Chapter 1 Atomic structure

In-text questions

1. **a)** J.J. Thompson discovered the electron.
   b) James Chadwick discovered the neutron in 1932.
   c) Ernest Rutherford's research led him to describe the atom as having a positively charged centre. He named the particles in this central area protons, from the Greek word 'Protos' meaning 'I am First'.
2.

Particle	Relative mass	Charge	Position in the atom
electron	1/1840 or almost 0	–1	in shells orbiting the nucleus
neutron	1	0	nucleus
proton	1	+1	nucleus

3. Thompson was investigating the way gases conduct electricity. He passed a high voltage across the terminals of a tube containing air and found out that the rays produced travelled in straight lines from the negative terminal and that these rays were deflected towards a positively charged plate. Since the particles in the ray were attracted towards a positively charged plate Thompson said they were negatively charged.
4. Neutrons were discovered later than protons and electrons perhaps because they had no charge and could not be attracted or repelled by charged plates.
5. IT presentations.
6. Atomic number of an element is the number of protons in an atom of that element. Mass number of an element is the number of protons and neutrons in an atom of that element.
7. Atoms are always neutral as the number of electrons is exactly equal to the number of protons. As the electrons have a negative charge and the protons have a positive charge the charges cancel each other out.
8.

Element	Mass number	Atomic number
a) Potassium K	40	19
b) Oxygen O	16	8
c) Phosphorous P	31	15

9.

Atomic number	Element
a) 17	Chlorine
b) 35	Bromine
c) 7	Nitrogen

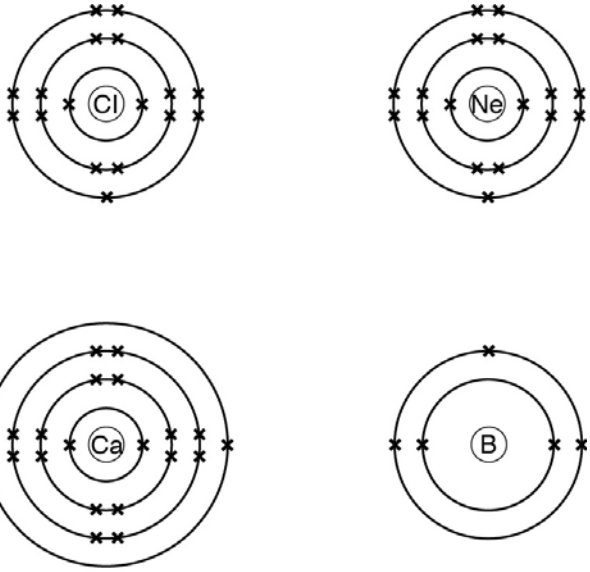
10.

Element	Number of electrons	Number of protons	Number of neutrons
a) $^{39}_{19}K$	19	16	39 – 19 = 20
b) $^{56}_{26}Fe$	26	26	56 – 26 = 30
c) $^{40}_{18}Ar$	18	18	40 – 18 = 22
d) $^{16}_{8}O$	8	8	16 – 8 = 8

11.

Element	Atomic number	Number of neutrons
Copper	29	64 – 29 = 35
Manganese	25	55 – 25 = 30
Phosphorous	15	16

12.



13. **a)** D
b) A
c) B

14.

Element	Mass number	Atomic number	Electronic configuration
Aluminium	27	13	2,8,3
Magnesium	24	12	2,8,2
Fluorine	19	9	2,7
Oxygen	16	8	2,6

15. $$\text{relative atomic mass of boron} = \frac{\text{sum of mass of all the atoms in the sample}}{\text{number of atoms in the sample}}$$
$$= \frac{(10\times 20)+(11\times 80)}{100}$$
$$= \frac{200+880}{100}$$
$$= \frac{1080}{100} = 10.8$$

16.

Atom	Number of protons	Number of electrons	Number of neutrons	Atomic number	Mass number
Magnesium	12	12	12	12	24
Potassium	19	19	20	19	39
Boron	5	5	6	5	11

17.

Isotope	Number of electrons	Number of neutrons	Number of protons
^{37}Cl	17	20	17
^{35}Cl	17	18	17

18.

Isotope	Number of electrons	Number of neutrons	Number of protons
$^{12}_{6}C$	6	6	6
$^{13}_{6}C$	6	6	7
$^{14}_{6}C$	6	6	8

Exam questions (pages 8–9)

1. a) i) An element is a substance which contains only one type of atom. An element is a substance which cannot be broken down into anything simpler by chemical means. *(2 marks)*

ii) Atomic number is the number of protons in the nucleus of the atom. *(1 mark)*

b)

Particle	Relative mass	Relative charge
proton	1	+1
electron	Almost 0 or $\frac{1}{1840}$	–1
neutron	1	0

(3 marks)

2. a)

Particle	Relative charge	Position in the atom
electron	+1	nucleus
proton	0	nucleus
neutron	–1	shells/obits around the nucleus

(3 marks)

b) The electron and proton were discovered first because they are charged particles and can be attracted or repelled by charged plates. The neutron is not charged. *(1 mark)*

3.

Particle	Charge	Relative mass
electron	–1	$\frac{1}{1840}$
neutron	0	1
proton	+1	1

(4 marks)

4.

Symbol	Mass number	Number of protons	Number of neutrons	Electronic structure
Li	7	3	4	2,1
F	19	9	10	2,7
Al	27	13	14	2,8,3
K	39	19	20	2,8,8,1

(8 marks)

5. a) i) Isotopes. *(1 mark)*

ii)

Atom	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons
^{35}Cl	17	35	17	18	17
^{37}Cl	17	37	17	20	17

(2 marks)

b) i) calcium – 2,8,8,2 *(1 mark)*

ii) chlorine – 2,8,7 *(1 mark)*

6.

Isotope	Mass number	Number of protons	Number of neutrons	Number of electrons
$^{206}_{82}Pb$	206	82	124	82
$^{207}_{82}Pb$	207	82	125	82
$^{208}_{82}Pb$	208	82	126	82

(4 marks)

Chapter 2 Bonding and structures

In-text questions

1. a) 2,8
b) 2,8
c) 2,8
d) 2,8
e) 2,8,8
f)

Name and formula of ion	Number of protons	Number of neutrons	Number of electrons
a) Sodium ion Na^+	11	12	10
b) Magnesium ion Mg^{2+}	12	12	10
c) Aluminium ion Al^{3+}	13	14	10
d) Fluoride ion F^-	9	10	10
e) Sulfur S^{2-}	16	16	18

2. a) E Sodium
b) A and G
c) H Magnesium and F calcium
d) E Sodium

3. a) The electronic arrangement of the four ions indicates the number of electrons in each ion. Using this and the charge on the ion will lead to the number of protons in the nucleus of the ion. The number of protons is unique to the atoms of an element and therefore the ion can be named.

A Number of electrons = 10
Charge on the ion 1–
This indicates this ion has one more electron than the number of protons.
Number of protons = 9
9 protons = fluorine
A is a fluoride ion, F^-.

B Number of electrons = 10
Charge on the ion 2+
This indicates this ion has two more protons than the number of electrons.
Number of protons = 12
12 protons = magnesium
B is a magnesium ion, Mg^{2+}.

C Number of electrons = 10
Charge on the ion 2–
This indicates this ion has two more electron than the number of protons.
Number of protons = 8
8 protons = oxygen
C is an oxide ion, O^{2-}.

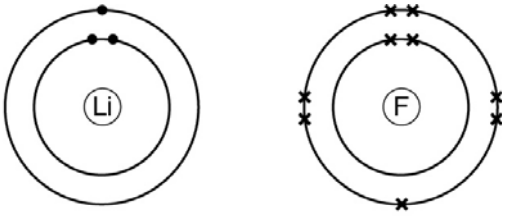
D Number of electrons = 10
Charge on the ion 3+

This indicates this ion has three more protons than the number of electrons.
Number of protons = 13
13 protons = aluminium
D is a aluminium ion, Al^{3+}.

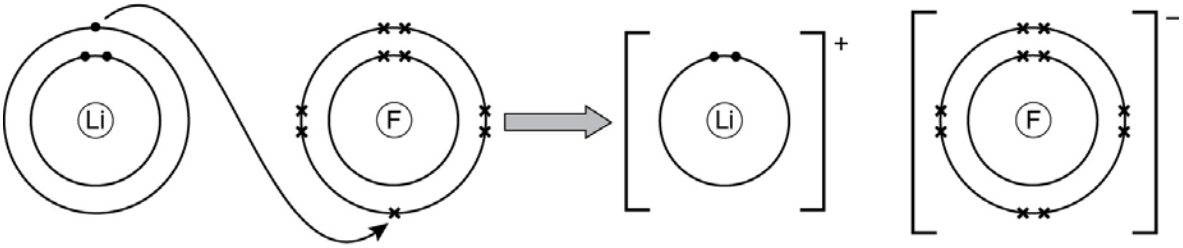
b) BA_2.

4. Calcium and oxygen react to form calcium **oxide**. When this happens a calcium atom transfers two **electrons** to an oxygen atom. After the reaction calcium ions with a charge of **2+** form while oxide ions with a charge of **2–** form. The ions are held together by strong **electrostatic** attractions. The chemical bond which results from these attractions is called an **ionic** bond.

5. a)



b) The lithium atom transfers one electron to the outer shell of the fluorine atom. The electronic arrangement of the lithium atom changes from 2,1 to 2. The electronic arrangement of the fluorine atom changes from 2,7 to 2,8.



c) To work out the charges on the ions information about the number of protons and electrons is needed. The number of protons can be found by looking up the atomic number of the atom on the Periodic Table (page 246 of the textbook).

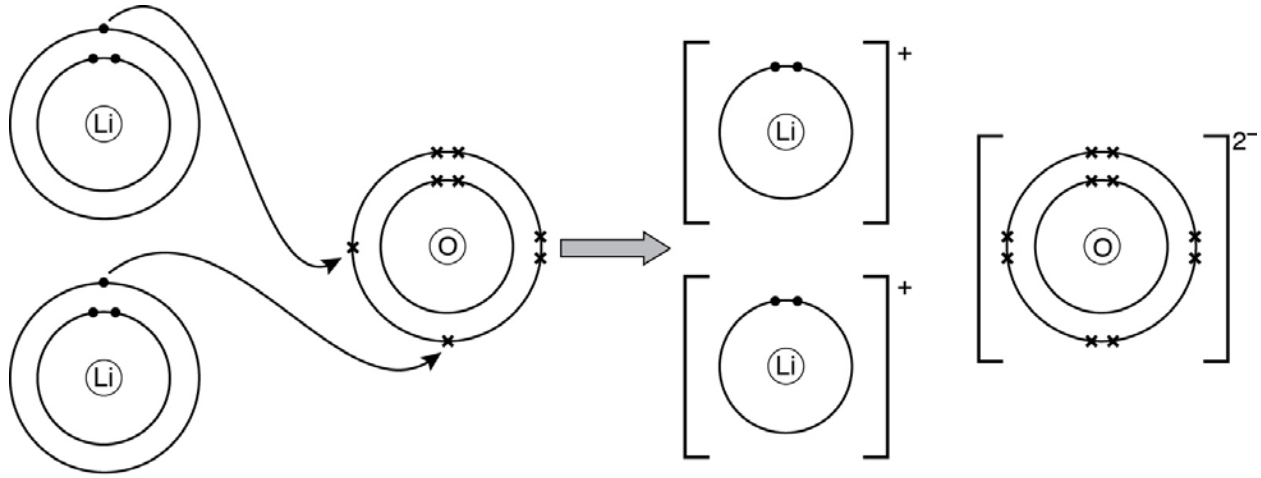
Ion	Number of protons	Number of electrons	Total charge of protons	Total charge of electrons	Overall charge of ion
Lithium ion	3	2	3+	2–	1+
Fluoride ion	9	10	9+	10–	1–

d) The lithium ion has an electronic structure 2, which is the same as the electronic structure of the helium atom. The fluoride ion has the electronic structure 2,8 which is the same as the electronic structure of an atom of neon.

6. Students should remember an atom will lose or gain electrons to produce an ion which has a full outer shell. A species with a full outer shell is much more stable than a species which does not have a full outer shell.

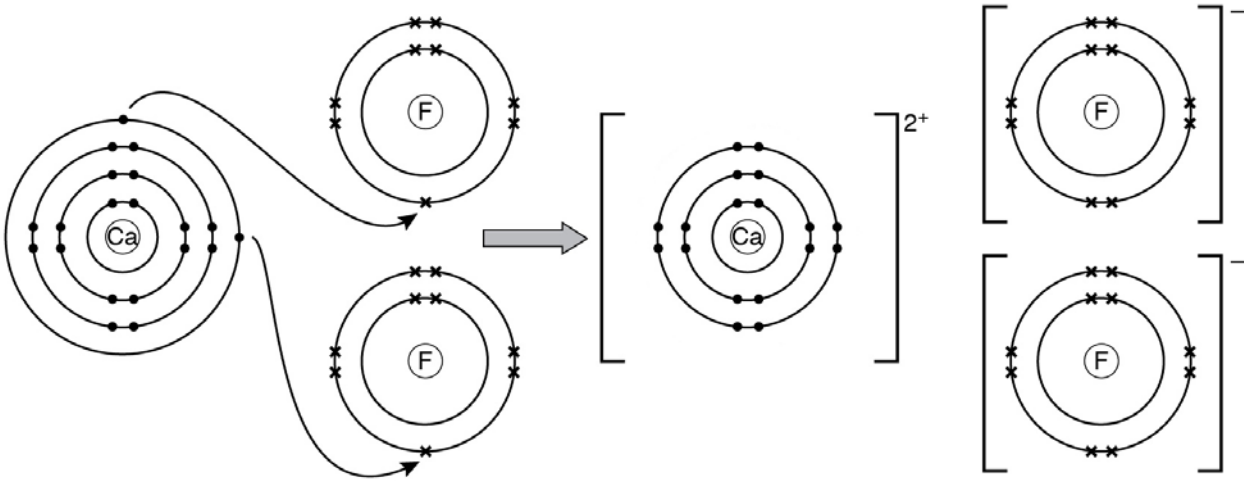
Name of atom	Electronic structure		Charge on ion formed from the atom
Magnesium	2,8,2	Loses 2 electrons	2+
Potassium	2,8,8,1	Loses 1 electron	1+
Chlorine	2,8,7	Gains 1 electron	1–
Aluminium	2,8,3	Loses 3 electrons	3+
Oxygen	2,6	Gains 2 electrons	2–
Calcium	2,8,8,2	Loses 2 electrons	2+
Fluorine	2,7	Gains 1 electron	1–

7.



The oxygen atom requires two electrons to fill the outer shell. The lithium atom can only donate one electron. Therefore, two lithium atoms are required to donate one electron each to the oxygen atom. This is written as Li_2O.

8. **a)** & **b)**



c) Calcium fluoride is a compound because it contains two different types of atoms which are chemically combined. (Calcium fluoride is a compound because it contains calcium atoms and fluorine atoms chemically joined together. Calcium fluoride is a compound as it contains two elements which are chemically combined.)

d) The formula of calcium fluoride is CaF_2. Ionic bonding is present in the compound.

9. a) B potassium, and D sodium.

b) B_2C.

c) 1.

d) Sodium ion, Na^+.

10. a) A covalent bond is formed when atoms share a pair of electrons.

b) i) See Figure 9, page 16 of the Student's Book.

ii) See Figure 10, page 17 of the Student's Book, section to the right of the red arrow only.

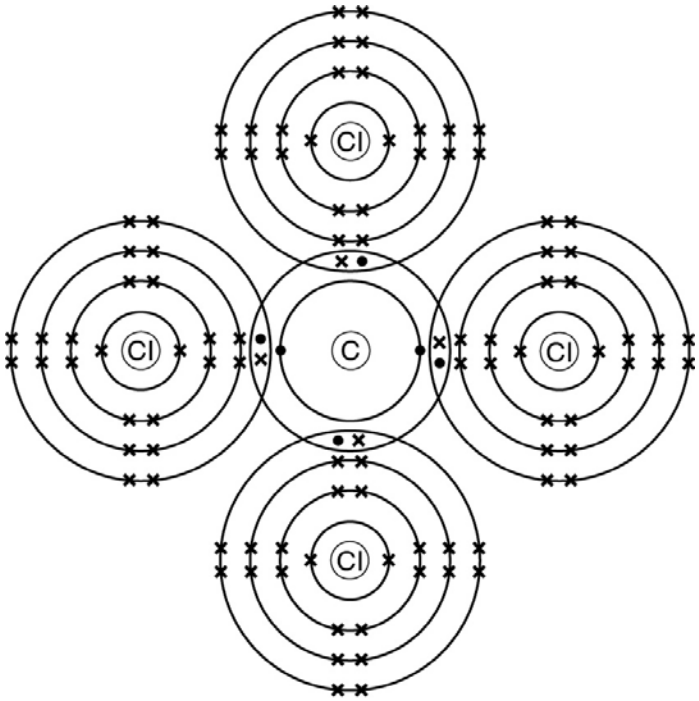
iii) See Figure 15, page 18 of the Student's Book.

iv) See Figure 13, page 18 of the Student's Book.

v) See Figure 11, page 17 of the Student's Book, section below the right of the red arrow only.

vi) See Figure 12, page 18 of the Student's Book.

