Answers

Section 1. Principles of chemistry

C1a States of matter

Page 11

1. (l).

2. Only the solid state has a fixed shape.

3. Fine sand will pour or flow like a liquid; it takes the shape of the container it is poured into (although under a microscope you would see gaps at the surface of the container).

Page 13

1. The particles in a solid vibrate.

2. Water particles are held together more strongly in liquid water.

3. Evaporation is the process in which faster-moving particles escape from the surface of a liquid.

4. A solid changes to a liquid at its melting point.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	Gas	1 mark
2	The particles in a liquid are close together, often touching. The particles can move around and are not in a fixed position.	1 mark 1 mark
3	Solid	1 mark
4	The forces between the particles (atoms) in aluminium are greater than those between the particles (atoms) in sodium.	1 mark
5 a)	Melting	1 mark
5 b)	Evaporation or boiling	1 mark
5 c)	Condensation	1 mark
5 d)	Freezing or solidification	1 mark
6	The boiling point	1 mark
7	The particles in a liquid are constantly moving even at a low temperatures in the polar regions. Water particles can break away from the surface (evaporate) and form water vapour.	1 mark 1 mark
8	The student's statement is correct. In both solids and liquids the particles are quite close together – in a gas the particles are much further apart. The speed of movement of the particles in solids and liquids are much more similar – in a gas the particles are moving at very high speeds.	1 mark 1 mark
	Total:	14 marks

C1b Atoms

Developing investigative skills, page 20

1. Using tongs and with the students wearing eye protection and rubber gloves.

2. Avoiding breathing the fumes or use a fume cupboard.

3. The ammonia.

4. It travelled approximately twice as far as the hydrogen chloride.

5. The hydrogen chloride has approximately double the mass of the ammonia.

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1. Diffusion is the random mixing and moving of particles in liquids and gases.

2. a) Brownian motion was first observed in the movement of pollen grains on water.

   b) The smoke particles are being constantly bombarded by rapidly moving air particles.

3. An element is made up of one kind of atom.

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1. Less liquid will be lost as vapour/the condenser is much more efficient at condensing the vapour as it is constantly kept cool.

2. B – boiling points.

3. The blue dye is the most soluble (it has moved the furthest up the filter paper).

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	Diffusion	1 mark
2	There is no physical barrier between the particles of bromine and air. The particles in these gases are moving at high speed and colliding with each other. Over time the mixing will be complete and so there will be air and bromine particles in both gas jars.	1 mark 1 mark
3 a)	You will see small specks of light moving at random.	1 mark
3 b)	The smoke particles reflect the light and are being knocked about by rapidly moving air particles.	1 mark
4	An atom is a single particle whereas a molecule is made up from two or more atoms.	1 mark
5	A compound is a fixed composition/ combination of elements joined together; a mixture has no fixed composition.	1 mark
6 a)	Chromatography	1 mark
6 b)	Filtration	1 mark
6 c)	Fractional distillation	1 mark
6 d)	Evaporation or distillation	1 mark
7	A distillate is a liquid that has been evaporated and then condensed (as in a distillation experiment).	1 mark

8	The inks in the black ink do not dissolve in water/are not soluble in water. Using a different solvent such as alcohol/ ethanol (this solvent might dissolve some of the dyes in the ink and so they would move up the paper).	1 mark 1 mark
	Total:	14 marks

C1c Atomic structure

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1. The electron has the smallest relative atomic mass.

2. Atoms have no overall charge, so the number of positive charges (protons) and negative charges (electrons) must cancel out.

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1. Isotopes are atoms of the same element with different atomic masses (different numbers of neutrons).

2. 96 g

3. $A_r = \frac{(51 \times 79) + (49 \times 81)}{100} = 79.98$

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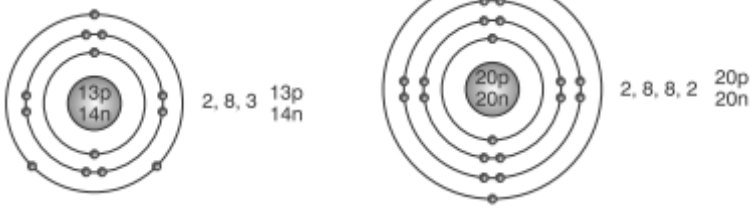
1. 2 electrons. Magnesium is in Group 2.

2. a) Aluminium b) Calcium



3. The noble gases have a full outer shell of electrons or have 8 electrons in their outer shell and so do not easily lose or gain electrons.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	A proton has a relative mass of 1 unit.	1 mark
2 a)	The atomic number is the number of protons (= number of electrons) in an atom.	1 mark
2 b)	The mass number is the number of protons + neutrons in an atom	1 mark
3 a)	Isotopes are atoms of the same element with different numbers of neutrons.	1 mark
3 b)	chlorine-35: 17 protons; 18 neutrons; 17 electrons chlorine-37: 17 protons; 20 neutrons; 17 electrons	1 mark 1 mark
4 a)	56/28 = 2 moles	1 mark
4 b)	3.1/31 = 0.1 moles	1 mark

Question	Correct answer	Marks
5	Completed table as shown below	4 marks

Atom	Number of protons	Number of neutrons	Number of electrons	Electron arrangement
Si	14	14	14	2,8,4
Mg	12	12	12	2,8,2
S	16	16	16	2,8,6
Ar	18	22	18	2,8,8

Question	Correct answer	Marks
6 a)	i) C ii) B iii) C or E or F iv) B v) C	1 mark 1 mark 1 mark 1 mark 1 mark
6 b)	Diagram should have 6 protons and 6 neutrons in the nucleus. There should be 2 electron shells with 2 electrons in the inner shell, and 4 in the outer shell.	2 marks
7 a)	Diagram should have 8 protons and 8 neutrons in the nucleus. There should be 2 electron shells with 2 electrons in the inner shell, and 6 in the outer shell.	2 marks
7 b)	Diagram should have 19 protons and 20 neutrons in the nucleus. There should be 4 electron shells with 2 electrons in the inner shell, 8 in the second shell, 8 in the third shell and 1 in the outer shell.	2 marks
8 a)	No	1 mark
8 b)	No	1 mark
8 c)	No	1 mark
8 d)	Yes. The number of electrons in the outer shell is the same as the group number.	1 mark
	Total:	27 marks

C1d Relative formula masses and molar volumes of gases

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1. 16 2. 46 3. 48

Page 44

1. a) 2 moles b) 0.5 moles c) 0.1 moles

2. a) 0.5 moles b) 0.1 moles c) 2 moles

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1. 1 mole of magnesium (24 g) produces I mole of hydrogen gas (24 000 cm^3). So 1/6 mole of Mg produces 1/6 mole hydrogen = 4000 cm^3 at room temperature and pressure.

2. 1 mole of oxygen gas is produced from 2 moles of hydrogen peroxide. So 0.5 moles of oxygen gas is produced from 1 mole of hydrogen peroxide.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	28 g	1 mark
1 b)	64 g	1 mark
1 c)	32 g	1 mark
2 a)	64/256 = 0.25 moles	1 mark
2 b)	9.8/98 = 0.1 moles	1 mark
2 c)	21/7 = 3 moles	1 mark
3 a)	2.5 × 88 = 220 g	1 mark
3 b)	0.25 x 40 = 10 g	1 mark
3 c)	0.1 × 109 = 10.9 g	1 mark
4 a)	24 000/24 000 = 1 mole	1 mark
4 b)	1200/24 000 = 0.05 moles	1 mark
5 a)	$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$	
	1 mole 2 moles	1 mark
	160 tonnes 112 tonnes	1 mark
	800 tonnes 560 tonnes	1 mark
5 b)	$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$	
	1 mole 3 moles	1 mark
	160 g 72 000 cm^3	1 mark
	320 g 144 000 cm^3	1 mark
6 a)	$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$	
	2 moles 1 mole 2 moles	1 mark
	48 g 32 g 80 g	1 mark
	4.8 g 3.2 g 8.0 g	1 mark
6 b)	3.2 g	1 mark
	Total:	21 marks

C1e Chemical formulae and chemical equations

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1. a) To allow oxygen from the air into the crucible

   b) To prevent the loss of the magnesium oxide

2. a) Platinum b) Oxygen

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1. Fe_2O_3 (0.10 moles of Fe reacts with 0.15 moles of O)
2. ZnO (0.20 moles of Zn combine with 0.20 moles of O)
3. C_4H_{10} (empirical formula mass is 29 – half of the relative formula mass)
4. H_2O_2 (empirical formula mass is 17 – half of the relative formula mass)

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1. It will not be possible to heat any copper(II) oxide near the mouth of the tube without melting the rubber bung.
2. To prevent the gas pressure from blowing the copper(II) oxide through the jet.
3. To prevent the hot copper reacting with oxygen in the air.
4. Black (copper(II) oxide) to pink (copper).
5. Mass of copper(II) oxide = 1.00 g

   Mass of copper = 0.77 g

   Mass of oxygen = 0.23 g
6. Number moles of copper = 0.77/64 = 0.012

   Number moles of oxygen= 0.23/16 = 0.014
7. Ratio Cu: O is 1 : 1.17
8. CuO
9. a) loss of copper(II) oxide during weighing or through the jet during heating

   b) not all copper(II) oxide converted into copper

   c) some hot copper reformed copper(II) oxide if the cooling was not complete when the gas flow stopped.

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1. a) $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$

   b) $2H_2S(g) + 3O_2(g) \rightarrow 2SO_2(g) + 2H_2O(l)$

   c) $2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$
2. a) $S(s) + O_2(g) \rightarrow SO_2(g)$

   b) $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

   c) $CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(l)$

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1. a) $2C_5H_{10}(g) + 15O_2(g) \rightarrow 10CO_2(g) + 10H_2O(l)$

   b) $Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$

   c) $2KMnO_4(s) + 16HCl(aq) \rightarrow 2KCl(aq) + 2MnCl_2(aq) + 8H_2O(l) + 5Cl_2(g)$

Page 63

1. 1 mole of $CaCO_3$ (40 + 12 + 16 + 16 +16 = 100 g) produces I mole of CaO (40 + 16 = 56 g)

   So 50/100 = 0.5 mole will produce 0.5 mole of CaO = 28 g
2. a) 2 moles b) 0.01 moles (100/1000 × 0.1) c) 0.25 moles (500/1000 × 0.5)

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	Cu O 0.64 g 0.16 g 0.64/64 0.16/16 0.01 0.01 The simplest formula is CuO	 1 mark 1 mark
2 a)	Na Br 2.3 g 8.0 g 2.3/23 8.0/80 0.1 0.1 The simplest formula is NaBr	 1 mark 1 mark
2 b)	C O 0.6 g 1.6 g 0.6/12 1.6/16 0.05 0.10 The simplest formula is CO_2	 1 mark 1 mark
2 c)	Fe Cl 11.12 g 21.08 g 11.12/56 21.08/35.5 0.20 0.59 The simplest formula is $FeCl_3$	 1 mark 1 mark
3	Ti Cl 25 g 75 g 25/48 75/35.5 0.52 2.11 The simplest formula is $TiCl_4$	 1 mark 1 mark 1 mark
4	Empirical formula mass of ethene = 12 + 1+1 = 14 g Molecular formula = CH_2 x 28/14 = C_2H_4	1 mark 1 mark
5 a)	C H 92.3 g 7.7 g 92.3/12 7.7/1 7.7 7.7 The empirical formula is CH	 1 mark 1 mark
5 b)	Empirical formula mass = 12 + 1 = 13 g As molecular formula mass is 26 g, the molecular formula is C_2H_2.	1 mark 1 mark
6 a)	$C(s) + O_2(g) \rightarrow CO_2(g)$	1 mark
6 b)	$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$	1 mark

Question	Correct answer	Marks
6 c)	$2Fe_2O_3(s) + 3C \rightarrow 4Fe(s) + 3CO_2(s)$	1 mark
6 d)	$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$	1 mark
7	$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$	
	2 moles 2 moles	1 mark
	46 g 80 g	1 mark
	46/20 = 2.3 g 80/20 = <u>4.0 g</u>	1 mark
8	$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$	
	1 mole 1 mole	1 mark
	5000 cm^3 0.2M 233 g	1 mark
	5000/100 = 50 cm^3 0.2M 233/100 = <u>2.33 g</u>	1 mark
9	2.1/2.8 × 100	1 mark
	75%	1 mark
10 a)	1/24 = 0.042 moles	1 mark
10 b)	100/1000 = 0.1 moles	1 mark
10 c)	1 mole of Mg reacts with 2 moles of HCl (from equation)	1 mark
	Therefore 0.042 moles Mg reacts with 0.084 moles of HCl	1 mark
	0.084 moles is less than 0.1 moles, so HCl is in excess	1 mark
10 d)	1 mole of Mg produces 1 mole of $MgCl_2$	1 mark
	24 g of Mg produces 95 g of $MgCl_2$	1 mark
	1 g of Mg produces 3.96 g of $MgCl_2$	1 mark
10 e)	1 mole of Mg produces 1 mole of H_2	1 mark
	24 g of Mg produces 2 g of H_2	1 mark
	1 g of Mg produces 0.083 g of H_2	1 mark
10 f)	2 g H_2 of occupies 24 000 cm^3	1 mark
	0.083g of H_2 occupies 1000 cm^3	1 mark
10 g)	3.1/3.96 × 100	1 mark
	78.3%	1 mark
	Total:	44 marks

C1f Ionic compounds

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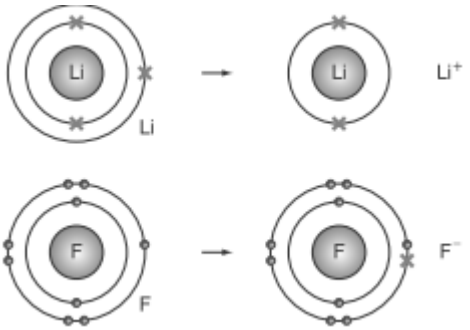
1.



