INTRODUCTION TO A LEVEL CHEMISTRY

This booklet of questions is for all prospective A level Chemistry students to complete, ahead of September.

The questions are about structures and bonding, along with some essential calculation skills.

Please complete this work and return to Mrs Coyne or Mrs Parker at the start of the new term in September

Useful websites:

https://www.bbc.co.uk/bitesize/examspecs/z8xtmnb

Q1.

This question is about structure and properties.

(a) Which pair of substances **both** contain atoms in hexagonal rings?

Tick (✓) **one** box.

Diamond and graphite ☐

Fullerenes and graphene ☐

Nanotubes and silica ☐

(1)

(b) Explain why the structure of copper allows the conduction of thermal energy.

___

___

___

___

___

___

(3)

(c) Explain why copper oxide (CuO) has a high melting point.

___

___

___

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___

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(3)

(d) Explain why water (H_2O) has a low melting point.

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(3)
(Total 10 marks)

Q2.

This question is about fluorine.

(a) Calcium reacts with fluorine to produce calcium fluoride (CaF_2).

Explain how oxidation and reduction have taken place in this reaction.

Write about electron transfer in your answer.

(4)

(b) Explain why calcium fluoride has a high melting point.

(4)

(c) Fluorine reacts with sulfur to produce sulfur hexafluoride (SF_6).

$$S + 3F_2 \rightarrow SF_6$$

Relative formula masses, M_r: $F_2 = 38$ $SF_6 = 146$

Calculate the mass of sulfur hexafluoride produced when 0.950 g of fluorine is reacted with an excess of sulfur.

Give your answer to 3 significant figures.

Mass = ____________________ g

(5)

(Total 13 marks)

Q3.

This question is about magnesium and magnesium chloride.

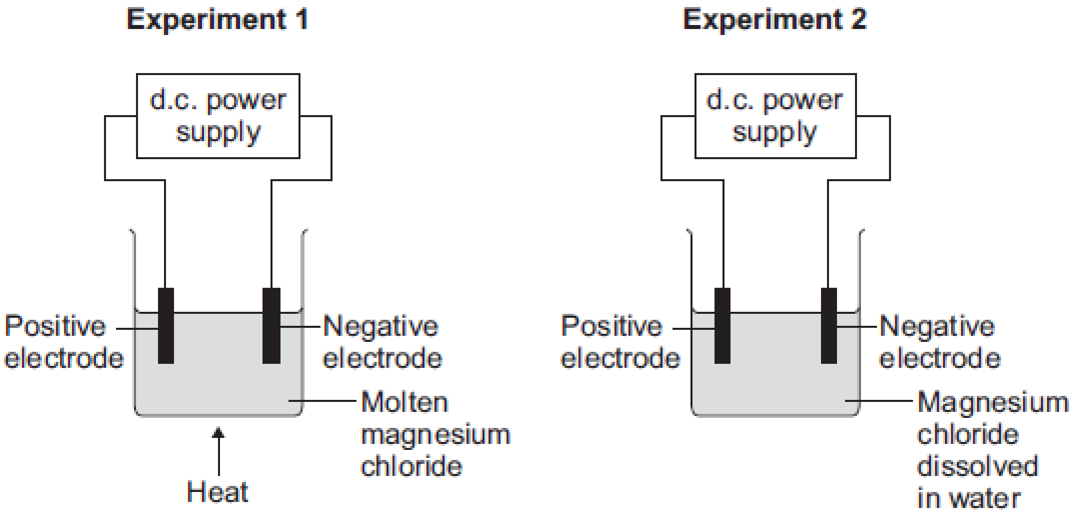
(a) Magnesium chloride contains magnesium ions (Mg^{2+}) and chloride ions (Cl^-).

Describe, in terms of electrons, what happens when a magnesium atom reacts with chlorine atoms to produce magnesium chloride.

(4)

(b) Magnesium chloride can be electrolysed.

The diagram below shows two experiments for electrolysing magnesium chloride.



(i) Explain why magnesium chloride must be molten or dissolved in water to be electrolysed.

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____

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(2)

(ii) Explain how magnesium is produced at the negative electrode in **Experiment 1**.

____

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(3)

(iii) In **Experiment 2** a gas is produced at the negative electrode.
Name the gas produced at the negative electrode.

____

(1)

(iv) Suggest why magnesium is **not** produced at the negative electrode in **Experiment 2**.

____

(1)

(v) Complete and balance the half equation for the reaction at the positive electrode.

$$\_\_\_\_\_ Cl^- \longrightarrow Cl_2 + \_\_\_\_\_$$

(1)

(c) Magnesium is a metal.

Explain why metals can be bent and shaped.

(2)

(Total 14 marks)

Q4.

This question is about sodium chloride and iodine.

(a) Describe the structure and bonding in sodium chloride.

(4)

(b) When sodium chloride solution is electrolysed, one product is chlorine.

Name the **two** other products from the electrolysis of sodium chloride solution.

(2)

(c) Many people do not have enough iodine in their diet.

Sodium chloride is added to many types of food. Some scientists recommend that sodium chloride should have a compound of iodine added.

Give **one** ethical reason why a compound of iodine should **not** be added to sodium chloride used in food.

____

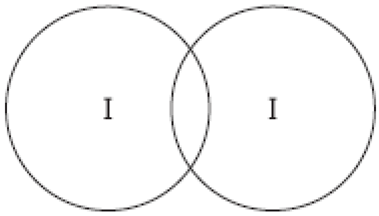
____

(1)

(d) The bonding in iodine is similar to the bonding in chlorine.

(i) Complete the diagram below to show the bonding in iodine.

Show the outer electrons only.



(2)

(ii) Explain why iodine has a low melting point.

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____

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(3)

(iii) Explain, in terms of particles, why liquid iodine does not conduct electricity.

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____

____

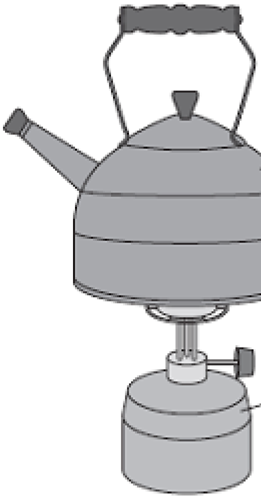
(2)
(Total 14 marks)

Q5.

The picture shows a copper kettle being heated on a camping stove.

Copper is a good material for making a kettle because:

- it has a high melting point
- it is a very good conductor of heat.



(a) Explain why copper, like many other metals, has a high melting point.

Your answer should describe the structure and bonding of a metal.