11. a)



b) The formula of ammonia is NH_3 because the central nitrogen atom needs to share 3 pairs of electrons to have a full outer shell. (In NH_2 the hydrogen atoms are each sharing one pair of electrons and have a full outer shell but the central nitrogen atom is sharing only two pairs. This means it has 7 electrons in its outer shell and the shell is not full.)

c) Methane is a covalent molecule. The atoms are held together with strong covalent bonds but the molecules are held together by weak forces of attraction (van der Waal's forces). It requires very little energy to overcome these weak forces of attraction and move the molecules further apart. (When a sample of methane boils the molecules gain more energy and move further apart. The molecule does not break up in to atoms. The forces between the

molecules are weak and very little energy is required to overcome them. Often students confuse the fact that the *atoms* in the molecule are held together by a very strong bond but the *molecules* are held together by a much weaker force of attraction. When a simple covalent substance melts or boils it is the forces between the molecules which are broken not the covalent bond between the atoms which make up the molecule.)

12. The bonds between the molecules in iodine are slightly stronger than the bonds between the molecules in bromine. It takes more energy to break the molecules apart in iodine than to break the molecules apart in bromine.
Bromine is a liquid at room temperature because the energy available at room temperature is enough to melt the substance but not to boil it.
Iodine is a solid at room temperature because the energy available at room temperature is not sufficient to melt the solid.

13.

Similarities	**Differences**
Both are made from atoms of carbon	In diamond each carbon atom is bonded to four others. Diamond shares four pairs of electrons in four single bonds per carbon atom and has no delocalised electrons. In graphite each carbon atom is attached to three others. Graphite shares three pairs of electrons per carbon atom in three single bonds and has one delocalised electron per carbon
Connected by covalent bonds	The atoms in diamond form a 3D structure of tetrahedral carbon atoms. In graphite the carbon atoms are formed into layers.
In a giant covalent structure	
Both have extremely high melting points	
Both are extremely insoluble in water	

14. a) When explaining high or low melting points it is essential to know what type of force of attraction is breaking apart. A substance with a high melting point must have some sort of strong forces of attraction or bonds as it takes a lot of energy to break these bonds. A substance with a low melting point must have weak forces of attraction holding it together as it takes very little energy to break the forces of attraction or the bonds. Students can get confused when a substance is held together by two different types of forces. They just have to decide which of these forces are being broken when the substance melts.
In this question a basic answer would be…..

> Diamond has a high melting point because it is held together by strong bonds. It takes a lot of energy to break these bonds.
> Chlorine has a low melting point as it is held together by weak bonds. It takes very little energy to break these bonds.

The examiner has asked about two specific substances and therefore the answer can be improved greatly by using knowledge of the specific bonding in the substances.
A better answer would read……

> Diamond has a high melting point because it is held together by strong **covalent** bonds. It takes a lot of energy to break these bonds.

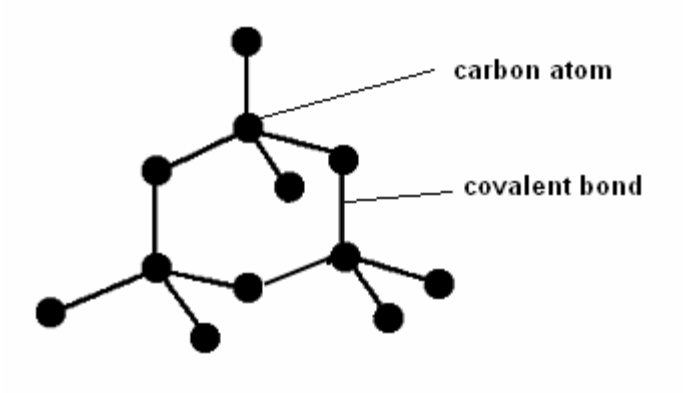
Chlorine has a low melting point as **the molecules are** held together by weak forces of attraction/Van Der Waals forces. It takes very little energy to break these bonds.

b) Graphite conducts electricity as it has delocalised electrons between the layers of carbon atoms. These delocalised electrons can move (when a potential difference is applied) and carry the charge.

c) Diamond is hard as each carbon atom in diamond is bonded to four others in a giant 3D covalent structure. The symmetrical, tetrahedral arrangement of the carbon atoms produce strong covalent bonds in all directions.

15. a) Allotropes are different forms of the same element in the same physical state.

b) See Figure 20, page 20 of the Student's Book. Students are not expected to draw the structure of diamond in as much detail as the diagram in the Student's Book in an examination. They are however, required to show some understanding of the basic elements of the structure. The diagram below shows three separate carbon atoms attached to four other carbons. These carbon atoms are shown to have four bonds in all directions. They are clearly tetrahedral. The diagram shows six carbons in a hexagon. This labelled diagram should achieve full marks.



Drawing of graphite should have at least two layers of at least five rings, with carbon atoms, covalent bonds and weak forces of attraction/van der Waal's forces labelled.

c) Elements with allotropes include sulfur and tin.

16. Malleable means to beat into sheets.

17. See Figure 23, page 23 of the Student's Book.

18. a) Iron is a relatively strong metal with a high melting point and a low cost compared to other strong metals.

b) Aluminium is a good conductor of electricity and is not liable to corroding easily. It is not however, the best conductor but it has a very low cost compared to other conductors.

c) Copper and silver are both excellent electrical conductors. Silver is slightly better than copper but silver is extremely expensive and copper is used due to cost considerations.

d) Iron corrodes easily and needs to be protected.

e) The information in the table is inconclusive. It may be due to the high density and keeps the pan from toppling over when cooking.

19. a) An alloy is a mixture of two or more elements, at least one of which is a metal and the resulting mixture has metallic properties.

b) Iron is a metal which is composed of a regular arrangement of layers of positive ions surrounded by delocalised electrons. When a force is applied the layers of positive iron ions can slip over each other without repelling due to the protection of the delocalised electrons.

Atoms of carbon are smaller than iron ions. This causes the layers to become irregular making it more difficult for the layers of iron ions to slip over one another.

20. a) C could be diamond as it has an extremely high melting point and does not conduct electricity.

b) E is composed of oppositely charged ions.

c) A, C and D all contain covalent bonds between atoms.

d) A and D contain covalent bonds between atoms and van der Waal's forces between molecules.

Exam questions (pages 28–29)

1. a) i) The calcium atom has an electronic configuration 2,8,8,2. The chlorine atom has an electronic configuration 2,8,7. The calcium atom transfers 2 electrons to 2 chlorine atoms producing one calcium ion with an electronic configuration 2,8,8 and two chloride ions with an electronic configuration 2,8,8. The calcium ion (Ca^{2+}) and the chloride ions (Cl^-) are held together by strong electrostatic forces of attraction. This question can be answered by using a set of **labelled** diagrams.
See Figure 3, page 12 of the Student's Book.
To gain the full marks for this question when using diagrams students must include the final sentence:
The calcium ion (Ca^{2+}) and the chloride ions (Cl^-) are held together by strong electrostatic forces of attraction. *(6 marks)*

ii) See Figure 14, page 18 of the Student's Book. *(3 marks)*

b) $\frac{(35 \times 75) + (37 \times 25)}{100} = 35.5$ *(3 marks)*

2. a) i) K *(1 mark)*

ii) J *(1 mark)*

iii) K *(1 mark)*

b) A metallic bond is the attraction between the regular arrangement of positive ions and the delocalised electrons in the metal structure. *(3 marks)*

c) i) Allotropes are different forms of the same element in the same physical state. *(2 marks)*

ii) Graphite has delocalised electrons which can move and carry the charge (when a potential difference is applied). *(2 marks)*

3. a) i) See Figure 11, page 17 of the Student's Book, below the red arrow. *(2 marks)*

ii) Any one from: hydrogen chloride, chlorine, hydrogen, methane, ammonia, oxygen, nitrogen, carbon dioxide. *(1 mark)*

iii) Water molecules are held together by weak forces of attraction (van der Waal's forces) which take only a little energy to break. Calcium fluoride is (an ionic compound) made from ions held together by strong (electrostatic) forces of attraction which take a lot of energy to break. *(3 marks)*

b) i) See Figure 23, page 23 of the Student's Book. *(3 marks)*

ii) 1 Iron is a dense metal because the positive ions have a high atomic number and are close together. *(2 marks)*

2 Iron is ductile as the layers of positive ions can slide over each other without repelling due to the delocalised electrons. *(2 marks)*

3 Iron can conduct electricity because it contains delocalised electrons which can move and carry the charge (when the potential difference is applied). *(2 marks)*

4. a) The diagram of the calcium atom should show 2 electrons in the first shell, 8 electrons in the second shell, 8 electrons in the fourth shell and 2 electrons in the outermost shell, the fourth shell. The diagram of the fluorine atom should show 2 electrons in the first shell, 7 electrons in the second shell. *(2 marks)*

b) The calcium atom loses two electrons to form an ion with an electronic configuration 2,8,8. Two fluorine atoms gain 1 electron each to form 2 ions with the electronic configuration 2,8. *(3 marks)*

c) CaF_2. *(1 mark)*

d) Ionic bonding. *(1 mark)*

5. a) The magnesium atom has an electronic configuration 2,8,2. The oxygen atom has an electronic configuration 2,6. The magnesium atom transfers 2 electrons to an oxygen atom producing one magnesium ion with an electronic configuration 2,8 and one oxide ion with an electronic configuration 2,8. The calcium ion (Mg^{2+}) and the chloride ions (O^{2-}) are held together by strong electrostatic forces of attraction. *(6marks)*

b) Magnesium oxide is (an ionic compound) made from ions held together by strong (electrostatic) forces of attraction which take a lot of energy to break. *(3 marks)*

6. See Figure 23, page 23 of the Student's Book. *(4 marks)*

7. a) See Figure 15, page 18 of the Student's Book. *(2 marks)*

b) See Figure 13, page 18 of the Student's Book. *(2 marks)*

8. a) Zinc is a metal so will conduct electricity as a solid. A could be zinc. *(1 mark)*

b) Simple molecular structures have low melting points and will not conduct electricity in any state. D could have a simple molecular substance. *(1 mark)*

c) C does not conduct electricity in any state so it contains covalent bonds. It has a very high melting point and is therefore a giant covalent compound. Covalent bonding is present in C. *(1 mark)*

d) Sodium chloride is an ionic compound so it will conduct electricity in the liquid state but not as a solid. B is therefore likely to be sodium chloride *(1 mark)*

9. a) Allotropes are different forms of the same element in the same physical state. *(2 marks)*

b) Graphite contains delocalised electrons which can move and carry the charge (when a potential difference is applied). *(2 marks)*

c) (Diamond can be used as a cutting tool as it is exceptionally hard.) **All** of the carbon atoms in diamond are covalently bonded to four other carbon atoms in a tetrahedral 3D structure. These bonds are extremely strong and are difficult to break. *(1 mark)*

Chapter 3 Elements, compounds and mixtures

In-text questions

1. **a)** One from: oxygen, nitrogen, fluorine, chlorine, helium, neon, argon, krypton, xenon, radon or hydrogen.
b) One from: mercury or bromine.
c) Most of the elements are solids at room temperature. Hopefully the students have chosen a solid and not one of the above!

2. **a)** Na
b) C
c) Cu
d) N

3. **a)** Cu
b) Cl_2
c) Si
d) Ne

4. Water (b) is not an element.

5. **a)** An element contains only one type of atom. It cannot be broken down into anything simpler by chemical means.
b) A compound is made from two or more different types of atoms which have been chemically combined. For example sodium and chlorine are elements but sodium chloride is a compound.
c) A mixture contains two or more substances. The substances can be elements or compounds. These substances are easily separated. The properties of the mixture are the same as the individual properties of the substances which are present in the mixture.

6.

Elements	Compounds	Mixtures
copper oxygen sulfur	baking soda (sodium hydrogen carbonate) sugar salt (sodium chloride) aluminia (pure aluminium oxide) carbon dioxide	milk sparkling water air diet coke sea water marble chips (these contain mostly calcium carbonate but also contain small amounts of other compounds, would still be awarded the mark if placed in compounds section)

7. hydrogen + chlorine → hydrogen chloride
iron + sulfur → iron sulfide
magnesium + oxygen → magnesium oxide
sulfur + oxygen → sulfur dioxide
calcium + bromine → calcium bromide

8. **a)** **i)** Chlorine.

ii) Calcium.
iii) Sodium chloride.
iv) Sulfur.

b) i) There are three different elements present in sodium carbonate, sodium, carbon and oxygen.
ii) There are 2 atoms of sodium, 1 atom of carbon and 3 atoms of oxygen in the formula for the compound sodium carbonate. Therefore, there are 2 + 1 + 3 atoms = 6.

9. Valency is the combining power of an atom or an ion. Silicon has a combining power of 4 while oxygen has a combining power of 2. Therefore to match the combining powers, valancies of the atoms two oxygen atoms are needed to combine with one silicon atom.

10. a) KCl.
b) MgO.
c) $CaBr_2$.
d) $ZnSO_4$.
e) $NaCO_3$.
f) $Ca(OH)_2$.
g) $Mg(HCO_3)_2$.
h) $Al_2(SO_4)_3$.
i) $Fe(OH)_2$.

11. a) SiO2.
b) HCl.
c) CCl_4.
d) NH_3.
e) PCl_3.
f) CH_4.

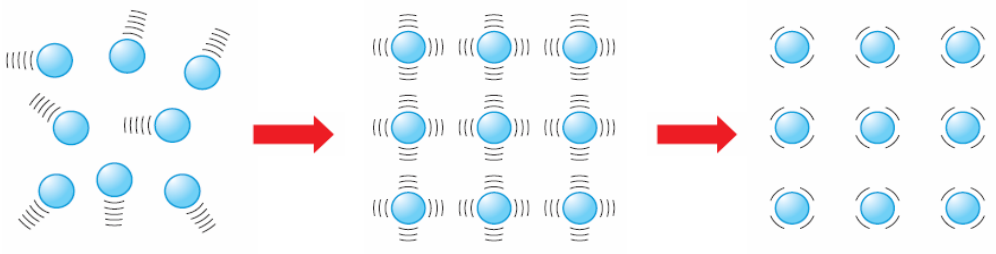
12. a) Li^+ I^-.
b) Mg^{2+} NO^{3-}.
c) Pb^{2+} NO^{3-}.
d) Cu^{2+} SO_4^{2-}.
e) Al^{3+} O^{2-}.

13. a) Boiling is the stage during heating a liquid when all the particles in a liquid gain sufficient energy to become a gas.
b) Freezing is the point when cooling a liquid it turns to a solid.
c) Evaporation is the change from a liquid to a gas below the boiling point.

14. a) Evaporation.
b) Melting.
c) Freezing.
d) Condensation.
e) Condensation.
f) Sublimation.

15. a) Endothermic.
b) Exothermic.
c) Exothermic.
d) Exothermic.
e) Exothermic.
f) Endothermic.

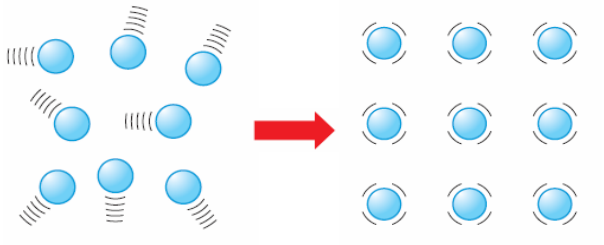
16. a)



steam water ice

The particles of steam are very far apart and do not have attractive forces between them. The particles move around very fast in all of the available space. As steam forms water, the particles lose energy and get closer together. The attractive forces between the molecules become stronger. As water cools to become ice the particles become very close together in a regular arrangement. The particles lose energy and can only vibrate about a fixed point. (The process of forming ice from steam is an exothermic process, the particles lose energy to their surroundings.)

b)



gaseous iodine solid iodine

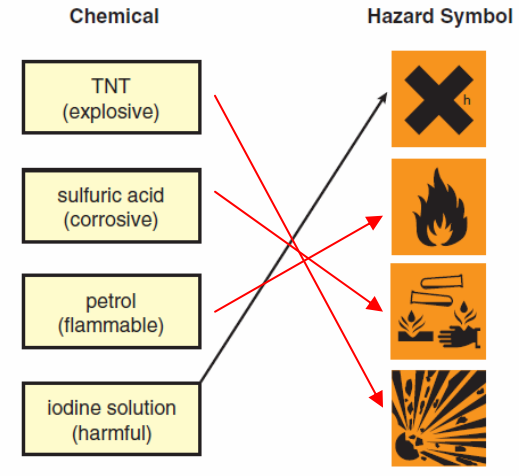
Iodine sublimes, therefore as it cools it will not form a liquid, it forms a solid directly. In gaseous iodine the particles are very far apart. There are no attractive forces between them. As iodine cools the particles lose energy, become closer together and form a regular arrangement with stronger attractive forces.

b) Water has a higher boiling point than alcohol because the forces of attraction between the molecules of water are stronger than the forces of attraction between the molecules of alcohol. Therefore it takes more energy to break the molecules of water apart.

Exam questions (pages 50–2)

1. a) Chromatography. *(1 mark)*
b) Pencil is insoluble in the solvent. *(1 mark)*
c) C. *(1 mark)*
d) B. *(1 mark)*
e) A. *(1 mark)*
f) Gas-liquid chromatography. *(1 mark)*

2. a)



(3 marks)

b) Any 2 from: they are used to warn of danger; they can be understood by people who cannot read; they are much more eye-catching than words; they are internationally known.

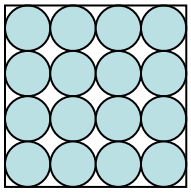
(2 marks)

3. a)

Substance	Element	Compound	Mixture
Crude oil			✓
Nitrogen	✓		
Copper oxide		✓	
Brass			✓
Pure water		✓	

(4 marks)

b)



(1 mark)

c) A. *(1 mark)*

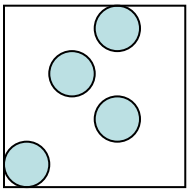
4. a) i) The element with the lowest boiling point has an atomic number of 9. The electronic structure is 2,9.

ii)

	Element with atomic number 17	Element with atomic number 35
Melting point/°C	–100	–10
Boiling point/°C	–35	60
Physical state at room temperature	gas	liquid

(6 marks)

iii) Chlorine is a gas at this temperature.



