Examiners' Report
January 2013

GCE Chemistry 6CH01 01

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Introduction

This paper tested a wide range of Unit 1 material and provided good opportunities for candidates to show their knowledge and understanding of the Chemistry covered by the Specification. The paper seemed to be well received by candidates and teachers. Calculations involving energy changes were generally done very well, in spite of both calculations being slightly unusual. Mole calculations were less well done, especially where concentrations of solutions and gases were involved. The reactions of alkenes were well known, but equations for alkane reactions were less known. Free radical reactions were poorly understood. Ionic equations seem beyond most candidates.

Many candidates are still failing to read the questions carefully enough. Candidates seemed to have very little knowledge of relatively straightforward practical techniques, and virtually no knowledge of safety hazards.

With a mean of almost 13 out of 20, the multiple choice marks were quite high.

The five easiest questions with easiest first were 12, 8, 11, 16a, and 2.

Hardest with hardest first were 6, 13, 9, 3, 14 and 5.

Question 17 (a) (i)

This ionic equation was beyond most candidates though it is simply a matter of removing the potassium ions, the only entities which do not change during the reaction. More practice at writing unfamiliar ionic equations is needed.

(a) The first step of the preparation involves adding an excess of aluminium foil to 10 cm^3 of 2 mol dm^{-3} potassium hydroxide to form potassium aluminate.

The equation for this reaction is

$$2Al(s) + 2KOH(aq) + 2H_2O(l) \rightarrow 2KAlO_2(aq) + 3H_2(g)$$

(i) Write a balanced **ionic** equation for this reaction.

$$\cancel{2Al} + \cancel{2K^+} + 2OH^- + 4H^+ + 2O^{-2} \rightarrow \cancel{2K^+} + \cancel{2Al} + 4O_2^{2-}$$

$$2OH^- + 2H_2O \rightarrow 4O_2^{2-} + 3H_2 .$$

ResultsPlus
Examiner Comments

If aluminium had not been omitted from both sides of this it would have received the mark as a good attempt at an unfamiliar equation.

ResultsPlus
Examiner Tip

Ensure everything that changes is included in an ionic equation.

(a) The first step of the preparation involves adding an excess of aluminium foil to 10 cm^3 of 2 mol dm^{-3} potassium hydroxide to form potassium aluminate.

The equation for this reaction is

$$2Al(s) + 2KOH(aq) + 2H_2O(l) \rightarrow 2KAlO_2(aq) + 3H_2(g)$$

(i) Write a balanced **ionic** equation for this reaction.

$$2Al_{(s)} + \cancel{2K^+_{(aq)}} + 2OH^-_{(aq)} + 2H_2O_{(l)} \rightarrow \cancel{2K^+_{(aq)}} + 2Al^{3+}_{(aq)} + 2O_2^-{}_{(aq)} + 3H_2$$

$$2Al_{(s)} + 2OH^-_{(aq)} + 2H_2O_{(l)} \rightarrow 2Al^{3+}_{(aq)} + 2O_2^-{}_{(aq)} + 3H_{2(g)}$$

ResultsPlus
Examiner Comments

Although this equation balances for entities, it does not balance for charge, there should be a total of two negative charges on each side.

ResultsPlus
Examiner Tip

Check that the totals of charges on each side of an ionic equation balance.

Question 17 (a) (ii) - (b) (ii)

The calculations and the balancing of the equation were generally well done, apart from the last part, calculating the volume of sulfuric acid.

Some failed to calculate the total mass added in part (v) and simply gave the mass of 10%.

A small number of candidates failed to interpret the mole ratios in the equation correctly in part (iii).

Though they have done some practical work candidates seem very unfamiliar with hazards. Better candidates recognised hazards without mentioning the chemical concerned. Some displayed a lack of knowledge of basic chemistry with responses such as 'potassium hydroxide is an acid so it is corrosive'.

(ii) Calculate the number of moles of potassium hydroxide used.

(1)

$\frac{10 \times 2}{1000} = 0.02$ moles

(iii) Hence state the number of moles of aluminium that react with the potassium hydroxide.

(1)

0.02

(iv) Use your answer to (iii) to calculate the mass of aluminium that reacts with the potassium hydroxide. Use the Periodic Table as a source of data.

(1)

$0.02 \times 13 = 0.26$ g

(v) Calculate the total mass of aluminium added to the potassium hydroxide if a 10% excess of aluminium is required.

(1)

0.26 g $\times 1.1 = 0.286$ g

(vi) Identify **two** hazards in this first step of the preparation.

(2)

Hazard 1 Potassium hydroxide is corrosive. It can damage your eyes and skin is exposed to it.

Hazard 2 The formation of $KAlO_2$ may be slightly alkaline, which can damage skin

(b) The second step of the reaction is the addition of a slight excess of 1 mol dm^{-3} sulfuric acid.

(i) Balance the following equation for the reaction

(1)

$$KAlO_2(aq) + 2\,H_2SO_4(aq) \rightarrow KAl(SO_4)_2(aq) + 2\,H_2O(l)$$

(ii) Calculate the volume of the 1 mol dm^{-3} sulfuric acid that reacts with the potassium aluminate.

(1)

0.02 moles of ~~H2SO4~~ KAlO2

= 0.04 moles H2SO4

∴ 40cm^3 of H2SO4 needed.

