

## Chemistry Contexts 2 second edition

## Sample Teaching Program

### Topic 8: The chemistry of art

Specific outcome	Content	References: coursebook and Teacher's Resource Pack	Teaching and learning strategies
H6, H13, H14	<ul style="list-style-type: none"> <li>Identify examples of chelated ligands.</li> </ul>		
H2, H13, H14	<ul style="list-style-type: none"> <li>Discuss the importance of models in developing an understanding of the nature of ligands and chelated ligands, using specific examples.</li> </ul>	<ul style="list-style-type: none"> <li>33.5 Colours of transition metal complexes</li> <li>Pages 108–9</li> </ul>	<ul style="list-style-type: none"> <li>Secondary source investigation: The range of colours that can be obtained from one metal in different ion complexes</li> <li>Secondary source investigation: Draw or model Lewis structures and analyse this information to indicate the bonding in selected complex ions involving the first transition series</li> <li>Review exercise 33.5 (p. 109)</li> <li>Application and investigation Q4–5 (p. 113)</li> </ul>

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**CHAPTER 1: ETHYLENE****Review exercise 1.1**

- 1 The word 'petrochemical' means any chemical that has been derived from petroleum, a liquid fossil fuel.
- 2 Fossil fuels are non-renewable resources with a huge demand. They are wanted both as a source of energy and as a source of petrochemical substances.

**Review exercise 1.2**

- 1 Ethylene (ethene) is the most widely used feedstock material derived from petroleum.
- 2
  - a Catalytic cracking produces shorter chain-length, lower-mass hydrocarbons from high mass petroleum fractions. Thermal steam cracking converts ethane and propane to ethylene.
  - b The proportions of products obtained from fractional distillation do not match the demands for the different products. Catalytic cracking allows for specific control of the types and amounts of products and hence more efficient use of the petroleum feedstock and its products.
  - c  $C_9H_{20}(g) \rightarrow C_7H_{16}(g) + C_2H_4(g)$
- 3 The catalysts used in cracking are zeolites. These solid crystalline substances adsorb the gaseous reactants, weakening their bonds and hence lowering the activation energies.

**Review exercise 1.3**

- 1 Alkenes are more reactive than alkanes because of the presence of the double bond, a centre of high electron density, in alkenes.
- 2 Place hexane and 1-hexene into separate test tubes. Add bromine water to a depth of about 1 cm, shake and allow to settle. If the bromine water is decolourised then the test tube contained 1-hexene and the product of this addition reaction is 1,2-dibromoethane. However, there may also be some 2-bromo-1-ethanol and hydrogen bromide as a result of the water present. If there is no change to the colour of the bromine water then the test tube contained hexane.
- 3
  - a  $C_3H_6 + Cl_2 \rightarrow C_3H_6Cl_2$  1,2-dichloropropane
  - b  $C_7H_{14} + HBr \rightarrow C_7H_{15}Br$  2-bromoheptane, 1-bromoheptane. In practice only 2-bromoheptane forms (Markovnikov's rule).
  - c  $C_6H_{12} + H_2O \rightarrow C_6H_{13}OH$  3-hexanol
- 4
  - a Addition of hydrogen chloride to 1-butene

- b Chlorination of 2-butene
- c Addition using chlorine water to 2-butene
- d Hydration of 1-butene
- e Oxidation of 2-pentene by reacting with cold dilute potassium permanganate

**Chapter 1 — Application and investigation****1 Investigation**

- 2 a Cracking is used to produce hydrocarbons with lower molecular mass which have greater market demand, e.g. petrol, branch-chained alkanes to improve the performance of petrol; and to produce ethene which can be used as a starting material for many organic compounds.
- b In catalytic cracking the material to be cracked is passed over a zeolite catalyst at a temperature of around 500°C. The reactants adsorb to the surface of the catalyst, which weakens their bonds, lowering the activation energy.
- c Catalytic cracking uses zeolite crystals as catalysts to lower the activation energy in the cracking of high molecular mass hydrocarbons. Thermal cracking uses very high temperatures (around 800–900°C) to crack hydrocarbons such as ethane and propane, to produce needed alkenes.

**4 Investigation**

- 5 Alkenes contain a reactive double bond, which readily undergoes addition reactions in order to gain a more stable single bond.

**6 a 1,2-dichloropropane**

- b 1-chlorobutane; 2-chlorobutane. In practice only 2-chlorobutane forms (Markovnikov's rule).

**c ethanol****7 Investigation and class experimental work:**

- a 2-pentene with HCl
- b 2-pentene with  $\text{Cl}_2$
- c propene with  $\text{H}_2\text{O}$  in the presence of a catalyst

- 8 Add bromine water to samples of each of cyclohexene and cyclohexane, shake and allow to settle. Cyclohexene undergoes an addition reaction with  $\text{Br}_2$  across the double bond and thus the bromine water is decolourised. There is no rapid visible reaction with cyclohexane.

**9 Investigation**

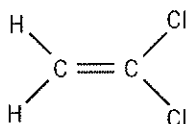
## CHAPTER 2: POLYMERS

## Review exercise 2.1

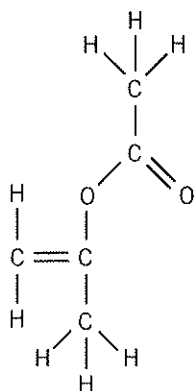
- 1 Polymerisation is the chemical reaction whereby monomers link together to form polymers.
- 2 Addition polymerisation: all atoms in the monomer are present in the polymer chain. Unsaturated monomers join together via breaking of a  $C = C$  double bond.
- Condensation polymerisation: a reaction between two monomers, which can be different, during which a small molecule, such as water, is eliminated.

- 3 a Monomers have  $C = C$  double bond.
- b Monomers each contain a functional group which may be different. Common groups are  $-COOH$  (carboxylic acid),  $-OH$  (alcohol) and  $-NH_2$  (amine) group.

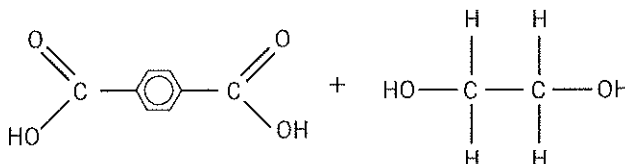
- 4 a i



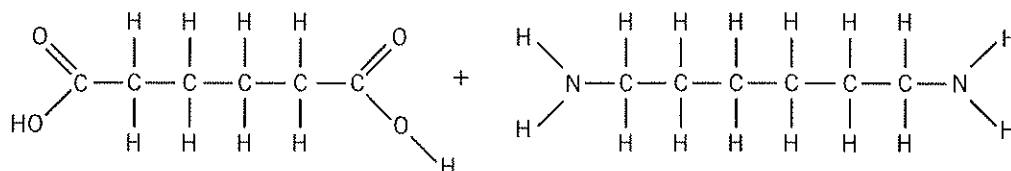
- ii



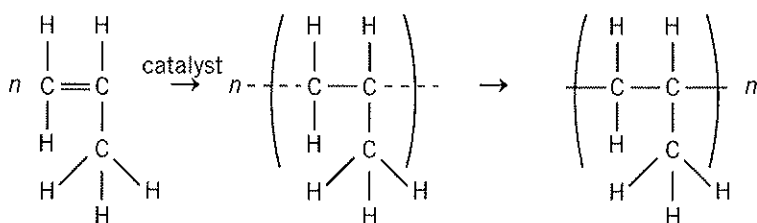
- b i



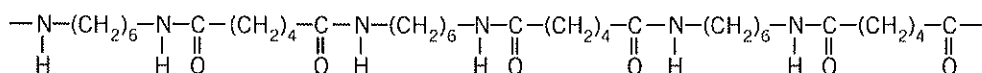
ii



5



6

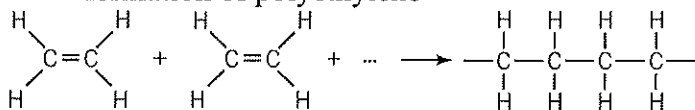


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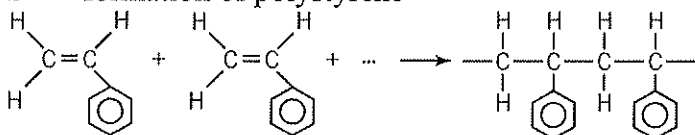
- Increased branching decreases hardness by making the polymer less compact and rigid.
- Cross-linking between polymer chains increases hardness because cross-linking is produced by covalent bonds linking chains together.
- Decreasing the length of polymer chains decreases hardness because there are less dispersion forces between the chains.
- Increasing the orderly arrangement of polymer chains increases hardness by making the polymer more dense and less flexible.
- Adding a plasticiser to a polymer decreases hardness because plasticisers are generally chosen to soften a polymer.