(1 mark)

vi) When a solid is heated until it melts the particles gain energy and move further apart. The attractions between the particles decrease. *(3 marks)*

v) Sublimation is the change of state from solid to gas without passing through the liquid state. *(1 mark)*

b) i) D. *(1 mark)*

ii) E. *(1 mark)*

iii) C. *(1 mark)*

iv) A. *(1 mark)*

v) B. *(1 mark)*

5. a) Any 2 from: they can be understood by people who cannot read; they are much more eye-catching than words; they are internationally known. *(2 marks)*

b) i) Barium nitrate. *(1 mark)*

ii) Ethanol. *(1 mark)*

iii) Ammonium dichromate is explosive. It is very dangerous to store explosive material in a garden shed. *(1 mark)*

6.

Chemical	Element	Compound	Mixture
Silver	✓		
Salt solution			✓
Aluminium	✓		
Sulfur dioxide		✓	
Water		✓	
Crude oil			✓

(5 marks)

7.
- Place the mixture into a beaker.
- Add water and stir to dissolve the salt.
- Filter the mixture in the beaker using filter paper in a filter funnel and a conical flask
- The sand is left in the filter paper/the sand is the residue.
- Transfer the solution in the conical flask to a evaporating dish and evaporate 2/3 of the solution using a Bunsen burner, tripod and wire gauze.
- Transfer the contents of the evaporating dish to a crystallising dish and allow to cool slowly.
- Filter the salt crystals from any excess water. *(6 marks)*

8. a) C. *(1 mark)*

b) B and D. *(1 mark)*

c) Test if the substance is malleable or ductile. *(1 mark)*

9. a) ii) Fe *(1 mark)*

b) iii) magnesium hydroxide *(1 mark)*

c) i) $CaSO_4$ *(1 mark)*

d) ii) 1 S atom and 2 O atoms *(1 mark)*

e) i) cobalt *(1 mark)*

10. a) iii) Na *(1 mark)*

b) i) NO_3^- *(1 mark)*

c) ii) antimony *(1 mark)*

d) ii) Cl_2 *(1 mark)*

e) i) all nitrates are soluble *(1 mark)*

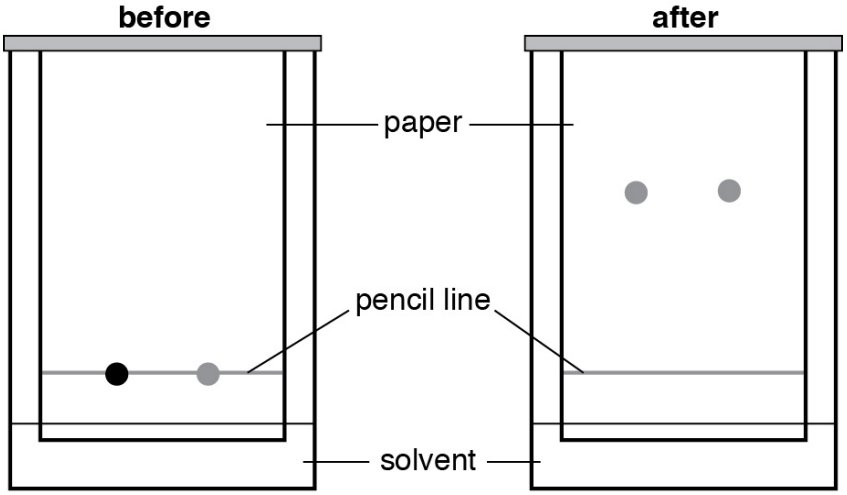
11. a) **i)** Chromatography. *(1 mark)*

ii) Red, green and blue. *(1 mark)*

iii) Blue. *(1 mark)*

iv) E. *(1 mark)*

b) The student should produce a chromatogram of the two dyes and compare the distance travelled from the pencil line by the blue colour in each dye. For example:
Set up the following experiment:



If the distance travelled is the same for each blue dye, the dyes in the two food colourings are the same. *(3 marks)*

Chapter 4 Chemical equations

In-text questions

1. hydrogen + nitrogen → ammonia
2. sulfur dioxide + oxygen → sulfur trioxide
3. hydrochloric acid + sodium hydroxide → sodium chloride + water
4. calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide
5. sulfuric acid + potassium oxide → potassium sulfate + water
6. copper carbonat → copper oxide + carbon dioxide
7. hydrate copper sulfate → anhydrous copper sulfate + water
8. copper oxide + hydrogen → copper + water
9. sulfur + oxygen → sulfu dioxide
10. iron + water + oxygen → hydrated iron(III) oxide
11. $2Al + 3CuO \rightarrow Al_2O_3 + 3Cu$
12. $Na_2 + H_2O \rightarrow 2NaOH$
13. $6Mg + P_4 \rightarrow 2Mg_3P_2$
14. $2Fe + 3Cl_2$
15. $V_2O_5 + 5CaS \rightarrow 5CaO + V_2S_5$
16. $P_4 + 3O_2 \rightarrow P_4O_6$
17. $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$
18. $Cl_2 + 2NaI \rightarrow 2NaCl + I_2$
19. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
20. $C_2H_6O + 4O_2 \rightarrow 3CO_2 + 3H_2O$
21. $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$
22. $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$
23. $2FeS + O_2 \rightarrow 4NO + 6H_2O$
24. $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
25. $Al_2(SO_4)_3 + K_2SO_4 \rightarrow 2KAl(SO_4)_2$
26. $3Pb(NO_3)_2 + 2AlCl_3 \rightarrow 3PbCl_2 + 2Al(NO_3)_3$
27. $Cu + 2AgNO_3 \rightarrow 2Ag + Cu(NO_3)_2$
28. $NaOH + HCl \rightarrow H_2 + NaCl$
29. $H_2 + I_2 \rightarrow 2HI$
30. $CaCl_{2(s)} + 2AgNO_{3(aq)} \rightarrow 2AgCl_{(s)} + Ca(NO_3)_{2(aq)}$
31. **a)** $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
    b) $2NCl_3 \rightarrow N_2 + 3Cl_2$
    c) $2Mg + O_2 \rightarrow 2MgO$
    d) $Br_2 + 2NaI \rightarrow 2NaBr + I_2$
    e) $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$
    f) $C_3H_6O_3 + 3O_2 \rightarrow 3CO_2 + 3H_2O$
    g) $2NaNO_3 + PbO \quad Pb(NO_3)_2 + Na_2O$
    h) $Fe + 2AgNO_3 \rightarrow Fe(NO_3)_2 + 2Ag$
    i) $(NH_4)_2CO_3 \rightarrow 2NH_3 + CO_2 + H_2O$
    j) $3AgBr + AlPO_4 \rightarrow Ag_3PO_4 + AlBr_3$
32. **a)** $Cl_2 + 2NaI \rightarrow I_2 + 2NaCl$
    b) $4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$

c) $2CO + O_2 \rightarrow 2CO_2$
d) $N2 + 3H2 \rightarrow 2NH3$
e) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
f) $H_2SO_4 + 2NaNO_3 \rightarrow 2HNO_3 + Na_2SO_4$
g) $NaOH + HCl \rightarrow H_2O + NaCl$
h) $Zn + CuSO_4 \rightarrow Cu + ZnSO_4$
i) $H_2SO_4 + CuCO_3 \rightarrow H_2O + CuSO_4 + CO_2$
j) $2SO_2 + O_2 \rightarrow 2SO_3$

33. a) $I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$
b) $2HCl + Na_2S_2O_3 \rightarrow SO_2 + S + 2NaCl + H_2O$
c) $N_2O_5 + H_2O \rightarrow 2HNO_3$
d) $2NO + Cl_2 \rightarrow 2NOCl$
e) $6K + B_2O_3 \rightarrow 3K_2O + 2B$
f) $4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$
g) $2CH_3COOH + Mg \rightarrow (CH_3COO)_2Mg + H_2$
h) $CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$
i) $K_2CO_3 + 2HCl \rightarrow 2KCl + H_2O + CO_2$
j) $4NO_2 + 2H_2O + O_2 \rightarrow 4HNO_3$
k) $C_4H_8S_2 + 9O_2 \rightarrow 4CO_2 + 2H_2O + 2SO_3$
l) $PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$
m) $Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3$

Chapter 5 The Periodic Table

In-text questions

1. Perhaps the greatest contributor to the development of The Periodic Table was the Russian scientist Dmitri Ivanovich Mendeleev in 1869. He stated that, "when elements are arranged in order of increasing atomic mass similar properties occur at intervals".He wrote down what he knew about each element on a separate card and then sorted the cards into "piles of elements" with similar properties. His inspiration was to leave gaps for undiscovered elements. Nowadays, the elements are arranged in order of increasing atomic number.
2. **a)** Any from: He, Ne, Ar, Kr, Xe or Rn.
   b) Any from: Be, Mg, Ca, Sr, Ba or Ra.
   c) Any from: F, Cl, Br, I or At.
   d) Any from: Li, Na, K, Rb, Cs or Fr.
3. **a)** Aluminium.
   b) Fluorine.
   c) Helium.
   d) Oxygen or sulfur.
4. **a)** Features of the Periodic Table as developed by Mendeleev:
   - The elements were arranged in order of increasing atomic mass.
   - Elements with similar properties were placed in the same vertical group.
   - Gaps were left for undiscovered elements.
   - Sometimes two elements occupied the same position.
   - In some cases he ignored the order of atomic masses placing greater emphasis on the similarities within the vertical group (example tellurium RAM 128 and iodine RAM 129).

   b) Features which are different in the modern Periodic Table:
   - The elements are arranged in order of increasing atomic number.
   - Gaps have been filled in with newly discovered elements.
   - Another group has been added – the Nobel Gases Group 0/8/VII.
   - Only one element occupies each space in the table.
   - The elements which have been taken out of double occupied spaces have been placed in a block of metals between Group 2/II and Group 3/III and named the transition metals.
5. **a)** Carbon has a giant covalent structure.
   b) Cl (if they answered K also award the mark).
   c) Chlorine.
   d) Metallic.
6. **a)** Alkali metals (a common mistake in examinations is to call this group the alkaline metals).
   b) See the sodium atom in Figure 1 page 10 of the Student's Book.
   c) Lithium (Li is the symbol and is not the correct answer to this question as it asks for the name).
   d) Francium.
   e) All of the alkali metals are stored under oil as they react violently with the water in the air.
   f) The reaction of caesium with water is extremely violent and cannot be controlled

7. a) Four from:
- the potassium will float on the water
- the potassium will move quickly around the surface of the water
- the potassium will burst into flame/burn with a lilac flame
- the potassium will completely disappear (not dissolve, strictly speaking the potassium is reacting with the water and is not dissolving)
- it leaves a colourless solution
- it is a violent reaction
- when universal indicator is added to this colourless solution the indicator turns purple indicating the colourless solution remaining after the reaction is a strong alkali.

b) potassium + water → potassium hydroxide + hydrogen

c) When universal indicator is added to this colourless solution the indicator turns purple indicating the colourless solution remaining after the reaction is a strong alkali

8. a) $2Na + Cl_2 \rightarrow 2NaCl$

b) $Na - e^- \rightarrow Na^+$ or more correctly $Na \rightarrow Na^+ + e^-$

c) All Group 1/I metals have similar chemical properties because they lose the one electron from their outer shell to form an ion with a charge of 1^+.

9. a) $2K + Cl_2 \rightarrow 2KCl$

b) $2Na + H_2O \rightarrow 2NaOH + H_2$

c) $4Li + O_2 \rightarrow 2Li_2O$

d) $Cl_2 + 2e^- \rightarrow 2Cl^-$

10. a) The halogens belong to Group 7 of the Periodic Table.

b) Bromine is a red-brown, liquid (with a low boiling point. At room temperature some of it is present as a vapour above the liquid in the container).

c) As the green chlorine gas bubbles into the colourless solution, the colourless solution turns a dark brown colour. (Note: this question is asking for **observations**. Also students tend to use the word clear when they mean **colourless**. A solution of copper sulfate is clear but it is not colourless.)
$Cl_2 + 2KI \rightarrow KCl + I_2$

d) Chlorine gas and iodine fumes are toxic. The fume cupboard ensures these gases are not released into the laboratory.

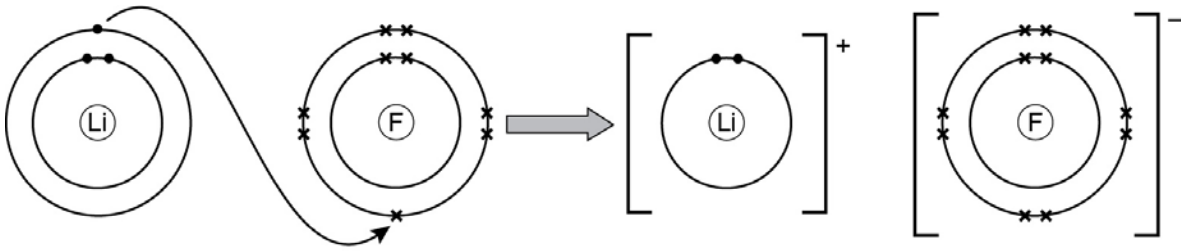
11. a) See top left of Figure 2, page 11 in the Student's Book.

b) Two chlorine atoms share the single electron on their outer shells producing a shared pair of electrons in a single covalent bond. See Figure 10 page 17 in the Student's Book. (Generally if the student makes a mistake when asked to draw a molecule of chlorine they will draw an atom of chlorine Cl and not a molecule Cl_2)

c) Chlorine has a low boiling point because the molecules are held together by weak forces of attraction/van der Waal's forces. It does not take a lot of energy to break these forces. (Chlorine is covalent molecule. Two atoms of chlorine are bonded together with a strong covalent bond. The molecules of chlorine are held together by weak forces of attraction/van der Waal's forces. When chlorine changes from a liquid to a gas, boils, only the weak forces of attraction have to be overcome.)

d) As Group 7 is descended the van der Waal's forces increase as the size of the molecule increases. As the attractive forces increase the melting point increases. The melting point of iodine is greater than the melting point of bromine.

12. a)



b) Lithium chloride should
- be soluble in water
- have a high melting point and boiling point (this counts as one mark and not two)
- not conduct electricity in the solid form but should conduct electricity when it is molten or dissolved in water
- be brittle.

13. a) $2K + I_2 \rightarrow 2KI$

b) $2NaBr + Cl_2 \rightarrow 2NaCl + Br_2$

c) $Cl_2 + H_2 \rightarrow 2HCl$

Exam questions (pages 75–9)

1. a) Four from:
- Mendeleev's table contains more elements/The pattern Mendeleev proposed fitted more elements than the Law of Octaves proposed by Newlands.
- Mendeleev has divided the table into groups and periods.
- Mendeleev's table contains the relative atomic mass of each of the elements.
- Mendeleev has placed the elements in order of relative atomic mass.
- Mendeleev has left spaces for elements which have yet to be discovered (for example the element in Group 3 Period 5).
- Mendeleev predicted the relative atomic mass of these missing elements, (for example element Group 3 Period 5 = 68).
- Mendeleev has placed more than one element in some spaces, (for example elements Fe, Co and Ni are all placed in Group VIII and Period 4). *(4 marks)*

b) i) 127 is the relative atomic mass of the element J. *(1 mark)*

ii) I. *(1 mark)*

c) i) The alkaline metals. *(1 mark)*

ii) Group 8/VIII. *(1 mark)*

iii) Sodium. *(1 mark)*

2. a) i) The law of Octaves. *(1 mark)*

ii) Group 8/VIII. They were not discovered at the time of Newland's as they are very unreactive gases. *(2 marks)*

b) i) Zinc and calcium react with water in a similar way/the chemical reactions of zinc are similar to the chemical reactions of calcium. *(1 mark)*

ii) Mendeleev left gaps for undiscovered elements. Mendeleev arranged the elements in order of increasing atomic mass but ignored this order if the chemistry did not fit (for example, tellurium and iodine). *(1 mark)*

iii)
- Mendeleev arranged the elements in order of atomic mass. The modern Periodic table arranges the elements in order of atomic number.
- There were gaps in Mendeleev's table for undiscovered elements.
- These elements have now been found and are included in the modern Periodic Table.
- A block of elements has been added between Group 2/II and 3/III called the Transition Metals. (Only some of these elements were known at the time of Mendeleev and they were not a separate block.)
- Group 8/0/VIII is now a group of elements called the Nobel Gases.
- Blocks of elements known as the Lanthanides and Actinides have been added to the modern Periodic Table. *(6 marks)*

c) i) E. *(1 mark)*

ii) A. *(1 mark)*

iii) D. *(1 mark)*

d) i) Carbon, Group 4. *(2 marks)*

ii) Students can use the graph to answer this question.