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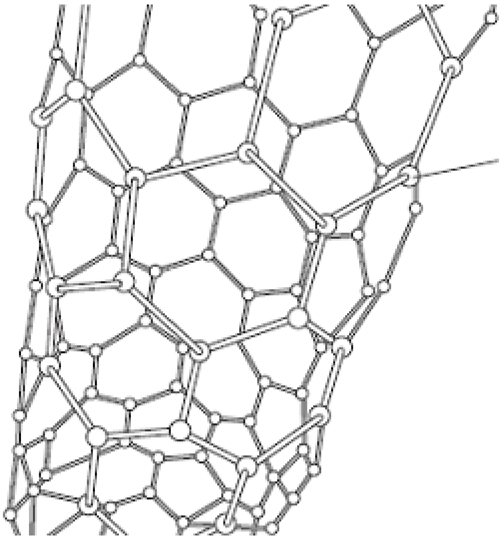
(4)

(b) Aeroplanes contain many miles of electrical wiring made from copper. This adds to the mass of the aeroplane.

It has been suggested that the electrical wiring made from copper could be replaced by carbon nanotubes which are less dense than copper.

The diagram shows the structure of a carbon nanotube.



(i) What does the term ‘nano’ tell you about the carbon nanotubes?

___

___

(1)

(ii) Like graphite, each carbon atom in the carbon nanotube is joined to three other carbon atoms.

Explain why the carbon nanotube can conduct electricity.

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___

___

(2)
(Total 7 marks)

Q6.

Millions of years ago the Earth formed as a giant ball of molten rock. The outer surface cooled forming a thin, solid outer crust. Volcanic activity on the surface produced an atmosphere containing the compounds carbon dioxide, ammonia, methane and water vapour.

Describe the bonding in any **one** of these compounds. You must include electronic structures in your explanation.

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___

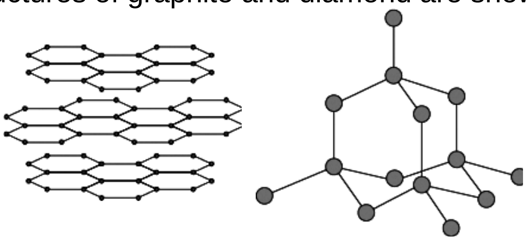
___

(Total 4 marks)

Q7.

Graphite and diamond are different forms of the element carbon.
Graphite and diamond have different properties.

The structures of graphite and diamond are shown below.



Graphite **Diamond**

(a) Graphite is softer than diamond.

Explain why.

(4)

(b) Graphite conducts electricity, but diamond does not.

Explain why.

(3)

(Total 7 marks)

Q8.

This question is about elements and compounds.

(a) shows a reactivity series.

Most reactive

Potassium

Magnesium

Metal **Y**

Carbon

Iron

Hydrogen

Copper

Least reactive

Give the method and conditions used to extract metal **Y** from a compound of metal **Y**.

(2)

Sodium reacts with titanium chloride ($TiCl_4$) to produce titanium.

(b) Complete the equation.

You should balance the equation.

$$\_\_\_Na + TiCl_4 \rightarrow \_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_$$

(2)

(c) The reaction between sodium and titanium chloride is a redox reaction.

Write a half-equation to show that sodium is oxidised in this reaction.

____

(2)

(d) 108 g of aluminum reacts with 1.21 kg of copper chloride to produce copper.

The equation for the reaction is:

$$2\ Al + 3\ CuCl_2 \rightarrow 3\ Cu + 2\ AlCl_3$$

Calculate the maximum mass of copper produced in grams (g).

You should determine the limiting reactant.

Relative atomic masses (A_r): Al = 27   Cu = 63.5

Relative formula masses (M_r): $CuCl_2$ = 134.5 $AlCl_3$ = 133.5

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____

Limiting reactant is ______________________

Mass of copper = ____________________ g

(6)

Sodium metal and sodium chloride are both able to conduct electricity.

(e) Describe how sodium metal conducts electricity.

____

____

____

(2)

(f) Explain how sodium chloride can conduct electricity.

(3)

(Total 17 marks)

Q9.

Silicon is an important element used in the electronics industry.

(a) Silicon can be made by heating a mixture of sand (silicon dioxide) with magnesium powder.

The equation for this reaction is shown below.

$$SiO_2 \text{ (s)} + 2Mg \text{ (s)} \rightarrow 2MgO \text{ (s)} + Si \text{ (s)}$$

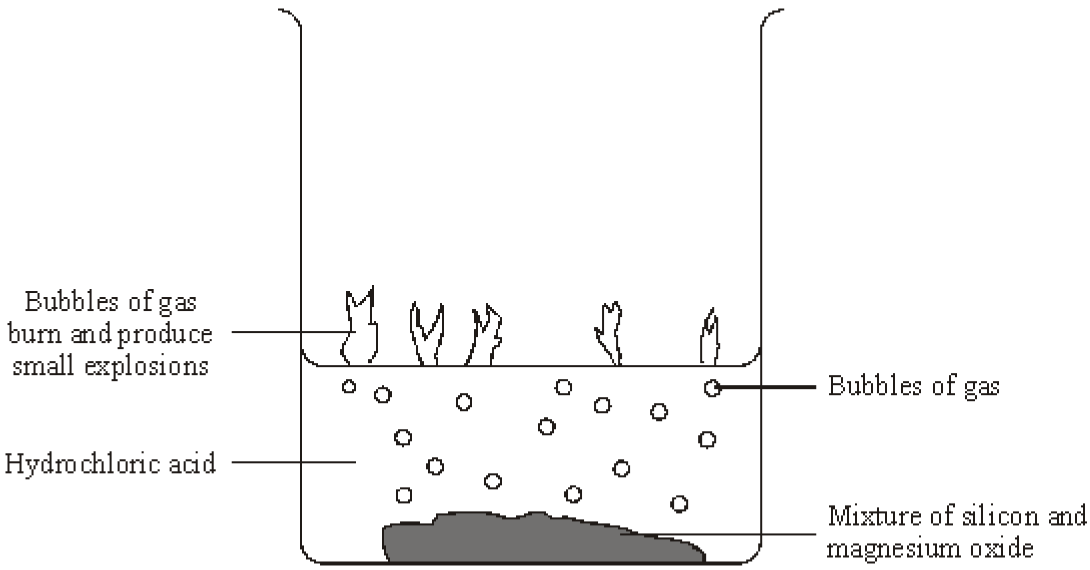
Calculate the mass of silicon dioxide needed to make 1 g of silicon.

