Unit 2: Physical sciences

Topic 5 Building blocks for understanding

Chapter 5.1: The periodic table

Lesson 5.1a Atomic number and the periodic table

1 aluminium

2 11 protons, 11 electrons

3 hydrogen 1 electron in outer shell; lithium 2 electrons in inner shell, 1 electron in outer shell 2,1

4 nitrogen 2,5

5 argon 2,8,8

6

	Atomic no.	Total no. of electrons	Electrons in 1st shell	Electrons in 2nd shell	Electrons in 3rd shell	Electrons in 4th shell
hydrogen	1	1	1			
helium	2	2	2			
lithium	3	3	2	1		
beryllium	4	4	2	2		
boron	5	5	2	3		
carbon	6	6	2	4		
nitrogen	7	7	2	5		
oxygen	8	8	2	6		
fluorine	9	9	2	7		
neon	10	10	2	8		
sodium	11	11	2	8	1	
magnesium	12	12	2	8	2	
aluminium	13	13	2	8	3	
silicon	14	14	2	8	4	
phosphorus	15	15	2	8	5	
sulfur	16	16	2	8	6	
chlorine	17	17	2	8	7	
argon	18	18	2	8	8	
potassium	19	19	2	8	8	1
calcium	20	20	2	8	8	2

Go in order from 1 to 8.

Lesson 5.1b Electronic structure and groups

1a 20

1b calcium

2 fluorine 2,7

3 2,8,6, sulfur, Group 6

4 Group 7

5 fluorine 2,7; chlorine 2,8,7; seven electrons in outer shell

6 chromium, molybdenum, tungsten, seaborgium

Lesson 5.1c Mendeleev and the periodic table

1 Group 1: lithium, sodium, potassium. Group 2: calcium, strontium, barium. Group 7: chlorine, bromine, iodine. The elements in the groups have the same number of electrons in the outer shell.

2 Döbereiner discovered that the relative atomic mass of the middle element in each triad was close to the average of the relative atomic masses of the other two. For example Li (atomic mass 7) Na (atomic mass 23) K (atomic mass 39).

3 Attempts had been made to order the elements according to their relative atomic mass.

4 Germanium was one of the elements whose existence was predicted in 1869 by Russian chemist Dmitri Mendeleev, after he noticed a gap between silicon and tin in his periodic table. Mendeleev provisionally called the predicted element eka-silicon. Germanium was discovered by Clemens A. Winkler in 1886.

5a Argon, ordered by atomic mass, has isotopes 36 and 40.

5b The order of elements by atomic number did not always match the order by relative atomic mass. The variable numbers of neutrons meant some elements were more massive than their neighbour with a smaller atomic number.

5c The discovery that most elements occurred as isotopes, with the same atomic number and identical chemical properties but different masses, confirmed that the elements should be arranged in order of atomic number. The modern periodic table is ordered by atomic number.

6 Disagree. There will always be new elements as long as we can continue adding protons.

Lesson 5.1d Metals and non-metals

1 iodine, non-metal

2 iron, metal

3 Aluminium has three electrons in its outer shell.

4 e.g. nitrogen

5 Oxygen is element 8 in the periodic table. It is a non-metal with 6 electrons in its outer shell. It forms a negative ion and gains electrons from metals when it reacts with them.

6 Li^+ – Lithium has atomic number 3, it has 1 electron in its outer shell.

Lesson 5.1e Key concept: Atoms into ions

1 two from: neon, krypton, xenon, radon

2 helium

3 Oxygen has 6 electrons in the outer shell and therefore 2 spaces to accept electrons.

4 Fluoride ions have a negative charge.

5 Sodium and lithium both need to lose one electron to become stable atoms. Sodium reacts more quickly than lithium. This is because the outer electron is further away from its nucleus in a sodium atom than in a lithium atom. The 'pull' on the electron by the sodium nucleus is less than the 'pull' on the electron by the lithium nucleus. The electron of sodium is more easily lost (transferred out). So sodium is more reactive.

6 Chlorine, fluorine and bromine, all elements in group 7, need to gain one electron to become stable atoms. The order of reactivity is, from highest to lowest, fluorine, chlorine, bromine and iodine. The elements with the outer electron shell nearest to its nucleus exert the most 'pull' on the electron coming in to fill the 'space'; therefore chlorine is less reactive than fluorine, but more reactive than bromine or iodine.

Lesson 5.1f Exploring Group 0

1 Neon 20, argon 40; the mass of argon is higher. The RAM increases as you go down the group.

2 Radon; the boiling point would be higher.

3 Boiling point increases with atomic mass.

4 Students' own diagrams, based on Figure 5.1.22 in the Student Book, but with only the inner ring. The outer shell is already full with 2 electrons, so it is stable.

5 Argon 2,8,8. Its outer shell has 8 electrons so is stable. The outer electron shell is further away from the nucleus than helium (It has a bigger radius than helium), and therefore the boiling point is higher.

6a $1\ Xe + 2\ F_2 \rightarrow XeF_4$

6b Because xenon already has 8 electrons in its outer shell, and is unreactive.

Lesson 5.1g Exploring Group 1

1 Sodium has a lower density than water.

2 hydrogen gas

3 Measure the pH; pH > 7 are alkaline.

4 They are more reactive as they go down the group.

5 Group 1 metals react with water to produce a metal hydroxide and hydrogen gas. Rubidium reacts vigorously with water to form rubidium hydroxide and is not suitable for safe demonstration in the school laboratory.

6 $2Na(s) + 2H_2O(l) \rightarrow (2NaOH(aq) + H_2(g)$

$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$

7 They are metals and have 1 electron in their outer shell.

8 Students' own diagrams, showing two concentric circles with two dots on the inner circle and one dot on the outer circle.

9a $2K + O_2 \rightarrow K_2O$

9b K_2O, two K ions and 1 oxygen atom. Two electrons are donated from the K atoms to the oxygen atom.

9c KOH, potassium hydroxide

Lesson 5.1h Exploring Group 7

1 $2Na + Br_2 \rightarrow 2NaBr$

2 lithium fluoride LiF

3

Halogen	Relative atomic mass	Relative formula mass	Melting point (°C)	Boiling point (°C)	State at room temperature
chlorine,Cl_2	35	71	−101	−34	gas
bromine, Br_2	80	160	−7	59	liquid
iodine, I_2	127	254	114	184	solid

4 Melting point is 114°C. Boiling point is 184°C. Since room temperature is somewhat lower than 114°C (the melting point to go from solid to liquid) this means that iodine is a solid at room temperature.

5 The boiling point increases as the molecular mass increases.

6 Fluorine, chlorine and bromine will displace iodine because they are more reactive.

7 $Cl_2 + 2KI \rightarrow 2KCl + I_2$

8a Astatine would be a solid.

8b $Cl_2 + 2NaAt \rightarrow 2NaCl + At_2$

8c No, because it is less reactive than iodine.

End of chapter questions

1 hydrogen [1 Mark]

2 B: helium [1 Mark]

3 Metals lose electrons from their outer shell, and non-metals gain electrons to their outer shell. Metals are found on the left-hand side and to the bottom of the periodic table, and the non-metals on the right and to the top. [2 Marks]

4 It has 1 electron in its outer shell. [2 Marks]

5 D: 7 [1 Mark]

6 sodium hydroxide NaOH [1 Mark]

7 The metals are more reactive as move down the periodic table/atomic number increases. [2 Marks]

8 Group 2; it loses electrons from its outer shell. [4 Marks]

9a Halogen X has a lower atomic number. The boiling point of halogens increases with atomic number. [1 Mark]

9b Halogen X is more reactive, halogen reactivity decreases with atomic number. [1 Mark]

10 calcium, 20 neutrons in the nucleus [2 Marks]

11 The distance from the nucleus increases as you go down the group an therefore the outer electrons are more likely to be reactive.. [2 Marks]

12 Melting point D lower, density E higher than Rb and Cs [2 Marks]

13a $Cl_2 + 2KI \rightarrow 2KCl + I_2$ [2 Marks]

13b Chlorine is more reactive than iodine and therefore displaces it in KI. [2 Marks]

14 It has 6 electrons in its outer shell. The radius of the nucleus is larger and thereforeit gains electrons from metals less easily than the examples with a smaller radius. [4 Marks]

15 Metal, rubidium. Group 1 elements have 1 electron in outer shell and react vigorously with water to produce an alkaline metal hydroxide and hydrogen gas. [4 Marks]

[Total: 34 Marks]

Chapter 5.2: Chemical quantities

5.2a Chemical equations

1 C element; CO_2 compound; Cl_2 element; SO_3 compound

2a CO_2 carbon dioxide (carbon, oxygen), S_8 sulfur, Cl_2 chloride, C carbon (sulfur, oxygen), C_{60} carbon/buckminsterfullerene, C_4H_{10} butane (carbon, hydrogen)

2b CO_2 2, S_8 1, Cl_2 1, SO_3 2, C_{60} 1, C_4H_{10} 2

2c CO_2 3, S_8 8, Cl_2 2, SO_3 4, C_{60} 60, C_4H_{10} 14

3a aqueous, aqueous, aqueous, solid

3b solid, solid, gas

4 Any Group 1 and Group 7, such as NaCl, KCl, NaF.

5 $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

6 $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3\ (s)$

7 d 1; e 2; f 2

5.2b Key concept: Conservation of mass and balanced equations

1 YZ

2 4

3 2 Na, 2 S, 3 O

4 2 Al, 3 S, 12 O

5a d 2, e 1, f 1, g 2

5b d 1, e 5, f 3, g 4

5.2c Explaining observed changes in mass

1 Carbon dioxide is given off.

2 0.7 g

3 0.9 g

4 1.6 g

5 6 minutes, the reaction is complete, no more carbon dioxide is being given off.

6 Students' own graphs, based on Figure 5.2.10 in the Student Book, with reaction stopping at 7 minutes and 4.0 g of carbon dioxide given off.

7a Nitric acid was limiting, because zinc was left at the end.

7b 6.97 g nitric acid + 3.62 g zinc

5.2d Relative formula mass

1 sodium 23, cobalt 59, aluminium 27

2 22

3 $^{12}{}_{6}C$ 6 protons and 6 neutrons, $^{13}{}_{6}C$ 6 protons and 7 neutrons and $^{14}{}_{6}C$ 6 protons and 8 neutrons

4 $MgSO_4$ = 24 + 32 + (4 × 16) = 120

5 $Cu(NO_3)_2$ = 63.5 + (14 × 2) + (16 × 6) = 187.5

6 Mg 1, Br 2, Ag 2, N 2, O 6, relative formula mass equal

7 molecular formula C_3H_8, relative formula mass = (3 × 12) + (8 × 1) = 44

5.2e Amounts in moles

1 (1 × 2) + 16 = 18 g

2 (39 + 80) × 3 = 357 g

3 $6.02 \times 10^{23} \times 2 = 12.04 \times 10^{23}$

4a 14 × 2 = 28 g/mol

4b 65.38 + 16 = 81.38 g/mol

4c 24.3 + 12 + (16 × 3) = 84.3 g/mol

4d (14 × 2) + (8 × 1) + 32 + (16 × 4) = 132 g/mol

5 atomic mass of H_2O = 18; 72 g = 4 moles

6a 2 moles of oxygen, $2O_2$

6b $4H_2O$ would need 8 g of H

5.2f Using balanced equations to calculate masses

1 6.0 g magnesium + 4.0 g oxygen = 10.0 g MgO

2 formula mass = 24 + 16 = 40; mass of Mg needed is 1.2 g

3 Since 1 mole of propane produces 4 moles of water, then 6 moles of propane will produce 24 moles of water. 6 × 4 = 24

4 Formula mass $ZnCO_3$ = 65.39 + 12 + (16 × 3) = 125.39, ZnO = 65.39 + 16 = 81.39. For 1.25 g of $ZnCO_3$, 0.81 g of ZnO would be formed.

5 $CuCO_3 \rightarrow CuO + CO_2$. Formula mass of $CuCO_3$ is 63.55 + 12 + (16 × 3) = 123.55 and CuO is 63.55 + 16 = 79.55. Therefore 12.35 g would be needed.

5.2g Balancing equations

1 $MgCO_3 \rightarrow MgO + CO_2$ formula mass $MgCO_3$ = 24.3 + 12 + (16 × 3) = 84.3.
MgO = 24.3 + 16 = 40.3, therefore 40 tonnes would be produced.

2 number of moles = mass of chemical/molar mass
Al_2O_3 = (27 × 2) + (16 × 3) = 102, therefore 204 g = 2 moles.
$2Al_2O_3 \rightarrow 4Al + 3O_2$ 4 moles of Al is produced.

3 $2Al_2O_3 \rightarrow 4Al + 3O_2$; mole ratio is 2 : 4 : 3.

5.2h Key concept: Amounts of reactants and products

1 Rate of reaction = 2 cm^3 per second.
For example, 60 cm^3 hydrogen ÷ 30 seconds = 2 cm^3 per second

2a Approximately 1 cm^3 per second × 35 seconds = 35 cm^3 hydrogen

2b Approximately 2 cm^3 per second × 35 seconds = 70 cm^3 hydrogen. Doubling the magnesium (reactant) doubles the amount of hydrogen produced (product)

3 35 ÷ 2 = 17.5 cm^3 hydrogen

4 The reactant that is used up by the end of the reaction.

5 The amount of product would quadruple.

6a 2 moles Mg

6b At least 4 moles

7 molar mass: Mg 24 g, HCl 36.5 g, $MgCl_2$ 95 g, H_2 2 g

8 If 3 g of magnesium had been used in the reaction, we should have made 11.938 g of $MgCl_2$.

5.2i Concentrations of solutions

1 20 g/100 cm^3, 8 g/50 cm^3, 20 g/1000 cm^3

2 32 g/dm^3, 12.8 g/dm^3, 12.8 g/dm^3

3 1.05 g

4 5.4 × 35 ÷ 100 = 1.89 g

5 The concentration would increase.

6 Decrease the mass of solute added, increase the volume of solution added.

7 (21.5 g ÷ 86 g) × 1000 cm^3 = 250 cm^3

5.2j Key concept: Amounts in chemistry

1 24.3 + 32 + (16 × 4) = 120.3

2a 40 + (14 × 2) + (16 × 6) = 164

2b (27 × 2) + (32 × 3) + (16 × 12) = 342

3 12 + (16 × 2) = 44; 132 g is 3 moles

4 2 × 6.02 × 10^{23} = 12.04 × 10^{23}

5 4.05 g

6 $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$, mass C_3H_8 = (12 × 3) + (1 × 8) = 44, and $3CO_2$ = (12 × 3) + (16 × 6) = 132.

For 660 g propane, 1980 g CO_2 is produced.

5.2k Maths skills: Change the subject of an equation

1 $2Mg + O_2 \rightarrow 2MgO$; 40 g is produced.

2 $MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + H_2O + CO_2$

mass H_2SO_4 = (1 × 2) + 32 + (16 × 4) = 98

? $MgCO_3$ + 49 g H_2SO_4 → 91 g $MgSO_4$ + H_2O + CO_2

$MgCO_3$ needed = 91 – 49 = 42 g

3 187.2 g

4 Mass $MgSO_4$ = 24.3 + 32 + (16 × 4) = 120.3; 36.0 g $MgSO_4$ produced

End of chapter questions

1 85 [1 Mark]

2 A: Mg + O_2 = MgO, 0.7 g [1 Mark]

3 Some is given off as a gas. [2 Marks]

4 Atoms are changed not destroyed. [2 Marks]

5 40 + (16 × 2) + (1 × 2) = 74 [1 Mark]

6 The reaction gives off the gas CO_2, so the mass is reduced. [2 Marks]

7 A: the same number of protons [1 Mark]

8 Mass Mg is 24, 10 g is 10 ÷ 24 = 0.4 moles [2 Marks]

9 A: 6.02 × 10^{23} [1 Mark]

10

Formula	Mass (g)	Molar mass (g/mol)	Amount (mol)
$MgCO_3$	42	84	0.5
$CaCO_3$	20	100	0.2
$Ca(OH)_2$	148	74	2
C_nH_{2n+2}	25	100	0.25

[4 Marks]

11a 5 : 7 [2 Marks]

11b $2Al(OH)_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6H_2O$

$2Al(OH)_3$ formula mass 2 × 78 g = 156 g.