Atomic number	Name of element	State at room temperature (20°C)
4	beryllium	solid
9	fluorine	gas

(4 marks)

iii) The reproduction of the graph from the past paper has been a little distorted. The question is referring us to element of atomic number 14 which does have a melting point around 1380°C. However, it is drawn on the graph as 1650°C. The electronic structure of the element with atomic number 14 is 2,8,4. *(1 mark)*

3. a) i) The law of Octaves. *(1 mark)*

ii) Group 8/VIII. *(1 mark)*

iii) They were not discovered at the time of Newland's as they are very unreactive gases. *(1 mark)*

b) i) Zinc, calcium and magnesium are metals. It reacts with water in a similar way to calcium and magnesium. *(2 marks)*

ii) Germanium. *(1 mark)*

iii) Two from:
- Mendeleev arranged the elements in order of atomic mass. The modern Periodic table arranges the elements in order of atomic number.
- There were gaps in Mendeleev's table for undiscovered elements.
- These elements have now been found and are included in the modern Periodic Table.
- A block of elements has been added between Group 2/II and 3/III called the Transition Metals. (Only some of these elements were known at the time of Mendeleev and they were not a separate block.)
- Group 8/0/VIII is now a group of elements called the Nobel Gases.
- Blocks of elements known as the Lanthanides and Actinides have been added to the modern Periodic Table. *(2 marks)*

c) i) Halogens. *(1 mark)*

ii) A diatomic molecule contains two atoms. *(1 mark)*

iii) Any one from: nitrogen, oxygen, hydrogen. *(2 marks)*

iv) Any one from: nitrogen, oxygen, hydrogen, helium, neon, argon, krypton, xenon, radon. *(1 mark)*

v) Mercury. *(1 mark)*

vi) Fluorine. *(1 mark)*

vii) Sublimation is the change of state from solid to gas without becoming a liquid. *(2 marks)*

4. a) i) (Dimitri Ivanovich) Mendeleev. *(1 mark)*

ii) The modern Periodic Table arranges the elements in the order of increasing atomic number whereas early versions of the Periodic Table arranged them in order of increasing atomic mass. *(2 marks)*

iii) One from:

- There were gaps in Mendeleev's table for undiscovered elements.
- These elements have now been found and are included in the modern Periodic Table.
- A block of elements has been added between Group 2/II and 3/III called the Transition Metals. (Only some of these elements were known at the time of Mendeleev and they were not a separate block.)
- Group 8/0/VIII is now a group of elements called the Nobel Gases.
- Blocks of elements known as the Lanthanides and Actinides have been added to the modern Periodic Table. *(1 mark)*

iv) Newlands. *(1 mark)*

b) i) 8. *(1 mark)*

ii) Group 1/I. *(1 mark)*

iii) The Nobel Gases. *(1 mark)*

iv) The reactivity of Group 2 increases as the group is descended. *(1 mark)*

c) i) Periods. *(1 mark)*

ii) The number of electrons in the outer shell of an atom of an element is the same as the group number (to which the element belongs). *(1 mark)*

iii) The size of the atoms of the elements decrease across the period from sodium to argon. *(1 mark)*

iv) Silicon/germanium. This element is a semi-conductor/shares some of the properties of a metal and a non-metal. *(2 marks)*

5. a) In 1869, a Russian chemist called **Mendeleev** produced a Periodic Table very similar to the one we use today. The elements of the modern Periodic table are arranged in order of increasing **atomic** number. In the Periodic Table the horizontal rows are called periods and the vertical columns of elements are called **groups**. Moving across a period, the size of the atoms **decreases** and the non-metallic character of the elements **increases**. *(5 marks)*

b) i) Alkali metals. *(1 mark)*

ii) Any of lithium, rubidium, caesium or francium. *(1 mark)*

iii) Lithium/Li. *(1 mark)*

iv)

Element	Electronic configuration of the atom of the element	
Sodium	2,8,1	The atoms of the elements in group 1 all have one electron on the outer shell of the atom.
Potassium	2,8,8,1	

(3 marks)

c) i) Any one from: He, Ne, Ar, Kr, Xe, Rn. *(1 mark)*

ii) Any one from: N, P, As, Sb, Bi. *(1 mark)*

iii) Any one from: B, C, P, As, S, Se, Te, I, At. *(1 mark)*

iv) Any one from: Be, Mg, Ca, Sr, Ba, Ra, Sc, Zn or any suitable transition metal, for example Fe. *(1 mark)*

v) Si. *(1 mark)*

6. a) i) Wear safety glasses/use a small sample of calcium. *(1 mark)*

ii) Calcium disappears; heat is evolved/the reaction vessel is warm to the touch; bubbles are produced; calcium begins to sink then rises due to the bubbles of gas/calcium bobs up and down through the water. *(3 marks)*

iii) calcium + water → calcium hydroxide + hydrogen *(2 marks)*

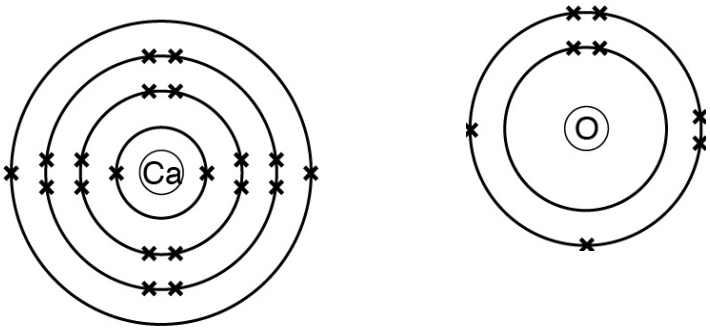
iv) Alkaline. *(1 mark)*

v) Any one from: strontium, barium, radium. *(1 mark)*

b) i) Magnesium burns with a bright white flame to produce a white-grey ash. *(2 marks)*

ii) $2Mg + O_2 \rightarrow 2MgO$ *(3 marks)*

c) i)



(2 marks)

ii) The calcium atom loses two electrons to become 2,8,8. The oxygen atom gains two electrons to become 2,8. *(3 marks)*

d) Calcium hydroxide, $Ca(OH)_2$. *(2 marks)*

Chapter 6 Acids, bases and salts – tests for ions

In-text questions

1. **a)** calcium oxide + hydrochloric acid → calcium chloride + water
   b) magnesium hydroxide + sulfuric acid → magnesium sulfate + water
   c) potassium carbonate + nitrate → potassium nitrate + water + carbon dioxide
   d) zinc carbonate + hydrochloric → zinc chloride + water + carbon dioxide
   e) calcium + ethanoic acid → calcium ethanoate + hydrogen
2. **a)** lithium oxide + sulfuric acid → lithium sulfate + water
   b) sodium oxide (or sodium hydroxide) + nitric acid → sodium nitrate + water
   c) sodium carbonate + hydrochloric acid → sodium chloride + water + carbon dioxide
   d) aluminium + sulfuric acid → aluminium sulfate + hydrogen
   e) copper(II) carbonate + ethanoic acid → copper(II) ethanoate + water + carbon dioxide
3. Balanced equations for Question 1:
   a) $CaO + 2HCl \rightarrow CaCl_2 + H_2O$
   b) $Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 2H_2O$
   c) $K_2CO_3 + 2HNO_3 \rightarrow 2KNO_3 + H_2O + CO_2$
   d) $ZnCO_3 + HCl \rightarrow ZnCl_2 + H_2O + CO_2$
   e) $Ca + 2CH_3COOH \rightarrow (CH_3COO)_2Ca + H_2$

   Balanced equations for Question 2:
   a) $Li_2O + H_2SO_4 \rightarrow Li_2SO_4 + H_2O$
   b) $Na_2O + 2HNO_3 \rightarrow 2NaNO_3 + H_2O$
   c) $NaOH + HNO_3 \rightarrow NaNO_3 + 2H_2O$
   d) $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$
   e) $Al + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2$
   f) $CuCO_3 + 2CH_3COOH \rightarrow (CH_3COO)2Cu + H_2O + CO_2$
4. **a)**

Soluble	**Insoluble**	**Sightly soluble**
Sodium carbonate	Silver bromide	Calcium hydroxide
Lead nitrate	Lithium oxide	
Copper sulfate	Magnesium hydroxide	
Aluminium sulfate	Silver iodide	
Magnesium nitrate	Copper oxide	
Ammonium phosphate	Barium sulfate	
Potassium ethanoate	Copper carbonate	
Calcium chloride		
Strontium nitrate		
Potassium oxide		
Sodium hydroxide		

   b) Sodium carbonate, lead nitrate, copper sulfate, aluminium sulfate, magnesium nitrate. ammonium phosphate, potassium ethanoate, calcium chloride, barium sulfate, strontium nitrate, silver bromide, silver iodide.

5. a) Technique 1 – adding a solid to an aqueous solution. This is also known as excess solid/filtration. Copper oxide is an insoluble solid and sulfuric acid is an aqueous solution.

b) Technique 2 – mixing two different aqueous solutions. This technique is called a titration.

c) Technique 1 – adding a solid to an aqueous solution. This is also known as excess solid/filtration. Calcium carbonate is an insoluble solid and hydrochloric acid is an aqueous solution

d) Technique 2 – mixing two different aqueous solutions. This technique is called a titration.

6.

Salt	Cation	Anion	Name of salt	Formula of salt
A	sodium ion Na^+	chloride ion Cl^-	sodium chloride	NaCl
B	iron (II) ion Fe^{2+}	carbonate ion CO_3^{2-}	iron(II) carbonate	$FeCO_3$
C	zinc ion or aluminium ion	sulfate ion SO_4^{2-}	zinc sulfate or aluminium sulfate	$ZnSO_4$ Or $Al_2(SO_4)$
D	Copper(II) ion Cu^{2+}	sulfate ion SO_4^{2-}	copper sulfate	$CuSO_4$

Exam questions (pages 94–6)

1. a) Neutralisation. *(1 mark)*

b) $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$ *(1 mark)*

2. a) Any two from: the green solid copper carbonate disappears; bubbles of gas are produced; the colourless solution becomes blue; the reaction releases heat. *(2 marks)*

b) Copper is an unreactive metal and will not react with sulfuric acid. *(1 mark)*

3. a) The alkali metals are stored in oil. *(1 mark)*

b) An alkali is a soluble base. *(1 mark)*

4. a)

Element	Group	Period	Electronic structure
Magnesium	2/II	3	2,8,2
Potassium	1/I	4	2,8,8,1

(4 marks)

b) i) Calcium. *(1 mark)*

ii) Any two from: the white solid calcium carbonate disappears; bubbles of gas are produced; the solution (was colourless at the beginning and) remains colourless at the end. *(2 marks)*

iii) calcium carbonate + hydrochloric acid = calcium chloride + water + carbon dioxide *(2 marks)*

c) i) Green.

ii) White.

iii) Blue.

iv) White. *(2 marks)*

5. a) Any two from: the grey metallic magnesium disappears; bubbles of gas are produced; a colourless solution was present at the beginning and the solution remains colourless at the end of the reaction; the reaction is exothermic/the reaction vessel feels hot to the touch. *(2 marks)*

b) $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2O$ *(2 marks)*

c) i) Hydrogen ions react with hydroxide ions to produce water/An acid reacts with a base to produce water as one of the products. *(2 marks)*

ii) $MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$ *(1 mark)*

iii) Bubble the gas through lime water. If the gas is carbon dioxide the lime water will become milky. *(2 marks)*

6. a) i) A salt is a substance formed when (some or all of) the hydrogen ions in an acid are replaced with metal ions. *(2 marks)*

ii) KNO_3. *(1 mark)*

iii) Potassium hydroxide and silver nitrate. *(2 marks)*

b) i) The green solid copper carbonate disappears; bubbles of gas are produced; the colourless solution becomes blue; the reaction releases heat. *(3 marks)*

ii) $CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$ *(3 marks)*

iii) Filter the solid copper(II) carbonate from the solution of the salt. *(1 mark)*

iv) $CuCl_2.2H_2O$ *(1 mark)*

c) i) Flame test: when copper ions are present the flame is blue-green in colour.
Add silver nitrate solution: a white precipitate indicates the presence of chloride ions. *(3 marks)*

ii)
- Clean a nichrome wire by dipping it into concentrated hydrochloric acid.
- Hold the wire in a hot Bunsen flame.
- Repeat until the wire does not produce any colour in the flame.
- Dip the clean nichrome wire into the concentrated hydrochloric acid again and then dip it into a small amount of the unknown solid. (A small sample of the solid will stick to the wire.)
- Place the wire in the Bunsen flame.
- Observe the colour of the flame.

The flame test can also be carried out using a flame test rod:
- Clean a flame test rod by dipping it into water and holding the rod in a hot Bunsen flame.
- Dip the clean flame test rod into the water again and then dip it into a small amount of the unknown solid. (A small sample of the solid will stick to the wire.)
- Place the rod in the Bunsen flame.
- Observe the colour of the flame. *(6 marks)*

d) i) The white solid absorbed the water in the air and dissolved in it to form a colourless liquid. *(3 marks)*

ii) Silver chloride. *(1 mark)*

iii) Ca^{2+}. *(1 mark)*

iv) Calcium chloride. *(1 mark)*

7. a) i) There are lots of examples of bases, for example, copper oxide. *(1 mark)*

ii) An alkali is a soluble base. *(1 mark)*

b) i) A pipette. *(1 mark)*

ii) To ensure all the acid is reacted (so that it will not contaminate the salt produced). *(1 mark)*

iii) The solid would be left at the bottom of the conical flask/no more bubbles would be produced on addition of more solid. *(1 mark)*

iv) Residue. *(1 mark)*

v) Filtrate. *(1 mark)*

vi) The solid becomes less soluble as the temperature decreases. *(2 marks)*

vii) The crystals can be placed in a low temperature oven. The crystals can be dried between two pieces of filter paper. *(2 marks)*

c) i) A white (gelatinous) precipitate is formed which redissolves/disappears when excess sodium hydroxide is added. *(2 marks)*

ii) $Zn^{2+} + 2OH^- \rightarrow Zn(OH)_2$ *(3 marks)*

8. a)
- Prepare the burette and fill with dilute sulfuric acid.
- Pipette 25cm^3 of aqueous potassium hydroxide/potassium hydroxide solution into a conical flask, using a pipette filler.
- Add three drops of phenolphthalein indicator. Swirl the flask gently.
- Add the acid from the burette, swirling gently to mix the solutions.
- Stop adding the acid at the end point. (At the end point of this titration the indicator will change from pink to colourless.)
- Record the volume of acid added.
- Repeat the titration with fresh samples of aqueous potassium hydroxide until two concordant results are obtained/two results within 0.1cm^3 of each other are obtained.
- Repeat the titration without the indicator.
- The conical flask now contains a solution of the salt in water.
- Transfer the solution to an evaporating dish.
- Evaporate 2/3 of the water using a Bunsen burner.
- Transfer to a crystallising dish and leave to cool slowly.
- Filter the crystals formed from any excess solution.
- Dry the crystals in a low temperature oven/between two pieces of filter paper. *(10 marks)*

b) $2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$ *(3 marks)*

c) Potassium carbonate/potassium oxide. *(1 mark)*

d) $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$ *(3 marks)*

Chapter 7 Solubility

Exam questions (pages 104–6)

1. a) Ammonium chloride/NH_4Cl *(1 mark)*

b) 59g/100g H_2O *(1 mark)*

c) At 65°C 100g of water holds 59g of dissolved solid. At 25°C 100g of water holds 40g of dissolved solid. Therefore 59 – 40 = 19g of solid will crystallise from the solution. *(1 mark)*

d) NaCl/sodium chloride. *(1 mark)*

2. a)
- Remove the test tube from the water bath and allow to cool.
- Record the temperature of the solution when crystals are first observed.
- Add another 2.5cm^3 of water.
- Replace the test tube in the water bath until all the solid is dissolved.
- Repeat the process of dissolving, cooling, recording the temperature and adding 2.5cm^3 of water until the test tube hold 20cm^3 of water.
- Calculate the solubility of potassium chlorate at the different temperatures (using the formula: $\text{solubility (g/100g H}_2\text{O)} = \frac{\text{mass of solid}}{\text{mass of water}} \times 100$
- Plot the solubility of potassium chlorate against the temperature. In this type of question the examiner will award one mark each for the first three steps given above. One mark for the explicit idea of repeating each step in the process and a final mark for stating calculate the solubility at each temperature. *(5 marks)*

b) i) $\text{solubility (g/100g H}_2\text{O)} = \frac{\text{mass of solid}}{\text{mass of water}} \times 100 = \frac{4}{10} = 40\text{g/100g H}_2\text{O}$

This type of question may be easier using simple ratio. If 4g dissolve in 10g of water, how many g will dissolve in 100g of water = 40g/100g H_2O. *(1 mark)*

ii) Solubility is the maximum mass of solid which will dissolve in 100g of water at a given temperature. *(4 marks)*

c) Solubility is the maximum mass of solid which will dissolve in 100g of water at a given temperature. *(4 marks)*

d) i) Potassium chloride. *(1 mark)*

ii) At 80°C according to the graph, 90g of potassium bromide will dissolve in 100g of water. Therefore, at least **200g** of water will be needed to dissolve 180g of potassium bromide. *(2 marks)*

iii) At 80°C 100g of water holds a maximum of 50g of potassium chloride; at 50°C 100g of water holds a maximum of 40g of potassium chloride; therefore, 50 – 40 = 10g of potassium chloride will precipitate out of 100g of water; therefore, **100g** of solid will appear when a solution containing 1000g/1Kg of water is cooled from 80°C to 50°C. *(4 marks)*

3. The fish requires oxygen to respire/survive. The solubility of the oxygen in the water decreases as the temperature of the water increases. Therefore, there is less oxygen available for the fish as the jar is warmed up. *(5 marks)*

4. a) i) Solubility is the maximum mass of solid which will dissolve in 100g of water at a given temperature. *(4 marks)*

ii) Solubility of sugar increases as the temperature of the water increases. *(1 mark)*

b) i) 42g/100g H_2O *(1 mark)*

ii) The graph shows the results for 100g of water. This is the standard unit that all solubility values are quoted in. However, in the laboratory a chemist may not be using 100g of water. The examiner will want to see if the student can apply the standard graph or value to other situations. The graph shows 100g of water, the question asks about 50g of water; if 19g of solid saturate 50g of water then 38g of solid will saturate 100g of water. Use the graph to find out the temperature at which 38g of potassium nitrate will saturate 100g of water. **35°C** *(2 marks)*

iii) There is a maximum of 2 marks for plotting the points. Students need to be careful to read the scale on the graph carefully. This graph is not the most difficult. One square on the x-axis represents 1°C. One square on the y-axis represents 1g/100g H_2O. The data used for the examination questions is real data and can be tricky to plot. The third mark is for drawing a smooth curve. This means the points should not be plotted using tiny straight lines. *(3 marks)*

iv) Award the mark if the value has been correctly read from the student's graph. *(1 mark)*

v) Again the exact values will depend on the student's graph. The value calculated using the information on the graph will need to be x 10 as the question asks about 1000g of water and the values on the graph are quoted as 100gH_2O. *(4 marks)*