### Review exercise 2.2

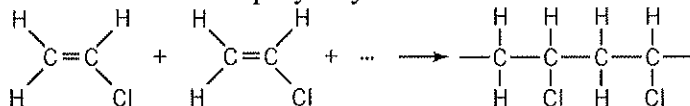
1 a formation of polyethylene



b formation of polystyrene



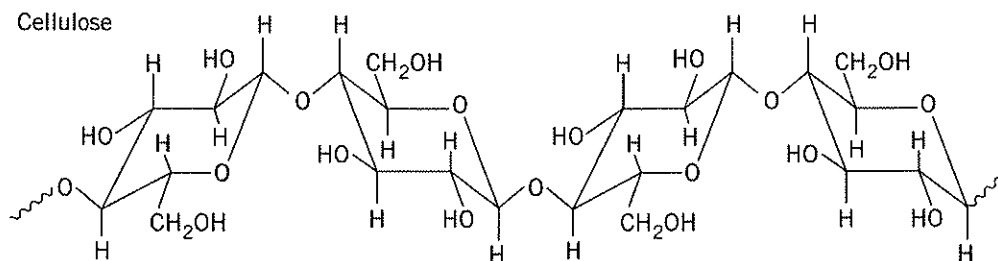
c formation of polyvinylchloride



- 2 a chloroethylene  
b phenylethylene or ethenylbenzene
- 3 LDPE is softer and more flexible due to greater branching of chains causing reduced dispersion forces.  
HDPE has fewer branched chains, causing greater dispersion forces and hence greater hardness and strength.
- 4 1 monomer unit has molar mass of 62.5 g, so 15 000 monomer units have molar mass of 937 500 g.
- 5 a polystyrene because it is a cheap, lightweight insulating polymer  
b low-density polyethene (LDPE) because it is mouldable, impermeable and flexible  
c polypropene/nylon because it is lightweight and strong and easily formed into fibres  
d LDPE because it is lightweight, cheap and flexible  
e HDPE because it is tough and durable  
f HDPE because it is rigid, tough and durable  
g Teflon because it is tough, frictionless and resistant to heat and chemicals  
h polyethene terephthalate (PET) because it is lightweight, tough and easily blown into a shapeable film

**Review exercise 2.3**

- 1 Most of the synthetic polymers made today are derived from the petrochemical industry, which relies on the non-renewable fossil fuel petroleum. However, these supplies will be rapidly used up, especially if we continue to demand their use as both a fuel and a feedstock. An alternative, renewable source of raw materials is needed.
- 2 Biomass is organic material derived from living organisms: plant material such as sugar and cellulose; animal material such as dung; and domestic and industrial organic waste.
- 3 Cellulose is a long-chain polymer of  $\beta$ -glucose units,  $\text{C}_6\text{H}_{12}\text{O}_6$ , where every second glucose unit is inverted to produce straightened chains.
- 4 A glucose unit loses an H from an  $-\text{OH}$  group and joins to a carbon on a second glucose unit which has lost its  $-\text{OH}$  group; this links the glucose units with the loss of  $\text{H}_2\text{O}$  and so the formation of cellulose is an example of condensation polymerisation.



- 5 Cellulose is made from repeating units of  $\beta$ -glucose with inversion of every second unit. This produces long, straight chains of cellulose which are linked to each other by hydrogen bonding. In plants, cellulose acts as a structural material. Starch (both amylose and amylopectin) is made from long-chain repeating units of  $\alpha$ -glucose, which are also highly branched. This results in tightly coiled, compact, insoluble starch molecules, which are used as energy stores in plants.
- 6 Existing plant cellulose can be modified to produce biopolymers, such as celluloid and rayon, or it can be broken down into smaller units that can be used to build new polymers such as corn-starch polymers.

#### Review exercise 2.4

- 1 Silk is a biopolymer used in its natural form; rayon uses cellulose in a chemically modified form; lactic acid can be produced from the breakdown of starch and then used to make polylactic acid (PLA).
- 2 Advantages are that biopolymers come from plant material, which is a renewable resource, and that plastics made from biopolymers are easily broken down by bacteria and fungi.  
  
Disadvantages include the cost of production and that they are easily biodegradable, which is not useful in some applications.
- 3
  - a Plastic-producing bacteria are grown in fermentation vats and fed on molasses or methanol. Extraction of plastic from the bacterium involves breaking down the bacterium's cell walls and separating this from the cell debris.
  - b The bacterium used is *Alcaligenes eutrophus*.
  - c The plastic produced is of a type known as PHAs—polyhydroxyalkanoates—which have similar properties to polypropene.

#### Chapter 2 — Application and investigation

- 1 Monomer: small repeating units that join by covalent bonds to form a polymer, e.g. ethylene.  
  
Polymer: large-chain molecule consisting of small repeating units called monomers, e.g. polyethylene.

## Solutions Manual: Module 1

### Production of materials

Chemistry  
**Contexts 2**  
SECOND EDITION

Polymerisation: the chemical reaction by which monomers link together to form polymers, e.g. formation of polyethylene by addition reaction.

2 Investigation

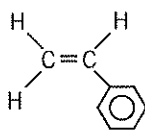
3 Polyethylene can have many different molecular chain lengths. Those with around 40 000 atoms per molecule are used for food wrap films; 60 000 atoms per molecule make milk containers; 80 000 atoms per molecule make bleach containers and 800 000 atoms per molecule can be used in artificial ice rinks. As chain length increases, density, hardness and melting point increase. Branching is possible in polyethylene, and as branching increases, density, hardness and melting point decrease, increasing the uses that can be made of polyethylene.

4 Molecular mass of 1 monomer = 28, so  $84\,500 \div 28 = 3018$  monomer units

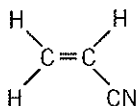
5 First-hand investigation

6 Investigation based on answer to Q5

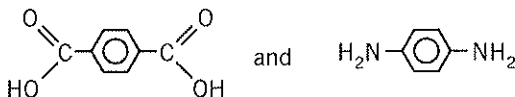
7 a



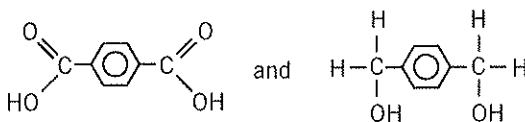
b



c



d



8 Investigation

9 Investigation

10 Investigation

## CHAPTER 3: ETHANOL

### Review exercise 3.1

1 a 1-propanol

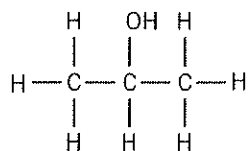
b 4-chloro-2-pentanol



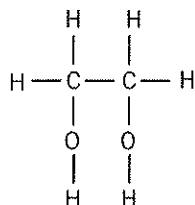
c 1,4-butanediol

d 2-methyl-2-propanol

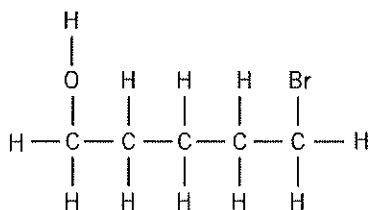
2 a



b

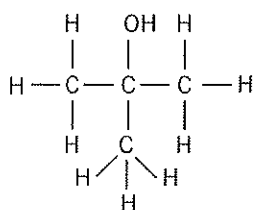


c



3

2-methyl-propanol



83°C

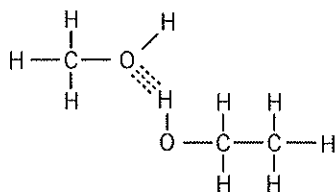
2-butanol <pre>       H   H   OH  H                     H — C — C — C — C — H                           H   H   H   H           </pre>	100°C
2-methyl-1-propanol <pre>       H   H   H                 H — C — C — C — OH                       H   C   H                       H           </pre>	108°C
1-butanol <pre>       H   H   H   H                     H — C — C — C — C — OH                           H   H   H   H           </pre>	118°C

- 4 Heat ethanol with an excess of concentrated sulfuric acid, or heat ethanol vapour over a catalyst at 350°C.
- 5  $\text{C}_2\text{H}_5\text{OH}(\text{l}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$

### Review exercise 3.2

- Methylated spirits are 95% ethanol, 5% methanol and small quantities of foul-tasting chemicals. The additives are used to discourage people from drinking it.
- Ethanol has a short non-polar chain, which allows it to dissolve some non-polar substances. The  $-\text{OH}$  functional group makes ethanol polar, which allows it to act a solvent for polar substances.
- The ethanol molecule contains the polar  $-\text{OH}$  end and the non-polar hydrocarbon chain. Hence it is able to be used as a solvent for non-polar substances such as perfumes and aftershaves. The low boiling point ethanol evaporates easily with body heat, leaving the heavier fragrance components on the skin.

4



- 5 Ethanol is described as renewable because it can be derived from the starch and sugars present in various crops such as sugar cane and corn.
- 6 Cars using ethanol produce fewer pollutants. Ethanol is a renewable resource. However, no commercially viable method of obtaining ethanol is available and cars will need to be significantly modified to run on pure ethanol.

