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# Examiners' Report

## June 2016

# GCSE Applied Science Chemistry
# 5CH2H 01

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# Introduction

As with the other units for GCSE Additional Science, this unit is externally assessed through a one-hour, 60-mark written paper consisting of six questions. The questions are designed to become progressively more challenging through each question and through the paper. As is standard practice, there were two 6-mark, levels based, free response questions towards the end of the paper.

Generally, candidates found the paper accessible, as evidenced by the few blank spaces reported by the examiners. The 6-mark question Q5b was more challenging than Q6d. Several candidates lost marks through the use of incorrect terms e.g. use of 'molecules' when answering on conductivity of metals, or how sodium forms ions.

Successful candidates:

- read the questions carefully and answered the questions as set
- used correct scientific terminology when writing about different types of particles
- could write balanced equations
- could carry out calculations, showing the working.

Less successful candidates:

- did not read the questions carefully and gave an answer that seemed to be answering another question
- rewrote the question probably to create thinking time, but this uses up valuable space for their answer
- think they have to use all the lines that were provided for the answer
- used the terms ions, atoms and molecules in the wrong places
- could not write balanced equations
- could not carry out calculations.

## *Question 1 (a) (i)*

Most candidates understood which group formed the noble gases and answered this correctly. However, some chose to look up element Z on the periodic table and gave their answer as Xe or as xenon. This translation from the letters on the table given as part of the question to elements on the periodic table was not required.

## *Question 1 (a) (ii)*

Most candidates understood the term 'period' with reference to the periodic table and gave the answer EGJ or TXZ, but more gave the answer TXZ. Again, some candidates chose to use the names or symbols of the elements – frequently getting T incorrect by calling it caesium rather than rubidium. The common error in this question was giving the combination ELT, i.e. a group rather than a period.

## *Question 1 (d)*

This question was about how metals conduct electricity. Although most candidates answered this well in terms of the delocalised electrons being able to move or to carry the current, a significant number did not state what happens to the electrons to cause the conduction of electricity. The most common misconceptions seen were:

- protons or positive ions or ions of both charges moving
- the electricity or the current was moving
- writing about 'particles' without identifying them
- writing instead about the conduction of heat by atoms vibrating.

(d) Element **Q** is a metal and a good conductor of electricity.

Explain how metals conduct electricity.

**(2)**

metals have small gaps between the particles that allow electricity through and traps some of it.

**ResultsPlus**
**Examiner Comments**

Not many, but a significant number of candidates did not know how metals conduct electricity.

**ResultsPlus**
**Examiner Tip**

Learn the idea of how metals conduct electricity.

(d) Element **Q** is a metal and a good conductor of electricity.

Explain how metals conduct electricity.

**(2)**

They have a regular structure of Cations surrounded by delocalised electrons which can carry a charge / current.

**ResultsPlus**
**Examiner Comments**

Many candidates could produce an answer of this quality. This scored 2 marks.

**ResultsPlus**
**Examiner Tip**

The marks here are for:

delocalised electrons (1)

which can carry a current (1)

## *Question 1 (e)*

The reason for the trend in reactivity in group 1 was well understood and it was very pleasing to see many high quality explanations at this level. Only a small number of candidates chose to explain why element E was less reactive than element T and reverse arguments were accepted. The idea of electron shell shielding was understood by the more able candidates, but a few were confused in their understanding by stating that as the outer electron was further from the nucleus, so the shielding was reduced.

Candidates do need to understand that there is only one outer shell. A significant number wrote that element T had 'more outer shells' and consequently lost that mark of the electron in T being further from the nucleus than in E.

It was noted in this question in particular by examiners that many candidates rewrote the question in some way and, although this might provide thinking time, it gains no credit and uses valuable answer lines. Answers such as 'because reactivity increases down the group' were just a rewrite of the question and so did not answer the actual question.

(e) Reactivity increases down group 1 of the periodic table.

Elements **E** and **T** are in group 1 of the periodic table.

Explain why element **T** is more reactive than element **E**.

**(2)**

Because element T is below element E it means that the atom get smaller so the electrons on the outer energy levels are more attracted so it is more reactive.

**ResultsPlus**
**Examiner Comments**

This candidate has misunderstood the ideas about why reactivity of the group 1 elements increases down the group and was unable to score as a result.

**ResultsPlus**
**Examiner Tip**

Practice past paper questions of this type. It will help you understand the ideas behind the science.

(e) Reactivity increases down group 1 of the periodic table.

Elements **E** and **T** are in group 1 of the periodic table.

Explain why element **T** is more reactive than element **E**.

**(2)**

Group 1 is alkali metals. The reactivity increases as you go down the group. As you go down the group there is an extra outer shell so the electrons are further away from the nucleus so its easier to react. As T is lower down its more reactive than E as has extra outer shells so easier to react.

**(Total for Question 1 = 8 marks)**

**ResultsPlus**
**Examiner Comments**

This is an example of where candidates are rewriting the question and gain no credit as a result. The examiner is only interested in the answer starting at line three. This is also an example where the candidate does not understand the term 'outer shell' but in essence the candidate does understand that as the number of electron shells increases so the outer electron shell is further from the nucleus.

**ResultsPlus**
**Examiner Tip**

All atoms only have one outer shell. They may have many completed inner shells, but the outer shell is the one that is furthest from the nucleus.

## *Question 2 (b) (iii)*

Although the majority of candidates scored full marks on the question, some only scored one mark by not stating how many electrons had to be lost from the sodium atom. The common errors were sharing electrons or mention of covalency 'gaining protons' (to achieve the positive charge).

(iii) Explain how a sodium atom, Na, becomes a sodium ion, $Na^+$.

**(2)**

Sodium loses two electrons, therefore gaining a +2 charge

**ResultsPlus**
**Examiner Comments**

This scored for losing electrons, but not for the number of electrons lost.

**ResultsPlus**
**Examiner Tip**

To form a metal ion, the number of electrons lost is the same as its periodic table group number.

To form a simple non-metal ion, the number of electrons gained is 8 minus its periodic table group number.