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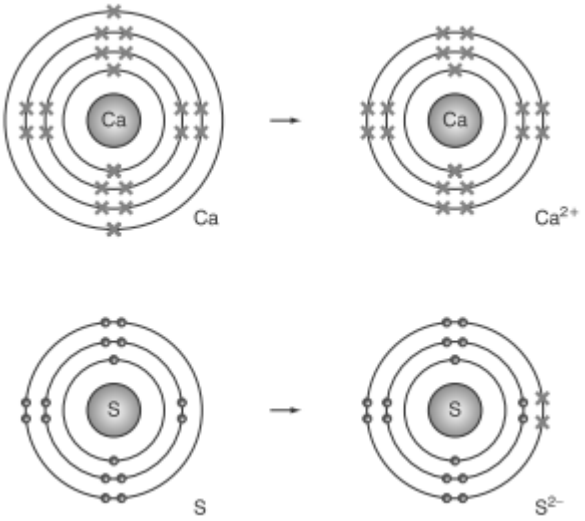

3. No. Both phosphorus and oxygen are non-metals. (A metal is needed to form an ionic bond.)

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1. The ions are held together strongly in a giant lattice structure. The ions can vibrate but cannot move around.

2. Sodium chloride is made up of singly charged ions, Na^+ and Cl^-, whereas the magnesium ion in magnesium oxide has a double charge, Mg^{2+}. The higher the charge on the positive ion, the stronger the attractive forces between the positive ion and the negative ion.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	Not ionic.	1 mark
1 b)	Not ionic.	1 mark
1 c)	Iconic	1 mark
1 d)	Not ionic	1 mark
1 e)	Ionic	1 mark
2 a)	K^+	1 mark
2 b)	Al^{3+}	1 mark
2 c)	S^{2-}	1 mark
2 d)	F^-	1 mark
3	Completed table as shown below	3 marks

Atom	Electronic arrangement of the atom	Electronic arrangement of the ion	Charge on the ion
X	2, 6	2, 8	2–

Y	2, 8, 8, 2	2, 8, 8	2+
Z	2, 1	2	1+ (or +)

4 a)	Dot and cross diagrams should show the following: potassium with four electron shells with two electrons in the inner shell, eight in each of the middle two and one in the outer shell oxygen with two electron shells, two electrons in the inner shell, eight in the outer shell Then: potassium with three electron shells, two in the inner one, eight in each of the other two, with the centre marked as K^+ oxygen with two electron shells, two in the inner one, eight in the outer one, with the centre marked as O^{2-}	2 marks
4 b)	Dot and cross diagrams should show the following: magnesium with three electron shells with two electrons in the inner shell, eight in the middle shell and two in the outer shell chlorine with three electron shells, two electrons in the inner shell, eight in the second shell and seven in the outer shell Then magnesium with two electron shells with two electrons in the inner shell, and eight in the outer shell with the centre marked as Mg^{2+} chlorine with three electron shells, two electrons in the inner shell, eight in each of the other two shells with the centre marked as Cl^-	2 marks
5 a)	There are strong electrostatic attractive forces between the ions. A lot of energy needs to be applied to break these attractions to form a liquid.	1 mark 1 mark
5 b)	The ions are able to carry the electric current. The ions need to be free to move; therefore the potassium chloride needs either to be in a molten state or in solution.	1 mark 1 mark
6	Magnesium forms a 2+ ion, oxygen a 2– ion and chlorine a 1– ion. The electrostatic attraction between 2+ and 2– ions is greater than between 2+ and 1– ions resulting in a higher melting point and boiling point.	1 mark 1 mark
	Total:	22 marks

C1g Covalent substances

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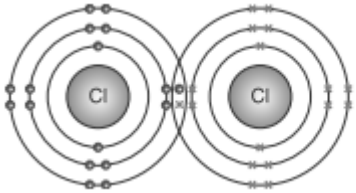
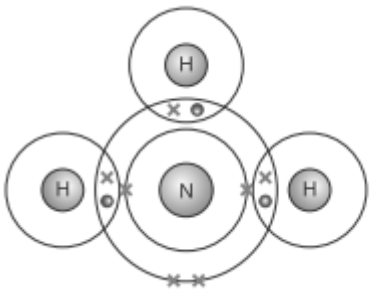
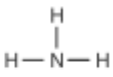
1.



Cl – Cl

2.





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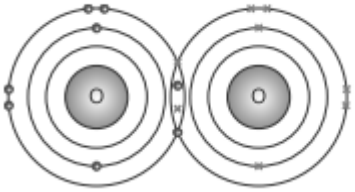
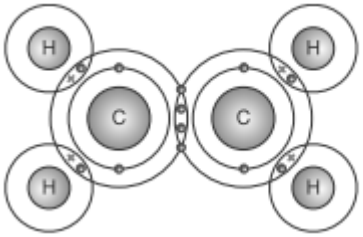
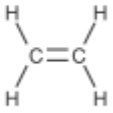


O=O

4.





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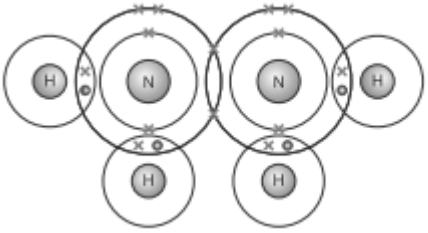

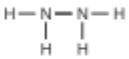

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1. The intermolecular forces of attraction between the molecules are weak.

2. No. There are no ions or delocalised electrons present.

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1. Each carbon atom is strongly covalently bonded to four other atoms forming a very strong giant lattice structure. A very high temperature is required to break down the structure.

2. In graphite each carbon atom is strongly covalently bonded to 3 other carbon atoms. The remaining outer shell carbon electron is delocalised and so can move along the layers formed by the covalently bonded carbon atoms.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	Dot and cross diagram of hydrogen fluoride showing: 1 electron shell for hydrogen with 2 electrons, both of which are shared with fluorine 2 electron shells for fluorine, 2 electrons in the inner shell, 8 in the outer shell, 2 of which are shared with fluorine. (1 mark for the correct electron arrangements, 1 mark for correct sharing of electrons)	2 marks
1 b)	Dot and cross diagram of carbon disulfide showing: a carbon atom with a sulfur atom on each side 2 electron shells for carbon, with 2 electrons in the inner shell, 8 in the outer shell, 4 shared with each sulfur atom 3 electron shells for each sulfur atom, with 2 electrons (1 mark for the correct electron arrangements, 1 mark for correct sharing of electrons)	2 marks
1 c)	Dot and cross diagram of ethanol. It should be the same as the dot and cross diagram for ethane (Fig. 1.65, page 78) with the following changes:	2 marks

Question	Correct answer	Marks
	hydrogen atom on one end is replaced with an oxygen atom and a hydrogen atom the oxygen atom has two electron shells with 2 electrons in the inner shell and 8 in the outer shell two electrons are shared with the carbon atom and two with the hydrogen atom (1 mark for the correct electron arrangements, 1 mark for correct sharing of electrons)	
2	The forces of attraction between the candle wax molecules are (relatively) weak. The energy needed to break these forces is (relatively) low.	1 mark 1 mark
3	The attractive forces between the particles (atoms or molecules) in a gas are (relatively) weak. In an ionic compound the attractive forces between the particles (ions) are (relatively) strong.	1 mark 1 mark
4	The attractive forces between the methane molecules are (relatively) weak. A (relatively) small amount of energy at the melting point is needed to break these attractive forces in solid methane.	1 mark 1 mark
5 a)	X is likely to be a liquid or a gas. In a simple molecular structure the attractive forces between the particles (atoms or molecules) are (relatively) weak, as in a liquid or gas.	1 mark 1 mark
5 b)	X is likely to have a (relatively) low boiling point. The attractive forces between the particles in liquid X are (relatively) weak and so not much energy is needed at the boiling point to break them.	1 mark 1 mark
6 a)	The layers of carbon atoms in graphite are held together by strong covalent bonds. As the covalent bonds in the layers are not easily broken, they will add strength to the tennis racquet.	1 mark 1 mark
6 b)	Between the covalently bonded layers in the graphite are delocalised electrons. These are able to move and carry an electric current.	1 mark 1 mark
7 a)	Diamond is a giant (atomic) structure with each carbon atom covalently bonded to 4 other carbon atoms. The lattice of strong covalent bonds gives diamond its hardness.	1 mark 1 mark
7 b)	Diamond is used in drills/cutting tools.	1 mark
	Total:	23 marks

C1h Metallic crystals

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1. A cation is a positive ion.

2. Metals contain delocalised electrons that are not fixed to a particular atom. They can move throughout the structure.

3. The structure is not rigid, the ions can move into different positions when it is bent.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	A metal structure is made up of metal ions. The ions are surrounded by a 'sea' of delocalised electrons.	1 mark 1 mark
2 a)	Metals contain a 'sea' or 'cloud' of delocalised electrons. The electrons are able to move and carry the electric current.	1 mark 1 mark
2 b)	The structure is held together by the attractive forces between the ions and the electrons. Beating the metal disrupts the arrangement of the ions but does not break the attractive forces between the ions and the electrons.	1 mark 1 mark
3	In the graphite structure the delocalised electrons are between the layers of covalently bonded carbon atoms. The electrons are not delocalised over the whole structure and so can only conduct electricity in one plane. In a metal the electrons are delocalised over the whole metal structure and so can conduct in all planes.	1 mark 1 mark 1 mark
4 a)	C	1 mark
4 b)	A	1 mark
4 c)	D	1 mark
4 d)	B	1 mark
5 a)	An alloy is a mixture of a metal and other elements.	1 mark
5 b)	They modify the property of the pure metal making it more useful. Alloys can be stronger/more hard-wearing than the pure metal (e.g. steel).	1 mark 1 mark
	Total:	16 marks

C1i Electrolysis

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1. The breaking down (decomposition) of a chemical compound by the use of electricity.

2. The positive electrode is the anode.

3. The substance must contain ions and they must be free to move (in molten/liquid state or dissolved in water).

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1. a) An inert electrode is an unreactive electrode. It will not be changed during electrolysis.

   b) Carbon is commonly used as an inert electrode.

2. a) Lead and chlorine

   b) Magnesium and oxygen

   c) Aluminium and oxygen

3. a) Hydrogen (sodium is above hydrogen in the reactivity series)

   b) Hydrogen (zinc is above hydrogen in the reactivity series)

   c) Silver (silver is below hydrogen in the reactivity series)

4. a) $2O^{2-}(aq) \rightarrow O_2(g) + 4e^-$

   b) The change takes place at the anode.

Developing investigative skills, page 97

1. Platinum is commonly used as a material for inert electrodes.

2. Hydrogen was formed at the cathode.

3. Fill the tubes to overflowing with the electrolyte, slide a small piece of paper over the end of the tube and invert the tube carefully. Carefully put the inverted tube in the dilute sulfuric acid above the electrode (the small piece of paper will float away).

4. Sulfuric acid solution is an electrolyte.

5. The volume of oxygen will be half that of the hydrogen.

6. The ions in dilute sulfuric acid are: H^+; SO_4^{2-} and OH^-.

7. $2H^+(aq) + 2e^- \rightarrow H_2(g)$

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1. 2 faradays of electricity are needed to produce 1 mole of calcium atoms.

2. 2 moles of chlorine gas will be produced by 4 faradays of electricity.

3. 0.5 faradays will produce 0.25 moles of hydrogen gas (H_2) = 0.5 g ($2H^+(aq) + 2e^- \rightarrow H_2(g)$)

Page 99

1. a) Diagram is the same as Fig. 1.87 but with the teaspoon replaced by a ring.

   b) Anode $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$; cathode $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

2. a) 1.6 A × (10 × 60 s) = 960 coulombs

   Number of faradays = 960/96 000 = 0.01

   Ag^+ ion has a charge of +1 (1 faraday will give 1 mole of Ag) so 0.01 faraday gives 1.08 g Ag

   so 1 faraday → 1.08/0.01 = 108 (relative atomic mass Ag)

   b) $Ag^+(aq) + e^- \rightarrow Ag(s)$

   Reduction is gain of electrons. Silver ions have gained electrons to become silver metal.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	Electrolysis is the breaking down of a (ionic) compound by a flow of electricity.	1 mark
1 b)	An electrolyte is a substance which when molten or dissolved in water allows an electric current to pass through it.	1 mark
1 c)	An electrode is the substance that is used to pass the electric current into and out of the electrolyte during electrolysis.	1 mark
1 d)	The anode is the positively charged electrode.	1 mark
1 e)	The cathode is the negatively charged electrode.	1 mark
2	The zinc bromide contains ions that are held in a lattice by strong electrostatic attractive forces. In the solid these ions are not free to move and carry the current.	1 mark 1 mark
3	Completed table as shown	4 marks

Electrolyte	Product at the anode	Product at the cathode
Silver bromide	*bromine*	*silver*
Lead(II) chloride	*chlorine*	*lead*
Aluminium oxide	*oxygen*	*aluminium*
Magnesium iodide	iodine	magnesium

4 a)	Anode: chlorine Cathode: sodium	1 mark 1 mark
4 b)	Anode: chlorine and oxygen Cathode: hydrogen	1 mark 1 mark
5 a)	$Al^{3+}(l) + 3e^- \rightarrow Al(l)$ (1 mark for correct charges, 1 mark for balanced equation)	2 marks
5 b)	$Na^+(l) + e^- \rightarrow Na(l)$ (1 mark for correct charges, 1 mark for balanced equation)	2 marks
5 c)	$2O^{2-}(l) \rightarrow O_2(g) + 4e^-$ (1 mark for correct charges, 1 mark for balanced equation)	2 marks
5 d)	$2Br^-(aq) \rightarrow Br_2(l) + 2e^-$ (1 mark for correct charges, 1 mark for balanced equation)	2 marks
5 e)	$4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$ (1 mark for correct charges, 1 mark for balanced equation)	2 marks
6 a)	Cathode	1 mark
6 b)	Silver	1 mark