7	Mass of methanol burned	=	1.10 g
	Mass of water	=	100 g
	Mass of copper	=	200.0 g
	Temperature change	=	5°C
	Specific heat capacity water	=	4.18 J K <sup>-1</sup> g <sup>-1</sup>
	Specific heat capacity copper	=	0.387 J K <sup>-1</sup> g <sup>-1</sup>
	Heat released per 1.10 g methanol	=	-(mCΔT(copper) + mCΔT(water))
		=	-(200 × 0.387 × 5 + 100 × 4.18 × 5)
		=	-2477 J released by 1.10 g methanol
	Heat released per mole of methanol	=	-2477 × $\frac{32}{1.10}$
		=	-72 058 J mol <sup>-1</sup>
	∴ Molar heat of combustion	=	72 kJ mol <sup>-1</sup>

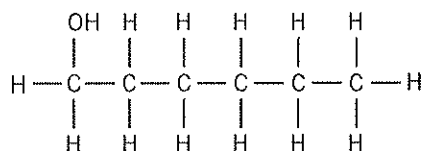
**Review exercise 3.3**

- 1 The acid catalyst is needed to cause the water molecule to attack the double bond in ethylene.
- 2
- $$\text{CH}_2=\text{CH}-\text{CH}_3(\text{g}) + \text{H}_2\text{O}(\text{g}) \xrightarrow{\text{H}^+} \text{CH}_3-\text{CHOH}-\text{CH}_3(\text{g}) \text{ (Markovnikov's rule)}$$
- 3 a carbohydrates, e.g. glucose, sucrose, starch, plus water and yeast

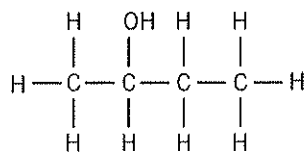
- b** The yeasts produce enzymes which act as catalysts in the conversion of glucose to ethanol and carbon dioxide.
- c** ethanol and carbon dioxide
- d** exothermic
- e** Once the ethanol concentration reaches 15% in the fermentation container, the yeast is killed and the reaction ceases. Therefore naturally fermented wines have ethanol concentrations of 12–15%.
- 4** Fermentation of glucose occurs best in the absence of oxygen (anaerobic conditions) and at a temperature of 35–40°C.
- 5** From the equation, and using  $n = \text{mass (g)} \div \text{molar mass (g)}$
- $$\begin{aligned} \text{mass (ethanol)} &= 2 \times \text{mass(glucose)} \div \text{molar mass(glucose)} \times \text{molar mass(ethanol)} \\ &= 2 \times 500 \div 180.156 \times 46.068 \\ &= 255.7 \text{ g} \end{aligned}$$
- 6** From the equation, and using  $n = \text{mass (g)} \div \text{molar mass (g)}$
- $$\begin{aligned} \text{mass (ethanol)} &= \text{mass (carbon dioxide lost)} \div \text{molar mass (carbon dioxide)} \times \text{molar mass (ethanol)} \\ &= 50.0 \div 44.01 \times 46.068 \\ &= 52.3 \text{ g} \end{aligned}$$

### Chapter 3 — Application and investigation

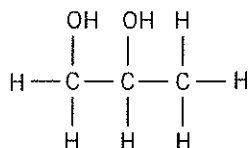
**1 a**



**b**



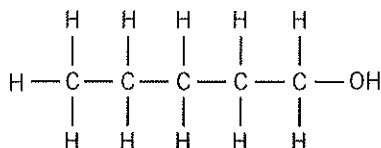
c



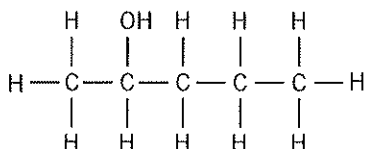
2 a 1-propanol

b 1,4-butanediol

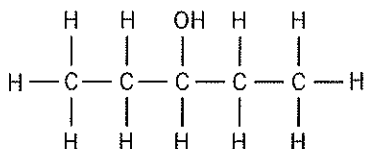
3



1-pentanol



2-pentanol



3-pentanol

4 Water, being polar, would not readily dissolve many esters with a non-polar component. Hexane, being non-polar, would not readily dissolve the polar esters. Ethanol, with its ability to dissolve both polar and non-polar components, is suitable for dissolving esters.

5 Investigation

6 Investigation

7 Investigation

8 Depends on responses to Questions 5, 6 and 7.

9 a Assume heat absorbed by copper is negligible.

Mass of fuel = 2.00 g

Mass of water = 500 g

Change in temp = 18.4°C

Specific heat water = 4.18 J K<sup>-1</sup> g<sup>-1</sup>**Methanol**Heat released by 2 g =  $-m\Delta T$

$$= -(500 \times 4.18 \times 18.4)$$

$$= -38\,456\text{ J}$$

i Heat of combustion/g  $= 38\,456 \div 2$

$$= 19\,228\text{ J g}^{-1} = 19.2\text{ kJ g}^{-1}$$

ii Heat of combustion/mole  $= 38\,456 \times \frac{32}{2}$

$$= 61\,5296\text{ J mol}^{-1}$$

**1-propanol**

$$= 615\text{ kJ mol}^{-1}$$

Heat released by 2 g

$$= -mC\Delta T$$

$$= -(500 \times 4.18 \times 28.5)$$

$$= -59\,565\text{ J}$$

i Heat of combustion/g  $= 59\,565 \div 2$

$$= 29\,782.5\text{ J g}^{-1} = 29.8\text{ kJ g}^{-1}$$

ii Heat of combustion/mole  $= 59\,565 \times \frac{60.1}{2}$

$$= 1\,789\,928\text{ J mol}^{-1}$$

$$= 1790\text{ kJ mol}^{-1}$$

**1-butanol**

Heat released by 2 g

$$= -mC\Delta T$$

$$= -(500 \times 4.18 \times 31.5)$$

$$= -65\,835\text{ J}$$

i Heat of combustion/g  $= 65\,835 \div 2$

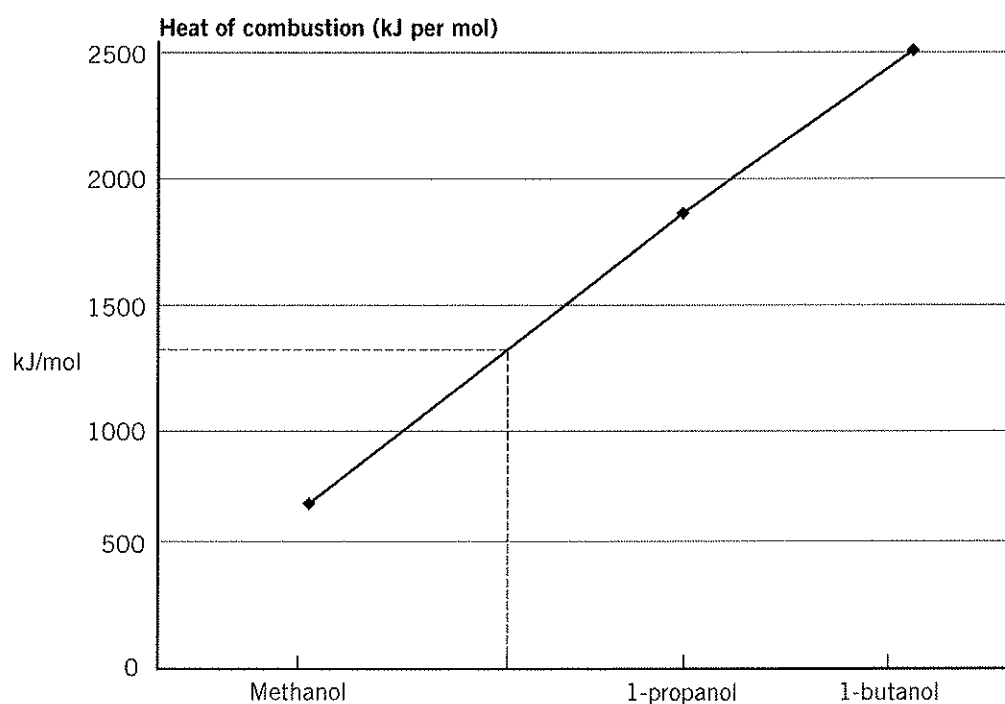
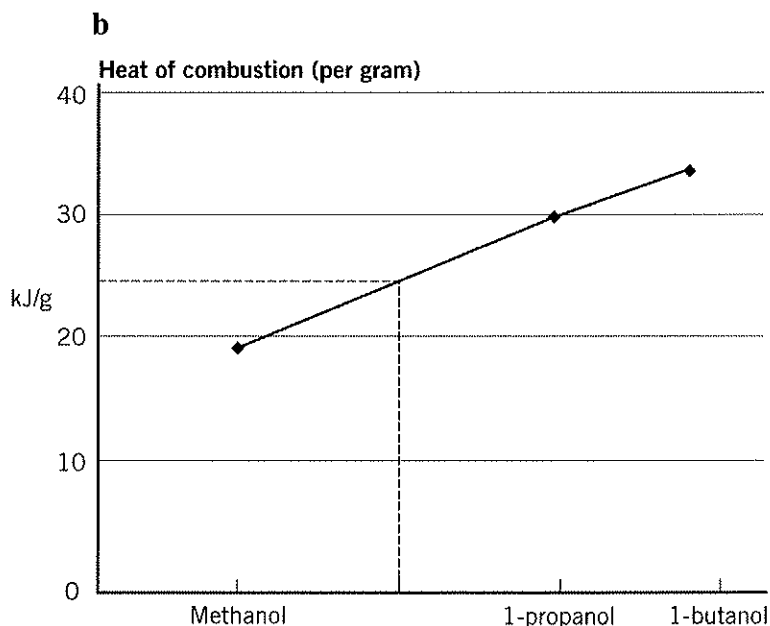
$$= 32\,917.5\text{ J}$$

$$= 32.92\text{ kJ g}^{-1}$$

ii Heat of combustion/mole  $= 65\,835 \times \frac{74.12}{2}$

$$= 2\,439\,845.1\text{ J}$$

$$= 2440\text{ kJ mol}^{-1}$$



- 10** The dehydration of ethanol to ethylene and water is carried out by heating ethanol with concentrated sulfuric acid as a catalyst, or by heating ethanol vapour over an alumina catalyst at  $350^{\circ}\text{C}$ . The hydration of ethylene to produce ethanol requires the addition of water in the presence of a sulfuric or phosphoric acid catalyst.