(iii) Explain how a sodium atom, Na, becomes a sodium ion, $Na^+$.

**(2)**

As when it reacts with a non-metal it gives away electrons, therefore looses electrons, so become a cation with a positive charge.

**ResultsPlus**
**Examiner Comments**

An example of where electrons were being lost, for which it scored one mark, but it did not indicate how many electrons were lost.

(iii) Explain how a sodium atom, Na, becomes a sodium ion, $Na^+$.

**(2)**

It becomes $Na^+$ when it bonds with another element which resulting in the sodium sharing it's only electron on its outer shell with the other element.

**ResultsPlus**
**Examiner Comments**

This scored 0 as a result of electron sharing.

## *Question 2 (c) (i)*

It would seem that many candidates had performed the filter, wash and dry procedure because it was often described particularly well. Where it hadn't been experienced, candidates wrote about fractional distillation (this seemed to come up in other places on the paper where separation was required, possibly the word separation itself being a trigger to this), chromatography and the use of a separating funnel. This was another question where candidates used valuable time describing the mixing process, effectively rewriting the stem.

(c) When sodium sulfate solution reacts with barium hydroxide solution, a white precipitate of barium sulfate forms in the mixture.

The barium sulphate precipitate can be separated from the mixture and purified.

(i) Describe how pure, dry barium sulfate can be obtained from the mixture.

**(2)**

The barium sulfate has to be filtered first to remove the other mixture, it then needs to be washed with distilled water, then dry out the pure barium sulphate in an oven at 50° to remove the water which removed and remaining impurities.

**ResultsPlus**
**Examiner Comments**

This was an ideal answer. The steps involved in producing the pure, dry barium sulfate are clear and detailed enough to score 2 marks.

**ResultsPlus**
**Examiner Tip**

To obtain a pure, dry insoluble salt:

filter, wash (with deionised water), dry (in a warm place).

(c) When sodium sulfate solution reacts with barium hydroxide solution, a white precipitate of barium sulfate forms in the mixture.

The barium sulphate precipitate can be separated from the mixture and purified.

(i) Describe how pure, dry barium sulfate can be obtained from the mixture.

**(2)**

After you mix the solutions together, you filter out the precipitate formed. You then wash it with distilled water and dry it with a paper towel.

**ResultsPlus**
**Examiner Comments**

The first line was not needed, but the rest of the question was an excellent answer that scored 2 marks.

## *Question 2 (c) (ii)*

The use of barium sulfate as a 'barium meal' has clearly been well understood by many candidates, with many candidates scoring full marks as a result. However, some candidates scored a mark for stating that the barium sulfate was insoluble, but did not score the second mark through an incorrect consequence such as low dosage or stomach acid neutralising it.

(ii) Before certain X-rays, patients are given a suspension of barium sulfate to drink.

Explain why this causes no harm to the patient, even though barium salts are toxic.

**(2)**

Because it doesn't get into the bloodstream and goes straight through the body.

**ResultsPlus**
**Examiner Comments**

This answer scored one mark for the barium sulfate not getting into the bloodstream. It missed the point about the salt being insoluble.

(ii) Before certain X-rays, patients are given a suspension of barium sulfate to drink.

Explain why this causes no harm to the patient, even though barium salts are toxic.

**(2)**

Because it's ~~an~~ insoluble so it can be absorbed in the bloodstream and cause toxic effects.

**ResultsPlus**
**Examiner Comments**

Unfortunately this only scored one mark through the use of 'can' instead of 'cannot' at the end of the first line.

## *Question 3 (a)*

The idea of exothermicity is well understood by candidates and they can write in detail explaining what would be seen in a reaction. However, this question was about the more challenging idea of endothermicity and it seemed there were almost as many suggesting the temperature would rise as suggested that it would fall. From the answers, it is clear that many of the candidates thought that taking in energy meant a rise in temperature. Many also described something about the appearance of the crystals dissolving, perhaps fizzing. One of the better reactions to use when teaching about energy changes in chemical reactions is the reaction between solid ammonium thiocyanate and solid barium hydroxide where a temperature reading drops below the scale on a standard -10 – 110 °C thermometer.

**3** (a) When ammonium nitrate dissolves in water, the change is endothermic.

In an experiment, a thermometer is placed in some water in a beaker and ammonium nitrate crystals are added.

State what you would **see** to show that the reaction is endothermic.

**(1)**

the products should have a higher amount of energy and it should be colder.

**ResultsPlus**
**Examiner Comments**

What has been written by the candidate is correct but it doesn't answer the question.

**ResultsPlus**
**Examiner Tip**

Where a question asks you to 'State what you would see ...', an observation is required.

**3** (a) When ammonium nitrate dissolves in water, the change is endothermic.

In an experiment, a thermometer is placed in some water in a beaker and ammonium nitrate crystals are added.

State what you would **see** to show that the reaction is endothermic.

**(1)**

on the thermometer
The temperature would increase as in endothermic reactions, heat is taken from surroundings

**ResultsPlus**
**Examiner Comments**

This highlights the misconception about endothermic reactions frequently seen by examiners.

**ResultsPlus**
**Examiner Tip**

Exothermic reactions release heat energy and the reaction mixture increases in temperature.

Endothermic reactions are the direct opposite:

Endothermic reactions take in heat energy and the reaction mixture decreases in temperature.

## *Question 3 (b)*

Some candidates were clearly well-prepared; giving a precise 'text-book' wording for the answer. However, the majority of candidates, as in the past, contradicted themselves by writing about energy being needed for both bond breaking and bond making, particularly so when it was not clear which part of the reaction they were referring to.

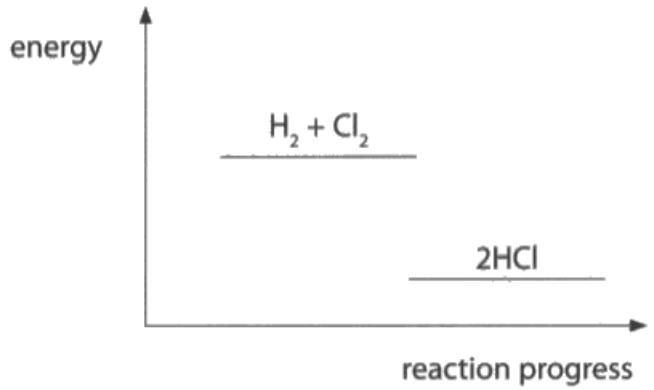
Another common misconception was that energy was released when bonds were broken.