7	$Al^{3+}(l) + 3e^- \rightarrow Al(l)$	1 mark
	3 F 27 g	1 mark
	1 F 9 g	1 mark
	Total:	30 marks

Section 1: Exam-style questions mark scheme

Question	Correct answer	Marks
2 a)	i) From top to bottom	
	Proton	1 mark
	Electron	1 mark
	Neutron	1 mark
	ii) 6	1 mark
	iii) 12	1 mark
2 b)	The same: the number of protons and electrons	1 mark
	Different: the numbers of neutrons	1 mark
3 a)	metals and non-metals (or non-metals and metals)	2 marks
	gained and lost (or lost and gained)	2 marks
	high and high	2 marks
3 b)	i) Mg 2,8,2	1 mark
	Cl 2,8,7	1 mark
	ii) Mg 2,8	1 mark
	Cl 2,8,8	1 mark
4	Mass of iron(III) oxide = 4.8 g	
	2 moles of $FeSO_4$ produces 1 mole of Fe_2O_3	1 mark
	304 g $FeSO_4$ produces 160 g Fe_2O_3	1 mark
	9.12 g $FeSO_4$ produces 4.8 g Fe_2O_3	1 mark
	volume of SO_3 = 720 cm^3	
	2 moles of $FeSO_4$ produces 1 mole of SO_3	1 mark
	304 g $FeSO_4$ produces 24 000 cm^3 SO_3	1 mark
	9.12 g $FeSO_4$ produces 720 cm^3 SO_3	1 mark
5 a)	There are mobile electrons between the layers of carbon atoms.	1 mark
5 b)	The lead and bromide ions	1 mark
	will not be able to move when lead(II) bromide is a solid.	1 mark
5 c)	First row: cathode (B)	1 mark
	reduction	1 mark
	Second row: anode (A)	1 mark
	oxidation	1 mark
5 d)	i) 0.05 moles lead	1 mark

	0.05 moles bromine	1 mark
	ii) Formula mass of Br_2 = 160	1 mark
	8 g bromine	1 mark

Section 2. Chemistry of the elements

C2a The Periodic Table

Page 110

1. a) 20

   b) The atomic number is the number of protons (which equals the number of electrons) in an atom of the element. Calcium has 20 protons and 20 electrons.

   c) Group 2 d) Period 4 e) Calcium is a metal

2. Halogens 3. Halogens are non-metals.

Page 112

1. A metalloid has some properties typical of a metal and some of a non-metal.
2. The metal can be drawn into a wire.
3. The metal can be beaten into a sheet.
4. Carbon in the form of graphite will conduct electricity.
5. Non-metals usually form acidic oxides.

Page 113

1. Aluminium has 3 electrons in the outer shell.
2. Oxygen will form an ion (the oxide ion) with a 2– charge.
3. Fluorine (F) 4. Barium (Ba)

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	b	1 mark
1 b)	a	1 mark
1 c)	d	1 mark
1 d)	c	1 mark
1 e)	b, d and f	1 mark
1 f)	d	1 mark
2 a)	Metal	1 mark
2 b)	Basic oxide – metals form basic oxides.	1 mark
3 a)	i) Can be beaten into sheets/shape ii) Can be drawn into wires	1 mark 1 mark
3 b)	Any metal (ideally not Group 1 but allow)	1 mark
4	Elements in the same group have the same number of electrons in their outer electron shell.	1 mark
5 a)	Na^+	1 mark
5 b)	Cl^-	1 mark

6 a)	Reactivity increases as you go down a group of metals.	1 mark
6 b)	Reactivity decreases down a group of non-metals.	1 mark
7	The noble gases have a full outer shell of electrons or 8 electrons in their outer electron shells. They do not easily gain or lose electrons.	1 mark 1 mark
	Total:	18 marks

C2b Group 1 elements

Page 117

1. They react with water to form alkaline solutions.

2. 1 electron in the outer shell.

3. The potassium atom is larger than the lithium atom so the outer electron is further from the attraction of the nucleus and can be more easily removed.

4. They are soft to cut (also have very low melting points).

Page 119

1. Sodium oxide is white.

2. Hydrogen. The solution formed is potassium hydroxide.

3. The compounds are soluble.

Page 121

1. a) A period is a horizontal row of elements in the Periodic Table. All the elements in the same period have the same number of electron shells.

For example: Period 1 elements: hydrogen (1) to helium (2) – 1 electron shell

Period 2 elements: lithium (2,1) to neon (2,8) – 2 electron shells

Period 3 elements sodium (2,8,1) to argon (2,8,8) – 3 electron shells

b) sodium, magnesium, aluminium, silicon, phosphorus, sulfur, chlorine, argon

c) 2,8,1; 2,8,2; 2,8,3; 2,8,4; 2,8,5; 2,8,6; 2,8,7; 2,8,8

d) First element 2,8,1 (1 electron in the outer shell, easily lost, will form positive ions, reactive metal)

Last element 2,8,8. (8 electrons in outer shell, full outer shell, noble gas, unreactive)

2. a) A group is a vertical column of elements having similar chemical properties because of their outer shell electronic structure.

b) lithium, sodium, potassium

c) All the elements in this group 1 have one electron in the outer shell.

d) The reactivity of these elements depends upon the ease at which the outer electrons are lost. One electron can easily be lost to form positive ions. The ease at which it can be lost increases down the group as the electron is less tightly held in the atom and therefore reactivity increases down the group.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	Potassium	1 mark

1 b)	To prevent reaction with air (oxygen) or water	1 mark
1 c)	Potassium	1 mark
1 d)	The elements react with the oxygen in the air.	1 mark
1 e)	Sodium is less dense than water.	1 mark
2	The group 1 elements react with water to form alkalis. The alkalis are hydroxides, such as sodium hydroxide.	1 mark 1 mark
3 a)	lithium + oxygen → lithium oxide $4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$ (1 mark for correct formulae, 1 mark for balancing)	1 mark 2 marks
3 b)	potassium + water → potassium hydroxide + hydrogen $2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$ (1 mark for correct formulae, 1 mark for balancing)	1 mark 2 marks
3 c)	potassium + chlorine → potassium chloride $2K(s) + Cl_2(g) \rightarrow 2KCl(s)$ (1 mark for correct formulae, 1 mark for balancing)	1 mark 2 marks
4	Potassium is a larger atom than sodium. The outer electron in potassium is further away from the nucleus than the outer electron in sodium. The outer electron in potassium is easier to remove (as in a reaction) than the outer electron in sodium.	1 mark 1 mark 1 mark
5 a)	Rubidium is a solid.	1 mark
5 b)	i) Hydrogen. ii) Rubidium hydroxide would be formed. Universal indicator would show the presence of an alkali.	1 mark 1 mark 1 mark
5 c)	Rubidium would be more reactive than potassium. The outer electron in rubidium is further away from the nucleus than that in potassium and so it will be more easily transferred in a reaction.	1 mark 1 mark
	Total:	25 marks

C2c Group 7 elements

Page 127

1. 7 electrons in the outer shell.

2. The atoms only need to gain one electron to achieve 8 in the outer shell.

3. The chlorine molecule is made up of two atoms combined/ bonded together, Cl_2.

4. A displacement reaction is where one Group 7 element takes the place of another in a metallic compound.

5. The displacement reaction involves one Group 7 element being reduced (gaining electrons) and one being oxidised (losing electrons).

Developing investigative skills, page 128

1. a) Make sure there are no naked flames in the room.

   b) Work in a fume cupboard or make sure the room is well ventilated.

   c) Don't dispose of the liquid mixture containing the cyclohexane down the sink.

2. Chlorine is more reactive than bromine (it displaced the bromine in sodium bromide).

   Chlorine is more reactive than iodine (it displaced the iodine in sodium iodide).

3. $Br_2(aq) + 2NaI(aq) \rightarrow 2NaBr(aq) + I_2(aq)$

4. Tube 6. Iodine is less reactive than bromine and so cannot displace bromine from sodium bromide. (The cyclohexane layer should have been violet.)

Page 130 (top)

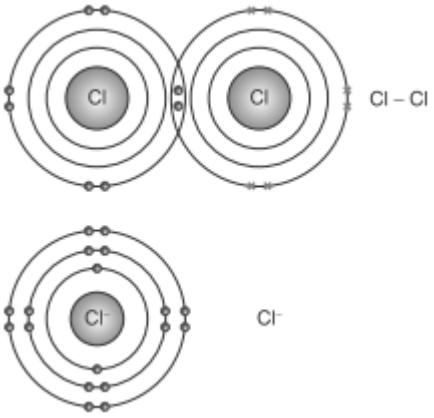
1. Chlorine kills any bacteria that might be present in the water.

2. H^+ and Cl^- ions are the main ions present in aqueous hydrochloric acid.

3. In methylbenzene no H^+ ions are formed.

Page 130 (bottom)

1. a)



   b) $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$. The chloride ions lose electrons.

   c) $2NaOH(aq) + Cl_2(g) \rightarrow NaCl(aq) + NaClO(aq) + H_2O(l)$

   d) Chlorine is a more reactive halogen than bromine. Chlorine will displace bromine from a solution of a bromide ions. (Chlorine will oxidise bromide ions to bromine.)

   Observations: chlorine water is pale green. When this is added to a colourless solution of potassium bromide the resulting solution will turn orange due to the presence of bromine.)

2. a) The reactivity of fluorine is due to its electronic structure 2,7. Fluorine only needs to gain one electron to form a fluoride ion. This is very easy because of its small size and high attractive force of the nucleus.

   b) $F_2(aq) + 2e^- \rightarrow 2F^-(aq)$

   c) Both chlorine and iodine are less reactive than fluorine. Fluorine could only be displaced from fluoride ions by a more reactive halogen. As there are no halogens that are more reactive than fluorine, fluorine will not be displaced from fluoride ions.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	Chlorine	1 mark
1 b)	Bromine	1 mark
1 c)	Iodine	1 mark
1 d)	Bromine is a red brown liquid.	1 mark
2 a)	The Group 7 elements have 7 electrons in the outer electron shell. The Group 7 elements only need to gain 1 electron in a reaction to achieve a full outer electron shell or 8 electrons in their outer electron shell.	1 mark 1 mark
2 b)	Fluorine is the smallest of the Group 7 atoms and so its outer electrons feel the strongest attraction to the nucleus. Fluorine therefore can gain an electron (in a reaction) more easily than the other elements can.	1 mark 1 mark
3 a)	sodium + chlorine → sodium chloride $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$ (1 mark for formulae, 1 mark for balancing)	1 mark 2 marks
3 b)	magnesium + bromine → magnesium bromide $Mg(s) + Br_2(l) \rightarrow MgBr_2(s)$ (1 mark for formulae, 1 mark for balancing)	1 mark 2 marks
3 c)	hydrogen + fluorine → hydrogen fluoride $H_2(g) + F_2(g) \rightarrow 2HF(g)$ (1 mark for formulae, 1 mark for balancing)	1 mark 2 marks
4 a)	This is a displacement reaction.	1 mark
4 b)	$Br_2(l) + 2NaI(aq) \rightarrow 2NaBr(aq) + I_2(aq)$ (1 mark for formulae, 1 mark for balancing)	2 marks
4 c)	I) Oxidation is the loss of electrons. The iodide ions have lost electrons and been oxidised. ii) Reduction is the gain of electrons. The bromine has gained electrons and been reduced.	1 mark 1 mark 1 mark 1 mark
5 a)	The hydrogen ion, H^+.	1 mark
5 b)	In solvents such as methylbenzene the hydrogen chloride does not form H^+ ions.	1 mark
	Total:	26 marks

C2d Oxygen and oxides

Page 136

1. Argon

2. 0.04%

3. Nitrogen

4. Copper(II) oxide

Page 137

1. a) A catalyst is a substance that increases the rate of a reaction.

   b) Manganese (IV) oxide.

2. A basic oxide will react with an acid to form a salt.

3. $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$

4. Acidic oxide. Phosphorus is a non-metal.

Developing investigative skills, page 138

1.

Volume readings	Volume of gas (cm^3)
Initial volume of air	100
Final volume of air	85
Reduction in volume	15

2. The iron filings would have turned orange as the iron rusted.

3. The iron has reacted with oxygen (it has rusted) and formed iron(III) oxide.

4. $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

5. a) The reaction may not be complete – some of the iron had not reacted.

   b) The air might not have been a normal sample (for example, it might have been expired air which contains less oxygen).

   c) Experimental error in setting up the experiment and taking the readings.

6. To equalise the pressure so both readings were taken at the same pressure (the volume of a gas will change as the pressure changes).

Page 141

1. Bubble the gas through lime water. A white precipitate indicates the presence of carbon dioxide.

2. Dry ice is solid carbon dioxide.

3. Carbonic acid.

Page 142

1. a) $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

   b) Manganese(IV) oxide. A catalyst will speed up the rate of a chemical reaction. It does this by providing an alternative route for the chemical reaction which has a lower activation energy.

c) Description to include:

Suitable apparatus to collect oxygen (ref. Fig. 2.27)

Pour hydrogen peroxide into conical flask

Cut small strips of liver to act as catalyst: weigh and record mass

Add catalyst to hydrogen peroxide: replace stopper and collect oxygen until reaction stops

Remove liver from solution and reweigh/or repeat a further experiment using the same pieces of liver

Mass of liver should be (the same)/liver can be re-used

d) Oxygen can be collected over water as it is only slightly soluble. Oxygen will rise to the top of a gas jar filled with water and displace the water by 'downward displacement'.

e) Oxygen can be obtained by the fractional distillation of liquid air.

2. a) When magnesium burns it reacts with oxygen to form magnesium oxide. Pure oxygen is 100% oxygen gas; the air is only 21% oxygen.

b) Magnesium nitride Mg_3N_2

c) Magnesium oxide is a base. Bases will react with acids to form salt + water. If dilute hydrochloric acid is added to magnesium oxide (white powder) it will dissolve to form a colourless solution of magnesium chloride (a soluble salt) + water.

