Student book answers

4.1 Synthesis and decomposition reactions can be represented by equations

Pages 90–91

Check your learning 4.1

Remember and understand

1 What is the law of conservation of mass?

Mass cannot be created or destroyed.

2 Why do decomposition reactions always produce more than one product?

Decomposition reactions occur when a single substance is broken down into several products.

Apply and analyse

3 Why would synthesis reactions sometimes be called combination reactions?

Synthesis involves adding/combining reactants together to form products.

4 Describe, in terms of the types of chemical reactions, major differences between the reaction used to produce ammonia and the reaction used to produce calcium oxide.

Calcium oxide is produced in a decomposition reaction. Ammonia is produced in a synthesis reaction.

5 Why is energy required in:

**a** decomposition reactions?

Energy is required in a decomposition reaction to break the bonds of the reactant to form new products.

**b** direct synthesis reactions?

Energy is required in direct synthesis reactions to form new bonds between the reactants, forming the product.

6 Predict the products of the following synthesis reactions and write a balanced chemical equation for each one.

**a** Calcium and oxygen

2Ca (s) + O2 (g) 🡪 2CaO (s)

**b** Hydrogen and chlorine

H2 (g) + Cl2 (g) 🡪 2HCl (l)

Student book answers

4.2 Acid reactions depend on strength and concentration

Pages 92–93

Check your learning 4.2

Remember and understand

1 What must you react with an acid to produce:

**a** hydrogen gas?

A metal

**b** carbon dioxide?

Metal carbonate

2 What is the reaction of an acid with a base called? Why is it given this name?

The reaction of an acid with a base is called neutralisation. It produces products (salt and water), which have a neutral pH (pH of 7).

Apply and analyse

3 Write equations for:

**a** dilute nitric acid (HNO3) reacting with magnesium metal

HNO3 (aq) + Mg (s) 🡪 Mg(NO3)2 (aq)+ H2 (g)

**b** dilute ethanoic acid (CH3COOH) reacting with solid potassium carbonate (K2CO3)

2CH3COOH (aq) + K2CO3 (s) 🡪 2CH3COOK (aq) + H2O (l) + 2CO2 (g)

**c** dilute hydrochloric acid reacting with calcium hydroxide solution.

2HCl (aq) + Ca(OH)2 (s) 🡪 CaCl2 (aq) + 2H2O (l)

4 Why is it unsuitable to store acids in metal containers?

Acids react with metals. This would corrode the metal and the acid would leak out of the container.

5 Would it require more, less or the same amount of base to neutralise 20 mL of 0.1 M strong acid than it would to neutralise 20 mL of 0.1 M weak acid?

It would require the same volume as both have the same concentration. Concentration determines the amount of base it would take to neutralise each acid, not the strength of the acid.

Student book answers

4.3 The solubility rules predict the formation of precipitates

Pages 94–95

Check your learning 4.3

Remember and understand

1 Draw a diagram to show which particles are present in a beaker containing a sodium chloride solution.

Students’ diagrams should show water molecules with sodium ions and chloride ions present.

2 What symbol is used to show the state of an insoluble compound?

s – lower case s, which stands for ‘solid’

Apply and analyse

3 Which of the following substances would be insoluble?

Copper(II) chloride, calcium hydroxide, silver nitrate, magnesium bromide, silver bromide, magnesium nitrate, potassium chloride, lead(II) nitrate, potassium nitrate, lead(II) chloride

Calcium hydroxide, silver bromide, lead(II) chloride

4 What precipitate would form if solutions of lead(II) nitrate and sodium sulfate were mixed?

Lead(II) sulfate (PbSO4) is insoluble (solid) in water.

5 Complete the following word equations and then write balanced chemical equations for each reaction.

a zinc nitrate + potassium hydroxide →

Zn(NO3)2 (aq) + 2KOH (aq) 🡪 2KNO3 (aq) + Zn(OH)2 (s)

b calcium nitrate + sodium carbonate →

Ca(NO3)2 (aq) + Na2CO3 (aq) 🡪 CaCO3 (s) + 2NaNO3 (aq)

Student book answers

4.4 Combustion reactions between hydrocarbons and oxygen produce carbon dioxide, water and energy

Pages 96–97

Check your learning 4.4

Remember and understand

1 Why are carbon fuels so important to our society?

Carbon fuels produce the energy (light and heat) and fuel that society requires to power houses, cars, electronic equipment and so on. Our society runs on carbon. It is a very important fuel. Carbon is the mainstream of our economy. This is why it is called a carbon economy.

