

## Topic 4: Managing Resources

TOTAL MARKS: 72

1. Butane is a fossil fuel commonly used to provide energy by combustion.

(a) Write a balanced equation for the complete combustion of butane ( $C_4H_{10}$ ).

\_\_\_\_\_ (2)

(b) The  $\Delta H$  of combustion of butane is  $2870 \text{ kJ mol}^{-1}$ . Calculate the heat released per gram of butane.

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\_\_\_\_\_ (2)

(c) Calculate the mass of butane which must be burnt to heat 1.0 L of water to  $100^\circ\text{C}$  from an initial temperature of  $25^\circ\text{C}$ , if 50% of the heat from the butane is lost to the surroundings.

The specific heat capacity of water is  $4.18 \text{ J g}^{-1} \text{ }^\circ\text{K}^{-1}$ .

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\_\_\_\_\_ (3)

(d) Burning of butane, a non-renewable carbon-based fuel, can contribute to global warming.

Bioethanol is a possible alternative fuel.

(i) Write a balanced equation for the production of bioethanol from glucose.

\_\_\_\_\_ (2)

(ii) State why bioethanol is considered to be a renewable energy source.

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\_\_\_\_\_ (1)

(iii) State another renewable energy source (other than biofuels).

\_\_\_\_\_ (1)

(e) State one advantage and one disadvantage (other than effects on the environment) of using carbon-based fuels as sources of heat energy

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\_\_\_\_\_ (2)

(f) Explain one undesirable environmental consequence (other than contribution to global warming) of burning butane in air.

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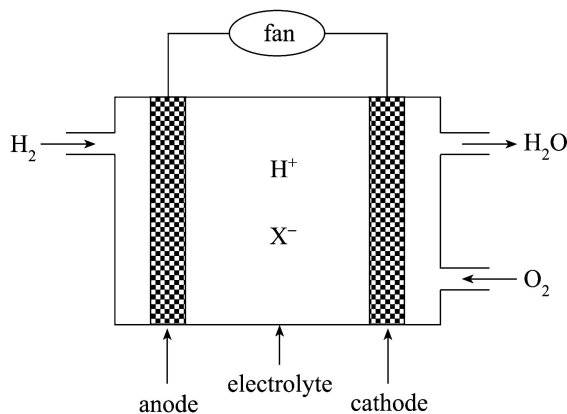
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(2)

2. Fuel cells use hydrogen as a fuel to produce energy. A diagram of a fuel cell is shown below:



(a) Write the half-equation for the reaction at the cathode.

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(2)

(b) Identify whether the anode or cathode is the negative electrode.

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(1)

(c) On the diagram above, draw an arrow to indicate the direction in which the negative ion,  $X^-$ , moves.

(1)

(d) On the diagram above, draw an arrow to indicate the direction in which electrons flow through the fan.

(1)

(e) State one advantage for the consumer of using fuel cells rather than other galvanic cells to produce energy.

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(1)

(f) State one disadvantage of the fuel cell compared with ordinary galvanic cells.

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(1)

(g) State one advantage of generating electricity using fuel cells compared to using steam turbines.

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(1)

- (h) One alternative type of fuel cell is the plant microbial fuel cell (plant MFC). In a plant MFC, one of the electrodes is placed beside plant roots. The plants excrete sugars through their roots. Bacteria around the roots break down these sugars, thus producing energy.

The energy produced by a plant MFC is not sufficient to power large-scale applications; however, researchers claim that more energy is produced by a plant MFC than by the combustion of biogases.

Researchers also claim that plant MFCs are more economically viable than solar panels for energy production in remote areas.

Using *one* of the key concepts of Science as a Human Endeavour, describe how plant MFC technology is an example of science as a human endeavour.

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(2)

3. The method used for extraction of a metal depends on the properties of the element.

- (a) State and explain which of silver or aluminium is more likely to occur uncombined in nature.