ResultsPlus Examiner Comments

Notice how this candidate has only lost two marks despite a major error in part (iv) multiplying by the atomic number rather than the molar mass. They lost a mark for the second hazard, but (b)(ii) was fine.

ResultsPlus Examiner Tip

Keep persevering with calculations even if a mistake has been made.

(ii) Calculate the number of moles of potassium hydroxide used.

(1)

0.01 × 2 = 0.02

0.02 moles

(iii) Hence state the number of moles of aluminium that react with the potassium hydroxide.

(1)

0.02 moles

(iv) Use your answer to (iii) to calculate the mass of aluminium that reacts with the potassium hydroxide. Use the Periodic Table as a source of data.

(1)

0.02 × 27 = 0.54

0.54 g

(v) Calculate the total mass of aluminium added to the potassium hydroxide if a 10% excess of aluminium is required.

(1)

0.54 × 0.1 = 0.054

  0.54
+ 0.054
  0.594

0.594g

(vi) Identify **two** hazards in this first step of the preparation.

(2)

Hazard 1 potasium hydroxide can be harmful.

Hazard 2 Could result in big chemical reaction (explosion).

(b) The second step of the reaction is the addition of a slight excess of 1 mol dm^{-3} sulfuric acid.

(i) Balance the following equation for the reaction

(1)

$$KAlO_2(aq) + 2H_2SO_4(aq) \rightarrow KAl(SO_4)_2(aq) + 2H_2O(l)$$

K-1 A-1 I-1 O-H-4 S-2   K-1 A-1 I-1 O-H-4 S-2

(ii) Calculate the volume of the 1 mol dm^{-3} sulfuric acid that reacts with the potassium aluminate.

(1)

$\frac{0.02}{1} = 0.02$

0.02 dm^3

ResultsPlus

Examiner Comments

This is a fairly typical mark profile for this question.

Everything is fine up to the hazards. Potassium hydroxide at this concentration dissolves the skin, turning it into soap, so harmful is an understatement. Hydrogen produced is explosive but is not mentioned in the second hazard.

The candidate has failed to use the equation in (b)(i) in the calculation in (b)(ii).

ResultsPlus

Examiner Tip

Learn the hazards associated with common chemicals.

Practise calculations involving equations.

Question 17 (b) (iii)

A practical way of showing the mixture was acidic was all that was needed here. Some who had the correct idea gave vague statements like 'use an indicator' or 'measure the pH'. Others having chosen an indicator did not give the colour change.

(iii) State how you would show that the acid had been added in excess.

(2)

Put in indicator paper. It would show that the mixture is acidic because it did not all react.

ResultsPlus
Examiner Comments

This is close to the first mark but does not say which indicator paper to use. The second mark cannot be given as the colour change is not given.

ResultsPlus
Examiner Tip

Be precise in naming chemicals.

(iii) State how you would show that the acid had been added in excess.

(2)

Add calcium carbonate. If a gas is produced, then acid was present in exess.

ResultsPlus
Examiner Comments

The method is fine but effervescence or bubbles need to be mentioned – the gas cannot be seen, it is colourless.

ResultsPlus
Examiner Tip

It is rare that gases are coloured so the result of a test as 'seeing' a gas form is rarely appropriate.

Question 17 (b) (iv)

Although this is possibly the most frequently asked practical question on Unit 1 examination papers, it was generally not well done. Candidates need to remember that chemistry is a practical subject and practical work is examined both in the coursework and through written examinations.

Quite a large proportion of candidates boiled the mixture to evaporate all the water which did not gain any credit.

Some gave inadequate detail for each step like 'leave the mixture to stand' or 'cool the mixture', without saying 'to allow crystals to form.

Some missed the last mark because they did not dry the crystals 'between filter papers' or 'in a desiccator'.

Some weaker candidates included steps like distillation.

*(iv) State and explain the steps necessary to obtain pure, dry crystals from the mixture.

(4)

add the potassium aluminate to the sulfuric acid so they may react and filter the solution. Heat the remaining filtrate so half the volume is given off (via evaporation) and leave to cool and crystalise. Filter once more to obtain the crystals. Spray with distilled water and dry the crystals between filter paper.

ResultsPlus

Examiner Comments

This is an almost perfect answer, well and concisely written. It does not filter out any excess aluminium to begin with but the mark scheme was such as to allow this on this occasion.

ResultsPlus

Examiner Tip

Notice how easy it is to read the writing and the excellent washing technique to minimise the amount of water added.

*(iv) State and explain the steps necessary to obtain pure, dry crystals from the mixture.

(4)

- Follow the first two steps
- Evaporate some of the mixture using a bunsen burner.
- Place the remaining mixture into a crystalization dish.
- Let the crystals dry by placing the dish into direct sunlight for 1 week.

ResultsPlus
Examiner Comments

The first point is well made.

The second omits to mention the formation of crystals.

There is no mention of how the crystals are collected.

The crystals should not be dried in the sun where the heat could remove the water of crystallisation.

ResultsPlus
Examiner Tip

Make each practical point as fully as possible, explaining each step.

Question 17 (b) (v)

Better candidates realised that as this was a compound of a non-transition ion it would form white crystals.

Question 17 (b) (vi)

About half of the candidates were able to recognise that another triply charged cation was needed.

