

**Unit 1.1 Writing chemical equations**

- 1 Reactants, arrow, products
- 2 '+' means 'and'; '→' means 'produces' or 'gives'.
- 3 Metallic, covalent, ionic
- 4 Matter can be neither created nor destroyed; it can only be changed from one form to another.
- 5 Because matter can be neither created nor destroyed, there must be the same number and types of atoms on both sides of the equation.
- 6 (s) for solid; (g) for gas; (l) for liquid; (aq) for substance dissolved in water
- 7 25°C; 1 atmosphere
- 8 The Law of Conservation of Mass is another way of stating the Law of Conservation of Matter, only in reference to chemical equations. It indicates that the mass of reactants and products must be the same.
- 9 The small subscript numbers represent the number of the preceding atom or ion. The large numbers are used in front of formulas to balance equations.
- 10  $\text{NaCl}_{(s)}$  is sodium chloride in crystalline form,  $\text{NaCl}_{(aq)}$  is sodium chloride dissolved in water.
- 11 Molecules: **a** ( $\text{CO}_2$ ), **b** ( $\text{H}_2\text{O}$ ), **e** ( $\text{N}_2$ ), **g** ( $\text{Ar}$ ). The rest ( $\text{NaCl}$ ,  $\text{Li}_2\text{CO}_3$  and  $\text{CaO}$ ) are ionic lattices.
- 12 Calcium chloride:  $\text{CaCl}_2$  (answer **C**)
- 13  $\text{H}_2\text{O}$  is a molecular formula because there are two hydrogen atoms and one oxygen atom in a water molecule.  $\text{Na}_2\text{SO}_4$  is an ionic compound, not a molecular formula, because it represents the ratio of sodium to sulfate ions in a lattice of sodium sulfate, not the actual number of atoms that can exist as a discrete unit.
- 14 Equation B is balanced. ( $2\text{HNO}_3 + \text{MgO} \rightarrow \text{Mg}(\text{NO}_3)_2 + \text{H}_2\text{O}$ )
- 15 Equation A is not balanced. ( $\text{C}_5\text{H}_{12} + 8\text{O}_2 \rightarrow \text{CO}_2 + 6\text{H}_2\text{O}$ ; should be  $5\text{CO}_2$ .)
- 16
  - a  $\text{H}_2\text{O}_{(l)}$
  - b  $\text{CO}_{2(g)}$
  - c  $\text{H}_2\text{SO}_{4(aq)}$
  - d  $\text{CaCl}_{2(s)}$
  - e  $\text{Ne}_{(g)}$
  - f  $\text{H}_{2(g)}$
  - g  $\text{MgCO}_{3(s)}$
  - h  $\text{HNO}_{3(aq)}$
- 17
  - a Mg—metallic
  - b  $\text{SrSO}_4$ —ionic (between ions  $\text{Sr}^{2+}$  and  $\text{SO}_4^{2-}$ , but covalent within the sulfate ion,  $\text{SO}_4^{2-}$ )
  - c  $\text{O}_2$ —covalent
  - d CO—covalent
  - e  $\text{CaCl}_2$ —ionic
  - f  $\text{SO}_2$ —covalent

- g Na—metallic  
h Ar—no bonding. The element consists of individual atoms.
- 18 a  $\text{P}_{4(\text{s})} + 5\text{O}_{2(\text{g})} \rightarrow 2\text{P}_2\text{O}_{5(\text{s})}$   
b  $2\text{KClO}_{3(\text{s})} \rightarrow 2\text{KCl}_{(\text{s})} + 3\text{O}_{2(\text{g})}$   
c  $\text{BaO}_{(\text{s})} + 2\text{HNO}_{3(\text{aq})} \rightarrow \text{Ba}(\text{NO}_3)_{2(\text{aq})} + \text{H}_2\text{O}_{(\text{l})}$   
d  $2\text{Pb}_3\text{O}_{4(\text{s})} \rightarrow 6\text{PbO}_{(\text{s})} + \text{O}_{2(\text{g})}$   
e  $2\text{Pb}(\text{NO}_3)_{2(\text{s})} \rightarrow 2\text{PbO}_{(\text{s})} + 4\text{NO}_{2(\text{g})} + \text{O}_{2(\text{g})}$
- 19 a  $2\text{H}_{2(\text{g})} + \text{O}_{2(\text{g})} \rightarrow 2\text{H}_2\text{O}_{(\text{l})}$   
b  $2\text{Na}_{(\text{s})} + \text{Cl}_{2(\text{g})} \rightarrow 2\text{NaCl}_{(\text{s})}$   
c  $\text{CaCO}_{3(\text{s})} \rightarrow \text{CaO}_{(\text{s})} + \text{CO}_{2(\text{g})}$   
d  $\text{CH}_{4(\text{g})} + 2\text{O}_{2(\text{g})} \rightarrow \text{CO}_{2(\text{g})} + 2\text{H}_2\text{O}_{(\text{l})}$   
e  $2\text{HNO}_{3(\text{aq})} + \text{Ca}_{(\text{s})} \rightarrow \text{Ca}(\text{NO}_3)_2_{(\text{aq})} + \text{H}_{2(\text{g})}$
- 20 a Reactants: copper(II) nitrate. Products: copper(II) oxide, nitrogen dioxide, oxygen.  
b copper(II) nitrate  $\rightarrow$  copper(II) oxide + nitrogen dioxide + oxygen  
c  $2\text{Cu}(\text{NO}_3)_{2(\text{s})} \rightarrow 2\text{CuO}_{(\text{s})} + 4\text{NO}_{2(\text{g})} + \text{O}_{2(\text{g})}$
- 21 a i sodium hydroxide + hydrochloric acid  $\rightarrow$  sodium chloride + water  
ii  $\text{NaOH}_{(\text{s})} + \text{HCl}_{(\text{aq})} \rightarrow \text{NaCl}_{(\text{aq})} + \text{H}_2\text{O}_{(\text{l})}$   
b i nitrogen + hydrogen  $\rightarrow$  ammonia  
ii  $\text{N}_{2(\text{g})} + 3\text{H}_{2(\text{g})} \rightarrow 2\text{NH}_{3(\text{g})}$   
c i carbon monoxide + oxygen  $\rightarrow$  carbon dioxide  
ii  $2\text{CO}_{(\text{g})} + \text{O}_{2(\text{g})} \rightarrow 2\text{CO}_{2(\text{g})}$   
d i iron + chlorine  $\rightarrow$  iron(III) chloride  
ii  $2\text{Fe}_{(\text{s})} + 3\text{Cl}_{2(\text{g})} \rightarrow 2\text{FeCl}_{3(\text{s})}$   
e i sodium hydroxide + sulfuric acid  $\rightarrow$  sodium sulfate + water  
ii  $2\text{NaOH}_{(\text{aq})} + \text{H}_2\text{SO}_{4(\text{aq})} \rightarrow \text{Na}_2\text{SO}_{4(\text{aq})} + 2\text{H}_2\text{O}_{(\text{l})}$   
f i ammonium nitrate  $\rightarrow$  ammonium ions + nitrate ions  
ii  $\text{NH}_4\text{NO}_{3(\text{s})} \rightarrow \text{NH}_4^+_{(\text{aq})} + \text{NO}_3^-_{(\text{aq})}$   
g i hydrochloric acid + calcium metal  $\rightarrow$  calcium chloride + hydrogen gas  
ii  $2\text{HCl}_{(\text{aq})} + \text{Ca}_{(\text{s})} \rightarrow \text{CaCl}_{2(\text{aq})} + \text{H}_{2(\text{g})}$
- 22 The  $\text{CO}_2$  gas has escaped to the atmosphere.
- 23 a sodium<sub>(s)</sub> + oxygen<sub>(g)</sub>  $\rightarrow$  sodium oxide<sub>(s)</sub>  
b  $4\text{Na} + \text{O}_2 \rightarrow 2\text{Na}_2\text{O}$   
c  $4\text{Na}_{(\text{s})} + \text{O}_{2(\text{g})} \rightarrow 2\text{Na}_2\text{O}_{(\text{s})}$   
d mass of reactants = mass of products

## Unit 1.2 More and faster! Rate and yield considerations

- 1 a An explosion  
b Rusting of iron
- 2 The yield is the amount of product obtained.
- 3 The rate of reaction is how fast the reaction proceeds.
- 4 The ideal yield would be 100%.

- 5 If industrial reactions do not have a fast reaction rate and good yield, they will not be economically viable.
- 6 A reaction will proceed faster if you heat it or add a catalyst.
- 7 It is the king of chemicals because it is produced in huge quantities worldwide and can be used to make many different chemicals and materials. It has many uses due to its varied properties.
- 8 Sulfuric acid can be used to make fertilisers, paints and pigments, and rayon.
- 9 Concentrated sulfuric acid is corrosive, colourless, oily, soluble and a strong acid.
- 10 Vanadium (V) oxide
- 11
  - a  $\text{H}_2\text{SO}_4$
  - b  $\text{SO}_2$
  - c  $\text{SO}_3$
  - d  $\text{H}_2\text{S}_2\text{O}_7$
- 12 Using several catalyst beds maximises the chance of reaction, and hence the yield of the reaction.
- 13 A possible reason for calling it the contact process is that, by passing the gases over several catalyst beds, the yield is increased due to the closer contact of the gas molecules.
- 14 In the converter, sulfur dioxide is reacted with oxygen, and converted to sulfur trioxide. The rate is increased by using a high temperature which increases the frequency of molecule collisions. The yield is increased by using a catalyst.
- 15  $\text{S}_{(\text{l})} + \text{O}_{2(\text{g})} \rightarrow \text{SO}_{2(\text{g})}$   
 $2\text{SO}_{2(\text{g})} + \text{O}_{2(\text{g})} \rightarrow 2\text{SO}_{3(\text{g})}$   
 $\text{SO}_{3(\text{g})} + \text{H}_2\text{SO}_{4(\text{l})} \rightarrow \text{H}_2\text{S}_2\text{O}_{7(\text{l})}$   
 $\text{H}_2\text{S}_2\text{O}_{7(\text{l})} + \text{H}_2\text{O}_{(\text{l})} \rightarrow 2\text{H}_2\text{SO}_{4(\text{l})}$
- 16 Diagrammatic answer required
- 17 Conditions in the reaction need to be modified to produce a maximum yield at a fast rate. Generally, this is achieved by changing temperature, changing pressure, using a catalyst, adding reactant and removing product.
- 18 Hydrogen, sulfur and oxygen
- 19 The percentage yield is 82.5%.

### Unit 1.3 100% organic

- 1 'Organic chemistry' means the chemistry of covalent carbon compounds.
- 2 The main elements in organic compounds are carbon, hydrogen, oxygen and nitrogen.
- 3 A hydrocarbon is a compound composed only of carbon and hydrogen.
- 4 Single bond = one shared pair of electrons, double bond = two shared pairs of electrons, triple bond = three shared pairs of electrons.
- 5
  - a Single bonds only: ethane, methane, propane, butane, pentane, hexane, etc
  - b Double bonds: ethene, propene, etc

- c Triple bonds: ethyne, propyne, etc
- 6 Five possible answers are: methane, ethyne, ethanol, ethene, 1,2-ethanediol.
- 7 A homologous series is a series of compounds differing in formula by a  $\text{-CH}_2$  unit.
- 8 Three homologous series are: alkanes, alkenes, alkynes.
- 9 a First three alkanes: methane, ethane, propane  
 b Fourth alkene: butene  
 c First alkyne: ethyne  
 d Polymer made from ethene: polyethylene
- 10 a In fractional distillation, the crude oil is heated and then allowed to cool. The different fractions condense at different temperatures.  
 b Cracking breaks large alkanes into more useful smaller alkanes and alkenes.
- 11 Alcohol contains the hydroxy group,  $\text{-OH}$ .
- 12 In complete combustion, a hydrocarbon burns in excess oxygen and produces carbon dioxide and water. In incomplete combustion there is less oxygen, so the products also contain less oxygen, for example carbon monoxide and/or carbon and water.
- 13 Carbon dioxide is considered an inorganic compound.
- 14 Methene and methyne cannot exist because there would be only one carbon, so double and triple bonds aren't possible.
- 15

Molecule name	Molecular formula
Pentane	$\text{C}_5\text{H}_{12}$
Butene	$\text{C}_4\text{H}_8$
Decyne	$\text{C}_{10}\text{H}_{18}$
Hexene	$\text{C}_6\text{H}_{12}$
Octane	$\text{C}_8\text{H}_{18}$
Propane	$\text{C}_3\text{H}_8$
Propyne	$\text{C}_3\text{H}_4$

- 16 The boiling point of each alkane increases as an extra carbon is added. This enables the alkanes in crude oil to be separated by heating each to its boiling point, where it turns into a vapour, which is separated and then cooled to obtain the pure alkane. In a fractionating column, the lower boiling point alkanes rise to the top of the tower first and, as more heat is applied, longer-chain alkanes are vaporised and separated.
- 17 Ethanol is in alcohol.
- 18 a Antifreeze: 1,2-ethanediol  
 b Acetylene: ethyne  
 c Methanol
- 19 a Complete combustion: carbon dioxide and water  
 b Incomplete combustion: carbon monoxide and water, or carbon and water

- 20** The blue flame results from complete combustion; the yellow flame results from incomplete combustion.
- 21** **a** Reactant: glucose. Products: ethanol, carbon dioxide.  
**b** Fermentation is used in the production of ethanol and in making bread.
- 22** Yeast is a catalyst because it helps the fermentation reaction go faster, but is not used up in the reaction.
- 23** *Complete combustion*: higher efficiency—more energy is released per amount of fuel, and cleaner products are released into the environment (i.e. only carbon dioxide and water).  
*Incomplete combustion*: lower efficiency—less energy is released per amount of fuel, and more polluting products are released into the environment, such as carbon, carbon monoxide, carbon dioxide, unburnt fuel and water.  
*Evaluation*: complete combustion is better in terms of both criteria.
- 24** Organic chemistry is important for society as most of the fuels we use are hydrocarbons. Hydrocarbons also form the basis of plastics. Alcohols have many uses in medicine and foods.

### Unit 1.4 Maths in chemistry! (on CD)

- 1** The mole is the SI unit for amount of a substance. It is the amount that contains a number of objects equal to the number of atoms in exactly 12 grams of carbon-12. This number is equal to Avogadro's number,  $6.02 \times 10^{23}$ .
- 2** Because atoms and molecules cannot be seen, they are difficult to quantify. By using moles, extremely large numbers of atoms and molecules can be converted into masses that can be seen and measured.
- 3** When a chemical equation is balanced, the coefficients used to balance the equation give the number of moles of reactant used and product formed.
- 4** The atomic masses of all the atoms appearing in the formula of water give the total of  $16 + 1 + 1 = 18$  g/mol.
- 5** Mole ratios can be used to predict the amount of product formed in a chemical reaction.
- 6** The Law of Conservation of Mass states that the mass of reactants equals the mass of products. Mole ratios enable masses to be calculated.
- 7** From the relative atomic masses there are 12 g of carbon in 44 g of carbon dioxide. The percentage of carbon is  $12/44 \times 100 = 27\%$ .
- 8** The Law of Constant Proportions states that a compound, regardless of how it is formed, will always contain the same elements in the same proportions by mass.
- 9** **a** 2  
**b** 12  
**c**  $6.02 \times 10^{23}$   
**d**  $6.02 \times 10^{23}$   
**e**  $5.02 \times 10^{22}$  dozen eggs  
**f**  $3.01 \times 10^{23}$  pairs of socks
- 10** **a** Iron sulphide: FeS

- b**  $\text{Fe}_{(s)} + \text{S}_{(s)} \rightarrow \text{FeS}_{(s)}$   
**c** 55.9 g of iron reacts with 32.1 g of sulfur, producing 88 g of iron(II) sulfide.  
**11 a** Two moles of hydrogen reacts with one mole of oxygen.  
**b** Two moles of water are produced.  
**c** 4 g of hydrogen reacts with 32 g of oxygen, producing 36 g of water.

- 12 a** 180 g/mol  
**b** 164 g/mol  
**c** 14 g/mol  
**d** 164 g/mol

**13**

Mass of lead reacting (g)	Mass of oxygen reacting (g)	Mass of lead oxide produced (g)
2.00	0.31	2.31
4.00	0.62	4.62
6.00	0.93	6.93
8.00	1.24	9.24

- 14** K 39%, H 1%, C 12%, O 48%  
**15 a** Hydrogen gas,  $\text{H}_2$   
**b** 2.5 g of magnesium is a greater proportion of a mole of magnesium than 2.5 g of calcium. This is because magnesium atoms have a lower formula weight than calcium (each atom of magnesium is lighter than that of calcium), so there are more atoms in 25 g of magnesium than in 25 g of calcium. Therefore magnesium will produce more gas as there are more magnesium atoms to react with the acid.  
**16 a**  $\text{CuCO}_{3(s)} \rightarrow \text{CuO}_{(s)} + \text{CO}_{2(g)}$   
**b** 9.3 g  
**17 a**  $\text{CH}_{4(g)} + 2\text{O}_{2(g)} \rightarrow \text{CO}_{2(g)} + 2\text{H}_2\text{O}_{(g)}$   
**b** 16 g  
**18 a** 28 g of nitrogen =  $28/2 = 2$  moles; 64 g oxygen =  $64/16$  moles = 4 moles. The mole ratio of N:O is 2:4 or 1:2.  
**b** The formula can be  $\text{N}_2\text{O}_4$  or  $\text{NO}_2$ .  
**19** It is cheaper to get anhydrous  $\text{Na}_2\text{CO}_3$  at \$2/kg, because the decahydrate form contains much less sodium carbonate.  
**20** For every 100 g of aluminium oxide, if 45 g are aluminium, this is the equivalent of  $45/27 = 1.7$  moles, and oxygen =  $55/16 = 3.4$  moles. This is a 1:2 ratio of aluminium:oxygen. It cannot be  $\text{Al}_2\text{O}_3$ .  
**21**  $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$ . 0.3 g of Mg =  $0.3/24.31$  g = 0.012 mol. 0.012 mol of MgO =  $0.012 \times 40.31 = 0.50$  g. This shows that Stephen is correct, as it is not possible to produce this much magnesium oxide from 0.3 g magnesium.

## Chapter review

- 1 In chemical reactions the mass of reactants always equals the mass of products.
- 2 A chemical equation is a shorthand way of representing a chemical reaction.
- 3 Solid (s); gas (g); liquid (l); dissolved in water (aq).
- 4 Various answers possible.
- 5 SLC means standard laboratory conditions of one atmosphere pressure and the current room temperature.
- 6 Various answers possible, e.g. remove products as they are formed, add reactants as they are used up, increase the temperature.
- 7 Percentage yield: 99%
- 8 & 9 The contact process produces sulfuric acid from molten sulfur.  
The first step is burning molten sulfur in air to produce sulfur dioxide gas:  
$$\text{S}_{(l)} + \text{O}_{2(g)} \rightarrow \text{SO}_{2(g)}$$
  
Yield and rate are increased in this step by providing plenty of oxygen.  
The second step is heating sulfur dioxide in oxygen to convert it to sulfur trioxide (using a catalyst, vanadium):  $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightarrow 2\text{SO}_{3(g)}$ .  
Yield and rate are increased here by passing over several catalyst beds.  
The third step is the conversion of sulfur trioxide to oleum:  
$$\text{SO}_{3(g)} + \text{H}_2\text{SO}_{4(l)} \rightarrow \text{H}_2\text{S}_2\text{O}_7(l)$$
  
The fourth step is hydration of oleum to form sulfuric acid:  
$$\text{H}_2\text{S}_2\text{O}_7(l) + \text{H}_2\text{O}_{(l)} \rightarrow 2\text{H}_2\text{SO}_{4(l)}$$
  
To increase rate and yield, these two reactions are maintained at a high temperature. Also, to increase the yield, products are removed as they are formed, and fresh reactants are added.
- 10 Sulfuric acid is corrosive, oily and soluble. It can be used to make fertilisers, paints and pigments, and rayon.
- 11 A homologous series is a series of compounds differing in formula by a  $-\text{CH}_2$  unit. Alkanes are an example.
- 12 Fuels, food, medicine, agriculture, plastics
- 13 A reaction could be fast in both directions, but still have a poor yield.
- 14 To be economically viable, an industrial reaction needs to produce a high yield in the shortest amount of time possible.
- 15  $\text{SO}_2$  is a molecular formula.  $\text{Na}_2\text{SO}_4$  is an ionic compound and forms a lattice, not discrete molecules.
- 16 a  $\text{Al}(\text{OH})_3 + 3\text{HNO}_3 \rightarrow 3\text{H}_2\text{O} + \text{Al}(\text{NO}_3)_3$   
b  $2\text{H}_2\text{O} + 2\text{K} \rightarrow \text{H}_2 + 2\text{KOH}$
- 17 Organic chemistry involves the large variety of carbon compounds formed when elements covalently bond to carbon. They form the basic structure of most living things so they were once known as organic compounds.
- 18 Diagrammatic answers required.
- 19 Pentane, pentene or pentyne

- 20** Many ethene monomer molecules are combined under specific temperatures and pressures, using a catalyst, to produce polyethylene, which is a polymer.
- 21** magnesium + hydrochloric acid → magnesium chloride + hydrogen
- 22 a** Two moles of sodium reacts with two moles of water, producing one mole of hydrogen and two moles of sodium hydroxide.
- b** One mole of copper(II) oxide reacts with two moles of nitric acid, producing one mole of copper(II) nitrate and one mole of water.
- 23 a** Lithium chloride, LiCl
- b** lithium carbonate + hydrochloric acid → lithium chloride + carbon dioxide + water
- c**  $\text{Li}_2\text{CO}_{3(\text{s})} + 2\text{HCl}_{(\text{aq})} \rightarrow 2\text{LiCl}_{(\text{aq})} + \text{CO}_{2(\text{g})} + \text{H}_2\text{O}_{(\text{l})}$
- 24 a i** hydrochloric acid + potassium hydroxide → potassium chloride + water
- ii**  $\text{HCl}_{(\text{aq})} + \text{KOH}_{(\text{s})} \rightarrow \text{KCl}_{(\text{aq})} + \text{H}_2\text{O}_{(\text{l})}$
- b i** sulfur dioxide + oxygen → sulfur trioxide
- ii**  $2\text{SO}_{2(\text{g})} + \text{O}_{2(\text{g})} \rightarrow 2\text{SO}_{3(\text{g})}$
- c i** magnesium + chlorine → magnesium chloride
- ii**  $\text{Mg}_{(\text{s})} + \text{Cl}_{2(\text{g})} \rightarrow \text{MgCl}_{2(\text{s})}$
- d i** silver nitrate + sodium chloride → silver chloride + sodium nitrate
- ii**  $\text{AgNO}_{3(\text{aq})} + \text{NaCl}_{(\text{aq})} \rightarrow \text{AgCl}_{(\text{s})} + \text{NaNO}_{3(\text{aq})}$
- 25** In complete combustion, a hydrocarbon burns in excess oxygen and produces carbon dioxide and water. In incomplete combustion there is less oxygen, so the products also contain less oxygen, for example carbon monoxide and/or carbon and water.
- 26** propane + oxygen → carbon dioxide + water
- $\text{C}_3\text{H}_{8(\text{g})} + 5\text{O}_{2(\text{g})} \rightarrow 3\text{CO}_{2(\text{g})} + 4\text{H}_2\text{O}_{(\text{l})}$
- 27 a** In fermentation, glucose in fruit or vegetables is converted into ethanol and carbon dioxide using a catalyst such as yeast.
- b** Fermentation is an important reaction as it can be used to produce useful products such as alcohol. Since alcohol can be used as an alternative fuel it means that vegetation could be used as a renewable resource to replace non-renewable fossil fuels.



