcome |  |  |  |  |

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| **P7.3 How are scientific explanations developed?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.3.2 describe and explain examples of scientific methods and theories that have developed over time and how theories have been modified when new evidence became available |  |  |  |  |
| P7.3.3 describe in broad outline the ‘peer review’ process, in which new scientific claims are evaluated by other scientists |  |  |  |  |
| P7.3.4 use a variety of models (including representational, spatial, descriptive, computational and mathematical models) to:   * solve problems * make predictions * develop scientific explanations and understanding * identify limitations of models |  |  |  |  |
| **P7.4 How do science and technology impact society?** | | | | |
| P7.4.1 describe and explain everyday examples and technological applications of science that have made significant positive differences to people’s lives |  |  |  |  |

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| **P7.4 How do science and technology impact society?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.4.2 identify examples of risks that have arisen from a new scientific or technological advance |  |  |  |  |
| P7.4.3 for a given situation:   * identify risks and benefits to the different individuals and groups involved * discuss a course of action, taking account of who benefits and who takes the risks * suggest reasons for people’s willingness to accept the risk * **distinguish between perceived and calculated risk** |  |  |  |  |
| P7.4.4 suggest reasons why different decisions on the same issue might be appropriate in view of differences in personal, social, economic or environmental context, and be able to make decisions based on the evaluation of evidence and arguments |  |  |  |  |
| P7.4.5 distinguish questions that could in principle be answered using a scientific approach, from those that could not; where an ethical issue is involved clearly state what the issue is and summarise the different views that may be held |  |  |  |  |
| **P7.4 How do science and technology impact society?** | | | | |
| **Learning outcomes**  You will be required to: | **R** | **A** | **G** | **Comments** |
| P7.4.6 explain why scientists should communicate their work to a range of audiences |  |  |  |  |

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| **Equations in Physics** | | | | | |
| ***recall and apply the following relationships using standard SI units*** | **R** | **A** | **G** | **Comments** |
| force = mass × acceleration (P4.3.9)) |  |  |  |  |
| kinetic energy = 0.5 × mass × (speed)2 (P4.4.3) |  |  |  |  |
| **momentum = mass × velocity (P4.3.4.) (P4.3.4)** |  |  |  |  |
| work done = force × distance (along the line of action of the force) (P4.4.2) |  |  |  |  |
| power = energy transferred ÷ time (P3.3.2, P4.4.9) |  |  |  |  |
| efficiency = useful energy transferred ÷ total energy transferred (P2.1.8) |  |  |  |  |
| weight = mass × gravitational field strength *g* (P4.1.7) |  |  |  |  |

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| **Equations in Physics** | | | | | |
| ***recall and apply the following relationships using standard SI units*** | **R** | **A** | **G** | **Comments** |
| In a gravity field:  gravitational potential energy = mass × gravitational field strength *g* × height (P4.4.4) |  |  |  |  |
| force exerted by a spring = extension × spring constant (P6.3.5) |  |  |  |  |
| average speed = distance ÷ time (P4.2.1) |  |  |  |  |
| acceleration = change in speed ÷ time taken(P4.2.6a) |  |  |  |  |
| wave speed = frequency × wavelength (P1.3.6) |  |  |  |  |
| charge = current × time (P3.1.2) |  |  |  |  |
| potential difference = current × resistance (P3.1.4a) |  |  |  |  |

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| **Equations in Physics** |

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| ***recall and apply the following relationships using standard SI units*** | **R** | **A** | **G** | **Comments** |
| power = potential difference × current = (current)2 × resistance (P3.4.4a and b) |  |  |  |  |
| energy transferred (work done) = power × time = charge flow × potential difference (P2.1.3, P3.3.3) |  |  |  |  |
| density = mass ÷ volume (P6.1.2) |  |  |  |  |
| potential difference = work done (energy transferred) ÷ charge (P3.2.1) |  |  |  |  |

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| **Equations in Physics** | | | | | |
| ***In addition, students should be able correctly to select from a list and apply the following relationships:*** | **R** | **A** | **G** | **Comments** |
| (final speed)2 – (initial speed)2 = 2 × acceleration × distance (P4.2.7) |  |  |  |  |
| change in internal energy = mass × specific heat capacity × change in temperature (P6.1.5a) |  |  |  |  |
| energy to cause a change of state = mass × specific latent heat (P6.1.6) |  |  |  |  |
| energy stored in a stretched spring = 1⁄2 × spring constant × (extension)2 (P6.3.7) |  |  |  |  |
| **force = magnetic flux density × current × length of conductor (P3.5.3)** |  |  |  |  |
| potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil (P3.3.5) |  |  |  |  |
| **change in momentum = resultant force × time for which it acts (P4.3.5)** |  |  |  |  |

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