Some misread the question and gave a name rather than a formula while some omitted to read the last phrase 'in combination with potassium and sulphate ions' and gave the sodium ion. Some forgot the charge.

(vi) Suggest the formula of another metal ion which could form an alum, in combination with potassium and sulfate ions.

(1)

Gallium

ResultsPlus
Examiner Comments

Neither the symbol nor the charge are given here but as this was quite a difficult application of knowledge, on this occasion, the recognition of a correct Group 3 element was accepted.

ResultsPlus
Examiner Tip

Read the question carefully.

(vi) Suggest the formula of another metal ion which could form an alum, in combination with potassium and sulfate ions.

(1)

Ga^{2+}

ResultsPlus
Examiner Comments

A correct Group 3 element symbol has been given with an incorrect charge so scores zero.

ResultsPlus
Examiner Tip

Think about and check answers after writing them.

Question 18 (a)

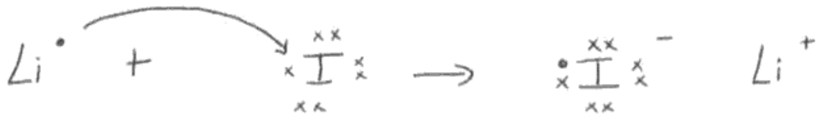
Failure to read the question often cost a mark when iodine inner electrons were omitted.

Many candidates also omitted charges on the ions which should always be included.

18 This question is about lithium iodide, an ionic salt.

(a) Draw dot and cross diagrams for the lithium and iodide ions. Show all the electrons in the lithium ion but only outer shell electrons in the iodide ion.

(2)



ResultsPlus
Examiner Comments

At first sight this a perfect answer. The candidate has shown how the ions are formed from the atoms concerned.

Unfortunately, the candidate has failed to read the question fully 'show all the electrons in the lithium'.

ResultsPlus
Examiner Tip

Check you have answered the question asked.

18 This question is about lithium iodide, an ionic salt.

(a) Draw dot and cross diagrams for the lithium and iodide ions. Show all the electrons in the lithium ion but only outer shell electrons in the iodide ion.

(2)

ResultsPlus
Examiner Comments

The electron configurations are fine but there are no charges on the ions.

ResultsPlus
Examiner Tip

Remember to include charges on ions in dot and cross diagrams.

Question 18 (b) - (c)

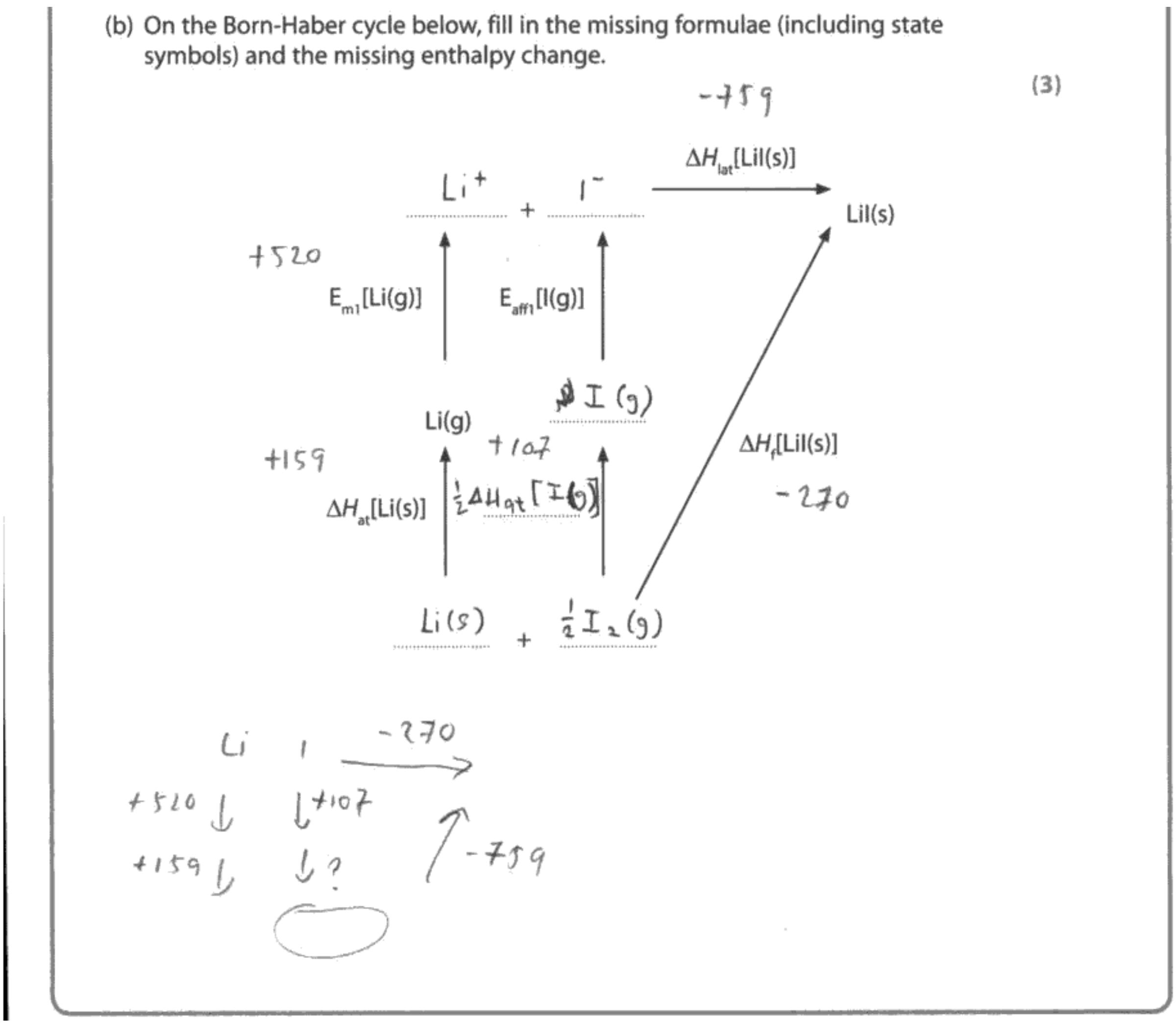
The first part was very discriminating with an equal proportion of candidates gaining each mark from zero to four.