**Unit 2.1 Pure metals and alloys**

- 1
  - a True
  - b False
  - c True
- 2 Metals are excellent electrical conductors, excellent thermal conductors, malleable (able to be bent and hammered), ductile (easily drawn into wires) and relatively dense.
- 3 Metal atoms have low electronegativity and tend to lose their outer-shell electrons.
- 4 Pure metals are too soft to be useful.
- 5 Copper and aluminium can be used in their pure form.
- 6 An alloy is a mixture of metals.
- 7 Choose any example from the table on page 26 of the coursebook.
- 8 If metals had a tight hold on their electrons they would be poor electrical conductors because the electrons would not be free to move and carry the current.
- 9 Coins are alloys: 'gold' coins contain copper, aluminium and nickel, and 'silver' coins are nickel and copper.
- 10 Metals are ideal for wiring because they are excellent electrical conductors and are ductile.
- 11 Both aluminium and copper are excellent electrical conductors. The density of aluminium is very low compared with copper, however, making it ideal for use in overhead cables. Longer strands of wire can be strung from poles, and poles and pylons can be lighter than would be needed for copper.
- 12 Mercury is ideal for thermometers because it is liquid at room temperature; it expands quickly when heated; and it leaves no trace in the tube when it retreats as the temperature drops.
- 13 The base metal in ferrous alloys is iron, Fe.
- 14 Wrought iron: very little carbon  
 Stainless steel: very little carbon but Cr and Ni added  
 Mild steel: 0.5% carbon  
 Hard steel: 1 to 2% carbon  
 Cast iron: 2.4 to 4.5% carbon
- 15
  - a Most abundant in Australian 'gold' and 'silver' coins: copper, Cu.
  - b The only metal that is liquid at normal room temperatures: mercury, Hg.
  - c The main component of steel: iron, Fe.
  - d Common to the alloys brass and bronze: copper, Cu.
  - e Added to iron to make stainless steel: chromium, Cr, and nickel, Ni.
- 16
  - a A 12-carat gold ring has  $12/24 = 1/2 = 50\%$  pure gold.
  - b A 9-carat gold nose-stud has  $9/24 = 3/8 = 37.5\%$  pure gold.
  - c A 22-carat gold chain has  $22/24 = 11/12 = 91.7\%$  pure gold.
- 17 Diagrammatic answer required.
  - a The breaking stress of:

- i a 50/50 alloy of copper/zinc:  $32 \times 10^6 \text{ N/m}^2$
- ii an alloy of 20% Cu and 80% Zn:  $12 \times 10^6 \text{ N/m}^2$
- iii an alloy containing 60% zinc:  $5 \times 10^6 \text{ N/m}^2$
- iv pure copper:  $33 \times 10^6 \text{ N/m}^2$
- v pure zinc:  $19 \times 10^6 \text{ N/m}^2$
- b Pure copper has a strength of  $33 \times 10^6 \text{ N/m}^2$ . Any part of the curve that is higher than this represents a copper/zinc alloy that is stronger than pure copper. To be stronger than pure copper, the alloy needs to have a composition somewhere between 52% copper (the remaining 48% being zinc) and 73% copper (27% zinc).
- c Pure zinc is represented on the graph and in the data as 0% copper. This metal has a strength of  $19 \times 10^6 \text{ N/m}^2$ . The part of the graph lower than this point represents alloys that are weaker than pure zinc. To be weaker than pure zinc, the alloy thus needs a composition of between 0% copper (pure zinc) and about 47% copper (53% zinc).
- d The strongest copper/zinc alloy is a 60% copper, 40% zinc mix.
- e The composition of three alloys that all break at a strain of  $25 \times 10^6 \text{ N/m}^2$  are approximately 48% copper (52% zinc), 78% copper (22% zinc) and 98% copper (2% zinc).

## Unit 2.2 Mining and metals

- 1 Native elements are elements that exist in nature as pure elements.
- 2 Silver, platinum, copper, gold
- 3 Nuggets, veins
- 4
  - a Metals that are not native elements are found as compounds.
  - b Rocks containing large amounts of metals are known as minerals.
  - c An ore contains sufficient metal to mine.
- 5 Choose any three from the table.
- 6 Three possible answers are: not sufficient metal in the ore; damage to the environment; lack of transport from the mine site.
- 7 Two possible answers are: the ore is easily obtainable and plentiful.
- 8 Problems are: water penetration and related pumping, threat of collapse and need for reinforcement, venting of poisonous and explosive gases, provision of fresh air.
- 9 Diagrammatic answer required.
- 10 Mined mineral is *crushed* by rollers or steel balls within a *ball mill*. Impurities known as *gangue* are separated by *froth flotation*. The remaining ore is now ready for *extraction*.
- 11 The activity series lists metals in the order of their ability to react chemically.
- 12 More reactive metals lose their outer-shell electrons faster than less reactive metals.
- 13 Extraction methods:
  - occur naturally (least active metals)
  - roasting in air

- heating with C or CO  
electrolysis (most active metals)
- 14 Potassium, sodium, calcium
  - 15 Diagrammatic answer required.
  - 16 Electrolysis requires electricity, which is expensive.
  - 17 Lead, iron, zinc
  - 18 Diagrammatic answer required.
  - 19 Slag is  $\text{CaSiO}_3$ .
  - 20  $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$   
 $\text{CO}_2 + \text{C} \rightarrow 2\text{CO}$   
 $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$   
 (slag creation  $\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_2$ )
  - 21 a False  
 b False  
 c True
  - 22 Disadvantage: recycling is expensive.  
 Advantage: recycling conserves non-renewable resources.
  - 23 Sodium atoms, Na, are very reactive and will react with nearly anything that they come in contact with. If the ion it forms,  $\text{Na}^+$ , was reactive then it would react to re-form the sodium atom, which would then react again to form the  $\text{Na}^+$  ion. Neither would exist for long.
  - 24 a Extracted by electrolysis: Al, Mg, Ca, Na, K (all metals can be listed)  
 b Extracted in a blast furnace: Pb, Fe, Zn  
 c Extracted by roasting in air: Cu  
 d Native: Au, Ag (Pt and Cu can be included)
  - 25 a Slag,  $\text{CaSiO}_2$ , is the waste from the chemical reactions that extract iron in a blast furnace. Gangue is all the impurities that are mixed with the ore. The gangue is removed even before the blast furnace stage.  
 b A mineral contains large amounts of a metal. When there is enough of the metal in the mineral to make extraction worthwhile, it is known as an ore.  
 c Overburden is the soil and rock covering the ore that is removed in open-cut mining.  
 d Electrolysis is the use of electricity to extract metals from their ores. Smelting uses heat, carbon and carbon monoxide to extract metals.  
 e Stable means that the chemical is unlikely to react. Reactive is the opposite to stable.
  - 26 Metals higher up the activity series are very reactive and will have formed compounds many millennia ago.
  - 27 Platinum is a native element and so should appear with other native elements such as gold and silver.
  - 28 Possible points in favour of mining: creation of jobs, creation of wealth and export opportunities, land owners may profit from the sale of land. Possible points against mining: people could be forced off their land, hostile political environment, cost of compensation, dust, noise and pollution in the environment.

- 29 A *shaft* is a vertical access tunnel, along which the cage or skip will travel and along which air and water will be pumped. A *drive* is horizontal and cuts into the ore body. A *stope* is dug along the seam of ore from a drive.
- 30 See Fig 2.2.3 on page 30 of coursebook.
- 31 Diagrammatic answer required.
- 32 a Electrons will swap to form  $\text{Na}^+$  ions and Au atoms since both are more stable than what we started with.  
 b No electrons would swap since the product would be more reactive and less stable than what we started with.  
 c Electrons will swap, forming  $\text{Mg}^{2+}$  ions and Cu atoms.  
 d Electrons will swap, forming Pb atoms and  $\text{Al}^{3+}$  ions.  
 e No electrons will swap.
- 33 Diagrammatic answer required.
- 34 a Diagrammatic answer required.  
 b The higher up the activity series a metal is, the more reactive it is, the more stable its compounds are and the harder it will be to extract. Newer and more complex technology was required to extract the metals high in the table. Metals low in the table need little if any effort to extract and need only primitive technology. Hence they were discovered long ago.

## Unit 2.3 Corrosion of metals

- Required for rusting: iron, air and water (as either liquid or vapour)
- Heat and salt speed up rusting.
- Equation for rusting:  $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$
- Three ways to protect iron and steel: corrosion-resistant alloy, galvanise, sacrificial protection
- Sacrificial protection is when a more reactive metal is coated on or attached to a metal of importance (usually iron). The metal will corrode instead of the iron.
- Aluminium oxide
- Anodising: an aluminium oxide coating is built up by electrolysis and a colour is added.
- $4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3$
- Metals that would be expected to show little or no corrosion would be the native metals: Au, Ag, Pt and Cu.
- Rusting* is a word given solely to the corrosion of iron. Zinc and other metals will *corrode* but never rust.
- When scratched, the exposed iron will begin to rust. After a short time the rust will flake, allowing more water to enter into the deeper layers of the car body and to the steel on either side of the scratch, including parts still covered with paint. Any paint on a rust-flake will lose adhesion and will flake off with it.

- 12 a** The iron of the steel can will rust when in contact with the water, salts and acids of foods and drinks. A protective layer of non-toxic and unreactive plastic or tin will keep the contents away from the steel.
- b** A dent or scratch may crack the protective plastic or tin layer, exposing the food to iron and after a short while rust. The food or drink will develop a strange taste and may begin to react itself.
- 13** Zn, Al, Mg, Ca, Na and K would all provide sacrificial protection to iron. The last two would react far too quickly to provide much protection, however.
- 14** Galvanising protects iron as long as some zinc remains on the surface. Scratches can occur, but rusting won't. Paint, however, needs to maintain a perfect layer without chips, cracks or scratches, to protect iron adequately.
- 15** Iron rusts and crumbles because rust is flaky, allowing water to enter the deeper layers. Aluminium is highly reactive but the dull oxide layer formed is tightly bound to the surface, stopping entry of water into the deeper layers.
- 16** Anodised aluminium window frames are usually coloured.
- 17** When magnesium blocks attached to piers dissolve away, new ones must be bolted/screwed on to continue their role as sacrificial protectors.
- 18** Al, Mg, Ca, Na and K would all protect a zinc structure from corrosion.
- 19** Points supporting the statement 'Iron is the most valuable metal on Earth':
- Iron consumption is nine times that of all other metals put together.
  - Steel is extremely strong, cheap, plentiful and easily worked.
- Points rebutting the statement:
- Other metals are more rare and therefore expensive and valuable.
  - Some have rare properties that make them extremely valuable in specialist roles (e.g. sodium as a nuclear reactor coolant).
- 20** Copper and tin will act like paint: if scratched, the iron underneath will begin to rust. Magnesium will provide sacrificial protection and the scratch will not rust.
- 21** Airborne salt and moisture will increase the rate at which the steel window frames will rust.
- 22** The surgical-grade metals will not corrode or rust when exposed to the sweat, salt and blood that will surround a piercing. Cheaper metals would corrode and infection would be very likely.

## Unit 2.4 Plastics and fibres

- 1** An organic compound is one with a carbon backbone.
- 2** Examples of groups of organic compounds are plastics, drugs, biological molecules, sugars, flavourings and alcohols.
- 3 a** Group IV
- b** Period 2
- c** Outer-shell electrons: 4
- d** Maximum number of bonds: 4
- e** Carbon lattices: diamond and graphite

- 4 A small molecule capable of joining together in a long chain is called a *monomer*. When small molecules join together they form a *polymer*. Small molecules join together in a process known as *polymerisation* and result in the production of *plastics*.
- 5 Thermoplastics soften when heated and can be moulded into shapes easily.
- 6 Thermoplastics are manufactured as powder, pellets or granules.
- 7 Plastics made by thermosetting are hard and rigid because their polymer strands are cross-linked.
- 8 Thermosetting plastics are hard, brittle and rigid.
- 9 Diagrammatic answer required.
- 10 Blow moulding is used to make bottles.
- 11 Toys, bottle caps and outdoor furniture are made by injection moulding.
- 12
  - a True
  - b False
  - c False
- 13
  - a Fibres are produced by extrusion.
  - b The nozzle is called a spinneret.
- 14 In a monofilament, each molecule is the same length as the monofilament.
- 15 Because each molecule is the same length as the monofilament, and therefore there are no weak spots. Fishing lines, for example, are stronger when made of a monofilament.
- 16 *Desirable* properties of plastics: non-reactive, non-biodegradable, light, easily moulded, thermal and electrical insulators.  
*Undesirable* properties of plastics: non-reactive, non-biodegradable, some will dissolve in organic chemicals, some produce toxic gases and smoke on burning, some will melt at low temperatures.
- 17 Natural fibres have a rough surface and thus a high surface area. They are like a towel in that they can absorb and hold water easily. Synthetic fibres do not absorb sweat because of their smooth surface. If you wear synthetic fibres you will feel wet and clammy. Wool can absorb a lot of water but is very warm.
- 18 Natural fibres: silk, wool, cotton, hair, fur, coir, linen.  
Synthetic fibres made from plastics: nylon, Kevlar, Terylene, polyester, Lycra, Spandex, Elastane.  
Synthetic fibres made from wood products: rayon, viscose, tri-acetate.
- 19
  - a The surface of a *natural* fibre is rough while the surface of a *synthetic* fibre is smooth.
  - b A *monomer* is a single, small molecule. A *polymer* is made up of many monomers linked together.
  - c *Thermoplastic* means that the plastic can be melted and remoulded into new shapes. *Thermosetting plastics* cannot be remoulded.
  - d In *injection moulding*, the required amount of molten plastic is squeezed into a mould and allowed to cool. A small bump is left where the plastic was injected. In *blow moulding*, a small amount of plastic is injected into a mould. Air then inflates the plastic to fill the mould. The mould is opened, leaving a seam.

- 20
  - a Synthetic polymers: PVC, polystyrene, acrylic, polythene, polyurethane, nylon
  - b Natural polymers: cellulose, lignin, resin, rubber, amber, gum, asphalt, pitch
  - c Inorganic polymer: asbestos
  - d Thermoplastic polymers: PVC, acrylic, polythene, nylon
  - e Thermosetting polymer: Bakelite
  - f Monofilament: nylon in fishing lines, Kevlar
- 21 If a train represents a polymer, then a single carriage would represent the monomer from which it is built.
- 22 Thermoplastics have only weak forces holding the long chains next to each other. When heated they can slip over each other easily, filling any new mould. On cooling, the weak forces become re-established, holding the chains in the new shape.
- 23 Once a thermosetting plastic powder was made it would remain a powder, because it could never be moulded into new shapes.
- 24 The longer the molecule, the stronger the fibre.
- 25 Fibres tend to break at weak spots. This will often be at the end of a molecule.
- 26 Care must be taken when drying and pressing synthetic fibres because the heat may soften the thermoplastic polymer, allowing it to melt or adopt new shapes.
- 27 Cross-links hold the polymer chains together. When heated, the chains cannot slip easily over each other. Heat will eventually break the bonds within the polymer chain and between chains, causing the plastic to decompose and char.
- 28 Diagrammatic answer required.
- 29 Many answers possible. The following offers an idea of what may be commented on by students:

Plastics have had a large effect on society. They have become one of the most widely used materials and have found uses in nearly all environments and societies on Earth. They are used for storage, packaging, clothing, insulation and food preparation, to make the structural components of tools, toys, furniture, buildings and cars, and they have many other uses.

Plastics have become so widespread because their properties can be developed to suit various applications. For example, they can be hard and heat-proof when used for saucepan handles, lightweight and flexible when used for bags, and strong and waterproof when used for pipes. It is difficult to imagine life without plastics, as they make up many of the items we rely on for daily living.

The effect of plastics on the environment is more problematic, as most plastics are non-biodegradable. That is, they stay in the environment for many years (possibly as long as a thousand years or more) before decomposing. Some new plastics are being made to break down faster in the environment either by bacteria or sunlight, and this may in time lessen the effect of plastics on the environment. The recycling of plastics is also a key factor in reducing their impact on the environment.

Controlling the disposal of plastics and recycling is important as plastics have many effects on the environment. Apart from looking terrible, plastics (plastic bags especially) can, for example, be mistaken for food by marine animals such as dolphins and whales, who think they are jellyfish. Many animals are also killed each year by getting tangled in plastic waste. This is especially problematic in rivers,

lakes and the ocean. In order to overcome some of these problems caused by plastics, we must find ways to reduce our use of plastics, and recycle all plastics produced. Purchasing products made of recycled plastics may help to promote better use of this non-sustainable resource.

## Unit 2.5 Soaps (on CD)

- 1
  - a Water is a polar molecule.
  - b Sodium chloride is an ionic compound.
  - c Water is not able to dissolve grease.
- 2 Polar molecules and ionic compounds dissolve in water.
- 3 Grease is an organic compound.
- 4 Organic solvents will normally dissolve grease—examples are turpentine, methylated spirits, petrol and nail polish remover.
- 5 Water normally dissolves ionic salts (e.g.  $\text{Na}^+\text{Cl}^-$ ) and polar molecules (sugars). The polar charge of the water molecule will attract the different charges on the solute, separating them. Once separated, the water will bind with the charges and stop them from re-bonding.
- 6 Reactants in saponification: animal fat or vegetable oils, alkaline solutions such as sodium hydroxide (caustic soda).
- 7 Calcium and magnesium make water hard.
- 8 Soft water is water that has less dissolved salts.
- 9 Soft water lathers better, feels smoother and requires less soap for cleaning.
- 10 Soap (and other surfactant molecules) has a long organic molecule. One end of the molecule will dissolve the patch of grease. The other end is negatively charged, however. This will be attracted to the polar charge of the water molecule and dissolve in it. Thus grease is dissolved by the soap and the soap dissolves in the water.
- 11 Cleaning is affected by: presence of surfactant (soap, detergent, shampoo), type and amount of grease, fabric type, temperature of water, amount of water, agitation, amount of lather produced, and hardness of water.
- 12 Lather helps stop grease from re-depositing on the fabric once it has been removed.
- 13 If shaving cream did not lather, the cut whiskers would remain on the face.
- 14 Any vegetable oil could be used for the production of soap. Some examples are olive oil, coconut oil, peanut oil, safflower oil, canola oil.
- 15 Animal fat could come from abattoirs (waste fat from meat production); whaling (in the past, whale blubber was used for the production of soap and candles); your skin.
- 16 Unlike soap, detergents do not produce scum or scale. They are made from chemicals from the petroleum industry and not from animal fat or vegetable oils.
- 17
  - a Soap molecules are similar to plastics in that both have a long organic part.
  - b Soap is similar to an ionic compound in that one end of the molecule is negatively charged and is bound to a positively charged metal ion.
- 18 fat + alkaline solution  $\rightarrow$  soap + glycerol



19 Diagrammatic answer required.

20 Diagrammatic answer required.

## Chapter review

- 1 Any alloy and its parent metal from the table of alloys in Unit 2.1 is acceptable.
- 2 The additives in alloys are usually metals but are sometimes the non-metals carbon or silicon.
- 3 Carbon content:
  - a Cast iron: 2.4 to 4.5%
  - b Tool steel: 1%
  - c Mild steel: 0.5%
- 4 Pure gold is 24 carat.
- 5 18-carat gold is  $18/24 = 3/4 = 75\%$  pure gold.
- 6
  - a Aluminium: overhead electricity cables, saucepans, cans, aluminium foil, base metal for alloys
  - b Zinc: coating of iron/steel in galvanised iron
  - c Cast iron: iron lace, some heavy cookwear
  - d Duralumin: aircraft frames
  - e Bronze: statues, ornaments, bells
  - f Haematite: iron oxide ( $\text{Fe}_2\text{O}_3$ ), the ore from which iron is extracted
  - g Bauxite: aluminium oxide ( $\text{Al}_2\text{O}_3$ ), the ore from which aluminium is extracted
  - h Celluloid: billiard balls, film, dolls
  - i Kevlar: bullet-proof vests, F1 fuel tanks, sails, fibre-optic cables, ropes
- 7
  - a Alloy of copper: brass, bronze, cupronickel
  - b Alloy of iron: any steel, cast iron
  - c Common impurity in iron: carbon
  - d Common pure metal: aluminium, copper
  - e Abundant non-metal: oxygen or silicon
  - f Scarce metal: any of copper, mercury, zinc, lead, tin, gold, silver
  - g Cheap metal to recycle: aluminium
  - h Ore: any of bauxite, chalcopyrite, galena, gold, haematite, pitchblende, rutile, sphalerite
  - i Native metal: any of gold, silver, platinum, copper
  - j Natural fibre: any of silk, wool, cotton, linen, coir, fur, hair
  - k Synthetic fibre from wood: any of rayon, viscose, acetate, tri-acetate
  - l Monofilament: nylon fishing line, Kevlar
  - m Surfactant: soap, detergent, shampoo
  - n Organic solvent: turpentine, petrol, nail polish remover, methylated spirits
- 8
  - a Electrolysis: aluminium, magnesium, calcium, sodium, potassium
  - b Smelting: lead, iron, zinc
  - c Roasting: copper
- 9 Blast furnace ingredients: iron ore, coke, limestone (and oxygen from the air)
- 10 The corrosion of iron is called rusting.