## CHAPTER 4: ELECTROCHEMISTRY

## Review exercise 4.1

- 1 a A pink-brown deposit of copper forms on the surface of the steel wool as the copper ions convert to elemental copper; the blue solution goes paler and slowly converts to a green solution as the copper ions decrease in concentration and the elemental iron converts to  $\text{Fe}^{2+}$  ions with increasing concentration.
- b oxidation:  $\text{Fe(s)} \rightarrow \text{Fe}^{2+}(\text{aq}) + 2\text{e}^-$   
 reduction:  $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)}$
- c  $\text{Fe(s)} + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Fe}^{2+}(\text{aq}) + \text{Cu(s)}$
- 2 a  $\text{Fe(s)} + \text{Sn}^{2+}(\text{aq}) \rightarrow \text{Fe}^{2+}(\text{aq}) + \text{Sn(s)}$ ; the iron would dissolve and the tin would coat the surface of the iron; the solution would change from colourless to green
- b  $\text{Pb(s)} + \text{Hg}^{2+}(\text{aq}) \rightarrow \text{Pb}^{2+}(\text{aq}) + \text{Hg(l)}$ ; the lead would dissolve and liquid mercury would form
- c no reaction
- d  $2\text{Cr(s)} + 3\text{Fe}^{2+}(\text{aq}) \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 3\text{Fe(s)}$ ; the chromium would dissolve and the iron would coat the chromium; both ions are generally green in aqueous solution
- 3 The iron container would dissolve as the iron was oxidised to its ions by the nickel ions, which would convert to elemental nickel.
- 4 a no reaction
- b  $\text{Sn(s)} \rightarrow \text{Sn}^{2+}(\text{aq}) + 2\text{e}^-$ ;  $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)}$ ; copper would coat the tin
- c  $\text{Sn(s)} \rightarrow \text{Sn}^{2+}(\text{aq}) + 2\text{e}^-$ ;  $\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag(s)}$ ; silver would coat the tin

## Review exercise 4.2

- 1 a  $\text{CO}_2$  : C = +4 O = -2  
 $\text{O}_2$  : elemental state  $\therefore$  0  
 $\text{NH}_3$  : N = -3 H = +1  
 $\text{H}_2\text{S}$  : S = -2 H = +1  
 $\text{HCl}$  : H = +1 Cl = -1
- b  $\text{SO}_2$  : S = +4 O = -2  
 $\text{SO}_3^{2-}$  : S = +4 O = -2  
 $\text{H}_2\text{S}_2\text{O}_7$  : H = +1 S = +6 O = -2  
 $\text{S}_2\text{O}_8^{2-}$  : S = +7 O = -2



## Solutions Manual: Module 1

### Production of materials

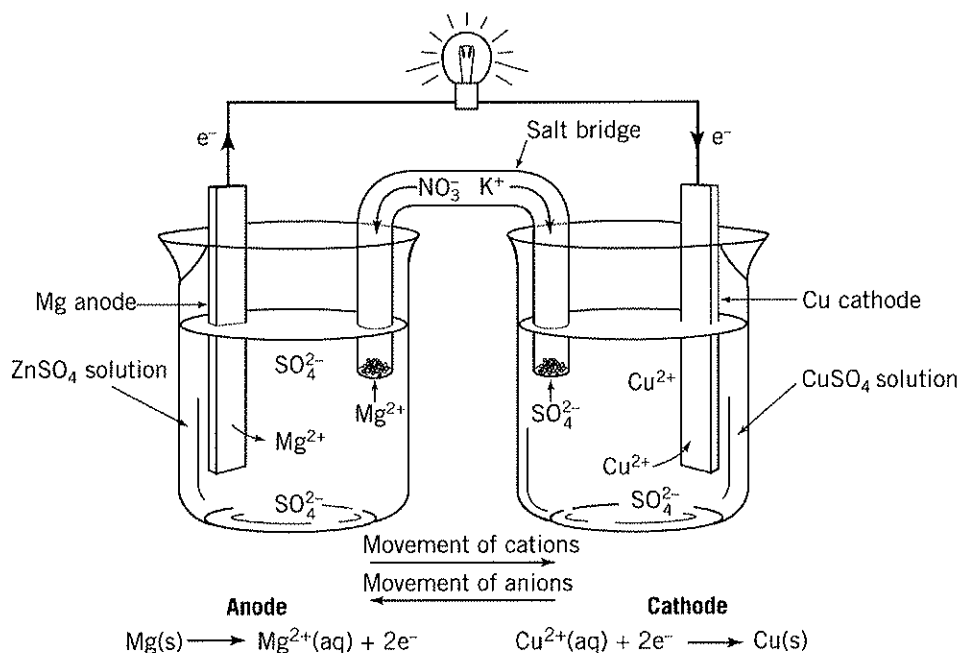
Chemistry  
**Contexts 2**  
SECOND EDITION

- $\text{HSO}_3^-$  : H = +1      S = +4      O = -2  
S : 0
- c**  $\text{NH}_4^+$  : N = -3      H = +1  
 $\text{ClO}_4^-$  : Cl = +7      O = -2  
 $\text{Cu}_2\text{S}$  : Cu = +1      S = -2  
 $\text{MgH}_2$  : Mg = +2      H = -1  
 $\text{PO}_4^{3-}$  : P = +5      O = -2
- 2** **a** redox reaction: Zn oxidised ( $0 \rightarrow +2$ ),  $\text{H}^+$  reduced ( $+1 \rightarrow 0$ )  
**b** not a redox reaction  
**c** not a redox reaction  
**d** redox reaction:  $\text{Fe}^{2+}$  oxidised ( $+2 \rightarrow +3$ ),  $\text{Cr}^{6+}$  reduced ( $+6 \rightarrow +3$ )
- 3** NO : +2       $\text{NO}_2$  : +4       $\text{N}_2\text{O}$  : +1       $\text{N}_2\text{O}_3$  : +3       $\text{N}_2\text{O}_4$  : +4  
 $\text{N}_2\text{O}_5$  : +5       $\text{HNO}_3$  : +5       $\text{HNO}_2$  : +3       $\text{NO}_2^-$  : +3       $\text{NO}_3^-$  : +5  
 $\text{NH}_2^-$  : -3       $\text{NH}_4^+$  : -3       $\text{N}_2$  : 0       $\text{N}_2\text{H}_4$  : -2       $\text{NH}_3$  : -3  
 $\text{NH}_2\text{OH}$  : -1       $\text{NH}_4\text{Cl}$  : -3
- 4**  $\text{Br}^-$  and HBr both have bromine in -1 oxidation state.  
 $\text{BrO}^-$  and  $\text{Br}_2\text{O}$  and HBrO each have bromine in +1 oxidation state.

### Review exercise 4.3

- 1** The salt bridge allows ions to move between each half-cell.

2 a



b See diagram in part a.

c anode: oxidation  $\text{Mg(s)} \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{e}^-$ cathode: reduction  $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)}$ 3 a  $3\text{Pb}^{2+}(\text{aq}) + 6\text{e}^- \rightarrow 3\text{Pb(s)}$  cathode $2\text{Cr(s)} \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 6\text{e}^-$  anodeb  $\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$  anode $2\text{Ag}^+(\text{aq}) + 2\text{e}^- \rightarrow 2\text{Ag(s)}$  cathode**Review exercise 4.4**1 a  $\text{Ca}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Ag}^+$ 