Relative atomic masses: O = 16; Si = 28

Mass = ______________________________g

(3)

(b) The resulting mixture of magnesium oxide and silicon is added to a beaker containing hydrochloric acid. The silicon is then filtered from the solution.



(i) The magnesium oxide reacts with the hydrochloric acid and forms magnesium chloride ($MgCl_2$) solution and water.

magnesium oxide + hydrochloric acid → magnesium chloride solution + water

Write a balanced symbol equation for this reaction, including state symbols.

____

(2)

(ii) The gases produced are a mixture of several silicon hydrides.

One of the gases produced in the reaction is the silicon hydride with the formula SiH_4. The structure of this molecule is similar to methane, CH_4.

Draw a diagram to show the bonding in a molecule of SiH_4. Represent the electrons as dots and crosses and only show the outer shell (energy level) electrons.

(1)

(iii) A sample of a different silicon hydride was found to contain 1.4 g of silicon and 0.15 g of hydrogen.

Calculate the formula of this silicon hydride. You must show all your working to gain full marks.

Relative atomic masses: H = 1; Si = 28

(4)

(iv) The silicon hydrides react immediately they come into contact with oxygen in the air. They burst into flames with a small explosion and give out energy.

Which letter, **A** to **H**, best describes this reaction?

Energy involved in breaking and forming bonds	Activation energy	Rate of reaction	Letter
The energy released from forming new bonds is greater than the energy needed to break existing bonds	high	fast	**A**
		slow	**B**
	low	fast	**C**
		slow	**D**
The energy needed to break existing bonds is greater than the energy released from forming new bonds	high	fast	**E**
		slow	**F**
	low	fast	**G**
		slow	**H**

Letter ___________

(1)

(c) The structure of silicon is similar to the structure of diamond.

Describe the structure of silicon and explain why it has a high melting point. You may draw a diagram if this helps.

(4)

(Total 15 marks)

Q10.

Aqamed is a medicine for children.

(a) The medicine is a formulation.

What is meant by a formulation?

(1)

(b) Children often do not like taking medicine.

Suggest a substance that could be added to Aqamed to increase the desire for children to take it.

Give a reason for your suggestion.

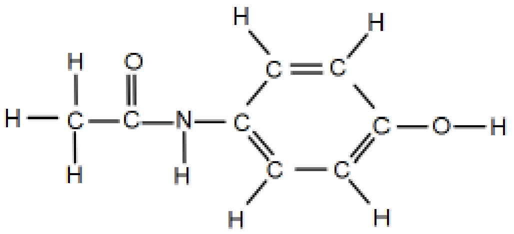
Substance

Reason

(2)

(c) The main ingredient in Aqamed is a painkiller called paracetamol.

The figure below represents a molecule of paracetamol.



Give the molecular formula of paracetamol.

Calculate its relative formula mass (M_r).

Relative atomic masses (A_r): H = 1; C = 12; N = 14; O = 16

Molecular formula

Relative formula mass

M_r = ________________________________

(2)

(d) Aspirin is a medicine for use by adults.

An aspirin tablet contains 300 mg of acetylsalicylic acid.

Calculate the number of moles of acetylsalicylic acid in one aspirin tablet.

Give your answer in standard form to three significant figures.

Relative formula mass (M_r) of aspirin = 180

____

____

____

____

____

____

Number of moles = ________________________

(4)

(Total 9 marks)

Q11.

This question is about oxygen (O_2) and sulfur dioxide (SO_2).

(a) Give the test and result for oxygen gas.

Test ____

Result ____

(2)

(b) The reaction between oxygen and sulfur dioxide is at equilibrium.

$$O_2(g) + 2\ SO_2(g) \rightleftharpoons 2\ SO_3(g)$$

Some of the sulfur trioxide (SO_3) is removed.

Explain what happens to the position of the equilibrium.

____

____

____

____

(2)

(c) Sulfur dioxide is an atmospheric pollutant.

Sulfur dioxide pollution is reduced by reacting calcium oxide with sulfur dioxide to produce calcium sulfite.

$$CaO + SO_2 \longrightarrow CaSO_3$$

7.00 g of calcium oxide reacts with an excess of sulfur dioxide.

Relative atomic masses (A_r): O = 16 S = 32 Ca = 40

Calculate the mass of calcium sulfite produced.

____

____

____

____

____

____

____

____

Mass of calcium sulfite produced = ____________________ g

(4)

(Total 8 marks)

Q12.

Fertilisers are formulations.

(a) What is a formulation?

____

____

(1)

(b) A bag of fertiliser contains 14.52 kg of ammonium nitrate (NH_4NO_3).

Relative formula mass (M_r): NH_4NO_3 = 80

Calculate the number of moles of ammonium nitrate in the bag of fertiliser.

Give your answer in standard form to 2 significant figures.

____

____

____

____

Moles of ammonium nitrate = _______________________ mol

(4)

(c) The fertiliser also contains potassium chloride.

Explain why potassium chloride has a high melting point.

(4)

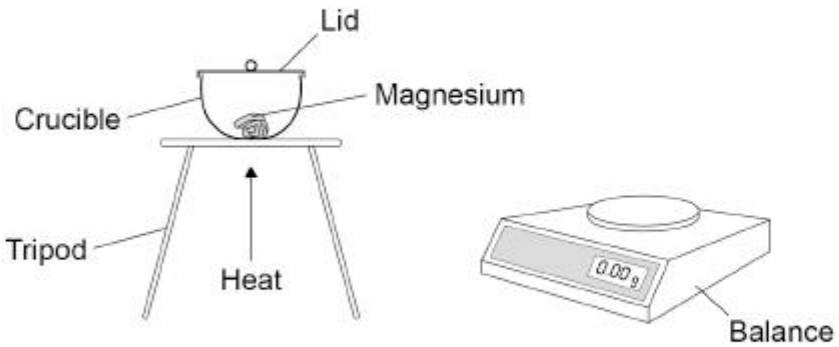
(Total 9 marks)

Q13.

Metal oxides are produced when metals are heated in air.

A student investigated the change in mass when 0.12 g of magnesium was heated in air.

The figure below shows the apparatus.



The student measured the mass of magnesium oxide produced.

(a) 0.12 g of magnesium reacted to produce 0.20 g of magnesium oxide.

Calculate the number of moles of oxygen gas (O_2) that reacted.

Relative atomic mass (A_r): O = 16

Moles of oxygen gas = ________________

(3)

(b) The student repeated the experiment **without** a lid on the crucible.