States or charges were often missing from the gaseous ions.

While the element lithium was usually correct, iodine seemed unfamiliar. Many thought iodine was a gas or liquid, and most thought it was monatomic. The symbol for atomisation including square brackets and the symbol for the starting material were rarely correct.

In contrast with part (b) this was generally quite well done with about half the candidates gaining full credit, for the correct answer with the correct sign. This was pleasing as the calculation may not have been as simple as the standard calculation of lattice energy.

Common errors were failure to give the sign, doing the wrong subtraction to obtain a positive sign or entering the incorrect data.



(c) Calculate the electron affinity of iodine, $E_{aff1}[I(g)]$, using the data below.

	ΔH/kJ mol^{-1}
Lattice energy for lithium iodide, ΔH_{lat}	−759
Enthalpy change of atomization of lithium, ΔH_{at}	+159
Enthalpy change of atomization of iodine, ΔH_{at}	+107
First ionization energy of lithium, E_{m1}	+520
Enthalpy change of formation of lithium iodide, ΔH_f	−270

(2)

$\Delta H_{at}\ Li(s) + E_{m1} + \frac{1}{2}\Delta H_{at}\ I(g) + E_{aff1}[I(g)] + \Delta H_{lat}[LiI(s)]$

$= \Delta H_f[LiI(s)]$

$+159 + 520 + 107 + E_{aff}[I(g)] + [-759] = -270$

$E_{aff}[I(g)] = -297$ kJ mol^{-1}

ResultsPlus

Examiner Comments

The state symbols are missing from the gaseous ions.

The candidate does not understand that enthalpy change of atomisation refers to one mole of atoms and they think the symbol includes the product rather than the starting material for atomisation. Though they know that iodine is diatomic and that half a mole is needed, they do not know that iodine is a solid.

The reasoning of the calculation is clear and gives the correct answer.

ResultsPlus

Examiner Tip

Be careful to learn the complete symbols for the enthalpies and energies involved in lattice energy calculations.

(c) Calculate the electron affinity of iodine, $E_{aff1}[I(g)]$, using the data below.

	ΔH/kJ mol^{-1}
Lattice energy for lithium iodide, ΔH_{lat}	–759
Enthalpy change of atomization of lithium, ΔH_{at}	+159
Enthalpy change of atomization of iodine, ΔH_{at}	+107
First ionization energy of lithium, E_{m1}	+520
Enthalpy change of formation of lithium iodide, ΔH_f	–270

(2)

~~ΔH~~

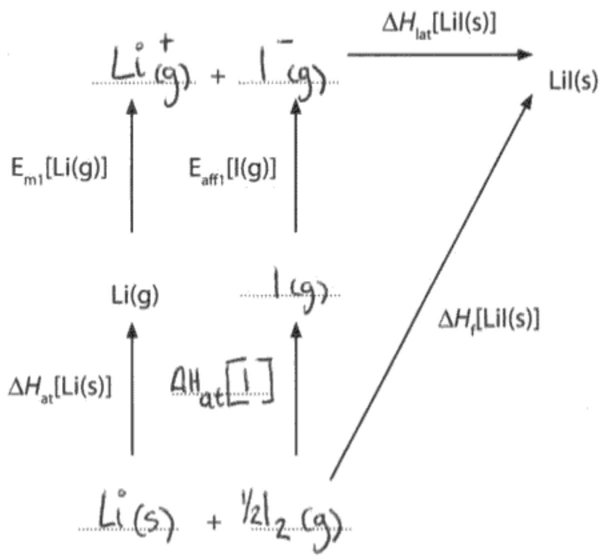
$e.a[I] = (-270) - (520 + 107 + 159 - 759)$

$= (-270) - 1545$

$= -1815$ kJmol^{-1}

(b) On the Born-Haber cycle below, fill in the missing formulae (including state symbols) and the missing enthalpy change.

(3)



ResultsPlus
Examiner Comments

The gaseous ions and lithium solid are fine.

They have the wrong state for iodine but the correct amount of the diatomic molecule.

They have used the product symbol without a state for the atomisation enthalpy.

They have made an arithmetic error with the last sign in the calculation, but they still get a mark for clear and correct working.

ResultsPlus
Examiner Tip

Show all working clearly in calculations.