b Ag, Sn, Cr, Mg

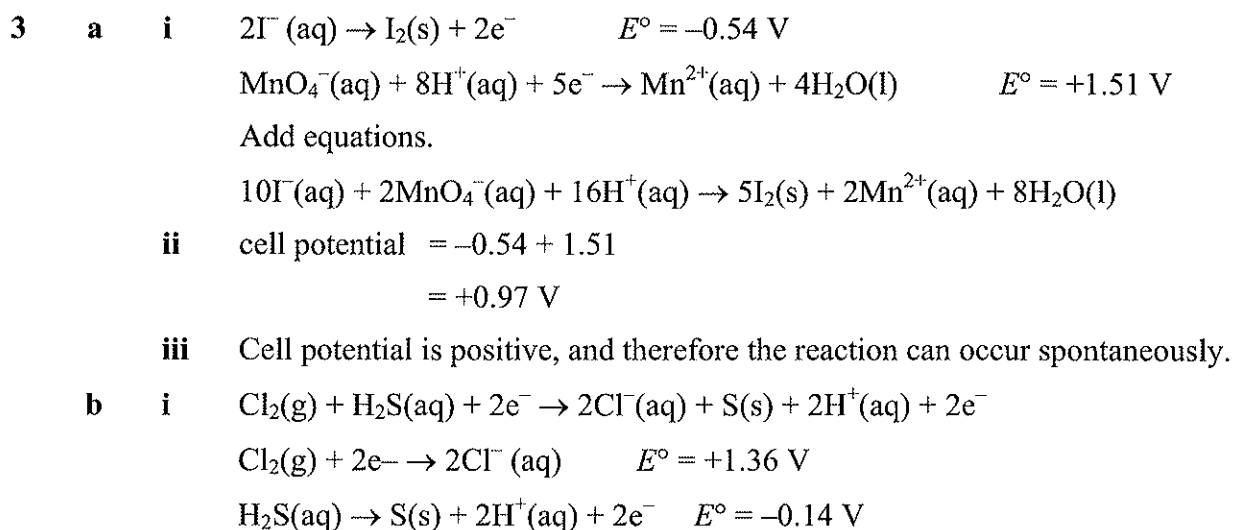
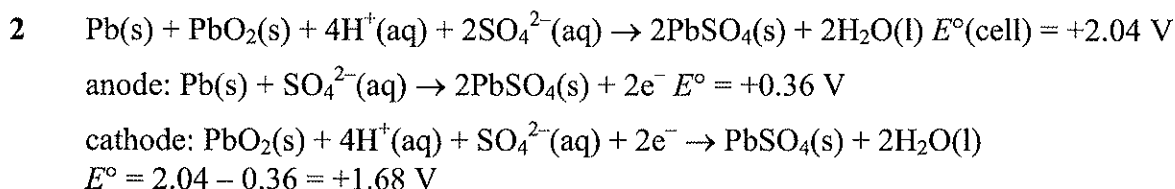
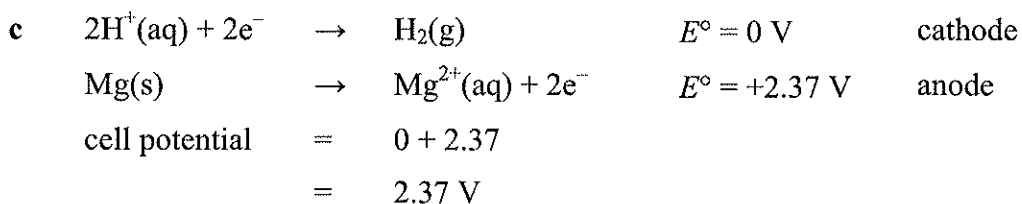
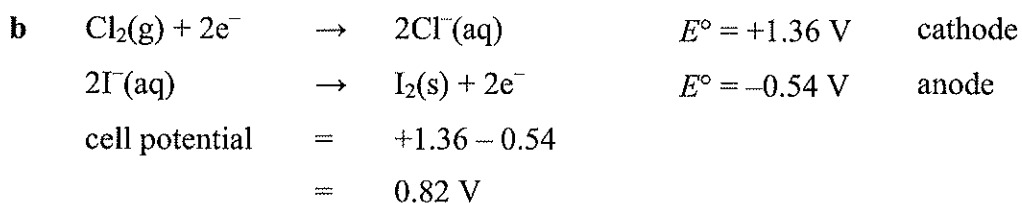
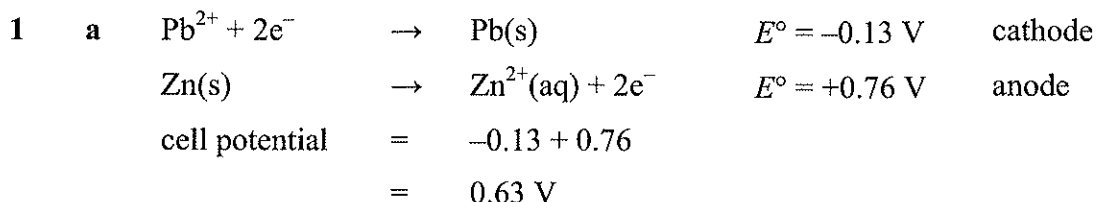
c strongest oxidising agent:  $\text{Ag}^+$ 

strongest reducing agent: Mg

2 a  $\text{H}_2\text{O}_2$ ,  $\text{HClO}$ ,  $\text{MnO}_4^-$ ,  $\text{Cr}_2\text{O}_7^{2-}$ b Mg, Zn,  $\text{H}_2$ ,  $\text{H}_2\text{S}$ 3 a  $\text{Cl}_2$ b  $\text{Sn}^{4+}$ c  $\text{Au}^{3+}$

d  $\text{MnO}_4^-$ 

## Review exercise 4.5

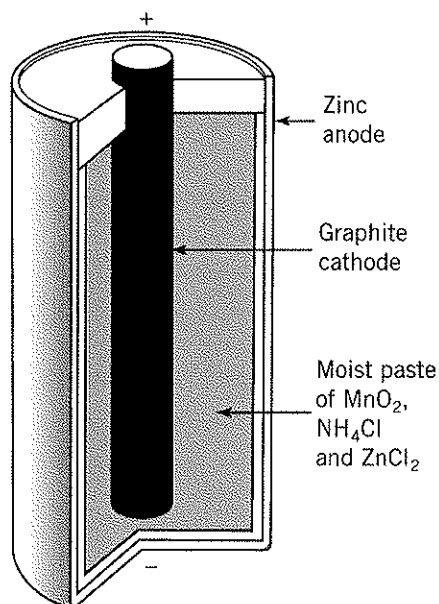


- ii cell potential  $= +1.36 - 0.14$   
 $= +1.22 \text{ V}$
- iii Cell potential is positive, and therefore the reaction can occur spontaneously.
- c i  $2\text{Cu}^+(\text{aq}) + \text{e}^- \rightarrow \text{Cu}^{2+}(\text{aq}) + \text{Cu}(\text{s}) + \text{e}^-$   
 $\text{Cu}^+(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + \text{e}^- \quad E^\circ = -0.16 \text{ V}$   
 $\text{Cu}^+(\text{aq}) + \text{e}^- \rightarrow \text{Cu}(\text{s}) \quad E^\circ = +0.52 \text{ V}$
- ii cell potential  $= -0.16 + 0.52$   
 $= +0.36 \text{ V}$
- iii Cell potential is positive, and therefore the reaction can occur spontaneously.
- 4 a  $\text{H}_2\text{O}_2(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l}) \quad E^\circ = +1.78 \text{ V}$   
 $\text{H}_2\text{C}_2\text{O}_4(\text{aq}) \rightarrow 2\text{CO}_2(\text{g}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \quad E^\circ = +0.48 \text{ V}$   
 $E^\circ(\text{cell}) = +1.78 + 0.48$   
 $= +2.26 \text{ V}$
- b A high activation energy may be necessary for this reaction to occur.
- c Mix the  $\text{H}_2\text{O}_2$  and  $\text{H}_2\text{C}_2\text{O}_4$  at a higher temperature and/or add a catalyst.

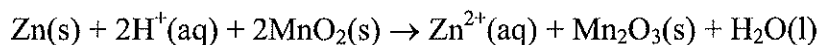
**Review exercise 4.6**

- 1 The dry cell is one of the most widely used sources of portable electricity. It has led to the proliferation of the portable devices we see around us. Without dry cells we would be a much less mobile society. Devices requiring electrical power would need to be in close proximity to permanent sources such as power points. Instead of torches we could still be using candles or kerosene lamps. However, the development of dry cells has led to landfill pollution.

2

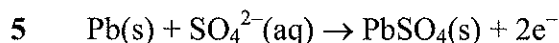
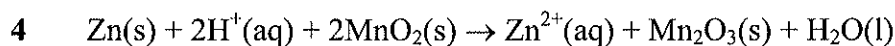


- 3 a If the Zn and MnO<sub>2</sub> were in direct contact, the following overall cell reaction would occur:

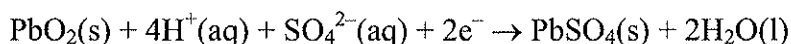


i.e. zinc is oxidised and manganese dioxide is reduced.

- b The cell would be useless because electron transfer would occur directly between the reactants and not through an external circuit.



(0) (+2) oxidation



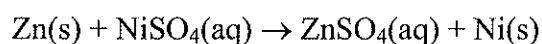
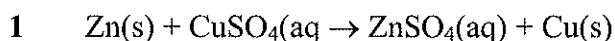
(+4) (+2) reduction

- 6 A 6V lead–acid battery would have three cells, each with a cell potential of 2 V.

- 7 Lead–acid batteries are very heavy and weight is an important issue for solar-powered cars in the World Solar Challenge.