5. a) Solubility is the maximum mass of solid which will dissolve in 100g of water at a given temperature. *(4 marks)*

b) i) 20g of potassium chloride dissolve in 50g H_2O. ?g of potassium chloride dissolve in 100g H_2O. 40g/100g H_2O. *(1 mark)*

ii) There is a maximum of 2 marks for plotting the points. Students need to be careful to read the scale on the graph carefully. This graph is not the most difficult. One square on the x-axis represents 1°C. One square on the y-axis represents 1g/100g H_2O. The data used for the examination questions is real data and can be tricky to plot. The third mark is for drawing a smooth curve. This means the points should not be plotted using tiny straight lines. The 4th mark is awarded for correctly labelled axes. The label must include the units. *(4 marks)*

iii) As the temperature increases the solubility increases. *(1 mark)*

iv) Award a correctly read value from the Student's graph you have drawn. *(1 mark)*

v) Again the exact values will depend on how well graph has been drawn. The value calculates using the information on their graph will need to be divided by 2 as the question asks about 50g of water and the values on the graph are quoted as 100g H_2O. *(3 marks)*

c) Chloride ions can be detected using nitric acid and silver nitrate solution. A white precipitate will form if chloride ions are present. *(3 marks)*

d) i) White solid sodium hydroxide absorbs water form the air and forms a colourless solution. Eventually a crust of white flakes are formed. (The crust is a product of the reaction between the sodium hydroxide solution and the carbon dioxide in the air. It is sodium carbonate.) *(3 marks)*

ii) Anhydrous means does not contain water of crystallisation. *(2 marks)*

Chapter 8 Quatitative chemistry 1

In-text questions

1. **a)** 38
   b) 58.5
   c) 30
   d) 184
   e) 160
   f) 124
   g) 78
   h) 138
   i) 234
   j) 60
2. **a)** 40%
   b) % Fe in FeO = 77%; % Fe in Fe_2O_3 = 70%
   c) % N in NH_4NO_3 = $\frac{14+14}{14+4+14+48} = \frac{28}{80} = 35\,\%$
3. 29.25g
4. 135.135g
5. 98.28g
6. 2 moles
7. no.of moles = $\frac{\text{mass}}{\text{RFM}} = \frac{0.125}{58.5} = 2.136\text{x}10^{-3}$
8.

Copy out the balanced chemical equation	$C_6H_{12}O_6$ +	$6O_2 \rightarrow$	$6CO_2$ +	$6H_2O$
Write in the ratio	1	6	6	6
Write in the information given in the question				432g
Calculate the number of moles				$\frac{432}{18} = 24$ moles
Use the molar ratio to work out the number of moles for all the substances in the equation	4 moles	24 moles	24 moles	24 moles
Answer the question mass = no.moles x rfm	mass = 4 x 180 mass = 720g			

9.

Copy out the balanced chemical equation	$2Pb_3O_4 \rightarrow$	$6PbO +$	O_2
Write in the ratio	2	6	1
Write in the information given in the question	2.74		
Calculate the number of moles	$\frac{2.74}{685} = 4x10^{-3}$ moles (0.004 moles)		
Use the molar ratio to work out the number of moles for all the substances in the equation		0.012 moles	0.002 moles
Answer the question mass = no.moles x rfm		mass = 0.012 x 223 = 2.676g = 2.68g	

10.

Copy out the balanced chemical equation	$Na_2B_4O_7 \rightarrow$	$2NaBO_2 +$	B_2O_3
Write in the ratio	1	2	1
Write in the information given in the question	5.05g		
Calculate the number of moles	$\frac{5.05}{202} = 0.025$ moles		
Use the molar ratio to work out the number of moles for all the substances in the equation		0.05 moles	0.025 moles
Answer the question mass = no.moles x rfm		mass = 0.05 x 66 = 3.3g	

11.

Elements present	Fe	O
Mass of element present	2.24g	0.96g
Number of moles $\text{number of moles} = \frac{\text{mass}}{\text{relative atomic mass}}$	$\frac{2.24}{56} = 0.04$ moles	$\frac{0.96}{16} = 0.06$ moles
Smallest whole number ratio	2	3
Empirical formula	Fe_2O_3	

12.

Elements present	Cu	S	O
Mass of element present	1.7g	0.85g	1.7g
Number of moles $\text{number of moles} = \frac{\text{mass}}{\text{relative atomic mass}}$	$\frac{1.7}{64} = 0.026$	$\frac{0.85}{32} = 0.0266$	$\frac{1.7}{16} = 0.10$
Smallest whole number ratio	1	1	4
Empirical formula	$CuSO_4$		

13.

Elements present	Cu	O
Mass of element present	89g	11g
Number of moles $\text{number of moles} = \frac{\text{mass}}{\text{relative atomic mass}}$	$\frac{89}{64} = 1.39$	$\frac{11}{16} = 0.068$
Smallest whole number ratio	2	1
Empirical formula	Cu_2O	

Elements present	Cu	O
Mass of element present	80g	20g
Number of moles $\text{number of moles} = \frac{\text{mass}}{\text{relative atomic mass}}$	$\frac{80}{64} = 1.25$	$\frac{20}{16} = 1.25$
Smallest whole number ratio	1	1
Empirical formula	CuO	

14. 21%
15. 36%
16. 51%

17.

Compounds present	$Al(NO_3)_3$	H_2O
Mass of compound present	68.39 – 64.13 = 4.26g	71.63 – 68.39 = 3.24g
Number of moles $\text{number of moles} = \frac{\text{mass}}{\text{relative atomic mass}}$	$\frac{4.26}{213} = 0.02$	$\frac{3.24}{18} = 0.18$
Smallest whole number ratio	1	9
Empirical formula	$Al(NO_3)_3 . 9H_2O$	

Exam questions (pages 121–3)

1.

Copy out the balanced chemical equation	FeO +	$H_2SO_4 \rightarrow$	$FeSO_4$ +	H_2O
Write in the ratio	1	1	1	1
Write in the information given in the question			7.6g	
Calculate the number of moles			$\frac{7.6}{152} = 0.05$ moles	
Use the molar ratio to work out the number of moles for all the substances in the equation	0.05	0.05	0.05	0.05
Answer the question mass = no.moles x rfm	mass = 0.05 x 72 = 3.6g			

a) 152 *(1 mark)*
b) 0.05 moles *(1 mark)*
c) 3.6g *(2 marks)*
d) 1 mole *(1 mark)*

2.

Copy out the balanced chemical equation	$2Mg(NO_3)_2 \rightarrow$	$2MgO +$	$4NO_2 +$	O_2
Write in the ratio	2	2	4	1
Write in the information given in the question		5g		
Calculate the number of moles		$\frac{5}{40} = 0.125$ moles		
Use the molar ratio to work out the number of moles for all the substances in the equation	0.125	0.125	0.25	0.0625
Answer the question mass = no.moles x rfm	mass = 0.125 x 148 = 18.5g			

a) 40 *(1 mark)*
b) 148 *(1 mark)*
c) 0.125 moles *(2 marks)*
d) 18.5g *(1 mark)*

3. a) i) The glowing splint would relight (as oxygen is produced in the decomposition).

ii)

Copy out the balanced chemical equation	$2Pb3O4 \rightarrow$	$6PbO +$	O_2
Write in the ratio	2	6	1
Write in the information given in the question	2.74g		
Calculate the number of moles	$\frac{2.74}{685} = 4x10^{-3}$ moles (0.004 moles)		
Use the molar ratio to work out the number of moles for all the substances in the equation		0.012	0.002
Answer the question mass = no.moles x rfm		mass = 0.012 x 223 = 2.676g = 2.68g	

b)

Copy out the balanced chemical equation	M(OH)2 +	2HCl →	MCl2 +	$2H_2O$
Write in the ratio	1	2	1	2
Write in the information given in the question	3.0 – 0.55 = 2.45g	50 cm3 1mol/dm3		432g
Calculate the number of moles		$\frac{50 \times 1}{1000} = 0.05$		$\frac{432}{18} = 24$
Use the molar ratio to work out the number of moles for all the substances in the equation	0.025	0.05	0.025	0.05
Answer the question mass = no.moles x rfm	mass = 2.45 x 0.025 = 98g			

i) 2.45g *(1 mark)*

ii) 0.05 *(2 marks)*

iii) 0.025 *(2 marks)*

iv) 98 *(2 marks)*

v) Rfm $M(OH)_2$ = 98
OH = 17
M = 98 – (2 x 17) = 64
M is copper *(2 marks)*

4. a) 0.12 *(1 mark)*

b) 0.36 *(1 mark)*

c) CH_3 *(2 marks)*

d) RFM = 30
RFM of CH_3 = 12 + 3 = 15
The molecule contains 2 x CH_3
Molecular formula = C_2H_6 *(2 marks)*

e) Ethane *(1 mark)*

f) Alkanes *(1 mark)*

5.

Copy out the balanced chemical equation	$C_6H_{12}O_6$ +	$6O_2 \rightarrow$	$6CO_2$ +	$6H_2O$
Write in the ratio	1	6	6	6
Write in the information given in the question				1.08Kg = 1080g
Calculate the number of moles				$\frac{1080}{18} = 60$ moles
Use the molar ratio to work out the number of moles for all the substances in the equation	10	60	60	60
Answer the question mass = no.moles x rfm	mass = 10 x 180 = 1800g = 1.8Kg			

(5 marks)

6.

Compounds present	$Al(NO_3)_3$	H_2O
Mass of compound present	58.39 – 54.13 = 4.26g	61.63 – 68.39 = 3.24g
Number of moles $\text{number of moles} = \frac{\text{mass}}{\text{relative atomic mass}}$	$\frac{4.26}{213} = 0.02$	$\frac{3.24}{18} = 0.18$
Smallest whole number ratio	1	9
Empirical formula	$Al(NO_3)_3 \,.\, 9H_2O$	

(7 marks)

7. a) i) The repeated heating, cooling and weighing until two records of mass are the same.

(1 mark)

Compounds present	$Na_2B_4O_7$	H_2O
Mass of compound present	4.04g	7.28 – 4.04 = 3.24g
Number of moles $\text{number of moles} = \frac{\text{mass}}{\text{RAM}}$	$\frac{4.04}{202} = 0.02$	$\frac{3.24}{18} = 0.18$
Smallest whole number ratio	1	9
Empirical formula	$Na_2B_4O_7 \,.\, 9H_2O$	

ii) 3.24g *(1 mark)*
iii) 0.18 moles *(2 marks)*
iv) 0.02 moles *(1 mark)*
v) 9 *(2 marks)*

b)

Copy out the balanced chemical equation	$Na_2B_4O_7 \rightarrow$	$NaBO_2 +$	B_2O_3
Write in the ratio	1	2	1
Write in the information given in the question	5.05g		
Calculate the number of moles	$\frac{5.05}{202} = 0.025$ moles		
Use the molar ratio to work out the number of moles for all the substances in the equation		0.05	0.025
Answer the question mass = no.moles x rfm		mass = 0.05 x 66 = 3.3g	

(5 marks)

8. a) $\frac{12}{(12+2+16)} \times 100 = \frac{12}{30} \times 100 = 0.4 \times 100 = 40\%$ *(3 marks)*

b) i) 0.03 moles *(2 marks)*

ii) 0.48g *(2 marks)*

iii) 0.01 *(2 marks)*

iv) 0.03 *(2 marks)*

v) $3SO_2 + O_3 \rightarrow 3SO_3$ *(1 mark)*

9. RFM of water = 18

RFM of $CaSO_4.H_2O$ = 40 + 32 + (16 x 4) + 18 = 154

% H_2O in gypsum = $\frac{18}{154}$ x 100 = 11.7% *(3 marks)*

Chapter 9 Oxidation and reduction

Exam questions (page 128)

1. a) i) When sulfur reacts with air the sulfur gains oxygen. Gain of oxygen is oxidation. *(2 marks)*

ii) Magnesium atoms lose 2 electrons. Loss of electrons is oxidation. *(2 marks)*

b) A redox reaction is one where oxidation and reduction happen at the same time. *(2 marks)*

2. a) Oxidation is a reaction where a substance gains oxygen (loses hydrogen or loses electrons). *(1 mark)*

b) i) In reaction 1 the substance being oxidised is methane. The formula of methane is CH_4. *(1 mark)*

ii) In reaction 2 the copper oxide is being reduced. *(1 mark)*

iii) In reaction 3 the nitrogen is said to be reduced as it is gaining hydrogen. The gain of hydrogen is reduction. *(2 marks)*

iv) $Cu^{2+} + Mg \rightarrow Mg^{2+}$ *(2 marks)*

3. This question looks deceptively simple but there are 7 marks awarded to this type of question so the answer must be accurate.

- Magnesium atoms lose 2 electrons. *(2 marks)*
- Loss of electrons is oxidation. *(1 mark)*
- Copper ions gain 2 electrons. *(2 marks)*
- Gain of electrons is reduction. *(1 mark)*
- When oxidation and reduction occur at the same time the reaction is said to be a redox reaction. *(1 mark)* *(7 marks)*

Chapter 10 Materials and electrolysis

In-text questions

1. Flax is the raw material and is a plant. The stems of the flax plant are used to produce linen. The oil which can be squeezed from the seeds of the flax plant is called linseed oil and is used to preserve wood.
2. PVC is obtained from crude oil.
3. **a)** The main advantage is of course that glass is transparent. Windows are not much use if you cannot see through them! Glass is also unreactive and can be made into a vast range of extremely uniform shapes and thicknesses.
   b) Small containers made from glass are light enough to lift. Glass does not react with any household liquids, even in the laboratory there are very few liquids which will react with glass. Glass can be blown into many different shapes and many different types of containers are made from it, example drinking tumblers, pint glasses, roasting dishes and flower vases.
4.

Manufactured material	Raw material obtained from
iron	rocks
aluminium/glass/ceramics/lime	rocks
PVC	crude oil
hydrogen	sea water
alcohol	plant/carbohydrates

5. Plastic bags have largely been replaced in supermarkets by cloth or paper bags because most of the plastics used to produce plastic bags does not biodegrade (rot in the environment) and remain in land fill sites indefinitely. (Some plastics release toxic compounds into the soil and can cause dangerous contamination to the soil.) There were millions and millions of plastic bags produced and this used up the dwindling resources of crude oil when it could be used to produce more important products like medicines.
6. **a)** An electrolyte is a substance which does not conduct electricity in the solid state but does conduct in the liquid state (either dissolved in water or molten).
   b) Electrolysis is the process of decomposition of a substance using an electric current.
   c) An electrode is a rod which is used to conduct the electricity (from the direct current) into the liquid electrolyte.
   d) Anode is the name given to the positive electrode.
   e) Cathode is the name give to the negative electrode.
   f) Anion is the name given to an ion with a negative charge.
   g) Cation is the name given to an ion with a positive charge.
7. **a)** Bromine, lead
   b) Chlorine, potassium
   c) Iodine, lithium
8. **a)** At the anode: $2Cl^- - 2e^- \rightarrow Cl_2$
   At the cathode: $Li^+ + e^- \rightarrow Li$
   b) At the anode: $2Br^- - 2e^- \rightarrow Br_2$
   At the cathode: $Pb^{2+} + 2e^- \rightarrow Pb$

c) At the anode: $2Cl^- - 2e^- \rightarrow Cl_2$
At the cathode: $Mg^{2+} + 2e^- \rightarrow Mg$

9. a) Aluminium is so reactive/high in the Reactivity series.

b) The process is costly as it uses so much electricity. Therefore, the cheapest sources of electricity are used.

c) The cryolyte is added to lower the melting point of the aluminium oxide, which lowers energy costs, and to help the aluminium oxide to conduct electricity.

d) The electrolysis cell is made from steel lined with carbon which becomes the cathode during electrolysis. Large carbon anodes are lowered into cell and electricity is passed through.

e) At the high temperature of the cell the carbon anodes burn in the oxygen produced to form carbon dioxide and so the anodes have to be replaced from time to time..

f) At the anode: $2O^{2-} - 2e^- \rightarrow O_2$.
At the cathode: $Al^{3+} + 3e^- \rightarrow Al$

g) As the aluminium is more dense than the aluminium oxide/cryolyte mixture it falls to the bottom of the cell. The aluminium can be tapped off as it is a liquid at 950°C.

10. The aluminium production facility has to be supplied with good quality raw materials. If the plant is not sited close to the raw materials it must have good transport links so that the raw materials can be supplied. Many aluminium extraction plants are sited close to sea ports as shipping in large quantities of ore is more cheaply done by sea than road.

The production of aluminium uses a lot of electricity. Electricity is expensive. When siting an aluminium extraction plant it should be close to a cheaper source of electricity. This is usually a hydroelectric plant.

A skilled workforce is needed so the aluminium production plant must be near to a large town or city or have excellent roads and rail networks from a large town or city.

Suitable facilities for waste disposal are needed.

11. Three from:

- The production of aluminium requires large amounts of energy. Recycling aluminium requires only 5% of the energy required to produce aluminium from its ore.
- The oxygen produced at the anode burns the carbon anode producing carbon dioxide a greenhouse gas. Recycling aluminium produces markedly less carbon dioxide. Recycling has a smaller 'carbon footprint' than the production of aluminium from its ore.
- Recycling reduces waste going into land fill sites.
- Recycling conserves valuable resources for future generations.