Formula mass $Al_2(SO_4)_3$ 54 + 96 + 192 = 342 g

Therefore 250 g $2Al(OH)_3$ produces 1.6 × 342 = 548 g $Al_2(SO_4)_3$.

[2 Marks]

11c $2Al(OH)_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6H_2O$

$2Al(OH)_3$ formula mass 2 × 78 g = 156 g.

Formula mass $Al_2(SO_4)_3$ 54 + 96 + 192 = 342 g.

Therefore 3000 kg $2Al(OH)_3$ produces 19 231 × 342 = 6577 kg $Al_2(SO_4)_3$.

[2 Marks]

[Total: 23 Marks]

Topic 6 Interactions over small and large distances

Chapter 6.1: Forces and energy changes

Lesson 6.1a Forces as vectors

1 There would be less contact force on the rope, so the tension and friction would be less.

2 The magnets would attract. Students' own diagrams, showing two arrows pointing towards each other.

3 In Figure 6.1.2 a: contact, b: non-contact, c: non-contact.

4 Contact force: any example for objects in contact e.g. normal force, friction, applied force, air resistance, tension. Non-contact force: any example for objects in no physical contact e.g. gravity, magnetism, electrostatics, nuclear force.

5a acceleration, force, momentum

5b All of these have magnitude and direction.

6 Final distance is 400 m; displacement is 0 m because the runner's overall position did not change.

Lesson 6.1b Combining forces

1 Resultant force = 40 N + 40 N − 50 N = 30 N

2 Resultant force = 1500 N − 1000 N − 500 N = 0 N

3 The car on the left has balanced forces.

4 Vertical arrows representing lift and weight are the same length and in opposite directions, therefore the jet is flying at constant height. Horizontal arrows representing thrust and drag are the same length and in opposite directions, therefore the velocity is constant.

5 Students' own free-body diagram, showing an upward arrow for the normal force from the ground and a downward arrow for the weight of the car.

Lesson 6.1c Finding forces from a vector diagram

1 Resultant force is 13 N at an angle of 67° upwards.

2 Force needed is 20 N at an angle of 53° upwards to balance the resultant force.

3 Measure the force generated by each tug (thrust) minus the friction from the water (drag). Use the angles of the tugs to the oil rig to calculate the resultant force. Combine the three resultant forces of the tugs.

4 The vertical and horizontal components are each 10 N.

5 Resultant force is 20 N.

Lesson 6.1d Work

1 The size of the force and the distance moved.

2 Weight

3 $W = F \times s$, therefore work done = 400 N × 1.5 m = 600 J

4 $W = F \times s$, therefore work done = 20 N × 0 m = 0 J

5 $W = \mathrm{F} \times s$, therefore distance = $W \div F$ = 300 J ÷ 200 N = 1.5 m

6 $W = F \times s$, therefore work done = 500 N × 4 m = 2000 J. There is a change from kinetic energy at the jump to potential gravitational energy.

7 $W = F \times s$, therefore force = $W \div s$ = 3000 J ÷ 12 m = 250 N

Lesson 6.1e Mass and weight

1 The weight of an object is the force acting on it due to gravity. It can be measured by a newtonmeter.

2 Weight is 5 N. Mass is 0.5 kg.

3a 70 N

3b 5 N

3c 4 N

4a 3 kg

4b $W = m \times g$, therefore gravity on Mars = $W \div m$ = 11.1 N ÷ 3 kg = 3.7g

5 Spring scales are measuring weight so they would only be accurate on Earth.
Balances weigh mass so the measurement is the same on any planet.

Lesson 6.1f Gravitational potential energy

1 GPE would decrease.

2 GPE remains constant.

3 Harry has the greater GPE because he has more mass.

4 $E_p = mgh$ = 0.06 kg × 10 N/kg × 2 m = 1.2 J

5 $E_p = mgh$ = 300 kg × 10 N/kg × 2 m = 6000 J

6 $E_p = mgh$ = 45 000 kg × 10 N/kg × 600 m = 270 000 000 J = 2.7×10^8 J or 2.7×10^5 kJ

Lesson 6.1g Elastic deformation

1 Students' own diagrams, showing the arrows for force 1 and force 2 in opposite directions

2 They would not return to their original length.

3 $F = ke$, therefore $k = F \div e$ = 4 N ÷ 0.08 m = 50 N/m

4 $F = ke$, so F = 2000 × (0.1 − 0.04) = 120 N

5 $E_e = ½\, k\, e^2$ = 0.5 × 300 N/m × $(0.1)^2$ m = 1.5 J

6 $E_e = ½\, k\, e^2$ = 0.5 × 500 N/m × $(0.25 - 0.2)^2$ m = 0.625 J

7 $E_e = ½\, k\, e^2$, therefore $k = (E_e \div e^2) \times 2$ = (12 J ÷ 0.16^2) × 2 = 938 N/m

Lesson 6.1h Required practical: Investigate the relationship between force and the extension of a spring

1 forcemeter

2 Forcemeters contain a spring connected to a metal hook. The spring stretches when a force is applied to the hook. The bigger the force applied, the longer the spring stretches and the bigger the reading.

3 By adding up the three repeated readings and dividing by three.

4 Spring 1, 1st reading: 20 N is anomalous

5 Yes, taking repeated values is a good way to get true values.

6 The spring is extending proportionally with the weight.

7 The spring is not extending proportionally with the weight.

8 At the higher weights, the spring is reaching the limit of its extension.

9 $y = mx + c$ spring B: $m = (y \div x) - c$ = (0.1 m ÷ 8) − 0 = 0.0125; spring C: $m = (y \div x) - c$ = (0.06 m ÷ 8) − 0 = 0.0075

10 $k = F/e$ spring B: k = 8 N ÷ 0.1 m = 80 N/m; spring C: k = 8 N ÷ 0.06 m = 133 N/m. Spring C is the stiffest.

11 Students' own diagrams, based on Figure 6.1.23 in the Student Book, but with x and y axes interchanged.

12a area = (0.16 m × 8 N) ÷ 2 = 0.64

12b $m = (y \div x) - c$ = (0.16 m ÷ 8 N) − 0 = 0.02
spring constant = $1/m$ = 1/0.02 = 50 N/m
$E_e = ½\, k\, e^2$ = 0.5 × 50 N/m × $(0.16)^2$ m = 0.64 J

12c The answers are the same. The area under the force versus displacement graph gives the work done by the force.

End of chapter questions

1 B: It stays the same. [1 Mark]

2 newtons [1 Mark]

3 $W = F \times s$, therefore work done = 400 N × 2 m = 800 Nm [2 Marks]

4 mass [1 Mark]

5 Contact force: any example for objects in contact e.g. normal force, friction, applied force, air resistance, tension. Non-contact force: any example for objects in no physical contact e.g. gravity, magnetism, electrostatics, nuclear force. [2 Marks]

6 $W = m \times g$, therefore weight = 50 kg ×10 N/kg = 500 N [1 Mark]

7 Because it has both magnitude and direction. [1 Mark]

8 $E_p = mgh$ = 7.5 kg × 10 N/kg × 2 m = 150 J [1 Mark]

9 $E_e = ½\, k\, e^2$ = 0.5 × 30 N/m × $(0.02)^2$ m = 0.006 J [2 Marks]

10 $E_p = mgh$ = 70 kg × 10 N/kg × 30 m = 21 000 J [1 Mark]

11a 13 m [1 Mark]

11b 3 m [1 Mark]

11c 3 m West [2 Marks]

12 Add an arrow from left to right of 3 N [1 Mark]

13 $E_e = ½\, k\, e^2 = 0.5 \times k \times (0.1)^2$ m $= k \times 0.005$ J

$E_p = mgh = 0.01$ kg $\times$ 10 N/kg $\times$ 1 m = 0.1 J

If all the energy transfers, then $k = 0.1/0.005 =$ 20 N/m. [3 Marks]

14a $E_e = ½\, k\, e^2 = 0.5 \times 148$ N/m $\times (0.05)^2$ m = 0.185 J [1 Mark]

14b $E_e = ½\, k\, e^2$, therefore $e^2 = (E_e \div k) \times 2 =$ (8 N $\div$ 148 N/m) $\times$ 2 = 0.108. So e = 0.33 [1 Mark]

14c $E_e = ½\, k\, e^2 = 0.5 \times 148$ N/m $\times (0.09)^2$ m = 0.6 N, therefore 60 g mass [1 Mark]

15 Students' own diagrams: force of 4.0 kN drawn with a suitable scale; force of 7.0 kN drawn to the same scale, at correct orientation to other force; resultant drawn in correct direction; resultant by scale drawing in the range 7.8 to 8.2 kN [4 Marks]

16 decrease in elastic potential energy stored in the spring (E_k) increases increase in store of gravitational potential energy (E_p) of the rocket [1 mark]

$E_e = ½\, ke^2 = 0.5 \times 2000$ N/m $\times (0.08)^2$ m = 6.4 J

rearrange $E_p = mgh$ to give maximum height reached, $h = E_p / mgh$

$h = 6.4 / (0.075 \times 9.8) = 8.7$ m [6 Marks]

[Total 34 Marks]

Chapter 6.2: Structure and bonding

Lesson 6.2a Types of chemical bonding

1 Ionic: compounds from metals combined with non-metals; particles are oppositely charged ions. Covalent: compounds of non-metals combined with non-metal; particles are atoms that share pairs of electrons.

2 metallic

3 The electrons are free to move about through the whole structure.

4 Covalent bonds allow electrons to be shared among atoms; but there are no delocalised electrons.

5 Electrons in the outer shell are on the 'outside' of the atom, furthest away from the nucleus, and can therefore interact with other atoms/molecules more easily.

Lesson 6.2b Ionic bonding

1 It loses electrons from its outer shell.

2 The electrons transfer *out from* a metal atom *in to* a non-metal atom. The resultant positive ions (such as Na+) and the negative ions (such as Cl^-) are then attracted to each other. These attractions spread to a number of other ions to make a solid lattice.

3 The stable neon atom has 10 electrons: two in an inner shell and eight in an outer shell.

4 The fluorine atom will need one electron.

5 The chloride ion is negative because it has gained one negatively charged electron.

6 Students' own diagrams, based on Figure 6.2.7 in the Student Book, showing two sodium atoms and one oxygen atom.

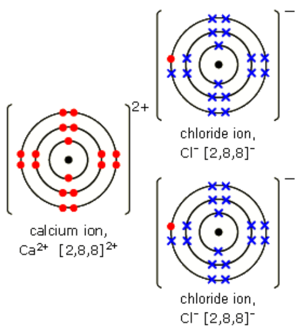
Lesson 6.2c Ionic compounds

1 Oppositely charged sodium and chloride ions are held together by strong electrostatic forces of attraction. They form very large, strong structures of ions in a regular arrangement called a giant lattice.

2 Students' own dot and cross diagrams showing potassium K losing one electron and fluorine F gaining one electron.

3 2 potassium atoms lose one electron each to one sulfur atom to form K_2S.

4



$CaCl_2$

5a Na_3N

5b Al_2O_3

Lesson 6.2d Properties of ionic compounds

1 Sodium chloride has a high melting point because of the large amount of energy needed to break its strong electrostatic forces.

2 No, ionic compounds do not conduct electricity when solid.

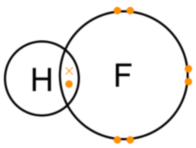
3 Sodium chloride ionsare not free to move about in the solid form, and therefore charge cannot flow between electrodes.

4 More energy is needed to overcome the higher electrostatic forces in MgO than those in NaCl or KCl.

Lesson 6.2e Covalent bonding

1 H–F

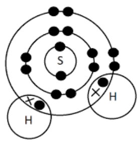
2



3 Three pairs of electrons are shared in ammonia.

4 CH_4

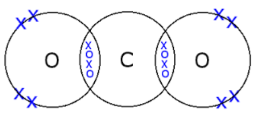
5



6 Oxygen atoms are connected by a double bond.

7 N_2 has a triple bond because the two atoms share three pairs of electrons.

8



Lesson 6.2f Properties of small covalent molecules

1 Methane is a small molecule; small molecules have low boiling points because the forces between the molecules are weak.

2 CO_2 has a higher mass than CO, therefore the boiling point of CO_2 is higher.

3 C_4H_{10} has a higher mass than C_3H_8, therefore the melting point of C_4H_{10} is higher.

4 SO_3 at 10°C is a solid, and CO at −200°C is a liquid.

5 Although the covalent bonds are strong, the intermolecular forces in N_2 are weak because it is a small molecule, and therefore the boiling point is low.

6 Sea water is a better conductor than pure water because the dissolved salts in sea water are good conductors.

7 Pentane is likely to have the higher boiling point because it has a linear shape and the molecules can get closer together.

8 The boiling points of halogens increase down the group because of the increasing strength of intermolecular forces as the size and relative atomic mass of the atoms increase.

Lesson 6.2g Polymers

1 Polythene is a large molecule; it has many forces linking its chains, therefore it is relatively strong and forms a solid at room temperature.

2 A monomer is a single chain; monomers bind together to form a polymer.

3 The plastic in the bag is a polymer. Polymers have weak intermolecular forces of attraction between molecules and can be stretched easily because the polymer molecules can slide over each other.

4 Students' own diagrams, based on Figure 6.2.18 in the Student Book, showing just the first two parts of the chain

5 Students' own diagrams, based on Figure 6.2.17 in the Student Book, but with a Cl atom instead of one of the H atoms

Lesson 6.2h Giant covalent structures

1 Differences: Diamond is made of one atom C, silicon dioxide is made of Si and O. Similarities: Non-conductors; form hexagonal repeating structure; giant structures joined by covalent bonds; very strong with high melting points.

2 Silicon dioxide is a covalent network structure that consists of a giant lattice of strong covalently bonded atoms. Water forms covalent bonds between O and H in the water molecule and weak bonds between hydrogen and oxygen atoms in different individual water molecules.

3 They both form a large covalent structure with strong bonds.

4 It is very hard and has a high melting point.

5 The carbon in graphite forms a giant covalent structure in layers that can slide over each other, therefore it is not as hard as silicon dioxide.

6 Graphite has a high heat capacity and thermal conductivity.

7 Graphite has high temperature strength and good thermal and electrical conductivity (since graphite has delocalised electrons)

8 Unlike graphite, they do not contain free (deocalised) electrons.

Lesson 6.2i Intermolecular forces

1 carbon and oxygen present in ethane, ethyne, ethanoic acid and glycine.

2 Decane has 10 carbon atoms, whereas octane has 8, therefore decane has more intermolecular forces along the chain than octane. The longer chain needs more energy to separate, therefore a higher boiling point.

3 Poly(propene) is a polymer and has more intermolecular forces holding it together than propene. More forces need more energy to separate and therefore a higher melting point.

Lesson 6.2j Metallic bonding

1 Magnesium has an atomic number of 12. It consists of three shells with two electrons in the inner shell, eight in the second shell and two in the outer shell.

2 A metallic bond is a strong electrostatic attraction between the negative delocalised electrons and the rest of the metal atoms with their positive charge. In lithium the single electrons in its outer shell are free to move.