Suggest why the mass of magnesium oxide produced would be different without a lid on the crucible.

(2)

(c) Copper reacts with oxygen to produce copper oxide.

63.5 g of copper produces 79.5 g of copper oxide.

Calculate the mass of copper oxide produced when 0.50 g of copper reacts with oxygen.

Give your answer to 3 significant figures.

Mass (3 significant figures) = ___________ g

(3)

(d) Iron reacts with oxygen to produce an oxide of iron.

0.015 moles of iron reacts with 0.010 moles of oxygen gas (O_2).

Determine:

- the formula of the iron oxide produced
- the balanced symbol equation for the reaction.

Formula of iron oxide = ________________

Balanced symbol equation

(4)
(Total 12 marks)

Mark schemes

Q1.

(a) fullerenes and graphene

1

(b) delocalised electrons

1

(which) move through the structure

1

(and) transfer energy

1

(c) strong (electrostatic) forces of attraction

1

(between the) oppositely charged ions

1

(so) large amounts of energy needed to break the many / strong bonds / forces

allow (so) large amounts of energy needed to break the bonds / forces in all directions

allow (so) large amounts of energy needed to break the bonds in the lattice

1

(d) small molecules

allow simple molecules

1

(with) weak forces between the molecules
or
(with) weak intermolecular forces

allow (with) weak intermolecular bonds

*do **not** accept incorrect references to covalent bonds*

1

(so) little energy required to overcome / break the forces between molecules
or
(so) little energy required to overcome / break the intermolecular forces

allow (so) little energy required to separate the molecules

allow (so) little energy required to overcome / break the intermolecular bonds

ignore less energy

1

[10]

Q2.

(a)

Level 2: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	3-4
Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1-2
No relevant content	0
Indicative content Ca / calcium (atom) loses two electrons / both outer electrons and is oxidised to Ca^{2+} ion F / fluorine (atom) gain one / an electron and is reduced to F^{-} ion **supporting points** • fluorine / F (atoms) gain electron(s) • negative ion produced • calcium (atoms) lose electron(s) • positive ion produced • reduction is gain of electrons • oxidation is loss of electrons	

4

(b) (because there are) strong electrostatic forces of attraction
or
ionic bonding

1

between Ca^{2+} and F^{-} ions / oppositely charged ions

1

(in a) giant structure / lattice

1

so a lot of energy is needed to overcome / break this attraction

1

(c) amount of F_2 = $\frac{0.95}{38}$ = 0.025 moles

mark is for ÷ 38

1

amount of SF_6 = $\frac{1}{3}$ × 0.25 = 0.008333 moles

mark is for ×1/3

1

mass of SF_6 = 0.008333 × 146

mark is for ×146 1

mass = 1.2166666 1

mass = 1.22 (g) 3 sig figs 1

[13]

Q3.

(a) magnesium loses two electrons **and** chlorine gains one electron

accept magnesium loses electrons ***and*** *chlorine gains electrons for 1 mark*

ignore oxidation and reduction

2

one magnesium and two chlorines

accept $MgCl_2$

1

noble gas structure

or

eight electrons in the outer shell

accept full outer shell (of electrons)

or

(electrostatic) attraction between ions

or

forms ionic bonds

do ***not*** *accept covalent bonds*

1

reference to incorrect particles ***or*** *incorrect bonding* ***or*** *incorrect structure =* ***max 3***

(b) (i) because ions can move

ignore ions attracted

do ***not*** *accept molecules / atoms moving*

do ***not*** *accept incorrect reference to electrons moving*

1

(and ions move) to the electrodes

or

(and ions) carry charge

1

accept converse for solid

(ii) magnesium (ions) attracted (to the electrode)

1

so magnesium ions gain electrons

accept magnesium ions are reduced

ignore oxidised

1

2 electrons

*accept a correct half equation for 2nd **and** 3rd marking points*

1

(iii) hydrogen

allow H_2

1

(iv) magnesium is more reactive than hydrogen

accept converse

*allow magnesium is high in the reactivity series **or** magnesium is very/too reactive.*

*do **not** accept magnesium ions are more reactive than hydrogen ions*

1

(v) $\mathbf{2}\ Cl^- \rightarrow Cl_2 + \mathbf{2e^-}$

must be completely correct

1

(c) layers (of particles/atoms/ions)

1

(particles/atoms/ions/layers) can slide

1

*any mention of intermolecular / weak bonds/forces = **max 1***

[14]

Q4.

(a) lattice / giant structure

*max **3** if incorrect structure or bonding or particles*

1

ionic **or** (contains) ions

1

Na^+ **and** Cl^-

accept in words or dot and cross diagram: must include type and magnitude of charge for each ion

1

electrostatic attraction

allow attraction between opposite charges

1

(b) hydrogen

allow H_2

1

sodium hydroxide

allow NaOH

1

(c) any **one** from, eg:
- people should have the right to choose
- insufficient evidence of effect on individuals
- individuals may need different amounts.

allow too much could be harmful

ignore religious reasons

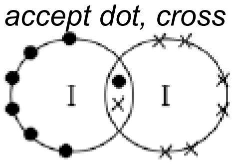
ignore cost

ignore reference to allergies

1

(d) (i) one bonding pair of electrons

accept dot, cross or e or − or any combination, eg



1

6 unbonded electrons on each atom

1

(ii) simple molecules

*max **2** if incorrect structure or bonding or particles*

accept small molecules

accept simple / small molecular structure

1

with intermolecular forces

accept forces between molecules

must be no contradictory particles

1

which are weak **or** which require little energy to overcome − must be linked to second marking point

reference to weak covalent bonds negates second and third marking points

1

(iii) iodine has no delocalised / free / mobile electrons or ions

1

so cannot carry charge

*if no mark awarded iodine molecules have no charge gains **1** mark*

1

[14]

Q5.

(a) *reference to incorrect bonding **or** incorrect structure **or** incorrect particles = max **3***

giant structure / lattice

ignore many bonds

1

made up of <u>positive</u> ions surrounded by delocalized / free electrons

allow <u>positive</u> ions surrounded by a sea of electons

1

with strong bonds / attractions

allow hard to break for strong

1

so a lot of energy is needed to break these bonds / attractions / forces

ignore high temperature

ignore heat

1

(b) (i) that they are <u>very</u> small

or

1-100 nanometres **or** a few(hundred) atoms

accept tiny / really small / a <u>lot</u> smaller / any indication of very small eg. microscopic, smaller than the eye can see

ignore incorrect numerical values if very small is given

1

(ii) delocalised / free electrons

allow sea of electrons

1

one <u>non-bonded</u> electron from each atom

accept electron(s) <u>moving through the structure / nanotube</u>

allow electron(s) carry / form / pass current / charge

1

[7]

Q6.

answers apply to:

accept diagrams and/or descriptions

carbon dioxide CO_2

ammonia NH_3

methane CH_4

water H_2O

*outer electronic structure of one atom correct **or** needs correct number of electrons to complete outer shell

1

*outer electronic structure of other atom correct **or** needs correct number of electrons to complete outer shell

1

*one shared **pair** of electrons (as one covalent bond) *use of ions or reference to ionic bonding negates this mark*

1

*outer electronic structure of compound correct **or** each atom now has a full outer shell/noble gas electron structure

1

[4]

Q7.