12. a) Nanotechnology refers to the study and use of particles which are 1 to 100 nanometers in size. 1 nanometer = 1nm = $1x10^{-9}$ meters. (The head of a pin is 1mm = 1,000,000 nm and a red blood cell = 2,500 nm, so 1 nm is extremely small)

b) Page 137 discusses many uses of nanotechnology. Clothing – scientists are using nanoparticles to create clothes that give better protection from UV radiation or make clothes stain-resistant (see advertisements for school uniforms). Self-cleaning glass – windows which never need to be cleaned again. When UV radiation from light hits the glass, nanoparticles gain energy and begin to break down and loosen dirt on the glass. When water makes contact with the glass, it spreads across the glass evenly, which helps wash the glass clean. Scratch resistant coating for spectacles – adding nanoparticles to scratch-resistant polymer coatings makes the coatings even more resistant to chipping and scratching increasing the life of the lenses.

c) There are 10^9 nanometers in 1 meter: 1,000,000,000 nm in 1 m.

13. a) A nanosilver particle is much smaller than a normal silver particle.

b) The nanosilver particles are so small they create a barrier that bacteria and viruses and spores from fungi cannot cross so nanosilver has antibacterial, antiviral and antifungal properties.

c) Nanosilver is used in sterilising sprays that are used to sterilise operating theatres in hospitals. It is also used in dressings to keep harmful micro-organisms out of wounds and so prevent infection in a wound.

d) $1nm = 10^{-9}m$

Exam questions (pages 138–9)

1. a) i)

Raw material	Useful material	
air	nitrogen	oxygen
rocks	iron	aluminium
crude oil	petrol	plastics
sea	sodium chloride/hydrogen	water

(4 marks)

b) i) Electrolysis is the process of decomposition of a (liquid) compound by the passage of electricity. *(2 marks)*

ii) The ions are not free to move to carry the charge. *(2 marks)*

c) i) Bauxite. *(1 mark)*

ii) $Al^{3+} + 3e^- \rightarrow Al$ *(3 marks)*

d) i) Nano particles refer to particles which are 1–100nm in size. The question asks for the size in meters which is $1x10^{-9}$ to $1x10^{-7}$ m. *(1 mark)*

ii) Some scientists think that the particles can cause harm to human cells. *(1 mark)*

2. a) i) When the lead bromide is molten the ions are free to move and carry the charge. *(1 mark)*

ii) $Pb^{2+} + 2e^- \rightarrow Pb$ *(2 marks)*

b) Impure aluminium ore, bauxite, is purified to form pure aluminium oxide, alumina. Alumina is mixed with substance A, which is called cryolyte, and placed in an electrolysis cell before being heated to 950°C. The cryolyte is added to lower the melting point of the aluminium oxide, which lowers energy costs, and to help the aluminium oxide to conduct electricity. The electrolysis cell is made from steel lined with carbon which becomes the cathode during electrolysis. Large carbon anodes are lowered into the cell and electricity is passed through. Aluminium is formed at the cathode: $Al^{3+} + 3e^- \rightarrow Al$.

As the aluminium is more dense than the aluminium oxide/cryolyte mixture it falls to the bottom of the cell. The aluminium can be tapped off as it is a liquid at 950°C. Oxygen is formed at the anode: $2O^{2-} - 2e^- \rightarrow O_2$.

At the high temperature of the cell the carbon anodes burn in the oxygen produced to form carbon dioxide and so the anodes have to be replaced from time to time. *(9 marks)*

3. a) When molten the ions are free to move and carry the charge. *(2 marks)*

b) i) See Figure 5, page 132. *(5 marks)*

ii) Graphite. *(1 mark)*

iii) Brown fumes of a gas would be observed bubbling off at the anode. *(2 marks)*

iv) Bromine and lead. *(2 marks)*

v) Bromine fumes are toxic. *(2 marks)*

4. a) When molten the ions are free to move and carry the charge. *(1 mark)*
b) The chlorine fumes produced are toxic. *(1 mark)*
c) Bubbles of green gas are observed/a smell similar to the smell of a swimming pool is observed. *(1 mark)*
d) $Li^+ + e^- \rightarrow Li$ *(2 marks)*

5. a) In the solid state the ions are not free to move so they cannot carry a charge. *(1 mark)*
b) The fumes of bromine produced are toxic. *(1 mark)*
c) A layer of a silver grey metal forms around the cathode. *(1 mark)*
d) $2Br^- - 2e^- \rightarrow Br_2$ *(3 marks)*

Chapter 11 Metals, metal compounds and the reactivity series of metals

In-text questions

1. a) Yes a reaction will take place as the aluminium is higher in the reactivity series than iron and will displace the iron from the solution of iron(III) sulfate forming aluminium sulfate.

b) No, a reaction will not happen as the calcium is lower in the reactivity series than sodium and will not be able to displace the sodium from the solution of sodium chloride.

c) Yes a reaction will take place as the zinc is higher in the reactivity series than copper and so will displace copper from the solution of copper(II) sulfate forming zinc sulfate.

2. The grey magnesium metal will become coated in a red-brown covering of copper. The blue colour of the copper sulfate solution will disappear and eventually become colourless. The reaction is exothermic and therefore it will be observed that heat is given out or that the reaction vessel will be warm to the touch.

3. a) $C + O_2 \rightarrow CO_2$
This is an oxidation as carbon gains oxygen. The gain of oxygen is known as oxidation.

b) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO$
The iron oxide is reduced in this reaction as it loses oxygen. Loss of oxygen is known as reduction. (The carbon monoxide is oxidised in this reaction as it gains oxygen. Gain of oxygen is known as oxidation.)

c) $CaCO_3 \rightarrow CaO + CO_2$
This reaction is an example of a thermal decomposition as a compound is broken down during heating.

Exam questions (pages 150–2)

1. a) Strontium will react more vigorously with water than calcium because strontium is further down Group 2 than calcium. The reactivity of Group 2 increases as the group is descended. *(2 marks)*

b) The alkaline solution is strontium hydroxide. The gas evolved is hydrogen. *(2 marks)*

c) SrO. *(1 mark)*

2. a) Copper is formed on the surface of the iron filings. The question asks for the colour of the solid. When copper forms in this way it forms as a salmon pink coloured solid. Accept any representation of the colour of copper, for example, pinky brown. *(1 mark)*

b) (The colourless turns blue as the copper displaces the silver from the silver nitrate to form copper sulfate solution.) The copper sulfate solution formed is blue. *(1 mark)*

c) Zinc, iron, copper, silver. *(2 marks)*

d) Zinc. *(1 mark)*

3. a) i) Group 2/II. *(1 mark)*

ii) Magnesium burns with a bright white flame. The grey metallic solid burns to form a white-grey ash. *(2 marks)*

iii) magnesium + oxygen → magnesium oxide *(1 mark)*

b) i) Any three from: calcium reacts quite vigorously with water; a gas is given off/bubbles of gas are produced; the calcium disappears; leaving a gritty solution behind; the calcium granules will begin to sink then bounce back to the surface again. *(3 marks)*

ii) Use small pieces of calcium/wear safety glasses/handle the calcium with tongs. *(1 mark)*

iii) calcium + water → calcium hydroxide + water *(2 marks)*

c) i) Hydrogen. *(1 mark)*

ii) Magnesium oxide. *(1 mark)*

d) i) Any two from: bubbles of gas are produced; the green solid disappears; the colourless solution becomes blue. *(2 marks)*

ii) Copper is low down in the reactivity series/copper is too unreactive. *(1 mark)*

e) i) Blue to colourless. *(2 marks)*

ii) $Mg + CuSO_4 \rightarrow MgSO_4 + Cu$ *(2 marks)*

iii) Redox. *(1 mark)*

4. a) Tube C. *(1 mark)*

b) The zinc is more reactive than iron/is higher up in the reactivity series than iron; so will react with the air and water first/before the iron. *(2 marks)*

5. a) Any two from: metals are sonorous; are good conductors of heat; are malleable/can be beaten into shape; are ductile/can be drawn into wires. *(2 marks)*

b) i) Potassium and sodium are stored under oil in the laboratory. *(1 mark)*

ii) An alkali is a soluble base. *(1 mark)*

c) i) Sodium reacts violently with water. In order to be safe a small piece of sodium is used. *(1 mark)*

ii) Any three from: sodium moves across the surface of the water; reacts very quickly; releasing bubbles of gas; forms a ball of molten metal; may burn with a yellow flame; disappears; the reaction releases heat. *(4 marks)*

d)

Element	Group	Period	Electronic structure
Magnesium	2/II	3	2,8,2
Potassium	1/I	4	2,8,1

(4 marks)

e) i) Calcium (is the most reactive of the three Group 2/II metals as it is further down the group than the other two and the reactivity of the group 2/II metals increases as the group is descended.) *(1 mark)*

ii) Any two from: bubbles of gas are released; heat is released; the white solid disappears. *(2 marks)*

iii) calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide *(2 marks)*

f) i) Green.

ii) White.

iii) Blue.

iv) White. *(2 marks)*

6. a) (Zinc displaced the copper from the blue copper sulfate to form) zinc sulfate which is colourless. *(1 mark)*

b) Magnesium, zinc, iron, copper. *(2 marks)*

c) Copper. *(1 mark)*

7. a) Coke C and limestone, CaCO3, are added at A. Hot air is blown into the furnace at the bottom. The coke burns in air in an extremely exothermic reaction to form carbon dioxide.

coke + oxygen → carbon dioxide

$C + O_2 \rightarrow CO_2$

At these high temperatures more coke reacts with the carbon dioxide to form carbon monoxide. Carbon monoxide is the main reducing agent in the blast furnace.

carbon dioxide + coke → carbon monoxide

$CO_2 + C \rightarrow 2CO$

The carbon monoxide reduces the iron ore to iron.

iron (III) oxide + carbon monoxide → iron + carbon dioxide

$Fe_2O_3 + 3CO \rightarrow 2Fe_{(l)} + 3CO_2$

The iron is a liquid at the temperature inside the furnace and falls to the bottom of the furnace where it is tapped off. The iron ore is not pure when it is added, it contains a lot of sand, silicon dioxide, SiO_2. The limestone is added into the furnace to remove the impurities. The limestone thermally decomposes to form calcium oxide and carbon dioxide.

calcium carbonate → calcium oxide + carbon dioxide
(limestone)

$CaCO_3 \rightarrow CaO + CO_2$

The basic calcium oxide reacts with the slightly acidic silicon dioxide to form calcium silicate, which is also known as slag. This falls to the bottom of the furnace and floats on top of the iron as it is less dense. The slag is removed at C.

calcium oxide + silicon dioxide → calcium silicate

$CaO + SiO_2 \rightarrow CaSiO_{3(l)}$ *(8 marks)*

b) $C + O_2 \rightarrow CO_2$ *(2 marks)*

c) i) $CO_2 + C \rightarrow 2CO$ *(3 marks)*

ii) The carbon monoxide is the main reducing agent in the blast furnace. *(1 mark)*

iii) $Fe_2O_3 + 3CO \rightarrow 2Fe_{(l)} + 3CO_2$ *(3 marks)*

d) i) $CaCO_3 \rightarrow CaO + CO_2$ *(2 marks)*

ii) $CaO + SiO_2 \rightarrow CaSiO_{3(l)}$ *(2 marks)*

8. a) Magnesium is a reactive metal, high in the Reactivity series. It forms compounds easily. Copper is a very unreactive metal, low in the reactivity series. *(2 marks)*

b) i) Ductile means to draw into wires. *(1 mark)*

ii) Metals have delocalised electrons which are free to move and carry charge when a potential difference is applied. *(3 marks)*

iii) Any two from: metals are malleable/can be beaten into shape; metals are sonorous; metals are good conductors of heat. *(2 marks)*

c) i)

Substance	Colour
copper(II) carbonate	green
copper(II) sulfate solution	blue

(2 marks)

d) i) A white-grey ash. *(2 marks)*

ii) $2Mg + O_2 \rightarrow 2MgO$ *(3 marks)*

iii) Mg_3N_2 *(1 mark)*

e) i) Bubbles of gas released; heat is evolved; magnesium disappears. *(2 marks)*

ii) $Mg + 2HCl \rightarrow MgCl_2 + H_2O$ *(3 marks)*

iii) Zinc. *(1 mark)*

Chapter 12 Water

Exam questions (pages 162–3)

1. a) Hard water wastes soap/hard water needs more soap to make a lather than soft water needs. *(1 mark)*

b) The water is temporary hard water (because it leaves a solid compound behind when it is boiled). *(1 mark)*

c) Any one from: hard water tastes nicer than soft water; hard water is good for bones and teeth; hard water may prevent heart disease; hard water is necessary for brewing beer; hard water is necessary for tanning leather. *(1 mark)*

d) An ion exchanger removes the hardness in the water (and the fine holes in the steam iron will not become clogged in scale). *(1 mark)*

2. a) Hard water has no effect on detergents. *(1 mark)*

b) Any two from: hard water tastes nicer than soft water; hard water is good for bones and teeth; hard water may prevent heart disease; hard water is necessary for brewing beer; hard water is necessary for tanning leather. *(2 marks)*

c) Hard water may also be softened by: adding washing soda/hydrated sodium carbonate; using an ion exchanger/ion exchange column/ion exchange resin. *(1 mark)*

3. a)
- Using same size of water sample/using 25cm^3 of each water sample
- add 1 cm^3 of soap solution (stopper container) and shake
- continue to add 1cm^3 of soap solution and shake until a permanent lather is formed/until a lather lasting at least 30 seconds is formed
- record the volume of soap solution added
- the sample of water which takes the most soap solution to form a permanent lather is the harder of the two samples. *(3 marks)*

b) Permanent hardness is hardness which cannot be removed by boiling. *(1 mark)*

c) Permanent hard water may also be softened by: adding washing soda/hydrated sodium carbonate; using an ion exchanger/ion exchange column/ion exchange resin. *(1 mark)*

4. a) Soap solution. *(1 mark)*

b) Use the same volume of water for each sample. *(1 mark)*

c) The sample which requires the larger volume of soap solution is the hardest water. *(1 mark)*

d) Temporary hardness can be removed boiling.
Any one from: wastes soap; causes hot water pipes to block; causes blockages in dish washers/washing machines; causes fur/scale on kettles. *(2 marks)*

5. a) Hard water is water which will not lather easily with soap. *(1 mark)*

b) i) Town P had the hardest water. *(1 mark)*

ii) The sample of water from town P needed the largest volume of soap solution to form a permanent lather. *(1 mark)*

c) i) A contains permanent hard water (as it does not form a lather even after boiling/the hardness cannot be removed by boiling). *(1 mark)*

ii) Any one from: calcium hydrogen carbonate; calcium sulfate; magnesium hydrogen carbonate; magnesium sulfate. *(1 mark)*

iii) The carbonate ions from the washing soda react with the calcium ions from the hard water forming an insoluble compound, calcium carbonate/a precipitate of calcium carbonate. *(3 marks)*

6. a) Hard water is water which will not lather easily with soap. *(2 marks)*

b) Calcium hydrogen carbonate or magnesium hydrogen carbonate. *(1 mark)*

c) $Ca(HCO_3)_{2(aq)} \rightarrow CaCO_{3(s)} + H_2O_{(l)} + CO_{2(g)}$ *(2 marks)*

d) The carbonate ions from the washing soda react with the calcium ions from the hard water forming an insoluble compound, calcium carbonate/a precipitate of calcium carbonate. *(5 marks)*

e) Any one from: wastes soap; causes hot water pipes to block; causes blockages in dish washers/washing machines; causes fur/scale on kettles. *(1 mark)*

7. a) Hard water is water which will not lather easily with soap. *(2 marks)*

b) i) Washing soda. *(1 mark)*

ii) Permanent hard water. *(1 mark)*

iii) The hardness was not removed by boiling. *(2 marks)*

8. a) Temporary hard water. *(1 mark)*

b) Calcium stearate. *(1 mark)*

9. a) Any two from: hard water tastes nicer than soft water; hard water is good for bones and teeth; hard water may prevent heart disease. *(2 marks)*

b) Brewing industry or leather tanning industry. *(1 mark)*

c) The calcium ions from the hard water swap places with the sodium or hydrogen ions on the ion exchanger. The sodium ions or hydrogen ions do not cause hardness in water. *(4 marks)*

10. a) Silica gel absorbs small amounts of water vapour from the air protecting the leather from damage. *(1 mark)*

b) Calcium oxide/calcium chloride/sodium hydroxide. *(1 mark)*

Chapter 13 Rates of reaction

In-text questions

1. a) There was the greatest loss in mass after 5 minutes in the reaction which used the small pieces of marble chips.

b) Large pieces: 3.29g lost after 5 minutes/300s

$$\text{rate of mass lost} = \frac{3.29}{300} = 1.10\text{x}10^{-2}\text{g/s}$$

Medium pieces: 3.73g lost after 5 minutes/300s

$$\text{rate of mass lost} = \frac{3.73}{300} = 1.24\text{x}10^{-2}\text{g/s}$$

Large pieces: 3.98g lost after 5 minutes/300s

$$\text{rate of mass lost} = \frac{3.98}{300} = 1.32\text{x}10^{-2}\text{g/s}$$

This is the fastest reaction as the rate is highest.

c) After 5 minutes the reactions using the small and medium marble chips have almost completed. The reaction which is still continuing is the reaction with the large marble chips.

d) The reaction using the small pieces of marble chips has stopped first. It took 7 minutes to reach completion.

e) The calcium carbonate is reacting with hydrochloric acid. The only compound which is leaving the flask is carbon dioxide. The loss of mass measured and recorded must be due to the carbon dioxide. 4.00g of carbon dioxide is formed at the end of each reaction.

f) The rate slows down as time progresses. The rate is fastest at the very beginning of the reaction, the initial rate.