3 Delocalised electrons are not associated with any molecule and are free to move throughout the whole structure.

4 More tightly. A cation is an atom that has lost one of its outer electrons, therefore the positive nuclear charge exceeds the negative charge that the electrons exert, and the positive nucleus pulls the electrons tighter.

5 A potassium atom (K) has electron structure 2,8,8,1 A calcium atom (Ca) has electron structure 2,8,8,2. A scandium atom (Sc) has electron structure 2,8,9,2. The electron configuration should be drawn with shells showing the correct configuration of electrons at each level.

6 potassium, calcium then scandium due to the boiling points

7 For metals to melt, the metallic bonds need to be disrupted. Metals such as potassium have one spare electron and need less energy to melt than metals such as calcium and scandium, which have two electrons in their outer shell. Scandium is a transition metal, which means that its third spare electron is in the shell below the outer shell. More energy is needed to disorder the metal lattice than for calcium.

Lesson 6.2k Properties of metals

1 Brass: copper and zinc. Bronze: copper and tin.

2 Alloys are harder than their individual metals.

3 False. Alloys are a mixture of a metal and another element that does not have to be a metal; for example, cast iron is an alloy of iron and carbon (or any similar example).

4 Copper forms a giant structure in which the atoms are able to slide over each other. This means that it can be pulled into a wire.

5 The giant structure contains delocalised electrons that can conduct an electric current through the lattice.

6a Pure silver is more malleable. Sterling silver is an alloy; the addition of copper to silver gives sterling silver more strength, but preserves its malleability.

6b 0.075 g or 75 mg

7 silver

8 Lithium has one electron in its outer shell, aluminium has three electrons in its outer shell, therefore aluminium has more delocalised electrons and is a better conductor.

Lesson 6.2l Maths skills: Visualise and represent 2D and 3D shapes

1 Students' own diagrams, showing a C atom attached to an O atom with three bonds.

2a molecule

2b lattice

3 Students' own diagrams, based on Figure 6.2.35 in the Student Book, but showing hexagonal rings of carbon atoms in a single layer

4 Buckminsterfullerene is made of carbon atoms that form a ring structure in a discrete molecule of 60 carbon atoms. Graphite is a lattice structure in which the layers of carbon atoms are held together with weak bonds.

End of chapter questions

1 b: ionic [1 Mark]

2 a: carbon dioxide [1 Mark]

3 d: giant metallic [1 Mark]

4 LiCl has no delocalised electrons, therefore it will not conduct electricity. [2 Marks]

5 K^+ ion; NO_2 small molecule; -(XZ)-$_n$ polymer [2 Marks]

6 Ionic bonding: two opposite ions attract each other and form the ionic bond. Covalent bonding: between non-metallic atoms pairs of electrons are shared. [2 Marks]

7 In a solution the electrons are free to move. [1 Mark]

8 **A** Low boiling points suggest weak intermolecular forces between molecules. Simple molecular substances do not conduct electricity because they have no delocalisable electrons.

B Giant metallic elements (and graphite) conduct electricity when solid, ionic compounds do not. Metals have high melting and boiling points due to strong metallic bonds. [4 Marks]

9 They are the most stable in this form. Students' own dot and cross diagrams. [6 Marks]

10 Silver is a metal with a single electron in its outer shell that can delocalise and move freely. [1 Mark]

11 covalent bond, sharing a pair of electrons [1 Mark]

12

[2 Marks]

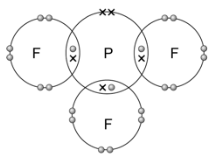
13a a large structure formed by bonding in many directions, e.g. diamond and silicon dioxide [2 Marks]

13b by covalent bonds [2 Marks]

13c increases the melting point [2 Marks]

14 Methane is a small structure; the intermolecular forces are very weak. [2 Marks]

15



[2 Marks]

16 The marks are in three bands according to the level of response.

Level 3 (5/6 marks): A detailed and coherent explanation comparing relevant data from the table and coming to a conclusion consistent with the reasoning.

Level 2: (3/4 marks): An attempt to compare relevant points which link together to form a conclusion. Some of the logic used may be inconsistent at times and some data or comparisons lacking, but builds towards a coherent argument.

Level 1: (1/2 marks): Separate, relevant points made. The steps may not be logically linked and the conclusion, if present, may not be consistent with the reasoning.
No relevant content: 0

Indicative content:

- intermolecular forces are weak compared with covalent bonds
- weaker intermolecular forces mean lower melting and boiling points
- as smaller amount of energy needed to separate the molecules when the substance melts or boils
- B has the lowest melting and boiling points and C has the highest melting and boiling points
- Even B has a relatively high melting and boiling point and is solid at room temperature so neither A, B nor C can be simple molecular substances
- Substance C does not conduct electricity
- so C does not contain charge carriers (neither free electrons nor free ions)
- hence C cannot be ionic (even though it has a high melting point and high boiling point)
- C must have giant covalent structure
- only B dissolves in water
- B conducts in liquid state so must contain ions which can move only in molten state
- ionic compounds also have high melting points and high boiling points because of the large amounts of energy needed to break the many strong bonds
- B cannot be metal as does not conduct in solid state
- B must have giant ionic lattice structure
- A conducts in solid state so must contain charge carriers that are free/delocalised electrons
- A must have metallic structure/metallic bonding
- high melting point and high boiling point of A are consistent with giant structure with strong metallic bonding

[Total 40 Marks]

Chapter 6.3: Magnetism and electromagnetism

Lesson 6.3a Magnets

1 They repel each other.

2 They are all in the first row of Group 8 of the periodic table.

3 Any correct answers such as speakers, smartphones, doors, microwaves, vacuum cleaners.

4 Steel pins or iron tacks become magnetic (induced magnet when placed near a permanent magnet), therefore they bind to permanent magnets. The particles in the steel and iron line up when magnetic; this is not retained in the tacks.

5 The pins and tacks are attracted to each other.

6 The other object will bind to the magnet or move away.

Lesson 6.3b Magnetic fields

1a The lines are closer together.

1b The lines are further apart.

2 The magnetic field will vary at different points around the magnet.

3 Students' own diagrams, based on Figure 6.3.5 in the Student Book, showing the direction of the field lines from north to south (and therefore attraction between two unlike poles and repulsion between two like poles)

4 Magnets are used in grain-milling facilities where wheat is ground into flour. Passing the grain through a magnetic field removes steel or iron fragments.

5 Special magnetic ink is needed, or any suitable answer.

Student Book answers

Lesson 6.3c The Earth's magnetism

1a Diagram shows south-seeking compass needle (north pole of magnet in compass) pointing away from the magnetic north pole.

1b Diagram shows south-seeking compass needle pointing towards magnetic south pole.

2 north

3 The south pole of the magnet inside the compass is the end that points towards geographic north, so it is called a north-seeking pole.

4 As the lava cools, the iron-rich minerals in the lava align themselves within the current Earth's magnetic field. When the field changes, the magnetism of new rock is aligned in the opposite direction.

5 Reversal only occurs about every 200 000 years.

Lesson 6.3d Magnetic effect of an electric current

1 They are closer together.

2 It would point in the opposite direction.

3 James Clerk Maxwell (1831–1879), most famous for formulating the theory of electromagnetism between 1847 and 1879.

4 Students' own diagrams, the first one based on Figure 6.3.9 in the Student Book. If the current is increased, the magnetic force is increased so students' second diagrams should show the lines closer together.

Lesson 6.3e The magnetic field due to a solenoid

1 Students' own diagrams, based on Figure 6.3.12 in the Student Book, showing arrows in the opposite direction.

2 south pole

3 Steel contains other components as well as iron. Replacing iron with steel would make the electromagnet weaker.

4 Disadvantage: It requires a current to become magnetic. Advantages: It can be switched on and off; it has a much stronger magnetic field than a coil of wire. Or any suitable answers.

Lesson 6.3f The motor effect

1 The lines go in circles clockwise around the wire. The field is strongest around the wire and to the right-hand side of the wire. It is weakest to the left-hand side of the wire.

2a The direction of the force and the motion is perpendicular to both the magnetic field and the current, therefore it moves to the right.

2b It moves to the right.

3 Decreasing the strength of the current, decreasing the strength of the magnetic field, changing to a steel core, decreasing the number of turns in the coil.

4 Students' own diagrams showing Figure 6.3.16 in the Student Book with Fleming's left-hand rule directions for motion, field and current drawn in.

5 When the bell-push completes the circuit (makes the circuit), a current passes through the electromagnet. When the circuit is broken, the current stops flowing and switches off the electromagnet. The spring pulls the strip back, so that contact is made, and the sequence begins again.

6 The iron strip is attracted to the electromagnet, and the hammer hits the gong.

7 The movement breaks the circuit, so the current stops flowing and switches off the electromagnet, so the iron strip is not attracted, and the hammer moves back.

Lesson 6.3g Calculating the force on a conductor

1 The field is constant and is proportional to both the applied current and the number of coil turns per unit length.

2a The force doubles.

2b The forces increases four times.

3 $F = B \times I \times L$

$F = 3 \times 10^{-5}\ \text{T} \times 3\ \text{A} \times 25\ \text{m} = 2.25 \times 10^{-3}\ \text{N}$

4a **Method 1**

$F = B \times I \times l$

$0.125\ \text{N} = 1 \times 10^{-4}\ \text{T} \times I \times 250\ \text{m}$

$I = 0.125\ \text{N}/(1 \times 10^{-4}\ \text{T} \times 250\ \text{m}) = 5\ \text{A}$

Method 2

$I = F/(B \times l)$

$I = 0.125\ N/(1 \times 10^{-4}\ T \times 250\ m) = 5\ A$

4b Either method can be easier.

5 $F = B \times I \times l$

$0.05\ N = 3 \times 10^{-5}\ T \times 2.5\ A \times l$

$l = 0.05\ N/(3 \times 10^{-5}\ T \times 2.5\ A) = 6.67 \times 10^{-2}\ m$

Lesson 6.3h Electric motors

1 Sewing machine, fan, washing machine, any other suitable answer.

2 The commutator allows the motor to continue to spin without reversing direction every time it gets to the vertical position. It does this by reversing the direction of current every half turn of the coil, which makes the rotation continue in the same circular path.

3 On the left-hand side of the coil in Figure 6.3.23 in the Student Book, the direction of the current is towards the commutator and the field is to the right. So the force is upwards. On the right-hand side of the coil, as the current is in the opposite direction, away from the commutator, the force will also be in the opposite direction, which is downwards. So the coil spins clockwise.

4 The coil is always at right angles to the magnetic field. Force is perpendicular to the current and the magnetic field.

Lesson 6.3i Key concept: The link between electricity and magnetism

1 When battery switched on and off, needle in compass deflected from magnetic north.

2 electromagnet

3 electric motor

4 A current-carrying conductor with a magnetic field around it is put it into a magnetic field. The magnetic field around the conductor interacts with the magnetic field of the magnet. The combination of the magnetic fields creates an instantaneous force between the magnet and the conductor.

5 Using Fleming's left-hand rule.

End of chapter questions

1 A: Near the poles [1 Mark]

2 D: Using a thicker wire [1 Mark]

3 Permanent magnet: produces its own magnetic field, retains its magnetism. Induced magnet: becomes a magnetic when placed in a magnetic field, loses magnetism when removed from a magnetic field. [2 Marks]

4 C: They repel [1 Mark]

5 Place steel pins onto the magnet and see if magnetism is induced in the pins (or any other suitable answer). [2 Marks]

6 B: Seeing how many paper clips it will attract [1 Mark]

7 C: Attract the striker to hit the gong [1 mark]

8 B: Change the number of turns on the coil [1 Mark]

9 No, force acts at right angles. [1 Mark]

10 Increase the size of the current, increase the strength of the magnetic field, change the voltage, increase the number of turns in the coil. [3 Marks]

11a $F = B \times I \times L$

$F = 0.05\ T \times 0.5\ A \times 2\ m = 0.05\ N$ [1 Mark]

11b $F = B \times I \times L$

$F = 0.1\ T \times 2\ A \times 0.5\ m = 0.1\ N$ [1 Mark]

12 Students' own diagrams, based on Figure 6.3.20 in the Student Book [4 Marks]

13a $F = B \times I \times L$

$0.03\ N = 0.2\ T \times I \times 0.3\ m$

$I = 0.03\ N/(0.2\ T \times 0.3\ m) = 0.5\ A$

Current is horizontal at right angles to the field [2 Marks]

13b $F = B \times I \times L$

$0.05\ N = B \times 3\ A \times 0.25\ m$

$B = 0.05\ N/(3\ A \times 0.25\ m) = 6.67 \times 10^{-2}\ T$ [2 Marks]

13c $F = B \times I \times L$

$B = F \div (I \times L) = 0.04\ N \div (2\ A \times 5\ m) = 0.004\ T$ [2 Marks]

14 The marks are in three bands according to the level of response.

Level 3 (5/6 marks): A detailed and coherent explanation covering all major steps. Each

statement is logically linked to the next one. Appropriate scientific terminology is used.
Level 2: (3/4 marks): Some detail lacking but each statement is logically linked to the next one.
Level 1: (1/2 marks): Some correct statements but lacks detail and the steps are not logically linked.
No relevant content: 0
Indicative content:

- When a current passes through the coil of wire, this creates an electromagnet.
- The field of the permanent magnet interacts with the field of the electromagnet.
- The direction of the current in the wire on the left side of the coil is opposite to the direction of the current in the wire on the right side of the coil.
- So the field of the electromagnet is in opposite directions on opposite sides of the coil.
- There are magnetic forces on the turns of the coil, which push one side up and the other side down.
- The direction of the force is in opposite directions on opposite sides of the coil.
- So the motor starts to rotate.
- After half a turn, the coil is horizontal again.
- To ensure the motion continues in the same direction the forces (on each side of the coil) must reverse in direction.
- The current is reversed using the split ring commutator (which reverses the current direction every half turn).
- When the current reverses direction, the magnetic force on the turns of the coil reverses in direction.
- This allows the coil to continue to spin in the same direction.

[6 Marks]

[Total 32 Marks]

Topic 7 Movement and interactions

Chapter 7.1: Forces and motion

Lesson 7.1a Speed and velocity

1 accelerating from starting and decelerating to stop; changes in climate and terrain

2 2.5 minutes = 150 seconds
mean speed = 50 m/150 s = 0.33 m/s

3 10 km = 10 000 m
one and three-quarter hours = 105 minutes = 63 000 seconds
mean speed = 10 000 m/6300 s = 1.59 m/s

4 10 000 m in 3600 s = 2.8 m/s

5 six orders of magnitude

6a circuit is (15 + 30) × 2 = 90 m
mean speed = 90 m/22 s = 4.1 m/s

6b 0 m/s

Lesson 7.1b Distance, speed and time

1 distance travelled = 0.5 mm/s × (60 × 60) s = 1800 mm = 1.8 m

2 The line would be steeper.

3a Students' own graphs, based on Figure 7.1.3 in the Student Book, but showing a shallower curve.

3b The car accelerates initially and then slows.

4 The gradient is initially shallow then steepens. This means that the car is accelerating from 0 to 10 s.

Lesson 7.1c Acceleration

1 Car A: 30 m/s in 6 s = 5 m/s^2. Car B: 10 m in 5 s = 2 m/s^2. Car A is accelerating faster.

2 The ball accelerates upwards, slows at the top of the curve and accelerates downwards.

3 20 m/s in 8 s; acceleration is 2.5 m/s^2

4a The velocity has increased.

4b The car is slowing.