#### Chapter 4 — Application and investigation

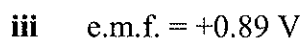
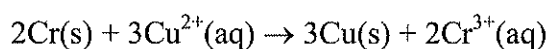
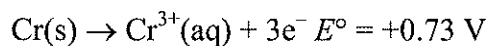
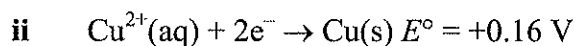
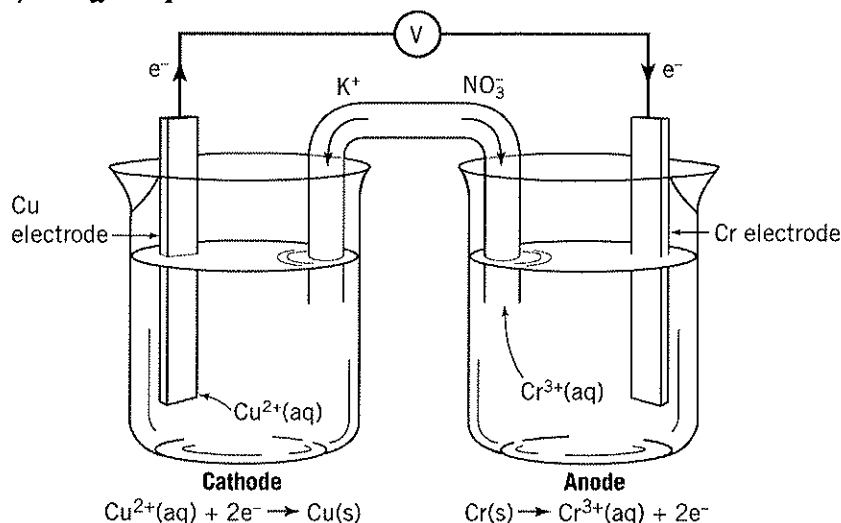
The following reactions will occur:



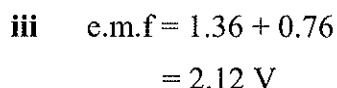
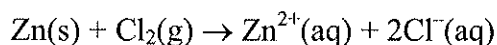
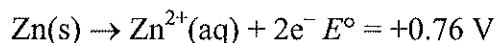
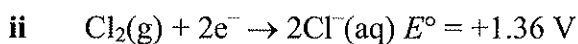
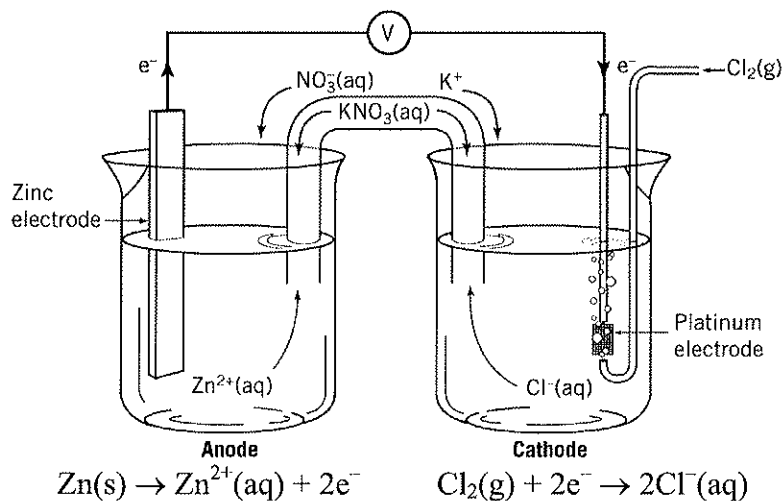
- 2 a i Yes. Fe<sup>2+</sup> ions will not oxidise Ni.

- ii No.  $\text{Fe}^{3+}$  will be reduced to  $\text{Fe}^{2+}$  and Ni oxidised to  $\text{Ni}^{2+}$ .
- b No. The steel will dissolve and displace the copper.
- 3 The student should determine gallium's position in the order of reactivity by attempting to oxidise it using the ions of the other metals in the list.
- 4
- |   |                                   |               |                               |           |
|---|-----------------------------------|---------------|-------------------------------|-----------|
| a | $\text{HNO}_3(\text{aq})$         | $\rightarrow$ | $\text{NO}_2(\text{g})$       | reduction |
|   | +5                                |               | +4                            |           |
| b | $\text{Cl}_2(\text{g})$           | $\rightarrow$ | $\text{ClO}_3^-(\text{aq})$   | oxidation |
|   | 0                                 |               | +5                            |           |
| c | $\text{NH}_3(\text{g})$           | $\rightarrow$ | $\text{N}_2(\text{g})$        | oxidation |
|   | -3                                |               | 0                             |           |
| d | $\text{Fe}_2\text{O}_3(\text{s})$ | $\rightarrow$ | $\text{FeO}(\text{s})$        | reduction |
|   | +3                                |               | +2                            |           |
| e | $\text{SO}_2(\text{g})$           | $\rightarrow$ | $\text{SO}_4^{2-}(\text{aq})$ | reduction |
|   | +4                                |               | +2                            |           |
| f | $\text{MnO}_4^-(\text{aq})$       | $\rightarrow$ | $\text{MnO}_2(\text{s})$      | reduction |
|   | +7                                |               | +4                            |           |
- 5
- a  $\text{Fe}(\text{s}) + \text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{FeSO}_4(\text{s})$   
 0    +4 -2    0    +2 +6 -2  
 Fe oxidised; S oxidised;  $\text{O}_2$  reduced
- b  $4\text{FeSO}_4(\text{s}) + \text{O}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}(\text{s}) + 4\text{H}_2\text{SO}_4(\text{aq})$   
 +2 +6 -2    0    +1 -2    +3 -2 +1 -2    +1 +6 -2  
 Fe oxidised;  $\text{O}_2$  reduced
- 6
- a All the  $E^\circ$  values would be 2.93 V higher.
- b Calculated e.m.f. values for cells are based on the difference in  $E^\circ$  between two half-cell reactions. These would be unchanged.

**7 a i**



**b i**



- 8 a The half-cells are separated in order to generate a flow of current in the external circuit.  
 b A salt bridge allows ions to move between each half-cell and complete the circuit.
- 9 a anode:  $\text{Zn(s)} \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^-$   $E^\circ = +0.76 \text{ V}$   
 cathode:  $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)}$   $E^\circ = +0.34 \text{ V}$   
 cell:  $\text{Zn(s)} + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu(s)}$   $E^\circ(\text{cell}) = +1.10 \text{ V}$
- b As the cell operates, the concentration of  $\text{Cu}^{2+}$  decreases and the  $\text{Zn}^{2+}$  concentration increases. Both changes would decrease the tendency of the forward reaction to take place and hence the cell e.m.f. would decrease.
- c i Transfer of electrons cannot occur, and therefore the reaction between the two half-cells will cease.  
 ii Transfer of charged ions between half-cells cannot occur.
- 10 The reduction potential of +1.7 V for  $\text{Au}^+$  is higher than that for the reduction of  $\text{O}_2$ , and therefore  $\text{O}_2$  would not oxidise the gold. The reduction potential for  $[\text{Au}(\text{CN})_2]^-$  (aq) is lower than that for  $\text{O}_2$ , and therefore in the presence of cyanide ion, gold can be oxidised.
- 11 a  $\text{Ni}^{2+}(\text{aq})$  or  $\text{Co}^{2+}(\text{aq})$  or  $\text{Cd}^{2+}(\text{aq})$   
 b  $\text{Mn(s)}$  or  $\text{Al(s)}$  or  $\text{Zn(s)}$
- 12 a i  $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$   $E^\circ = -0.77 \text{ V}$   
 $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$   $E^\circ = +1.51 \text{ V}$   
 $E^\circ(\text{cell}) = +0.74 \text{ V}$
- ii  $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$   $E^\circ = -1.36 \text{ V}$   
 $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$   $E^\circ = +1.51 \text{ V}$   
 $E^\circ(\text{cell}) = +0.15 \text{ V}$
- iii  $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$   $E^\circ = -0.77 \text{ V}$   
 $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$   $E^\circ = +1.33 \text{ V}$   
 $E^\circ(\text{cell}) = +0.56 \text{ V}$
- iv  $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$   $E^\circ = -1.36 \text{ V}$   
 $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$   $E^\circ = +1.33 \text{ V}$   
 $E^\circ(\text{cell}) = -0.03 \text{ V}$

Thus a redox reaction should occur in **i**, **ii** and **iii**.

- b **iv** above shows that  $\text{Cr}_2\text{O}_7^{2-}$  will not oxidise the  $\text{Cl}^-$  ion of  $\text{HCl}$ , but **ii** shows that  $\text{MnO}_4^-$  will. Hence, it is inappropriate to use  $\text{HCl}$  to acidify solutions involving permanganate titrations.



- 13 a An *anode* is the electrode at which oxidation takes place. A *cathode* is the electrode at which reduction takes place.
- b A *salt bridge* allows a flow of ions between two half-cells. An *external circuit* allows a flow of electrons from anode to cathode.
- c A *secondary cell* can be recharged, whereas a *primary cell* cannot.
- 14 a i anode:  $\text{Pb(s)} + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{PbSO}_4(\text{s}) + 2\text{e}^-$   
cathode:  $\text{PbO}_2(\text{s}) + 4\text{H}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + 2\text{e}^- \rightarrow \text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O(l)}$
- ii anode:  $\text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O(l)} \rightarrow 2\text{e}^- + \text{SO}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) + \text{PbO}_2(\text{s})$   
cathode:  $\text{PbSO}_4(\text{s}) + 2\text{e}^- \rightarrow \text{Pb(s)} + \text{SO}_4^{2-}(\text{aq})$
- b i On discharging, the density decreases.  
ii On recharging, the density increases.
- c Chemical potential energy is transformed into electrical energy and some heat energy as the battery is discharged. On charging, electrical energy is transformed into chemical potential energy and some heat energy.
- 15 a Anode:  $\text{Al(s)} \rightarrow \text{Al}^{3+}(\text{aq}) + 3\text{e}^-$   
Cathode:  $\text{O}_2(\text{g}) + 2\text{H}_2\text{O(l)} + 4\text{e}^- \rightarrow 4\text{OH}^-(\text{aq})$
- b  $\text{Al(s)} \rightarrow \text{Al}^{3+}(\text{aq}) + 3\text{e}^-$   $E^\circ = +1.66 \text{ V}$   
 $\text{O}_2(\text{g}) + 2\text{H}_2\text{O(l)} + 4\text{e}^- \rightarrow 4\text{OH}^-(\text{aq})$   $E^\circ = +0.40 \text{ V}$   
 $E^\circ(\text{cell}) = +2.06 \text{ V}$   
Cell e.m.f. would be 2.06 V.
- c It would weigh much less.  
It avoids use of corrosive  $\text{H}_2\text{SO}_4$ .  
It uses  $\text{O}_2$  from the air as a cathode.
- 16–18 Investigation

## CHAPTER 5: NUCLEAR CHEMISTRY

## Review exercise 5.1

- 1 a Atoms are not conserved in nuclear reactions.
- b *Chemical reactions* involve changes in electrons between atoms. *Nuclear reactions* involve the particles in the nucleus.
- c Temperature, pressure/concentration and catalysts have no effect on nuclear reactions.

d Far more energy is obtained from nuclear reactions.