(a) **Graphite:**

because the layers (of carbon atoms) in graphite can move / slide

it = graphite

1

this is because there are only weak intermolecular forces **or** weak forces between layers

accept Van der Waals' forces allow no <u>*covalent*</u> *bonds between layers*

1

Diamond:

however, in diamond, each carbon atom is (strongly / covalently) bonded to 4 others

allow diamond has three dimensional / tetrahedral structure

1

so no carbon / atoms able to move / slide

allow so no layers to slide ***or*** *so diamond is rigid*

1

(b) because graphite has delocalised electrons / sea of electrons

allow free / mobile / roaming electrons

1

which can carry charge / current **or** move <u>through the structure</u>

1

however, diamond has no delocalised electrons

accept however, diamond has all (outer) electrons used in bonding

1

[7]

Q8.

(a) electrolysis

1

of molten compound (of metal **Y**)

allow liquid for molten

1

OR

displacement (1)

by heating with a more reactive metal
or
by heating with potassium / magnesium (1)

(b) 4 Na + $TiCl_4$ → 4 NaCl + Ti

allow multiples

*allow **1** mark for NaCl **and** Ti with incorrect / no balancing*

2

(c) Na → Na^+ + e^-

allow multiples

*allow **1** mark for Na → Na^+ + e^- with incorrect balancing*

2

ignore state symbols

(d) **method 1:**

(moles of Al = $\frac{108}{27}$ =) 4

1

(moles $CuCl_2$ = $\frac{1210}{134.5}$ =)
8.996

allow 9

1

(identifying limiting reagent)
4 moles Al gives 6 moles Cu
8.996 moles $CuCl_2$ gives
8.996 moles Cu

allow correct use of an incorrectly calculated value(s) for moles of Al and / or $CuCl_2$

1

therefore aluminium is the limiting reagent

<u>must</u> follow on from MP3

1

(mass of Cu = 2 × 3 × 63.5)
= 6 × 63.5

1

= 381 (g)

1

method 2:

2 Al + 3 $CuCl_2$ → 3 Cu + 2 $AlCl_3$

(2 × 27) (3 × 134.5) (3 × 63.5)

54 (g) 403.5 (g) 190.5 (g)
(1) (1) (1)

(so)

108 g Al (reacts with 807 g $CuCl_2$) to produce 381 g Cu (1)

allow correct use of an incorrect calculation of mass for Al / $CuCl_2$ / Cu

(so) there is excess $CuCl_2$

or

807 g $CuCl_2$ is less than 1210 g $CuCl_2$(1)

therefore aluminium is limiting reactant (1)

<u>must</u> follow on from MP4 / MP5

method 3:

134.5 g $CuCl_2$ produces 63.5 g Cu (1)

(mass conversion 1.21 kg $CuCl_2$ =) 1210 (g) (1)

1210 g $CuCl_2$ produces ($\frac{63.5}{134.5}$ × 1210 =) 571 g Cu (1)

allow correct use of an incorrect / no conversion of mass of $CuCl_2$

54 g Al produces 190.5 g Cu (1)

108 g Al produces ($\frac{190.5}{54}$ × 108 =) 381 (g) (1)
(therefore) aluminium is the limiting reactant (1)

<u>must</u> follow on from MP3 and MP5

(e) delocalised electrons

allow free electrons

1

carry (electrical) charge through the metal / sodium

ignore throughout for through

ignore current / electricity

MP2 is dependent upon MP1

1

(f) (conducts electricity) when liquid / molten
or
(conducts electricity) in (aqueous) solution

allow (conducts electricity) when dissolved in water

1

(because) <u>ions</u>

1

(ions) are free to move
or
(ions) allow charge to flow

1

[17]

Q9.

(a) M_r (SiO_2) = 60

if M_r incorrect ecf for max 2

1

60 g SiO_2 → 28 g Si

*correct answer for **3** marks*

1

2.14 g SiO_2 → 1 g Si

allow 2, 2.1, 2.14 (or anything rounding to 2.14), 2.16 or 2.2

a unit is not required but an incorrect unit loses the third mark

OR M_r (SiO_2) = 60 (1)

moles if silicon needed = $\frac{1}{28}$ = 0.0357

mass of SiO_2 needed = 0.0357 × 60 (1)

= 2.14 g (1)

allow 2, 2.1, 2.14 (or anything rounding to 2.14), 2.16 or 2.2

OR M_r (SiO_2) = 60 (1)

mass SiO_2 = 1 × $\left(\frac{60}{28}\right)$ (1)

= 2.14 g (1)

allow 2, 2.1, 2.4 (or anything rounding to 2.14), 2.16 or 2.2

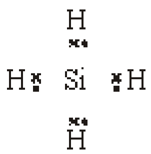
3

(b) (i) $MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$

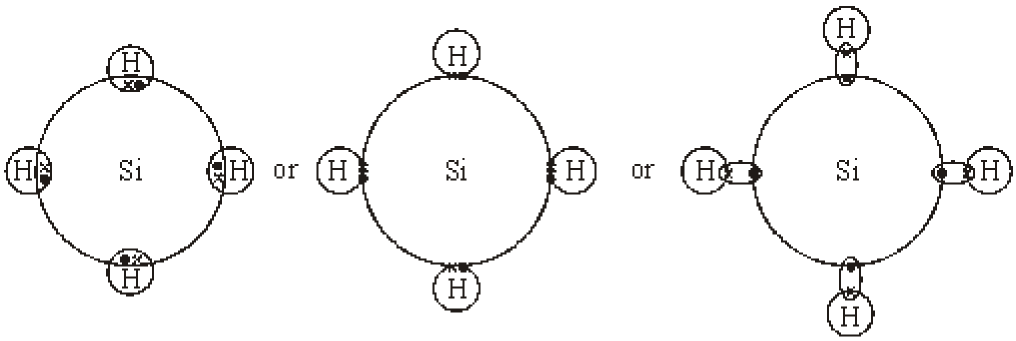
*penalise incorrect symbols correctly balanced equation for **1** mark state symbols for **1** mark*

allow correct multiples / fractions

2

(ii) 

or



ignore inner shell electrons of silicon
allow correct drawings without symbols
must clearly indicate four shared pairs of electrons with one electron from each atom