It was hoped that the inclusion of the energy level diagram would prevent such contradictions, but it seemed that many candidates did not pay attention to the diagram.

(b) The reaction between hydrogen and chlorine to form hydrogen chloride is exothermic.

$$H_2 + Cl_2 \rightarrow 2HCl$$

The energy change taking place when the reactants, hydrogen and chlorine, form the product, hydrogen chloride, is shown in the diagram.




Explain, in terms of the breaking of bonds and the making of bonds, why this reaction is exothermic.

**(2)**

The reaction is exothermic because the covalent bonds between the hydrogen and chlorine break are being formed to create HCl.

**ResultsPlus**
**Examiner Comments**

There was no reference to the energy involved in forming the bonds in hydrogen chloride so this answer could not score a mark.

(b) The reaction between hydrogen and chlorine to form hydrogen chloride is exothermic.

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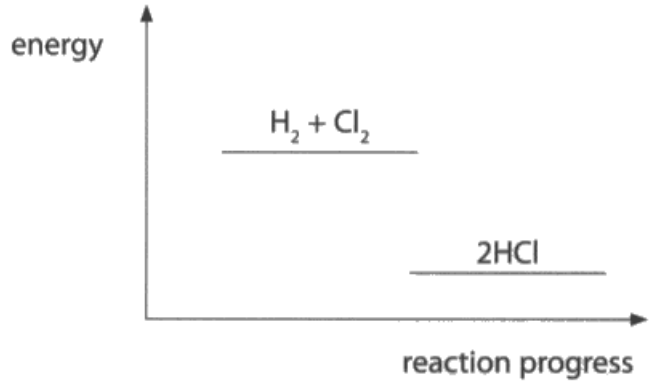
The energy change taking place when the reactants, hydrogen and chlorine, form the product, hydrogen chloride, is shown in the diagram.




Explain, in terms of the breaking of bonds and the making of bonds, why this reaction is exothermic.

**(2)**

More energy is released when making the new bonds than is taken in breaking the original bonds.

**ResultsPlus**
**Examiner Comments**

This answer exactly matches the mark scheme and so deserves the two marks.

**ResultsPlus**
**Examiner Tip**

Remember that bond breaking requires energy, bond making releases energy.

For endothermic reactions: energy needed to break bonds > energy released to make bonds

For exothermic reactions: energy needed to break bonds < energy released to make bonds

## *Question 3 (c) (i)*

The '2' on the left to balance for HCl was often correctly given, much less often than the $CO_2$ and $H_2O$ as products. There were many guesses at $CO_3$ and H or $H_2$. Candidates also failed to score by being careless with the case of letters, particularly the O in $CO_2$ and in $H_2O$, and subscription of numbers in formulae ($Co_2$ and $H_2o$ – in many cases the 2 being as big as if not bigger than the o).

(c) Marble chips react with dilute hydrochloric acid.

Marble is a form of calcium carbonate.

(i) Complete the balanced equation for this reaction.

H = 2 O = 3
Ca = 1 C = 1
Cl = 2

(2)

H = 2 Cl = 2
Ca = 1 O = 3
C = 1

$CaCO_3$ + 2 HCl → $CaCl_2$ + $H_2O$ + $CO_2$

**ResultsPlus**
**Examiner Comments**

A correct answer scoring 2 marks.

**ResultsPlus**
**Examiner Tip**

Practise writing and balancing equations for a variety of reactions met in the course.

(c) Marble chips react with dilute hydrochloric acid.

Marble is a form of calcium carbonate.

(i) Complete the balanced equation for this reaction.

(2)

$CaCO_3$ + 2 HCl → $CaCl_2$ + 2 H + $CO_3$

**ResultsPlus**
**Examiner Comments**

All too often this answer was seen. Candidates should know that carbon dioxide is evolved when an acid reacts with a carbonate.

## *Question 3 (c) (ii)*

While many candidates scored well, many got this the wrong way round, thinking that smaller chips meant less surface area and therefore decreased rate of reaction. Some failed to score the first mark, giving good explanations in terms of collisions but not the basic information about the rate itself.

(ii) Explain how using smaller sized marble chips affects the rate of this reaction, when all the other conditions remain the same.

**(2)**

Smaller marble chips have a smaller surface area meaning that the dilute hydrochloric acid can break the chips down faster speeding up the reaction rate.

**ResultsPlus**
**Examiner Comments**

It was surprising how many candidates thought that having smaller marble chips meant the surface area would be smaller. This answer did score a mark for stating that the reaction rate would be faster though.

**ResultsPlus**
**Examiner Tip**

Make sure it is understood how and why the factors of concentration, temperature, surface area and the presence of a catalyst affect the rate of a reaction.

(ii) Explain how using smaller sized marble chips affects the rate of this reaction, when all the other conditions remain the same.

**(2)**

smaller sized marble chips will take less time than normal or larger sized ones

**ResultsPlus**
**Examiner Comments**

There was no mention of the effect of particle size on the surface area nor on the rate of the reaction, so no marks were awarded.

## *Question 3 (c) (iii)*

This question was less well answered than Q3cii. Most understood this concept but could not express themselves well enough to score the marks. Many candidates missed the first marking point by not mentioning particles or by describing the particles as atoms. Too few candidates scored the second mark. Candidates did not include reference to time basis of collisions, simply saying more collisions, leaving out the 'frequent' or 'in the same time'. Many still seem to think that greater concentration means that the particles will have more energy or move more quickly. A minority thought that the hydrochloric acid would have a higher pH, give more energy or act as a catalyst.

(iii) Explain, in terms of collisions between particles, how increasing the concentration of the hydrochloric acid affects the rate of this reaction, when all the other conditions remain the same.