3. a) carbon dioxide can be prepared by

Adding dilute acid to a metal carbonate/metallic carbonate

Decomposition of a metal carbonate/metallic carbonate

b) Description to include:

Suitable apparatus (see Fig. 2.31)

Use sodium carbonate and dilute hydrochloric acid.

Collect carbon dioxide in gas jars over water.

c) $Na_2CO_3(s) + 2HCl(aq) \rightarrow \_2NaCl(aq) + H_2O(l) + CO_2(g)$

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	21% (allow 1/5)	1 mark
1 b)	0.04%	1 mark
2 a)	When air is passed over heated copper the oxygen in the air reacts with the copper to form copper(II) oxide. As the oxygen is removed from the air the volume of gas is reduced eventually by about 1/5).	1 mark 1 mark
2 b)	In the presence of moisture, oxygen in the air reacts with iron to form iron(III) oxide. As the oxygen is removed from the air, external air pressure causes the water to rise up the tube.	1 mark 1 mark
3	Manganese(IV) oxide acts as a catalyst. It increases the rate at which the hydrogen peroxide decomposes to form oxygen.	1 mark 1 mark
4 a)	i) $4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$	2 marks

Question	Correct answer	Marks
	(1 mark for formulae; 1 mark for balancing) ii) $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$ (1 mark for formulae; 1 mark for balancing) iii) $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ (1 mark for formulae; 1 mark for balancing)	 2 marks 2 marks
4 b)	The oxides are basic – they are oxides of metals.	1 mark
5	Calcium carbonate (allow other metal carbonates). Dilute hydrochloric acid (allow dilute nitric acid and dilute sulfuric acid providing the salt formed is not insoluble: for example, don't allow sulfuric acid with calcium carbonate.)	1 mark 1 mark
6 a)	Decomposition means the breaking down of a compound to form smaller compounds.	1 mark
6 b)	$CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$ (1 mark for formulae; 1 mark for balancing)	2 marks
7	Carbon dioxide does not support combustion (do not allow 'it does not burn'). It is denser than air and so settles on a fire and smothers it (excludes the air).	1 mark 1 mark
8	A greenhouse gas prevents some of the energy on the Earth's surface being lost from the Earth's atmosphere. (It absorbs and emits radiation.) Such gases are thought to be responsible for global warming.	1 mark 1 mark
	Total:	24 marks

C2e Hydrogen and water

Page 147

1. aluminium + hydrochloric acid → aluminium chloride + hydrogen

2. $2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$

3. Hydrochloric acid forms salts called chlorides.

Page 148

1. Without water/without water of crystallisation

2. Determine the boiling point of the liquid. (Pure water boils at 100 ºC at normal pressure).

3. $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	Effervescence/bubbling. The magnesium slowly disappears/gets smaller.	1 mark 1 mark
1 b)	i) $Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$	2 marks

Question	Correct answer	Marks
	(1 mark for formulae; 1 mark for balancing) ii) $Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$ (1 mark for formulae; 1 mark for balancing) iii) $2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$ (1 mark for formulae; 1 mark for balancing)	 2 marks 2 marks
2	Put a lighted splint into the gas. The gas burns with a pop.	1 mark 1 mark
3	Add anhydrous copper(II) sulfate to the liquid. The anhydrous copper(II) sulfate turns from white (very pale blue) to deep blue.	1 mark 1 mark
4	Heat a sample of water in a test tube to its boiling point. If the water is pure, a thermometer in the boiling water will record 100 ^oC (at normal pressure).	1 mark 1 mark
5 a)	$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ (1 mark for formulae; 1 mark for balancing)	2 marks
5 b)	Advantage: the product of burning the fuel is water (environmentally friendly). Disadvantage: the gas is highly flammable and extreme care needs to be taken during storage and filling of the car.	1 mark 1 mark
	Total:	18 marks

C2f Reactivity series

Page 153

1. No. Copper is below hydrogen in the reactivity series.

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

3. $Mg(s) + PbO(s) \rightarrow MgO(s) + Pb(s)$

4. No. Carbon is below magnesium in the reactivity series.

Developing investigative skills, page 154

1. A metal cannot displace itself from a solution of its salt.

2. She already knows that metal D cannot displace the other three metals and so must be the least reactive metal.

3. B, C, A, D

4. 10 – yes, 11 – yes, 12 – yes

5. $B(s) + C(NO_3)_2(aq) \rightarrow B(NO_3)_2(aq) + C(s)$

6. Copper.

Page 155

1. Air (oxygen) and water must be present.

2. The grease can be easily removed or wiped away.

3. a) Galvanizing involves coating iron or steel with zinc.

b) As zinc is more reactive than iron, moist air will react with zinc in preference to the iron.

Page 157

1. a) $2Al(s) + Fe_2O_3(s) \rightarrow 2Fe(s) + Al_2O_3(s)$

b) Aluminium is higher in the reactivity series than iron, therefore it is more reactive. Aluminium is able to displace the less reactive iron from its oxide and so form iron and aluminium oxide.

c) Any metal which is higher than iron in the reactivity series can be selected. The higher the metal in the series, the more reactive metal and the more reactive the reaction will be. If the chosen metal is above aluminium, the reaction is more reactive.

d) Aluminium is displacing iron in iron(III) oxide and becoming aluminium oxide by losing electrons. Iron(III) oxide is gaining electrons to become iron metal.

Redox is when oxidation and reduction occur. Aluminium is losing electrons (oxidation). Iron(III) oxide is gaining electrons (reduction).

2. a) oxygen + water

b) chromium protects iron from oxygen and water/used as it is shiny – good decorative effect.

3. Aluminium forms aluminium oxide which acts as a protective layer – does not react with the air.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	Sodium, calcium, magnesium, zinc, copper (minus 1 for each misplaced metal)	2 marks
2 a)	$Mg(s) + PbO(s) \rightarrow MgO(s) + Pb(s)$ (1 mark for correct formulae; 1 mark for balancing)	2 marks
2 b)	Magnesium	1 mark
2 c)	A redox reaction is one involving reduction and oxidation.	1 mark
3 a)	Y, Q, Z, X (minus 1 mark for each misplaced metal)	2 marks
3 b)	i) Y ii) X oxide iii) X oxide iv) Y	1 mark 1 mark 1 mark 1 mark
4 a)	Displacement reaction	1 mark
4 b)	Zinc is more reactive than copper.	1 mark
5 a)	Galvanising	1 mark
5 b)	The zinc is more reactive than the iron. The zinc reacts with oxygen in the air before the iron does.	1 mark 1 mark
5 c)	Painting, applying grease, plastic coating (1 mark for each)	3 marks
	Total:	20 marks

C2g Tests for ions and gases

Page 161

1. Calcium ions produce a brick red flame colour.

2. A nichrome wire is used in a flame test.

3. Add sodium hydroxide solution. Fe^{2+} produces a green precipitate; Fe^{3+} produces a reddish brown precipitate.

Page 164

1. Add dilute sodium hydroxide and heat. An alkaline gas (turns red litmus paper blue) indicates the presence of an ammonium compound.

2. a) Carbon dioxide

   b) Bubble the gas through lime water. A white precipitate forms.

3. The Fe^{3+} ion is present in solution X.

4. The Cl^- ion is present in solution Y.

Page 165

1. Ammonia

2. Oxygen

3. Chlorine

Page 166

1. a) Dip wire in concentrated hydrochloric acid, heat strongly in flame until absence of any yellow colour (sodium)

   b)

Name of cation	**Colour of precipitate**
Zinc/lead	white
Magnesium/calcium	white
Copper(II)	blue
Iron(II)	green/turns brown slowly
Iron(III)	rust brown/orange

   c) $Ag^+(aq) + X^-(aq) \rightarrow AgX(s)$ where X^- is Cl^-, Br^-, I^-.

   d) HCl is added to remove any carbonate ions that may be present.

2. Plan needs to check for testing of both anion and cation for each sample and should include practical instructions.

   Blue compound

   Test for copper(II) – sodium hydroxide: result blue precipitate

   $Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)^2(s)$

   Test for sulphate – hydrochloric acid/barium chloride: result white precipitate

   $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

White compound

Flame test for Na^+ – yellow

Test for carbonate – add dilute acid – effervescence/carbon dioxide evolved – turns lime water milky

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

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	Use a nichrome wire. Dip the wire into concentrated hydrochloric acid, then the solid, then the flame.	1 mark 1 mark
1 b)	Sodium compounds produce a yellow/orange flame. Potassium compounds produce a lilac/purple flame.	1 mark 1 mark
2 a)	Cu^{2+} ions.	1 mark
2 b)	Ammonium ions, NH_4^+	1 mark
2 c)	Fe^{3+} ions	1 mark
3	Completed table as shown below	3 marks

Gas	Test	Observations
Chlorine	Damp universal indicator paper	*Indicator paper bleached/goes white*
Carbon dioxide	Bubble through lime water	White precipitate of suspension forms
Hydrogen	*Apply a lighted splint*	Burns with a 'pop'

4	Use a flame test (nichrome wire, concentrated hydrochloric acid). Lithium ions produce a bright red flame. Add dilute hydrochloric acid and bubble any gas through lime water. A carbonate will produce carbon dioxide which will turn the lime water cloudy.	1 mark 1 mark 1 mark 1 mark
5 a)	Add dilute hydrochloric acid. Then barium chloride solution. A white precipitate indicates the presence of a sulfate ion.	1 mark 1 mark 1 mark
5 b)	Add dilute nitric acid. Then silver nitrate solution. A yellow precipitate indicates the presence of the iodide ion.	1 mark 1 mark 1 mark
	Total:	20 marks

Section 2: Exam-style questions mark scheme

Question	Correct answer	Marks
2 a)	Si	1 mark
2 b)	S	1 mark
2 c)	Group 1	1 mark
2 d)	Group 2	1 mark
2 e)	Group 7	1 mark
3 a)	2, 8, 7	1 mark
3 b)	7	1 mark
3 c)	Brown fumes to colourless gas	1 mark
3 d)	i) Red hydrogen iodide forms an acid in water ii) Green hydrogen iodide will not form an acid unless dissolved in water – it would be neutral	1 mark 1 mark 1 mark 1 mark
4 a)	Magnesium, zinc, iron	1 mark
4 b)	Magnesium + sulfuric acid → magnesium sulfate + hydrogen	1 mark
4 c)	$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$	1 mark
4 d)	Copper (silver, gold)	1 mark
4 e)	The reaction with water/steam or the reaction with oxygen	1 mark
5 a)	Use nichrome wire, dip into concentrated hydrochloric acid Then the solid, then in the flame	1 mark 1 mark
5 b)	Sodium carbonate Sodium hydrogen carbonate	1 mark 1 mark
5 c)	Any two of: lithium carbonate, calcium carbonate, lithium hydroxide, calcium hydroxide	1 mark for each
6 a)	i) Displacement/redox reaction ii) $Mg(s) + PbO(s) \rightarrow MgO(s) + Pb(s)$ iii) Magnesium. It displaces lead from lead(II) oxide/it reduces the lead(II) oxide to lead	1 mark 2 marks 1 mark
6 b)	i) Magnesium ii) Lead(II) oxide iii) Lead(II) oxide iv) Magnesium	1 mark 1 mark 1 mark 1 mark
6 c)	i) $Mg(s) + Pb(NO_3)_2(aq) \leftrightarrow Mg(NO_3)_2(aq) + Pb(s)$ ii) Any metal above Pb in the reactivity series, e.g. aluminium iii) Any metal below lead in the reactivity series, e.g. copper	2 marks 1 mark 1 mark

Section 3. Organic chemistry

C3a Alkanes

Page 179

1. a) Contains no C=C double bonds

   b) A compound containing hydrogen and carbon only

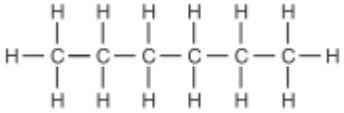
2. a) $C_{15}H_{32}$

   b) Carbon dioxide and water

Page 180

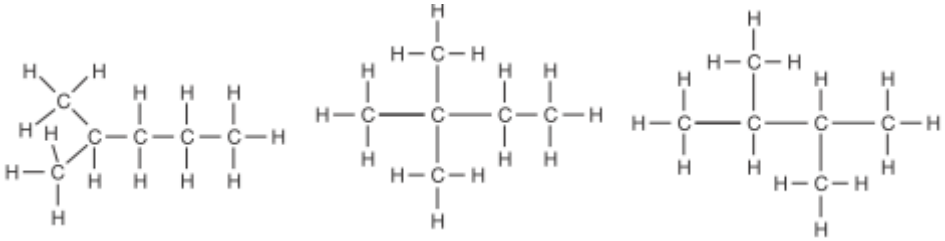
1. Isomers are molecules with the same molecular formula but different structural formulae.

2.



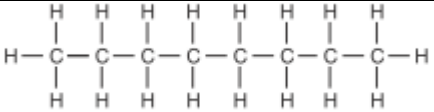
The molecular formula is C_6H_{14}.