5 velocity changes from 24 m/s to 0 m/s in 3 s
acceleration = −8 m/s^2 (the car is slowing)

6 speed change = 108 km/h – 72 km/h = 36 km/h = 10 m/s
acceleration = 10 m/s ÷ 5 m/s = 2 m/s^2

7 The glacier's speed is increasing by 4 mm/s over a 1-year period.

8 When the carousel moves around at a constant speed, its direction of movement is changing. This means that its velocity is changing because velocity is a vector. When the velocity of an object is changing, it is accelerating.

Lesson 7.1d Using velocity–time graphs

1 Students' own graphs, showing positive velocity from A to B, then negative velocity from B to A

2a acceleration = change in velocity ÷ time = 25 m/s ÷ 5 s = 5 m/s^2

2b acceleration = change in velocity ÷ time = −25 m/s ÷ 5 s = −5 m/s^2

2c acceleration = change in velocity ÷ time = 0 m/s ÷ 5 s = 0 m/s^2

3 Initial velocity is 20 m/s, final velocity is 0 m/s, therefore change in velocity = 0 − 20 = −20 m/s. Acceleration = −20 m/s ÷ 5 s = −4 m/s^2.

4 Acceleration = change in velocity ÷ time. Acceleration = (final velocity − 25 m/s) ÷ 4 s = −2 m/s^2. Multiply both sides by 4 s, therefore (final velocity − 25 m/s) = −8 m/s. Final velocity = 17 m/s.

5a Acceleration 15 m/s for 60 s; constant velocity 15 m/s for 210 s; acceleration −15 m/s for 30 s.

5b Train travelled (15 × 60) + (15 × 210) + (15 × 30) = 4500 m = 4.5 km.

6 Students' own graphs, showing constant velocity for the first 10 seconds, then decreasing velocity to 0, then increasing velocity

7 Counting the area under the graph where a large square = 2 m and a small square = 0.08 m = approximately 12 m.

Student Book answers

Lesson 7.1e Using an equation for uniform motion

1a velocity at the start of measurement

1b velocity at the end of measurement

2 Acceleration is the rate at which the velocity changes.

3 $v^2 - u^2 = 2as$

$v^2 - 0^2 = 2 \times 7.5\ \text{m/s}^2 \times 50\ \text{m} = 750$, $v = 27\ \text{m/s}$ to 2 significant figures.

4 $v^2 - u^2 = 2as$

$v^2 - 0^2 = 2 \times 4\ \text{m}^2 \times 150\ \text{m} = 1200$, $v = 35\ \text{m/s}$ to 2 significant figures. This is 126 km/h.

5 $v^2 - u^2 = 2as$

$60^2 - 0^2 = 2 \times a \times 720\ \text{m}$

$a = 3600 \div (2 \times 720) = 2.5\ \text{m/s}^2$

6 $s = 0.5 \times 4\ \text{s} \times 3\ \text{m/s}^2 = 6\ \text{m}$

7 $v^2 - u^2 = 2as$

$0^2 - 40^2 = 2 \times -2\ \text{m/s}^2 \times s$

$s = -1600 \div -4 = 400\ \text{m}$

Lesson 7.1.f Free fall

1 Because it is pulled towards the centre of the Earth due to the force of gravity.

2 Because the feather has a larger surface area making it more affected by air resistance or drag.

3 It was high enough to demonstrate that their time of descent was independent of their mass, so that the experiment could be conducted without any interfering factors. Or any suitable answer.

4a It will increase.

4b As the parachutist slows, the air resistance decreases until the forces are in balance and the parachutist reaches a new terminal velocity.

5 $v^2 - u^2 = 2as$

$0^2 - 11^2 = 2 \times 9.8\ \text{m/s}^2 \times s$

$s = -121 \div 19.6 = 6.17\ \text{m}$

6 $v^2 - u^2 = 2as$

$v^2 - 0^2 = 2 \times 9.8\ \text{m/s}^2 \times 2.5\ \text{m} = 49$, $v = 7\ \text{m/s}$

Lesson 7.1g Newton's first law

1 1 N

2 No, the object can be moving at constant speed.

3a same weight

3b opposite directions

4 They are the same.

5 The resultant force is zero.

6 It is a stationary object. Gravity acts downwards, and another contact force acts upwards through the boulder from contact with the ground.

7 The forward thrust is equal to the friction with the air.

8 The cyclist will no longer be travelling at steady speed in a straight line.

9 The Earth would continue to travel at a steady speed in a straight line.

Lesson 7.1h Newton's second law

1 resultant force = 40 N + 40 N − 50 N = 30 N forward

2 resultant force = 1500 N − 1000 N − 500 N = 0 N balanced

3a forward

3b backward

3c balanced

4 The resultant force is now forward.

5 $F = ma$

$4200\ \text{N} = 1200\ \text{kg} \times a$

$a = 4200 \div 1200 = 3.5\ \text{m/s}^2$

6 $F = ma$

$1\ \text{N} = m \times 9.8\ \text{m/s}^2$

$m = 1 \div 9.8 = 0.1\ \text{kg}$

7 $F = ma$

force weight plus force to overcome gravity

$F = 4000 \times 2\ \text{m/s}^2 = 8000\ \text{N}$

weight = mass × 9.8 = 4000 × 9.8 = 39 200 N

acceleration = resultant force ÷ mass

downward $g = 9.8 \div 4000 = 0.0025\ \text{m/s}^2$

accelerate upward $F = 4000\ \text{kg} \times (2 + 0.0025)\ \text{m/s}^2 = 8010\ \text{N}$

8 Inertia is the natural tendency of objects to resist changes in their velocity. Inertial mass = force ÷ acceleration.

Lesson 7.1i Required practical: Investigating the acceleration of an object

1 The trolley moves to the right.

2 Force due to gravity. The mass × acceleration of the falling object, $F = ma$.

3 Change the weight of the falling mass.

4 Increase the mass of the trolley by the same amount.

5 By adding masses to the trolley.

6a The acceleration would increase.

6b The table shows that increase in force leads to increase in acceleration.

7 Students' own graphs; approximately a straight line

8 Force is proportional to acceleration.

9 The acceleration decreases.

10 a straight line

11 Plots of both results are a straight line.

12 It increases six times.

Lesson 7.1j Newton's third law

1 They are equal in size; they act in opposite directions; they act on different objects.

2 The force from the road pushing up on the car.

3a The chairs will move away from each other.

3b Forces act in opposite directions.

4 The force in the opposite direction. Kim moves backwards.

5a The forces are of equal size in opposite directions.

5b The lorry will decelerate less than the car because the lorry probably has more mass than the car.

6 Push the backpack away from the ship; the resultant force means that she will move towards the ship.

7a gravitational force

7b The cat exerts gravitational force upwards on the Earth.

8a normal contact force

8b forward and backward motion on the table (or any suitable answer)

9 weight, resultant force

Lesson 7.1k Momentum

1 velocity = momentum ÷ mass

momentum = velocity × mass

= 20 m/s × 1000 kg = 2000 kg m/s

2 velocity = momentum ÷ mass

= 240 kg m/s ÷ 60 kg = 40 m/s

3a upwards

3b downwards

3c zero

4 forwards and backwards in opposite directions

5 backwards in opposite direction to the football

6 $m_1u_1 + m_2u_2 = (m_1 + m_2)v$

1200 kg × 30 m/s + m × 0 m/s = (1200 kg + m_2) 4 m/s

m_2 = (36 000 ÷ 4) – 1200 = 7800 kg

7 $m_1u_1 + m_2u_2 = (m_1 + m_2)v$

(2 kg × 8 m/s) + (6 kg × 0 m/s) = (2 + 6)v

v = 16 ÷ 8 = 2 m/s

Lesson 7.1l Kinetic energy

1 The adult has a greater mass than the child.

2 food

3a $E_k = ½mv^2$

= ½ × 50 × 4 = 100 J

3b It quadruples.

4 $E_k = ½mv^2$

= ½ × 1200 kg × (30 − 10)^2 m/s

= 600 × 400 m/s = 240 000 J

5 240 km/h = 240 000 ÷ 360 = 66.7 m/s

6a Before it is dropped.

6b As it falls for the first time.

7 It increases its gravitational energy store.

8 GPE = mgh

= 2 kg × 9.8 N/kg × 20 m = 392 N

If all GPE transfers to kinetic energy:

$E_k = 0.5mv^2$

v^2 = 392 ÷ (0.5 × 2)

v = 19.8 m/s

Student Book answers

Lesson 7.1m Stopping distances

1a 18 m/s

1b 24 m

1c 36 m

2 80 km/h = 22 m/s, distance = 14 + 36 = 50 m

3 It increases more and more.

4 The braking distance will increase.

5 Kinetic energy is transferred away from a vehicle that is slowing down. Work done by the friction force between the brakes and the rotating wheel reduces the kinetic energy of the vehicle. Energy is transferred to the brake pads, which heat up.

6 estimate mass of car as 1000 kg
estimate deceleration as 25 m/s
$E_k = 0.5(mv^2) = 0.5 \times (1000 \times 625) = 312\ 500$ J (or Nm)
estimate braking distance as 100 m
work done = Fs
F = work done / s = 3125 N to 3 significant figures = 3130 N or 3.13 kN

End of chapter questions

1 newton [1 Mark]

2 c: mass [1 Mark]

3 It has both magnitude and direction. [1 Mark]

4 speed = 100 m / 5 s = 20 m/s [1 Mark]

5a The distance stays the same, and so the object is stationary. [3 Marks]

5b graph showing 0 velocity over time [2 Marks]

6a m = 1500 kg, v = 30 m/s, time to v = 0 = 6 s
momentum = velocity × mass = 30 × 1500 = 45 000 kg m/s [1 Mark]

6b $a = -30$ m/s ÷ 6 s $= -5$ m/s^2 [1 Mark]

6c $F = ma = 1500 \times -5 = -7500$ N [1 Mark]

7 an object travelling at constant speed [1 Mark]

8 Two from: speed of the car, condition of the road, condition of the tyres, driver's response time [2 Marks]

9 The speed of the object remains constant. The velocity of the object changes. [2 Marks]

10 At constant speed acceleration is 0. Force is mass × acceleration + force needed to oppose friction = 1500 N. [1 Mark]

11 u = 10 m/s
v = 0 m/s
$a = -9.8$ m/s^2
$v^2 - u^2 = 2as$
$0 - (10\text{ m/s})^2 = 2 \times -9.8\text{ m/s}^2 \times s$
$-100\text{ m}^2/\text{s}^2 = -19.6\text{ m/s}^2 \times s$
$s = 100\text{ m}^2/\text{s}^2 \div 19.6\text{ m/s}^2 = 5.1$ m [2 Marks]

12 Forces in a pair act in opposite directions. [3 Marks]

13 The marks are in three bands according to the level of response.
Level 3 (5/6 marks): A detailed and coherent explanation covering all major steps. Each statement is logically linked to the next one. Appropriate scientific terminology is used.
Level 2: (3/4 marks): Some detail lacking but each statement is logically linked to the next one.
Level 1: (1/2 marks): Some correct statements but lacks detail and the steps are not logically linked.
No relevant content: 0
Indicative content:

- Glider is released at the left end of the air track / given a gentle push
- Card attached to the glider passes through both gates as the glider moves
- Glider moves on a cushion of air reducing friction
- Check that glider travels at a steady speed along the air track when there is no accelerating force present (friction compensation)
- Glider is travelling at a steady speed if the readings on the timers connected to both light gates have the same value
- Adjust height of one end of track until track compensated for friction
- The weights attached by string to the glider provide the force that accelerates the glider
- Measure length of card (to nearest millimetre)

- Use equation speed = distance travelled/time taken to calculate the glider's velocity as it passes through each light gate
- Time values are obtained automatically using electronic timers
- Measure distance between the light gates (to nearest millimetre)
- Find acceleration from (final velocity)^2 − (initial velocity)^2 = 2 × acceleration × distance
- For each value of force, time measurements should be repeated and calculated values for acceleration averaged
- Plot a graph of acceleration against force acting on the glider

[6 Marks]

14a upwards; normal contact force [2 Marks]

14b $v = \sqrt{2as}$ or $v^2 = 2as - 0 = \sqrt{(2 \times 9.8 \times 0.75)}$;
3.83(4) 3.8 m/s (2 significant figures) [4 Marks]

15 a = 3500/1500 = 2.33 m/s^2
$v^2 = u^2 - 2as$
$s = (25)^2/(2 \times 2.33)$ = 133.9(2) m
130 m (2 significant figures) [4 Marks]

16 The marks are in three bands according to the level of response.
Level 3 (5/6 marks): A detailed and coherent explanation covering all major steps. Each statement is logically linked to the next one. Appropriate scientific terminology is used.
Level 2: (3/4 marks): Some detail lacking but each statement is logically linked to the next one.
Level 1: (1/2 marks): Some correct statements but lacks detail and the steps are not logically linked.
No relevant content: 0
Indicative content:

- Before the collision, the red ball had no momentum because it was stationary
- Before the collision, the total momentum equals the momentum of the white ball
- After the collision, the white ball has no momentum because it is stationary
- After the collision, the total momentum equals the momentum of the red ball
- This is a closed system since there is no friction
- Total momentum after the collision = total momentum before the collision
- So momentum of red ball after the collision = momentum of white ball before the collision
- Momentum = mass × velocity
- So if the red ball's velocity after the collision equals the white ball's velocity before the collision then the balls must have the same mass
- Since the velocity is the same, then the red ball must be moving in the same direction that the white ball moved

[6 Marks]

[Total 45 Marks]

Chapter 7.2: Electricity

Lesson 7.2a Electric current

1 The circuit must have a source of potential difference, and the circuit must be a complete loop with no gaps.

2 From positive to negative.

3 $Q = It$
$I = Q/t$ = 80/16 = 5 A

4 $Q = It$
$t = Q/I$ = 96/6 = 16 s

Lesson 7.2b Current, resistance and potential difference

1 Electrons 'pushed' around a circuit by a battery bump into the metal atoms in the conductor making metal atoms vibrate and the conductor hotter. The increased vibrations of the atoms make it harder for the electrons to travel through the conductor, so its resistance increases. The filament in a lamp connected in a circuit becomes so hot that it emits light.

2 $Q = It = 1 \times 60 = 60$ C

1 V = 1 J/C

6 V = 6 J/C = 6/60 = 0.1 V

3 An ammeter is connected in series to measure the current flowing through the circuit. A voltmeter is connected in parallel with a circuit component to measure the difference in charge from one side to the other.

4 $V = IR$

$R = V/I = 12/3 = 4\ \Omega$

5 $V = IR = 1.5 \times 6 = 9$ V

Lesson 7.2c Key concept: What's the difference between potential difference and current?

1 The jumper has become charged and a current of electricity is produced when it is pulled over the head.

2 Use two car batteries of 12 V each placed in series.

3 Only if the discharge current is also high.

4 $P = VI = 230 \times 0.05 = 11.5$ W

5 $V = IR$

$R = V/I = 230/0.05 = 4600\ \Omega$

Lesson 7.2d Ohmic and non-ohmic conductors

1 Potential difference is proportional to current.

2 voltmeter

3 The graph is not a straight line, so current is not proportional to potential difference, and therefore it does not obey Ohm's law.

4 The resistance changes as the temperature changes; because $V = IR$, the potential difference and current values change depending on the change in resistance.

5a $R = V/I$

at 1 V: $R = 1/0.2 = 5\ \Omega$

at 5 V: $R = 5/0.39 = 12.8\ \Omega$

5b Students' own graphs, showing a straight line to represent the time immediately after the lamp is switched on, when the values of V and I are low.