- 11 Anodised aluminium has had a thick and protective layer of aluminium oxide built up on it by electrolysis.
- 12 A thermosetting plastic is hard, brittle, rigid, will char but not soften, and cannot be remoulded.
- 13 The base metal of *rose-gold* is gold. The 'rose' or orange-red colour comes from added copper.
- 14 Cooking pits would have produced extreme heat. The ash from the fire would have provided the carbon needed to smelt the iron. Limestone may also have been used around the pit.
- 15 Gold and silver are native metals and would have been found in their natural state. Most other metals need some effort to extract them. Accidents would have led to the discovery of the other metals.
- 16 Salt speeds up the rate of rust production.
- 17 Stainless steel is strong and will not corrode once implanted in the body.
- 18 **a** After all the zinc coating has corroded off galvanised iron, the iron itself will rust.  
**b** After a few years the sheets will need to be replaced, since it is not economical to re-dip them.
- 19 Although car bodies are galvanised, paint gives them further protection. The galvanising will not be needed until the paint is scratched or dented. Painting is also done for appearance.
- 20 Unless specifically designed to break down in sunlight, plastic shopping bags do not rot, dissolve or decay once thrown out. We can instead use paper bags, string bags, backpacks etc to carry our shopping in.
- 21 An optic fibre is a monofilament. Any break in the structure may interfere with the signal being transmitted by light.
- 22 Natural fibres tend to hold water and thus will take a long time to drip dry. The extra weight and prolonged drying time would also stretch them. They need to have a lot of the water squeezed or spun out before they dry.
- 23 Diagrammatic answer required.
- 24 Diagrammatic answer required.
- 25 Diagrammatic answer required.
- 26 The diagram shows that there is a strong aluminium oxide layer that forms over the aluminium metal. Oxygen and water are unable to penetrate this layer.
- 27 Diagrammatic answers required.

## Unit 3.1 Electricity

- 1 A circuit is a path from one side of a power source (e.g. a cell, battery or power pack) to the other.
- 2 Energy source, conducting path, load, switch
- 3 *Voltage* is a measure of the energy available to push current through a circuit, and may be thought of as the size of the 'push'. *Current* is the flow of charge, usually electrons. *Resistance* is the ability of a substance to reduce the flow of current.
- 4 Voltage is measured in volts (V); current is measured in amperes (A); resistance is measured in ohms, or  $\Omega$  for short.

5

Electrical circuit	Water pump circuit
Battery	Pump
Wire	Pipe
Voltage or energy	Kinetic energy of water
Switch	Valve
Current	Water flowing through pipe
Resistor	Water wheel

- 6 Diagrammatic answer required.
- 7 The waterwheel resists the flow, slowing down the water. This is because the water has to push the wheel to make it move, using up some of the water's energy.
- 8 Light, heater, buzzer, LED, anything that uses electricity
- 9
  - a *Series circuit*: components are connected in a line.
  - b *Parallel circuit*: components are connected side by side, in different branches.
- 10 In series, each light would be dimmer than those in parallel, but equal to each other in brightness. In parallel, the lights would both be the same brightness and brighter than those in series.
- 11 voltage = current  $\times$  resistance,  $V = I R$
- 12 The graph would be a straight line through the origin, with current on the x-axis and voltage on the y-axis.
- 13 *Direct current* or *DC* electricity is a direct flow of electrons through a conductor in one direction only. *Alternating current* or *AC* electricity is a back-and-forth movement of electrons in a wire. This occurs when the voltage constantly changes from positive to negative to positive and so on.
- 14
  - a In the home: AC
  - b In a battery-operated appliance: DC

- 15 The movement back and forth is measured in Hertz – 1 cycle per second = 1 Hz. In Australia the household AC moves back and forth 50 times every second or 50 Hz and has a voltage of 240 V.
- 16 In series, if one globe blew, both globes would go out. In parallel, the second globe would continue to glow.
- 17 Lights in the home are wired in parallel so that if one goes out, all the others do not. They will all stay at maximum brightness.
- 18 Diagrammatic answers required.
- 19

Current (amps)	Voltage (volts)	Resistance (ohms)
3	15	5
5	30	6
13.3	240	18
10	240	24
0.5	7	14
8	12	1.5

- 20 Current in the circuit:  $V = 12$  volts,  $R = 50$  ohm.  $I = \frac{V}{R} = \frac{12}{50} = 0.24$  amps
- 21 a Diagrammatic answer required.
- b Current in the circuit:  $I = \frac{V}{R} = \frac{8}{75} = 0.11$  amps

## Unit 3.2 Electromagnetism

- 1 1820
- 2 See Fig 3.2.1 on page 68 of the coursebook.
- 3 A *solenoid* consists of coils of wire mounted on a hollow tube. An *electromagnet* is a solenoid containing an iron core.
- 4 An electromagnet can be turned on and off.
- 5 Various answers possible, e.g. bell, speaker, maglev train.
- 6 a Placing the magnet in the coil produces a current.  
b Removing the magnet from the coil causes current to flow in the opposite direction.  
c Continually moving the magnet in and out produces a continuous alternating current.
- 7 Various answers, e.g. a bicycle dynamo, a moving-coil microphone.
- 8 A transformer is used for boosting or reducing voltages.

- 9 Power station (generation), step-up transformer, transmission lines, step-down transformers, substation, consumers
- 10 Two types of transformer are step-up and step-down.
- 11
  - a Laptop computer: step-down
  - b Long-distance transmission: step-up
  - c Substation: step-down
  - d Mobile phone: step-down
- 12 Step-up has more secondary coils than primary coils. A step-down has fewer secondary coils than primary.
- 13 The operation of electromagnetic devices relies upon the magnetism that results in completion of an electric circuit. A possible example is the door latch in Fig 3.2.4, which keeps the door closed by magnetic attraction when current flows if the switch is turned on.
- 14 If the coin is an incorrect one, it does not slow down by the correct amount when it passes through an electromagnet.
- 15
  - a Yes
  - b No
  - c Yes
  - d Yes
  - e Yes
  - f Yes
- 16 Much higher voltage is used in power lines than at home—long-distance transmission of electricity is between 220 000 and 500 000 V, whereas in the home it is 240 V.
- 17 Higher voltages result in less power loss in transmission lines.
- 18 High-voltage power lines are deadly.
- 19 Diagrammatic answer required.

### Unit 3.3 Waves in communication

- 1 Transverse, longitudinal
- 2 In a *transverse* wave, particle movement is perpendicular to the wave direction. In a *longitudinal* wave, particle movement is in the same direction as the wave direction.
- 3 A light wave is made up of changing *electric* and *magnetic* fields that are *perpendicular* to each other, and moves at 300 000 000 metres per second.
- 4
  - a True
  - b True
  - c False
  - d False
- 5 The wavelengths and frequencies vary, but the speed is the same.
- 6 300 000 000 metres per second
- 7 Shortest wavelength to longest: gamma rays, X-rays, ultraviolet rays, visible light, infra-red rays, microwaves, radio waves

- 8 AM: amplitude modulation; FM: frequency modulation
- 9 Modulating radio waves enables them to be carried to a receiver, which then converts them to sound or video.
- 10 FM provides clearer reception, while AM travels further.
- 11 White light is made up of a mixture of colours of various wavelengths.
- 12 a Greatest wavelength: red  
b Highest frequency: violet
- 13 Blue, green, yellow
- 14 Infra-red cameras can detect body heat in contrast to the surroundings.
- 15 Microwaves can penetrate the Earth's atmosphere.
- 16 Gamma rays are released in a nuclear explosion.
- 17 A small amount of UV helps produce vitamin D. Too much can cause damage to the skin, including skin cancers.
- 18 A Geiger counter and gamma radiation could be placed on either side of an object. The amount of radiation detected by the counter could give an indication of the thickness of the object.
- 19 5 cm
- 20 Frequency = 20 waves per 10 seconds = 2 waves per second = 2 Hz
- 21 a Period = 0.5 seconds  
b C If the frequency increases, the period will decrease.
- 22 a Radio wave  
b Radio wave  
c Infra-red ray  
d Visible light
- 23 You would see nothing (darkness).
- 24 Diagrammatic answers required.
- 25 a 0.000 000 6 metres  
b 850 nanometres
- 26

Type of electro-magnetic radiation	Typical wavelength (approx.)	Source	How it is detected	Use/s
Gamma rays	1/1 000 000 000 000 m	Radioactive materials	Photographic film, Geiger counter	Treatment of cancer cells, medical imaging
X-rays	1/1 000 000 000 m	X-ray machine (suddenly decelerated electrons)	X-ray film	X-ray photographs
Ultraviolet	1/100 000 000 m	The Sun	Skin damage	Sterilisation,

radiation			/ tanning	brightening of clothes
Visible light	1/1 000 000 m	The Sun, very hot objects	Cones in the eye, photographic film	Sight, photography
Infra-red rays	1/100 000 m	Warm objects, electronic devices	Felt as heat or effect on a device being operated by a remote control	Remote controls, radiator heaters
Microwaves	1/100 m or 1 cm	Vibrating electrons, radio transmitters	Radio receiver, heats food	Communications, microwave ovens
Radio waves	1000 m or 1 km	Vibrating electrons, radio transmitters	Radio receiver	Radio and satellite communications

**27** Diagrammatic answers required.

- 28 a** 107.5 megahertz  
**b** 1278 kilohertz

### Unit 3.4 The communications network

- Various answers, e.g. smoke signals, drums, telegraph.
- Morse code is named after its inventor, Samuel Morse.
- 3.2 kilometres
- Digital signals
- Much of the current network was designed for use with analogue signals.
- Frequency division multiplexing (FDM) and time division multiplexing (TDM)
  - FDM sends signals using waves of different frequencies. TDM breaks up signals into chunks and sends them over the one frequency for sorting out later.
- B-ISDN (Broadband Integrated Services Digital Network)
- All household services will be connected to one cable.
- Various answers, e.g. fax, mobile phone, e-mail.
- Each digit must contain five symbols. For the digits 1 to 5, start with that number of dots, and make up a total of five symbols with dashes. For the digits 6 to 0, start with a dash or dashes and think of a dash as worth two dots. Sum the 'dots' value and ensure a units total equal to the digit.
- With a digital signal, several messages can be sent using the one data stream and there is less chance of signal corruption.

- 12 The word 'call' implies a spoken message, but messages today may involve data such as pictures and electronic files, so 'signal' is a better term.
- 13 There would be more interference (e.g. crossed lines) and less clear reception.
- 14 It does not spread out (disperse) much as it travels and can be produced in rapid bursts suited to digital communication.
- 15 They are called cell phones because of the shape of the regions in which the mobile phone network is divided. The regions are arranged like biological cells.
- 16 If one communication path breaks down, other options are still available.
- 17 Various answers, e.g. telephone, fax, Internet, interactive services.
- 18 It is easy to communicate instantly with any part of the world, as if everyone was living in the one small village.
- 19 Various answers, e.g. you may be more reserved about making a call from the bath.
- 20 The contact arm is in layer 3 (third down starting from the top), touching contact number 3 from the left.
- 21 To avoid direct interference between adjacent towers.
- 22 a Various answers, e.g. 5 to 10 words per minute.  
b Various answers, e.g. 100 words per minute.
- 23 Various answers
- 24 I am having fun.
- 25 Diagrammatic answer required.
- 26 1500

### **Unit 3.5 Electronics (on CD)**

- 1 A resistor is used to control current and voltage in a circuit. They can convert electrical energy into heat and protect sensitive components from damage.
- 2 Different-sized resistors have different bands of colour; the bands are a code representing the resistance in ohms.
- 3 A thermistor is a device whose resistance drops when it is warmed up.
- 4 Thermistors are used in circuits that respond to changes in temperature.
- 5 a An LDR has a variable resistance.  
b More light decreases the resistance of an LDR  
c An LDR can be used in changing light conditions.
- 6 A capacitor can store small amounts of charge.
- 7 Diagrammatic answer required.
- 8 Capacitance is the charge-storing ability of a capacitor and is measured in farads, F, or microfarads,  $\mu\text{F}$ .
- 9 A diode is used to protect a circuit from current going the wrong way and for converting AC current to DC current.
- 10 Silicon, germanium



- 11 When connected one way (forward biased) a diode will conduct. When connected in reverse (reverse biased) it will not conduct.
- 12 William Shockley, Walter Brattain and John Bardeen
- 13 Diagrammatic answer required.
- 14 Transistors replaced valves, which were much larger, thus leading to the miniaturisation of electronics.
- 15 The microchip is a miniaturised electric circuit with millions of connected semiconductor components on thin wafers of silicon.
- 16 Many answers possible e.g. computers, amplifiers.
- 17 a Thermistor (as well as transistor, resistor)  
b Light-dependent resistor (as well as transistor, resistor)
- 18 Flashing LEDs mean the battery will last longer, and flashing is more obvious to other road users.
- 19 a No, unless you live in a palace.  
b Up to ten 'standard' size bedrooms would be needed.
- 20 Double the amount
- 21 a 680  $\Omega$   
b 15 000  $\Omega$   
c 270 000  $\Omega$   
d 2 500 000  $\Omega$
- 22 a Green, blue, brown  
b Orange, orange, red  
c Yellow, violet, yellow  
d Brown, red, green

23

Component	Sketch	Use	Symbol
Resistor	Diagram required	Controls current and voltage	Diagram required
Thermistor	Diagram required	Detects heat	Diagram required
LDR	Diagram required	Detects light	Diagram required
Capacitor	Diagram required	Stores charge	Diagram required
Diode	Diagram required	Protects circuits, gives out light (LED)	Diagram required
Transistor	Diagram required	Amplification, switching	Diagram required

- 24 Prac set-up or diagram required.
- 25 Diagrammatic answer required.
- 26 Various answers, e.g. 100 to 500.

## Chapter review

- 1
  - a voltage: volts (V)
  - b resistance: ohms ( $\Omega$ )
  - c current: ampere or amps (A)
- 2 A series circuit has components connected in a line. A parallel circuit has components connected side by side in different branches of the circuit.
- 3
 

load	Uses up electrical energy
voltage	The energy available to push current through a circuit
current	The flow of charge, usually electrons
conducting path	Wires for the electricity to flow through
resistance	The ability of a substance to reduce the flow of current
switch	Turns the current on or off
- 4 AC: alternating current, constantly changes direction. DC: direct current, flows only in one direction.
- 5
  - a A magnetic field is produced by any current-carrying wire.
  - b Electricity can cause magnetism and magnetism can cause electricity.
  - c Electromagnets can be turned on and off.
  - d A relay is an electromagnetic switch.
  - e A generator produces current when a magnet moves inside or near its coils or the coils move relative to the magnet.
  - f More energy is lost in power transmission lines when the voltage is lower.
  - g All charges (free or in wires) experience a force due to a magnetic field.
- 6 Longitudinal and transverse
- 7 If voltage is stepped up to 220–500 kV, less power will be lost during transmission, but it needs to be stepped down again to 240 volts before connecting to houses.
- 8 Many answers possible, e.g. computers, amplifiers, mobile phones, digital watches, CD and DVD players.
- 9 See Fig 3.3.5 on page 78 of the coursebook.
- 10 Small pointers were moved using transmitted currents.
- 11
  - a Samuel Morse—invented Morse code.
  - b Alexander Bell—invented the telephone.
  - c Almon Strowger—invented the automatic telephone exchange.
  - d William Shockley—headed the team that invented the transistor.
- 12 Diagrammatic answers required.
- 13

Electrical circuit	Water pump circuit
Switch	Valve
Battery	Pump
Resistor	Water wheel
Voltage or energy	Kinetic energy of water

Current	Water flowing through pipe
Wire	Pipe

- 14 a Diagrammatic answer required.  
 b The slope represents resistance.  
 c Resistance = 1.25 ohms

15

Current	Voltage	Resistance
3 amps	15 V	5 $\Omega$
10 amps	60 000 V	6 k $\Omega$
7500 amps	240 kV	32 $\Omega$

- 16 Series circuits:  
 a The voltage is shared **equally** between each resistor.  
 b The current is **the same** for each resistor.  
 c If any component is removed, the circuit **will not** work.  
 Parallel circuits:  
 d The voltage is **the same** for each resistor.  
 e The current **divides into** each branch of the circuit.  
 f If one branch of the circuit is broken the other branches **will** still work.
- 17 A step-down transformer is used close to homes, to reduce the voltage to a safer (but still dangerous) level.
- 18 The visible spectrum is a small part (that we see as light, containing the colours of the rainbow) of the electromagnetic spectrum.
- 19 As frequency increases, the wavelength decreases.
- 20 Waves of laser light are all of the same wavelength and colour and are in step (coherent).
- 21 Coaxial cable—uses existing cabling. Optical fibre—high capacity, cheap, suited to transfer of digital information. Microwaves—requires no cabling (uses electromagnetic waves), useful for long distances, satellite communications.
- 22 If the same frequency was used, several conversations could be heard by unrelated callers (i.e. crossed lines, lack of privacy).
- 23 Radios used valves (which were much larger and heavier than transistors) to amplify radio signals for conversion into sound waves.
- 24 a Frequency: 0.5 Hz  
 b Wavelength: 15 mm  
 c Amplitude: 10 mm
- 25 Message 1: MY HOVERCRAFT IS FULL OF EELS.  
 Message 2: THE PRICE OF EGGS HAS GONE UP!
- 26 Each letter could be given a code made up of zeros and ones (in a similar way to how each letter is made up of dots and dashes in Morse code).

## Unit 4.1 Inheritance

- 1
  - a Genetics is the study of heredity.
  - b Mendel studied inheritance in a systematic and scientific manner. He generalised, based on many observations. He introduced ideas like hereditary factors, and dominant and recessive features.
- 2 Seeds that were round or wrinkled; seeds that were yellow or green; pods that were smooth or constricted; pods that were green or yellow; and stems that were long or short.
- 3 A true-breeding plant is a plant that consistently produces offspring the same as itself for a certain characteristic. In simple dominant/recessive genetics, it is homozygous for the particular characteristic.
- 4  $F_1$  is the first generation;  $F_2$  is the second generation.
- 5 The dominant trait appears in the  $F_1$  generation; the recessive trait is masked and reappears in the  $F_2$  generation.
- 6 Mendel concluded that pea plants possess two hereditary factors for each characteristic.
- 7 A gene is a hereditary unit which controls a particular characteristic.
- 8 Genes are made of deoxyribonucleic acid (DNA).
- 9
  - a A chromosome is a long, coiled thread-like structure found in cell nuclei. It is made of DNA and protein.
  - b A gene is a small segment of a chromosome. Each chromosome may have thousands of genes along its length.
- 10
  - a Human body cell: 46 chromosomes
  - b Sperm cell: 23 chromosomes
- 11 Chromosomes exist in pairs that are similar in size and shape, one inherited from the mother and one from the father—these are called homologous pairs.
- 12 *Diploid* cells contain two of each type of chromosome, e.g. human body cells with 46 chromosomes. *Haploid* cells contain only one of each type of chromosome, e.g. human sperm cells with 23 chromosomes.
- 13
  - a *Mitosis*: a type of cell division that produces daughter cells identical to the parent cell.  
*Meiosis*: a type of cell division producing daughter cells with half the chromosome number of the parent cell.
  - b Mitosis occurs in almost all cells. Meiosis occurs in the sex organs, and results in the production of gametes.

14

	Mitosis	Meiosis
Number of daughter cells	2	4

Type of daughter cells	Identical to parent cell	Gametes
Occurrence	Almost all cells	Cells in sex organs/gamete-producing cells

- 15** Alleles      Alternate forms of the same gene  
 Phenotype      The physical appearance of an organism for a particular characteristic  
 Genotype      The genes for a particular characteristic present in an organism  
 Homozygous      An organism with the same genes for a particular characteristic  
 Heterozygous      An organism with different genes for a particular characteristic
- 16** Codominance occurs when two genes are equally expressed, as in the case of animals with a 'roan'-coloured coat from pure-bred parents of different-coloured coats.
- 17** Incomplete dominance occurs when neither gene dominates, as in the case of flowers that turn out a colour which is a blend of its parents.
- 18** If a gene for brown eyes (*B*) is dominant over another gene (*b*), then genotypes *BB* and *Bb* will produce the same phenotype (brown eyes).
- 19** a Codominance  
 b Complete dominance  
 c Complete dominance
- 20** Eight (*XYZ*, *XyZ*, *XYz*, *xYZ*, *Xyz*, *xYz*, *xyZ*, *xyz*)
- 21** a X  
 b Z  
 c Y  
 d V  
 e W
- 22** a Red  
 b White  
 c  $P_2$   
 d 50%  
 e 50%
- 23** a Black (*BB*), white (*WW*), blue (*BW*)  
 b 25% black, 25% white, 50% blue  
 c The cross of two blue fowls will always give only a 50% chance of producing a blue fowl. Given the codominant nature of the genes, and the fact that blue fowls are heterozygous, blue fowls that produce only blue fowls (true-breeding) are not a possibility.
- 24** a *Hh*  
 b *HH*, *hh*, *Hh*  
 c Short hair, long hair  
 d Short hair 75%, long hair 25%
- 25** a *Ww*, *ww*  
 b 50% of each  
 c 50%

- 26 a For the  $F_1$  generation all plants are  $Ll$ . The Punnett square for the  $F_2$  generation shows the four possibilities as  $LL$ ,  $Ll$ ,  $Ll$ ,  $ll$ , each with 25% chance.  
 b The possible phenotypes are 75% long stem ( $LL$  and  $Ll$ ), 25% short stem in the 3:1 ratio Mendel observed.