Question 18 (d)

The first mark was achieved by less than half the entry, as some still insisted on terms like increase or decrease. Various justifications were acceptable, whatever the first statement. The most common correct justification was for a degree of covalency. Care was needed to refer to distortion or polarization of **iodide ions,** the terms iodine 'atoms' or even 'molecules' were regrettably frequent.

(d) The experimental lattice energy for lithium iodide is $-759\ kJ\ mol^{-1}$. The theoretical lattice energy is different from this value.

Will the experimental lattice energy be more negative or less negative than the theoretical lattice energy? Justify your answer.

(3)

less negative as the bonding is not purely ionic, the Li^+ cation polarises the I anion giving a degree of covalent character.

ResultsPlus
Examiner Comments

The answer identifies there is some covalent character in the bonding, and explains this arises due to the polarization of the anion by the cation.

Unfortunately the reference to energy is incorrect.

Notice that 2 marks are scored in spite of this error.

ResultsPlus
Examiner Tip

Your reasoning often gains more credit than the main answer to a question as it does here.

(d) The experimental lattice energy for lithium iodide is $-759\ kJ\ mol^{-1}$. The theoretical lattice energy is different from this value.

Will the experimental lattice energy be more negative or less negative than the theoretical lattice energy? Justify your answer.

(3)

The experimental lattice energy would be more negative than the theoretical. The theoretical assumes LiI is purely ionic, however Li^+ is a small charged cation and has polarizing power. I^- is a large anion and is easily polarized. In $LiI_{(s)}$ the Li^+ polarizes I^-, leading to significant covalent characters. Therefore the bonding in LiI is stronger than expected.

ResultsPlus
Examiner Comments

This is an example of a perfect answer.

Notice also that it is easy to read.

ResultsPlus
Examiner Tip

Try to write as clearly as possible.

(d) The experimental lattice energy for lithium iodide is –759 kJ mol^{-1}. The theoretical lattice energy is different from this value.

Will the experimental lattice energy be more negative or less negative than the theoretical lattice energy? Justify your answer.

(3)

The experimental lattice will be less negative because Lithium ion ~~is~~ has a small ionic radius thus can easily Polarise the ~~anion~~ ~~it~~ Iodine ion which has a small charge and large size making it easy to be polarised. ~~The~~ ~~to~~ ~~the~~

ResultsPlus
Examiner Comments

Though 'less negative' is incorrect, justification marks could still have been scored. If it had been clear that the iodide ion was polarized a mark could have been given, though the final statement is worrying, iodide ions are polarized because of their relatively large size. A small charge makes them less polarizable.

ResultsPlus
Examiner Tip

Be clear in the selection and use of terms like atom, molecule and ion and only give additional information if it is correct.

Question 18 (e)

In spite of direction in past examiners' reports and the clear direction in the previous part of the question, the phrase 'less negative' was rarely seen. Less, more increase and decrease in electron affinity were seen with almost equal frequency.

Candidates need to remember that such descriptions are too vague for energy changes. Imprecise expressions also cost marks in the reason for this change which could be awarded even if the first part was inadequate.

Statements like 'It is further from the nucleus' (rather than 'the electron...') and 'there is shielding' (rather than '...more shielding') were typical.

Question 19 (a)

This question illustrated a number of weaknesses. First, candidates failed to read the question, thinking it referred to nuclei, rather than atoms, and omitted to give any comment about electrons. Another common answer was to correctly make the statements about protons and electrons, but to simply say 'different numbers of neutrons' which was insufficient at this level. Some gave the incorrect numbers of neutrons, most commonly one for protium etc. Very weak candidates gave differing numbers of electrons or protons.

19 Hydrogen has three isotopes, ^{1}H, known as protium, ^{2}H, deuterium, and ^{3}H, tritium.

(a) In terms of sub-atomic particles, give the similarities and differences between atoms of these three isotopes of hydrogen.

(3)

They have the same number of protons but a different number of neutrons which means that their mass/charge density is different

ResultsPlus
Examiner Comments

This candidate has failed to mention electrons and given an insufficient statement about neutrons.

ResultsPlus
Examiner Tip

Read the question carefully and remember to give Advanced level answers.

19 Hydrogen has three isotopes, ^{1}H, known as protium, ^{2}H, deuterium, and ^{3}H, tritium.

(a) In terms of sub-atomic particles, give the similarities and differences between atoms of these three isotopes of hydrogen.

(3)

Three of the isotops have same number of electron (1) and number of proton (1). However, protium has one neutron, deuterium has 2 neutron and tritium has three neutron.

ResultsPlus
Examiner Comments

This is an instructive 2 mark answer.

The candidate has the electrons and protons correct, but has not considered what the effect of their neutron numbers will be on the mass numbers of the isotopes.

ResultsPlus
Examiner Tip

Check answers carefully and critically.

Question 19 (b)

Though an unfamiliar type of equation, many candidates applied their understanding of mass number and atomic number to arrive at the correct answer. Some gave the correct numbers with the wrong element, while others gave the wrong numbers with the correct element.

(b) When a nitrogen atom collides with a high energy neutron, one atom of tritium and one atom of another element are formed. Complete the equation below.

(1)

$$^{14}_{7}N + ^{1}_{0}n \rightarrow ^{3}_{1}H + ^{11}_{6}C$$

ResultsPlus
Examiner Comments

This equation is not balanced for neutrons, giving the wrong mass number for carbon.