Lesson 7.2e Control circuits

1 As the temperature increases, the resistance of the thermistor decreases.

2 Resistance is not proportional to temperature – the graph is not a straight line.

3 Resistance values at high temperature are lower than those at low temperature.

4 As light levels increase, the resistance decreases.

5 If the LDR is covered, the resistance is high and current is low. When the LDR is uncovered, resistance is low and current increases.

6 When the potential difference is negative there is no current flow, so resistance is high.

Lesson 7.2f Required practical: Investigate, using circuit diagrams to construct circuits, the *I–V* characteristics of a filament lamp, a diode and a resistor at constant temperature

1 An ammeter is connected in series to measure the current flowing through the circuit. A voltmeter is connected in parallel with a circuit component to measure the difference in charge from one side to the other.

2 Current is the independent variable, and potential difference is the dependent variable.

3 To stop any change from temperature increase.

4 Current is proportional to potential difference.

5 Current is not proportional to potential difference.

6 The filament lamp is a non-ohmic device.

7 There is no current at negative potential difference because resistance is high.

8 Resistance increases as temperature increases, so the component becomes non-ohmic. So Ohm's law no longer applies for data analysis.

Lesson 7.2g Series and parallel circuits

1 Series circuit: close the switch; remove a lamp from the circuit. Parallel circuit: close the switch.

2 The brightness decreases.

3 Series circuit: all the lamps would stop shining. Parallel circuit: no difference.

4a $V = IR$, $I = V/R = 12/10 = 1.2$ A

4b $R_{total} = R_1 + R_2 = 30\ \Omega$

4c $V = V_1 + V_2 = 12 - 4 = 8$

4d The current through the lamp would decrease.

5a $V = I \times R$

$I = V/R = 12/20 = 0.6$ A

5b $V = I \times R = 1.2 \times 10 = 12$ V

5c Smaller: the total resistance of a parallel circuit is always smaller than the smallest resistance of any component.

5d If the resistance increases then the current will decrease.

Lesson 7h Required practical: Use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits, including the length of a wire at constant temperature and combinations of resistors in series and parallel

1 $R = V/I$. So as the potential difference increases, the current increases.

2 Potential difference is 0 − 12 V. If the resistance increases then the current will decrease.

3 The temperature increases.

4 Potential difference, current, length of wire.

5a The resistance will increase as the length of wire increases.

5b Students' own graphs showing length of wire versus resistance.

6 Any suitable answer such as turning the current off between measurements.

7a Students' own diagrams, based on Figure 7.2.21 in the Student Book, showing a voltmeter around a component and an ammeter in the circuit.

7b For series combined resistance or individual components: the total resistance is the sum of all the resistances. For parallel combined resistance and individual components: the total resistance is always smaller than the smallest resistance of any component.

8a First resistor $R = V/I = 6/0.1 = 60\ \Omega$. Second resistor = 3/0.2 = 15 Ω. In series = 3.9/0.05 = 78 Ω. The combined resistance is not the sum of the individual components.

8b The resistance may be changing, for example due to an increase in temperature.

Lesson 7.2i Electricity in the home

1 Alternating potential difference changes current direction.

2 The curves would be lower and more spaced apart.

3 Plastic forms an insulating layer.

4 To prevent confusion and danger of electric shock.

5 A cell or battery has two terminals, positive and negative. Live, neutral and earth wires can be seen in a plug. In a battery, the current is d.c. Mains electricity has a much higher potential difference.

6 If the appliance is working properly, there should be no current in the earth wire. If the appliance is faulty and the person receives an electric shock, then the charge flows safely down the earth wire.

Lesson 7.2j Power

1 kettle

2 Work = power × time. The television might be used for longer than the food blender.

3 $P = W / t = 108\,000 / 120 = 900$ W

4 $W = P \times t = 2000 \times 30 = 60\,000$ J = 60 kJ

5a W = force × distance = 4000 N × 6 m = 24 000 J

5b $P = W / t = 24\,000 / 20 = 1200$ W

6a W = force × distance = 800 N × 5 m = 4000 J

6b $P = W / t = 4000$ J / 10 s = 400 W

7 Force to move Louis's weight is 10 × 60 kg = 600 N.

Work done = 600 N × 300 m = 180 000 J

Power = 180 000 J / 900 s = 200 W

8 Force to move Emma's weight = 10 × 60 kg = 600 N

Total height = 10 cm × 20 step-ups = 200 cm = 2 m

Work done = 600 N × 2 m = 1200 J

Power = 1200 J / 30 s = 40 W

9a 108 km/h = 108 000 m / 360 s = 300 m/s. So car moves 300 m in 1 second.

9b Work done = 1000 N × 300 m = 300 000 J

Power = work done / time taken

= 300 000 J / 1 s = 300 000 W

Lesson 7.2k Power of an electrical device

1 Increase the speed of flow of electrons.

2 The 850 W microwave.

3 $P = V \times I$

$I = P / V$ = 1100 W / 230 V = 4.78 A

4a $P = V \times I$ = 230 V × 4 A = 920 W

4b $P = I^2 \times$ R

$R = P / I^2$ = 920 / 4^2 = 57.5 Ω

5a $P = V \times I$

$I = P / V$ = 36 W / 12 V = 3 A

5b $P = I^2 \times R$

$R = P / I^2$ = 36 W / 3^2 A = 4 Ω

Lesson 7.2l Power and domestic appliances

1 Energy is transferred from the a.c. mains supply to the thermal energy store of hot water.

2a The electric drill transfers energy from the a.c. mains supply and stores it as kinetic energy.

2b Power = work / time = 400 J / 1 s = 400 W

3 P = 2.5 kW = 2500 W

$E = Pt$ = 2500 J/s × (46 × 60) s = 6 750 000 J = 6750 kJ

4 $E = Pt$

$P = E / t$ = 10 000 J ÷ 5 s = 2000 J/s = 2000 W

5 $E = Q \times V$ = 30 C × 230 V = 6900 J

6 $V = E / Q$ = 1800 J / 75 C = 24 V

7a $E = Pt$ = 1150 W × (5 × 60) s = 345 000 J

$E = QV$

$Q = E / V$ = 345 000 J / 230 V = 1500 C

7b Estimating factory appliance voltage as 11 000 V (from Figure 7.2.39 in the Student Book): 345 000 J / 11 000 V = 31 C.

Lesson 7.2m The National Grid

1 Electrical power in your house can come from lots of different power stations in case one breaks down.

2 National: a collection of power cables and transformers that connect power stations to factories and houses across the UK. Grid: everything is connected up in a grid so that electrical power can be transferred along many different routes.

3 A potential difference of 400 000 V is very large.

4 Wasted energy makes the Grid less efficient.

5 Increasing the potential difference reduces the current; the lower the current the less energy is wasted as heat.

6 Between the National Grid and homes.

7 To maximise the energy transferred to the National Grid.

8 The birds are not touching the ground, so there is no complete circuit for the current to pass through the birds' bodies to the Earth, so they do not get an electric shock.

Lesson 7.2n Maths skills: Using formulae and understanding graphs

1a $V = IR$ = 10 A × 100 Ω = 1000 V

1b $V = IR$ = 5 A × 3 Ω = 15 V

2 $R = V/I$

3 $P = VI$ = 230 V × 5 A = 1150 W

4 $I = P/V$

5 $P = VI = (IR) \times I$ = (5 × 1000) × 5 = 25 000 W

6 Current is proportional to potential difference.

7 The graph would be a curve rather than a straight line.

Lesson 7.2o Maths skills: Calculations using significant figures

1 $E_p = mgh$ = 70 kg × 9.8 N/kg × 2 m = 1372 J

2 $E_p = mgh$ = 0.05 kg × 9.8 N/kg × 10 m = 4.9 J

3 E_e = 350 N/m = 350 N × 0.09 m = 31.5 J or 32 to 2 significant figures

Student Book answers

End of chapter questions

1 green/yellow stripe [1 Mark]

2 letter V inside a circle [1 Mark]

3 in series [1 Mark]

4 The National Grid is a collection of power cables and transformers that connect power stations to factories and houses across the UK. Everything is connected up in a grid so that electrical power can be transferred along many different routes. [2 Marks]

5 Neutral wire should connect to bottom left pin, earth wire should connect to the top pin. [2 Marks]

6 $Q = It$

$I = Q / t$ = 100 C / 20 s = 5 A [2 Marks]

7 a box with a bent line through it [1 Mark]

8 frequency is 50 Hz; voltage is 230 V [2 Marks]

9 $V = IR$

V = 0.5 A × 20 Ω = 10 V [1 Mark]

10 All the lamps will dim. [2 Marks]

11 $P = VI$

$I = P / V$ = 2000 W / 230 V = 8.7 A [2 Marks]

12 The resistance increases. [1 Mark]

13 A fuse is always connected in the live wire. If the current becomes higher than the fuse's rating then the fuse will melt and switch off the circuit. [2 Marks]

14a Students' own circuit diagrams, based on Figure 7.2.10 in the Student Book [2 Marks]

14b The marks are in two bands according to the level of response.

Level 2 [3–4 Marks]: A detailed and coherent explanation of the processes involved in fractional distillation, presented in a logical sequence.

Level 1 [1–2 Marks]: Separate, relevant points made. The steps may not be presented in a logical sequence.

No relevant content: [0 Marks]

Indicative content:

- Measure the length of wire (connected in the circuit) using a metre rule
- Record the ammeter and voltmeter readings
- Divide the voltmeter reading by the ammeter reading to get the resistance of the wire
- Repeat the procedure for several different lengths of wire (connected in the circuit)
- Repeat the measurements for the same lengths of wire
- Calculate the mean of the two resistance values for each length
- Plot a graph of resistance against length

[4 Marks]

14c Same thickness/diameter of wire, or same temperature. [1 Mark]

15 $I = V / R$ = 12 V / 8 Ω = 1.5 A [2 Marks]

16 C was a filament lamp; D was a high-valued resistor [2 Marks]

17a $V = IR$; $I = V_2 / (R_1 + R_2)$ = 5 V / (6 + 10 Ω) = 0.31 A [1 Mark]

17b 0.31 A [1 Mark]

17c $V = IR = V_1$ = 0.31 A × 6 Ω = 1.88 V [1 Mark]

17d $V_T = V_1 + V_2$ = 1.88 V + 5 V = 6.88 V [1 Mark]

18 $P = VI$ and $V = IR$, therefore $P = (IR) \times I$ or $P = I^2R$ [1 Mark]

19 Resistors in series: the total resistance is the sum of all the resistances. Resistors in parallel: adding a resistor decreases the total resistance because an alternative path for the electric charge is provided. [2 Marks]

20 $E = Pt$ = 60 W × 60 s = 3600 J [2 Marks]

21 The food mixer

Kettle $E = Pt$ = 3000 W × 20 s = 60 000 J

Microwave E = 920 W × 60 s = 55 200 J

Torch $E = Pt$, $P = VI$, therefore $E = VIt$ = 12 V × 5 A × 200 s = 12 000 J

Food mixer $E = VIt$ = 230 V × 6 A × 50 s = 69 000 J [2 Marks]

22 $R = V/I$, so $I = V/R$ [1 Mark]; $Q = It$ [1 Mark]; substitute $I = V/R$ into $Q = It$ giving $Q = It/R$ [1 Mark] = (5 × 180)/200 = 4.5C [1 Mark]

[Total 46 Marks]

Chapter 7.3: Acids and alkalis

Lesson 7.3a Reaction of metals with acids

1 magnesium chloride

2 iron + sulfuric acid → iron(II) sulfate

3 $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

4 $Fe + 2HCl \rightarrow FeCl_2 + H_2$

5 $Zn - 2e^- \rightarrow Zn^{2+}$

$2H^+ + 2e^- \rightarrow H_2$

6 Iron is oxidised, and the hydrogen atom is reduced.

7 $2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$

$2Al - 6e^- \rightarrow 2Al^{3+}$

$6H + 6e^- \rightarrow 3H_2$

Lesson 7.3b Making salts

1 To ensure that the reaction is completed.

2 Heating produces a more concentrated solution and a more concentrated (saturated) solution will form crystals.

3 To ensure that no impurities mix with the crystals.

4 Check the melting point.

5 $ZnCl_2$

6 $Cu(NO_3)_2$

7 $CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$

Lesson 7.3c Reactions of carbonates with acid

1 zinc carbonate + sulfuric acid → zinc sulfate + water + carbon dioxide

2 copper carbonate + nitric acid → copper nitrate + water + carbon dioxide

3 zinc nitrate

4 copper sulfate

5 Turns limewater 'milky/cloudy'.

6 Reacts with acids to produce carbon dioxide, carbon dioxide would turn limewater 'milky'.

7 $4H^+(aq) + 2CO_3^{2-}(aq) \rightarrow 2CO_2(g) + 2H_2O(l)$

Lesson 7.3d Required practical: Preparing a pure, dry sample of a soluble salt from an insoluble oxide or carbonate

1 magnesium oxide (or carbonate) and sulfuric acid

2 Weight for the magnesium oxide, and volume for the sulfuric acid.

3 Magnesium oxide in grams, sulfuric acid in millilitres.

4 Safeguarding against splashing when adding to the warm acid.

5 Some unreacted magnesium oxide will be left.

6 filtration

7 Heating the concentrate slightly and leave to cool – the remaining water will evaporate and the salt will crystallise to produce a solid salt. Then the crystals are obtained by evaporating the water out.

8 Crystals should be washed in distilled (pure) water, dried and recrystallised.

9 Check the melting point.

10 Impurities will change the melting point.

11 More readings will give a more accurate average result.

12 $MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + CO_2 + H_2O$

13 $MgCO_3$ 4.2 g; H_2SO_4 4.9 g

14 To ensure that the reaction has gone to completion and the solution is saturated.

15 The yield will decrease.

16 The difference was not significant for any reading because the experiment melting point measurements were more than a 0.2°C difference from the data book value. Alex's result is the most accurate because it is the nearest to the data book value.

Lesson 7.3e Key concept: Energy changes and reactions

1 exothermic

2 8 g

3 Students' own graphs plotted using the data given in the table; exothermic reaction up to 25 ml acid added; reaction completed after 25 ml added

4 The polystyrene cup does not affect the temperature of the reaction.

5 Keep constant the mass of citric acid and sodium hydrogen carbonate. Change the cup, or any other suitable answer.

6 The indicator may affect the alkali concentration. The acid may drip near the

thermometer when adding it. Heat may be lost from the cup. Improve by mixing the alkali solution when adding the acid or adding an insulated lid.

Lesson 7.3f Required practical: Investigate the variables that affect temperature changes in reacting solutions, such as acid plus metals, acid plus carbonates, neutralisations, displacement of metals

1 Temperature would depend on reactant and concentration.

2 Type of first metal, type of ions of second metal, concentration of first metal, concentration of second metal.

3 Each variable would change the reaction, so to monitor change one variable should be altered at a time.

4 The size of the metal or the volume of acid added.

5a 7.2, 5.4, 11.1, 3.7

5b Value for 1 mol dm/cm^3 is anomalous (The 11.1 temperature change). This measurement should be discarded.

5c The more concentrated the acid, the greater the temperature change.

6a Evidence shows their hypothesis is correct.

6b It is insoluble, so the same reagents cannot be used to repeat the experiment.

6c So the container would not heat up and affect the temperature readings.