2 Why does the amount of oxygen available affect the products formed in the combustion process?

Unlimited oxygen forms CO2 + H2O, limited oxygen forms CO + H2O, and severely limited forms C + H2O. The less oxygen used, the less that can bond to the carbon, therefore determining whether CO2, CO or C is formed.

3 Which group of elements do not react with oxygen?

Group 18 – the noble gases

4 Why is it important to burn hydrocarbons in a well-ventilated area?

Combustion requires oxygen for the chemical reaction to occur. If there is no oxygen, then other types of reactions will occur, producing new (and potentially more dangerous) products.

Apply and analyse

5 Give an example of a substance that might be considered a fuel by a:

**a** firefighter

Students’ answers will vary, such as wood/ construction materials; and tanks filled with hydrogen, oxygen, methane, petrol or propane.

**b** chemist.

Students’ answers will vary, such as gas for a Bunsen burner; biomolecules provide fuel for the body; and diesel, LPG, petrol (hydrocarbons), rocket fuel.

6 Write a balanced equation for the combustion of each of the following hydrocarbons in excess oxygen.

**a** Petrol

2C8H18 (l) + 25O2 (g) 🡪 16CO2 (g) + 18H2O (l)

**b** LPG

C3H8 (l) + 5O2 (g) 🡪 3CO2 (g) + 4H2O (l)

**c** Natural gas

CH4 (g) + 2O2 (g) 🡪 CO2 (g) + 2H2O (l)

**d** Diesel

4C12H23 (l) + 71O2 (g) 🡪 48CO2 (g) + 46H2O (l)

7 Which fuel in question 6 requires the most oxygen to burn cleanly?

Diesel requires the most oxygen as it requires 71 oxygen molecules.

Student book answers

4.5 Polymers are long chains of monomers

Pages 98–99

Check your learning 4.5

Remember and understand

1 What are the differences between a linear polymer and a cross-linked polymer?

Linear polymers are long chains of polymers that may have branches hanging off them. Cross-linked polymers are giant covalent lattices in which the monomers are linked in several directions.

2 What is the monomer unit of polyethene?

Ethene

3 What are the properties of elastomers? Use their structure to explain their properties.

Elastomers are occasionally cross-linked polymers. They are termed ‘elastomers’ because they are elastic. That is, they can be stretched and, when you let them go, they spring back into shape.

Apply and analyse

4 For each of the following applications, state whether it would be better to make the object from a thermosetting polymer or a thermoplastic polymer.

a Food wrap

Thermoplastic

b Light switch

Thermosetting

c Disposable cup for soft drinks

Thermosetting

d Wash bottle for a science laboratory

Thermoplastic

e Handles of barbecue tongs

Thermosetting

5 Which would you expect to be a thermosetting plastic: a linear polymer or a cross-linked one? State your reasoning.

A thermosetting plastic is most likely to be a cross-linked polymer because it is less able to be stretched out of shape as a result of the extensive cross-linking. Any attempt to melt this plastic may cause decomposition before the melting temperature is reached.

Student book answers

4.6 Temperature, concentration, surface area and stirring affect reaction rate

Pages 100–103

Check your learning 4.6

Remember and understand

1 Are products formed every time molecules of reactants collide? Explain your answer.

No, molecules must collide in the correct orientation and with sufficient energy to result in new products.

2 Why does increasing the surface area increase the rate of reaction?

The larger the surface of a reactant, the more of the chemical that can react. This increases the number of successful collisions as there will be more surface to collide with.

3 Why does diluting a solution decrease the rate of reaction?

Dilution results in a decrease in concentration. Therefore, there are fewer reactant molecules to collide with and this will decrease the number of successful collisions.

4 Why does a reaction occur faster when the reactants are stirred together?

When stirring a reaction, you are increasing the amount of kinetic energy. This will increase the energy that the reactants have to collide with one another and increase the rate of the reaction.