ResultsPlus
Examiner Tip

It is always a good idea to try out lots of examples of applying your knowledge to unfamiliar situations.

(b) When a nitrogen atom collides with a high energy neutron, one atom of tritium and one atom of another element are formed. Complete the equation below.

(1)

$$^{14}_{7}N + ^{1}_{0}n \rightarrow ^{3}_{1}H + ^{12}_{6}N$$

ResultsPlus
Examiner Comments

A common example of the incorrect element, which does not match the proton number.

ResultsPlus
Examiner Tip

Make sure you understand the significance of atomic number.

Question 19 (c) (i) - (ii)

In part (i) it was necessary to first calculate the molar mass of tritium-deuterium. This proved quite a challenge. Provided candidates made it clear they had calculated molar mass, by stating "Molar mass =", they could get a transferred error mark for the second mark if they correctly divided the mass by the molar mass.

Similarly in (ii) they received a transferred error mark from their calculated number of moles. Answers were acceptable in cubic centimetres or cubic decimetres, but if given in cubic decimetres the unit was essential. There were a few incorrect units.

(c) Tritium-deuterium gas, consisting of molecules each containing one deuterium atom and one tritium atom, is used in some nuclear warheads. Typically, each warhead has about 4.0 g of the gas added.

(i) Calculate the number of moles of tritium-deuterium in 4.0 g. **(2)**

$mol = \frac{mass}{mol\ mass} = \frac{4}{3}$ ~~2.13 mol~~ $= 1.33\ mol$

(ii) Calculate the volume, in cm^3, of 4.0 g of tritium-deuterium gas.

[Molar volume of a gas under these conditions = 24 000 $cm^3\ mol^{-1}$] **(1)**

Vol = mol x mol volume

= 1.33x24000

= 32000 cm^3

ResultsPlus
Examiner Comments

Though the candidate has the wrong molar mass in part (i), they have made clear what it is, so get one mark.

In part (ii), they should have got an answer of 31920, but the use of the original fraction from part (i) was not penalised.

ResultsPlus
Examiner Tip

With calculations always make working clear.

(c) Tritium-deuterium gas, consisting of molecules each containing one deuterium atom and one tritium atom, is used in some nuclear warheads. Typically, each warhead has about 4.0 g of the gas added.

(i) Calculate the number of moles of tritium-deuterium in 4.0 g.

(2)

moles = mass / mr = 4 / 2

= 2 moles

(ii) Calculate the volume, in cm^3, of 4.0 g of tritium-deuterium gas.

[Molar volume of a gas under these conditions = 24 000 cm^3 mol^{-1}]

(1)

V = ~~conc~~ / moles   moles / conc

= 2 / 24 000

ResultsPlus

Examiner Comments

Notice that the candidate has indicated the molar mass in part (i), so even though it is incorrect they get the second mark.

Unfortunately they divided by the molar volume in (ii) so do not gain any credit.

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Examiner Tip

It is worth practising this very common type of calculation, calculating a volume of a gas from its mass, without using the density.

Question 19 (d)

Candidates needed to show their working clearly if they got the wrong answer, which many did because they were unable to give their answer to four decimal places. A few lost a mark for incorrect units, though the unit was not required.

(d) Tritium is not usually included in calculations of the relative atomic mass of hydrogen, because it is radioactive and has a relatively short half-life.

Calculate the relative atomic mass of hydrogen with the following isotopic composition. Give your answer to four decimal places.

(2)

Isotope	Mass number	Relative abundance
^{1}H	1.0078	99.9850
^{2}H	2.0141	0.0150

$$\frac{(1.0078 \times 99.9850) + (2.0141 \times 0.0150)}{100} = 1.00795$$

$$= 1.0080$$

ResultsPlus

Examiner Comments

A well set out correct answer.

ResultsPlus

Examiner Tip

Always show your working - it may get you credit even if you make an arithmetic error.

(d) Tritium is not usually included in calculations of the relative atomic mass of hydrogen, because it is radioactive and has a relatively short half-life.

Calculate the relative atomic mass of hydrogen with the following isotopic composition. Give your answer to four decimal places.

(2)

Isotope	Mass number	Relative abundance
^{1}H	1.0078	99.9850
^{2}H	2.0141	0.0150

$$\frac{(1\cdot0078 \times 99\cdot9850) + (2\cdot0141 \times 0\cdot0150)}{100}$$

$$= 1\cdot0079$$

ResultsPlus
Examiner Comments

Although the candidate has the correct expression for calculating the relative atomic mass which gained the first mark, the answer is not given to four decimal places.

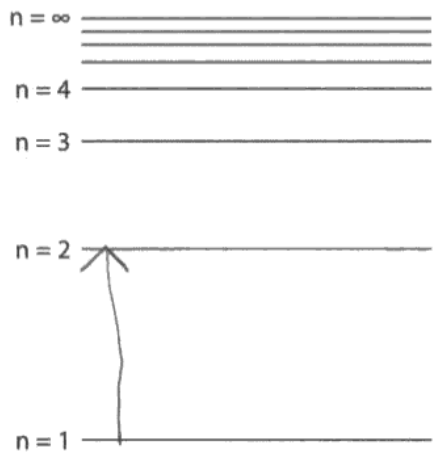
ResultsPlus
Examiner Tip

Ensure you understand the difference between significant figures and decimal places.