## Unit 4.2 Human inheritance

- 1 Albinism, Huntington's disease and night blindness
- 2 Both parents are heterozygous.
- 3 a 100%  
b 25% or 1 in 4
- 4 Simple inheritance: the Rh system is controlled by two alleles, one dominant over the other. A person may be homozygous or heterozygous Rh positive, or homozygous Rh negative.
- 5 The ABO system involves three different alleles, and is codominant.
- 6  $I^A$ ,  $I^B$  and  $I^O$
- 7  $I^A$ ,  $I^B$  are codominant and  $I^O$  is recessive.
- 8 Three gene pairs are thought to influence eye colour.
- 9 Sharply defined characteristics such as left- or right-handedness are described as showing *discontinuous variation*. The opposite is *continuous variation*, where a range of characteristics occur—examples are height and eye colour.
- 10 Genes and environment influence intelligence.
- 11 Pedigrees are used to gather information on inheritance.
- 12 Diagrammatic answer required.
- 13 a The X chromosome is responsible for male and female characteristics.  
b Males have the genotype XY.  
c The Y chromosome carries less genetic coding than the X chromosome.  
d Sex-linked diseases occur because the X chromosome has defective genes present.  
e Diseases like haemophilia are inherited through females in a family.
- 14 a A carrier of haemophilia is heterozygous. She has the recessive gene, but does not show the disease.  
b A male cannot be a carrier of haemophilia. The male has only one gene for the characteristic, because haemophilia is X-linked. His genotype can only be either  $X^hY$  or  $X^HY$ . If he has the  $X^h$  gene (the gene for haemophilia), then he has the disease. If he has the  $X^H$  gene (the normal gene), then he does not have the disease and is not a carrier.
- 15 a *Discontinuous variation*: blood group, ability to roll the tongue  
b *Continuous variation*: height, skin colour
- 16 The parents must be heterozygous ( $Cc$ ), since they do not have the disease, but each has given the child a recessive gene for the disease. There is a 75% chance that their child will not have cystic fibrosis.
- 17 a A

- b A  
c AB  
d B  
e B  
f O
- 18 Albino  $aa$ , non-albino  $Aa$
- 19 a Both parents must be homozygous ( $aa$ ) to be albino. The only possible genotype of the offspring is  $aa$ .  
b 50% (equally probable genotypes of offspring are  $Aa$  and  $aa$ )
- 20 Females have the genotype  $XX$ . All ova carry the X chromosome. Males have the genotype  $XY$ . Half the sperm carry an X chromosome; the other half carry Y. There is an approximately equal chance of either sperm fertilising an ovum, hence an approximately equal chance of producing a male or a female.
- 21 The person would be male, due to the presence of the Y chromosome.
- 22 None. The parents are homozygous ( $rr$ ). All offspring will be homozygous ( $rr$ ) and will not be able to roll their tongue.
- 23 a The child has genotype  $I^A I^B$ , the mother  $I^A I^O$  or  $I^A I^A$ .  
b The possible genotypes of the father are  $I^B I^O$  or  $I^B I^B$  or  $I^A I^B$  (blood groups AB or B).
- 24 Sperm only have one sex chromosome, so they are not truly male or female. A male (XY) or female (XX) has two sex chromosomes.
- 25 A Male with the inherited characteristic  
B Mating of a male and female  
C Female without the inherited characteristic  
D Deceased male  
E Identical twin boys
- 26 a  $Rr$   
b  $RR$  or  $Rr$   
c  $rr$
- 27 The pedigree should look like the one shown in Fig 4.2.12 on page 112 of the coursebook.
- 28 The man has genotype  $I^B I^O$  or  $I^B I^B$ , the woman  $I^A I^O$  or  $I^A I^A$ . The possible genotypes of the child are  $I^B I^O$ ,  $I^B I^A$ ,  $I^A I^O$  or  $I^O I^O$ . The child could therefore have blood group B, AB, A or O.
- 29 a Non-colour-blind female  $X^N X^N$  or  $X^N X^n$ , colour-blind female  $X^n X^n$ , non-colour-blind male  $X^N Y$ , colour-blind male  $X^n Y$ .  
b i 0%. Daughters will all be  $X^N X^n$ , non-colour-blind.  
ii 100%. Sons will all be  $X^n Y$ , colour-blind.
- 30 a i Haemophiliac male:  $X^h Y$   
ii Non-haemophiliac male:  $X^H Y$   
b There are two possible genotypes for the sons:  $X^h Y$  (haemophiliac) and  $X^H Y$  (non-haemophiliac). So each son has a 50% chance of being haemophiliac.

**Unit 4.3 DNA: The molecule of life**

- 1 DNA: sugars, phosphates and nitrogen bases
- 2 A = adenine, T = thymine, C = cytosine, G = guanine
- 3 Nitrogen bases pair in a very specific manner to form the cross-links between the sugar-phosphate backbones of the DNA molecule. A pairs with T, and C pairs with G. These are called complementary pairs.
- 4 Each DNA segment differs in the sequence of the four bases, A, T, C and G.
- 5 During mitosis the DNA is copied exactly – this is known as replication.
- 6 DNA must replicate in order to pass on genes to the next generation, and to each new cell in the body.
- 7 Diagrammatic answer required. Strands are unzipped. Each base is matched by its complementary base. One old and one new strand are re-zipped together. For diagram, see Fig 4.3.2 on page 114 of the coursebook.
- 8 Proteins differ from each other in their number, type and sequence of amino acids.
- 9 A codon is a set of three bases which codes for a particular amino acid.
- 10 Diagrammatic answer required.
- 11 Gene expression is the appearance in the organism of the characteristic for which the gene codes.
- 12 A mutation is a spontaneous change in a gene or chromosome that may produce an alteration in the characteristic it codes for.
- 13 X-rays, gamma rays and benzene
- 14 Sickle cell anaemia
- 15 Down syndrome
- 16 GCCTATTCGAT
- 17 Each amino acid requires a codon (a set of three bases). Two hundred amino acids will need at least 600 bases.
- 18 Mutations give rise to genetic variation in a population. Examples of beneficial mutation are: the mutation causing bacterial resistance to the antibiotic penicillin (beneficial to the bacteria, not us); Granny Smith apples.
- 19 Mutations in body cells are not inherited.
- 20 By mutation, bacteria can become resistant to antibiotics. With large-scale use, many bacteria may become resistant to many different antibiotics. These resistant bacteria may therefore cause untreatable infections in the future.
- 21 If the radiation damaged the genes for the production of tyrosinase in some cells then the skin would develop white spots. This colouration is often seen on people who have had excessive sun exposure over time.
- 22 a There are three chromosomes instead of two for the twenty-first pair.  
b Male (X and Y)
- 23 a Diagrammatic answer required. See Fig 4.3.1 for example.  
b Diagrammatic answer required.



## Unit 4.4 Controlling inheritance

- 1 Various answers, e.g.:
  - Using seeds from only the best plants to produce next year's crop
  - Crossing a cow with high milk production with a disease resistant bull to give a robust, high-yielding dairy cow.
- 2 Selective breeding enables production of desirable characteristics and introduction of disease resistance.
- 3 Genetic engineering is the manipulation of the DNA within an organism.
- 4 Various answers, e.g.:
  - Genetically modified cotton which is resistant to the *Heliothis* caterpillar
  - Production of insulin using recombinant DNA techniques.
- 5 **a** A genetically modified plant is a plant with an altered gene sequence.  
**b** A transgenic animal is an animal with a new, introduced gene.
- 6 **a** A plasmid is a circular piece of DNA.  
**b** They are found in bacterial cells.  
**c** Plasmids are used to carry foreign DNA into a new cell. DNA is inserted into the plasmid to create a 'mixed' molecule called recombinant DNA.
- 7 Recombinant DNA is a 'mixed' molecule containing DNA from two different organisms.
- 8 A gene probe is a small piece of DNA with a base sequence identical to part of a gene.
- 9 Gene probes are used to detect genetic diseases in embryos, and to match samples of DNA found in criminal cases.
- 10 The sex, abnormal chromosome numbers and the presence of some genetic diseases.
- 11 Amniocentesis and chorionic villus sampling. A needle is inserted into the uterus to remove cells which 'fall off' the embryo.
- 12 *Cloning* involves making a copy of a complete organism. *Therapeutic cloning* involves the cloning of only certain cell types, which are then implanted back into the person from whom the original cell came.
- 13 Gene cell therapy is the removal, manipulation and reinsertion of genetic material from body cells.
- 14 Gene cell therapy is used in the treatment of diseases such as cancer, and in the treatment of inherited DNA to prevent diseases such as haemophilia.
- 15 The human genome is a genetic map showing the positions of genes on human chromosomes.
- 16 99.9% of the code is the same for all people. The map contains only 32 000 genes.
- 17 The protein may kill other insects which feed on the cotton. Predators of the caterpillar may also be affected.
- 18 **a** Cloning is the production of an organism from a single cell. The new organism is genetically identical to the parent.  
**b** The clone has the same genotype. However, learned characteristics such as the response to a certain voice would not necessarily be the same.

- 19 a They may change their diet to remove fat, salt and other foods associated with increased risk of heart disease.  
b They may consider the person a 'bad risk', and therefore discriminate against them (by not offering the policy or the employment).
- 20 This procedure is beneficial to humans if the end result is the production of useful hormones such as insulin or human growth hormone, or antibiotics, or vaccines. Insertion of human DNA sequences into bacteria has the benefit of causing fewer side effects in humans when the drug is used.
- 21 The procedure is useful diagnostically in order to assess whether a foetus is normal. The test does carry a slight risk of miscarriage. From an ethical point of view, it is debatable whether the life of an abnormal foetus should be ended.
- 22 Student opinion required in evaluation.

## Chapter review

- 1 Heredity: characteristics inherited from parents, such as eye colour.  
Environment: type of diet might influence growth.
- 2 Various answers possible, for example:
  - a pale skin, blue eyes, curly hair
  - b above-average height, high forehead, large hands
  - c ears like my grandfather
- 3 a *Alleles* are different forms of the same gene. For example, the dominant form of the gene is 'long stems' and the recessive form of the same gene is 'short stems'.  
b *Genotype* is the combination of genes for a particular characteristic. For stem length the genotypes are *LL*, *Ll* and *ll*.  
c *Phenotype* refers to the appearance of the characteristic in the organism. Stems are either long or short.  
d '*Homozygous*' refers to having only one type of gene for a particular characteristic. For stem length this means either *LL* or *ll*.  
e '*Heterozygous*' refers to having two types of gene for a particular characteristic. For stem length this means *Ll*.
- 4 a A gene is a hereditary unit which controls a particular characteristic.  
b Deoxyribonucleic acid
- 5 *Genes* are hereditary units which code for particular characteristics. Genes are made of *DNA*. Several thousand genes are found on each chromosome. *Chromosomes* are long, thread-like structures found in cell nuclei. They are made of protein and *DNA*.
- 6 Meiosis Cell division that produces gametes  
Mitosis Cell division that produces daughter cells identical to the parent cell  
Diploid A cell that has two of each type of chromosome  
Haploid A cell that has one of each type of chromosome  
Gene A hereditary unit  
DNA Chemical that carries the genetic code
- 7 In *dominant inheritance* the heterozygous individual shows only the dominant characteristic. In the fruit fly, for example, both *Rr* and *RR* have red eyes. In *codominant inheritance* the heterozygous individual shows characteristics which are

a combination of both the homozygous characteristics. For example, shorthorn cattle are red (*RR*), white (*WW*) or roan (*RW*).

- 8 Where there are sharply defined or discrete types, a characteristics shows *discontinuous* variation—for example, albino or not, able to roll the tongue or not, blood group A, B AB or O. Characteristics like height and skin colour show *continuous* variation, in which there is a range of values which ‘flow’ into one another—for example, a person’s height can be anywhere within a range; they are not simply tall or short.
- 9 DNA strands are unzipped. An exact copy of each strand is made by matching complementary bases. One old and one new strand are then re-zipped together.
- 10 Codon A sequence of three bases that codes for an amino acid  
Genetic map Shows the positions of genes on chromosomes  
Plasmid A circular piece of DNA  
Gene probe A small piece of DNA that recognises a gene  
Recombinant DNA A molecule containing DNA from two organisms  
Transgenic organism An organism with a new gene  
Mutagen Causes a spontaneous change in a gene or chromosome
- 11 a *Gene technology* is the manipulation of the DNA within an organism.  
b *Cloning* is the production of an organism from a single cell. The clone is genetically identical to the parent.  
c *Gene cell therapy* is the removal, manipulation and reinsertion of genetic material from body cells.  
d *Therapeutic cloning* is the cloning of cells from a person to transplant back into the person.
- 12 Various answers, e.g.:  
a Gene technology is a faster and more efficient way to introduce variety into plants and animals than using conventional selective-breeding techniques. Food production will be increased due to better disease and drought resistance in plants. Animals will produce leaner meat, thicker wool and have increased productivity.  
b Genetic modification is not natural. Interfering with a highly evolved and delicate system may upset it in unpredictable ways. GM plants with inbuilt pesticides may kill insects that are not pests. Multinational companies own the rights to most GM plants. Farmers will incur costs in using the modified plants.
- 13 a Mitosis: i, ii, v  
b Meiosis: i, iii, iv
- 14 a Not possible. Some of the children have the ability to taste PTC. They must have at least one dominant gene. The parents cannot both be non-tasters (homozygous with only the recessive gene).  
b Possible. Both could be heterozygous and therefore both could be tasters.
- 15 a  $X^N X^n$  and  $X^n Y$   
b They carry the gene but do not show the disorder. They are heterozygous for colour blindness.
- 16 a Alternating sugar and phosphate units  
b Pairs of nitrogen bases  
c A double helix

- 17 a** A mutation in a body cell may cause cancer. This mutation will not be inherited and therefore does not affect the species.
- b** A mutation in a sperm cell may not affect the parent, but may give rise to a disease in the offspring. This disease then becomes part of the gene pool of the species.
- c** Mutations may cause a characteristic which leads some individuals to survive under changed circumstances. This may help the species survive.
- 18 a** 99.9%
- b** Yes, if they are identical twins.
- 19 a** Red eye heterozygous,  $Rr$ ; white eye,  $rr$
- b**  $Rr$  or  $rr$
- c** 50% of each
- d** Tongue rollers or non tongue rollers
- e** 50% of each
- 20 a** 50% red, 50% pink
- b** 25% red, 25% white, 50% pink
- 21** The father has genotype  $I^A I^B$ , the mother  $I^O I^O$ . The possible genotypes of the child are  $I^B I^O$  or  $I^A I^O$ . The child could therefore have blood group A or B.
- 22 a** No. The gene is recessive. Heterozygous individuals do not show the disease.
- b** 25%
- 23 a**
- i**  $X^M Y$
  - ii**  $X^m X^m$
  - iii**  $X^m Y$
- b** A recessive gene. Two unaffected heterozygous parents in generation III produce an affected child.
- c** 50% (equal chance of  $X^M$  or  $X^m$  from the heterozygous mother)

## Unit 5.1 Describing motion

- 1
  - a  $s$ , metres (m)
  - b  $t$ , seconds (s)
- 2 *Distance* is the actual distance covered. *Displacement* is the distance that you end up from the start after your travels. For example, a swimmer completes a 1500 m race. He ends up back at the starting blocks, so has not moved anywhere, despite having travelled 1500 m to do so. Hence distance = 1500 m, displacement = 0 m (no direction can be specified here, since displacement is 0).
- 3 Speed is the rate at which distance is covered.
- 4 Speed,  $v$ , is measured in metres per second (m/s or  $\text{m s}^{-1}$ ).
- 5 Instantaneous speed is the speed measured in a given instant.
- 6 *Speed* is the rate at which we move. It can be an average and needs no direction. Average speed = distance/time. *Velocity* includes a direction. Average velocity = displacement/time. In a weather report, for example, the velocity of wind gusts will include the direction from which the wind is blowing.
- 7
  - a average speed = distance/time or  $v = s/t$
  - b distance = average speed  $\times$  time or  $s = vt$
  - c average velocity = displacement/time
- 8 In words,  $t = s/v$  means: time equals distance travelled divided by average speed.
- 9 Motion is recorded as dots. The distance between the dots indicates the speed of the moving object. Knowing the time taken, speed can be calculated.
- 10 The ticker-timer can only record motion in a straight line.
- 11 A distance–time graph shows the total distance travelled by an object as time progressed.
- 12
  - a A horizontal graph indicates no movement at all: the object is at rest or is stationary.
  - b Constant speed
- 13 The slope or gradient of a distance–time graph gives us its speed.
- 14 The area under a speed–time graph gives the distance that the object has travelled up to that point.
- 15 Distance = speed  $\times$  time or  $s = vt$
- 16
  - a Trying to get their foot onto the brake, change direction etc. There is a delay between the time the person sees the emergency and their reaction to it, as their body processes the information.
  - b Inexperienced drivers are probably slower to react in an emergency even without drinking alcohol. With alcohol also slowing reaction times, on top of inexperience, the likelihood of serious accidents increases even further. Therefore a zero alcohol limit means a young driver will have a better chance of responding quickly in an accident.
- 17 Distance always increases because it is a total. But our displacement can drop because we can move away from the start and then travel back to it.

**18** Factors that could be expected to influence reaction time are: drugs and alcohol in the blood, fatigue, age, distractions (radio, talking, mobile phone, noisy kids in the back).

- 19 a**
- i** Distance =  $2 + 2 + 1 + 3 + 7 + 5 = 20$  km
  - ii** Displacement = 4 km south
  - iii** Average speed =  $20/4 = 5$  km/h
  - iv** Average velocity =  $4/4 = 1$  km/h south
- b**
- i** Distance =  $6 + 1 + 2 + 5 + 4 = 18$  m
  - ii** Displacement = 0 m (no direction needed since it is 0)
  - iii** Average speed =  $18/9 = 2$  m/s
  - iv** Average velocity =  $0/9 = 0$  m/s (no direction needed since it is 0)

**20**

Speed	km/h	m/s
Athlete sprinting	42.1	11.7
Bushwalker	4.0	1.1
Race horse	68.4	19.0
Cheetah	100.0	27.8
Greyhound	65.9	18.3
Cockroach	4.5	1.3
Speed of sound	1202.4	334
Antelope	88.0	24.4

- 21 a**  $v = s/t = 990/9 = 110$  km/h
- b**  $v = s/t = 24/2 = 12$  cm/s
- 22 a**  $s = vt = 800 \times 6 = 4800$  km
- b**  $s = 11.7 \times 8 = 93.6$  m
- 23 a**  $t = s/v = 75/2.5 = 30$  s
- b**  $t = s/v = 300/60 = 5$  h
- 24** Time taken was  $8.15$  to  $8.45 = 30$  min =  $0.5$  h  
 Average speed =  $x/t = 1.5/30 = 0.05$  km/min  
 or average speed =  $x/t = 1.5/0.5 = 3$  km/h
- 25** Length of hair =  $5.15$  m =  $5150$  mm  
 Time = 77 years
- a**  $v = x/t = 5150/77 = 66.9$  mm/y
  - b** The assumption made was that the hair was never cut in the 77 years.
  - c** The speed calculated is an average. We have averaged its actual growth.
- 26 a**  $t = s/v = 149\,600\,000/300\,000 = 498.7$  s = 8.3 minutes
- b**  $t = s/v = 384\,403/300\,000 = 1.3$  s
- c**  $t = s/v = 5\,750\,400\,000/300\,000 = 19\,168$  s = 319.5 min = 5.3 h

27

Speed (km/h)	Speed (m/s)	Reaction time (s)	Reaction distance (m)
20	5.6	0.7	3.9
50	13.9	0.6	8.3
60	16.7	0.9	15.0
100	27.8	0.5	13.9
110	30.6	0.8	24.5

- 28 a Diagrammatic answer required.
- b Distance up = 5.9 km. Time taken = 40 s.  $v = s/t = 5.9/40 = 0.1475$  km/s = 147.5 m/s = 531 km/h.
- c 5.9 km up and 5.9 km down, hence 11.8 km in total. Using the scale of the photo, the distance is a little longer, approximately 6.2 km up and 6.2 km down. Hence total displacement is about 12.4 km in total.
- d Using the scale, the displacement is approximately 3.5 km to the left of its start.
- e The shape of the trajectory is a parabola.
- 29 a Distance = 58 mm  
Number of dots = 6  
Number of sections between dots = 5  
Time =  $5 \times 0.02 = 0.1$  s  
 $v = s/t = 58/0.1 = 580$  mm/s = 58 cm/s
- b Distance = 45 mm  
Number of dots = 16  
Number of sections between dots = 15  
Time =  $15 \times 0.02 = 0.3$  s  
 $v = s/t = 45/0.3 = 150$  mm/s = 15 cm/s
- c Distance = 51 mm  
Number of dots = 9  
Number of sections between dots = 8  
Time =  $8 \times 0.02 = 0.16$  s  
 $v = s/t = 51/0.16 = 318.8$  mm/s = 3.19 cm/s
- 30 First gradient:  
Graph rose from 0 to 4 m and ran from 0 to 2 s  
Gradient = rise/run =  $4/2 = 2$  m/s  
Second gradient:  
Graph rose from 4 to 6, a rise of 2 m. It ran from 2 to 6, a run of 4 s.  
Gradient = rise /run =  $2/4 = 0.5$  m/s
- 31 a Area = rectangle =  $L \times W = 6 \times 4 = 24$  m  
b Area = triangle =  $1/2bh = 1/2 \times 6 \times 4 = 12$  m  
c Area = rectangle + triangle =  $6 \times 4 + 1/2 \times 6 \times 2 = 24 + 6 = 30$  m
- 32 a Sharnika travelled 6 km out and 6 km back, 12 km in total.  
b Her displacement was zero.

- c She was away 6 h in total.
- d First leg speed =  $s/t = 6/2 = 3$  km/h.
- e Return speed =  $s/t = 6/3 = 2$  km/h.
- f She was stationary between  $t = 2$  h and  $t = 3$  h.
- g Average speed =  $s/t = 12/6 = 2$  km/h.

## Unit 5.2 Acceleration

- 1 Acceleration is the rate at which speed changes.
- 2  $a = (v - u)/t$
- 3  $v$  is the final speed given in m/s;  $u$  is the initial or starting speed given in m/s;  $t$  is the time taken for the change in speed given in s; and  $a$  is acceleration in metres per second per second,  $\text{m/s}^2$  or  $\text{m s}^{-2}$ .
- 4 If an object slows, it is decelerating. Deceleration is negative acceleration.
- 5 The car is increasing its speed by 10 kilometres per hour every second.
- 6 It means the runner is decelerating.
- 7  $v = u + at$
- 8 Final speed,  $v$ , equals starting speed,  $u$ , plus acceleration,  $a$ , times time taken,  $t$ .
- 9
  - a C
  - b A
  - c B
  - d D
- 10 15 m/s is added to speed every second.
- 11
  - a
    - $t = 0$  s,  $v = 0$  m/s
    - $t = 1$  s,  $v = 5$  m/s
    - $t = 2$  s,  $v = 10$  m/s
    - $t = 3$  s,  $v = 15$  m/s
    - $t = 4$  s,  $v = 20$  m/s
  - b
    - $t = 0$  s,  $v = 2.5$  m/s
    - $t = 1$  s,  $v = 7.5$  m/s
    - $t = 2$  s,  $v = 12.5$  m/s
    - $t = 3$  s,  $v = 17.5$  m/s
    - $t = 4$  s,  $v = 22.5$  m/s
- 12 The most appropriate unit for acceleration for a car would be km/h/s, since a car normally accelerates to high speeds (measured in km/h) in a few seconds.
- 13 **D** It could be at rest, or travelling at constant velocity/speed.
- 14 Deceleration is always a negative number because the final speed is less than the starting speed.
- 15
  - a Fastest: legs, slowest: head and shoulders.
  - b Spacing of the images gets larger as the diver rotates. This suggests increasing speed.
  - c An even spacing of images suggests there is no acceleration.