(iii) **Si** **H**

$\frac{1.4}{28}$ $\frac{0.15}{1}$

1

= 0.05 = 0.15

1

1 3

for whole number ratio can be implied

1

Si H_3

accept H_3 Si ***or*** *any correct formula with 1:3 ratio*
if in step 1 they get either of ratios incorrect they lose first 2 marks but can be ecf for 3rd and 4th mark
evidence of mass / A_r ***1*** *mark*
proportions of each ***1*** *mark*
whole number ratio ***1*** *mark*
correct formula ***1*** *mark*

1

(iv) **C**

accept c

1

(c) any **four** from:

- giant structure / macromolecule / lattice / giant molecule
  allow giant molecular / giant atomic structure
- each silicon atom joined to four other atoms
  (or diagram)
- covalent bonds
- bonds are strong **or** large amount of energy needed to break bonds
  accept hard to break bonds
- large number of bonds to be broken

*mention of giant **ionic** structure **or** intermolecular forces **or** intermolecular bonds max **1** mark*

*diamond **or** carbon discussion max **3** marks unless clearly linked to silicon*

4

[15]

Q10.

(a) (medicine is) a mixture **and**

(designed as) a useful product

1

(b) sugar / flavouring

1

to make it taste better

or

colouring

to make it look more attractive

1

(c) $C_8H_9NO_2$

any order of elements

1

151

1

(d) mass of acetylsalicylic acid = 0.3 g

1

$= \frac{0.3}{100}$ (mol)

method mark – divide mass by M_r

1

= 0.00167 (mol)

allow 0.0016666(66)

1

1.67×10^{-3} (mol)

*correct answer with or without working scores **4** marks*

allow ecf from steps1, 2 and 3

1

[9]

Q11.

(a) glowing splint

1

relights

1

(b) equilibrium shifts to right-hand side

allow towards the products

allow in favour of the forward reaction

1

(because) concentration of SO_3 decreases

this marking point is dependent on first marking point being awarded

allow pressure decreases

allow to increase the concentration of SO_3 allow to re-establish equilibrium

1

(c) (M_r CaO =) 56

1

(M_r $CaSO_3$ =) 120

1

$\frac{7}{56} \times 120$

1

= 15(.0 g)

*an answer of 15(.0 g) scores **4** marks*

in all approaches allow a correct calculation using an incorrectly calculated M_r

alternative approach A

(M_r CaO =) 56 (1)

$\frac{7}{56}$ = 0.125 (moles) (1)

(mass $CaSO_3$ =) 0.125 × 120 (1)

= 15(.0 g) (1)

1

alternative approach B

M_r CaO =) 56 (1)

$\frac{56}{7}$ = 8 (factor) (1)

M_r $CaSO_3$ =) 120 (1)

$\frac{120}{8}$ = 15(.0 g) (1)

alternative approach C

M_r CaO =) 56 (1)

M_r $CaSO_3$ =) 120 (1)

$\frac{120}{56}$ = 2.14235714 (factor) (1)

2.14235714 × 7 = 15(.0 g) (1)

[8]

Q12.

(a) a mixture designed as a useful product

1

(b) mass = 14 520 g

1

$(=) \frac{14520}{80} \text{ (mol)}$

allow correct substitution of incorrectly converted mass
must use M_r given (80) to gain marks in steps 2 and 3

1

(=) 181.5 (mol)

1

(=) 1.8×10^2 (mol)

allow answer correctly given in standard form to correct sig figs from an incorrect calculation

1

*an answer of 1.8×10^2 (mol) gains **4** marks*

(c) (giant) lattice

allow giant structure

1

ionic

1

strong bonds **or** strong electrostatic forces

*do **not** accept strong intermolecular forces / bonds*

1

large amounts of energy needed to overcome

ignore heat

1

***max 2 marks** for incorrect reference to bonding **or** structure **or** particles*

[9]

Q13.

(a) (mass of oxygen = 0.20 – 0.12) = 0.08 (g)

1

(moles of oxygen) = $\frac{0.08}{32}$

1

= 0.0025

*allow **1** mark for 0.005*

if derived from $\frac{0.08}{16}$

1

(b) (without a lid the) mass of magnesium oxide was less 1

(because) products escaped allow magnesium oxide escaped 1

(c) (mass of copper oxide =)

$\frac{79.5}{63.5} \times 0.5$ 1

= 0.62598 (g) 1

= 0.626 (g)

allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses all the values in the question 1

(d) 3:2 ratio Fe : O_2 (molecules)

or

3:4 ratio Fe : O (atoms) 1

(formula) Fe_3O_4

*allow **1** mark for Fe_3O_2 from 3:2 ratio Fe : O (atoms) (MP2 but not MP1)* 1

3 Fe + 2 O_2 $\rightarrow$ Fe_3O_4

allow multiples

allow correct use of incorrectly determined formula

*allow **1** mark for Fe, O_2 and Fe_3O_4*

or

*allow **1** mark for Fe, O_2 and incorrectly determined formula* 2

[12]

Examiner reports

Q1.

(a) 60% of students identified that fullerenes and graphene both contain atoms in hexagonal rings. Diamond / graphite was the most common distractor selected.

(b) In this question students were asked to explain why the structure of copper allows the conduction of thermal energy. Just under one half of students gained one mark for stating that delocalised electrons were responsible with approximately a quarter of these students then describing that these electrons move through the structure. The idea that these electrons transfer energy through the metal was infrequently recognised for the third marking point. Many answers confused the carrying of movement of electrical charge rather than thermal energy.

(c) This question proved to be a good discriminator but students found the question difficult. Students were asked to explain why copper oxide has a high melting point. There was a lot of confusion over types of bonding and forces, with students often contradicting themselves during their response. The majority of those who gained 1 mark usually scored MP3 for stating that large amounts of energy is needed to break the strong forces.

(d) Students had to describe why water has a low melting point. This question also proved to be a good discriminator. If a student refers to breaking the ‘forces’ or ‘bonds’ for then it must be clear they are referring to the intermolecular forces with no possible confusion that it is covalent bonds being broken. Students must explain that little energy is needed to break the bonds, less energy is insufficient. Nearly 40% of students gained at least 1 mark which was usually gained for stating that little energy is required to overcome the intermolecular forces. Few students described water as existing as small molecules which have weak intermolecular forces.