- 2 a i  $^{17}\text{O}$  : 8 protons; 9 neutrons  
 ii  $^{52}\text{Fe}$  : 26 protons; 26 neutrons  
 iii  $^{137}\text{I}$  : 53 protons; 84 neutrons  
 iv  $^{258}\text{Md}$  : 101 protons; 157 neutrons

- b i  $^{148}_{62}\text{Sm}$   
 ii  $^{93}_{41}\text{Nb}$   
 iii  $^{208}_{82}\text{Pb}$

- 3 a  $\alpha$  large mass;  $\beta$  very small mass;  $\gamma$  no mass  
 b  $\alpha$  2+ charge;  $\beta$  1– charge;  $\gamma$  no charge  
 c  $\alpha$  least penetrating, about 5 cm through air  
 $\beta$  about 1 m through air, stopped by aluminium  
 $\gamma$  can pass through several cm of lead

- 4 a  $^4_2\text{He}$   
 b  $^0_{-1}\text{e}$   
 c  $^1_0\text{n}$   
 d  $^1_1\text{p}$   
 e  $^0_1\text{e}$

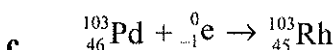
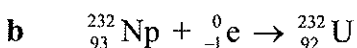
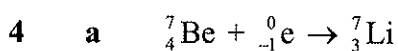
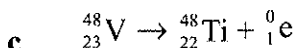
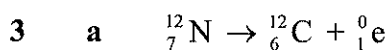
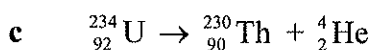
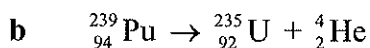
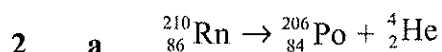
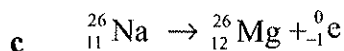
- 5 *Photographic film*: becomes dark on exposure. Darkness increases with length of exposure and greater intensity of radiation.

*Geiger counter*: The argon gas inside a metal tube is ionised into positive ions and electrons. These move towards electrodes which conduct a current measured by a recording device.

*Scintillation counter*: Electrons in substances such as zinc sulfide are excited by radiation and emit photons of light as they return to lower energy states. Radiation is measured by counting flashes of light.

### Review exercise 5.2

- 1 a  $^3_1\text{H} \rightarrow ^3_2\text{He} + ^0_{-1}\text{e}$   
 b  $^{27}_{12}\text{Mg} \rightarrow ^{27}_{13}\text{Al} + ^0_{-1}\text{e}$



5 a beta emission

b positron emission

c alpha emission

d positron emission

6 a positron or electron capture

b  $\beta$  decay

c  $\alpha$  decay

7 a No, the neutron : proton ratio is too high and outside the zone of stability.

b No, the neutron : proton ratio is too low and outside the zone of stability.

c Yes, the neutron : proton ratio is in the zone of stability.

### Review exercise 5.3

1 After 1st 2.6 hours:  $0.1/2 = 0.05$  g

After 5.2 hours: 0.025 g

After 7.8 hours: 0.0125 g

2 1st half-life:  $0.120/2 = 0.06$  g

2nd half-life:  $0.06/2 = 0.03$  g

3rd half-life:  $0.03/2 = 0.015$  g

$\therefore$  3 half-lives in 24 days

I-131 has a half-life of 8 days.

- 3    **a**    2.1 g = 21%  
      **b**    164 g  $\rightarrow$  20.5 g, i.e. 12.5% left = 3 half-lives,  $\therefore$  84 years  
      **c**    Half-life is 28 years.
- 4    Thallium-201 and gallium-67: suitable, as have a short half-life; sulfur-35 and hydrogen-3: unsuitable as half-life is too long.

**Review exercise 5.4**

- 1    To overcome the electrostatic repulsion alpha particles and protons will encounter in the nuclide. Neutrons do not carry a charge and therefore do not need to be accelerated.
- 2    They are produced synthetically.
- 3    **a**     ${}^{15}_7\text{N} + {}^1_1\text{p} \rightarrow {}^{12}_6\text{C} + {}^4_2\text{He}$   
      **b**     ${}^{56}_{26}\text{Fe} + {}^2_1\text{H} \rightarrow {}^4_2\text{He} + {}^{54}_{25}\text{Mn}$   
      **c**     ${}^6_3\text{Li} + {}^1_0\text{n} \rightarrow {}^3_1\text{H} + {}^4_2\text{He}$   
      **d**     ${}^{59}_{27}\text{Co} + {}^2_1\text{H} \rightarrow {}^{60}_{27}\text{Co} + {}^1_1\text{p}$   
      **e**     ${}^{53}_{24}\text{Cr} + {}^4_2\text{He} \rightarrow {}^{57}_{25}\text{Mn} + {}^0_1\text{n}$
- 4    The nuclear transformations in **a**, **b**, **d** and **e** would all take place in a cyclotron, as the charged particles are used to bombard the nucleus.  
      Nuclear transformation **c** would take place in a nuclear reactor, as it involves bombardment by neutrons.
- 5     ${}^{56}_{26}\text{Fe} + {}^2_1\text{H} \rightarrow {}^{54}_{25}\text{Mn} + {}^4_2\text{He}$

**Chapter 5 Application and investigation**

- 1    **a**    90 protons; 140 neutrons  
      **b**    96 protons; 148 neutrons  
      **c**    77 protons; 115 neutrons
- 2    Chemical reactions involve changes in the arrangements of electrons around the nucleus. Nuclear reactions involve changes within the nucleus.

## Solutions Manual: Module 1

### Production of materials

Chemistry  
**Contexts 2**  
SECOND EDITION

- 3    **a**    *Ionisation counter*: uses a tube filled with an inert gas. As radiation enters the tube it causes the gas to be ionised, forming cations and free electrons. These particles are attracted to electrodes of the opposite charge, causing a current to flow, which is heard as an audible click and can be recorded as a digital readout.
- b**    *Scintillation counter*: electrons in some substances, such as zinc sulfide, are excited by radiation and emit photons of light when the electrons return to a lower energy state. The flashes of light are counted electronically to measure the amount of radiation.
- 4    **a**     $\beta$  decay
- b**     $\alpha$  decay, positron emission, electron capture
- 5    **a**     ${}_{94}^{241}\text{Pu} \rightarrow {}_{92}^{237}\text{U} + {}_2^4\text{He}$
- b**     ${}_{86}^{210}\text{Rn} \rightarrow {}_{87}^{210}\text{Fr} + {}_{-1}^0\text{e}$
- c**     ${}_{23}^{48}\text{V} \rightarrow {}_{22}^{48}\text{Ti} + {}_1^0\text{e}$
- d**     ${}_{48}^{107}\text{Cd} + {}_{-1}^0\text{e} \rightarrow {}_{47}^{107}\text{Ag}$
- e**     ${}_{92}^{234}\text{U} \rightarrow {}_{90}^{230}\text{Th} + {}_2^4\text{He}$
- f**     ${}_{11}^{26}\text{Na} \rightarrow {}_{12}^{26}\text{Mg} + {}_{-1}^0\text{e}$
- g**     ${}_{7}^{12}\text{N} \rightarrow {}_{6}^{12}\text{C} + {}_1^0\text{e}$
- h**     ${}_{93}^{232}\text{Np} + {}_{-1}^0\text{e} \rightarrow {}_{92}^{232}\text{U}$
- 6    Uranium and thorium undergo alpha emission spontaneously. Therefore helium is found within the ore.
- 7    Elements with high neutron-to-proton ratios emit  $\beta$ -particles, thereby raising the number of protons and lowering the number of neutrons. Elements with low neutron-to-proton ratios undergo either positron emission or electron capture, thereby raising the number of neutrons and lowering the number of protons.
- 8    **a**    unstable;  $\beta$  decay
- b**    unstable; positron emission or electron capture
- c**    unstable; positron emission or electron capture
- d**    unstable;  $\beta$  decay
- e**    stable

# Solutions Manual: Module 1

## Production of materials

Chemistry  
**Contexts 2**  
SECOND EDITION

f unstable;  $\alpha$  decay

9 a 3 half-lives  $\therefore \frac{0.8}{2} = 0.4; \frac{0.4}{2} = 0.2; \frac{0.2}{2} = 0.1 \text{ mg}$

b 2 half-lives  $\therefore 12.3 \times 2 = 24.6 \text{ years}$

10 a 35%

b  $20\% \times 500 \text{ g} = 100 \text{ g}$  remaining

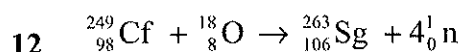
c 84 days

d 25 days

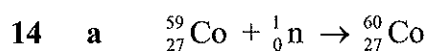
11 a 32 days is 4 half-lives

$\therefore 0.625 \text{ mg}$  remaining after 32 days

b 5 half-lives drop to  $0.312 \text{ g}$ , so  $< 0.5 \text{ g}$  in 36 days

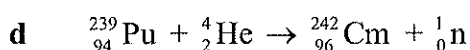
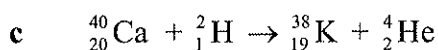
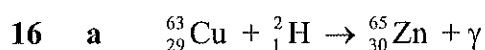


13 Investigation



b  ${}^{60}\text{Co}$  would be made in a nuclear reactor as it involves the capture of a neutron. In a nuclear reactor, atoms are bombarded with neutrons. A cyclotron is used to bombard atoms with charged particles.