Question 19 (e) (i)

Though this was the easiest question of this type, it was rather poorly done with arrows from and to the wrong energy levels, and both up and down.

(e) The electronic energy levels in hydrogen are shown below.



(i) Mark on the energy level diagram, with an arrow, the transition that represents the ionization energy of hydrogen.

(1)

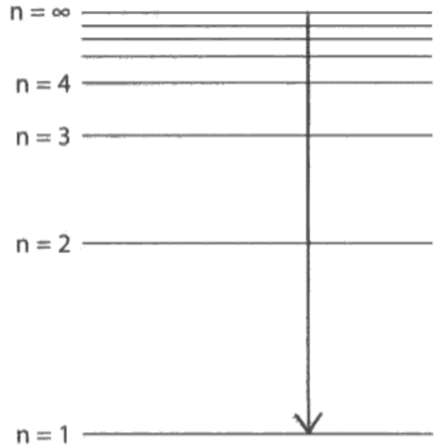
ResultsPlus
Examiner Comments

Though this starts from the correct level and goes in the correct direction, the arrow only reaches n=2 which is not enough.

ResultsPlus
Examiner Tip

Try out lots of these types of questions with different elements, for different ionization energies.

(e) The electronic energy levels in hydrogen are shown below.



(i) Mark on the energy level diagram, with an arrow, the transition that represents the ionization energy of hydrogen.

(1)

ResultsPlus

Examiner Comments

Here the energy levels are correct but the arrow is in the wrong direction for ionization.

ResultsPlus

Examiner Tip

Think about what ionization means when answering questions like this.

Question 19 (e) (ii)

Lower scoring candidates gave the electronic configuration for lithium but could still score the second mark.

In the second part it was essential to mention the term 'outer', so answers like 'both have a half filled s shell' or 'same electron configuration were insufficient'.

(ii) In some versions of the Periodic Table, hydrogen is placed in the same group as sodium. Give the electronic configurations for both a hydrogen atom and a sodium atom, using the *s* and *p* notation.

Use these electronic configurations to suggest why this is a reasonable grouping.

(2)

H $1s^1$

Na $1s^2, 2s^2, 2p^6, 3s^1$

Because both hydrogen and sodium have a half filled s - sub shell.

ResultsPlus
Examiner Comments

A typical one mark answer for the correct electron configurations.

ResultsPlus
Examiner Tip

Try to be critical of your own answers. Have you said everything you know which is relevant?

(ii) In some versions of the Periodic Table, hydrogen is placed in the same group as sodium. Give the electronic configurations for both a hydrogen atom and a sodium atom, using the *s* and *p* notation.

Use these electronic configurations to suggest why this is a reasonable grouping.

(2)

H $1s^1$

Na $1s^2\ 2s^2\ 2p^6\ 3s^1$

Both of them only have one electron in their s orbitals and their outer shells.

ResultsPlus
Examiner Comments

This answer secures the second mark at the end with the words 'and their outer shells'. It also benefits from extremely clear writing.

ResultsPlus
Examiner Tip

Write clearly in black ink making lower case letters large enough to be read easily.

Question 19 (f)

Lower scoring candidates selected elements other than helium. Though hydrogen could score justification marks, it was not possible to credit justifications for any other elements of which neon was the most common.

Some who correctly gave helium only made generalisations of ionization energies rising across periods or down groups when something more concrete relating to helium was needed. Similarly reference to a filled electron sub-shell was insufficient.

*(f) Which element in the Periodic Table has the highest first ionization energy? Justify your answer.

(3)

Helium is the element with the highest first ionization energy. This is because Helium exsists in group 8, meaning it's an ~~[crossed out]~~ unreactive noble gas because it is stable. Also Helium has a complete 1s sub shell [↑↓], so it would take more energy to break off that one electron.

(Total f...

ResultsPlus
Examiner Comments

Although true statements about helium are given, they are insufficient explanations to justify the answer.

ResultsPlus
Examiner Tip

Justifications should always attempt to answer the question 'why' as fully as possible.

*(f) Which element in the Periodic Table has the highest first ionization energy? Justify your answer.

(3)

Helium because it has a stable full outer shell with no shielding so the electrostatic attraction from the nucleus is very high. Plus it is close ~~the~~ to the nucleus ~~and has a~~ therefore very high amounts of energy are required to remove the electron. Plus electrostatic repulsion means the 2nd electron doesn't want to lose it's pair.

(Total for Question 19 = 15 marks)

ResultsPlus
Examiner Comments

Helium and more (electron) shielding are worth 2 marks.

The structure of the second sentence can be construed as 'it' refers to an electron which is close to the nucleus, so a mark was awarded on this occasion.

ResultsPlus
Examiner Tip

Always try to be precise in answers.

Question 20 (a)

Only a few candidates gave the incorrect formulae, but the states gave more problems. In spite of the standard enthalpy of combustion being mentioned water was often given as a gas. Much worse were the candidates who gave ethane as a liquid or solid, suggesting they did not know that the first four alkanes are all gases under standard conditions.

Some could not balance the equation, oxygen being the major problem.

20 This question is about the gas ethane, C_2H_6, and its reactions.

(a) Write the equation, including state symbols, which represents the reaction taking place when the standard enthalpy change of combustion of ethane is measured.