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(2)

- (b) Explain why zinc can be obtained by reduction using carbon whereas this is not possible for aluminium.

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(2)

- (c) Aluminium is obtained by reduction using electrolysis of molten compound.

- (i) Write a half-equation for the electrode reaction in which aluminium is produced.

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(1)

- (ii) State the electrode at which aluminium is produced.

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(1)

- (d) Explain why reduction using electrolysis of a solution is preferable to electrolysis of a melt.

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(2)

4. Nitrogen is an essential plant nutrient that can be found naturally in various compounds. Some of these compounds can be used by plants while others must be converted to a more useful form.

(a) Nitrogen-fixing bacteria found in the root nodules of legumes are able to produce ammonia,  $\text{NH}_3$ .

Identify the reactant in air that bacteria use to produce ammonia.

\_\_\_\_\_ (1)

(b) Nitrate ions are the product of the decomposition of some plants.

State why nitrate released in this manner provides nitrogen in a form suitable for use by plants.

\_\_\_\_\_ (1)

5. Water quality can be improved by adding aluminium ions and chlorine to water.

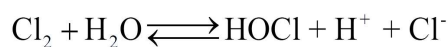
(a) Describe how  $\text{Al}^{3+}$  removes suspended matter from water.

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\_\_\_\_\_  
\_\_\_\_\_ (2)

(b) State how chlorine kills bacteria.

\_\_\_\_\_ (1)

(c) One equilibrium that is established when chlorine is added to water is shown in the equation below:



State the effect that the addition of sodium hydroxide would have on the concentration of  $\text{Cl}_2$  in the water.

\_\_\_\_\_ (1)

6. Another aspect of water quality is hardness, which can have an impact of the effectiveness of cleaning agents.

Silicate materials such as zeolites can be used to reduce water hardness.

- (a) Explain how the zeolite with formula  $\text{Na}_2(\text{Al}_2\text{Si}_3\text{O}_{10}) \cdot 2\text{H}_2\text{O}$  is able to remove hardness from water.

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(3)

- (b) State the charge on a silicate anion that has an Si:O ratio of 5:12.

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(1)

- (c) State the value of  $x$  in  $\text{Al}_2(\text{Si}_2\text{O}_6)_2^x$ .

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(1)

Cleaning agent effectiveness can also be improved by the addition of phosphates to detergent mixtures.

- (d) Describe the consequences of the release of detergents containing phosphates into the waterways.

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(3)

If water contains a high concentration of dissolved salts, it may be processed using reverse osmosis.

- (e) Describe how reverse osmosis lowers the concentration of dissolved salts in water.

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- (f) State one environmental disadvantage of desalination by reverse osmosis.

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(1)

7. Over the last century, synthetic polymers have replaced traditional materials for many uses.

(a) State one advantage and one disadvantage of synthetic polymers.

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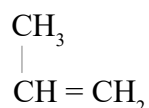
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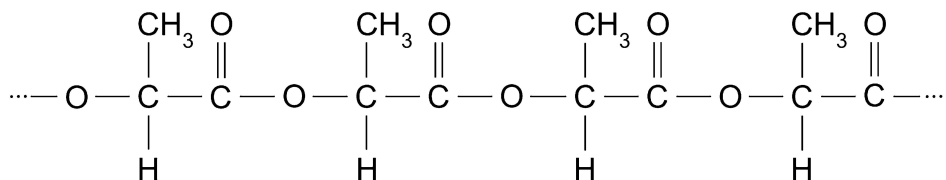
(b) Draw the structural formula of a section of the polymer that would form from the monomer below:



(2)

Poly(lactic acid) (PLA) is a synthetic polymer widely used in 3D printing.

A section of a polymer chain of poly(lactic acid) (PLA) is shown below.



(c) State the name given to the type of polymerisation reaction that produces PLA.

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(1)

(d) State why PLA is biodegradable.

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(1)

(e) Draw the structural formulae for the monomer(s) used to make PLA.

(2)

