Topic 4: Managing resources

Subtopic 4.1: Energy

This subtopic extends the work on writing combustion equations introduced in Stage 1 subtopic 3.3, enthalpy introduced in Stage 1 subtopic 4.4, and galvanic cells introduced in Stage 1 subtopic 6.3.

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| Photosynthesis and respiration are important processes in the cycling of carbon and oxygen on Earth.  In photosynthesis the light energy absorbed by chlorophyll is stored as chemical energy in carbohydrates such as glucose.   * Describe and write the equation for photosynthesis.   The chemical energy present in carbohydrates can be accessed by respiration and combustion.   * Describe and write the equation for the aerobic respiration of glucose. |
| Fossil fuels (coal, petroleum, and natural gas) have been formed over geological time scales by anaerobic decomposition of dead organisms. They are considered to be non-renewable because reserves are depleted more quickly than they are formed.  Carbon-based fuels provide energy and are feedstock for the chemical industry.   * Discuss the advantages and disadvantages of using carbon-based fuels as sources of heat energy, compared with their use as feedstock. |
| Renewable energy is generated over time scales of years to decades, from sources that are replenished much more quickly than fossil fuels.   * Identify bioethanol, biodiesel, sunlight, and wind as renewable energy sources. * Compare the contributions of fossil fuels to global warming with those from renewable energy sources.   Biofuels are produced by present-day biological processes.   * Identify bioethanol and biodiesel as biofuels. * Describe the production, from biological materials, of ethanol and biodiesel, including the writing of chemical equations for the reactions involved. * Explain how fossil fuels contribute more than biofuels to global warming. |
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| The complete combustion of fuels containing carbon and hydrogen produces carbon dioxide and water and energy.   * Write thermochemical equations for the complete combustion of fuels in which the only products are carbon dioxide and water.   Incomplete combustion, producing carbon (soot) and carbon monoxide, is more likely with longer-chain carbon-based fuels.   * Explain why incomplete combustion is more likely with longer-chain carbon-based fuels than with shorter chains. * Discuss the undesirable consequences of incomplete combustion. |
| The energy released in combustion of fuels can be determined experimentally.   * Use experimental data to determine the enthalpy of combustion of a fuel. * Undertake thermochemical calculations involving enthalpy changes and temperature changes of a specified mass of water given the necessary data.   Fuels, including fossil fuels and biofuels, can be compared in terms of their energy output and the nature of products of combustion.   * Calculate the quantities of heat evolved per mole, per gram, and per litre (for liquids) for the complete combustion of fuels. * Compare fuels given appropriate data. |
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| Although most electricity is generated using fuels to drive steam turbines, electrical energy can be also be generated using photovoltaic cells (known as solar cells) and directly from oxidation of fuels using galvanic cells.   * Explain the advantages and disadvantages of direct electricity generation (photovoltaic and fuel cells) compared to using steam turbines.   Fuel cells, including flow cells, are galvanic cells in which the electrode reactants are available in continuous supply.   * State the advantages and disadvantages of fuel cells compared with other galvanic cells. * Identify the anode and cathode and their charges, as well as the direction of ion and electron flow, in a fuel cell, given sufficient information. * Write electrode half-equations for a fuel cell given sufficient information. * Discuss the advantages of flow cells compared with other fuel cells.   Hydrogen is a fuel that is produced from fossil fuels, biomass, or water.   * Compare the benefits of producing hydrogen from each of these three sources. * Describe the benefits of using hydrogen, rather than fossil fuels, as a fuel. |
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Subtopic 4.2: Water

This subtopic extends the work on ionic interactions introduced in Stage 1 subtopic 4.2 and on pH in Stage 1 subtopic 5.3.

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| Water from different sources is treated with different methods depending on its origin and intended use.  Suspended matter is commonly removed from water by flocculation, followed by sedimentation and filtration.  The surface of fine silicate and aluminosilicate particles in clays is negatively charged and can be flocculated into larger particles by the addition of salts containing highly charged cations such as aluminium ions or polymers.   * Explain the use of aluminium ions and polymers in flocculating clay particles suspended in water.   Hard water contains high concentrations of Ca2+ and Mg2+ ions. Hard water renders soaps less effective and causes build-up of precipitates.  Natural and modified zeolites can be used in the purification and softening of water, through the exchange of cations.   * Explain the use of zeolites in water softeners.   Reverse osmosis is a filtration technique whereby water is forced, under pressure, through a semi-permeable membrane.   * Explain how reverse osmosis produces potable water from saline water.   Desalination is a process used to remove minerals from saline water to produce fresh potable water. Reverse osmosis and thermal distillation are two widely used methods for desalination.   * Describe the disadvantages of using desalination for the production of potable water.   Hypochlorous acid, chlorine, and hypochlorites are oxidisers used for water disinfection.   * Explain the effect of pH on the equilibrium between chlorine and water, and hydrochloric acid and hypochlorous acid. |
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Subtopic 4.3: Soil