Lesson 7.3g The pH scale and neutralisation

1 hydrogen

2 1^-

3 Left (red) is acid pH 0, and right (purple) is alkali pH 14.

4 It will change to green.

5 Hydrogen and hydroxide ions react to form water.

6 $2H^+(aq) + O^{2-}(aq) \rightarrow H_2O(l)$

Lesson 7.3h Strong and weak acids

1 hydrogen, nitrogen and oxygen

2 Has a high pH; in water only a few of the acid molecules become ions; does not ionise fully.

3 The concentration of hydrogen ions.

4 pH 0 to 1

5 0.5 litres of water = 0.5 dm^3
60 g in 0.5 dm^3 = concentration of 120 g/dm^3

6 100 cm^3 water = 0.1 dm^3
6 g in 0.1 dm^3 = concentration of 60 g/dm^3

End of chapter questions

1 b: magnesium oxide [1 Mark]

2 c: hydrogen [1 Mark]

3 b: endothermic [1 Mark]

4 The colour in the flask changes from acid (red) to neutral green. When excess sodium carbonate is added, the colour changes to more alkali (blue). [2 Marks]

5 Ignites a glowing splint with a pop sound. [1 Mark]

6 10 : 1 [2 Marks]

7 2 g [1 Mark]

8 The concentration of the acid; the concentration of the metal; the container in which they are reacting. [3 Marks]

9 Turns limewater 'milky' (cloudy). [1 Mark]

10a The reaction bubbles and a gas is given off. [1 Mark]

10b $MgCO_3(aq) + HNO_3(aq) \rightarrow MgNO_3(aq) + H_2O(l) + CO_2(g)$ [1 Mark]

11 Add the zinc to sulfuric acid, stir, warm if necessary, and continue until no more of the solid reacts and the solid is in excess.
$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
Filter off the excess solid to leave a solution of the salt.
Heat the salt solution a little to concentrate it.
Leave the concentrate to cool – the remaining water will evaporate and the salt will crystallise to produce a solid salt.
To remove impurities, rinse the crystals with distilled water and recrystallise.
Check the purity by measuring the melting point.
[6 Marks]

12 Low concentration of hydrogen ions. [1 Mark]

13 $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ [1 Mark]

14 Should use an insulated beaker / polystyrene cup (with a lid) to reduce transfer of thermal energy to the air rather than take temperature reading immediately; should stir and record the maximum temperature reached. [4 Marks]

15a aluminium sulfate + water [2 Marks]

15b $Al_2O_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2O$

[1 Mark for formula Al_2O_3; 1 Mark for formula $Al_2(SO_4)_3$; 1 Mark for correct balancing]

[Total 32 Marks]

Chapter 7.4: Rate and extent of chemical change

Lesson 7.4a Progress of a reaction

1 1.7 g

2 Between 0 and 2 minutes. The reaction is fastest at this time.

3 18 cm^3

4 60 s

5 Carry out the reaction with different starting concentrations of sodium thiosulfate.

6 The reaction is very slow; there may be discrepancy in estimating the time for the cross to disappear. The precipitate may not form equally over the bottom of the flask. Measure the time for an amount (1 g) of sulfur to be produced. Use bigger reaction volumes to get more accurate measurements. Or any other suitable answer.

Lesson 7.4b Calculating rates

1a medium

1b fast

1c slow

2 mean rate of reaction = quantity of product formed / time taken = 30 cm^3 / 50 s = 0.6 cm^3/s

3 mean rate of reaction = quantity of product formed / time taken = 30 cm^3 / 20 s = 1.5 cm^3/s

4 mean rate of reaction = quantity of product formed / time taken = 50 cm^3 / 20 s = 2.5 cm^3/s
mean rate of reaction = quantity of product formed / time taken = 64 cm^3 / 40 s = 16 cm^3/s

5a blue 1 cm^3/s; red 1.75 cm^3/s

5b blue 0 cm^3/s; red 0.6 cm^3/s

Lesson 7.4c Factors affecting rate

1 Increases the rate of reaction.

2 Small pieces.

3 56 s

4 Increase in temperature decreases the time taken for the cross to disappear as the reaction is faster.

5 Temperature is being changed. All other variables should be kept the same.

6 The time would decrease, and the reaction rate would increase.

7 Experiment is not valid, because two variables were changed at the same time.

8 Students' own graphs, based on Figure 7.4.11 in the Student Book, with *x* and *y* axes labelled 'Concentration' and 'Time taken', respectively.

Lesson 7.4d Effect of surface area on reaction rate

1 1g of powdered calcium carbonate.

2 Fine powders such as flour can be ignited easily.

3 The honeycomb framed structure affords a larger surface area for the harmful cases to come into contact with. Coating thinly means that smaller quantities are needed for the large surface area.

4 1.5 g

5 The smaller the chip size, the shorter the time taken to produce carbon dioxide.

6 mean rate of reaction = quantity of product formed / time taken
single chip: = 2.2 g / 480 s = 0.00458 g/s/
small chip: = 2.2 g / 300 s = 0.0073 g/s 5 min
powder: = 2.2 g / 48 s = 0.0458 g/s

7 All experiments started with the same mass of reactants.

8 Increase the concentration of magnesium (to increase the rate); increase the concentration of hydrochloric acid (to increase the rate); increase the temperature (to increase the rate).

Lesson 7.4e Collision theory

1 Increasing the pressure will increase the number of collisions.

2 Particles move faster as the temperature increases. The reacting particles of magnesium and dilute hydrochloric acid have more kinetic energy, and so the number of successful collisions increases and the rate of reaction increases.

3 The particles are more crowded in the same volume, there are more collisions, and so there are more chances of successful collisions, and the rate of reaction increases.

4 rate is 5×10^{10} collisions per second
for 1×10^6 collisions, time taken is
$1 \times 10^6 / 5 \times 10^{10} = 0.2 \times 10^{-4}$ s $= 2 \times 10^{-5}$ s

Lesson 7.4f Maths skills: Use the slope of a tangent as a measure of rate of change

1a 0–30 s

1b 30–40 s

1c 40–60 s

2a The rate of collision between particles is fastest.

2b There are no successful collisions between particles.

3a 59.5 cm^3 – 21 cm^3 = 38.5 cm^3

3b mean rate = 38.5 cm^3 / 20 s = 1.93 cm^3/s

3c mean rate = 21 cm^3 / 10 s = 2.1 cm^3/s

3d The gradient between 10 and 30 seconds is smaller. The reaction rate decreases with time so the gradient decreases with time.

4a 42/15 = 2.8 cm^3/s

4b 52/40 = 1.3 cm^3/s
The gradient for the red line is less. So the rate of reaction for the red line is less. It may be that the concentration of acid is lower or the temperature is lower for the red reaction.

5a 2.7 cm^3/min

5b 8.5 cm^3/min =0.141 cm^3 in 1 second

Lesson 7.4g Required practical: Investigate how changes in concentration affect the rates of reactions by a method involving the production of a gas and a method involving a colour change

1 The higher the temperature, the more chances of successful particle collisions taking place.

2 Concentration of acid.

3 Amount of carbonate, size of carbonate fragment, temperature, air pressure.

4 To measure the amount of hydrogen released.

5 The stopper needs to be put quickly in the bottle. The stopclock needs to be started.

6 Effect of temperature on the reaction between acid and calcium carbonate.

7 Second 10 s reading at 30°C is too high.

8 Students' own graphs, plotted using the data from the table given in the Student Book.

9 Increase in temperature increases the rate of reaction.

10 mean rate = 52 cm^3 / 40 s = 1.3 cm^3/s

11 Their data support the conclusion, but after 50 s there is no increase in volume of gas with temperature because all the reactions have completed.

12 They performed each experiment twice.

13 They used the same apparatus and method for all the reactions.

14 Insulate the reaction flask, monitor the temperature of the reaction, repeat the experiment a third time, or any suitable answer.

15 Change one of the variables such as using different components.

16 Increase in temperature increases kinetic energy, therefore the number of successful collisions, so that the reaction rate is faster.

Lesson 7.4h Activation energy

1 The energy from a lighted match.

2 Students' own diagrams, based on Figure 7.4.26 in the Student Book.

3 Students' own diagrams, based on Figure 7.4.25 in the Student Book.

4 exothermic

5 Students' own diagrams, based on Figure 7.4.27 in the Student Book, but with 'Energy taken in during reaction' (upward arrow) and 'Activation energy' arrow pointing downward.

Lesson 7.4i Bond breaking and bond formation

1 Students' own diagrams, based on Figure 7.2.29 in the Student Book, but using the profile from Lesson 7.4h Q5.

2 Bond energy C−H 3 × 412 kJ/mol; C−C 368 kJ/mol; C−O 352 kJ/mol, C=O 532 kJ/mol, O−H 465 kJ/mol = 2953 kJ/mol

3 Reactants: C−H 12 × 412 kJ/mol + C−C 4 × 368 kJ/mol + O=O 8 × 498 kJ/mol = 10 400 kJ/mol (individual molecules values are 4944 1472 3984)
Products: C=O 10 × 532 kJ/mol + O−H 12 × 465 kJ/mol = 10 900 kJ/mol (individual molecules values are 5320 and 5580)
Energy change is −500 kJ/mol

4 $CH_2=CH_2 + H_2 \rightarrow C_2H_6$
Reactants: C=C 614 kJ/mol + C−H 4 × 412 kJ/mol + H−H 432 kJ/mol = 2694 kJ/mol
Products: C−C 368 kJ/mol + C−H 6 × 412 kJ/mol = 2840 kJ/mol
Energy release is 146 kJ/mol

Lesson 7.4j Catalysts

1 Magnesium chloride and copper chloride are not catalysts; copper is a catalyst.

2 $Zn + H_2SO_4 + Cu \rightarrow ZnSO_4 + H_2 + Cu$

3 Vanadium oxide increases the rate reaction of sulfur dioxide gas with oxygen gas.

4a $2H_2O_2 \rightarrow 2H_2O + O_2$

4b Catalase enzyme, lowers the activation energy of the reaction to 23 kJ/mol.

4c Greater than 58 kJ/mol (actual activation energy is 75 kJ/mol). Catalysts lower the activation energy to 58 kJ/mol or lower.

4d To catalyse the reaction to H_2O and O_2, to prevent the harmful oxidising effects of hydrogen peroxide.

Lesson 7.4k Enzymes

1 An enzyme is a biological catalyst.

2 Enzymes help to break down large molecules into smaller ones, build large molecules from smaller ones and change one molecule into another molecule.

3 Because the optimum temperature for reaction is 37°C, so the reaction will be slower at 60°C than 40°C.

4 Each enzyme fits only a specific substrate, like a key fits into a specific lock.

5 An enzyme does not increase the number of collisions per second. Instead, it works by making the collisions that take place more successful. This ensures the successful collisions have enough energy to overcome the activation energy.

Lesson 7.4l Required practical: Investigate the effect of pH on the rate of reaction of amylase enzyme

1a 10 cm^2 calibrated measuring cylinder

1b 10 cm^2 calibrated dropping pipette

2 Time taken is related to total amount of iodine added.

3 Iodine is toxic and should not be ingested, wear gloves and safety goggles to protect skin and eyes.

4 orange

5 To determine the time for the colour reaction to occur.

6 To get a rough idea of when to take measurements.

7 Every 10 s.

8 A line graph when comparing changes over a period of time.

9a Taking means of replicates makes the results more accurate.

9b Run 2 pH 9.

9c Remove it from the data.

10 Mean time: pH 5 157 s; pH 6 73 s; pH 7 43 s; pH 8 73 s; pH 9 120 s.

11 Reaction rate: pH 5 0.0064 s^{-1}; pH 6 0.014 s^{-1}; pH 7 0.23 s^{-1}; pH 8 0.014 s^{-1}; pH 9 0.0083 s^{-1}.

12 Students' own graphs, plotted from the data given in the answer to question 11

13 Amylase is an enzyme that works most efficiently at pH 7. This pH must be the reaction conditions at which it acts in the body. So pH 7 is the optimum pH at which to use this enzyme.

Lesson 7.4m Reversible reactions

1a irreversible

1b reversible

1c reversible

2 It is reversible; water can be evaporated to recover the sodium chloride.

3 Energy is transferred into the reaction.

4 Increasing the pressure increases the number of collisions, so the forward reaction rate is faster. The position of the equilibrium moves in the direction where there are the least molecules.

Lesson 7.4n Dynamic equilibrium

1 If gas is lost the reaction cannot be reversed so equilibrium is not reached.

2 The forward and backward reactions take place at the same rate the reaction has reached equilibrium and the overall effect is no change.

3 Over to the left.

4 The system will respond by making more A + B, so the equilibrium will shift to the left.

5 The reaction shifts to the left; after HCl the reaction would shift to the right.

Lesson 7.4o Effect of concentration on position of equilibrium

1 sulfur trioxide

2 Remove the methanol after it has been produced.

3 More lead chloride would be produced and a precipitate would form.

Lesson 7.4p Effect of temperature on position of equilibrium

1a Reactants 54%, products 46%

1b Reactants 58%, products 42%

2 To make more product the temperature must be raised. This means that the forward reaction is transferring in energy − endothermic.

3 To make more product the temperature must be lowered. This means that the forward reaction is transferring out energy − exothermic.

4a To make more product the temperature must be raised. This means that the forward reaction is transferring in energy.

4b If the forward reaction is transferring in energy it is endothermic.

4c To make more product the pressure must be lowered. At higher pressures there is more kinetic energy, therefore the reaction goes backwards to counteract this.

Lesson 7.4q Effect of pressure on position of equilibrium

1 Reactants 48%, products 52%.

2 Increase in pressure reduces the percentage of product.

3a Reactants 5 molecules, products 4 molecules, increase in pressure.

3b Reactants 2 molecules, products 3 molecules, decrease in pressure.

3c Reactants 2 molecules, products 3 molecules, decrease in pressure.

Lesson 7.4r Translate information between graphical and numerical form

1 13%

2 18°

3 54%

4 250 atm

5 Students' own pie charts, drawn using the data given in the Student Book

6 Students' own graphs, drawn using the data given in the Student Book

End of chapter questions

1 d: exothermic [1 Mark]

2 two from: concentration, surface area, pressure [2 Marks]

3 a: catalyst [1 Mark]

4 the third tube with the powder [1 Mark]

5 Carbon dioxide gas is given off. [2 Marks]

6 d: Increases from zero [1 Mark]

7 The reactant particles must collide with enough energy for the particles to react. [2 Marks]

8 an arrow going both ways [1 Mark]

9 increases the number of collisions [2 Marks]

10 to increase the rate of the reaction [2 Marks]

11 Place the reactants in a flask. Seal the lid. Collect the hydrogen into a graduated syringe. Measure the amount of hydrogen released over fixed time intervals under different conditions. [4 Marks]

12 The weight of the marble chips and the weight of the marble powder should be the same. The amount of acid added should be the same in both reactions. [2 Marks]

13a temperature [1 Mark]

13b amount of aqueous hydrochloric acid or amount of solid potassium chloride [1 Mark]

13c no anomalous results [1 Mark]

13d Volume of gas collected increases with increase in temperature. [1 Mark]

14 When the pressure is increased in a gaseous reaction then it moves the equilibrium towards to side of the reaction with fewer gaseous molecules. In this reaction 4 molecules of gas react to create 2 molecules of gas as products, so increasing the pressure will drive the reaction to produce more NH3 [2 Marks]

15 A decrease in pressure will move the position of equilibrium to the left, to the side with most molecules / 2 to 3 molecules. This decreases the yield of nitrogen dioxide. [2 Marks]

16a Reactant bond energy = $(4 \times 414) + (2 \times 498) = 2652$

Product bond energy = $(2 \times 806) + (4 \times 465) = 3472$

Overall energy change = 2652 – 3472 = –820 kJ/mol. Negative sign not essential. [4 Marks]

16b $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

Reactant bond energy = $(8 \times 414) + (5 \times 498) + (2 \times 346) = 6494$

Product bond energy = $(6 \times 806) + (8 \times 465) = 8556$

Overall energy change = 6494 – 8556 = –2062 kJ/mol. Negative sign not essential.