5 How does collision theory explain the dramatic increase in the rate of a reaction as the reactants are heated?

Collision theory states that, for a chemical reaction to occur, the particles must collide with enough energy for that reaction to occur. Heating a reaction will increase the amount of kinetic energy within a reaction and make the molecules move faster, resulting in more successful collisions.

Apply and analyse

6 A reaction is carried out in a well-ventilated environment with outside air regularly circulating. A chemical engineer noticed that a reaction that gave a high yield of a product in summer gave a low yield of that same product in winter, despite the reagents and concentrations being identical. What is a possible explanation for the different yields?

In summer the reaction would take place under an increased temperature. This means that particles will move faster, have increased kinetic energy and undergo more frequent collisions with increased energy. This will increase the rate of the reaction, producing a higher yield of product.

Student book answers

4.7 Catalysts increase the rate of a reaction

Pages 104–105

Check your learning 4.7

Remember and understand

1 What is a catalyst?

A catalyst is a substance that speeds up a chemical reaction but is not used up in the reaction.

2 Explain the two ways in which catalysts can work.

Some catalysts provide a surface on which the two reactants can meet in the correct orientation, allowing the products to be formed. The products are then released. Other catalysts take part in the initial reaction and are regenerated in the final reaction.

3 What is a catalytic converter? Why are they used?

A catalytic converter is a honeycomb-like grid of metals that acts to convert harmful exhaust gases into less harmful products. Catalytic converters are used to reduce pollution from exhaust gases.

Apply and analyse

4 Why is it important that the amount of ozone in the atmosphere remains stable?

If the ozone layer degrades, there would be less UV absorption. This will cause more UV light to enter Earth’s atmosphere, causing increased temperatures, more ice melting and more skin cancers.

5 What has caused a change in the amount of ozone in the atmosphere over time?

The introduction of CFCs into the atmosphere, which degrades the ozone layer

6 Which part of the CFC molecule destroys ozone? How does this atom become detached?

The free chlorine atom destroys ozone. This chlorine atom acts as a catalyst to decompose the ozone (O3) and is reformed by reacting with the products of this breakdown – it is a regeneration catalyst.

Student book answers

4.8 Green chemistry reduces the impact of chemicals on the environment

Pages 106–107

Extend your understanding 4.8

1 How do scientists determine how safe a product is?

Scientists detect changes caused by natural events, as well as by human actions. They monitor the environment for changes that may have been caused by the actions of society.

2 The ‘old masters’, the painters of the 1600s to 1800s, used pigments made of compounds of lead, mercury and cadmium. Why are these paints no longer available to today’s artists?

Lead, mercury and cadmium are heavy metals that accumulate in the bodies of living things, including people, causing severe health issues and sometimes death as they are toxic to humans.

3 If you discovered an important new chemical, could you be responsible for any consequences that occurred 30 years in the future? Could the people who are affected in 30 years’ time blame you?

The company that produces the chemical and sells it in commercial quantities is responsible for conducting the tests to determine the chemical’s safety. The results of those tests must be submitted to the relevant government authorities. If those tests are not sufficient, or there are some errors or misleading information in the testing, then the company is responsible, such as in recent thalidomide court cases.

4 What other materials can be recycled to reduce the risk of chemical pollution?

Other materials that can be recycled include plastics with the triangular arrows around the numbers 1–3. Clothing can also be recycled, as can many building products.

5 What are the properties of substances that would make them suitable for recycling?

Any substance that can be broken down into smaller components can be reconstituted and reused. Other substances that can have contaminants removed can also be reused.

6 What other actions can you take to reduce your impact on the environment? Your actions will make a small difference, but when others join you, the effect is quite dramatic.

Students’ answers will vary, such as switching off lights, recycling and walking/riding to school.

Student book answers

Review 4

Pages 108–109

Remember and understand

1 Describe the differences between decomposition reactions and direct synthesis reactions.

Decomposition reactions usually involve a single reactant breaking apart into several products. Direct synthesis reactions involve several reactants chemically bonding to form a single product.