*This subtopic revisits concepts about ionic substances introduced in Stage 1 subtopics 2.2 and 4.2, and concepts of equilibrium introduced in subtopic 2.2.*

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| Plants require nutrients, which they obtain from the soil.   * Explain why plants need soil nutrients in soluble form.   Soil productivity is related to the availability of plant nutrients, which need to be replenished naturally or by the addition of fertilisers.  Nitrogen, phosphorus, and potassium are the major nutrients that plants require from the soil.   * Explain how natural processes (including lightning, nitrogen-fixing bacteria, and decay) replenish soil nitrogen. * Explain why fertilisers are required to improve the productivity of some soils.   Excess nitrogen and phosphorus can be leached from soils and can cause eutrophication in water bodies.   * Explain the process and consequences of eutrophication. |
| Silicon dioxide, silicates, and aluminosilicates are important components of rocks and soils.   * Write the formula of the anion given the formula of a silicate or aluminosilicate.   Cations adsorbed on the surface of soil silicates and aluminosilicates are in equilibrium, and can be exchanged with, the cations in soil water, which are available as sources of plant nutrients.  Soil silicates and aluminosilicates are able to adsorb H+ and release cations.   * Explain how cations on the surface of soil silicates and aluminosilicates become available to plants.   Nutrient cations on the surface of soil silicates and aluminosilicates are replaced if the concentrations of H+ or Na+ in soil water become too high.   * Explain how acidic or saline conditions (i.e. high concentrations of H+ or Na+) deplete the nutrient value of soils. |

Subtopic 4.4: Materials

Polymers extends the work on materials introduced in Stage 1 subtopics 1.1 and 2.1, addition polymerisation introduced in Stage 1 subtopic 3.4, and condensation polymerisation in Stage 2 subtopics 3.7 and 3.8.

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| Polymers  Polymers are produced from monomers by addition or condensation reactions.   * Identify whether a molecule could undergo polymerisation, given its structural formula and, if so, the type of polymerisation. * Identify a polymer as being the product of an addition polymerisation or a condensation polymerisation, given its structural formula. * Identify the repeating unit of a polymer, given its structural formula. |
| The production of synthetic polymers allows the manufacture of materials with a diverse range of properties.   * Discuss the advantages and disadvantages of synthetic polymers. * Compare the effects of heating on thermoplastic and thermoset polymers.   Organic polymers can have different properties, such as rigidity, depending on the monomers and the degree of cross-linking between chains.   * Compare the physical properties of polymers with different degrees of cross-linking and secondary interactions between polymer chains. |
| Polymers can be made from fossil resources or from renewable materials.   * Discuss the advantages and disadvantages of making polymers from fossil resources or from renewable materials.   Some polymers are biodegradable — being able to be broken down by microorganisms and other living things.   * Explain why some polymers are biodegradable but others are not. * Explain the advantages of polymers being biodegradable. |
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Metals applies the concepts of reactions of acids from Stage 1 subtopic 5.2, and draws on concepts of redox, metal reactivity, and electrochemistry introduced in Stage 1 Topic 6.

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| Metals  The occurrence of metals in combined or uncombined form in the Earth’s crust is related to the reactivity of the metal.  The production of some metals requires the conversion of minerals to a form suitable for reduction.   * Explain, with the aid of equations, the methods chosen for the conversion of a mineral to a metal, given sufficient information.   The method used in the reduction stage in the production of a metal is related to the reactivity of the metal and the availability of energy.  Given the position of a metal in the activity series of metals:   * Predict whether the metal is likely to occur in nature in a combined or uncombined form. * Predict and explain the likely method of reduction of the metal compound, including electrolysis of the molten compound, electrolysis of an aqueous solution of the metal compound, and use of carbon as a reducing agent. * Explain the benefits of one method of reduction compared with another, given relevant information.   Electrolytic cells are used to produce required substances.   * Identify the anode and cathode and their charges, as well as the direction of ion and electron flow in an electrolytic cell, given sufficient information. * Write electrode half-equations for an electrolytic cell, given sufficient information. |
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Recycling draws on concepts introduced in Stage 1 subtopics 2.1, 3.2, and 3.4.

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| Recycling  There is a finite amount of materials on Earth. Materials that can be recycled reduce the amount of new materials that need to be produced from the Earth’s crust.   * Explain the advantages of recycling materials.   Some objects are difficult to recycle.   * Explain the difference in the ease of recycling thermoplastic and thermoset polymers.   Composite materials comprise two or more constituent materials to produce a material with properties different from the individual components.   * Explain the advantages using of composite materials. * Explain the difficulties associated with recycling materials and objects comprising two or more different materials with different properties. |
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