**(2)**

Increasing the concenteration cincreases the rate of successful collisions as there cs more particals to collide with.

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**Examiner Comments**

This answer scored 2 marks. 1 mark for 'more particals (sic)' and 1 mark for increased rate of successful collisions.

**ResultsPlus**
**Examiner Tip**

Make sure that the explanations in terms of collisions affecting the various factors of changing rate are known.

(iii) Explain, in terms of collisions between particles, how increasing the concentration of the hydrochloric acid affects the rate of this reaction, when all the other conditions remain the same.

(2)

The more concentrated hydrochloric acid the more particles in it meaning more chance of collisions, increasing the speed of reaction.

**ResultsPlus**
**Examiner Comments**

This answer only scored 1 mark for the increased number of particles. Increasing chance of collisions is not sufficient to indicate that the collisions will occur more frequently.

(iii) Explain, in terms of collisions between particles, how increasing the concentration of the hydrochloric acid affects the rate of this reaction, when all the other conditions remain the same.

(2)

Increasing the concentration of hydrochloric acid means that there are more particles per unit volume of acid. This increases the frequency and success of collisions as there are more particles to collide with. An increase in the frequency means that the rate of reaction is increased

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**Examiner Comments**

This was an excellent answer which unfortunately happened only occasionally on this examination. 2 marks were awarded.

## *Question 4 (a) (i)–(iii)*

Q4ai: Most candidates gave the correct answer in this question, but some had the numbers in the wrong order. Several candidates wrote 19p /20n to score 1 mark but then gave the number of electrons as 39. Some thought that there was just 1 electron, while others thought that there was just 1 neutron, with 19 protons and 19 electrons. Yet others gave the charges.

Q4aii: Generally this question was well answered; several candidates missed the first marking point by not referring to the nucleus by name or only describing the electrons, often in greater detail than required, effectively answering Q4aiii here as well.

Q4aiii: Mostly this question was well answered – 2,8,9 came up a few times, as did 2,8,8,8,8,5 even where the number of electrons was correctly given in i. It was surprising that a common error was 2,8,1.

**4** (a) An atom of potassium has an atomic number of 19 and a mass number of 39.

(i) Complete the table to show the number of protons, neutrons and electrons in this potassium atom.

**(2)**

| number of | | |
|---|---|---|
| **protons** | **neutrons** | **electrons** |
| 19 | 39 | 20 |

(ii) Describe the positions of these particles in the potassium atom.

**(2)**

Around the outer shell which go around the nucleus.

(iii) State the electronic configuration of this potassium atom.

**(1)**

8,8,2

**ResultsPlus**
**Examiner Comments**

Q4ai – although the number of protons is correct, it is clear how the candidate has confused the deduction of the number of neutrons and the number of electrons. This scored 0 marks.

Q4aii – the answer has not stated which particles are where and so scored 0 marks.

Q4aiii – an incorrect electronic configuration, so scored 0 marks.

**ResultsPlus**
**Examiner Tip**

Learn the meaning of terms such as atomic number and mass number. Learn how to work the number of protons, neutrons and electrons given the atomic number and mass number of an atom.

Learn the location of the sub-atomic particles: protons and neutrons in the nucleus, electrons in shells surrounding the nucleus.

Learn how to work out the electronic configuration for the first 20 elements.

**4** (a) An atom of potassium has an atomic number of 19 and a mass number of 39.

(i) Complete the table to show the number of protons, neutrons and electrons in this potassium atom.

**(2)**

| number of | | |
|---|---|---|
| **protons** | **neutrons** | **electrons** |
| 19 | 19 | 39 ~~19~~ ~~20~~ |

(ii) Describe the positions of these particles in the potassium atom.

**(2)**

Protons and neutrons are both in the ~~Nucleus~~ Nucleus and electrons are in the shells around the nucleus.

(iii) State the electronic configuration of this potassium atom.

**(1)**

Negative

**ResultsPlus**
**Examiner Comments**

Q4ai – the number of protons is correct, but the numbers of neutrons and electrons are incorrect, so 0 marks

Q4aii – the location of the protons, neutrons and electrons are correctly described, so 2 marks were awarded.

Q4aiii – the electronic configuration is incorrect and the candidate has given the charge on an electron, so 0 marks.

## Question 4 (a) (iv)

Mostly this question was well answered. Wrong answers seemed to have no pattern but included one of the numbers from earlier in the question (19/20/39) or -1, others a mis-remembered fraction.

## Question 4 (b) (ii)

Calculating the relative atomic mass from isotopic abundance was well answered – it appeared that candidates had been well-prepared for this item.

It was not too uncommon to give 2 marks for the total mass of Ga-69 and the Ga-71 through multiplication but some missed the 3rd mark as they failed to divide by 100. Some added the 69 and 71 and then divided by the 140. A few missed the 3rd mark due to rounding errors.

Some of the wrong working seen included: (60.2/69) + (39.8/71) and averaging the isotopic masses – 69+71/2, and 69+71 as the denominator of the fraction.