Q3.

(a) This question differentiated well, with the majority of students gaining two or more marks. The best responses were generally succinct and clearly expressed. The ratio of one Mg to two Cl (third marking point) was least frequently awarded. Although the direction of electron transfer was often correct, the number of electrons involved was less often correct. Some students used the terms “ions” and “atoms” interchangeably, limiting their response to a maximum of three marks. A minority of students gained only one mark, often for the final marking point, giving “full outer shell” or “ionic bond”.

Some students suggested that an electron became delocalised because magnesium needed to lose two electrons, but chlorine could only gain one.

Sharing of electrons was sometimes linked with a correct description of electron transfer. These students seemed to think that “sharing” meant to transfer, like sharing out sweets.

(b) (i) A minority of students knew that the movement of ions is necessary, and that this is why the magnesium chloride must be molten or in aqueous solution for electrolysis to take place. Fewer students indicated that the movement is directional (ie to the electrodes) or that the ions carry charge to gain the second marking point. Some students failed to specify a type of particle which should move, or gave an incorrect type of particle, suggesting that electrons, atoms elements or electrodes would move.

(ii) Some students clearly understood the processes involved, giving a succinct explanation, gaining all three marks. Most students accessed the first marking point, realising that magnesium is attracted to the negative electrode. Many of these students realised that two electrons were transferred, also gaining the third marking point. The second marking point was least often awarded as there was some confusion between the loss and gain of electrons.

(iii) Only a minority of students knew the gas produced to be hydrogen. Frequently seen incorrect responses included chlorine, oxygen, carbon dioxide and magnesium oxide or magnesium hydroxide.

(iv) Incorrect responses often focussed on whether the gas dissolved or whether heating was involved. Only a small number of students gained the mark.

(v) Only a small number of students gained credit. The most commonly seen errors included adding another element or compound into the equation, eg Mg, CO_2 or H_2O, but a small number of students made a valiant attempt and only omitted the charge on the electron, or made a small error in balancing.

(c) Many students realised that metals are formed of layers of atoms, but were then unable to describe the movement accurately. Some students listed the properties of metals or suggested that there are weak (intermolecular) forces or bonds between the layers.

Q4.

(a) Only a very small minority of students were able to fully describe the structure and bonding without introducing an incorrect term, the most common of which was intermolecular. A large number of students included a description of the losing and gaining of an electron, or included the properties of an ionic compound. Students should be sure to read questions carefully, and answer the question which has been set.
Many students included covalent bonding in their response. Some students attempted to include iodine in their descriptions.

(b) Most students were able to name one of the products of electrolysis of sodium chloride solution, usually hydrogen. Non-creditworthy products frequently seen included sodium, water and carbon dioxide. Sodium oxide was also commonly seen.

(c) Only a minority of students gained credit. Harmful was commonly given, but not accepted unless qualified to indicate that too much iodine can be harmful. A significant minority of students suggested that iodine should not be added because it is unnatural, even suggesting that it is unnatural because it is a chemical.

(d) (i) There were many correct responses, with about two thirds of students gaining both marks. Of those gaining 1 mark, most gave the bonding electron pair correctly, but gave an incorrect number of non-bonding electrons. Some gave 2 bonding pairs.

(ii) Despite some excellent responses, this question proved challenging to many students, many of whom confused the strong covalent bonds within an iodine molecule with the weak intermolecular forces between the molecules. Some students referred to the weak intermolecular forces, but omitted to mention that iodine has simple molecules. There were many references to the reactivity of iodine, and its electron structure, especially the strength of attraction of electrons to the nucleus. Reference to weak covalent bonds negates any mention of intermolecular forces.

(iii) Most students gained the first marking point by identifying that iodine has no ions or delocalised electrons. However, only a few gained the second marking point for the idea that the ions or delocalised electrons are needed to carry charge.
Some students referred to the iodine being liquid, and stated that the particles were too far apart to conduct, and particles have to be closer (as in a solid) to collide and conduct electricity. This was not creditworthy.

Q5.

(a) The bonding in metals was not well understood. About two thirds of students gained only one mark in this question, and about half of those gained a further mark. Few gained full credit. A number of students wrote about the layers in metals, relating these to flexibility, and many wrote about delocalised electrons, explaining that good conductivity of heat caused the high melting point.

Some students appeared to write down all they knew about metals, in the hope that some of it was relevant, and there were many references to incorrect bonding for example intermolecular or covalent bonding.

(b) (i) There were many correct responses. The few students who did not gain credit generally only indicated that the carbon nanotubes were small, rather than very small.

(ii) Students generally recognised that delocalised or free electrons are responsible for electrical conductivity in carbon nanotubes, with about half of the students gaining one of the two available marks. Some responses were not sufficiently clearly expressed to gain credit (for example “delocalised bonds”). Some students thought that the current could flow between the atoms because they were all joined together.

Q6.

A minority of candidates missed the point of this question and failed to describe detailed bonding of any of the compounds mentioned. It was rare to see a covalent bond described as a shared pair of electrons. Diagrammatic responses tended to score better than written descriptive answers. Only a few candidates gave a full account of rock recycling rather *than* the standard rock cycle with igneous, sedimentary and metamorphic rocks.

Q7.

(a) This question proved to be a good discriminator. The marking point relating to the intermolecular forces in graphite was gained by only the most able students, but that relating to layers sliding in graphite proved the most accessible. A small minority of students referred to incorrect bonding (eg intermolecular forces in diamond) or structure (simple molecular) in their answers. A small minority of the students also referred to crosslinking and thermosetting. Some students mistook softness for flexibility, referring to graphite being able to bend. Some students were content to explain why graphite was soft but then failed to go on to address why diamond was not soft, therefore not gaining the marks for that part of the mark scheme.

(b) Conductivity in graphite and diamond was well understood by many candidatesstudents, although some failed to refer to the delocalised electrons as charge or current carriers or as moving throughout the structure so did not gain the second marking point. A small minority of students were unable to relate conductivity to electron structure at all, and some referred to the need for graphite to be molten to conduct electricity.

Q8.

(a) Students had to recognise the relative position of a metal in a reactivity series and to deduce the method and conditions used to extract the metal from a compound of the metal. Over 50% of students gained 1 mark. Electrolysis was the most common answer. However, many students then went on to talk about electrolysis of a solution rather than the molten compound. The displacement route was less common and those who chose this method often only scored 1 mark as they failed to mention ‘heating’ when talking about potassium or magnesium.