Propane gives out (1242 KJ/mol) more energy than methane. [4 Marks]

[Total 37 Marks]

Chapter 7.5: Atoms into ions and ions into atoms

Lesson 7.5a A reactivity series for metals

1 Sodium reacts with water, zinc does not.

2 Zinc has a greater tendency to form positive ions than iron.

3 $Mg(s) + NiSO_4(aq) \rightarrow MgSO_4(aq) + Ni(s)$

4 $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$

5 $Mg(s) + CuCl_2(aq) \rightarrow MgCl_2(aq) + Cu(s)$

6 $Mg(s) + Ag^{2+}(aq) \rightarrow Mg^{2+}(aq) + Ag(s)$

Lesson 7.5b The process of electrolysis

1 so they can move freely within a solution

2 Cu^{2+} and Cl^-

3 because they are positively charged

4 $Cu^{2+} + e^- \rightarrow Cu$

$2Cl^- - 2e^- \rightarrow Cl_2$

5a $2Br^- - 2e^- \rightarrow Br_2$

5b Mg

5c from water in the solution

Lesson 7.5c Electrolysis of molten ionic compounds

1 cathode

2 anode

3 sodium at the cathode, and bromine gas at the anode

4 cathode: $Cu^{2+} + e^- \rightarrow Cu$

anode: $2Br^- - 2e^- \rightarrow Br_2$

Student Book answers

Lesson 7.5d Electrolysis of aqueous solutions

1 In the electrolysis of aqueous solutions, the water molecules break down to produce H^+ ions and OH^- ions. The H^+ ions migrate to the cathode, along with the silver ions in solution. Silver is produced (discharged first) as H^+ ions are more reactive than Ag^{2+}, H^+ ions stay in solution.

2 For the NaCl and $CuSO_4$ mixture Cu is produced at the cathode and Cl_2 is produced at the anode. A $CuSO_4$ solution alone would produce Cu at the cathode and O_2 at the anode.

3 For $NaSO_4$: cathode: $2H^+ + 2e^- \rightarrow H_2$
anode: $4OH^- - 4e^- \rightarrow O_2 + 2H_2O$

4 For $CuCl_2$: cathode: $Cu^{2+} + e^- \rightarrow Cu$ reduction
anode: $2Cl^- - 2e^- \rightarrow Cl_2$ oxidation

5 For H_3PO_4: cathode: $6H^+ + 6e^- \rightarrow 3H_2$ reduction
anode: $12OH^- - 12e^- \rightarrow 3O_2 + 6H_2O$ oxidation

Lesson 7.5e Required practical: Investigating what happens when aqueous solutions are electrolysed using inert electrodes

1 cathode

2 Hydrogen; test by making a lighted splint go pop.

3 Zinc and sodium; prediction is wrong, hydrogen is given off. Copper and silver prediction is correct, copper and silver are deposited.

4 More reactive metals displace less reactive ones.

5 Copper and silver are less reactive than hydrogen; sodium and zinc are more reactive. Hydrogen was given off.

6 Model showing at the cathode: $Cu2^+ + 2e^- \rightarrow Cu$; at the anode: $4OH^- - 4e^- \rightarrow 2H_2O + O_2$. For the anode, hydroxide ions discharge in preference to give oxygen gas.

7 Water and oxygen.

8 For the cathode, more reactive metals displace less reactive ones. Their hypothesis was wrong, the less reactive the metal the easier it is to deposit on an electrode.

9 The conclusion supports the hypothesis that reactivity series is linked to the ability of a metal ion to deposit on an inert electrode.

Lesson 7.5f Tests for gases

1 The splint burns in oxygen.

2 Hydrogen ignites with a pop as it gives off thermal energy.

3 General test: puts out a lighted splint. Specific test: bleaches damp litmus paper.

4 c: Carbon dioxide should be collected by downward delivery as it is heavier than air.

End of chapter questions

1 zinc, magnesium, calcium, potassium, copper, gold [2 Marks]

2 cathode and anode [2 Marks]

3 decreasing reactivity of metal in D, G, F, E; based on the extent of fizzing that takes place [2 Marks]

4 ability to make a lighted splint go pop [1 Mark]

5 bleaches damp litmus paper [1 Mark]

6 because lead bromide needs to be in solution for the ions to move [2 Marks]

7 zinc, metal X, copper [2 Marks]

8a positive [0.5 Marks]

8b negative [0.5 Marks]

9 Students' own diagrams based on Figure 7.5.12 in the Student Book [4 Marks]

10 Fe(s) + CuSO4(aq) → FeSO4(aq) + Cu(s) [1 Mark]

11 hydrogen at the cathode, and oxygen and water at the anode [2 Marks]

12 electrons are gained [2 Marks]

13 cathode: $Mg^{2+} + e^- \rightarrow Cu$ reduction
anode: $2Cl^- - 2e^- \rightarrow Cl_2$ oxidation. [2 Marks]

14a hydrogen at the cathode and iodine gas at the anode [1 Mark]

14b cathode: $2H^+ + 2e^- \rightarrow H_2$ reduction
anode: $2I^- - 2e^- \rightarrow I_2$ oxidation. [1 Mark]

15 $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$; electrons are lost during the reaction, so this is oxidation [2 Marks]

16 The marks are in three bands according to the level of response.

Level 3 (5/6 marks): A detailed and coherent explanation covering all major steps. Each statement is logically linked to the next one. Appropriate scientific terminology is used.

Level 2: (3/4 marks): Some detail lacking but each statement is logically linked to the next one.

Level 1: (1/2 marks): Some correct statements but lacks detail and the steps are not logically linked.

No relevant content: 0

Indicative content:

- potassium chloride solution contains potassium ions, chloride ions, hydrogen ions and hydroxide ions
- potassium ions are positive
- so are attracted to the inert cathode or inert negative electrode
- potassium ions are, however, not discharged because potassium is more reactive than hydrogen
- so hydrogen ions are preferentially reduced / gain electrons to form hydrogen gas
- chloride ions are negative
- so attracted to the positive electrode (anode)
- and oxidised by electron loss to give chlorine molecules
- the unchanged potassium ions and hydroxide ions mean that the residual solution contains potassium hydroxide.

[6 Marks]

[Total 34 Marks]

Topic 8 Guiding Spaceship Earth towards a sustainable future

Chapter 8.1: Carbon chemistry

Lesson 8.1a Diamond

1 Involves the sharing of electrons pairs between atoms.

2 Diamond is formed as a giant molecular structure where the carbon atoms covalently bond to other carbon atoms forming a tetrahedral structure. All the covalent bonds are very strong and a lot of energy is needed to separate them.

3 The structure of silicon dioxide is less strong and requires lower temperatures to disrupt the bonds.

4 All of carbon's four outer electrons are used to form covalent bonds.

5 It is very hard; the atoms are joined together by strong covalent bonds that involve electron sharing. This arrangement gives strength in all directions and requires a large amount of energy to break the bonds.

Lesson 8.1b Graphite

1a four

1b three

2 The forces are weak, and the layers can slide over each other.

3 Carbon atoms have four electrons in the outer electron shell. In diamond every carbon atom is covalently joined to four others in a three-dimensional tetrahedral lattice, therefore there are no free electrons. Graphite has a layered arrangement in which each carbon atom is covalently bonded to three others, forming single layers of regular hexagons. This formation means each carbon atom has one electron in its outer shell, free to move anywhere along the layer.

4 Graphite has delocalised ions that are free to move throughout its structure.

5a Graphite, like metals, is also a good conductor of thermal energy due to its delocalised electrons.

5b Graphite is classified as a non-metal due to the electronic structure of its atoms and position in the periodic table. Often, non-metals combine by covalent bonding.

6 Graphite has a similar melting point to that of diamond, so it is stable at high temperature. Due to these two properties, graphite can also be used as electrodes in the electrolysis of *molten* electrolytes.

7 Both are made from carbon atoms (but are in a different arrangement).

8 In graphite, delocalised electrons can move along layers, so graphite is able to conduct electricity. Diamond has no delocalised electrons, so it cannot conduct electricity.

Lesson 8.1c Graphene and fullerenes

1 Graphene is a single layer of graphite, one atom thick hexagonal rings of carbon. Fullerenes are hexagonal rings of carbon with a hollow shape that also contain rings with five or seven carbon atoms.

2 Diamonds are made of carbon atoms; each carbon atom forms four bonds; the four bonds form as far from each other as possible in the shape of a tetrahedron. In diamond, each carbon atom forms four covalent bonds with other carbon atoms in all directions.
In graphite, the carbon atoms are arranged differently and only make three bonds with other carbon atoms; the carbon atoms bond to make six-sided rings; the rings stack to make layers.
In fullerenes, carbon atoms in rings can form hollow 3D shapes; the structure of fullerenes is based on hexagonal rings of carbon atoms, but they may also contain rings with five or seven carbon atoms.

3 Cylindrical shapes are very hard to break; they have very high length to diameter ratios.

4 Diamond has a higher melting point as the atoms are held together with tight covalent bonds as a giant covalent structure. Buckminsterfullerene is not a giant covalent structure but forms a hollow ball.

5 Graphene is a single layer of graphite, one atom thick hexagonal rings of carbon. In graphite, each carbon atom forms three strong covalent bonds with three other carbon atoms, forming layers of hexagonal rings that have no covalent bonds between the layers. Only weak forces hold the layers together, so the layers are free to slide over each other. Graphene, like graphite, has delocalised electrons that make it a good conductor of electricity. The single layers of carbon atoms in graphene are even better conductors than graphite.

6 Graphene has a higher tensile strength than graphite; its structure is harder to break.

Lesson 8.1d Hydrocarbons in crude oil

1 coal, gas

2 Because fossil fuels are a finite resource, they are not being replaced. Wind power is a renewable resource.

3 Pentane – one carbon atom and two hydrogen molecules are added each time in the series C_nH_{2n+2}.

4 C_8H_{18} – octane

5 C_nH_{2n+2} for 18 carbon atoms = $C_{18}H_{38}$

6 $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ or students' own sketches of the displayed formula showing 7 C atoms and 16 H atoms.

7 Students' own sketches of the displayed formula for straight chain and two branched chains for pentane C_5H_{12}.

Lesson 8.1e Fractional distillation of crude oil

1 Different fractions of crude oil, fuels are used for combustion, petrochemicals are used for a wide variety of products such as plastics.

2 Crude oil is a mixture of many products and these products need to be separated to be individually useful

3 C_6H_{14} and C_7H_{16}, they have similar numbers of carbon atoms.

4 Hydrocarbon X and hydrocarbon Y have different boiling points and condensation points because the molecules are different sizes. Larger molecules have stronger molecular forces and therefore higher boiling points.

Lesson 8.1f Properties of hydrocarbons

1 diesel oil

2a Viscosity increases.

2b Flammability decreases.

3 340–400°C

4 The larger the hydrocarbon chains, the more of the weak forces *between* the molecules, so more energy is needed to separate them. This means that more energy is needed for the molecules to be free enough to form a vapour.

5a Melting point increases as number of carbon atoms increases.

5b Molecules with 4 or 5, 6 or 7, 8 or 9 and 10 or 11 carbon atoms have more similar melting points.

Lesson 8.1g Combustion of hydrocarbon fuels

1 Blue flame indicates the gas is burning completely. Yellow flame indicates incomplete combustion when there is a shortage of oxygen because the hole is closed.

2 $C_4H_{10} + 6.5O_2 \rightarrow 4CO_2 + 5H_2O$, and balanced $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

3 $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

4 $C_{10}H_{22} + 6O_2 \rightarrow 9C + CO + 11H_2O$

5a $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ (complete)
$C_8H_{18} + 5O_2 \rightarrow 7C + CO + 9H_2O$ (incomplete)

5b Complete combustion releases more energy due to the increased oxidation of carbon and hydrogen in the fuels.

Lesson 8.1h Cracking hydrocarbons

1 Turn kerosene into petrol.

2 petrol, diesel, kerosene

3 high temperature, steam or catalyst

4 $1C_{14}H_{30} \rightarrow 1C_7H_{16} + 1C_3H_6 + 2C_2H_4$
D, E and F = 1; G = 2

5 Polymer plastics are widely used in modern life. They are not biodegradable and so take a long time to break down. Usually, polymers are disposed of as landfill or are incinerated, which causes problems for the environment − or any suitable argument.

Lesson 8.1i Maths skills: Visualise and represent 3D models

1 Students' own diagrams based on ethane from Figure 8.1.25 in the Student Book, but with three carbon atoms and eight hydrogen atoms.

2 decane

3 Students' diagrams showing $(CF_2{=}CF_2)n = 3$ polymer.

4 Students' diagrams showing $CHCl{-}CH_2$.

5 four

6 Because the active site is a unique 3D shape.

End of chapter questions

1 A molecule consisting of hydrogen and carbon atoms. [1 Mark]

2 Hottest at the bottom. [1 Mark]

3 Complete: carbon dioxide and water. [1 Mark]
Incomplete: carbon, carbon monoxide and water. [1 Mark]

4 four [1 Mark]

5a A cylindrical tube consisting of a single layer of carbon atoms in a 3D shape. [1 Mark]

5b A hollow ball consisting of a single layer of 60 carbon atoms. [1 Mark]

6 Tetrahedral formation of carbon atoms in hexagonal shape. [1 Mark]

7 Layer of one carbon atom thick. [1 Mark]

8 Boiling points increase as the number of carbon atoms increases. [2 Marks]

9a To produce lower molecular weight hydrocarbons from kerosene. [1 Mark]

9b $C_7H_{16} \rightarrow C_2H_6 + C_3H_6 + C_2H_4$ [1 Mark]

10 Due to its structure of carbon atoms of six-sided rings that are stacked together to make layers; there are no covalent bonds between the layers, so the graphite is soft and slippery

[1 Mark]. Students' own sketches, based on Figure 8.1.6 in the Student Book, showing single layer of hexagonal rings [1 Mark].

11 Boiling points F > E > D [1 Mark]. Boiling point and viscosity increase with molecular size [1 Mark].

12 $C_{20}H_{42}$ [1 Mark]

13 $2C_7H_{16} + 9O_2 \rightarrow 12C + 2CO + 16H_2O$ [2 Marks]

14 In graphite, delocalised electrons can move along layers so graphite is able to conduct electricity. Diamond has no delocalised electrons so cannot conduct electricity. [2 Marks]

15 Octane, C_8H_{18}. Boiling point increases with molecular size. [2 Marks]

16 Any of: conducts electricity, strong material, good elasticity, cheap, transparent. [3 Marks]

17 Fractionating of crude oil, use catalytic cracking or steam cracking to make these hydrocarbons from kerosene. [3 Marks]

18 The marks are in two bands according to the level of response:

Level 2 [3–4 Marks]: A detailed and coherent explanation of the processes involved in fractional distillation, presented in a logical sequence.

Level 1 [1–2 Marks]: Separate, relevant points made. The steps may not be presented in a logical sequence.

No relevant content: [0 Marks]

Indicative content:

- Crude oil is a mixture of hydrocarbon compounds.
- Crude oil is heated at the bottom of the fractional distillation column.
- The hydrocarbons boil/evaporate/turn into gases and rise up.
- Vapours cool as they rise.
- Condense (into fractions) at different levels/temperatures/boiling points.
- The larger the molecule, the higher the boiling point.
- The bottom of the column is the hottest part of the column.
- Large hydrocarbon molecules/long-chain molecules will condense (and be drained off) near the bottom because they have high boiling points.
- Because large amount of energy needed to separate the molecules when the substance boils (more weak forces of attraction to overcome).
- The parts/fractions that do not condense (temperature is above their boiling point) pass up the column.
- Smaller hydrocarbon molecules will condense (and be drained off) nearer the top because they have lower boiling points.
- Because lower amount of energy needed to separate the molecules when the substance boils (fewer weak intermolecular forces).