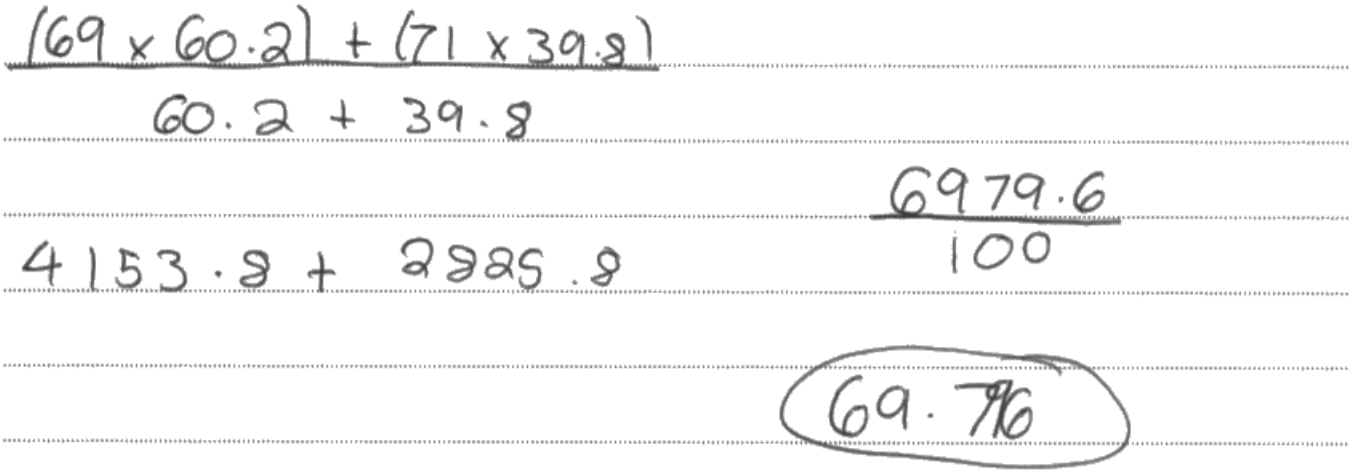
The weakest candidates just wrote 70 with no working.

(ii) The sample of gallium contains

60.2% of gallium-69
39.8% of gallium-71

Calculate the relative atomic mass of gallium.

(3)




**ResultsPlus**
**Examiner Comments**

A well executed answer, clearly showing the calculation and so three marks were awarded.

**ResultsPlus**
**Examiner Tip**

Set your calculations out in a way that someone else such as the examiner can follow your working.

(ii) The sample of gallium contains

60.2% of gallium-69
39.8% of gallium-71

Calculate the relative atomic mass of gallium.

(3)

RAM = $\frac{60.2}{100}$ = 0.602 0.602 × 39.8 = 24.0

$\frac{39.8}{100}$ = 0.398 0.398 × 60.2 = 24.0

Relative atomic mass of Gallium = 24.0

**ResultsPlus**
**Examiner Comments**

The isotopic masses were not being used in the calculation and so this will lead to an incorrect answer. There was nothing to credit here.

**ResultsPlus**
**Examiner Tip**

Practise calculating relative atomic masses from abundance data.

(ii) The sample of gallium contains

60.2% of gallium-69
39.8% of gallium-71

42.75

Calculate the relative atomic mass of gallium.

(3)

60.2% of 69 +
39.8% of 71
66.258

0.602 × 69 = 41.538 +
0.398 × 71 = 28.258
= 69.796

**ResultsPlus**
**Examiner Comments**

Using the percentage route and adding them together still gives the correct answer. The candidate did not change the number of significant figures in the answer.

## *Question 5 (a) (i)*

The first marking point was very often scored, the second less so; too many candidates omitted information about the number of electrons in the bond.

**5** Chlorine is an element in group 7 of the periodic table.

(a) Chlorine, $Cl_2$, is a simple molecular, covalent substance.

The atoms in a molecule of chlorine are held together by a covalent bond.

(i) Explain what is meant by the term **covalent bond**.

A shared pair of electrons across two atoms (2)

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**Examiner Comments**

Shared electrons scored the first mark, the correct number of electrons being shared scored the second mark.

**ResultsPlus**
**Examiner Tip**

Make sure you can give explanations of the three different types of bond met in this course: covalent, ionic and metallic.

**5** Chlorine is an element in group 7 of the periodic table.

(a) Chlorine, $Cl_2$, is a simple molecular, covalent substance.

The atoms in a molecule of chlorine are held together by a covalent bond.

(i) Explain what is meant by the term **covalent bond**.

Double bond, ~~Double bond~~ A covalent bond is a double bond Shared by 2 ~~elements~~ atoms (2)

**ResultsPlus**
**Examiner Comments**

Even though the candidate refers to 'sharing', there is no mention of electrons or the number, so 0 marks were awarded.

## *Question 5 (a) (ii)*

This question was mostly well answered, with candidates rising to the challenge of four 8-electron shells.

The few that only scored 1 mark usually was due to not checking the number of outer electrons on the chlorine atoms. Although answered well, many examiners reported that some correct diagrams were too small or very untidy and therefore difficult to mark. Some only drew one chlorine atom, some shared just 1 or 3 electrons per bond and a few showed ionic bonding.

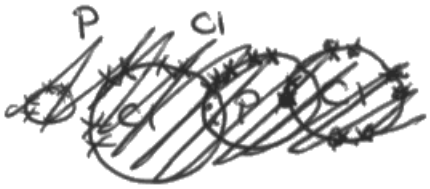
(ii) Phosphorus reacts with chlorine to form phosphorus trichloride, $PCl_3$.

A phosphorus atom has five electrons in its outer shell.

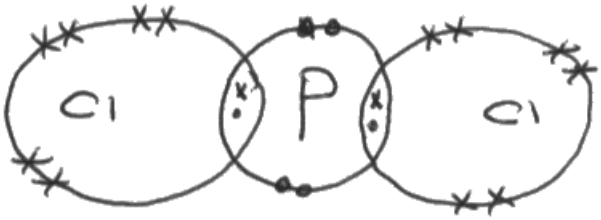
A chlorine atom has seven electrons in its outer shell.

Draw the dot and cross diagram to show the bonding in a molecule of phosphorus trichloride, $PCl_3$.

Show outer electrons only.




(2)




**ResultsPlus**
**Examiner Comments**

There were not enough chlorine atoms drawn and so the first mark could not be obtained. So this scored 0 overall.

**ResultsPlus**
**Examiner Tip**

Look at the information given in the question. The formula shows that 3 chlorine atoms are needed for the diagram.

(ii) Phosphorus reacts with chlorine to form phosphorus trichloride, $PCl_3$.