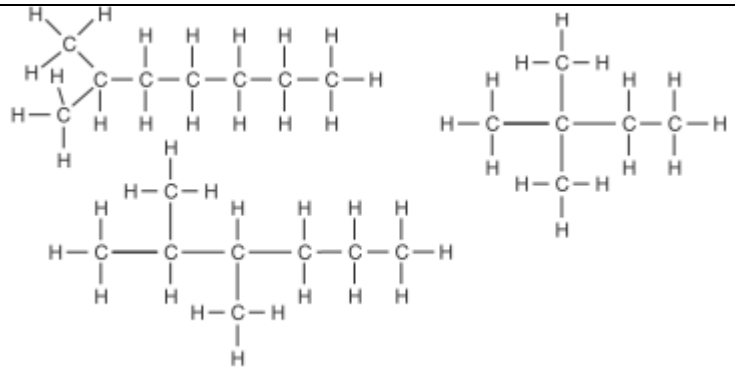
3. Any two of the following:



4. Hexane will be a liquid. Its physical properties will most closely resemble those of pentane.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	A homologous series is group of organic compounds with the same general formula, similar chemical properties and physical properties which change gradually from one member to the next.	1 mark
1 b)	Structural isomerism is the existence of compounds with the same molecular formula but different structural formulae.	1 mark
2	$C_{10}H_{22}$	1 mark
3	No. This compound does not have the general formula of C_nH_{2n+2}.	1 mark
4 a)		1 mark
4 b)	Diagram must have 8 carbon atoms and 18 hydrogen atoms with at least one branch. Some examples are shown here.	1 mark

		
4 c)	Liquid	1 mark
4 d)	Octane is a saturated hydrocarbon – it contains only C-C single bonds (no C=C bonds).	1 mark
5 a)	C_2H_6	1 mark
5 b)	Carbon dioxide Water	1 mark 1 mark
5 c)	Blue flame	1 mark
5 d)	$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$ (1 mark for formulae; 1 mark for balancing)	2 marks
5 e)	Carbon Carbon monoxide	1 mark 1 mark
5 f)	Yellow flame	1 mark
6 a)	Substitution	1 mark
6 b)	In the presence of ultra violet (UV) light.	1 mark
6 c)	Bromomethane	1 mark
	Total:	20 marks

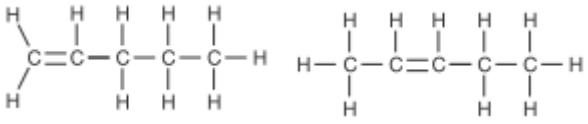
C3b Alkenes

Page 187

1. It contains at least one C=C double bond.

2. The manufacture of polymers (polyethene).

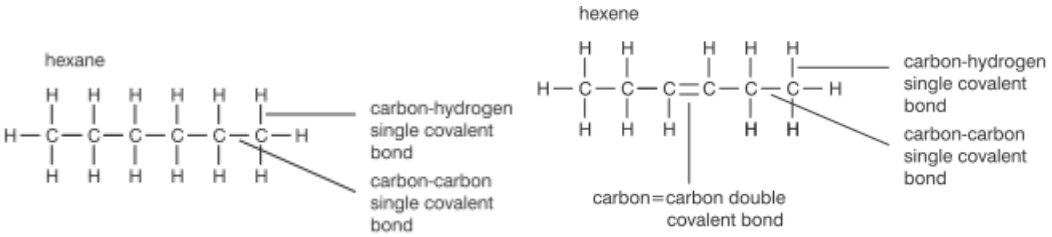
3.



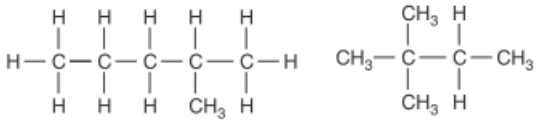
Page 188

1. a) Saturated compounds contain only covalent single bonds. Alkanes contain only carbon–carbon and carbon–hydrogen single bonds and are therefore saturated hydrocarbons. (Alkenes contain C=C double bond and are therefore unsaturated.)

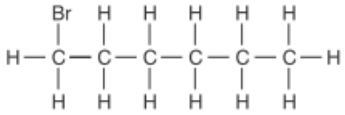
   b) Alkane: C_6H_{14}, alkene C_6H_{12}. The position of the double bond can be between any pair of carbon atoms, but there should be one less hydrogen attached to the double-bonded carbons.



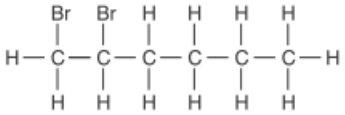
c) Isomers of hexane – need to have 5 carbon atoms in a straight chain with a carbon as a branch or 4 carbons in a line and two branches (a straight chain should not be written with a bend).



d) Hexane undergoes substitution reaction with bromine (any H can be substituted with Br/can have more than one substitution). HBr is also formed in the reaction. The diagram shows 1-bromohexane.



Hexene undergoes an addition reaction with bromine (note bromine loses its colour – this is a test for unsaturation). The bromine will add across the double bond. Example shows addition of hex-1-ene to form 1,2 dibromohexane.



2. a) Fuels are substances that provide heat energy. Alkanes burn readily in air combining with oxygen to produce carbon dioxide and water vapour and large quantities of heat.

b) Incomplete combustion leads to the formation of carbon monoxide instead of carbon dioxide. It is a very poisonous gas and particularly dangerous as it has no odour and causes drowsiness. Carbon monoxide is poisonous because it reacts with the haemoglobin in the blood, forming 'carboxyhaemoglobin'. The haemoglobin is no longer available to carry oxygen to the body and death results from oxygen starvation.

c) Short-chain hydrocarbons are more likely to form carbon dioxide and water as their main products as there is less carbon per molecule in these hydrocarbons to react with the available oxygen. Longer-chain hydrocarbons often burn with a smoky flame and leave black carbon deposits as there is insufficient oxygen to form carbon dioxide, with the many carbons in the longer chains. Carbon monoxide is also formed.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	Yes. It has the general formula of an alkene – a series of unsaturated hydrocarbons (contain C=C double bonds).	1 mark
1 b)	Heptene	1 mark
1 c)	Isomers of heptene: diagrams should have seven carbon atoms with a double bond between two carbon atoms. There should be 14 hydrogen atoms. Carbon atoms with a double bond should only have one hydrogen atom attached to them, except when the carbon is on the end of the chain and it will then have two hydrogen atoms attached to it.	2 marks
2 a)	C_8H_{16}.	1 mark

Question	Correct answer	Marks
2 b)	Liquid – pentene with 5 carbon atoms is a liquid so octane is likely to be a liquid.	1 mark
3 a)	Carbon dioxide Water	1 mark 1 mark
3 b)	i) $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$ (1 mark for formulae; 1 mark for balancing) ii) Blue flame	2 marks 1 mark
3 c)	i) $C_2H_4(g) + O_2(g) \rightarrow 2C(g) + 2H_2O(l)$ (1 mark for formulae; 1 mark for balancing) ii) Yellow flame	2 marks 1 mark
4 a)	For diagrams of hexane and hexene see answers to Question 1b) page 188	2 marks
4 b)	Hexene	1 mark
4 c)	Bromine water	1 mark
5 a)	Orange To colourless/decolourised	1 mark 1 mark
5 b)	$C_3H_6(g) + Br_2(aq) \rightarrow C_3H_6Br_2(l)$ (1 mark for formulae; 1 mark for balancing)	2 marks
5 c)	An addition reaction	1 mark
6	Unsaturated fat	1 mark
	Total:	24 marks

C3c Ethanol

Page 193

1. C_4H_9OH

2. It is a relatively ‘clean’ fuel and releases only carbon dioxide and water into the atmosphere. (It does not release sulfur dioxide and nitrogen oxides, as petrol does when it burns.)

3. A solvent is a liquid that dissolves other substances (solutes) to form solutions.

Page 194

1. Fermentation is the process in which ethanol is made from sugar, yeast and water.

2. The optimum temperature is in the range 25 to 30 ºC.

3. The yeast contains enzymes which increase the rate of the reaction.

4. Carbon dioxide

Developing investigative skills, page 195

1. Use a thermostatically controlled heater in the water bath or leave the apparatus near to a heater to maintain the temperature within the range needed or heat gently with a Bunsen burner or add hot water to maintain temperature

2. To show that gas was being produced (by the bubbles) and to identify the gas as carbon dioxide (turns the lime water cloudy).

3. Frothing in the flask/bubbles in the limewater/limewater turning milky.

4. No more bubbles through the lime water.

5. Ethanol. The boiling point of ethanol is 76 °C which is below that of water (100 °C).

Page 198

1. a) $CH_2{=}CH_2(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$ (ΔH = –45 kJ/mol)

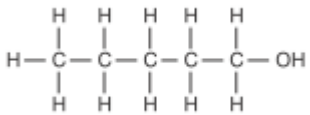
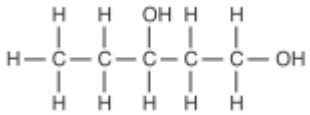
Any reaction in which heat is given out by a system to the surroundings is called an exothermic reaction.

b) The reaction for the formation of ethanol is reversible. The forward reaction is exothermic and therefore low temperatures are favoured in order to produce maximum product (that is, to shift the position of equilibrium to the right). Low temperatures however slow down the rate of the reaction. Manufacturers are trying to produce as much ethanol as possible each day and therefore a compromise temperature is used to balance the amount of ethanol produced with the time it takes. High temperatures, although would increase the rate would produce a poor yield of ethanol.

c) In the reaction for the formation of ethanol from ethene and steam there are two molecules on the left hand side of the equation but only one on the right, therefore the formation of ethanol is favoured by high pressure. High pressures also increase the rate of reaction, but high pressures are expensive as the plant needs strong pipes and containment vessels and high energy requirements. High pressure also causes the ethene to polymerise. Pressures of 60–70 atmospheres are therefore used.

d) Although adding phosphoric(V) acid as a catalyst does not produce any greater percentage of ethanol in the equilibrium mixture, it does ensure that the reaction is fast enough for the dynamic equilibrium to be set up within the time the gases are within the reactor. Without the catalyst the reaction would be too slow to make the manufacture of ethanol cost-effective.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	$C_nH_{2n+1}OH$	1 mark
2 a)	$C_5H_{11}OH$	1 mark
2 b)	Pentanol: 	1 mark
2 c)	i) An isomer is a molecule with the same molecular formula as another molecule but different structural formula. ii) Pentan-3-ol 	1 mark 1 mark
3	Sugar cane Sugar beet	1 mark 1 mark
4 a)	Enzymes present in the yeast speed up the fermentation process Enzymes are denatured at temperatures above about 35 °C	1 mark 1 mark

Question	Correct answer	Marks
4 b)	Fermentation is an anaerobic process and takes place in the absence of oxygen. If oxygen were present the ethanol would be oxidised (to ethanoic acid or vinegar).	1 mark 1 mark
5 a)	Ethene is obtained from crude oil.	1 mark
5 b)	The phosphoric acid is a catalyst.	1 mark
5 c)	Temperature 300 °C Pressure 60-70 atmospheres	1 mark 1 mark
5 d)	$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$	1 mark
6 a)	Fermentation uses renewable resources/ethanol has suitable flavour for alcoholic drinks.	1 mark
6 b)	The method involving ethene is a much faster process than fermentation.	1 mark
7 a)	Aluminium oxide catalyst Heat/high temperature	1 mark 1 mark
7 b)	$C_2H_5OH(l) \rightarrow C_2H_4(g) + H_2O(l)$	1 mark
7 c)	Dehydration	1 mark
	Total:	22 marks

Section 3: Exam-style questions mark scheme

Question	Correct answer	Marks
2 a)	i) True ii) False iii) True iv) False v) False Subtract 1 mark for each mistake, but no negative marks.	2 marks
2 b)	i) A compound/molecule containing carbon and hydrogen only ii) A compound/molecule containing only C to C single bonds	1 mark 1 mark
2 c)	i) C_3H_8 ii) Diagram as shown in Table 3.1 on page 177 of Student Book	1 mark 2 marks
3 a)	C_6H_{12}	1 mark
3 b)	Liquid	1 mark
3 c)	55–75 °C	1 mark
3 d)	i) Add bromine water ii) The bromine water will be decolourised iii) No reaction	1 mark 1 mark 1 mark
3 e)	Diagrams as shown in Fig. 3.11 on page 187 of the Student Book.	2 marks

3 f)	i) Ethanol ii) Phosphoric acid iii) $C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$	1 mark 1 mark 2 marks
4 a)	i) Fermentation ii) Dehydration	1 mark 1 mark
4 b)	i) Temperature 25–30 °C ii) Yeast as a catalyst	1 mark 1 mark
4 c)	$C_2H_5OH(g) \rightarrow C_2H_4(g) + H_2O(g)$	1 mark
4 d)	i) Phosphoric acid catalyst ii) 300 °C iii) 60–70 atmospheres pressure	1 mark 1 mark 1 mark
4 e)	Diagram as shown in Table 3.6 on page 191 of the Student Book	1 mark

Section 4: Physical chemistry

C4a Acids, alkalis and salts

Page 209

1. Both solutions are alkalis. Solution A is a weakly alkaline whereas solution B is a strongly alkaline.

2. The solution is acidic.

3. The basicity of an acid is tells you how many hydrogen ions can be replaced (for example in a reaction with a base).

4. Calcium is a metal. The oxides (and hydroxides) of metals are bases.

Page 214

1. A salt is formed when a replaceable hydrogen of an acid is replaced by a metal.

2. Sulfuric acid

3. Potassium chloride will be soluble in water (as are all potassium salts).

4. Calcium nitrate

5. Neutralisation is the reaction between and acid and an alkali or base to form a salt and water.

6. $H_+(aq)$ 7. $OH^-(aq)$

Developing investigative skills, page 216

1. a) The pipette should be washed with distilled water and then a small amount of the potassium hydroxide solution (discard the solution used for washing).

b) The burette should be washed with distilled water and then a small amount of the sulfuric acid solution (discard the solution used for washing).

2. A pipette bulb (suction bulb) could be used to suck the potassium hydroxide solution into the pipette.

3. Using a funnel (and pouring below eye level by lifting the stand off the bench and down onto a stool).

4. Use a white tile or white card/paper under the conical flask. The methyl orange changes from yellow (in the potassium hydroxide solution) to pink (when too much sulfuric acid solution has been added).

5. Wash the conical flask with distilled water and discard the washings.

6. In the first experiment the student had no real idea how much acid would be needed. After the first experiment she knew approximately how much acid was needed and would be much more likely to get the colour change on adding just one drop.

7. 17.0 cm^3. The result from the first experiment is very different and likely to be the most inaccurate (as just explained).