2 What types of products are formed when acids react with metals, carbonates or bases?

Acids + bases → water + salt

Acids + carbonates → water + salt + carbon dioxide

Acids + metals → salt + hydrogen

3 Describe two different types of reactions that produce carbon dioxide.

Acids + carbonates and some combustion reactions

4 In terms of particles, what is required for a chemical reaction to take place?

Particles must collide in the correct orientation and with sufficient energy.

5 List four factors that will affect the rate of a chemical reaction.

Temperature, concentration, surface area, stirring, catalyst

6 Describe two ways that the rate of chemical reactions can be measured.

Students’ answers will vary, but they must relate to measurement in the laboratory; for example, time the reaction (using a stopwatch), and measure the amount of heat it produces (temperature rise), the amount of gas it produces.

7 Describe one situation where it could be dangerous if a reaction occurs too quickly.

In a combustion reaction, where light and heat are produced, if they are produced too rapidly an explosion may occur.

8What is the link between CFCs and the ozone layer?

The chlorine atom in CFCs will act as a catalyst in the breakdown of ozone.

Apply and analyse

9Polypropylene is a plastic that can be easily melted and formed into a range of products. Describe the likely structure of polypropylene and explain how its structure allows the plastic to be moulded into a range of shapes.

Polypropylene is a thermoplastic that softens when heated. These ‘plastics’ have a linear structure that allows them to be melted and moulded into set shapes.

10 A student mixed the following solutions together in a beaker: ammonium nitrate, sodium chloride, lead(II) nitrate, sodium sulfate. Describe what would be seen in the beaker. Explain your answer using a chemical equation.

Soluble sodium nitrate will be formed along with two precipitates, namely ammonium sulfate and lead chloride.

Ammonium nitrate + sodium sulfate → sodium nitrate + ammonium sulfate (s)

Lead(II) nitrate + sodium chloride → lead chloride (s) + sodium nitrate

11 Sodium metal was used to produce aluminium from purified bauxite (Al2O3).

aWhat type of reaction would be occurring?

Decomposition

b Write a chemical equation for the process, ensuring that the law of conservation of mass is applied to the equation.

2Al2O3 (s) 🡪 4Al (s) + 3O2 (g)

12 Describe two examples of the use of catalysts in the production of chemical products.

Platinum, palladium and rhodium catalyse the breakdown of CO and NO to form CO2 and N2. The chlorine atom in CFCs break down the ozone molecule. Enzymes in the digestive system break down for absorption into the body.

13 In many industrial environments, the presence of a fine dust is regarded as an explosion hazard. Why is coal dust more likely to explode than chunks of coal?

Coal dust has small particles with a large surface area for a reaction to occur. This will increase the rate of a reaction. As a result, coal dust is more explosive than large chunks of coal.

14 What are some examples of green chemistry that you could apply at home?

Recycle, use less chemical products, use your own shopping bag rather than a plastic one, composting, don’t use aerosols, always use biodegradable products and ride your bike or walk to school.

Evaluate and create

15 How does the particle model of matter help us understand the rate of reactions?

The movement of the particles in matter helps scientists explain why the rates of reactions increase. Factors that increase the movement of the particles will increase the rate of a reaction.

16 The reaction 2SO2(g) + O2(g) → 2SO3(g) is very slow at room temperature. The reaction occurs in two steps, which are shown below. The reaction occurs more quickly in the presence of nitrogen dioxide gas.

Step 1

2SO2(g) + 2NO2(g) → 2SO3(g) + 2NO(g)

Step 2

2NO(g) + O2(g) → 2NO2(g)

Explain two reasons why the nitrogen dioxide is regarded as a catalyst.

The presence of nitrogen dioxide increases the rate of the reaction and, because it is reformed at the end of the reaction, the amount does not decrease as a result of the reaction. Therefore, nitrogen dioxide is a catalyst in this reaction.

Ethical understanding

17 In the 1920s, the compound tetraethyl lead was developed to prevent ‘knocking’ in car engines. (‘Knocking’ is where the spark plugs fire too early, resulting in loss of power and possible engine damage.) Adding tetraethyl lead saved the cost of additional refining of petrol, which reduced costs for consumers and motorists. However, some people were concerned about the use of a lead compound that was being released from the exhaust of cars. If you had been part of the debate in the 1920s, what arguments would you make against the use of tetraethyl lead?