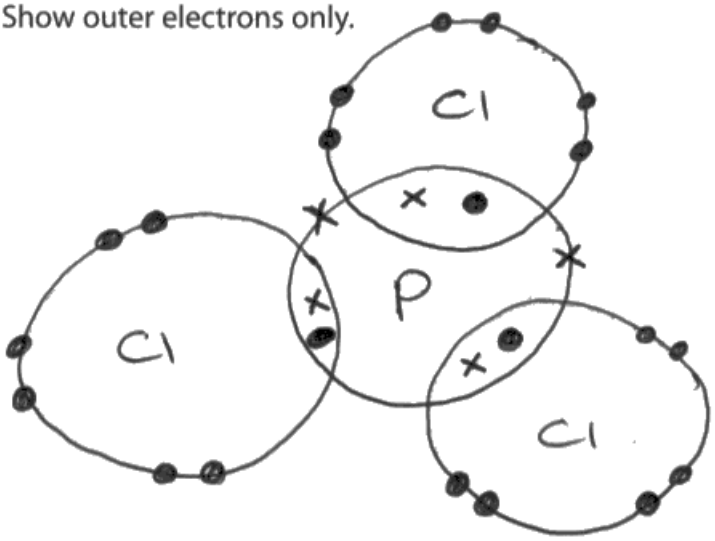
A phosphorus atom has five electrons in its outer shell. 5

A chlorine atom has seven electrons in its outer shell. 7

Draw the dot and cross diagram to show the bonding in a molecule of phosphorus trichloride, $PCl_3$.

Show outer electrons only.

(2)




**ResultsPlus**
**Examiner Comments**

It was good to see so many candidates handle dot and cross diagrams for unfamiliar substances such as $PCl_3$. The majority scored two marks.

**ResultsPlus**
**Examiner Tip**

Practise drawing dot and cross diagrams for a variety of molecules.

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A chlorine atom has seven electrons in its outer shell.

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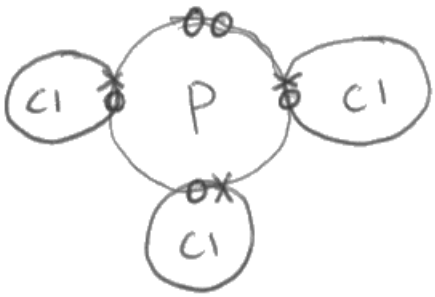
**(2)**




**ResultsPlus**
**Examiner Comments**

This only scored 1 mark for the three covalent bonds. Despite the instruction that chlorine has 7 electrons in its outer shell, this was ignored and so that mark was not achieved.

## *Question 5 (a) (iii)*

Generally this question was poorly answered, many candidates seeming to believe that the number of chlorine atoms in a chlorine molecule is flexible, with $Cl_3$ and Cl being seen very often; $Al_2$ was also seen but less often. The most popular answer was $Al + 3Cl \rightarrow AlCl_3$, but those who understood and could handle the numbers did well.

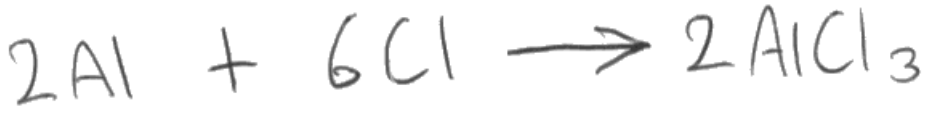
Most candidates who used the correct formulae of reactants and products could also balance the equation correctly, so only a few 1 mark answers seen.

Fortunately, incorrect use of wrong case letters or superscripts was very rare.

(iii) Aluminium reacts with chlorine to form aluminium chloride, $AlCl_3$.

Write the balanced equation for this reaction.

(2)




**ResultsPlus**
**Examiner Comments**

To see this doubled was rare, more commonly seen was $Al + 3Cl \rightarrow AlCl_3$.

**ResultsPlus**
**Examiner Tip**

Practise writing balanced equations.

(iii) Aluminium reacts with chlorine to form aluminium chloride, $AlCl_3$.

Write the balanced equation for this reaction.

(2)


**ResultsPlus**
**Examiner Comments**

This was a common incorrect response seen of this question. A very large number of candidates were choosing to use $Cl_3$ as the formula for chlorine.

**ResultsPlus**
**Examiner Tip**

Learn the formulae for the common substances met in the course. These include the gases and well as the acids, alkalis and other common substances such as water.

## *Question 5 (b)*

Disappointingly, this question was poorly answered. Relatively few candidates appeared to be able to answer the question as asked. Many failed to link bonding ideas with properties. Many more gave other properties not asked for, e.g. electrical conductivity. Many included incorrect phraseology and did not achieve a particular level as a result, e.g. describing every bond as intermolecular, describing the particles in sodium chloride or zinc as atoms or molecules or the bonds merely as 'strong bonds' without further detail. Many stated that the covalent bonds in chlorine were weak. All this limited the number of level 3 answers.

Examiners also reported that candidates tended to re-quote the question as responses and only gained marks from low level solubility responses, and students were also misusing phrases such as intermolecular forces for diamond. Also a high number stated strong bonds for zinc, diamond and sodium chloride without explaining why. Most knew that salt dissolved in water but diamond didn't but couldn't offer suggestions why this was the case.

*(b) Chlorine, $Cl_2$, is a simple molecular, covalent substance.
Diamond is a giant molecular, covalent substance.
Sodium chloride is an ionic substance.
Zinc is metallic.

As a result of their different structures these substances have the following different properties.

- Solid chlorine has a very low melting point but diamond, sodium chloride and zinc have high melting points.
- Diamond and sodium chloride have different solubilities in water.

In terms of the structure and bonding of these substances, explain these properties.

(6)

Diamond ✝ is a giant molecular, covalent substance which means it is very strong, it can be used as cutting tools. Its bonding has no weak layers. It has a high boiling point due to this and can conduct electricity.
Chlorine is a simple molecular, covalent substance which means its ● has a weaker bond compared to diamond. Its layers are weaker and therefore has a low boiling point.
Sodium chloride is an ionic substance which● means its two element combined that are sharing electrons. Sodium chloride is soluble

in water, diamonds are not.
Zinc is a metal where its structure is atoms in rows, this makes it weaker than diamond.

**ResultsPlus**
**Examiner Comments**

This was a very muddled answer, often confusing different structure types and introducing properties that were not being asked for. The only creditworthy part is that about solubility. So this was a level 1 answer – 2 marks.