- d An increasing spacing suggests acceleration.
- e To calculate speed, you would need a scale from which distances could be estimated and the time taken between each 'flash' or image.
- 16 a Constant speed for four dots, then constant acceleration.
- b Constant acceleration for first five dots, then deceleration until it stops.
- c Constant deceleration to a slow speed (never stops though) then constant acceleration.

17 a

Speed (km/h)	Reaction distance (m)	Braking distance (m)	Stopping distance (m)
20	4	3	7
50	10	15	25
60	12	22	34
80	16	38	54
100	20	60	80

- b Lowering the suburban speed limit from 60 to 50 km/h has reduced the stopping distance from 34 to 25 m, a distance of 11 m (roughly 2 to 3 car lengths).
- c Assume a car is about 4 to 5 m long. The reaction distance at 60 km/h is 12 m (roughly 2 to 3 car lengths). At 100 km/h the reaction distance is 20 m (about 4 to 5 car lengths).

18

Starting speed (m/s)	Final speed (m/s)	Time taken (s)	Acceleration ( $\text{m/s}^2$ )
0	50	10	5
10	50	4	10
50	30	5	-4
At rest	25	10	2.5
60	Stationary	12	-5

19

Starting speed (m/s)	Acceleration ( $\text{m/s}^2$ )	Time taken (s)	Final speed (m/s)
0	15	3	$15 \times 3 = 45$
20	8	5	$20 + 8 \times 5 = 60$
16	1	4	$16 + 1 \times 4 = 20$

30	-2	10	$30 + -2 \times 10 = 10$
15	-5	3	$15 + -5 \times 3 = 0$

20 a  $a = 50/5 = 10 \text{ km/h/s}$

b  $50 \text{ km/h} = 13.9 \text{ m/s}$ , so  $a = 13.9/5 = 2.78 \text{ m/s}^2$

21 Section #1:

$a = \text{gradient} = 8/2 = 4 \text{ m/s}^2$

$x = \text{area of triangle} = \frac{1}{2} \times 2 \times 8 = 8 \text{ m}$

Section #2:

$a = \text{gradient} = 0/10 = 0 \text{ m/s}^2$  (constant speed)

$x = \text{area of rectangle} = 2 \times 8 = 16 \text{ m}$

Section #3:

$a = \text{gradient} = 2/3 = 0.67 \text{ m/s}^2$

$x = \text{area of rectangle} + \text{triangle} = 8 \times 3 + \frac{1}{2} \times 2 \times 3 = 24 + 3 = 27 \text{ m}$

22 a Linh  $a = 24/5 = 4.8 \text{ km/h/s}$

Beth  $a = 1.8/2 = 0.9 \text{ m/s}^2$

Brianna  $a = 3.0/0.5 = 6.0 \text{ m/s/min}$

b Linh  $a = 6.67/5 = 1.33 \text{ m/s}^2$

Beth  $a = 0.9 \text{ m/s}^2$

Brianna  $a = 3.0/30 = 0.10 \text{ m/s}^2$

c Linh broke away the quickest

d In ascending order: Brianna was slowest, then Beth, and Linh was fastest.

23 Diagrammatic answer required.

## Unit 5.3 Newton's first law

1 A force is a push, pull or twist.

2 A force applied to an object will increase its speed (accelerate), decrease its speed (decelerate), change its direction, or change its shape.

3 *Contact forces*: friction, air resistance, buoyancy, lift, thrust, drag

*Non-contact forces*: weight, electrostatic, magnetic

4 Newton's First Law Part #1: Anything at rest will stay that way unless pushed or pulled.

Newton's First Law Part #2: Anything that is moving will keep moving at the same speed and in the same direction unless a force changes it.

5 Inertia is the tendency of a body to maintain its state of rest or of uniform motion in a straight line. Newton's first law is often called the law of inertia.

6 a True

b False

c False

d False

e True

7 a As the car turns left, the occupants tend to keep moving in the same direction as before. They seem to move right, compared to the car.

- b** As the car suddenly accelerates, it 'leaves' the occupants behind. They will sink deep into the seats until accelerated by the seats. If there is no headrest, their heads will flick back.
  - c** As the car goes fast over a speed hump, the occupants will keep moving upwards. They lose a little contact with the seat and will feel lighter because of it.
  - d** As a car goes over a dip in the road, the occupants will tend to keep going into the dip. They will get pushed further into their seats and will feel heavier because of it.
  - e** If the car collides head-on with a wall, the occupants will keep travelling forward until the seatbelts, airbag or windscreen stops them.
  - f** If the stationary car is hit from behind, a situation similar to **b** will happen.
  - g** If the stationary car is hit from the left, the car will be pushed to the right, but the occupants will remain at rest due to inertia. They will appear to have moved left with respect to the interior of the car and towards the hitting car. More realistically, however, their backsides and lower bodies will have some friction force from the seat. This friction will tend to pull the lower bodies along with the seats. The upper body and head will have no such friction force and will remain where they were. Thus only the heads/upper bodies of the occupants will appear to move left.
- 8** Seatbelts, airbags, collapsible steering columns, rear vision mirrors, handles and attachments that will break off if hit, padded dash.
- 9** A seatbelt will spread its force over a wide area of chest. The chest has some flexibility and some padding. Although important, the organs that it contains will not necessarily cause death if damaged. In contrast, the head has almost no padding and contains *the* vital organ, the brain. Any force on the head will tend to be far more localised (e.g. on the forehead) and thus greater.
- 10** There is no atmosphere in space and therefore no air resistance to slow a rocket. Once moving, it will keep moving without needing engines.
- 11 a** Once started, a car on ice will keep travelling in the same direction. It will not turn or stop until it hits something. The ice is not providing enough friction to give the required grip.
- b** Friction is needed. Snow chains may help.
- 12** The reaction time in an accident is between 0.5 and 1 s, while the accident will be completely over within 0.1 s. The accident is over before you realise it has started. There is no way of preparing for it. You are in a seatbelt and so will stop with the car. The baby's inertia will keep it travelling. You will probably lose your grip on the baby.
- 13** The inertia of a passenger in the rear of a car will be enough to send them over the front seats to hit the front occupants or the windscreen.
- 14** A passenger in a bus has the same inertia as in a car moving at the same speed. If seated, you probably won't hit the windscreen but will hit seats and other passengers. If standing, your body will continue to move forward. Your feet will lag behind a little due to friction. You will thus lose balance, fall over and move towards the front of the bus, hitting seats, other passengers and very likely the

windscreen (especially if the bus is not crowded). It is therefore safer if each passenger is seated with a seatbelt.

- 15 Even when not wearing a seatbelt, friction with the seat will slow the lower body. The head will travel faster compared to the lower body.
- 16
  - a Seatbelts must provide enough force to decelerate you at the same rate as the car. Depending on the speed and the deceleration, this may be enough to bruise and crack ribs.
  - b Bruises and broken ribs are painful but will mend. Brain injuries do not mend. You could injure not just yourself but others also, when your body collides with them inside the car.
- 17 The load that a truck is carrying is travelling at the same speed as the truck. Even slight deceleration will send the load into the back of the cabin, injuring the driver if it breaks through. Truck cabins therefore need to be rigid to stop it.
- 18
  - a The china is stationary and will stay that way unless a force acts on it. If pulled fast, the tug of the tablecloth will not be enough of a force to get the china moving.
  - b There is some friction between the tablecloth and the china. Although not great it may be enough to move the china a little in the direction of the pull.
- 19
  - a The collision was probably a rear-end collision.
  - b Frame #1: the driver was stationary, perhaps at traffic lights.  
Frame #2: the car has been hit from behind. The head was stationary and remains so, while the seat back pushes the body forward with the car. The head drops back compared to the rest of the body.  
Frame #3: the spine and neck drags the head along and it 'recoils'.
  - c Modern cars are fitted with headrests to ensure that the head travels forward with the body in a rear-end collision.
- 20 Diagrammatic answer required.

## Unit 5.4 Newton's second law

- 1 Mass is the amount of matter in an object.
- 2 As mass increases, acceleration decreases.
- 3 As a force is increased, acceleration increases.
- 4 The object will accelerate and the acceleration will depend on the mass of the object.
- 5 Force = mass  $\times$  acceleration or  $F = ma$
- 6 When forces are balanced, an object will remain stationary or keep travelling in the same direction.
- 7 A (A change in direction is a change in velocity and is therefore acceleration.)
- 8 B They reduce acceleration and impact force.
- 9
  - a By sliding, rugby players increase the time they take to come to a stop.
  - b Their deceleration is less and the impact force on them will be less.

- 10 If airbags did not deflate as a person collapsed into them, they would be as hard and dangerous as the dash or windscreen. By collapsing, they cushion the body, increasing the time taken to stop and thus decreasing the deceleration.
- 11 a Because a hammer is hard, when it hits a nail the deceleration and impact force is high, making the blow effective in pushing the nail in.  
b A rubber hammer provides less force because it comes to a stop more slowly. Its deceleration is less and therefore the force is less.
- 12 *Second car compared with first car:* D. The car with the empty trailer would have an acceleration half that of the car by itself (because the total mass is double, i.e. car + trailer).  
*Third car compared with first car:* E. The car with the full trailer would have an acceleration one-third that of the car by itself (the mass is now equivalent to three cars).
- 13 *Acceleration of 200 g mass:* B. The pull of the 100 g hanging mass was  $0.5 \text{ m/s}^2$ . The pull of the 200 g mass is twice that and will produce twice the acceleration, i.e.  $1.0 \text{ m/s}^2$ .  
*Acceleration of 300 g mass:* A. The 300 g mass would produce three times the acceleration of the 100 g mass, i.e.  $1.5 \text{ m/s}^2$ .

14

Force (N)	Mass (kg)	Acceleration ( $\text{m/s}^2$ )
20.0	5.0	4.0
12.2	6.1	2.0
12.0	4.0	3.0
16.4	2.0	8.2
9.3	3.1	3.0

- 15 a  $F = ma = 5 \times 4.1 = 20.5 \text{ N}$   
b  $F = ma = 1300 \times 2 = 2600 \text{ N}$   
c  $F = ma = 0.4 \times 4 = 1.6 \text{ N}$
- 16 a  $a = F/m = 40/0.5 = 80 \text{ m/s}^2$   
b  $a = F/m = 0.5/50 = 0.01 \text{ m/s}^2$
- 17  $m = F/a = 35/7 = 5 \text{ kg}$
- 18 a The body picked up  $20 \text{ m/s}$  in  $5 \text{ s}$ , so it must have picked up  $4 \text{ m/s}$  every second. Hence  $a = 4 \text{ m/s}^2$ .  
b  $F = ma = 3.5 \times 4 = 14 \text{ N}$
- 19 a Overall force =  $400 - 150 = 250 \text{ N}$  right,  $a = F/m = 250/50 = 5 \text{ m/s}^2$  right  
b Overall force =  $800 - 770 = 30 \text{ N}$  down,  $a = F/m = 30/20 = 1.5 \text{ m/s}^2$  down
- 20 a Mass =  $m = 1500 \text{ kg}$   
b  $a = F/m = 3000/1500 = 2 \text{ m/s}^2$   
c This is a deceleration and so would be negative.  
d It would take  $5 \text{ s}$  to decelerate to a stop from  $10 \text{ m/s}$ .

## Unit 5.5 Newton's third law

- 1 For every action force there is an equal and opposite reaction force.
- 2 Batting a ball; hitting a golf ball; firing a cannon
- 3
  - a Second
  - b First
  - c Third
  - d First
- 4 When the thrust (action) overcomes the weight of the rocket, it lifts-off (reaction).
- 5 Diagrammatic answer required.
- 6 A balloon shoots around the room because of the reaction force the air gives back on it. The action force comes from the balloon squeezing out the air.
- 7
  - a The hose is pushing out the water with a great force. The water gives an equal force back on the hose, meaning that firefighters need to brace themselves or have extra help to hold it in place.
  - b If they did not do this, the hose would very likely push them backwards.
- 8 Michael can move only by using action/reaction. To do this he needs to expel something or throw something away. The reaction force would be enough on such slippery ice to get him moving. Once he is moving, inertia will keep him moving.
- 9
  - a The action force is from Pat's arm on the ball.
  - b It accelerated the ball from rest to a high speed.
  - c The ball pushed Pat back.
  - d It slowed her throw and provided stress on her muscles and joints.
- 10
  - a Thrust = weight of rocket: on launchpad, 'hovering', no movement.
  - b Thrust > weight of rocket: launching, accelerating.
  - c Thrust < weight of rocket: before launch, sitting on launch pad (or something's gone horribly wrong!).
  - d Thrust = 0: no flames, well before launch.
- 11 As fuel is consumed, the mass of the rocket gets less. The thrust force is still the same, though. Acceleration therefore increases.
- 12 The mass of a rocket will decrease when used fuel tanks are discarded. The thrust now pushes a much lighter rocket, so it will accelerate even faster and reach higher speeds.
- 13 Diagrammatic answers required.
- 14 Diagrammatic answers required.
- 15 Diagrammatic answer required.

## Unit 5.6 Gravity

- 1 Gravity is the rate of acceleration at which objects fall.
- 2 Symbol:  $g$   
 Unit: metres per second squared (gravity is acceleration)  
 Unit abbreviation:  $\text{m/s}^2$  or  $\text{ms}^{-2}$

- 3 On the Earth's surface the acceleration of all objects is  $9.8 \text{ m/s}^2$ .
- 4 An object pushes air out of its way as it falls. The air pushes back with an equal, upward force called air resistance.
- 5 The force that is caused by gravity is called weight.
- 6  $\text{Weight} = \text{mass} \times \text{acceleration due to gravity}$ ;  $w = mg$
- 7 An object falls at constant speed when the speed of falling is balanced by air resistance. This is known as terminal velocity.
- 8 Terminal velocity depends upon the shape and size of an object.
- 9
  - a Heavier objects fall at the same rate as light ones, unless air resistance is significant.
  - b There is no air in a vacuum and therefore no air resistance.
  - c Mass is constant regardless of which planet you are on.
  - d Weight is measured in newtons, *or* mass is measured in kilograms.
  - e You would feel weightless in a falling lift.
- 10 *Weight* is the force due to the gravitational attraction of the nearby planet or star. It changes with gravity;  $w = mg$ . *Mass* never changes, because it measures the amount of matter in an object.
- 11 There is no air resistance when there is no air, e.g. on the surface of the Moon.
- 12 Air would rip off the fragile solar panels and antennae of a spacecraft as it travels through the atmosphere. In space there is no atmosphere and so there is no force to rip them off.
- 13 A hammer and a feather would fall at the same rate on the Moon because there is no air and therefore no air resistance.
- 14 The terminal velocity of a pumpkin and skydivers is about the same. They will fall at the same rate and will be level with each other at each stage. Once the chutes are open, however, the skydivers will fall at  $5 \text{ m/s}$ , whereas the pumpkin will fall much faster, at  $50 \text{ m/s}$ .
- 15
  - a A force of  $8 \text{ g}$  means that a human is experiencing a force eight times that of their normal weight.
  - b They will feel eight times heavier. Blackouts could result.
- 16 g-forces on a human can be increased or decreased due to the effects of inertia.
  - a They could be increased when driving, for example, by going through a dip, in a turn or when stopping.
  - b They could be decreased by going over a hump.
- 17 We can only be truly weightless in deep space where there is no gravity.
- 18 Occupants of the space shuttle appear weightless in orbit because both they and the shuttle are dropping at the same rate due to gravity.
- 19
  - a B
  - b C
  - c A
- 20 Diagrammatic answer required.
- 21
  - a  $w = mg = 55 \times 9.8 = 539 \text{ N}$
  - b  $w = mg = 55 \times 1.63 = 89.7 \text{ N}$

- c  $w = mg = 55 \times 3.7 = 203.5 \text{ N}$
- 22 a Angelo's mass on Planet X would still be 70 kg.  
 b  $w = mg$  so  $g = w/m = 350/70 = 5 \text{ m/s}^2$ .  
 c Planet X has a smaller gravity than Earth and so is probably smaller than it.

## Unit 5.7 Work and energy

- 1 Energy is the ability to do work.
- 2 Work done equals the force applied to an object times the distance it moves.
- 3 Force,  $F$ , is always measured in newtons (N) and distance,  $s$ , in metres (m). Work,  $W$ , is a form of energy and, like all energy, is measured in joules, abbreviated as J.
- 4 When something moves, it has kinetic energy.
- 5 Kinetic energy equals half the mass of an object times its speed squared.  
 $KE = \frac{1}{2}mv^2$
- 6 Kinetic energy is measured in joules (J), mass in kilograms (kg) and speed in metres per second (m/s).
- 7 Potential energy is stored energy. It gives the object the potential to do work.
- 8 Gravitational potential energy equals mass times acceleration due to gravity times height.  $GPE = mgh$
- 9 GPE is measured in joules (J);  $m$  in kilograms (kg);  $h$  in metres (m); and  $g$  is measured in metres per second squared ( $\text{m/s}^2$ ).
- 10 Potential to do work is stored in the elasticity of an object.
- 11 Elastic bands and springs store energy when they are stretched or extended.
- 12 Elastic potential energy equals half the spring constant times extension squared.  
 $EPE = \frac{1}{2}kx^2$
- 13 Here,  $x$  is the extension or compression of the elastic band or spring (measured in metres) and  $k$  is its spring constant (in newtons per metre, N/m).
- 14 Friction between moving surfaces wastes useful energy, converting some of it into heat and sound.
- 15 Efficiency is a measure of how much useful energy is retained in a conversion.
- 16  $\text{efficiency} = \text{useful energy after the conversion} / \text{energy before the conversion} \times 100\%$
- 17 C and E both require no force to do what they are doing. Inertia controls their actions. Both do not involve work being done.
- 18 a Kinetic energy = 'moving' energy  
 b Gravitational potential energy = 'height' energy  
 c Elastic potential energy = 'spring' energy  
 d Work done = 'rearranging' energy
- 19 If speed is doubled, then the kinetic energy has been increased by a factor of four. The energy that needs to be used up as heat and work done is therefore four times what it was. The accident will be four times as dangerous.



- 20** If crumple zones were not incorporated into the front and rear of cars, the kinetic energy would be converted into work done on the occupants and not the car itself. The occupants would be more likely to sustain injury. Some of the energy would still be used up as heat and sound.
- 21** If a tennis ball was 100% efficient, all the energy that was stored in the rubber on bouncing would be released back as kinetic energy, which would enable the ball to reach its old height. No heat or sound would be produced.
- 22** Each time a ball bounces, energy is wasted as heat and sound.
- 23** A slingshot that is stretched double the distance does roughly four times the damage because it stores four times the amount of energy.
- 24** Stiffest to least stiff: D, C, A, B.
- 25** combination 1 (at left) – graph B; combination 2 – graph C; combination 3 – graph A; combination 4 – graph D
- 26** a  $W = Fx = 7 \times 2 = 14 \text{ J}$   
 b  $W = Fx = 20 \times 0.5 = 10 \text{ J}$
- 27** a  $KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 400 \times 25^2 = 125\,000 \text{ J}$   
 b  $KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 50 \times 9^2 = 2025 \text{ J}$   
 c  $KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.02 \times 2^2 = 0.04 \text{ J}$   
 d  $KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.03 \times 0.05^2 = 3.75 \times 10^{-5} \text{ J}$
- 28** a  $GPE = mgh = 60 \times 9.8 \times 11 = 6468 \text{ J}$   
 b  $GPE = mgh = 2.5 \times 9.8 \times 0.7 = 17.15 \text{ J}$   
 c  $GPE = mgh = 65 \times 9.8 \times 250 = 159\,250 \text{ J}$   
 d  $GPE = mgh = 55 \times 9.8 \times 9500 = 5\,120\,500 \text{ J}$
- 29** a  $GPE = mgh = 50 \times 9.8 \times 10 = 4900 \text{ J}$   
 b This energy came from her climbing the stairs to the top. It came from her own stored chemical energy that she has gained from food.  
 c When she dives, the potential energy is converted into kinetic energy (i.e. speed).  
 d The proof of this conversion is that she is travelling very fast when she strikes the water.  
 e Nearly all of her gravitational energy (minus a little heat and sound) would have been converted into kinetic energy. Therefore roughly 4900 J would be expected to convert into kinetic energy.  
 f She retains some of her kinetic energy as she enters the water. She shifts a lot of water around (splashes, etc.). Work is being done on the water. Some heat and sound are generated.
- 30** a Before the bounce  $GPE = mgh = 0.03 \times 9.8 \times 2 = 0.588 \text{ J}$   
 After the bounce  $GPE = mgh = 0.03 \times 9.8 \times 1.5 = 0.441 \text{ J}$   
 b Efficiency =  $0.441/0.588 \times 100\% = 75\%$ .
- 31**  $EPE = \frac{1}{2}kx^2 = \frac{1}{2} \times 6 \times 0.1^2 = 0.03 \text{ J}$ ;  $EPE = \frac{1}{2}kx^2 = \frac{1}{2} \times 6 \times 0.2^2 = 0.12 \text{ J}$  (four times the previous energy)
- 32** a  $EPE = \frac{1}{2}kx^2 = \frac{1}{2} \times 5 \times 3^2 = 22.5 \text{ J}$

- b  $EPE = \frac{1}{2} kx^2 = \frac{1}{2} \times 25 \times 0.5^2 = 3.1 \text{ J}$   
 c Extension =  $90 - 15 = 75 \text{ cm} = 0.75 \text{ m}$ ;  $EPE = \frac{1}{2} kx^2 = \frac{1}{2} \times 30 \times 0.75^2 = 8.4 \text{ J}$   
 d Extension =  $4 - 0.15 = 3.85 \text{ m}$ ;  $EPE = \frac{1}{2} kx^2 = \frac{1}{2} \times 30 \times 3.85^2 = 222.3 \text{ J}$