19 The marks are in two bands according to the level of response:

Level 2 [3–4 Marks]: A detailed and coherent explanation of the processes involved in both polymerisation and cracking, presented in a logical sequence.

Level 1 [1–2 Marks]: Separate, relevant points made. The steps may not be presented in a logical sequence.

No relevant content: [0 Marks]

Indicative content:

- Poly(ethene) is made by polymerising ethene, C2H4.
- Drawing for the structure of the monomer molecule, ethene, showing all its atoms and bonds.
- Drawing for the structure of poly(ethene).
- The carbon-carbon double bond in ethene breaks open and joins to other ethene molecules forming a very long molecule or polymer.
- Ethene can be obtained by cracking

alkanes in crude oil or natural gas (such as decane, C10H22).

- Cracking breaks down long-chain hydrocarbon molecules into smaller ones, some of which are alkenes.

- In catalytic cracking the long-chain hydrocarbon is passed at high temperature over a catalyst (of silica or alumina).

[Total 38 Marks]

Chapter 8.2: Resources of materials and energy

Lesson 8.2a Key concept: Electron transfer, oxidation and reduction

1 Sodium loses an electron, and chlorine gains an electron.

2 They have stable electron configurations.

3a Oxidation of zinc – loss of an electron to oxygen.

3b Reduction of iron(III) – gain of an electron to give iron.

4a Oxidation (lose electrons).

4b Reduction (gain electrons).

Lesson 8.2b Metal extraction by reduction of oxides

1 Zinc is reduced (loses oxygen), and carbon is oxidised (gains oxygen).

2 oxidation

3 reduction

4 Carbon has been oxidised (gained an oxygen).

5 Iron is reduced, and carbon is oxidised.

6a $Cu_2O + C \rightarrow 2Cu + CO$

6b Copper is reduced, and carbon is oxidised.

Lesson 8.2c Metal extraction by electrolysis

1 Metals more reactive than carbon need to be extracted by electrolysis. Sodium is too reactive.

2 potassium, sodium, calcium, magnesium, aluminium

3 Molten metal is produced at the cathode. Oxygen molecules are produced at the anode.

4 The process uses a lot of electricity during manufacture.

5 The positive ions migrate towards the negative electrode (cathode) and are discharged at the electrode, making a molten metal. The oxide ions are negative ions that migrate to the positive electrode (anode). The oxide ions are discharged as oxygen molecules.

6 For $CaCl_2$, $Ca^{2+} + 2e^- \rightarrow Ca$

$2Cl^- - 2e^- \rightarrow Cl_2$

7 $KF_2 \rightarrow K + F_2$

$K^{2+} + 2e^- \rightarrow K$

$2Fl^- - 2e^- \rightarrow F_2$

Lesson 8.2d Metal extraction by biological methods

1 The Earth's resources of metal ores are limited. Copper ores are becoming scarce, and the price of this valuable metal is rising sharply. Copper's electrical conductivity is high, so it is used for wiring and in alloys. It is recycled, but smaller amounts can be extracted using other methods.

2 Plants will naturally absorb compounds from the soil through their root systems. Certain metals that plants absorb are poisonous to them, but other plants collect these metals in their leaves.

3 Bioleaching uses bacteria to produce leachate solutions that contain metal compounds. These can then be processed to obtain the metal. Copper compounds in leachate solution can be used to obtain pure copper by displacement using scrap iron. Phytomining uses plants to absorb metal compounds. The plants are harvested and then burned to produce ash that contains the metal compounds.

4 Bioleaching is a cleaner process than the traditional leaching that uses cyanide. However, the fact that it is a slow process and has sulfuric acid as a byproduct may mean that other methods will be looked for.

5 Some bacteria can convert metal sulfides to metal sulfates, to recover mainly copper. However, the costs are still quite high and do not yet compare with smelting processes. So, although there may be some environmental advantages, the process will also need to have economic advantages compared with mining and smelting before it is used on a large scale.

6 1.9×10^7 tonnes $\times$ 20% = 3.8×10^6 tonnes

Lesson 8.2e Energy resources

1 Two from: wind, wave, hydroelectric, solar, geothermal, tidal, nuclear energy.

2 Some countries have no access to coastline or do not have enough to make wave power viable.

3 Because new trees can be planted for use as biofuel.

4 Nuclear energy from radioactive sources.

5 Biofuels are made from plants that can be replaced with new plants. Fossil fuels are made from dead plants and animals that take millions of years to convert it into usable material.

6 Ethical: Will the gas extraction cause long-term problems for the local environment? Social: Will the gas extraction affect the local people in a bad way such as those living close to the extraction site, or in a good way such as create jobs? Economic: Is the gas extraction the most economical way to provide fuel for energy? Or any other suitable answers.

Lesson 8.2f Energy conservation and dissipation

1 The total amount of energy remains the same.

2 Energy can be transferred from one store to several different stores simultaneously, for example a light bulb transfers electrical energy as both light energy (which is the required product) and thermal energy (which is not).

3 Energy stored due to friction or air resistance cannot be easily used.

4 heat, sound

5 by sound

6 Energy is lost at all stages to surroundings, burning fuel as heat, stored in water as steam, steam transferred to movement of turbines.

7 m = 0.5 kg, h = 2 m, g = 10 N/kg

$E_p = mgh = 0.5 \times 10 \times 2 = 10$ J

8 power = 2 kW or 2000 W, t = 1 minute or 60 s

$E = Pt = 2000 \times 60 = 120\,000$ J

Electrical energy is transferred as thermal energy.

Lesson 8.2g Key concept: Preventing unwanted energy transfers

1 By oiling the wheels of the scooter.

2 Paper is a good thermal insulator.

3 Through doors and windows; from car wheels. Improve insulation on doors and windows.

4 Energy conservation design to reduce heat loss, such as thick walls, cavity wall insulation, triple glazing, small windows, or any suitable answer.

5 copper = 398 kW/m/°C; aluminium = 237 kW/m/°C, so ratio = 5 : 3.

6a copper: good thermal conductivity

6b expanded polystyrene: poor thermal conductivity

6c wood, brick or concrete: poor thermal conductivity

Lesson 8.2h Energy efficiency

1 Loss of thermal energy to heat the surroundings.

2 An electric car uses the energy from its battery with an efficiency of about 85%. A petrol car uses the energy from burning fuel with an efficiency of only about 15%.

3 efficiency = useful energy output ÷ total energy input

= 80 J ÷ 100 J = 80%

4a efficiency = useful energy output ÷ total energy input

= 135 J ÷ 500 J = 27%

4b Much thermal energy is lost up the chimney.

5 Metal or plastic are good conductors, so thermal energy is lost to the surroundings.

6 useful energy output = efficiency × total energy input
= 0.65 × 200 J = 130 J

7 LED

8 Students' investigations of cost of halogen bulbs versus cost of LED bulbs.

Lesson 8.2i Life cycle assessment

1 plastic

2 Both recycled. Paper bag.

3 From the start of the manufacturing process to the end of the object's life.

4a qualitative

4b quantitative

5 The students are making subjective judgements based on their personal viewpoints.

6 How and where have the data been gathered (source of the LCA)? What is meant in the statement as a typical car (do the people issuing this figure have a particular bias)? What part of the data has been taken to give this figure (is only some of the data presented to promote a particular argument)? Or any similar answer.

7 All environmental costs after manufacture for use, operation and disposal, such as selling (packaging, promotion and transport from the manufacturer) and disposal of the cups (costs for recycling or waste disposal/littering from the coffee shop).

Lesson 8.2j Interpreting data

1 pulp production

2 A

3 Resources used for fuel, in electricity production and for distribution.

4 A: 0.6×10^{-3} m^3; B: 3.4×10^{-3} m^3
ratio 0.6 : 3.4 or 1 : 5.7

5 B

6 2.4×10^{-3} m^3 more in electricity generation than in paper production (to 2 significant figures)

7 B may be using hydroelectric power generation.

8 Human health effects of climate change: A 0.5×10^{-4} B 0.4×10^{-4} (or 5×10^{-5} B 4×10^{-5}). Fossil fuel depletion: A 7.5×10^{-4} B 6.5×10^{-4}.

9 Factory B scores less than factory A for human health effects of climate change, fossil fuel depletion, agricultural land occupation and water for paper production. Factory B scores the same as factory A for human health effects of particulates and water use for pulp transport. Factory B scores more than factory A for water use in electricity generation and pulp production. If the water for electricity production is hydroelectric power, this would have low environmental impact and then the statement is correct.

Lesson 8.2k Recycling

1 Easy to recycle because it can be melted and reformed in another shape; glass is also easy to separate from other rubbish such as paper and plastic due to its high density; worthwhile because energy needed to recycle is less than the energy needed to make new glass from its raw materials.

2 If products are reused, this prevents the environmental impact of making replacement products and the environmental impacts of recycling and disposal.

3 Metals and glass are produced from raw materials that mostly have to be dug up from the ground, which has an environmental impact. Metals can be recycled by melting and recasting or reforming into different products. Glass is easy to recycle because it can be melted and reformed in another shape; glass is also easy to separate from other rubbish such as paper and plastic due to its high density. The energy needed to recycle glass is less than the energy needed to make new glass from its raw materials.

4 Crude oil is a finite resource.

5 Any suitable answers for disposable products, for example plastic cups, bags, cutlery, bottles, containers.

6 Reduce: use alternative transport and the need to buy new cars. Reuse: repair or buy second hand rather than buying new car; reuse the metal and glass components for other purpose. Recycle: metals in bodywork, engines, alternators and pumps; plastics in petrol tank, lights, dashboard and bumpers; glass; engine oil; oil filters; batteries; rubber hoses; and tyres in cars can all be recycled.

7 Assembling a car near to where it is sold would mean transporting all the car components to there. Alternatively, assembling the car far from where it is sold would mean transporting the finished car to where it is sold. Probably more savings on limited resources in making and assembling the car near to where it is sold.

8 Only produce the products that are needed. Have good quality control to reduce defects and remaking products. Or any other suitable answer.

9a Reduces the use of crude oil, which is a finite resource. Reduces the environmental impact of recycling; plastic is difficult and expensive to separate. Plastics do not degrade easily and take up valuable land when dumped in landfill sites that need to last for decades.

9b 1.5×10^9

End of chapter questions

1 a: sodium [1 Mark]

2 d: carbon neutral in manufacturing [1 Mark]

3 iron(III)oxide and carbon monoxide [2 Marks]

4 The manufacture of products using wood from a managed forest has less environmental impact than the production of plastic products from crude oil. [2 Marks]

5 Renewable: wind, wave, hydroelectric, solar, geothermal, tidal. Non-renewable: oil, gas, coal, nuclear fuel. [2 Marks]

6 One in which there is a gain of an electron. [1 Mark]

7 Energy can be transferred usefully, stored or dissipated, but the total amount of energy does not change. [1 Mark]

8 Most heat is lost from the black roof, under the balcony and the windows. [2 Marks]

9 Should be recycled. Glass is easy to recycle because it can be melted and reformed in another shape; glass is also easy to separate from other rubbish such as paper and plastic due to its high density; energy needed to recycle is less than the energy needed to make new glass from its raw materials. [1 Mark]

10 c: iron(III) oxide [1 Mark]

11 Some metals are too reactive to be extracted by reduction with carbon or the metal reacts with carbon. These metals are found towards the top of the reactivity series. They can be extracted from molten compounds using electrolysis. [1 Mark]

12 By removing an electron or by adding oxygen. [2 Marks]

13 For $NaCl_2$, sodium loses an electron (oxidation) and chlorine gains an electron (reduction).

$2Na - 2e^- \rightarrow 2Na^+$ oxidation

$Cl_2 + 2e^- \rightarrow 2Cl^-$ reduction [1 Mark]

14 Advantages: renewable resource, no gas pollution, no atmospheric emissions, no fuel cost. Disadvantages: noise pollution, changes the view, depends on strength of the wind. [3 Marks]

15 Decrease the weight. Decrease the friction with the road. Make it more aerodynamic in shape. Convert it to an electric car or hybrid car. [1 Mark]

16 For plastic-lined cartons or glass milk bottles the environmental impact at each stage of its life should be examined. Four from:

- extracting and processing the raw materials
- manufacturing the product and packaging
- use and operation of the product during its lifetime
- disposal at the end of its useful life
- transport and distribution and waste are included at each stage.

[4 Marks]

17 E used = 20 000 J
weight = 60 N, g = 10 N/kg, h = 50 m
work done = force × distance = 60 N × 60 m = 3600 J
efficiency = useful energy output ÷ total energy input
= 3600 J ÷ 20 000 J = 18% [2 Marks]

18a An electric car uses the energy from its battery with an efficiency of about 85%. A petrol car uses the energy from the burning fuel with an efficiency of only about 15%. This means an electric car can transfer a greater portion of energy in the form of kinetic energy from the original energy store. [1 Mark]

18b Batteries have to be charged and the power station supplying the electric current is only 40% efficient, therefore efficiency is
80% × 40% = 36%
which is only slightly more efficient than the diesel engine. [1 Mark]

19a $SnO_2 + C \rightarrow Sn + CO_2$ [1 Mark]

19b $Sn^{4+} + 4e^- \rightarrow Sn$ (reduction) [1 Mark]
$C - 4e^- \rightarrow C^{4+}$ (oxidation) [1 Mark]

19c Tin is less reactive than carbon so its oxides can be extracted by reduction with carbon and therefore does not have to extracted by electrolysis. [1 Mark]

20a They are non-renewable resources [1 Mark] and so will run out [1 Mark].

20b Any three from:

- Only small changes/no trend for coal, natural gas, nuclear and renewables from 1990 to about 2001
- The consumption of all resources/fuels has increased since around 2001 and is predicted to continue increasing
- The biggest changes between 2001 and 2040 involve coal
- The consumption of nuclear fuel remained steady between 1990 and around 2015, but is projected to increase from 2015 to 2040
- The proportion of coal used as a fuel relative to gas, nuclear or renewables is predicted to increase
- The proportion of renewable fuels used relative to nuclear is predicted to increase.

[3 Marks]

20c 220×10^{18} J or 2.2×10^{20} J (allow answers in range 2.15 to 2.25×10^{20} J) [1 Mark]
= 2.2×10^{8} TJ [1 Mark]
= 2.2×10^{11} GJ [1 Mark]

21 The marks are in three bands according to the level of response:
Level 3 [5–6 Marks]: A detailed, coherent answer making logical links between factors that could affect the amount of crude oil used in manufacturing plastics, relative to other uses of crude oil.
Level 2 [3–4 Marks]: Some valid suggestions are made, with reasons. The links made between factors and explanation may not be complete, and the logic may be unclear.
Level 1 [1–2 Marks]: Simple, relevant points made about factors, but no attempt to link to explanations.
No relevant content: [0 Marks]
Indicative content:

- Global production of plastic likely to rise as population increases and economies of developing countries expand
- Meaning more oil used in plastics manufacturing in industry and by consumers
- However, demand for use of crude oil as a fuel is also likely to increase, meaning percentage of oil used in manufacturing plastics may remain the same
- If finite oil supplies begin to run out, there may be increased use of renewable energy in the manufacturing process

- Manufacturers may reduce the amount of plastic packaging used in selling consumer products
- Meaning less oil used in plastics manufacturing
- As environmental pressures grow, governments may encourage increased reuse or recycling of plastics, meaning less oil used as a raw material and less oil used as an energy resource in plastic manufacture
- Reuse and recycling will not be sufficient to meet future demand for plastic resources.

[Total 48 Marks]