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In terms of the structure and bonding of these substances, explain these properties.

**(6)**

Chlorine:

Chlorine is a simple molecular covalent substance that bonds with a shared pair of electrons. It has a very low melting point because it has weak inter molecular forces which are easy to overcome.

Diamond:

Diamond is a very strong giant covalent substance and makes four bonds to each carbon atom so it has a high melting point because the bonds made are very strong. It is insoluable in water because of how strong the structure is and can't be broken down when dissolved.

Sodium Chloride:

Sodium chloride bonds ionic-ally and occurs between a metal and non metal which are oppositely charged so they attract to make a full outer shell. It has strong electrostatic forces which are difficult to overcome which gives it a high melting point. It is

soluable in water.

Zinc:

Zinc is a metal in which a sea of delocalised electrons are around the nucleus.

**(Total for Question 5 = 12 marks)**

**ResultsPlus**
**Examiner Comments**

This is an excellent answer hitting all the indicators of a level 3 answer – 6 marks

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- Diamond and sodium chloride have different solubilities in water.

In terms of the structure and bonding of these substances, explain these properties.

**(6)**

- Solid chlorine has a very low melting point as simple molecular covalent substances have very weak bonds which means it can be easily broken by energy.

- Diamond has a high melting point as giant molecular substance have

very strong bonds which means there bonds are very hard to break using energy

-Sodium chloride has a high melting point as it is arrange in a lattice structure which means there are very strong forces of attraction between the positive and negative ions which also makes it hard to melt using energy

**ResultsPlus**
**Examiner Comments**

Only the explanation of the melting point of sodium chloride was considered sufficiently creditworthy for a level 1 answer – 2 marks. The explanations for chlorine and diamond were not detailed enough.

Nothing was written about zinc or the solubilities of sodium chloride and diamond.

**ResultsPlus**
**Examiner Tip**

For the 6-mark questions, make sure enough detail is given in explanations. Giving lists of properties or types of bond in the question without any links would score a maximum of one mark.

## *Question 6 (a)*

This question proved to be another well-answered calculation. Where candidates scored partial marks, they obtained the correct relative formula mass of 80 and used (2 x 14) of 28 as the numerator, but combined them with 100 in an incorrect fraction, or they used 14 rather than 28. Some confused the relative atomic mass of nitrogen with oxygen and some candidates had initially calculated an incorrect relative formula mass of ammonium nitrate, but continued with a correct second part of the calculation to be awarded two marks. Several candidates had a correct method of calculation, but had an incorrect final answer.

**6** (a) Calculate the percentage by mass of nitrogen in ammonium nitrate, $NH_4NO_3$.
(relative atomic masses: H = 1.0, N = 14, O = 16)

**(3)**

RAM: $H_4 + (1 \times 4) + 14 + (16 \times 3) = 80$

$28 + 4 + 48 = 80$

$\frac{28}{80} = 0.35$ ans x 100 = 35

percentage by mass of nitrogen = 35 %

**ResultsPlus**
**Examiner Comments**

A perfectly executed calculation leading to the correct answer. 3 marks.

**ResultsPlus**
**Examiner Tip**

Practise all types of calculation you meet in this course. There will be a variety of calculations that you have met in the course on examination papers.

**6** (a) Calculate the percentage by mass of nitrogen in ammonium nitrate, $NH_4NO_3$.
(relative atomic masses: H = 1.0, N = 14, O = 16)

(3)

Ar: $NH_4$ $14 + 1.0 \times 4 = 18$ | $Ar: NO_3$ $14 + 16 \times 3 = 62$

RFM $= 62 + 18 = 80$ $\times 100 = 17.5$

$\frac{80}{14}$

percentage by mass of nitrogen = 17.5 %

**ResultsPlus**
**Examiner Comments**

Looking at the numbers it can be seen that the relative formula mass of ammonium nitrate is being calculated, and for that it scored a mark. However, the second stage of the calculation (80/14) (x)100 is not correct.

Many candidates did use just one nitrogen in the second stage of the calculation (14/80) x 100 = 17.5% and were awarded 2 marks. In this case the only error was to use just 14 and not 14 x 2 as the numerator.

**ResultsPlus**
**Examiner Tip**

Make sure you set out your answers logically and for calculations, make it clear to the examiner what you are doing at each stage.

## *Question 6 (b)*

This calculation was answered less well, with many candidates randomly combining the 3 numbers given in the stem.

Examiners reported seeing many blank responses here. Those who knew what they were doing obtained the correct answer.

Several candidates seem to think that having carried out a sum on the calculator it has to be approximated for a subsequent calculation.

(b) In the extraction of titanium from its ore, the final stage involves the reaction between titanium(IV) chloride, $TiCl_4$, and sodium.

$$TiCl_4 + 4Na \rightarrow Ti + 4NaCl$$

Calculate the maximum mass of titanium that can be obtained from 500 tonnes of titanium(IV) chloride in this reaction.

(relative atomic mass: Ti = 48
relative formula mass of $TiCl_4$ = 190)

**(2)**

500 ÷ 190 = 2.6̇ ↓ = 2

48 × 2 = 96

mass of titanium = 96 tonnes

**ResultsPlus**
**Examiner Comments**

The candidate firstly calculated a scaling factor – 500/190 – for which they scored a mark. However, the dot above the 6 is reserved for indicating a recurring number and this is not the case here. In addition, approximating this from 2.63157 down to 2 is incorrect, and candidates need to be deterred from doing so.

(b) In the extraction of titanium from its ore, the final stage involves the reaction between titanium(IV) chloride, $TiCl_4$, and sodium.

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Calculate the maximum mass of titanium that can be obtained from 500 tonnes of titanium(IV) chloride in this reaction.

(relative atomic mass: Ti = 48
relative formula mass of $TiCl_4$ = 190)

**(2)**

$\frac{48}{190} = 0.25$

$0.25 \times 100\% = 25\%$

$25\%$ of $500 = 125$

mass of titanium = 125. tonnes

**ResultsPlus**
**Examiner Comments**

48/190 = 0.25 is a an approximation. When scaled up to 500 tonnes, there is a significant difference in the calculated mass.