## Chapter review

- 1
  - a Energy, J
  - b Displacement, m
  - c Time, s
  - d Velocity, m/s
  - e Acceleration,  $\text{m/s}^2$
  - f Force, N
  - g Work done, J
- 2
  - a Distance,  $x$
  - b Speed,  $v$
  - c Acceleration,  $a$
  - d Force,  $F$
  - e Mass,  $m$
- 3
  - a *Instantaneous* speed is the speed at any particular instant. *Average* speed ignores the actual instantaneous speeds, averaging them out into one number.
  - b *Mass* is the amount of matter in an object. It never changes. *Weight* is a force that depends on mass and gravity:  $w = mg$ .
  - c *Work* provides the ability to exert a *force*.
- 4 During 'reaction time' a driver detects the emergency, processes the information and possible solutions, and moves their arms and legs to take action. In the 'braking time' the driver is applying the brakes. There is little the driver can do now except steer the car, because the stopping distance will now depend on the car and road surface.
- 5 Examples of inertia could come from car accidents, or movement in cars and buses.
- 6 For work to have been done, a force needs to have been applied and the object must have been shifted or rearranged.
- 7 *Newton's First Law*: An object will stay at rest unless acted on by a force. A moving object will keep moving at the same speed and direction unless acted on by a force.  
*Newton's Second Law*:  $F = ma$ , i.e. force causes acceleration.  
*Newton's Third Law*: For every action force there is an equal and opposite reaction force.
- 8
  - a Newton's Third Law (action/reaction)
  - b Newton's First Law (inertia)
  - c Newton's Third Law (action/reaction)
  - d Newton's First Law and Third Law (inertia and action/reaction)
  - e Newton Second Law and Third Law ( $F = ma$  and action/reaction)
  - f Newton's Third Law (action/reaction)

9

Distance travelled	Time taken	Speed
20 m	5 s	4 m/s
480 km	6 h	80 km/h
1000 km	10 h	100 km/h
2.5 cm	0.5 s	5 cm/s
7.0 m	0.2 s	35 m/s

- 10 a At rest or stationary, C  
 b Moving at constant speed, B (C is also acceptable because it is a constant zero speed)  
 c Accelerating, A  
 d Decelerating, D
- 11 The statement is a bit of both. If two objects have similar shapes then they can be expected to fall at the same rate because their air resistance is the same. However, if their shapes are very different, so will be the air resistance on them. They can then be expected to fall at different rates. The statement is definitely true for all objects, regardless of shape, that fall in a vacuum, where there is no air resistance.
- 12 Luggage, shopping etc. will keep moving in an accident. In a sedan, all this will stay within the boot. In a station wagon, the contents will be able to move forward in the car and hit the occupants.
- 13 The hard ground forces us to stop in a short time. The deceleration,  $a$ , is high and so will be the impact force,  $F$ . A spongy mat will decrease  $a$  and  $F$ .
- 14 Dashboards are padded to increase the time it takes to stop in a collision. Deceleration will be reduced and the impact force will be less than if we strike a metal dash.
- 15 Doubling the speed gives us four times the kinetic energy.
- 16 A car's kinetic energy is converted mainly into work on the panels. Heat and sound are also produced.
- 17 Squash balls do not store all the energy of the bounce in their change of shape. A lot of it is converted into heat that warms the ball. The stored energy is released back as kinetic energy, allowing it to bounce again. The amount of kinetic energy is less than before, however, and the bounce will not be as high.
- 18 Distance =  $3 + 3 = 6$  m; displacement = 0 (no direction needed because it is zero)
- 19 Distance =  $3 + 3 + 1 = 7$  m; displacement = 1 m below hand level
- 20 Distance =  $20.1 + 0.5 = 20.6$  m, time = 0.83 s; average speed =  $x/t = 24.8$  m/s = 89.3 km/h

21

Starting speed	Accelerated for this time	Rate of acceleration	Final speed
0	5 s	15 m/s <sup>2</sup>	75 m/s
0	12 s	4 m/s <sup>2</sup>	48 m/s
18 m/s	6 s	2 m/s <sup>2</sup>	30 m/s
40 km/h	5 s	5 km/h/s	65 km/h
20 m/s	Half minute	3 m/s <sup>2</sup>	110 m/s

22 Diagrammatic answers required.

23 Diagrammatic answers required.

## Unit 6.1 Health

- 1 Good health means you have a sense of wellbeing and can function effectively in a given environment.
- 2 Three things needed for good health are **good nutrition**, a healthy **mind** and adequate **exercise**. A **balanced** diet is essential to good health. Animals must take in **nutrients** to survive. Energy-giving **nutrients** can be either **fats**, **carbohydrates** or **proteins**.
- 3 A nutrient is a substance taken in by an organism and used as a source of energy or to build living tissue.
- 4 *Psychosomatic*: caused by the mind.  
*Nutrient*: substance taken in and used for energy or to build tissue.  
*Organism*: any plant or animal.  
*Calcium*: a mineral used by the body.
- 5 37°C
- 6 Various, e.g. calcium in bones.
- 7 Various, e.g. vitamin C helps repair damaged tissues.
- 8 Choose from: plants, seeds, nuts, fruits, witchetty grubs, birds, fish, kangaroos.
- 9 The traditional food was low in fat and sugars (low in kilojoules), but high in carbohydrates, fibre, protein and nutrients.
- 10 Flour, sugar and processed meat
- 11 Protein, vitamins and minerals
- 12 a False  
b True  
c False  
d True
- 13 It is approximately equivalent to a small rubbish bin full of water.
- 14 'Health' is relative because it depends on where you are and your environment.
- 15 Teenage boys would, in general, be growing at a faster rate than teenage girls and may also be more active. One or both factors would require a higher energy demand. So teenage boys would most likely need to eat more.
- 16 In order from most to least: elite athlete, active teenage boy, postman, secretary, baby.
- 17 Various answers, e.g. anger might increase blood pressure; depression might affect immunity.
- 18 In an environment with reduced gravity there is less weight-bearing exercise, so muscle fibres would break down.
- 19 Various answers
- 20 Various answers

- 21 The traditional diet was low in fat and sugars (low in kilojoules), but high in carbohydrates, fibre, protein and nutrients. The hunter-gatherer lifestyle also gave Aborigines plenty of exercise.
- 22 Various answers
- 23 Various answers
- 24
  - a Aborigines were made to work in European ways, so they could not continue their hunter-gatherer lifestyle. Easy access to European foods meant that there was less need to collect their own foods. Pressure to conform meant that Aboriginal lifestyles were not supported.
  - b Various answers such as education programs, discounted fresh foods for Aborigines, support groups.
- 25
  - a Various answers
  - b Answer depends on student's interpretation.

## Unit 6.2 Disease

- 1 Disease is anything that makes you feel unwell or unable to function properly in a given environment.
- 2 Various answers, e.g. flu: fever, tiredness, aching, etc.
- 3 *Symptom*: outward sign of disease  
*Pathology*: study of disease  
*Microbe*: very small organism  
*Agent*: causes disease  
*Host*: organism being affected by agent  
*Parasite*: agent using host for food or shelter  
*Infectious*: can be passed on to another host
- 4 Forensic pathologists determine the cause of an individual's death.
- 5 *Endemic* means that a disease is constantly affecting a small number of people in the population. An *epidemic* is when there are higher than normal numbers of people being affected by a particular disease in a certain place.
- 6
  - a Infectious: bacteria, viruses, protozoa and fungi, parasites
  - b Lifestyle-related: malfunction, environment-related, caused by drug abuse, alcohol, smoking
  - c Built into the body: genetic disorders, malfunction
- 7
  - a *Micro-organism*: an organism that is only visible through a microscope
  - b *Infectious disease*: a disease that is easily passed on to another host
  - c *Parasite*: an agent that uses the host for food or shelter
- 8 Smallpox, influenza, tuberculosis, syphilis
- 9 Aborigines had no resistance and no traditional remedies, because they had never encountered these diseases before.
- 10 Obesity, cardiovascular disease, diabetes, high blood pressure, certain cancers, and stroke.

- 11 When more people than usual are affected by a particular disease in a certain place over a period of time, it is called an *epidemic*. A common term for a disease suddenly getting out of control is an *outbreak*.
- 12 Examples of answers: They are easily transported and breathed in. They can travel in the air and remain unseen, so the host does not know they are even carrying a disease.
- 13 Coughing without covering one's mouth, sneezing without covering one's nose and mouth, spitting, not washing one's hands after going to the toilet or before preparing food, kissing, sexual intercourse, etc.
- 14 Various answers
- 15
  - a Diseased people do not function well in their environments.
  - b A parasite uses a host for food or shelter.
  - c Not all diseases are infectious.
  - d Symptoms like blurred vision can be signs of disease.
- 16 A non-infectious disease is a disease that is not caused by a pathogen. Examples are genetic disorders and diseases caused by lifestyle factors.

### Unit 6.3 Infectious diseases

- 1 Various, e.g. they can help digestion in the intestines.
- 2 A pathogen is a disease-causing micro-organism.
- 3 Bacteria, viruses, protozoa, fungi
- 4 Cocci, rods, spiral forms
- 5 *Yersinia pestis*
- 6
  - a Rabies: paralysis, spasms, fever, overproduction of saliva
  - b Giardia: fever, chills, rash, exhaustion
- 7 Viruses get inside cells and reprogram them to make more viruses.
- 8 Viruses do not reproduce, grow, feed or move.
- 9 A protozoa is a single-celled animal.
- 10 An opportunistic pathogen attacks when conditions are ideal.
- 11 A macroscopic parasite can be seen with the naked eye.
- 12 Various answers, e.g. intestinal fluke, live fluke, tapeworm.
- 13 The tapeworm eats the nutrients ingested by the host.
- 14 The cysts produced by the hydatids can kill.
- 15 *Macroscopic* means visible to the naked eye; *microscopic* means can only be seen through a microscope.
- 16 To get an accurate diagnosis, as many diseases have common symptoms.
- 17 *Endemic* means a small number of cases are always present in the population; *epidemic* means an unusual number of cases are present.
- 18 Pandemic is the spread of a disease throughout a whole country, continent or the whole world.
- 19
  - a Spherical bacteria are called cocci.

- b Viruses are smaller than bacteria.
  - c Fungi rarely cause disease in humans.
  - d Parasites rarely kill their hosts.
- 20 Diagrammatic answer required.
- 21 Various answers, e.g. not many fungi affect humans. Fungi are easily kept out of human bodies by our natural defences. Most fungi break down dead organic matter and do not live on live organic matter such as humans.
- 22 Washing removes disease-causing microbes.
- 23 They form coverings around themselves.
- 24 Various answers, e.g. Villagers don't travel far from their villages. The disease kills quickly before villagers can spread it to another area.
- 25 a Various answers, e.g. Amazon or northern Queensland  
b There are more mosquitoes in these areas.
- 26 Various answers, e.g. Use mosquito repellent and take anti-malarial medication.
- 27 Various answers, e.g. Cook food thoroughly, wash hands, avoid contaminated water.
- 28 Various answers
- 29 Diagrammatic answer required.

## Unit 6.4 Transmission and control of infectious diseases

### Case study: AIDS

- 1 HIV: human immunodeficiency virus; AIDS: acquired immune deficiency syndrome
- 2 1959 in Zaire
- 3 By contact with bodily fluids like semen and blood.
- 4 Night sweats, fever, lymph node swelling, fatigue, weight loss
- 5 HIV+ means that you have contracted the virus and carry it in your blood. It does not mean you have AIDS. HIV is diagnosed by a blood test.
- 6 Don't have unprotected sex; don't use dirty needles.
- 7 Poor hygiene, lack of contraception, lack of good health services and education about disease.
- 8 With high rates of death, poor availability of medication and treatments, there are many effects on families and communities, with problems including family members dying, fewer people to grow foods and do daily work, more sick to look after, fear of getting sick, lack of hope for the future, etc.
- 9 Secondary infections cause illness that the body cannot fight off. It is these secondary infections, such as pneumonia, that kill people with AIDS.
- 10 There is hope for a vaccine if scientists can use a part of the virus that will not mutate to cause the body to produce antibodies. This has been tricky so far but given enough research, money and time it may happen in the future. If AIDS mutates again then any antibody produced may become useless.



- 11 I would evaluate AIDS as a very effective disease. It is effective as it is easily spread, can stay dormant and be carried for long periods of time. It attacks the immune system, which is supposed to protect us from disease, making us vulnerable to other infections. It avoids control because people do not take proper precautions, and many countries do not have good health systems to help educate people and control AIDS. We do not have good drugs against viruses, and it takes a very long time to develop treatments. AIDS could easily mutate into new forms that make it even harder to control.

## Unit 6.4 Questions

- 1 Direct transmission of disease comes about by direct contact with the infected person or by contact with droplets of body fluid.
- 2 Contagious diseases
- 3 The mosquito is the vector that carries the disease malaria.
- 4 Skin is a physical barrier stopping microbes from getting into our body. It can shed bad microbes with dead skin.
- 5 Leucocytes travel to the site of infection via the bloodstream, where they can surround microbes and digest them.
- 6 Pus is dead micro-organisms and white cells.
- 7 *Antigen* means foreign substance; *antibody* means chemicals that act against antigens.
- 8 When a foreign substance is present in the body, it stimulates the production of antibodies.
- 9 Antibodies are part of a group of chemicals called immunoglobulins. Once your body has produced an antibody it will keep producing it for a period of time. Your body is immune as long as those antibodies are present.
- 10 Diagrammatic answer required.
- 11 A serum containing a live strain of a disease is injected into a person in order to stimulate the production of antibodies ready to fight the disease if exposed.
- 12 Because the virus is *inside* the host's cells.
- 13 Overuse of antibiotics makes it more likely that antibiotic-resistant strains of bacteria will develop.
- 14 **a** Leucocytes  
**b** Infection  
**c** Inoculated, vaccine, immunity  
**d** Antibodies
- 15 In *active* immunity the body is stimulated to make its own antibodies by injecting a live but disabled version of the virus or bacteria. In *passive* immunity the body is injected with antibodies previously produced by another organism.
- 16 Active immunity is more effective than passive immunity as it lasts longer. However, even active immunity does not last forever. Booster shots may be needed

after a period of time as some antibodies stop being produced or are produced in quantities too small to give immunity.

- 17 Measles antibodies keep being produced throughout life.
- 18 Each year there are new strains of a virus with cold-like symptoms. Each virus is different, so immunity is not possible for every new virus.
- 19 Sometimes antibodies work against similar antigens, not just one kind.
- 20 A microbe is entering the body and multiplying, and the body's immune system is responding by producing antibodies.

## Unit 6.5 Non-infectious diseases

- 1 The genetic code on the chromosomes is faulty.
- 2 Through mutations
- 3 Radiation, drugs, chemicals and some viruses
- 4 Haemophilia, Down syndrome
- 5 Malnutrition, eating disorders, diabetes, obesity
- 6 Various, e.g. high blood pressure, joint problems
- 7 Glucose is not used correctly due to a lack of the hormone insulin.
- 8 Poor diet, smoking, lack of regular exercise
- 9
  - a *Thrombosis*: disease-causing mass in blood vessel
  - b *Embolism*: blockage of blood vessel
  - c *Hypertension*: persistent high blood pressure
  - d *Arteriosclerosis*: hardening of the arteries
- 10 Various, e.g. not smoke, low-fat diet, exercise
- 11
  - a An embolism in the brain can cause a stroke.
  - b A thrombosis in the legs can move out of the legs to the lungs, heart or brain, and cause a fatal blockage.
- 12 Cigarette smoking (lung cancer), exposure to the sun (skin cancer), poor diet (bowel cancer), and exposure to certain chemicals (carcinogens).
- 13 Surgery, radiotherapy (using radiation to kill localised growths) and chemotherapy (using chemicals).
- 14 Metastases make it difficult to treat cancer, because when there are cancer growths in many different places in the body it is hard to know exactly where the growths are, and some parts of the body are difficult to treat – e.g. the brain, the liver.
- 15 A drug is any substance which has the ability to alter a person's body chemistry.
- 16 A psychoactive active drug alters one's mood. Various examples, e.g. speed causes agitation and excited speech.
- 17 Various answers
- 18 Various answers, e.g. positive effects could be a sense of warmth, wellbeing and loss of inhibitions. Negative effects could be embarrassment from loss of inhibitions, vomiting, liver damage.
- 19 Above levels of 0.60% alcohol causes death through heart and respiratory failure.

- 20 Malnutrition and vitamin deficiencies; liver is slowly destroyed by cirrhosis; brain cells are destroyed.
- 21 Withdrawal symptoms include intense craving, anxiety, sweating, depression, sleep problems and difficulty concentrating.
- 22 Various answers, e.g. cough, bad breath, premature aging.
- 23 Various answers, e.g. radiation causes cancer, heavy metals may cause neurological damage or foetal damage, other chemicals may cause cancer.
- 24 Schizophrenia, depression, bipolar disorder
- 25 Haemophilia is an inherited genetic disorder, whereas Down syndrome is not usually inherited, as its risk increases with maternal age.
- 26 A benign tumour is not lethal, whereas a malignant tumour is cancerous and fatal if it leads to metastases.
- 27
  - a False
  - b False
  - c True
  - d False
  - e True
- 28 Drug *use* implies a beneficial effect, whereas drug *abuse* produces negative effects.
- 29 Various, e.g. insecurity, peer-group pressure
- 30 There is a need to weigh up short-term pleasurable feelings of closeness to others and its stimulant effect with the possibility of permanent brain damage. In the short-term there is also the risk of death due to increased body temperature.
- 31 Various answers are possible, identifying issues for and against this change e.g. *for* – reduction in road deaths and other car accidents; *against* – criminal record seems harsh, but then so is killing a best mate.
- 32 Various, e.g. there is a stigma attached.
- 33 Various, e.g. lung cancer, skin cancer, diabetes, heart disease.
- 34 Diagrammatic answer required.

## Chapter review

- 1 *Health* means wellbeing and that a person can function in their environment; *disease* is the opposite.
- 2 Fats, carbohydrates, proteins, vitamins, minerals
- 3 Various, e.g. anorexia nervosa
- 4 Various, e.g. flu: runny nose, chills, muscle pain
- 5 Virulence is a measure of how much damage a disease does to the host.
- 6 A pathogen is a disease-causing microbe, e.g. *Yersinia pestis* causes plague.
- 7 Bacteria, fungi, protozoa, viruses
- 8 Leucocytes (white blood cells), antibodies, antigens, skin
- 9 Vaccinations, antibiotics, healthy eating, good hygiene etc.
- 10
  - a Chromosomes carry genes.

- b A mutation is a mistake in the genetic code.
- c It can be inherited, caused by radiation, chemicals, or be of unknown origin.
- 11 Thrombosis, hypertension, arteriosclerosis, varicose veins, coronary heart disease, angina, heart attack
- 12 *Benign* tumours do not lead to death, whereas *malignant* tumours often result in death unless completely removed surgically.
- 13 Metastasis is when cancer spreads from the original site to other parts of the body. It is dangerous because it means the cancer will be very difficult to control.
- 14 Respiratory problems, depression, memory problems and reduced levels of sex hormones
- 15 Lead, mercury, thallium, bismuth
- 16 Foetal deformities, mental impairment in children
- 17 The study of disease is called *pathology*. A plant or an animal is an *organism*. A very small *organism* is called a *micro-organism*. An *agent* causes disease. Parasites use a *host* for food and *shelter*. *Virulence* is a measure of how much a disease damages the host. Another name for an epidemic is an *outbreak*.
- 18 To find the cause of death, so a death certificate can be signed, and also to determine whether cause of death was natural or due to suspicious circumstances.
- 19 a Various, e.g. stay out of the water  
b Various, e.g. wear a mask, quarantine the area
- 20 They have protective capsules around them and remain inactive until conditions are suitable.
- 21 They attack only when conditions are ideal but are normally harmless.
- 22 Vaccinations can produce natural immunity by stimulating the body to make its own antibodies against diseases (active immunity), or they can produce passive immunity by providing the body with antibodies that were produced by another organism.
- 23 The people shown are well-dressed, well-nourished, and seem to have a sense of purpose in life. These are elements of good health.
- 24 The people running and the rugby players would be getting health benefits from being active. Actively engaging in sport strengthens body, mind and spirit. However, the rugby players are at risk of injury from the rough game. The runners would need to be sensible about how far they run, and drink adequately while running, etc.
- 25 High temperature
- 26 a *Vibrio cholerae*  
b *Candida albicans*  
c *Clostridium botulinum*
- 27 Host = rat, vector = flea
- 28 Live, less-virulent strain; dead organisms; antibodies produced in another organism
- 29 Diagrammatic answer required.

## Unit 7.1 The evolution of a theory

- 1 An adaptation is an inherited characteristic which aids the survival of an organism, e.g. the colouration of an animal which allows it to blend with the background, thus avoiding predators.
- 2 Various answers, e.g.:
  - a The long neck of a giraffe allows it to avoid competition for grass.
  - b Desert animals which burrow to avoid the heat of the day.
- 3 Individuals have genetic differences (different genes and chromosomes inherited from parents; also mutations occur) and environmental differences (individuals develop different characteristics throughout their lifetime as a result of different activities, e.g. muscle development in a weight-lifter).
- 4 A theory is a collection of hypotheses which have been tested and consistently supported by available evidence. A theory is constantly subject to scrutiny, re-evaluation and change.
- 5 The theory of evolution is based on current scientific observations and evidence. It can be re-evaluated if further scientific evidence becomes available. It can only ever be a theory because it deals with events that happen over huge time periods, so we can't observe these events directly.
- 6 A creationist view considers that the world and everything in it was made by supernatural means, by a god or gods.
- 7 Creation accounts can be factual accounts of what happened or symbolic stories about relationships between gods, humans and the world around them.
- 8 Various answers. Giraffe's neck example: Giraffes stretched their necks to reach food high in the trees. This acquired characteristic (a longer neck) was passed on, so that offspring inherited the characteristic of a longer neck. This is not true, as we have been observing giraffes for long periods of time in zoos and their necks do not keep getting longer if we put food higher. Changes in body cells (acquired characteristics) cannot be passed from parents to offspring. For example, weight-lifters do not produce children with stronger muscles.
- 9 The 14 species were created separately, or the 14 species radiated from a common ancestor.
- 10
  - a Darwin *was not* the first to think of the idea of evolution.
  - b Darwin was the first to explain how evolution occurred by *natural selection*.
  - c Darwin believed that the evolutionary process involved *inherited* characteristics being passed on to offspring.
  - d Darwin published his theory *many years after* he returned from his five-year voyage on HMS *Beagle*.
- 11 Presentation of a paper by Wallace on evolution by natural selection prompted Darwin to present his own theory in 1858.
- 12 Neo-Darwinism is a restatement of Darwin's theory in terms of modern genetics.
- 13 Dark ocean caves. The red bristles act as extensions of sensory organs.