15 Investigation



17 Investigation

18  $\alpha$  particles can cause serious damage to cells.

19 Investigation

20 Investigation

21 Research based on information gathered in Questions 19 and 20

## Module 1

### REVIEW

1 D

2 A

3 D

4 D

5 D

6 A

7 D

8 B

9 B

10 A

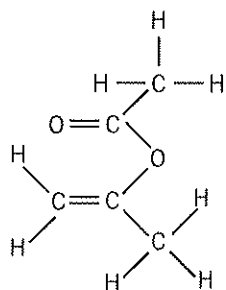
11 a Ethylene is more reactive due to the presence of the double bond.

b addition

c polyethylene

d HI

12 a



b vinyl chloride

i chloroethene

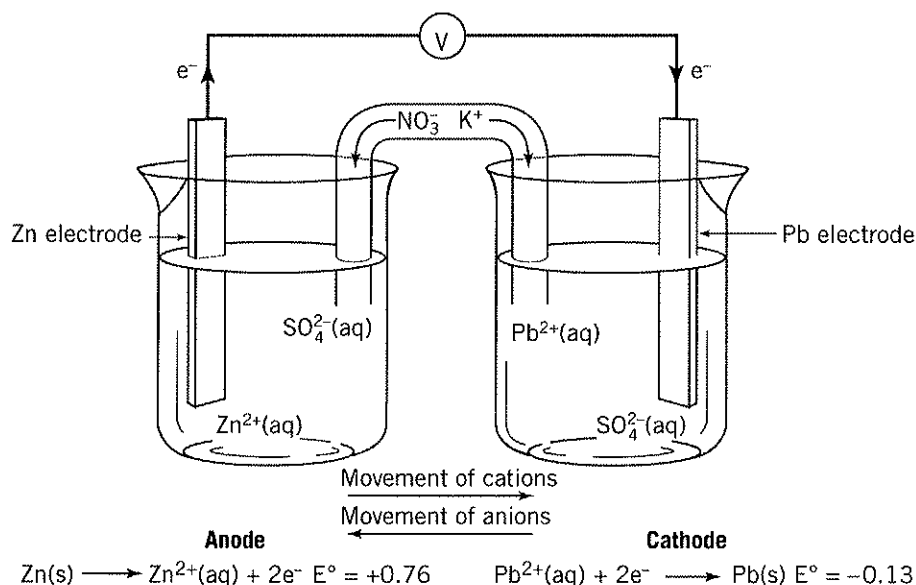
ii polyvinylchloride (PVC)

iii PVC is a thermoplastic with long chains with weak dispersion forces between them. This allows the polymer to be heated and remoulded. With additives, PVC can be used as a rigid plastic (e.g. guttering, water pipes) or as a flexible plastic (e.g. garden hoses).

- 13 a** LDPE has a greater degree of branching between its polymer chains, reducing the dispersion forces between the chains. HDPE has less branching, resulting in a stronger and more dense plastic.
- b** cling wrap, insulation for wires
- c** LDPE: Organic peroxides are used as catalysts to attack the ethene double bond and form a covalent bond with a carbon atom. This new molecule then attacks another ethene molecule, causing the chain to grow (propagate). Branches are formed when the chain curls back and removes a hydrogen from a carbon in the chain, which will in turn react with another ethene molecule. The reaction terminates when two polymer radicals react together.
- HDPE: Ionic catalysts (Ziegler–Natta catalysts) are used. Ethene molecules are added to the polymer on the surface of the catalyst, which reduces the amount of branching.
- d** The polymer chains in HDPE are packed tightly together due to less branching of the chains. This gives HDPE greater strength and toughness but reduces its flexibility.
- 14 a** Biomass is organic material derived from living organisms, such as: plant material (e.g. sugar and cellulose); animal material (e.g. dung); and domestic and industrial organic waste.
- b**  $\beta$ -glucose
- c** Cellulose is formed as a condensation polymer when  $\beta$ -glucose monomers combine with the removal of a water molecule. Polyethylene forms as an addition polymer from ethylene monomers as the double bond breaks.
- 15** Use spirit burners containing each fuel, weigh mass before and after use (to give mass of fuel burnt), heat same volume of water, record temperature rise. Fuels are volatile and can easily ignite if care is not taken.
- 16 a i**  $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) \rightarrow 2\text{C}_2\text{H}_5\text{OH}(\text{l}) + 2\text{CO}_2(\text{g})$
- ii** anaerobic (no oxygen); temperature 35–40°C
- b** Harvest cane, extract sugars, ferment to ethanol using yeast, warmth and anaerobic conditions.
- c**  $\text{C}_2\text{H}_5\text{OH}(\text{g}) \rightarrow \text{C}_2\text{H}_4(\text{g}) + \text{H}_2\text{O}(\text{g})$   
The reaction requires a catalyst, e.g. concentrated  $\text{H}_2\text{SO}_4$
- 17** No commercially viable method of producing ethanol from crops is yet available. Fuel mixtures containing greater than 15% ethanol require some modification to the car before being used.
- Ethanol is a renewable fuel and petroleum is not.

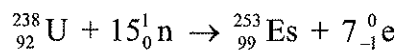


18 a

b Cell potential =  $+0.76 - 0.13 = 0.63 \text{ V}$ 

c Zinc

19 Uranium-238 is bombarded with neutrons to form einsteinium.

20 a  ${}_{38}^{90}\text{Sr} \rightarrow {}_{39}^{90}\text{Y} + {}_{-1}^0\text{e}$ 

b Sr is in the same periodic group as calcium and therefore is chemically similar.

c 85.3 years is three half-lives  $\therefore > 0.125 \text{ g}$  remains at 85 years.

21 a Iodine-131 is used in the diagnosis of thyroid misfunction and in treatment of thyroid tumours.

b I-131 is produced by neutron bombardment in a reactor.

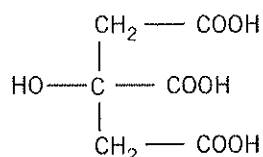
c Benefit: short half-life and therefore is only in the body for a short time.

Problem: I-131 can destroy some healthy cells when used for radiation.

## CHAPTER 6: ACIDS, BASES AND INDICATORS

## Review exercise 6.1

- 1 a acetic acid,  $\text{CH}_3\text{COOH}$   
citric acid, 2-hydroxypropane-1,2,3-tricarboxylic acid



- b sulfuric acid,  $\text{H}_2\text{SO}_4$   
nitric acid,  $\text{HNO}_3$
- c magnesium hydroxide,  $\text{Mg}(\text{OH})_2$
- 2 Own answers
- 3 Own answers
- 4 a  $\text{Zn}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{H}_2(\text{g})$   
b  $\text{CO}_3^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$   
c  $2\text{H}^+(\text{aq}) + \text{K}_2\text{O}(\text{s}) \rightarrow 2\text{K}^+(\text{aq}) + \text{H}_2\text{O}(\text{l})$   
d  $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
- 5 a  $2\text{Cr}(\text{s}) + 2\text{OH}^-(\text{aq}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow 2[\text{Cr}(\text{OH})_4]^- (\text{aq}) + 3\text{H}_2(\text{g})$   
b  $\text{Cr}(\text{OH})_3(\text{s}) + \text{OH}^-(\text{aq}) \rightarrow [\text{Cr}(\text{OH})_4]^- (\text{aq})$
- 6 Acid solutions have excess hydrogen ions and base solutions have excess hydroxide ions. These ions are free to move and carry a current.

## Review exercise 6.2

- 1 a  $\text{K}_2\text{O}$  ionic bonding;  $\text{Ga}_2\text{O}$  ionic;  $\text{Br}_2\text{O}_7$  covalent  
b  $\text{K}_2\text{O}$  basic;  $\text{Ga}_2\text{O}$  amphoteric;  $\text{Br}_2\text{O}_7$  acidic
- 2  $\text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{CO}_3(\text{aq})$
- 3 Natural sources of sulfur dioxide:
- bacteria decomposing organic matter to make  $\text{H}_2\text{S}$ , which is then oxidised atmospherically.
  - volcanic gases
  - bushfire smoke.