**ResultsPlus**
**Examiner Tip**

Avoid making approximations in the middle of a calculation. Only reduce the number of significant figures at the final stage of a calculation.

## *Question 6 (c)*

Most candidates who focussed on the waste product as asked in the question scored the mark here. The two most popular responses were about the difficulty of separating the waste or the cost associated with disposing of waste. There was a lot of good knowledge about the problems of landfill. Candidates lost the mark by not doing this, commenting on reduced yield of the main product. Some candidates thought that this is a waste of chemicals as you don't get the right product.

(c) Reactions used in the chemical industry often produce unwanted products together with the required product.

State a problem this may cause for the manufacturer.

(1)

disposal. these unwanted Products are often toxic, and difficult to get rid off safely

**ResultsPlus**
**Examiner Comments**

This answer focusses on the aspect of disposal of the unwanted products, and this scored the mark.

(c) Reactions used in the chemical industry often produce unwanted products together with the required product.

State a problem this may cause for the manufacturer.

(1)

The waste products can cause social issues such as an increase in housing price.

**ResultsPlus**
**Examiner Comments**

While this might be the case, the candidate did not answer the question as set – a problem for the manufacturer – and so did not score.

**ResultsPlus**
**Examiner Tip**

Focus on what the question is asking.

## *Question 6 (d)*

There was a clear difference in the answers to this question from those who had possibly carried out the practical with those, probably a majority, who had not and were clearly guessing at the procedure, including leaving magnesium ribbon out in air/oxygen, dissolving in acid, and something involving a gas syringe. However, even those who had clearly performed the procedure found it difficult to describe it in sufficiently accurate detail. Full marks were generally obtained by a fully correct calculation and some sort of description. Several candidates were able to perform the routine calculation but some struggled with it. Many candidates presumed the formula for magnesium oxide but having shown effectively that there were equal numbers of magnesium atoms and magnesium oxide formula units, they were unable to say why this showed a correct hypothesis. Almost as many divided the mass of magnesium oxide by 16, got to a 1:2.5 ratio but were then unable to proceed.

*(d) An experiment is carried out to determine the empirical formula of magnesium oxide.

magnesium + oxygen → magnesium oxide

The following results are obtained

mass of magnesium ribbon reacted = 0.420 g

mass of magnesium oxide formed = 0.700 g

0.700 - 0.420 = 0.280

Describe an experiment to produce these results. As part of your answer show how these results can be used to obtain the empirical formula of the magnesium oxide.

mass = 0.42 mass = 0.7 - 0.42 = 0.28

(relative atomic masses: Mg = 24.0, O = 16.0)

(6)

Calculate the empirical formula:

Mg = $\frac{0.420}{24}$ → 0.0175 [smallest number]

O = $\frac{0.280}{16}$ → 0.0175

$\frac{0.0175}{0.0175}$ = 1 $\frac{0.0175}{0.0175}$ = 1

Empirical formula = MgO

To produce these results - magnesium would have to be heated with a bunsen burner in order to react with the oxygen. This would then produce magnesium oxide, which would be weighed on a balance and compared with the mass of Mg before the reaction. Comparing with the original mass of Mg before will give the results of how much of it reacted to produce magnesium oxide (0.420).

**ResultsPlus**
**Examiner Comments**

The determination of the empirical formula was correct and clear enough and the description of the experiment that could be carried out to obtain the results was sufficient, although not perfect, for this answer to be level 3 – 6 marks.

**ResultsPlus**
**Examiner Tip**

Make sure you know the various experiments that are detailed in the course and can give a clear description that would enable someone else to follow and carry out that experiment.

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magnesium + oxygen → magnesium oxide

The following results are obtained

| | |
|---|---|
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Describe an experiment to produce these results. As part of your answer show how these results can be used to obtain the empirical formula of the magnesium oxide.

(relative atomic masses: Mg = 24.0, O = 16.0)

**(6)**

You add a strip of magnesium ribbon ~~with~~ to a beaker of water, the magnesium will fizz and the gas given of is magnesium oxide as the oxygen leaves the hydrogen as magnesium is more reactive.

**ResultsPlus**
**Examiner Comments**

It seems clear that this candidate did not recognise the experiment that was looked at in this question. It could be that it was not carried out, even though it is detailed in the specification. There was insufficient here that could be credited, so this answer scored 0 marks.

*(d) An experiment is carried out to determine the empirical formula of magnesium oxide.

magnesium + oxygen → magnesium oxide

The following results are obtained

| | |
|---|---|
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| mass of magnesium oxide formed | = 0.700 g |

Describe an experiment to produce these results. As part of your answer show how these results can be used to obtain the empirical formula of the magnesium oxide.

(relative atomic masses: Mg = 24.0, O = 16.0)

the experiment is oxidation (adding oxygen) this could be by pumping air into a sealed container containing magnesium. How much oxygen or magnesium we need to fully react will help us determine the emperical formula, which is the simplest form of the compound.

0.700 - 0.420 = 0.28

$\frac{0.420}{24}$ $\frac{0.28}{16}$

= 0.0175 : = 0.0175

x1000 = 175 : 175

÷175 = 1 : 1

emperical formula is MgO

This shows us that the amount of Magnesium we need is proportional to the amount of Oxygen.

**ResultsPlus**
**Examiner Comments**

The empirical formula was correctly determined, but the description of how the results could be obtained did not merit credit. So for the correct empirical formula determination, this answer was level 2 – 4 marks.

## Paper Summary

On the basis of their performance on the current examination candidates are offered the following advice to improve their performance:

- practise calculations showing all working using a logical step by step approach
- practise writing balanced chemical equations
- understand the differences between the terms atoms, ions and molecules and how these terms should be used when identifying the types of particles in substances
- learn how to write the formulae of ionic compounds when given the symbols of the individual ions
- practise answering the 6-mark questions from past GCSE papers.

## Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx



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