- 14 Large ears radiate heat. Large ears also allow better hearing for these primarily nocturnal animals.
- 15 The colours and displays are used to attract females for mating. The most colourful and spectacular males are successful, and therefore they produce the most offspring. These offspring inherit the father's colourful characteristics.

16

<b>Adaptation</b>	<b>Survival value</b>	<b>Habitat</b>
Body colour that blends with the background	Avoidance of predators	Any
Production of small volumes of concentrated urine	Enables waste removal with minimal water loss	Saltwater
Hooks and suckers on the head end of the organism	Avoids dislodgment by moving fluids	Intestines of a sheep
Broad, flat, bright green leaves	Maximum absorption of sunlight	Rainforest
Live underground by day, and are active at night	Avoidance of the hottest parts of the day	Desert

- 17 b, d, e (Note: Some resistance to bacterial infection could be acquired following initial infection and development of antibodies to the infective agent.)
- 18 Life on Earth has changed over time. Different species have gradually developed from common ancestors.
- 19 Those individuals with the least-favourable characteristics (those least adapted to their environment or those with the least genetic variation) do not survive long enough to reproduce. Organisms that are best adapted do survive to reproduce, and so their characteristics (genetic material) are passed on to the next generation.
- 20 The series of sketches should match the ideas shown in Fig 7.1.11.
- 21 Religious leaders objected to the suggestion/implication that humans had evolved from apes. They believed that humans were made in the image of God, and therefore could not have evolved from animals.
- 22 a Differences in genes and chromosomes; differences due to genetic mutation  
b Darwin had no knowledge of DNA or inheritance. These discoveries were made later.

## Unit 7.2 Evolution unravelled

- 1 Natural selection is the process in which the environment 'selects' favourable characteristics, thereby reducing the frequency of unfavourable characteristics.
- 2 A species will become better adapted to its environment.
- 3 a Natural variation refers to differences between individuals in a species. For example, some moths are light, some dark.

- b** In natural selection the environment ‘selects’ favourable characteristics (dark moths on dark trees). The individuals with these characteristics survive (dark moths survived, light moths were eaten), and pass on the characteristics to their offspring. In time, the proportion of individuals with these characteristics increases (by 1890, 95% of moths were dark colour).
- 4** The virus can multiply only within a live rabbit. The less virulent strain allows the rabbit to live longer, enabling more viruses to be produced. Since this is advantageous to the virus, the less virulent strain was ‘selected for’.
- 5** Mosquitos becoming resistant to chemical pesticides; antibiotic resistance
- 6** Different environments mean different characteristics will be ‘selected for’. Different mutations will occur in each population, giving rise to different variants in the two populations.
- 7** Geographic isolation, natural selection, formation of a subspecies, reproductive isolation, further natural selection, formation of a species
- 8** Various answers: continental drift, volcanic eruption, earthquakes.
- 9** They are different species when they are reproductively isolated—when they can no longer interbreed, even when placed together.
- 10** Divergent evolution, convergent evolution, parallel evolution
- 11** Divergent evolution is the process in which many new forms evolve from a single ancestor.
- 12** There must be new environments for the evolving species to inhabit.
- 13** As ancestral organisms evolved in different environments they took on new forms to suit those environments. For example, the pentadactyl limb of mammals has radiated to flippers, legs, wings, etc. Australia’s marsupials have radiated to possums, kangaroos, wombats, etc.
- 14** Analogous structures are structures which look similar but are the result of different ancestral backgrounds, e.g. the membrane in Australia’s gliding possum (a marsupial), and that in an American flying squirrel (a placental).
- 15** Parallel evolution is the process in which related species evolve similar features while separated from each other. For example, the prehensile tails of Old and New World monkeys have adapted to their environments.
- 16** Virulence is the ability of a disease to kill.
- 17** Some bacteria have a gene for antibiotic resistance. These bacteria survive the initial antibiotic treatment. Their offspring inherit the resistance. After several generations, most of the surviving bacteria carry the gene for resistance.
- 18** The gene may have originated by a mutation of a gene or chromosome section.
- 19** Artificial selection is very controlled in the selection of individuals to be mated. Only carefully chosen individuals with the desired characteristics are mated to give the required features in the offspring. Natural selection works on populations where this kind of rigorous selection of parents does not take place. Mixing of characteristics in nature is a fairly random process.
- 20** In *convergent* evolution, the organisms have different ancestors and evolve to become similar to each other. In *divergent* evolution, the organisms have common ancestry and evolve to become less similar, with new forms developing as a result of

different environments. In *parallel* evolution, related species evolve in a similar way while remaining separate from each other.

- 21 Species living in conditions of little change, i.e. in a stable environment.
- 22
  - a Convergent
  - b In similar habitats the same types of characteristics are 'selected for'. The anteater and armadillo both 'hunt' ants and termites, so have similar structures for this purpose.
- 23 The lichen-covered tree will select for the light moth, because light moths will be better hidden from predators and so are more likely to survive and reproduce. The blackened tree will select for the dark moth in the same way.
- 24 Various answers
- 25 Various answers

### Unit 7.3 Evidence for evolution

- 1 Palaeontology is the study of fossils.
- 2
  - a A fossil is preserved evidence of past life, usually found in sedimentary rocks.
  - b Various answers: actual organisms like mammoths frozen in ice, hard parts of organisms like a skull.

3

<b>Era</b>	<b>Time (millions of years ago)</b>
Cenozoic	65–present
Pre-Cambrian	4500–570
Mesozoic	570–248
Palaeozoic	248–65

- 4 Ammonia, methane, hydrogen (and water)
- 5 They have remained unchanged for 400 million years.
- 6 It has reptilian features and feathers (a feature of birds, not reptiles).
- 7 Anatomical studies, embryonic development, biogeography
- 8 Comparisons of the anatomy of various plants and animals provide indirect evidence of their evolution from common ancestors. The pentadactyl limb is an example of this.
- 9
  - a Homologous structures are structures which are fundamentally similar but look different and perform different functions.
  - b They are useful because their similarities suggest a common ancestor.
- 10 Vestigial organs are thought to show ancestry. These structures were functional in ancestors, but have been reduced to a functionless state in the evolutionary process.
- 11 Embryonic stages are thought to reflect the evolutionary history of the organism. Similar embryonic structures suggest a common ancestor.



- 12 DNA and the genetic code provides evidence for evolution as the code is universal. Almost all organisms (except some viruses) use the same basic code. This universality supports the idea that all living things are related and have evolved from common ancestors.
- 13 a Gene duplication occurs when an organism has an extra gene for a particular characteristic.  
b An error in meiosis produces an organism with an extra gene for a particular characteristic.  
c The extra gene could mutate to produce a new feature (such as milk protein in mammals).
- 14 a Chimpanzees  
b Possibly viruses, since their genetic code is different from ours.
- 15 The close match of amino acid sequences in proteins from humans and various apes suggests close ancestry.
- 16 *Analogous* structures come from different ancestral backgrounds. *Homologous* structures come from a common ancestral background. Analogous structures look alike. Homologous structures look different.
- 17 There was no oxygen, a raw material for photosynthesis.
- 18 Stromatolite reefs contain single-celled blue-green algae. The reefs have been dated at 3500 million years old.
- 19 Various answers: organisms must 'fall into' conditions where decay does not occur; geological processes destroy rocks containing fossils.

20

Event	Time (millions of years ago)
Life on Earth begins	3500
First land organisms appear	400
Humans first appear	0.2
Complex cellular structures appear	1500
Dinosaurs become extinct	65
Earth forms	4500
First animals appear	600

- 21 Each day represents approximately 10 million years. Humans appear on the calendar on 31 December. This indicates that it took 10 million years for the first human-like ancestral organisms to appear. Relative to the whole of evolutionary history, the presence of humans is less than one minute.
- 22 Camels migrated from a common point in North America and then underwent independent evolution.
- 23 a The southern continents were once joined to form the supercontinent Gondwana.

- b Following separation of the continents, the plants in different locations evolved differently.
- 24 Use diagrams of the pentadactyl limb to show evidence from a common ancestor.
- 25 Diagrammatic answer required.

## Unit 7.4 Human evolution

- 1 Forward-facing eyes, pentadactyl digits, four upper and four lower incisor teeth, opposable digits, nails on the digits, large brains for their body size, a flexible skeleton
- 2 Prosimians, New World monkeys, Old World monkeys, apes, humans
- 3 Tree-dwelling shrew-like insectivore
- 4 The first true 'human-like' fossils belong to the genus *Australopithecus*.
- 5 Various answers: written communication, and sense of right and wrong.
- 6 Various answers, e.g. development of forward-facing eyes and opposable digits.
- 7 Hominoid refers to the most recently evolved group of primates. It includes the lesser apes (gibbons), great apes (gorillas, chimpanzees and orang-utans) and humans.
- 8 Dryopithecus, Ramapithecus, *Australopithecus afarensis*, *Homo habilis*, Cro-Magnon, Neanderthal man.
- 9 Various answers: increased brain size, bipedalism, flatter faces.
- 10 Cultural evolution is the passing on of stored experience from generation to generation.
- 11 Various answers e.g. use of tools, writing, complex social structures.
- 12 Humans walk upright, have fewer and smaller teeth, flattened faces, a very large skull capacity, and large brain. In addition, they make and use tools, and use various languages to communicate.
- 13 a Bipedalism means walking on two legs.  
b It frees the hands for food gathering. Greater height gives a better view of predators.
- 14 *Homo habilis* means 'handy man' – these humans were able to use tools.  
*Homo erectus* means 'upright man' – they lived in caves and used fire.  
*Homo sapiens* means 'intelligent man' – this species made increasing use of tools, developed modern speech, creativity, written communication and moral reasoning.
- 15 A larger brain means a greater number of neurons, and neural connections, which allows faster processing of information, development of memory, ability to learn, etc.
- 16 Culture is an acquired characteristic. We develop our understanding, memory, etc. during our lifetime. We pass these acquired characteristics to our offspring, as Lamarck's theory proposed.
- 17 Various answers.
- 18 B then C then A. Progressive increase in brain size, reduction in eyebrow ridges, flattening of the face and smaller teeth.

- 19 a *Ramapithecus* is 10 million years younger than *Dryopithecus* and has a larger forehead and back of the head, a smaller jaw, less sharp teeth.  
 b These changes would correspond to increasing brain size and a change to a diet less reliant on hunting.

## Chapter review

- 1 a An adaptation is an inherited structural, functional or behavioural characteristic which aids the survival of an organism.  
 b Various answers, e.g. streamlined shape for easier movement through water
- 2 a Favourable characteristics are those characteristics which enable the individual to survive and reproduce.  
 b The species becomes well adapted to its environment.
- 3 Natural selection, reproductive isolation
- 4 Fossils are ancient remains of living things, so the fossil record makes it possible to trace major changes in the history of life on Earth. Fossil records can show evolutionary change.
- 5 a Homologous structures are structures which are fundamentally similar but look different and perform different functions.  
 b Divergent evolution  
 c Analogous structures are structures which look similar but are the result of different ancestral backgrounds.  
 d Convergent evolution
- 6 Differences in genes and chromosomes, and mutations
- 7 Knowledge of DNA and inheritance explains variation in species. The idea of gene duplication may explain the source of new characteristics.
- 8 a Biogeography is the study of the distribution of organisms both now and in the past.  
 b The ratites evolved independently following their isolation when Gondwana split up. They share common ancestry, but different conditions have led to different characteristics developing.
- 9 Humans walk upright, have fewer and smaller teeth, a flattened face and a very large skull capacity.
- 10 *Homo habilis* and *Homo erectus*
- 11 Cultural evolution
- 12 a Lamarck  
 b Darwin  
 c Darwin  
 d Lamarck
- 13 a Elephants had short trunks. In order to reach food, they stretched their trunks. This characteristic was passed to the offspring. Over the generations, this stretching and inheritance produced long trunks for all elephants.

- b Elephants had a variety of trunk lengths. Those with longer trunks were better able to find food, and therefore survived. They produced offspring with longer trunks. Eventually all surviving elephants had long trunks.
- c Both proposed that species changed in response to environmental factors. Darwin hypothesised that the fittest would survive and be naturally selected, whereas Lamarck hypothesised that change occurred during an individual's struggle to survive.
- 14 iii, v, i, iv, ii
- 15 a Continental drift and an earthquake
- b In different conditions, different characteristics will be 'selected for'. Different mutations would occur, producing variation on which natural selection could act.
- c A change in colour could mean that mates are not recognised. An altered chromosome could make sperm and egg cells incompatible.
- 16 They occurred in the absence of oxygen and with the aid of ultraviolet rays. The Earth's atmosphere now has oxygen, and it screens out much of the ultraviolet light.
- 17 To be preserved as a fossil, the plant or animal's remains must be in conditions that preserve it. Geological processes and human activity can both destroy fossils. Soft tissues are not preserved. Transitional forms that would help complete the fossil record are likely to have formed in small, isolated populations, and these are harder to find evidence of.
- 18 a Gills and the heart structure
- b Through a common ancestry
- 19
- | Term                 | Description   |
|----------------------|---|
| Parallel evolution   | Produces structurally similar, closely related organisms that live in different places. |
| Convergent evolution | Results in structurally similar but unrelated organisms                                 |
| Divergent evolution  | Evolution that results in adaptive radiation  |
- 20 a Birds evolved from reptiles, retaining some of their features.
- b Convergent evolution produces similar features in organisms with similar habitats and lifestyles.
- c Humans and the plant-eating mammals share common ancestors. In humans the appendix has become functionless during the evolutionary process.
- 21 a Increased brain size and use of tools
- b Increased brain size and more upright stance
- c Development of written communication and higher-reasoning powers
- 22 True: a, d, f
- a Adaptations are inherited characteristics.
- b Speciation usually involves geographic isolation followed by reproductive isolation of a population.
- c Charles Darwin was not the first to think of the idea of evolution.
- d DNA testing shows that the species closest to humans is the chimpanzee.

- e The fossil record does not show clearly that all organisms have evolved slowly and gradually.
- f A bat's wing, a seal's flipper and a human arm are all homologous structures.
- g Modern humans evolved from an ape-like ancestor.
- h Most of Darwin's ideas regarding evolution are now thought to be correct.

**23** Creation by supernatural means; an extraterrestrial source; evolution by natural selection

**24**

<b>Fossil name</b>	<b>Classification</b>	<b>Time of appearance (years ago)</b>
Upright man	<i>Homo erectus</i>	1.5 million
Cro-Magnon	<i>Homo sapiens</i>	40 000
Handy man	<i>Homo habilis</i>	2 million
Neanderthal	<i>Homo sapiens</i>	100 000
Lucy	<i>Australopithecus</i>	5 million

**25**

<b>Event</b>	<b>Time</b>
Complex cells first appear	7.00 a.m.
Australopithicines first appear	11.59 p.m.
Dinosaurs become extinct	11.47 p.m.
The Palaeozoic era begins	10.00 p.m.
Land organisms first appear	10.40 p.m.

## Unit 8.1 Global warming

- 1 Carbon dioxide
- 2 Greenhouse gases trap heat within the Earth's atmosphere, helping to keep temperatures suitable to sustain life.
- 3 The Sun's energy reaches the Earth as shorter-wavelength electromagnetic waves. The energy is absorbed by the Earth and re-emitted into the atmosphere as longer-wavelength radiation. This radiation is less able to pass through carbon dioxide and back into space and is therefore trapped within Earth's atmosphere, warming it.
- 4 It would be 30°C colder.
- 5 Gases like carbon dioxide have built up.
- 6 When a thicker layer of greenhouse gases builds up, less heat is able to escape from the Earth and heat builds up, leading to global warming.
- 7 Burning fossil fuels (coal, gas and oil); deforestation
- 8 Greenhouse gases are released when forests burn; the destroyed trees are no longer available to use carbon dioxide in photosynthesis.
- 9 27 billion tonnes per year
- 10 Methane, nitrous oxide, CFCs, surface ozone
- 11 Greenhouse gases can take a long time to leave the atmosphere. For example, carbon dioxide remains in the atmosphere for more than 100 years, while methane, which is twenty times more effective than carbon dioxide at warming the atmosphere, remains for 11 years.
- 12 When the snow falls, air bubbles are trapped in the ice. The deeper you go into the ice, the older the ice is, as each year new snow falls on top. Analysis of these trapped gases reveals the amount of carbon dioxide that was in the past atmosphere.
- 13 Carbon dioxide levels have fluctuated over time, but are now at their highest levels ever.
- 14 The graph in Figure 8.1.6 shows carbon dioxide levels in the Earth's atmosphere for the last 420 000 years. It is normal for the level of carbon dioxide to go up and down, but the amount of carbon dioxide in the atmosphere is now at the highest level ever. Notice that the Earth's temperature changes in line with changes in the amount of carbon dioxide in the air. On the temperature line, the troughs represent the ice ages, when the average temperature was up to six degrees lower than today. The peaks are when warmer periods occurred on Earth.
- 15 C
- 16 Various answers, e.g. more bushfires, drought, cyclones.
- 17 The Pacific Ocean contains warmer water than other oceans. In a normal year, trade winds push this warmer water west towards the east coast of Australia, where high levels of evaporation cause normal amounts of rainfall. Every few years when trade winds weaken, the warm, moist air does not reach the coast and drought occurs.

- 18 Trade winds push warmer water towards South America instead of Australia, so Australia experiences drought.
- 19 There is much more carbon dioxide produced than methane.
- 20 Because greenhouse gases remain in the atmosphere for many years (e.g. carbon dioxide persists for over 100 years) greenhouse gas concentrations would not fall quickly.
- 21 Higher global temperatures will cause greater evaporation from the oceans, and therefore more rainfall.
- 22 Various answers, e.g. more profits for companies using existing fuel and car design.
- 23 Plants use CO<sub>2</sub> in photosynthesis, so more CO<sub>2</sub> may actually increase plant growth in crops such as wheat.
- 24 Higher population leads to more use of fossil fuels and more demand for manufacturing by industry, increasing global warming.
- 25 Mud slides
- 26 Venus, due to its thick carbon dioxide rich atmosphere
- 27

Greenhouse gas	Chemical formula	Sources
Carbon dioxide	CO <sub>2</sub>	Vehicles and industry
Methane	CH <sub>4</sub>	Rotting vegetation, cattle emissions
Nitrous oxide	N <sub>2</sub> O	Forest fires, fertilisers
CFCs	Various	Refrigerators, aerosol sprays
Surface ozone	O <sub>3</sub>	Produced by the action of sunlight on pollution

- 28 a CO<sub>2</sub>: between 280 and 285 ppm; CH<sub>4</sub>: steady at a little over 600 ppm  
b Around 1800 because of the Industrial Revolution  
c CO<sub>2</sub> concentrations increased from 295 ppm to over 340 ppm  
CH<sub>4</sub> concentrations more than doubled, from 750 ppm to 1700 ppm  
d CO<sub>2</sub>: 15% increase, CH<sub>4</sub>: 127% increase
- 29 Diagrammatic answer required.
- 30 a 7.56 billion litres per day (7 560 000 000 L/day)  
b 2.76 trillion litres per year (2 759 400 000 000 L/year)
- 31 a Diagrammatic answer required.  
b It is disappointing to note that Australia has the second highest per capita emissions.
- 32 a Uncertainty in emissions, and climate  
b  
i 0.5°C to 2.0°C  
ii 1.0°C to 4.5°C

- 33 a** 146.5 million cars in the United States  
**b** 929 000 cars in China  
**c** 650 million  
**d** It would have disastrous consequences for global warming.

## Unit 8.2 The ozone layer

- 1** In the stratosphere at about 20 to 30 kilometres above the Earth's surface.
- 2** Diagrammatic answer required.
- 3** Colourless gas; pungent odour
- 4** Ozone is a pollutant at ground level where it is poisonous, causing eye, nose and throat irritation and lung damage.
- 5** Diagrammatic answer required.
- 6** The ozone layer is the region in the stratosphere where ozone is thinly distributed.
- 7** Non-poisonous, odourless, stable
- 8** Diagrammatic answer required.
- 9** Aerosol spray can propellants; refrigerators and air-conditioners; to produce bubbles within polystyrene; and electronic components
- 10** Chlorine
- 11** Space shuttles and volcanoes
- 12** Nitrogen oxides also speed up ozone destruction. These gases are produced when jet aircraft engines burn fuel. Supersonic aircraft fly higher and inject these gases directly into the stratosphere. A space shuttle releases ozone-attacking hydrogen chloride when its boosters fire during launch. Each launch releases 68 tonnes of hydrogen chloride gas (gaseous hydrochloric acid!) into the atmosphere. Volcanoes also release hydrogen chloride. Lightning causes reactions that split ozone molecules.
- 13** The 'thickness' of the ozone layer is measured in Dobson units or DU.
- 14** 100 Dobson units correspond to a layer of pure ozone 1 millimetre thick at ground level.
- 15** A value of less than 220 DU is considered to be an ozone 'hole'.
- 16** It is thinnest at the end of winter in August, and peaks by the end of October.
- 17** It was an agreement by many countries to limit the use of CFCs.
- 18** Ozone levels take 10 years to peak, so they will rise at first, but they may drop again to normal levels by 2045.
- 19** At ground level, ozone is toxic, but in the stratosphere it acts to screen out harmful UV rays.
- 20** UV rays help the skin to produce vitamin D, which is necessary for healthy bones. However, too much increases the incidence of eye damage and skin cancers.
- 21** Less photosynthesis in plants would result in lower crop yields.
- 22** The ozone is very thinly distributed in the upper atmosphere; at ground level it would only be 5 mm deep.