8 Moles of H_2SO_4 added = $17.0/1000 \times 0.1 = 0.0017$

From the equation the ratio of H_2SO_4 : KOH is 1:2

Moles of KOH = 0.0034

Concentration of KOH = $1000/25 \times 0.0034 = 0.136$ mol/dm^3

Page 215

1. Precipitation is the formation of an insoluble salt as a result of a chemical reaction taking place in aqueous solution.

2. Filtration

3. Washing with cold water will remove traces of any remaining soluble salts.

4. a) lead(II) nitrate + sodium chloride → lead(II) chloride + sodium nitrate

   b) $Pb(NO_3)_2(aq) + 2NaCl(aq) \rightarrow PbCl_2(s) + 2NaNO_3(aq)$

Page 218

1. a) Magnesium carbonate + sulphuric acid → magnesium sulphate + carbon dioxide + water

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

   Note: Magnesium sulfate is hydrated and the correct formula is $MgSO_4.7H_2O$ (water could be added to both sides of the equation if this formula was required)

   b) Any risk assessment format could be used: ensure

   Hazard: Risk: Precautions are included

   All chemicals to be included (both reactants and products)

   All glassware

   Basic laboratory safety may be included but this could be listed or the lab rules referred to

   c) Equipment: beaker (100 cm^3/250 cm^3); measuring cylinder (250 cm^3); spatula; glass rod; filter paper and funnel; stand and clamp for filtering/tripod and gauze; Bunsen burner evaporating basin

   d) Instructions

   Complete and follow risk assessment during experiment.

   Measure (50 cm^3) dilute sulphuric acid into a beaker.

   Using a spatula add magnesium carbonate and stir the mixture. Continue adding the magnesium carbonate until fizzing stops and the magnesium carbonate is in excess.

   Filter the excess magnesium carbonate and collect the magnesium sulfate in an evaporating basin.

   Heat the solution in the evaporating basin until about half of the water has been removed. Leave the solution at room temperature and crystals of magnesium sulfate should form.

   e) The white powder is anhydrous magnesium sulfate – this is magnesium sulfate without the water of crystallisation. The presence of the water gives the crystalline structure, if this water is removed a powder is produced.

   f) In order to prepare a salt using an acid–base titration method both reactants need to be solutions. Magnesium carbonate is not soluble in water and therefore a standard solution cannot be prepared.

   g) Anhydrous form formula $MgSO_4$. It can act as a drying agent as it readily absorbs water from the air. (It is hygroscopic.)

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	An indicator is a substance that will distinguish between an acid and an alkali.	1 mark
1 b)	The pH scale shows how strongly acidic or how strongly alkaline a substance is.	1 mark
1 c)	i) Weakly acidic ii) Weakly alkaline iii) Strongly alkaline	1 mark 1 mark 1 mark
2 a)	An acid is a substance that forms H^+ ions in water.	1 mark

Question	Correct answer	Marks
2 b)	An alkali is a substance which forms OH^- ions in water.	1 mark
2 c)	Neutralisation	1 mark
3 a)	A base	1 mark
3 b)	A salt	1 mark
3 c)	Soluble	1 mark
3 d)	The calcium oxide is added to warm dilute hydrochloric acid with stirring. When no more solid will react filter the mixture. Heat the filtrate in an evaporating basin until it is saturated/reaches crystallisation point (remove a sample onto a cold watch glass to see if it crystallises). Leave the solution to cool and crystallise.	1 mark 1 mark 1 mark 1 mark
3 e)	$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$ (1 mark for balanced equation; 1 mark for state symbols)	2 marks
4 a)	Sulfuric acid	1 mark
4 b)	Barium chloride or barium nitrate	1 mark
4 c)	Mix solutions of dilute sulfuric acid and barium chloride/barium nitrate. Filter the suspension to isolate the solid. Wash the solid on the filter paper with distilled water and leave to dry/dry in a low temperature oven.	1 mark 1 mark 1 mark
4 d)	$BaCl_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2HCl(aq)$ or $Ba(NO_3)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2HNO_3(aq)$ (1 mark for balanced equation; 1 mark for state symbols)	2 marks
5 a)	$K_2SO_4(aq) + 2H_2O(l)$ (1 mark for balanced equation; 1 mark for state symbols)	2 marks
5 b)	$MgCl_2(aq) + H_2O(l)$ (1 mark for balanced equation; 1 mark for state symbols)	2 marks
5 c)	$Ba(NO_3)_2(aq) + CO_2(g) + H_2O(l)$ (1 mark for balanced equation; 1 mark for state symbols)	2 marks
5 d)	$ZnCl_2(aq) + H_2(g)$ (1 mark for balanced equation; 1 mark for state symbols)	2 marks
5 e)	$ZnCO_3(s) + 2KCl(aq)$ (1 mark for balanced equation; 1 mark for state symbols)	2 marks
	Total:	34 marks

C4b Energetics

Page 224

1. A reaction that releases heat energy to the surroundings.

2. A reaction that absorbs energy from the surroundings.

3. Polystyrene is a very good insulator and so very little energy is transferred to the surroundings.

4. Energy change = 100 × 4.2 × 6 = 2520 J

Page 225

1. A high proportion of the energy released is transferred to the surrounding air.

2. Energy = 30 × 4.2 × 15 = 1890 J for 0.1 g corn puffs. Energy for 1 g corn puffs = 1890 × 10 = 18 900 J

3. Energy = 200 × 4.2 × 14 = 11 760 J. Energy per mole = 11 760 × 46/0.5 = 1 081 920 J (1082 kJ)

Page 226

1. Endothermic

2. The activation energy

Developing investigative skills, page 227

1. Measuring cylinders or burettes.

2. Wear protective gloves and goggles. Mop up any spillages quickly with a damp cloth.

3. Putting a lid on the polystyrene cup.

4. Enthalpy change = 100 × 4.2 × 7 = 2940 J

5. Molar enthalpy change = 2940 × 1000/50 (the solutions each contained 0.05 moles)

= 58 800 J/mol or 58.8 kJ/mol

ΔH = –58.8 kJ/mol

6. As the same volume of each solution was used, the ‘starting temperature’ could have been taken as the average of the two. So, for example, if the sodium hydroxide was at 20 °C and the hydrochloric acid at 18 °C, the starting temperature would have been 19 °C.

7. Possible errors were: loss of heat energy during the reaction (likely to be the greatest); and heat energy absorbed by the polystyrene.

Page 230

1. The sign indicates whether the reaction is exothermic (negative sign) or endothermic (positive sign).

2. Energy is needed to break bonds.

3. In an endothermic reaction more energy is needed to break bonds than is recovered on forming bonds.

4. The units are kJ/mol.

5. $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

Energy needed to break bonds = (2 × 436) + 498 = +1370 kJ

Energy released on forming bonds = 4 × 464 = –1856 kJ

Energy change = (+1370) – (1856) = –486 kJ

Page 232

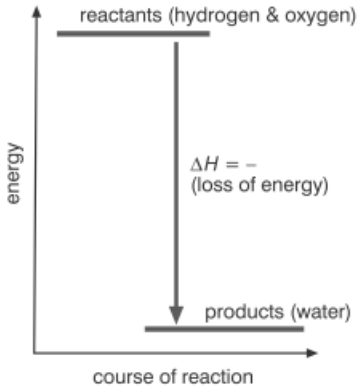
1. a) $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

b) In an exothermic reaction energy is transferred to the surroundings and the temperature rises.

c) Exothermic reaction

d)

Bonds broken (energy absorbed)		Bonds formed (energy released)	
O=O	498	O-H×4	464×4
H-H×2	436×2 = 872		
Total	1370		1856



Overall energy change 1856 – 1370 = 486 kJ

Equation $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

Therefore overall energy change is 486/2 = 243 kJ/mol of hydrogen burned.

2. At present it is expensive to manufacture hydrogen by using electrolysis of water. (Although obtaining hydrogen from electrolysis using wind or solar generated electricity is now being considered.)

Hydrogen also requires much more storage volume than the volume of petrol that produces the equivalent energy.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	Energy = mass × specific heat capacity × temperature change	1 mark
	Energy = 40 × 4.2 × 32	1 mark
	Energy = 5376 J	1 mark
1 b)	Energy per g of magnesium = 5376 × 1.0/0.2 = 26 880 J (26.88 kJ)	1 mark
1 c)	Energy per mole of magnesium = 26.88 × 24 J	1 mark
	Energy per mole of magnesium = 645.12 kJ/mole (allow 645 kJ)	1 mark

2 a)	A metal container Metal is a good conductor of heat.	1 mark 1 mark
2 b)	A considerable amount of energy is lost to the environment. Not all the energy is transferred to the water.	1 mark 1 mark
2 c)	Surround the fuel and container with heat resistant mats. To exclude drafts.	1 mark 1 mark
3 a)	The reaction is exothermic.	1 mark
3 b)	The energy released on forming new bonds is greater than the energy used to break the bonds.	1 mark
4	The energy needed to break the H–H and Cl–Cl bonds Is less than the energy released on forming H–Cl bonds	1 mark 1 mark
5 a)	Energy needed to break bonds = 4E(C–H) + 2E(O=O) = (4 × 413) + (2 × 498) = 2648 kJ Energy released on forming bonds = 2E(C=O) + 4E(O–H) = (2 × 745) + (4 × 464) = 3346 kJ Energy change = 2648 – 3346 = -698 kJ/mole (Must include the negative sign)	1 mark 1 mark 1 mark
5 b)	The reaction is exothermic.	1 mark
	Total:	20 marks

C4c Rates of reaction

Page 238

1.a) The particles must collide.

b) There must be sufficient energy in the collision (to break bonds).

2. An effective collision is one which results in a chemical reaction between the colliding particles.

3. It is an energy barrier. Only collisions which have enough energy to overcome this barrier will lead to a reaction.

Page 240

1. A gas syringe will accurately measure the volume of gas produced.

2. No gas is being produced – the reaction hasn't started or it is finished.

3. The quicker reaction will have the steeper gradient.

Developing investigative skills, page 242

1. To ensure that it was a fair test – the depth of liquid above the cross would always be the same.

2. The reaction starts as soon as the hydrochloric acid is added – during the stirring and positioning of the flask onto the pencil cross the reaction is taking place.

3. A burette or measuring cylinder. (The burette will be more accurate.)

4. The greater the volume of sodium thiosulfate (that is, the greater the concentration of the solution) the greater the rate of the reaction.

5. 45 s (range 42 to 48 s).

6. a) Deciding when the pencilled cross is no longer visible (it disappears quite slowly, particularly for the more dilute solutions)

b) Starting the stop clock consistently at the same point in mixing the solutions. Losing liquid while swirling or stirring is another possibility.

Page 244

1. The units of concentration for solutions are mol/dm^3.

2. The particles are more closely packed together and so there will be more (effective) collisions per second.

3. Increasing temperature means the particles: have more (kinetic) energy; more of the collisions will have energy greater than or equal to the activation energy; there will be more effective/successful collisions per second are moving faster and so will collide more often and with more energy in the collisions.

Page 247

1. A catalyst is a substance that changes the rate of a chemical reaction.

2. A biological catalyst is called an enzyme.

3. Changes in pressure affect reactions involving gases.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	There must be enough energy in the collision. To exceed the activation energy/break bonds	1 mark 1 mark
2 a)	The activation energy is an energy barrier, it is the minimum energy required for a reaction to take place.	1 mark
2 b)	Reaction A is likely to have the greater rate of reaction at a particular temperature. It has a lower activation energy.	1 mark 1 mark
3 a)	Carbon dioxide	1 mark
3 b)	$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$ (1 mark for balanced equation; 1 mark for state symbols)	2 marks
3 c)	Marks for the graph: Suitable scale for axes Points plotted correctly Smooth curve drawn	 1 mark 1 mark 1 mark
3 d)	i) 20 cm^3 ii) 16 cm^3 iii) 13 cm^3 iv) 0 cm^3	1 mark 1 mark 1 mark 1 mark
3 e)	The rate of reaction is greatest at the beginning of the reaction. The rate decreases as the reaction proceeds and is zero after 70 seconds.	1 mark 1 mark

Question	Correct answer	Marks
3 f)	The concentration of the reactants is greatest at the beginning of the reaction and so there will be more effective collisions. As the reactants are used up there will be fewer effective collisions and so the rate of the reaction will decrease.	1 mark 1 mark
3 g)	Marks for the graph: The line should start from the origin. The curve should be steeper/have a greater gradient and not cross the other curve. The curve should reach the same plateau but sooner.	 1 mark 1 mark 1 mark
3 h)	The question does not state which reactant is in excess so there are some possibilities. Marks for the graph: The line should start from the origin. The curve should be less steep/have a smaller gradient and not cross the first curve. The curve should reach a plateau below or at the same level as the original plateau but after a longer time.	 1 mark 1 mark 1 mark
4	As the particles will be moving quicker there will be more collisions per second. There will also be more energy available in the collision to overcome the activation energy/ break bonds	1 mark 1 mark
5 a)	The catalyst provides an alternative pathway for the reaction The pathway has a lower activation energy	1 mark 1 mark
5 b)	Manganese(IV) oxide (allow alternatives)	1 mark
5 c)	Phosphoric acid	1 mark
6	Increasing pressure will increase the rate of reaction The gas particles will move closer together so there will be more effective collisions per second	1 mark 1 mark
	Total:	33 marks

C4d Equilibria

Page 254

1. The copper(II) sulfate crystals can be converted into anhydrous copper(II) sulfate by heating and removing the water in the crystals. When the water is added back to anhydrous copper(II) sulfate the copper(II) sulfate crystals are re-formed.

2. The concentration of each of the products and reactants remains constant unless a change is made to the reaction.

3. Reactants are constantly being converted into products and products are constantly being converted back into reactants. The rates of these two reactions are the same.

Page 257

1. a) Low temperature

   b) High pressure

   c) Using a catalyst has no impact on the position of equilibrium.

2. a) The catalyst increases the rate of the reaction (but has no affect on the position of equilibrium).