Students’ answers will vary. For example:

• It is a heavy metal and therefore toxic to humans.

• Its potential hazards have not been tested and so it should not be used.

• Data needs to be collected that outlines the impact of the chemical on humans and the environment.

Critical and creative thinking

18 Some catalysts work by providing a surface on which reactions can occur. These surface catalysts work by allowing the reacting particles to interact together on the surface of the catalyst.

a Why would attracting particles onto a surface of another chemical encourage a chemical change to occur?

Particles that become stuck to a surface are forced into contact with one another, creating an increased number of successful collisions. Therefore, collisions are no longer random; they occur at the surface of the catalyst.

b Why would a substance that actually bonded chemically to the reacting particles not make a good catalyst?

If a substance bonded chemically to a reactant, it may prevent other molecules or atoms binding or colliding with the reactant, thus preventing the reaction from occurring.

c Give an example of the use of a surface catalyst, describing in detail the chemical reaction.

Students’ answers will vary.

For example, a platinum catalyst is used to convert CO and NO into CO2 and N2:

2CO(g) + 2NO(g) → 2CO2(g) + N2(g)

The CO and NO will bind to the surface of the platinum catalyst. The oxygen then detaches from the nitrogen and binds to the CO, forming CO2. The nitrogens (which have just lost their oxygens) bond together to form N2. The products then leave the surface of the catalyst.

d Use your knowledge of collision theory to explain why most catalysts are used in the form of a powder or fine mesh.

Catalysts work most effectively when they can provide a large surface area for the reactants to interact. The larger surface area of small powder particles or a fine mesh will increase the rate of a reaction to a greater degree than large clumps of enzymes.

19 Haemoglobin is responsible for the transport of oxygen in the bloodstream from your lungs to the cells in your body, where respiration takes place. The oxygen molecules interact with the haemoglobin and combine to form oxyhaemoglobin. When the blood reaches the cells (having been pumped through the heart), the oxyhaemoglobin releases the oxygen. If carbon monoxide molecules are breathed into the lungs, they can attach themselves permanently to haemoglobin molecules, thus preventing the essential transfer of oxygen. Carbon monoxide poisoning is a very real danger and many Australians are killed by it each year.

a Use a diagram to represent the transfer of oxygen from the lungs to body cells.

Students’ diagrams should show oxygen moving from the alveoli in the lungs into the red blood cells in the bloodstream, and then being transferred around the body until the oxygen moves into muscle and other cells.

b Explain why the chemical changes occurring between haemoglobin and oxygen need to be reversible.

Chemical reactions between haemoglobin and oxygen must be reversible so that the oxygen can leave the haemoglobin and move into the body’s cells.

c Do you think that the reaction between carbon monoxide and haemoglobin is reversible? Explain your answer.

The reaction between carbon monoxide is not reversible (except in the presence of extremely high oxygen concentrations) because the bond is much stronger than that between haemoglobin and oxygen.

d Suggest two ways that carbon monoxide poisoning can be prevented.

Carbon monoxide poisoning can be prevented by checking all heaters regularly and ensuring that any devices (such as barbecues and patio heaters) have a sufficient supply of oxygen when being used.

Research

20 Choose one of the following topics for a research project. Some questions have been included to help you begin your research. Present your report in a format of your own choosing.

Rare metals

A range of rare metals is used in microelectronic devices. Many of these metals, such as tantalum and niobium, are sourced from Australia. Find out more about where these metals are found in Australia, in what form they occur naturally and what chemical processes are used to extract the pure metals.

Minamata disease

Minamata disease is caused by people eating seafood contaminated with a compound containing mercury. The condition was called a ‘disease’ because when it was first described no one knew its cause. Research this disease and present your findings using the following headings.

– Symptoms

– Cause

– Action taken

– Lasting consequences (for the people affected, chemical industry and the world)

Ozone and CFCs

Although governments limited the use of CFCs to reduce the damage to the ozone layer, it took time for many countries to recognise the risks and act on the advice from scientists. Investigate how evidence for ozone depletion was discovered and how countries responded to the evidence, and discuss implications for possible future action (or inaction) of governments based on scientific advice.

Students’ answers will vary.