(b) Students had to complete an equation for the displacement reaction between sodium and titanium chloride. Some students were not able to identify the products. Titanium was usually identified, but sodium chloride was often written as $NaCl_4$. Without the correct formulae balancing was not possible. Generally, element symbols were written well with upper and lower case letters in the appropriate place. Nearly 20% of students gained both marks.

(c) Students were asked to write the half equation to show the oxidation of sodium. This proved very challenging. Approximately 5% gained two marks with about a fifth of students not attempting the question. One mark was infrequently scored, since identifying the equation and not the balancing proved to be the problem.

(d) This reacting mass calculation where students had to identify the limiting reagent proved very challenging. Only a small percentage of students were able to show that aluminium was the limiting factor. Although there were several methods available to students, many attempted to use more than one method to get to the answer. Many students could work out the number of moles of aluminium and copper chloride or the ratio of masses that reacted together, but then were unable to use these numbers further. 30% of students scored 3 marks in this calculation but few scored any further marks..

(e) Students had to describe how sodium metal conducts electricity. More than 50% of students gained 1 mark for stating that delocalised electrons or free electrons were responsible for electrical conduction in metals. The idea that these delocalised electrons carry the charge through the metal was infrequently given (the second marking point). Many students suggested throughout or around, which did not give direction to their answer.

(f) Students had to explain how sodium chloride conducts electricity. Many students gave the impression that sodium chloride is a liquid or (to a lesser extent) aqueous solution, rather than conveying that conductivity is restricted to when sodium choride is in these states. Many incorrectly described the electrons as the particles that were able to move. 10% of students gained all 3 marks for stating that sodium chloride needed to be either molten or in aqueous solution in order to conduct electricity and went on to mention ions that are free to move.

Q9.

This question was a good discriminator.

(a) This proved an easy part for the majority of candidates. Those candidates who incorrectly calculated the relative formula mass of silicon dioxide usually managed to score two marks through consequential marking.

(b) (i) While most candidates gave a balanced equation, state symbols were usually omitted or incorrect when included. Hydrochloric acid was very frequently thought to be liquid (rather than aqueous) and water was written as '$H_2O(aq)$' or '$H_2O(g)$'. Hydrochloric acid written as HCL, Hcl or HcL received no credit. Hydrochloric acid was sometimes written as 'H_2SO_4' and magnesium chloride as 'MgCl'.

(ii) Most candidates correctly drew the bonding in silane, SiH_4. Some candidates included a lone pair of electrons on the silicon or an extra electron on each hydrogen, while others did not make it clear that both atoms contributed one electron to the shared pair.

(iii) This part was a good discriminator. The common error was to have the mole ratio inverted and this led to Si_3H with consequential marking.

(iv) This part was usually well answered, with **A** and **G** being the common distractors.

(c) The more able candidates knew what they had to say and produced some excellent answers, but many otherwise good answers were negated by mentioning 'intermolecular forces', 'molecular bonds' or 'ionic bonds'. Some candidates attempted to justify a graphite type layered structure with each atom joined to three other atoms, while others decided they would write about the *boiling* point (rather than the *melting* point). Candidates who just wrote about carbon (rather than silicon) atoms were penalised once. Candidates should talk about *strong bonds* rather than refer to a *strong structure*. Few candidates realised that the high melting point was partly because of the large number of bonds which need to be broken.

Q11.

(a) The correct test and result for oxygen gas was known by about 54% of students. Using a splint (not glowing) or a 'blown-out splint' to test for oxygen were the most frequently seen incorrect answers.

(b) Less than a quarter of students achieved credit on this question, with around 4% of students achieving both marks. Students were able to suggest a shift in the equilibrium but often in the wrong direction. Few of the students who correctly answered the directional shift were able to explain why. Many students simply suggested 'to counteract the change'.
The most common correct response was 'to re-establish equilibrium'.

(c) Over a quarter of students gained full marks and around 80% of students gained some credit for their calculation. The most common answers that gained either 1 or 2 marks were for correctly calculating the M_r for calcium oxide (56) and/or calcium sulfite (120). The highest-attaining students were able, through a variety of approaches, to successfully calculate the mass of $CaSO_3$ produced (15.0 g). Using a ratio approach was more popular than using moles as a method to arrive at the answer.

The most common mistake seen was to multiply the mass of CaO by the M_r of $CaSO_3$ ($7 \times 120 = 840$).

Q12.

(a) 22% of students knew the definition from the specification or were able to give an equivalent statement. Often students mentioned only that it was 'a mixture or chemicals mixed together' but omitted the idea of 'to form a useful product'. Some students were able to give examples, but not a definition.

As the question stem mentioned fertilisers, a few students answered the question with phrases such as a substance / something to help plants grow or to enhance plant growth.

(b) 5% of students achieved full marks but many students (63%) gained some credit for their calculation. The most common answers that achieved two marks were 0.18 or 0.1815, (not converting 14.52 kg to g and an omission or incorrect conversion of their calculation into standard form to two significant figures).

An answer of 1.8×10^{-1} achieved three marks, the calculation being correct, but the students had not undertaken the initial conversion of kg into g. Several students had multiplied an answer within their calculation by Avogadro's number.

(c) 51% of students achieved some credit on this question. However, there were many references to intermolecular forces (often strong intermolecular forces), covalent bonds and molecules, all of which limited the response to a maximum of two marks.

Many students described in detail how potassium, being in Group 1 of the periodic table would transfer one electron to chlorine which is in Group 7 to obtain full outer shells meaning that the compound would have a high melting point. 'Ionic bonds' was often seen but normally as part of a lengthy explanation of how and why potassium transfers one electron to chlorine.

1% of students achieved full marks, with 7% of students achieving three marks; the description of a 'lattice' or 'giant structure' was seldom seen.

Q13.

(a) Just over one-tenth of students gained full marks in this calculation. Having correctly calculated the mass of oxygen the most common error was to incorrectly calculate the number of moles by dividing by the relative atomic mass of oxygen (16) rather than the relative formula mass of oxygen molecules (32).

(b) Few students realised that without a lid the mass of products would decrease as magnesium oxide would escape during the reaction.

(c) This calculation was answered correctly by approximately one fifth of students. A small number were not able to round their answer correctly to three significant figures.

(d) Students found this question challenging. Very few students were able to make the link between the moles of reagents that reacted and the formula of the product. Just under one sixth of students were able to correctly write a balanced chemical equation using their iron oxide product from the earlier part of the question.