- 23 The ozone hole is really a region where ozone is below a certain concentration.
- 24 Australia's ozone layer becomes thinner after October when global winds blow ozone towards the Antarctic and repair the ozone hole. This leaves Australia exposed to more dangerous levels of UV radiation.
- 25 Falling levels of plankton may affect much more of the food chain, since fish feed on plankton, and other animals (including humans) feed on fish. Also, less carbon dioxide would be absorbed into the ocean, causing more of the enhanced greenhouse effect.
- 26 Read the label and make sure there are no chlorine-containing or ozone-depleting gases present.
- 27 a Around 30 million square kilometres  
b September 2000
- 28 These are 'error bars', representing uncertainty in measurements.
- 29 a i 10 million km<sup>2</sup>  
ii 23 million km<sup>2</sup>  
b i 1986  
ii Between 1985 and 1990  
c 1983–84
- 30 2.2 millimetres
- 31 Diagrammatic answer required.

### Unit 8.3 Nuclear radiation: good or evil?

- 1 Radiation can be fast moving **particles** or electromagnetic **waves**.
- 2 a Nuclear force  
b Electrostatic force
- 3 Isotopes of an element have the same number of protons, but different numbers of neutrons. Radioactive isotopes emit energy from the nucleus in order to become more stable.
- 4 Various answers, e.g. uranium-238, plutonium-239, tritium, iodine-131, carbon-14
- 5 Large atoms have large numbers of particles in their nucleus. The nuclear force is not strong enough to hold the nucleus together. The nucleus is therefore unstable. The larger the atom, the more unstable the nucleus becomes.
- 6  ${}_{20}^{42}\text{Z}$
- 7 Alpha radiation, beta radiation, gamma radiation
- 8 a alpha  
b beta  
c gamma  
d gamma  
e alpha

9

	Alpha particles	Beta particles	Gamma rays
Speed	One-tenth the speed of light	Nine-tenths the speed of light	Speed of light
Penetration ability	Low: stopped by sheet of paper	Medium: stopped by a few millimetres of aluminium	High: largely absorbed by lead or concrete but never totally absorbed

- 10 Half-life is the time taken for half of the atoms in a sample of a radioisotope to decay.
- 11 a 2 kg  
b 1 kg  
c 0.5 kg
- 12 The Earth is continually being struck by solar radiation and cosmic radiation produced, for example, by collapsing stars. Terrestrial radiation originates from substances in the Earth's crust – an example is the decay of uranium in rocks in the Earth's crust.
- 13 The decay of natural underground uranium produces radioactive radon gas.
- 14 Ions attract other atoms and molecules, so they are more likely to become involved in chemical reactions that may destroy or mutate cells.
- 15 Gieger counter or dosimeter
- 16 You receive a dose of about 300  $\mu\text{Sv}$  annually from cosmic radiation, and 1400  $\mu\text{Sv}$  from terrestrial radiation = 1700  $\mu\text{Sv}$
- 17 Measurement of thickness of sheets of metal or rubber, checking for leaks in pipes.
- 18 *Advantage:* Food lasts longer due to bacteria and fungi being killed. *Disadvantage:* Possible creation of other unwanted chemicals within the food.
- 19 A dirty bomb is a bomb that has radioactive material such as nuclear waste in it. When the dirty bomb explodes, this radioactive material is spread in very fine particles across large areas, floating in the air, and contaminating water and food.
- 20 By bombarding normal gold atoms (gold-197) with neutrons in a nuclear reactor.
- 21 Alpha particles may do damage after being inhaled.
- 22 Cells like cancer cells that divide rapidly are more sensitive to radiation damage.
- 23 Bones can be X-rayed, but internal organs do not show up well in X-rays. Radioactive tracers are more suitable for internal organs as they can travel to particular sites where they may be detected using a gamma-ray camera, which produces an image of the site.
- 24 No. Alpha particles would not penetrate cardboard. A beta particle emitter may be suitable instead.
- 25 They would not penetrate out of the body and are therefore not able to be detected and used for imaging purposes. They have a high ionising ability and so are dangerous to cells, causing damage and mutations.

- 26 Hair cells, like cancer cells, are growing quickly, and so are more susceptible to radiation.
- 27 Soldiers and other personnel who were in the region may have inhaled radioactive substances. Once inside the body, radioisotopes are much closer to body cells and may cause a great deal more damage to living tissue. The effects may take years to become obvious. There may also still be radioactive substances in the area where the ammunition was used that could affect locals.
- 28 Their cells are still growing and dividing quickly, and growing cells are more susceptible to radiation damage.
- 29 a Not a cause for concern  
b Probably not a cause for concern  
c Very serious, causing radiation sickness and greater chance of cancer

30

	Alpha particles	Beta particles	Gamma rays
Charge	+2	-1	0
Mass	4 units	0 units	0 units
Speed	One-tenth the speed of light	Nine-tenths the speed of light	Speed of light
Penetration ability	Low	Medium	High
Stopped by	Sheet of paper	A few millimetres of aluminium	Largely absorbed by lead or concrete but never totally absorbed
Ionising ability	High	Low	Low

- 31 a  ${}_{84}^{218}\text{Po} \rightarrow {}_{82}^{214}\text{Pb} + {}_2^4\alpha$   
b  ${}_{11}^{24}\text{Na} \rightarrow {}_{12}^{24}\text{Mg} + {}_{-1}^0\beta$   
c  ${}_{54}^{133}\text{Xe} \rightarrow {}_{54}^{133}\text{Xe} + \gamma$   
d  ${}_{26}^{59}\text{Fe} \rightarrow {}_{27}^{59}\text{Co} + {}_{-1}^0\beta + \gamma$

- 32 One-eighth
- 33 No. It takes 24 000 years for the level of radioactivity from plutonium to halve, so 10 years wouldn't make much difference at all.
- 34 Diagrammatic answer required.
- 35 Four carbon-14 half-lives ( $4 \times 5730$  years) or approximately 23 000 years.

**Unit 8.4 Energy crisis**

- 1 Diagrammatic answer required.
- 2 When the neutrons released during a fission reaction cause other atoms to split and the process keeps repeating itself, huge quantities of energy are released in a fraction of a second.
- 3 A nuclear bomb is a device which makes use of uranium enriched to over 90% uranium-235 to cause a massive chain reaction.
- 4 Both use uranium-235, but the nuclear reactor is like a controlled nuclear bomb and uses uranium that has been enriched to about 2.5% uranium-235 compared to 90% in a nuclear bomb.
- 5 To prevent an uncontrolled chain reaction, control rods made of neutron-absorbing boron or cadmium are used to 'soak up' neutrons so that on average just one escapes from each fission to go on to cause another fission.
- 6 Electricity generation; submarine fuel; radioisotopes
- 7
  - a Moderator
  - b Control rods
  - c Coolant
- 8 Nuclear accidents, nuclear waste disposal
- 9 Spent fuel rods are stored under water for several years until their radiation levels drop and they cool down. The waste can also be melted down to form glass blocks and stored underground in stainless steel drums.
- 10 Waste can have half-lives of many thousands of years. During this time containers could be damaged or natural disasters could lead to leakage into the environment.
- 11 Diagrammatic answer required.
- 12 There is no nuclear waste.
- 13 Temperatures of hundreds of millions of degrees are needed for fusion.
- 14 Solar, wind, hydro, wave, tidal, fuel cells and others
- 15
  - a Uranium provides much more energy per kilogram than coal.
  - b Unstable atoms emit radiation.
  - c Natural uranium contains 0.7% uranium-235.
  - d A critical mass of uranium-235 will start a chain reaction.
  - e Fission is the splitting of an atom.
  - f One type of fusion reactor is a tokamak.
- 16 Diagrammatic answer required.
- 17 Subcritical
- 18 France and Sweden
- 19 It produces radioisotopes that are used in industry and medicine.
- 20 A magnetic bottle is a way of containing the superheated fuel in a fusion reactor.
- 21
  - a The disaster may have been prevented by engineers sticking to safety procedures.
  - b Swedish scientists first became aware of a nuclear accident in Russia by detecting radiation which had drifted over their country.

- c The long-term death toll will be far greater because of the higher cancer rate caused by the radiation.
- 22 a No
- b No
- c No
- 23 Radioactive fallout on the ground could be absorbed by grass which is then eaten by cows. Milk from these cows could contain radioactive isotopes and might then be drunk by children. Radiation, once inside the body, is much closer to cells and therefore much more dangerous.
- 24 If a small leak occurs, air rushes into the reactor, not out of it.
- 25 a High
- b Low
- c Intermediate
- 26 Various opinions may be expressed. Reasons should be given.

## Chapter review

- 1 Carbon dioxide, methane, nitrous oxide
- 2 By reducing our reliance on fossil fuels
- 3 Rising sea levels, more extreme weather
- 4 In the stratosphere, about 20 to 30 km above the surface of the Earth.  
Diagrammatic answer required.
- 5 Chlorine (or bromine)
- 6 Alpha particle, beta particle, gamma ray, neutron
- 7 Neutrons
- 8 1 sievert
- 9 a Geiger counter—ions created by radiation cause a pulse of current which makes a speaker ‘click’.
- b Smoke detector—smoke reduces the flow of ions created by a small radioactive source in the detector which normally stops the alarm from sounding.
- c Radioactive tracers—these accumulate at a particular site in the body and emit radiation which can be detected by a special camera.
- d Radiotherapy—a high, localised dose of radiation is delivered to a site and kills fast-growing cells such as cancer cells more readily than other cells.
- e Carbon dating—the amount of radioactive carbon-14 left in something which was once living is compared with the amount of normal carbon. The comparison allows the object to be approximately dated.
- 10 Diagrammatic answer required.
- 11 Refrigerators manufactured using CFCs are still in use today, and are still being dumped, allowing the release of CFCs into the atmosphere. Poorer countries may be using older air-conditioning equipment.
- 12 They do not have the funds or technology to manufacture or use CFC alternatives.
- 13 a Gamma

- b** Beta
- 14** 30 000
- 15** *Fission* is the splitting of atoms with the release of energy, and *fusion* is the combination of atoms with the release of energy.
- 16** Any neutrons released by the fission of uranium-235 are absorbed by uranium-238, which constitutes 99.3% of natural uranium.
- 17** Plutonium absorbs neutrons faster than uranium-235.
- 18** This practice is not desirable for many reasons. For example, containers will inevitably break down, contaminating oceans and allowing radiation to spread through the food chain.
- 19** The cost of operation is greater than the cost of the energy generated. Safety concerns relating to large-scale use need to be addressed.
- 20** 7.3 tonnes per person.
- 21** **a** 33  
**b** 35
- 22** Alpha
- 23**  ${}_{88}^{226}\text{Ra} \rightarrow {}_{86}^{222}\text{Rn} + {}_2^4\alpha$
- 24** About 1 gram
- 25** Diagrammatic answer required.

## Unit 9.1 Being an individual

- 1 Various answers depending on student preference.
- 2 Various answers depending on student preference.
- 3 A mentor is a person who will support and advise you when you need help.
- 4

Characteristic	Description
Organisation	Make lists and collect resources before starting work and then proceed in a series of steps.
Dedication	Meet goals and see a project through to completion.
Resourcefulness	Make the most of the available resources and take advantage of opportunities.
Self-motivation	Comes from being interested, and knowing the reason why you want to do something.
Creativity	Invent new ways of doing things and solve problems in unusual ways.

- 5 Various answers depending on student preference.
- 6 Various answers, may include ideas such as logic and reasoning, good research ability.
- 7 A mentor can support you when times are difficult. They can offer advice and ideas that you can use, and they often come up with alternative solutions to problems that you have not thought of. Therefore a mentor is valuable as they can allow you to continue to progress when you have become stuck.
- 8 Various answers depending on student examples.
- 9 Being involved in something that you enjoy and think is worthwhile. Having people to share things with, e.g. good mentors, friends and family. Feeling rewarded for your efforts. Other answers may be given by students.
- 10 A *creative* person will be able to come up with new ideas, see relationships between information, and invent new ways of doing things. They may solve problems in unusual ways. To be *resourceful* involves creativity because being resourceful involves thinking outside the square, making the most of the resources, changing plans, and taking advantage of opportunities that arise.
- 11 **a, b** Various answers, may include: *Creativity*: this is needed to come up with exciting lesson ideas. *Organisation*: for planning and preparing for lessons. *Resourcefulness*: to take advantage of situations that arise in the classroom in order to maximise learning experiences. *Dedication*: to helping people learn. *Self-motivation*: to keep on top of organisation and planning, and to work with difficult people.
- 12 Various answers, may include:

- a The main skills are probably developing and applying scientific thinking and problem-solving techniques, identifying problems and coming up with creative solutions to them, designing, conducting and evaluating an investigation.
  - b The main characteristics are probably resourcefulness and creativity.
  - c Either:
    - i The skills and characteristics are all equally important, as you need to be able to do a bit of all these things to get out of this situation alive.
    - ii Students may select a skill or characteristic and say it is more important. This should be accompanied by a reason.
- 13 Various answers, may include:
- a Dedication, self-motivation, organisation
  - b Working safely in different environments, developing and applying scientific thinking and problem-solving techniques, finding a mentor to support you through difficult times.
  - c Finding a mentor would possibly be most important, as the largest threat in this case will be boredom, which would then affect dedication and motivation. A mentor to support you in this situation would be essential.

## Unit 9.2 My investigation

- 1 Any of the following, or students may propose other answers. Consider whether:
  - it is challenging enough for your level of ability
  - you are interested in learning about your chosen topic
  - it is safe and does not pose a danger to people or the environment
  - you can get the required materials
  - it can be finished in the agreed time.
  - it is open-ended, meaning there are many possible solutions and it cannot be answered with a simple answer such as true/false or yes/no.
- 2 First-hand investigation, demonstration of a scientific principle, construction of a model (either static or working)
- 3 Building a model to demonstrate a scientific principle involves proving that a scientific principle is true by using a model to show it. Building a model to investigate an aspect of science means using a model to perform an investigation that may find new information. It does not involve proving a current principle to be true but may involve using information related to a scientific principle.
- 4 Aim, hypothesis, variables, equipment, method, results, discussion, conclusion, bibliography
- 5 *Independent variable*: the variable that is changed. *Dependent variable*: the variable that is being measured.
- 6 A *controlled variable* is kept the same throughout an experiment.
- 7 Results or data that are numerical are called *quantitative* as they usually measure amounts or quantities. If you are using your senses to observe, you are making *qualitative* observations. Qualitative observations are written down as a description or recorded as a picture or diagram.
- 8 The purpose of a conclusion is simply to summarise the results of an experiment.



- 9 May include the following:
  - oral presentation (using props)
  - demonstration of a model to the class
  - website
  - PowerPoint presentation
  - poster or visual display
  - photographic, video, or audio material
  - a journal article
  - newspaper article.
- 10 The *aim* outlines the idea or scientific question you are trying to test. A *hypothesis* is a prediction or ‘educated guess’ about what you may find in an experiment. They both are about what will be achieved or found out by an investigation but are presented in different forms.
- 11 Various answers including graphs, tables, descriptive observations, numbers or data, photographs, drawings, actual samples
- 12 You should only change one variable at a time so that it is clear that the measured result of the experiment is related to this changing variable, and that the result is not caused by something else.
- 13 Quantitative: mass, time, force, length, current, temperature, weight  
Qualitative: colour, smell, texture
- 14 Because people have different learning styles, some are better at taking in information in certain forms, such as verbal or visual, or even by doing something. This means that when you are communicating, to ensure that more people get the message you should deliver it in various ways, or by different techniques.
- 15 Overhead projector, data show, computer screen, video, poster, whiteboard, handout, photos etc.
- 16 A newspaper article is aimed at the general public and should be written in a friendly, readable style. A journal article is aimed at other scientists and needs to be accurate in its use of evidence, and can be written in a style that it is expected other scientists will understand. This means difficult scientific words and explanation can be included.
- 17 The purpose of a discussion is to analyse and evaluate the results of an experiment. The discussion should do the following:
  - analyse and present your data or observations in different ways to show any patterns or trends. This is where a graph may be useful.
  - explain any trends or patterns in your observations, data and results
  - explain why the results occurred and what they demonstrated
  - evaluate the success of your investigation
  - outline any errors or mistakes that may have affected your results
  - describe any difficulties or problems you had in doing the investigation
  - explain how your experiment could be improved to gain better or more dependable results.
- 18 Conclusions are required as a way of summarising your findings. They are an easy way for other scientists to quickly access your main ideas without having to read the

whole discussion. Therefore they are an important tool and resource for investigating other people's work, and finalising your ideas.

- 19 An experiment should be replicated to make sure the results are accurate and consistent. Without replication we would not know whether the results are just a once-off or are a true representation of what would occur.
- 20 a Closed  
b Closed  
c Open  
d Open  
e Closed  
f Open
- 21 Student answers may vary. The following are a guide.
- a To find out which type of glass lets the least light through.
- b Opaque glass will let the least amount of light through.
- c The independent variable is the type of glass, and the dependent variable is the amount of light passing through the glass.
- d Distance of light source from glass, distance of light detector from glass, brightness of the room, thickness of the glass
- e No specific observations are required if data logger equipment is working accurately. You could qualitatively observe the relative brightness of light coming through each piece of glass to ensure that it is in line with the data logger results.
- f Amount (brightness) of light coming through glass. Measured using light sensor.
- g 1 Place glass in position and measure 20 cm to left and place light source at this distance.  
2 Measure 20 cm to right of glass and place light sensor in this position. Ensure light source is pointing at sensor.  
3 Turn off room lights and close curtains.  
4 Start measurement using data logger and record results for each type of glass.  
5 Repeat until each type of glass has been tested three times using different samples each time.
- h

Type of glass	Light intensity or brightness			
	Sample one	Sample two	Sample three	Average
Opaque				
Translucent				
Transparent				
Coloured				

- 22 a Independent variable is the amount of fertiliser.  
b Dependent variable is the height of the plant.

- c Controlled variables include the amount of soil, water and sunlight, temperature, size and colour of pot, method of measurement.
- d That more fertiliser will produce more growth in plants.
- e Diagrammatic answer required.
- f The plant with no fertiliser grew the least, while the one with 5 grams of fertiliser grew the most. The plant with 10 grams of fertiliser grew more than the one with no fertiliser but did not grow as well as the 5 gram plant.
- g That 5 grams of fertiliser made the plant grow best.
- h No. You could not rely on these results as the experiment has not been replicated. Therefore we cannot be sure that they are correct and would occur next time.
- i It is not a fair test, as there is no replication. The other variables seem to have been controlled well, though.
- j Repeat the experiment three more times. Count the number of leaves to judge new growth as well as height. Look at any problems caused by too much fertiliser, such as discolouration of leaves.

## Chapter review

- 1 When completing an independent investigation you will need to set suitable **time lines**. You will need to work **safely** while you design, **conduct** and **evaluate** your investigation.  
As problems arise you may need to apply **scientific** thinking and problem-solving techniques. This will involve **identifying** problems and coming up with **creative** solutions to them. Having a **mentor** to support you through difficult times can help when working **alone**. After completing an investigation it is necessary to **communicate** information and results to others. This will involve presenting **data** and information in suitable forms.
- 2 Answers may include the following or other alternatives:  
*Creativity:* A creative person will be able to come up with new ideas, see relationships between information, and invent new ways of doing things. They will often solve problems in unusual ways.  
*Organisation:* An organised person will plan timelines and resources carefully. They may make lists, find out what they need, and collect resources before they start working. They will then often proceed in a series of steps.  
*Resourcefulness:* Being resourceful involves thinking outside the square. It involves making the most of the resources you have available. It may also include changing plans as new ideas emerge, and taking advantage of opportunities that arise.  
*Dedication:* Dedicated people want to achieve. They are able to meet goals and see a project through to completion.  
*Self-motivation:* Self-motivation goes hand in hand with dedication. Self-motivated people know why they want to do something. Self-motivation often comes from being interested, so make sure when selecting your topic for investigation that it will be interesting and challenging for you.
- 3 Various answers possible.
- 4 a True

- b False
- c True
- d False
- e False

5

Report section	Purpose	Description of what should be included
Title	To identify the project and what it is about	A title
Aim	Outlines the idea or scientific question you are trying to test	A statement about what you will be finding out about
Hypothesis	A prediction or 'educated guess' about what you may find in an experiment	A predicted answer that you think will be discovered
Equipment	To identify all materials, resources and equipment required	List of equipment and resources
Variables	To identify all of the variables that may affect your results and then work out which ones to change and control	Independent variable: the variable that is changed  Dependent variable: the variable that is being measured  Controlled variables: the variables that are kept the same throughout an experiment
Method	To provide clear, unambiguous instructions that other scientists could follow to accurately repeat your experiment	Step-by-step set of instructions Diagrams, or photographs  How variables will be changed and controlled
Results	To show data and observations collected during investigation	Quantitative data and qualitative observation. Information about what happened during the experiment.
Discussion	To analyse and evaluate your results in detail	Explanations of trends, results, errors and mistakes, problems, improvements. Display results in various forms such as graphs, diagrams or photos.
Conclusion	To summarise the results of your experiment	Whether you answered the aim. Whether the hypothesis was proved or disproved and why.
Bibliography	To identify references, and	Lists of resources including books,

	sources of information used	websites, journal articles etc.
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- 6** An investigation to demonstrate a scientific principle will involve understanding the scientific principles and performing an investigation to prove that it is correct. An investigation into an aspect of science of your choice involves researching something that you do not know the answer to.
- 7**
- a** Diagrammatic answer required
  - b** The following point on the graph is out of line with the others:  
40°C for boiled water is 6.9 It should be about 6.3 or 6.4.
  - c** As temperature increases, the solubility of oxygen decreases.  
Solubility decreases more when the temperature is first increased, and less with further temperature increases.  
The solubility of oxygen in both tap water and sea water was reduced by boiling. Sea water has a lower solubility of oxygen than tap water. This is also the case after boiling each sample.
  - d** Increasing the temperature of water decreases the solubility of gases. This is the case for both tap and sea water.
  - e** The experiment is probably not a fair test, as there is no repetition to prove that the results are correct. We are also not told how or whether variables were controlled, so it is hard to judge other factors.
  - f** The solubility of oxygen in water is reduced at higher temperatures. No fish were caught, because the temperature when the El Niño current arrives is higher, and the fish move to water that is at a lower temperature. (This explanation is in reality unlikely, as the temperature would not be high enough to eliminate fish completely. It is more likely related to the species of fish caught and the habitat they prefer, which would be colder water.)