2. 80s.

3. 80cm^3.

4. The graph should be labelled A. It must begin at (0,0) and finish at 100cm^3. As the temperature has increased the graph should be above the original one and reach 100cm^3 at around 60s.

5. The graph should be labelled B. It must begin at (0,0) and finish at 100cm^3. As the concentration of the acid has decreased the graph should be below the original one and reach 100cm^3 at around 90s.

Exam questions (pages 175–8)

1. a) Decrease the concentration of the sulfuric acid; decrease the temperature; use the same mass of zinc granules instead of zinc powder. *(3 marks)*

b) Excess zinc would be left at the bottom of the flask/bubbles would stop. *(1 mark)*

2. a) i) calcium carbonate + citric acid → calcium citrate + water + carbon dioxide *(1 mark)*

ii) The carbonate and the citric acid form carbon dioxide which is a gas and bubbles off. *(1 mark)*

b) i) The sketch should include a conical flask on the balance, a Fizzer tablet and a liquid in the conical flask, some cotton wool in the top of the conical flask and a stop watch at the side of the balance. Only award the mar ks if the diagram is labelled. *(3 marks)*

ii) The mass of the flask and contents decreases as the carbon dioxide produced escapes into the air. *(2 marks)*

iii) The cotton wool plug prevents splashes of liquid leaving the conical flask. (The loss of mass must only be due to the CO_2 escaping not any liquid.) *(2 marks)*

c) i) Student's graph. *(3 marks)*

ii) Should be correctly read off from the student's graph. Somewhere between 60 and 80 seconds. *(1 mark)*

iii) The loss in mass for the complete tablet was 0.43g (101.33 –100.90 = 0.43g). The loss in mass would be half of this for half a tablet. Loss in mass = 0.215g. *(2 marks)*

iv) The rate of reaction would increase; as the surface area of the tablet has increased; allowing more collisions/more successful collisions/more collisions with the required activation energy in a fixed period of time. *(3 marks)*

v) The graph should begin at (0, 101.33) and end at 100.90g but as this reaction happens faster the curve should be steeper/be below the first graph and should be completed around 60 s. The graph should be labelled B. *(4 marks)*

3. a) Percentage yield of ammonia increases as the pressure increases. *(1 mark)*

b) 350°C and 400 atm. *(2 marks)*

c) 26%. *(1 mark)*

4. a) i) Student's graph. *(3 marks)*

ii) Loss in mass/g. *(1 mark)*

iii) The graph should begin at (0, 0) and end at 4.0g but as this reaction happens faster the curve should be less steep/be below the first graph. The graph should be labelled X. *(2 marks)*

iv) Increasing the concentration of the acid will increase the rate of reaction; as there will be more H^+ ions present; more collisions/more successful collisions/more collisions with the required activation energy in a fixed period of time. *(3 marks)*

b) i) Increasing the temperature decreases the yield of ammonia. *(1 mark)*

ii) It is expensive to produce pressures of 1000 atm due to the specialist equipment required. The production of high pressures such as this can be extremely dangerous. *(1 mark)*

5. a) i) $2H_2O_2 \rightarrow 2H_2O + O_2$ *(3 marks)*

ii) The cotton wool plug (allows the gas to escape but) prevents the loss of liquid due to splashing. *(1 mark)*

iii) Student's graph. *(3 marks)*

iv) Will depend on the Student's own graph. Give the mark if the amount is read off correctly. *(1 mark)*

v) Measure the volume of oxygen produced. *(1 mark)*

b) i) The diagram should be similar to the one on page 36, Figure 6. Award marks for a clear diagram of assembled apparatus which is clearly labelled, including filter paper, filter funnel and a suitable container for the filtrate, a beaker or a conical flask. The manganese(IV) oxide also be labelled as the residue in the filter paper. *(3 marks)*

ii) Weigh and record the mass of manganese(IV) oxide at the beginning of the experiment. After the experiment (collect and dry the manganese(IV) oxide and) weigh it. The mass will be identical showing the manganese(IV) oxide has not been used up. *(2 marks)*

c) As the temperature is increased the rate of reaction increases; as the particles gain energy there will be more collisions; more successful collisions/more collisions with the activation energy to react; in a fixed period of time. *(4 marks)*

6. a) $Ag^+ + e^- \rightarrow Ag$ *(2 marks)*

b) i) A = thistle funnel; B = conical flask; C = beehive shelf. *(3 marks)*

ii) Manganese(IV) oxide/manganese dioxide. *(1 mark)*

iii) Gas syringe. *(1 mark)*

iv) A catalyst is a substance which will speed up the rate of a chemical reaction and remains chemically unchanged at the end of the reaction. *(3 marks)*

v) $2H_2O_2 \rightarrow 2H_2O + O_2$ *(3 marks)*

c) As the temperature is increased the rate of reaction increases; as the particles gain energy there will be more collisions; more successful collisions/more collisions with the activation energy to react; in a fixed period of time. *(4 marks)*

Chapter 14 Non-metals and their compounds

Exam questions (pages 209–10)

1. a) Temperature: 450°C; pressure: 200 atm; catalyst: iron. *(3 marks)*

b) $N_2 + 3H_2 \rightleftharpoons 2NH_3$ *(3 marks)*

c) See page 180 for uses of elements and compounds required by the specification. Ammonia is used in the manufacture of nitrogenous fertilisers, used in the manufacture of nitric acid and the manufacture of nylon. *(2 marks)*

2. a) i) Sulfur dioxide. *(1 mark)*

ii) Any two from:

- When acid rain falls on plants it harms the leaves making it difficult for the plant to photosynthesise.
- When acid rain falls onto soil it leaches the nutrients out of the soil leaving unhealthy plants which are susceptible to disease.
- When the acid rain is prolonged and severe it can cause complete deforestation.
- When acid rain falls onto rivers, streams or lakes the water becomes acidic. Fish are very susceptible to even small changes in the pH of the water in which they live and the fish die.
- Acidic water will absorb more poisonous metals which contaminates the water and fish die.
- When acid rain falls onto buildings structures or pavements made from limestone the limestone reacts and corrodes. *(2 marks)*

iii) Any one from: the sulfur can be removed from the fuel before it is burnt; the chimneys can be fitted with attachments known as scrubbers which remove the sulfur dioxide before it is released into the atmosphere. *(1 mark)*

iv) See page 180 for uses of elements and compounds required by the specification. Sulfur is used to vulcanise rubber/as a fungicide. *(1 mark)*

v) Sulfur is a yellow solid. *(2 marks)*

b) i) $2C + O2 \rightarrow 2CO$ *(3 marks)*

ii) Carbon monoxide is a toxic gas. When there is plenty of oxygen present the carbon burns completely to form carbon dioxide and not carbon monoxide. *(2 marks)*

c) i) Hydrogen is lighter than air. *(1 mark)*

ii) Carbon dioxide does not burn and is heavier than air. *(1 mark)*

iii) Chlorine kills the bacteria in the water. *(1 mark)*

3. a)

Gas	Compound	Colourless	Poisonous
hydrogen	NO	YES	NO
carbon dioxide	YES	YES	NO
chlorine	NO	NO	YES
helium	NO	YES	NO
carbon dioxide	YES	YES	YES

(4 marks)

b) i) Black to salmon pink/pinky brown. *(2 marks)*

ii) Water. *(1 mark)*

iii) Hydrogen is a clean fuel because when it is burned it produces no toxic products. *(1 mark)*

4. a) Carbon dioxide is one of the greenhouse gases. As the amount of carbon dioxide in the atmosphere increases the temperature of the earth increases, causing (any two of):
- the polar ice caps to melt
- sea levels to rise
- flooding in low lying or costal regions
- a change in weather patterns
- which will affect the growth of crops which will lead to food shortages
- habitats will change causing certain plants and animals to struggle for survival. *(2 marks)*

b) Carbonic acid. *(1 mark)*

5. a) Sulfur dioxide. *(1 mark)*

b) Any two from:
- When acid rain falls on plants it harms the leaves making it difficult for the plant to photosynthesise.
- When acid rain falls onto soil it leaches the nutrients out of the soil leaving unhealthy plants which are susceptible to disease.
- When the acid rain is prolonged and severe it can cause complete deforestation.
- When acid rain falls onto rivers, streams or lakes the water becomes acidic. Fish are very susceptible to even small changes in the pH of the water in which they live and the fish die.
- Acidic water will absorb more poisonous metals which contaminates the water and fish die.
- When acid rain falls onto buildings structures or pavements made from limestone the limestone reacts and corrodes. *(2 marks)*

c) Any one from: the sulfur can be removed from the fuel before it is burnt; the chimneys can be fitted with attachments known as scrubbers which remove the sulfur dioxide before it is released into the atmosphere. *(1 mark)*

6. a) Sulfur is a yellow solid. *(2 marks)*

b) The iron and sulfur mixture glows red. When the heat is removed the mixture continues to glow red. A brittle grey solid remains at the end of the reaction. *(2 marks)*

7. a) A dehydrating agent removes water from a compound. *(1 mark)*

b) Initially the sulfuric acid becomes dark in colour. The sugar turns black. Eventually a black column rises from the beaker. Steam pours out from the top of the beaker. A lot of heat is released. There is a smell of burnt caramel. *(3 marks)*

8. a) i) Combustion is a chemical reaction between a fuel and oxygen to produce oxides and release energy. *(3 marks)*

ii) Hydrogen is a clean fuel because when it is burned it produces no toxic products. *(1 mark)*

b) i) Black colour of the copper oxide disappears and the salmon pink colour of freshly formed copper appears. *(2 marks)*

ii) $CuO + H_2 \rightarrow Cu + H_2O$ *(2 marks)*

iii) The copper oxide has lost oxygen. The loss of oxygen is known as reduction.
Or: The copper ions have gained electrons. Gain of electrons is reduction. *(2 marks)*

9. a) i) Allotropes are different forms of the same element in the same physical state. *(2 marks)*

ii) A is diamond. B is graphite. *(3 marks)*

iii) A carbon atom. *(1 mark)*

iv) Van der Waal's forces. *(1 mark)*

b) i) Sulfur is a solid at room temperature. It is not soluble in water. *(2 marks)*

ii) Rhombic sulfur, monoclinic sulfur and plastic sulfur. *(3 marks)*

c) i) Silicon/nitrogen. *(1 mark)*

ii) $S + O_2 \rightarrow SO_2$ *(2 marks)*

iii) $SO_2 + H_2O \rightarrow H_2SO_3$ *(2 marks)*

iv) Acid rain. *(1 mark)*

Chapter 15 Organic chemistry 1

In-text questions

1. a) Coal, oil, LPG, peat, lignite.

b) There is a limited supply of non-renewable fuels they cannot be replaced in our lifetime. A fossil fuel is one which has been produced by the action of heat and pressure on the remains of dead animals and plants over many millions of years.

c) Hydroelectric energy, wind energy, tidal energy, solar energy and geothermal energy are renewable energy sources.

d) methane + oxygen → carbon dioxide + water

e) $CH_4 + O_2 \rightarrow CO_2 + H_2O$

2. a) A hydrocarbon is a compound which contains the elements hydrogen and carbon only.

b) Crude oil is heated to cause continual evaporation followed by condensation. The different hydrocarbons in crude oil are separated as they have different boiling points.

c) Refinery gas.

d) Bitumen is used to produce waterproof felts for roofs on houses and garages. It is used to waterproof pipes and high voltage cables which are laid on the sea floor. It is used in the construction of roads and motorways, airport runways, Olympic standard athletics tracks. Most panels used for sound deadening in cars and household appliances contain bitumen.

e) Crude oil may accidentally leak while being extracted or accidentally spill from the large container ships used to transport the oil. A leak or spill will cause major environmental problems such as severe water pollution, can harm and eventually kill sea birds, fish and mammals.

f) The world's reserves of crude oil are quickly getting less. Crude oil provides a wide range of substances we cannot do without. If the extraction of crude oil is more efficient the dwindling reserves will last longer.

3. a) A homologous series is a series of carbon compounds which have the same general formula, have very similar chemical properties and show a gradation in physical properties. One member in a homologous series differs from the next by a $–CH_2$ group.

b) i) $C_nH_{(2n+2)}$

ii) C_nH_{2n}

iii) $C_nH_{(2n+1)}OH$

iv) $C_nH_{(2n+2)}COOH$

c) i) See Table 1, page 215. C_2H_6.

ii) See Table 1, page 215. C_3H_6.

iii) See Table 1, page 215. CH_3OH.

iv) See Table 1, page 215. CH_3COOH.

4. a) A saturated hydrocarbon contains only C–C single bonds. An unsaturated hydrocarbon contains C=C double bonds.

b) Bubble the gas through orange-brown bromine water. If the bromine water remains orange brown the gas is ethane. If the bromine water changes from orange-brown to colourless the gas is propene.

5. a) i) $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

ii) $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

b) $2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$

6. a) Fossil fuels burn to form carbon dioxide which is a green house gas. Greenhouse gases in the atmosphere cause the temperature of the atmosphere at the surface of the earth to increase as they trap the energy from the sun's rays.

b)
- When acid rain falls onto soil it leaches the nutrients out of the soil leaving unhealthy plants which are susceptible to disease.
- When the acid rain is prolonged and severe it can cause complete deforestation.
- When acid rain falls onto rivers, streams or lakes the water becomes acidic. Fish are very susceptible to even small changes in the pH of the water in which they live and the fish die.
- Acidic water will absorb more poisonous metals which contaminates the water and fish die.
- When acid rain falls onto buildings structures or pavements made from limestone the limestone reacts and corrodes.
- When acid rain falls onto buildings structures or pavements made from limestone the limestone reacts and corrodes.
- Sulfur can be removed from fossil fuels before they are burnt in combustion engines or power stations.
- Power station chimneys can be fitted with attachments known as scrubbers which remove the sulfur dioxide before it is released into the atmosphere.
- The use of renewable sources of energy can be increased.

c) Ensure a excess of air/oxygen is available as carbon monoxide is produced in a limited supply of air.

Chapter 16 Organic chemistry 2

In-text questions

1. a) Polythene is suitable for food packaging as it is light and flexible and will not react the food.
b) Ethene is the monomer used to produce polythene.
c) Polythene is produced by addition polymerisation.

2. a) i) See Table 3, page 217. C_3H_6.
ii) As PVC diagram on page 220, but with CH_3 in place of Cl.
b) A wool carpet is extremely expensive. A carpet made from polypropene is much less expensive. It is resistant to damage by water or chemicals and is long lasting.

3. a) Non-biodegradable means that the material cannot be broken down by microbes.
b) Polymers can be disposed of in landfill sites or by incineration.
c) Recycling polymers helps to prevent the increase of landfill and decreases the toxic combustion products/decreases toxic products produced when the polymer is burned.
d)
- Dumping plastics into landfill sites is now no longer free. There is a tax imposed on households to pay for dumping plastics.
- Councils use advertising and/or information leaflets to inform householders of the toxic effects of dumping plastics in landfill sites.
- Councils run information sessions for pupils in schools to encourage them into a recycling pattern early in life.
- Councils provide collection points in supermarkets and provide or support kerb side recycling initiatives to make it easy for households to recycle plastic.

4. a) PVC is used to produce window frames, leather-like materials for clothes and furniture, insulation on electric wires, water pipes, waste pipes, drain pipes, gutters, facia boards among other uses.
b) Vinyl chloride contains a chlorine atom. Hydrocarbon molecules contain hydrogen and carbon and no other element.
c) See page 220.
d) Vinyl chloride contains carbon, hydrogen and chlorine atoms. There are three different elements in a molecule of vinyl chloride.
e) See page 220.

5. a) ethene + steam → ethanol
$C_2H_{4(g)} + H_2O_{(g)} \rightarrow C_2H_5OH_{(g)}$
b) See Table 3, page 223.
c) Yeast is added to water and sugar in the absence of air and left in a warm place (35°C) for a few days. Ethanol and carbon dioxide are formed.
d) The ethanol can be separated from the fermentation solution by fractional distillation.

6. a) i) Acidified potassium dichromate/acidified sodium dichromate.
ii) See Table 4, page 226.
b) i) Ethanoic acid is a weak acid as it only partly breaks down into ions when dissolved in water.
ii) A dilute solution of ethanoic acid is called vinegar and is used to flavour and preserve certain foods.