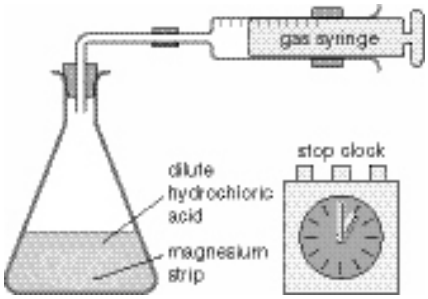
   b) The rate of the reaction would be very low.

Page 258

1. a) Magnesium + hydrochloric acid $\rightarrow$ magnesium chloride + hydrogen

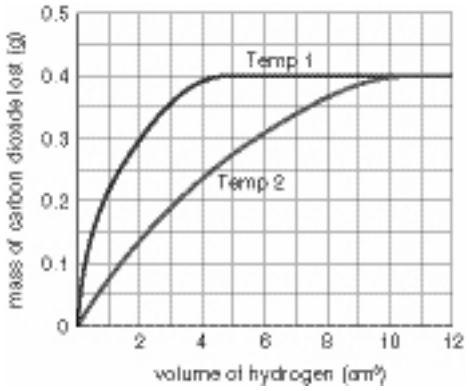
   $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

   b) i)



   ii) Length of magnesium strip; concentration and volume of hydrochloric acid.

   iii) In experiment 1 the curve is steeper (has a greater gradient) than in experiment 2.



   Experiment 1 – is at the higher temperature. Hydrogen is evolved at a faster rate. Reaction complete as shown (indicated as the volume of gas stays constant).

   Experiment 2 – gradient of graph less showing hydrogen gas evolved at a slower rate reaction complete as shown.

   c) Initially the mass would be the total mass of the container + the unreacted reactants. The rate of loss of mass would be greater at the start of the reaction due to higher concentrations of reactants. The mass would then decrease until the reaction was complete and there would be no more change of mass. If the reactions were monitored at two different temperatures the graphs would start at the same point and lose the same amount of mass. The reaction at the higher temperature would lose the mass at a greater rate.

2. The initial rate of each of the chemical reactions can be found by drawing a gradient to the curve at the starting point (time = 0 seconds).

   A gradient needs to be drawn at the start of the reaction – gradient found as change of Y-axis/change in X-axis:

Change in volume/unit time or loss in mass/unit time

The initial rate of the reactions for the experiments performed at the same temperatures should be the same as long as the same length of magnesium/concentration and volume of hydrochloric acid are used. The initial rate of the experiment at the higher temperature will be greater and the same for both methods of measurement as long as the conditions were the same. The value for the initial rate of a reaction is independent of the method of monitoring. Units need to be stated.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	A reversible reaction is one in which the reactants form the products but the products can reform the reactants.	1 mark
2	In a dynamic equilibrium the reactants are constantly being converted into products and products are constantly being converted back into reactants. The rates of the forward and backward reactions are the same.	1 mark 1 mark
3 a)	Hydrated copper(II) sulfate are blue crystals. On heating steam is given off and condenses as water on the cooler part of the tube. A white/very pale blue powder remains.	1 mark 1 mark 1 mark
3 b)	On adding water steam is produced/the test tube gets warm. A blue solid is formed.	1 mark 1 mark
4	$CuSO_4.5H_2O(s) \leftarrow CuSO_4(s) + 5H_2O(l)$ (1 mark for formulae; 1 mark for state symbols; 1 mark for reversible reaction sign)	3 marks
5	White solid Colourless fumes form on heating. The smoke reforms a white solid on the cooler parts of the tube.	1 mark 1 mark 1 mark
6a)	The equilibrium moves to the right hand side. The equilibrium moves in the direction that reduces the amount of oxygen.	1 mark 1 mark
6 b)	The equilibrium moves to the right hand side. The equilibrium moves in the direction that produces fewer molecules.	1 mark 1 mark
6 c)	The equilibrium moves to the left hand side. The equilibrium absorbs heat energy, the endothermic reverse reaction.	1 mark 1 mark
7 a)	A catalyst increases the rate of a reaction. It provides a reaction pathway with a lower activation energy.	1 mark 1 mark
7 b)	A catalyst does not affect the equilibrium position of a reaction. It increases the rates of the forward and backward reactions to the same extent.	1 mark 1 mark
	Total:	24 marks

Section 4: Exam-style questions mark scheme

Question	Correct answer	Marks
2 a)	i) Correctly plotted graph	3 marks
	Deduct one mark for each incorrectly plotted point.	
	ii) Point at 44 °C circled	1 mark
	iii) Any one sensible source of error: incorrect measurement of temperature, loss in mass or even volume.	1 mark
2 b)	58 ± 2 s	1 mark
	35 ± 2 s	1 mark
2 c)	i) 0.017 ± 0.01	1 mark
	0.029 ± 0.02	1 mark
	ii) g/s	1 mark
	iii) The rate increases.	1 mark
	iv) When the temperature increases the particles will move faster	1 mark
	and collide more frequently.	1 mark
	There will also be more energy involved in the collision and so more collisions will lead to a reaction.	1 mark
2 d)	Put the acid in a fridge or freezer until the temperature falls to 5 °C.	1 mark
3 a)	Energy taken in = +2468 kJ	1 mark
	Energy given out = –2958 kJ	1 mark
	ΔH = –490	1 mark
	kJ/mol	1 mark
3 b)	ii) Axes labelled Energy (kJ) and (Course of) Reaction	1 mark
	Lines for reactants (SO_2 and O_2) and product (SO_3)	1 mark
	ΔH correctly labelled	1 mark
3 c)	i) Pipette used for potassium hydroxide solution	1 mark
	Burette for dilute sulphuric acid	1 mark
	Methyl orange indicator used	1 mark
	Colour change at end point yellow to pink (Phenolphthalein: colour change at end point pink to colourless)	1 mark
	ii) number moles KOH = 0.00375	1 mark
	number of moles of H_2SO_4 = 0.00188	1 mark
	concentration of H_2SO_4 =0 125	1 mark
	M or moles/dm^3	1 mark

Section 5: Chemistry in society

C5a Extraction and uses of metals

Page 271

1. Gold or silver

2. Potassium, sodium, calcium or magnesium

3. Aluminium is above carbon in the reactivity series and so carbon cannot reduce aluminium oxide to aluminium.

4. a) The cryolite produces an electrolyte that has a lower melting point than that of the aluminium oxide and so reduces energy costs.

   b) Aluminium atoms form at the cathode.

   c) $Al^{3+(}l) + 3e^- \rightarrow Al(l)$

   d) The aluminium ions are reduced. They accept electrons.

   e) The carbon electrodes react with the oxygen produced in the electrolysis and form carbon dioxide.

5. Aluminium has a high strength to weight ratio/low density/resists corrosion.

Page 275 (top)

1. Iron ore (haematite), coke and limestone

2. Iron(III) oxide

3. Carbon dioxide, carbon monoxide, nitrogen (from the air)

4. $2Fe_2O_3(s) + 3C(s) \rightarrow 4Fe(s) + 3CO_2(g)$

5. a) An alloy is a mixture of a metal and another element.

   b) The proportion of carbon is reduced by heating the pig iron in oxygen.

   c) The pig iron is brittle – steel is more flexible and more resistant to corrosion.

Page 275 (bottom)

1. a) Haematite Fe_2O_3; bauxite Al_2O_3

   b) Carbon is not a strong enough reducing agent to remove titanium from its ore. (Note: titanium does form titanium carbide TiC if it is heated with carbon.)

   c) i) titanium(IV) oxide + chlorine + carbon(coke) $\rightarrow$ titanium (IV) chloride + carbon monoxide

   $TiO_2(s) + 2Cl_2(g) + 2C(s) \rightarrow TiCl_4(l) + 2CO(g)$

   ii) titanium(IV) chloride + sodium $\rightarrow$ titanium + sodium chloride

   $TiCl_4(l) + 4Na(s) \rightarrow Ti(s) + 4NaCl(s)$

   iii) Displacement/redox

   iv) Sodium is a reactive metal and will displace titanium from its chloride. Sodium is acting as a reducing agent. Sodium metal will lose electrons to form sodium ions (sodium chloride). Titanium (chloride) will gain electrons to become titanium.

   v) Sodium is a very reactive metal (reacts with water and air) the reaction therefore needs to be carried out in an inert atmosphere. Magnesium is still more reactive than titanium and will displace titanium from titanium chloride, but magnesium is not as reactive as sodium so absence of water/air is not as important. (Note, however, $TiCl_4$ does react violently with water)

   Reaction $TiCl_4(l) + 2Mg(s) \rightarrow Ti(s) + 2MgCl_2(s)$

vi) Copper is low in the reactivity series. It will not displace titanium from its compounds. Copper is not a strong enough reducing agent to remove titanium from its ore.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	Gold and silver are found in their pure state. They are not combined with other elements (as compounds).	1 mark
2 a)	$2Fe_2O_3(s) + 3C(s) \rightarrow 4Fe(s) + 3CO_2(g)$ (1 mark for formulae; 1 mark for balancing)	2 marks
2 b)	The iron(III) oxide is reduced – it has lost oxygen.	1 mark
2 c)	The limestone forms calcium oxide. The calcium oxide combines with impurities such as sand (silicon dioxide) to form a slag (calcium silicate).	1 mark 1 mark
3 a)	$2ZnO(s) + C(s) \rightarrow 2Zn(s) + CO_2(g)$ (1 mark for formulae; 1 mark for balancing) (Also allow: $ZnO(s) + C(s) \rightarrow Zn(s) + CO(g)$)	2 marks
3 b)	The electrolysis requires the zinc oxide to be in a molten state. This requires considerable amounts of energy and so the process is very expensive.	1 mark 1 mark
4 a)	In electrolysis the ions must be free to move (to the electrodes). The ions are able to move in a solution but not in a solid.	1 mark 1 mark
4 b)	$2O^{2-}(l) \rightarrow O_2(g) + 4e^-$ (1 mark for formulae; 1 mark for balancing)	2 marks
4 c)	The carbon anodes react with the oxygen produced in the reaction. Forming carbon dioxide OR correct equation: $C(s) + O_2(g) \rightarrow CO_2(g)$	1 mark 1 mark
4 d)	$Al^{3+}(l) + 3e^- \rightarrow Al(l)$ (1 mark for formulae; 1 mark for balancing)	2 marks
4 e)	The process has a high demand for electricity (for melting and electrolysis). Hydroelectric power is a relatively cheap source of electricity.	1 mark 1 mark
5 a)	An alloy is a mixture of a metal with one or more other elements.	1 mark
5 b)	Steel contains iron (96% approx.) and carbon (4% approx.).	1 mark
6 a)	Like copper, aluminium is a good conductor of electricity. Aluminium is less dense than copper so the cables are lighter.	1 mark 1 mark
6 b)	Aluminium is non-toxic/impermeable/resistant to corrosion. Any two.	2 marks
6 c)	High strength to weight ratio/low density/resistant to corrosion. Any two.	2 marks
6 d)	Steel is stronger/less brittle/more resistant to corrosion than iron. Any two.	2 marks
6 e)	Chloride ions will be discharged at the anode.	1 mark
6 f)	$2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$	2 marks

Question	Correct answer	Marks
	(1 mark for formulae; 1 mark for balancing)	
7 a)	An alloy is a mixture of a metal with one or more other elements.	1 mark
7 b)	Steel contains iron (96% approx.) and carbon (4% approx.).	1 mark
8 a)	Like copper, aluminium is a good conductor of electricity. Aluminium is less dense than copper so the cables are lighter.	1 mark 1 mark
8 b)	Aluminium is non-toxic/ impermeable/ resistant to corrosion. Any two.	2 marks
8 c)	High strength to weight ratio/ low density/ resistant to corrosion. Any two.	2 marks
8 d)	Steel is stronger/ less brittle/ more resistant to corrosion than iron. Any two.	2 marks
	Total:	40 marks

C5b Crude oil

Page 283

1. The supplies of crude oil are limited – it takes millions of years for crude oil to be formed.

2. Natural gas or methane. It is trapped in pockets above the oil.

3. Small chain of carbon atoms.

4. Long chain of carbon atoms.

5. These fractions ready form a vapour.

Developing investigative skills, page 284

1. The gases must be insoluble in water.

2. To prevent a ‘suck back’ (where water is forced back through the apparatus as the gases cool and contract) and water reaching the boiling tube that has been heated.

3. a) The liquid paraffin is flammable. Care must be taken to make sure the apparatus is assembled securely.

   b) The boiling tube could crack while it is being heated. Safety glasses should be worn.

   c) There is danger of a ‘suck back’ when heating is stopped. This can be prevented by removing the delivery tube from the trough of water.

4. The first test tube would contain a large volume of air displaced from the apparatus.

5. The gas (hydrocarbon) must be unsaturated, that is, it contains a carbon-to-carbon double bond.

6. $C_{14}H_{30}(g) \rightarrow C_{12}H_{26}(g) + C_2H_4(g)$

Page 285

1. Ethene is a member of the alkene homologous series.

2. The fractional distillation of crude oil produces a high proportion of long-chain hydrocarbons, which are not as useful as short-chain hydrocarbons. Cracking converts the long-chain hydrocarbons into more useful shorter chain hydrocarbons.

3. The conditions required for cracking oil fractions are a temperature of between 600 and 700^{o}C and a catalyst of silica or alumina.

Page 287

1. The fuel will burn with a yellow (rather than blue) flame.

2. Carbon and carbon monoxide.

3. It combines with the haemoglobin to form carboxyhaemoglobin, which prevents the haemoglobin from combining with oxygen.

4. Wind, wave, solar and nuclear power are alternative ways of generating energy.

Page 289

1. The sulfur dioxide combines with oxygen and water to form sulfuric acid.

2. Nitrogen oxide reacts with oxygen and water to form nitric acid.

3. An alkali such as slaked lime.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	Crude oil is formed from the remains of animals. Pressed together under layers of rock (over millions of years).	1 mark 1 mark
1 b)	It takes millions of years to form – crude oil used cannot be replaced.	1 mark
2 a)	Fractional distillation	1 mark
2 b)	The boiling point decreases	1 mark
2 c)	Some parts of the mixture condense and form liquids (which are drained off). The parts that do not condense (temperature above the boiling point) pass up the column.	1 mark 1 mark
3 a)	A hydrocarbon is a substance that contains carbon and hydrogen atoms only.	1 mark
3 b)	A catalyst of silica or alumina A temperature of between 600 and 700 °C	1 mark 1 mark
3 c)	C_8H_{18}	1 mark
3 d)	The alkane series	1 mark
3 e)	Cracking converts the less useful longer chain molecules into more useful shorter chain molecules.	1 mark 1 mark
4 a)	Carbon dioxide Water	1 mark 1 mark
4 b)	$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(l)$ (1 mark for formulae; 1 mark for balancing)	2 marks
4 c)	Carbon monoxide is highly poisonous. It reduces the capacity of the blood to transport oxygen around the body.	1 mark 1 mark
5 a)	Sulfur dioxide/nitrogen oxide/carbon dioxide. Any two.	2 marks
5 b)	It damages plants/animals that feed on the plants/leaches minerals out of the soil. Any two.	2 marks

5 c)	Burn less fossil fuels/use filters to remove gases such as SO_2 at power stations/add lime to lakes and rivers. Any two.	2 marks
	Total:	26 marks

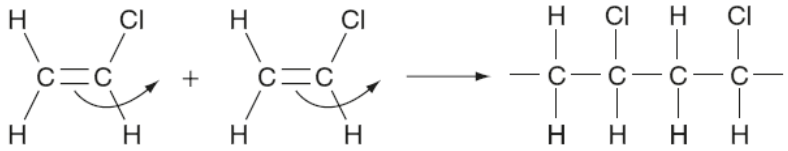
C5c Synthetic polymers

Page 297

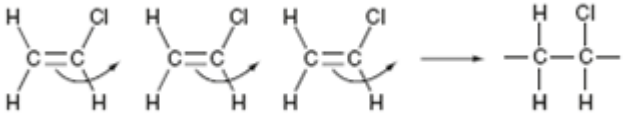
1. The individual beads are like monomer molecules. The string of beads is like a polymer made by joining together many of these monomers.

2. Poly(ethene)/polythene is used to make plastic bags.

3. a)



b)



4. Poly(chloroethene) is an addition polymer.

Page 298

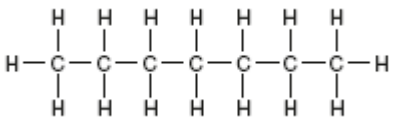
1. Nylon is made from two monomers and a small molecule is eliminated when the two monomers combine. An addition polymer has only one monomer.

2. To produce a polymer chain the monomers need to be able to join together at both ends of the molecules.

Page 299

1. Fractional distillation: can be used to separate crude oil into different fractions having different boiling points. (Note more detail may be included – see 'How does fractional distillation work?') Cracking: is the splitting up of a large chain hydrocarbon into shorter more useful one. Polymerisation: There are two types addition polymerisation and condensation polymerisation. Addition polymerisation is the formation of a polymer formed by the addition which occurs across carbon-carbon double bonds when monomer units combine, such as ethene to poly(ethene). Condensation polymerisation is the formation of a polymer in which the combination of two substances is accompanied by the elimination of a small simple molecule such as water or hydrogen chloride: for example, nylon is a condensation polymer.

2. a) Heptane C_7H_{16}



b) Heptane forms part of a fraction called gasoline which is a very volatile low boiling point liquid. The state of alkane will be determined by the length of the carbon–carbon chain and the strength of the intermolecular forces. The larger the molecules the stronger the intermolecular forces. The simplest alkanes are gases, the longer chains are liquids and even longer 20+ C solids heptane is a liquid.

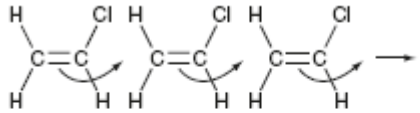
c) $C_7H_{16} \rightarrow C_5H_{12} + C_2H_4$ (any combination of alkanes and alkenes which add up to 7C and 16H)

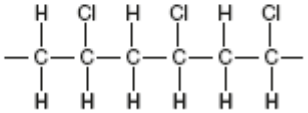
d) Step 1 formation of ethene. By the cracking of any long chain alkane to give a product of ethene (C_2H_4) (any balanced equation of alkane $\rightarrow$ shorter alkane + C_2H_4)

Step 2 formation of chloroethane: By an addition reaction between ethene and HCl

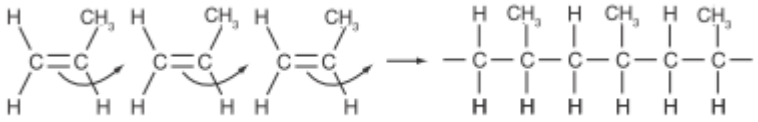
$CH_2=CH_2 + HCl \rightarrow CH_3CH_2Cl$

Step 3 formation of PVC: By the addition polymerisation of chloroethene to form poly(chloroethene)





End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	A monomer is a molecule that can combine with other molecules to form a polymer.	1 mark
1 b)	A polymer is a giant (large) molecule made up of one or more monomers.	1 mark
2 a)	An addition polymer is formed when molecules of a single monomer join together in large numbers.	1 mark
2 b)	A C=C double bond	1 mark
2 c)		2 marks
2 d)	Propane is a saturated hydrocarbon and does not contain a C=C double bone. It cannot undergo addition reactions and so cannot form a polymer.	1 mark 1 mark
3	Completed table as shown below.	3 marks

Addition polymer	Use	
Poly(ethene)	Buckets/bowls/plastic bags	Any one. (1 mark)
Poly(propene)	Packaging/ropes/carpets	Any one. (1 mark)
Poly(chloroethene)	Plastic sheets/artificial leather	Any one. (1 mark)

4 a)	Addition polymers cannot be broken down. By the bacteria in the soil.	1 mark 1 mark
4 b)	Plastics have to be separated from other recyclable materials. There are different types of plastic – they need to be separated. Only some (thermoplastic) plastics can be melted and reformed others	1 mark 1 mark

	(thermosetting) decompose on strong heating.	1 mark
5 a)	A condensation polymer is made from two different monomers. A small molecule (such as water) is also produced when two monomers combine.	1 mark 1 mark
5 b)	i) Nylon/terylene/allow polyester/polyurethane. Any one. ii) Nylon/terylene/polyester used in clothing (accept other sensible alternatives).	1 mark 1 mark
	Total:	20 marks

C5d The industrial manufacture of chemicals

Page 304

1. a) Nitrogen is obtained from the air.

   b) Hydrogen is obtained from natural gas or the cracking of hydrocarbons.

   c) The forward reaction (exothermic) is favoured by a low temperature.

   d) Iron is the catalyst.

   e) The catalyst has no effect on the yield of ammonia (just the rate of the reaction).

2. In ammonium nitrate %N = 28/80 × 100 = 35%. In ammonium chloride %N = 14/53.5 × 100 = 26.2%

Page 306

1. A higher temperature is used to give a suitable rate of reaction.
2. The catalyst is vanadium(V) oxide.
3. Increasing the pressure would be uneconomical because the yield is already very high at 98%.
4. Sulfuric acid reacts with ammonia to produce ammonium sulfate.

   $2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$

Page 309

1. a) Na^+, Cl^-, H^+, OH^-

   b) Na^+ and H^+ ions are attracted to the cathode. The more reactive ion (less reactive atom) will be discharged, H^+.

   c) $2H^+(aq) + 2e^- \rightarrow H_2(g)$

2. Sodium hydroxide is used to manufacture bleach, paper and soap.

Page 310

1. Main points which can be included: ammonia NH_3; manufactured by Haber process $N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$; Nitrogen for this process obtained from the air. Obtained by fractional distillation – need to consider costs of obtaining this raw material.
   Sulfuric acid H_2SO_4: Manufactured by the contact process

   Step 1: sulfur burned in excess dry air to form sulphur dioxide; $S(s) + O_2(g) \rightleftharpoons SO_2(g)$

   Step 2: The gas mixture (sulphur dioxide and air) is filtered and then passed over a series of converters containing a catalyst where sulphur dioxide and oxygen from the air produce sulphur trioxide:
   $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

2. Main points which can be included: A catalyst is a substance that increases the rate of a chemical reaction and is chemically unchanged at the end of the reaction. Catalysts work by providing an alternative 'route' for the reaction which has a lower activation energy. The lower activation energy means that more of the collisions per second between particles will be effective. (These can be linked to iron and vanadium (V) oxide). See also Fig. 4.34.

a) Haber process: Manufacture of ammonia

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

Exothermic reaction under normal conditions of temperature and pressure is slow.

Finely divided iron is used as catalyst to increase the rate of reaction – large surface area as the catalyst is surface active (reaction takes place on the surface of the catalyst).

Catalyst will increase the rate of both the forward and reverse reaction.

Catalyst will enable the equilibrium position to be reached more rapidly.

b) Contact process: Manufacture of sulfuric acid Sulphur dioxide and oxygen combine in contact with the catalyst vanadium(V) oxide (in a series of converters containing trays of catalyst) in an exothermic reaction to produce sulphur trioxide; $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$.

Gas reactions take place on surface of catalyst – therefore need large surface area. Reaction needs to be dust free as this will reduce the effective surface area 'poisoning it' and limiting its efficiency (although vanadium(V) oxide is an efficient catalyst and is not easily poisoned).

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	Nitrogen Hydrogen	1 mark 1 mark
1 b)	$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$ (1 mark for formulae and state symbols; 1 mark for balancing; 1 mark for reversible reaction sign) Use correct sign for reversible reaction.	3 marks
1 c)	Completed table as shown	3 marks

Reaction conditions	Conditions chosen
Temperature	450 °C
Pressure	200 atmospheres
Catalyst	Iron

1 d)	At a lower temperature the rate of reaction is very low. The higher temperature used is a compromise; it increases the rate but reduces the yield.	1 mark 1 mark
1 e)	Cooling allows the ammonia formed to liquify. Removing the ammonia causes the equilibrium to move to the right so converting nitrogen and hydrogen into ammonia.	1 mark 1 mark
2 a)	$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$ (1 mark for formulae and state symbols; 1 mark for balancing; 1 mark for reversible reaction sign.)	3 marks

	Use correct sign for reversible reaction.	
2 b)	Complete table as shown overleaf.	3 marks

Reaction conditions	Conditions chosen
Temperature	450 °C
Pressure	Normal pressure
Catalyst	Vanadium(V) oxide

2 c)	Sulfuric acid is used to make fertilisers/detergents/paints/dyes. Any two.	2 marks
3 a)	i) Chlorine is formed at the anode. ii) $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ (1 mark for symbols and state symbols; 1 mark for balancing)	1 mark 2 marks
3 b)	i) Hydrogen is formed. ii) $2H^+(aq) + 2e^- \rightarrow H_2(g)$ (1 mark for symbols and state symbols; 1 mark for balancing)	1 mark 2 marks
3 c)	The sodium hydroxide forms in the cell. From the Na^+ and OH^- ions that are not discharged.	1 mark 1 mark
	Total:	28 marks

Section 5: Exam-style questions mark scheme

Question	Correct answer	Marks
2 a)	The alkene homologous series	1 mark
2 b)	Monomer	1 mark
2 c)	Use Fig 5.26 but replace the Cl atoms with CH_3 units	1 mark 1 mark
2 d)	Again use Fig 26 for the repeat unit BUT replace Cl by CH_3 and only show a chain with 2 carbon atoms	1 mark 1 mark
2 e)	Addition polymer	1 mark
2 f)	Packaging/ ropes/ carpets (Any two)	2 marks
2 g)	They are non-biodegradable They are not easily broken down by bacteria in the soil	1 mark 1 mark
2 h)	i) It is a condensation polymer It is made from two different monomers	1 mark 1 mark
3 a)	A: haematite B: molten iron C: slag	1 mark 1 mark 1 mark

3 b)	i) $C(s) + O_2(g) \rightarrow CO_2(g)$	1 mark
	ii) $CO_2(g) + C(s) \rightarrow 2CO(g)$	1 mark
3 c)	The limestone decomposes to form calcium oxide (CaO).	1 mark
	The calcium oxide then combines with sand (silica) to form a slag.	1 mark
3 d)	The iron(III) oxide has lost oxygen.	1 mark
3 e)	i) Aluminium is higher in the reactivity series	1 mark
	than carbon.	1 mark
	ii) Any two of the following use/property combinations: packaging (non-toxic); In aeroplanes (high strength to weight ratio – low density); electrical cables (good electrical conductivity); kitchen utensils (shiny appearance/ non-toxic).	2 marks
4 a)	i) Bitumen	1 mark
	ii) Gasoline	1 mark
	iii) Bitumen	1 mark
4 b)	(Catalytic) cracking (1)	1 mark
	The long-chain hydrocarbon is passed at high temperature (600–700 °C)	1 mark
	over a catalyst of silica or alumina.	1 mark
4 c)	i) $2CH_4(g) + 3O_2(g) \rightarrow 2CO(g) + 4H_2O(l)$	2 marks
	ii) Carbon monoxide molecules attach themselves to the haemoglobin in the blood	1 mark
	and this prevents the haemoglobin from transporting oxygen.	1 mark
5 a)	Reversible reaction	1 mark
5 b)	The reaction is exothermic	1 mark
5 c)	A low temperature will give a high yield	1 mark
	A high temperature will give a good rate of reaction	1 mark
	450^oC provides an optimum balance of reasonable yield at reasonable rate	1 mark
5 d)	i) A catalyst provides an alternative pathway for the reaction	1 mark
	With a lower activation energy	1 mark
	ii) Vanadium(V) oxide is the catalyst	1 mark
	The reaction between sulfur trioxide and water is highly exothermic	1 mark
	The reaction with oleum is much less violent and so is safer.	1 mark