7. a) The white sodium carbonate disappears. Bubbles of gas are produced. The reaction vessel becomes hot as the reaction gives out heat. A colourless solution remains at the end of the reaction.

b) Magnesium or zinc.

c) sodium carbonate + ethanoic acid → sodium ethanoate + water + carbon dioxide

$$NaOH + CH_3COOH \rightarrow CH_3COONa + H_2O + CO_2$$

Exam questions (pages 229–32)

1. a) Carbon. *(1 mark)*

b) Carbon dioxide. *(1 mark)*

c) Wood. *(1 mark)*

d) Heat. *(1 mark)*

e) Oxygen. *(1 mark)*

2. a) i) Bubble through lime water. If the gas is carbon dioxide the limewater will turn milky. *(3 marks)*

ii) Carbon monoxide. *(1 mark)*

iii) Carbon dioxide and water *(2 marks)*

iv) Exothermic. *(1 mark)*

v) A hydrocarbon is a compound which contains (atoms of the elements) hydrogen and carbon only. *(2 marks)*

vi) $2H_2 + O_2 \rightarrow 2H_2O$ *(3 marks)*

b) i) Any two from: hydroelectric power; others (wood alcohol); solar power. *(2 marks)*

ii) A non-renewable source of energy cannot be replaced in our lifetime. A renewable source of energy can be replaced in a short period of time. *(2 marks)*

iii) Crude oil. *(1 mark)*

3. a) i) A hydrocarbon is a compound which contains (atoms of the elements) hydrogen and carbon only. *(2 marks)*

ii) Combustion is a chemical reaction between a fuel and oxygen to produce oxides and heat. *(3 marks)*

iii) A homologous series is a series of carbon compounds which have the same general formula have very similar chemical properties and show a gradation in physical properties. One member in a homologous series differs from the next by a $–CH_2$ group. *(2 marks)*

iv) x=2; y=4 *(2 marks)*

v) Ethene. *(1 mark)*

vi) Red-brown/yellow brown. *(1 mark)*

vii) Alkanes. *(1 mark)*

b) i) Vinyl chloride. *(1 mark)*

ii) See page 220. *(2 marks)*

c) i) (Most) polymers are non-biodegradable (cannot be broken down by living organisms) and remain on the landfill site for over 500 years. *(1 mark)*

ii) Incineration. *(1 mark)*

iii) Recycling plastics preserves the Earth's limited resources of crude oil and decreases the amount of rubbish piling up on landfill sites. *(1 mark)*

4. a) The energy required to break the bonds; in the silicon dioxide and the carbon is less than; the energy released when the bonds are made; in the carbon dioxide and the silicon. *(5 marks)*

b) SiO_2 is reduced as it has lost oxygen. A loss of oxygen is defined as reduction. *(2 marks)*

5. The reaction is exothermic as; the energy required to break the bonds; in the methane and the oxygen; is less than; the energy released when the bonds are made; in the water and the carbon dioxide. *(4 marks)*

6. a) A hydrocarbon is a compound which contains (atoms of the elements) hydrogen and carbon only. *(2 marks)*

b) i)

	Name of homologous series	**Molecular formular**
ethane	alkanes	C_2H_6
ethene	alkenes	C_2H_4

(4 marks)

ii) A homologous series is a series of carbon compounds which (any two from): have the same general formula; have very similar chemical properties and; show a gradation in physical properties. One member in a homologous series differs from the next by a $–CH_2$ group. *(2 marks)*

c) i) $C_2H_{4(g)} + H_2O_{(g)} \rightarrow C_2H_5OH_{(g)}$ *(2 marks)*

ii)

	Molecular formula	**Structural formula**	**Physical state at room temperature**
ethanol	C_2H_5OH	see Table 3, page 223	liquid

(2 marks)

iii) Ethanol is not a hydrocarbon as it contains oxygen in addition to hydrogen and carbon. A hydrocarbon contains atoms of hydrogen and carbon only. *(1 mark)*

iv) By the fermentation (of carbohydrates/sugars). *(1 mark)*

d) i) See Table 4, page 226. *(1 mark)*

ii) Any two from: the white sodium carbonate disappears; bubbles of gas are produced; the solution remaining is colourless; the reaction vessel feels warm to the touch/heat is evolved during the reaction. *(2 marks)*

iii) Any one from: the reaction of sodium carbonate with hydrochloric acid would be faster; more heat would be evolved when sodium carbonate reacts with hydrochloric acid than when it reacts with ethanoic acid. *(1 mark)*

7. a) i) Alkanes. *(1 mark)*

ii) $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ *(3 marks)*

iii) A non-renewable source of energy cannot be replaced in our lifetime. *(2 marks)*

b) i) CH_3COOH *(1 mark)*

ii) See Table 4, page 226. *(2 marks)*

c) i) Any three from: the green copper carbonate disappears; bubbles of gas are produced; a blue solution is produced; the reaction vessel feels warm to the touch/heat is evolved during the reaction. *(3 marks)*

ii) Hydrogen gas. Hold a lighted splint to the mouth of the test tube containing hydrogen; the hydrogen will burn with a squeeky pop. *(3 marks)*

iii) Sodium ethanoate, CH_3COONa. *(2 marks)*

8. a) i) See Table 3, page 217. *(2 marks)*

ii) Bubble ethene through bromine water; the red-brown colour of the bromine water would disappear; leaving a colourless liquid. *(3 marks)*

iii) Hydrocarbons contain atoms of hydrogen and carbon only. Halothane also contains Cl, Br and F atoms. *(1 mark)*

iv) $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ *(3 marks)*

v) Gas. *(1 mark)*

b) i) Polythene does not react with the chemicals in the body/polythene is long lasting/ polythene can be moulded into the exact shape required. *(1 mark)*

ii) A polymer is a large macromolecule; formed by joining shorter molecules (monomers) into a chain. *(2 marks)*

iii) See Table 1, page 220. *(2 marks)*

c) i) See Table 3, page 223. *(2 marks)*

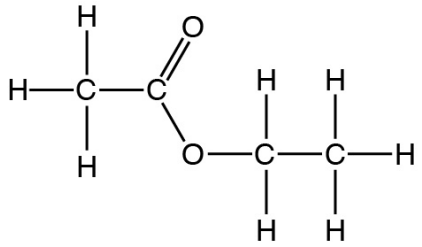
ii) $C_2H_{4(g)} + H_2O_{(g)} \rightarrow C_2H_5OH_{(g)}$ *(2 marks)*

iii) The sugars/carbohydrates are mixed with water and yeast and heated to 35°C in the absence of air. *(3 marks)*

d) i) See Table 4, page 226. *(2 marks)*

ii) Vinegar/food preservative, i.e. pickling. *(1 mark)*

iii)



(2 marks)

9. a) i) A hydrocarbon is a compound which contains (atoms of the elements) hydrogen and carbon only. *(2 marks)*

ii) Propane is an alkane. Propene is an alkene. *(2 marks)*

iii) A homologous series is a series of carbon compounds which (any two from): have the same general formula; have very similar chemical properties and; show a gradation in physical properties. One member in a homologous series differs from the next by a $–CH_2$ group. *(2 marks)*

iv)

Hydrocarbon	**Molecular formula**	**Structural formula**
Propane	C_4H_{10}	See Table 1, page 215
Propene	C_3H_6	See Table 3, page 217

(4 marks)

v)

Test	bubble the gas through bromine water
Observations with propane	the red-brown colour of the bromine water remains
Observations with propene	the red-brown colour of the bromine water disappears leaving a colourless liquid

(4 marks)

b) i) Addition polymerisation. *(2 marks)*

ii) Solid. *(1 mark)*

c) $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ *(3 marks)*

Chapter 17 Quantitative chemistry 2

In-text questions

1. 40%.
2. % Fe in FeO = 77%
   % Fe in Fe_2O_3 = 70%
3. % N in NH_4NO_3 $= \frac{14+14}{14+4+14+48} = \frac{28}{80} = 35\%$
4. 0.5 mol/dm^3.
5. 0.05 mol/dm^3.
6. concentration (mol/dm^3) $= \frac{\text{no. of moles} \times 1000}{\text{volume (cm}^3\text{)}} = 11.77$ mol/dm^3
7. number of moles of sodium hydroxide required to dissolve in 500cm^3 of water to produce a concentration of 0.18 mol/dm^3:

   $$\text{no. of moles} = \frac{\text{volume (cm}^3\text{)} \times \text{concentration (mol/dm}^3\text{)}}{1000}$$
   $$= \frac{500 \times 0.18}{1000}$$
   $$= 0.09 \text{ moles}$$

   mass of 0.09 moles of sodium hydroxide:

   method 1: substitute the values into the formula and use cross multiplication:

   $$\text{no. of moles} = \frac{\text{mass (g)}}{\text{RFM}}$$
   $$0.09 = \frac{\text{mass (g)}}{40}$$
   0.09 x 40 = mass (g)
   mass = 3.6g

   method 2: rearrange the formula then substitute the values
   mass = no. of moles x RFM
   = 0.09 x 40
   = 3.6g
8. $\text{no. of moles} = \frac{\text{volume (cm}^3\text{)} \times \text{concentration (mol/dm}^3\text{)}}{1000} = \frac{400 \times 2.5}{1000} = 1$ moles

   K_2CO_3: 39 + 39 + 12 + (3x16) = 138g
9. **a)** 0.003125 moles
   b) 0.003125 moles
   c) 0.145mol/dm^3
10. **a)** $\text{no. of moles} = \frac{\text{volume (cm}^3\text{)} \times \text{concentration (mol/dm}^3\text{)}}{1000} = \frac{25 \times 0.25}{1000} = 0.00625$ moles

    b) 0.003125 moles

    c) concentration (mol/dm^3) $= \frac{\text{no. of moles} \times 1000}{\text{volume (cm}^3\text{)}} = \frac{0.003125 \times 1000}{28.9} = 0.108$ mol/dm^3

11. $\text{no. of moles} = \frac{\text{volume (cm}^3\text{)} \times \text{concentration (mol/dm}^3\text{)}}{1000} = \frac{26.6 \times 0.094}{1000} = 0.0025$ moles HNO_3

2 moles HNO_3 to 1 mole $Na_2B_4O_7$
so 0.00125 moles $Na_2B_4O_7$

$$\text{concentration (mol/dm}^3\text{)} = \frac{\text{no. of moles} \times 1000}{\text{volume (cm}^3\text{)}} = \frac{0.00125 \times 1000}{25} = 0.05 \text{ mol/dm}^3$$

Exam questions (pages 238–40)

1. a) i) $\frac{26.7 + 26.5}{2} = 26.6$ *(2 marks)*

ii) Orange/yellow to red/pink. *(2 marks)*

iii) $\frac{26.6 \times 0.094}{1000} = 0.0025$ moles *(2 marks)*

b) i) 0.00125 moles *(2 marks)*

ii) $\frac{0.00125 \times 1000}{25} = 0.05$ mol/dm^3 *(2 marks)*

iii) 4.775g in 250 cm^3 = 4.775 x 4 in 1000cm^3 = 19.1g/dm^3 *(1 mark)*

vi) 19.1g = 0.05 moles

$$\text{RFM} = \frac{\text{mass}}{\text{no.of moles}} = \frac{19.1}{0.05} = 382$$

$Na_2B_4O_7.XH_2O = 382$
$Na_2B_4O_7 = 202$
therefore $XH_2O = 382 - 202 = 180$
X = 10 *(3 marks)*

2. a) $\text{no.of moles} = \frac{\text{mass}}{\text{RFM}} = \frac{5.53}{158} = 0.035$ moles *(2 marks)*

b) 1:2 ratio: 0.035 x 2 = 0.07 moles *(2 marks)*

c) $\text{no. of moles} = \frac{\text{volume (cm}^3\text{)} \times \text{concentration (mol/dm}^3\text{)}}{1000}$

$0.07 = \frac{\text{volume} \times 2}{1000}$

volume = 35cm^3 *(2 marks)*

3. a) 3 – 0.55 = 2.45g *(1 mark)*

b) $\text{no. of moles} = \frac{\text{volume (cm}^3\text{)} \times \text{concentration (mol/dm}^3\text{)}}{1000} = \frac{50 \times 1}{1000} = 0.05$ moles *(2 marks)*

c) 1:2 ratio: $\frac{0.05}{2} = 0.025$ moles *(2 marks)*

d) 0.025 moles = 2.45g, therefore 1 mole = 2.45 x 40 = 98g *(2 marks)*

e) $M(OH)_2 = 98$
M = 98 – (2 x 17) = 64
M is copper *(2 marks)*

4. a) i) $\text{no. of moles} = \frac{\text{mass}}{\text{RAM}} = \frac{2390}{239} = 10$ moles PbS

1:1 ratio

$$10 = \frac{\text{mass}}{223}$$

mass = 10 x 223
= 2230 g
= 2.23 kg PbO *(5 marks)*

ii) 10 moles of PbO are produced which will produce 10 moles of Pb
mass = no. of moles x RFM
mass = 10 x 207 = 2070 g = 2.07 kg *(3 marks)*

b) i) A = burette; B = pipette *(2 marks)*

ii)
- rinse the pipette with de-ionised water
- rinse the pipette with the alkali using a pipette filler
- fill the pipette above the line using a pipette filler
- release the alkali until the bottom of the meniscus is on the line
- release the alkali into the conical flask
- touch the tip of the pipette onto the surface of the alkali *(4 marks)*

c) 16.4 x 0.04 = 6.56×10^{-4} moles HCl
2:1 ratio
3.28×10^{-4} $Ca(OH)_2$

$$\text{no. of moles} = \frac{\text{volume} \times \text{concentration}}{1000}$$

$$3.28 \times 10^{-4} = \frac{25 \times \text{concentration}}{1000}$$

concentration = 0.013 mol/dm^3 *(4 marks)*

5. a) i)
- use safety pipette filler
- rinse the pipette with de-ionised water
- rinse with barium hydroxide solution
- draw up liquid until (bottom of) meniscus on line
- release into conical flask
- touch tip of pipette on to surface of solution *(4 marks)*

ii) pink to colourless *(2 marks)*

b) i) 22.45 cm^3 *(2 marks)*

ii) $\text{no. of moles} = \frac{\text{volume} \times \text{concentration}}{1000} = \frac{22.45 \times 0.2}{1000} = 4.49 \times 10^{-3}$ *(2 marks)*

iii) 1:2 ratio

$$\frac{4.49 \times 10^{-3}}{2} = 2.245 \times 10^{-3}$$ *(2 marks)*

iv) 0.0898 mol/dm^{-3} *(2 marks)*

c) i) 0.12dm^{-3} *(5 marks)*

ii) 5 cm^3 *(4 marks)*

iii) 17.1% *(3 marks)*

Chapter 18 Energetics

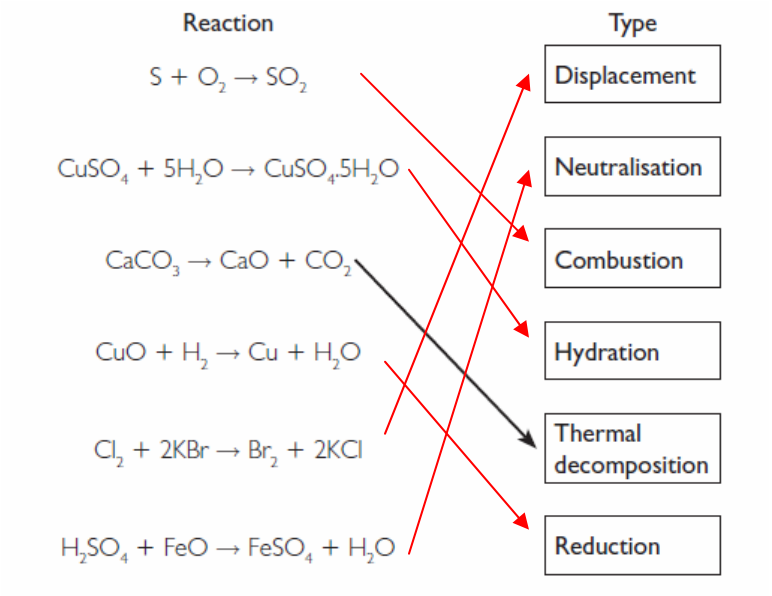
Exam questions (pages 244–5)

1.

Term	Reaction A	Reaction B
Exothermic		✓
Endothermic	✓	
Thermal decomposition	✓	
Thermal cracking		
Combustion		
Neutralisation		✓
Displacement		

(3 marks)

2.



(5 marks)

3. **a)** Copper is red-brown. *(1 mark)*
b) Copper(II) oxide is black. *(1 mark)*
c) Copper(II) carbonate is green. *(1 mark)*

4. **a)** Copper(II) carbonate is green.
b) Magnesium oxide is white.
c) Hydrated copper(II) sulfate is blue.
d) Anhydrous copper(II) sulfate is white. *(2 marks)*

5. Copper oxide/copper(II) oxide. *(2 marks)*

6. **a)** Thermal decomposition means to break down a compound using heat. *(2 marks)*
b) $CaCO_3 \rightarrow CaO + CO_2$ *(2 marks)*
c) Endothermic means to take in heat from the surroundings. *(2 marks)*

7. The energy required to break the bonds in the silicon dioxide and the carbon is less than the energy released when the bonds in the silicon and the carbon dioxide are made. *(5 marks)*

8. a) Haematite/magnetite. *(1 mark)*

b) Thermal decomposition. *(2 marks)*

c) $CaCO_3 \rightarrow CaO + CO_2$ *(2 marks)*

d) Limestone is added to remove the main impurity in the iron ore, sand. *(1 mark)*

e) Carbon dioxide is one of the greenhouse gases. As the amount of carbon dioxide in the atmosphere increases the temperature of the earth increases causing (any one of): the polar ice caps to melt; sea levels to rise; flooding in low lying or costal regions; changes in the temperature of (the atmosphere close to) the earth causing a change in weather patterns; which will affect the growth of crops which will lead to food shortages; habitats will change causing certain plants and animals to struggle for survival. *(1 mark)*

9. a) Combustion is the reaction of a fuel with oxygen to form oxides and release energy. *(3 marks)*

b) A clean fuel does not produce any toxic combustion products. When hydrogen burns it produces only water which is not toxic. *(1 mark)*

c) The energy required to break the bonds in the hydrogen and oxygen is less than the energy released when the bonds are made in water. *(5 marks)*

10. a) Thermal decomposition is the breakdown of a compound using heat. *(2 marks)*

b) $CaCO_3 \rightarrow CaO + CO_2$ *(2 marks)*

c) Calcium oxide is composed of oppositely charged ions held together by strong electrostatic forces. These forces take a lot of energy to break. *(2 marks)*

11. The energy required to break the bonds in the hydrogen and oxygen is less than the energy released when the bonds are made in water. *(4 marks)*

12. The energy required to break the bonds in methane and oxygen is less than the energy released when the bonds are made in water and carbon dioxide. *(6 marks)*