(2)

$C_2H_{6(g)} + 5O_{2(g)} \rightarrow 3H_2O_{(l)} + 2CO_{2(g)}$

ResultsPlus

Examiner Comments

This equation has the correct entities with their states.

It is balanced for hydrogen and carbon, but not for oxygen.

ResultsPlus

Examiner Tip

Always check equations balance by adding up atoms on each side.

20 This question is about the gas ethane, C_2H_6, and its reactions.

(a) Write the equation, including state symbols, which represents the reaction taking place when the standard enthalpy change of combustion of ethane is measured.

(2)

$C_2H_{6(l)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$

ResultsPlus

Examiner Comments

The state of ethane is wrong as is probably the state of water and the equation is not balanced.

ResultsPlus

Examiner Tip

Be familiar with the states and uses of the first four alkanes.

Make state symbols very clear - if a mistake is made cross it out and write the correct state next to it.

Remember equations will always be expected to be balanced.

Question 20 (b)

The majority of candidates gained full marks.

Some candidates gave structural and not displayed formulae in the equation losing the first mark. Remember displayed formulae show all the atoms and all the bonds.

Good candidates made it clear which bonds were breaking and which were making and realised that bond enthalpies are for dissociating or breaking bonds so the sign needs to be reversed when bonds are made.

(b) Ethane can react with chlorine to form chloroethane and hydrogen chloride.

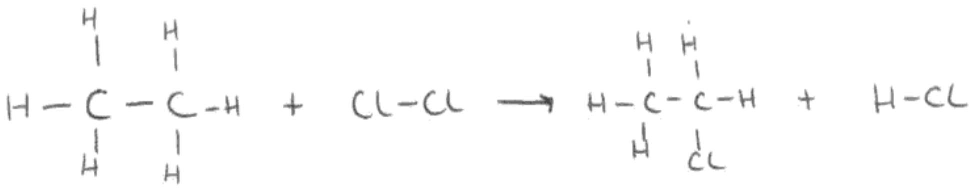
$$C_2H_6(g) + Cl_2(g) \rightarrow C_2H_5Cl(g) + HCl(g)$$

Bond	Bond enthalpy/kJ mol^{-1}
C—H	413
C—C	347
C—Cl	346
H—Cl	432
Cl—Cl	243

Rewrite this equation using displayed formulae.

Use the equation you have written, together with the bond enthalpy data, to calculate the enthalpy change for the reaction.

(4)



6 (413) + 347   243 → 5(413) + 346 + 347 + 432

ResultsPlus
Examiner Comments

The candidate has done much unnecessary work including bonds which do not break or make and then failed to appreciate that bond enthalpies are for bond breaking.

ResultsPlus
Examiner Tip

In calculations it is important to think about what you are doing.

Question 20 (c) (i)

Many candidates failed to get the first mark as they misread the question and gave the overall reaction type rather than the type of step.

The condition of UV radiation was well remembered.

(c) This reaction takes place in a number of steps, some of which are shown below.

Step 1 $Cl_2 \rightarrow 2Cl\bullet$

Step 2 $CH_3CH_3 + Cl\bullet \rightarrow HCl + CH_3CH_2\bullet$

(i) State the type of reaction occurring in step 1 and the conditions needed for this step.

(2)

Type Free radical substitution.

Conditions UV light

ResultsPlus
Examiner Comments

A typical one mark answer. The candidate has given the overall reaction type, rather than the name of the step. The condition is correct.

ResultsPlus
Examiner Tip

Be careful in reading the question - it is a good idea to highlight or underline key words like 'step'.

(c) This reaction takes place in a number of steps, some of which are shown below.

Step 1 $Cl_2 \rightarrow 2Cl\bullet$

Step 2 $CH_3CH_3 + Cl\bullet \rightarrow HCl + CH_3CH_2\bullet$

(i) State the type of reaction occurring in step 1 and the conditions needed for this step.

(2)

Type Initiation step (Free radical substitution)

Conditions UV light (high temperature).

ResultsPlus
Examiner Comments

The candidate has been fortunate as both parts contain additional information.

In the first part it could be construed that the candidate meant an initiation step in a free radical substitution.

In the second part the candidate is fortunate that the additional information happens to work.

ResultsPlus
Examiner Tip

Only give additional information if you are absolutely sure it is correct.

Question 20 (c) (ii)

Many candidates managed to get the correct products, chloroethane and a chorine free radical, but the use of half arrows was rarely given correctly. Full arrows were sometimes used. Often only one half of the Cl-Cl bond was broken, or there was no pairing of electrons to form the C-Cl bond.

Question 20 (c) (iii)

Most candidates were familiar with termination steps, some offering more than two which providing they were all correct were acceptable. Some misread the question and gave propagation steps. Some omitted the dots representing the unpaired electrons which lost a mark. Some put dots in the wrong places, some in the products. Some gave the electron movements correctly as well, though this was not required.

(iii) Write equations for **two** termination steps in this reaction. (2)

$CH_3CH_2\bullet + CH_3CH_2\bullet \rightarrow CH_3CH_2CH_3CH_2$

$CH_3CH_2\bullet + Cl\bullet \rightarrow CH_3CH_2Cl$

ResultsPlus
Examiner Comments

This was an instructive error. The first equation has the correct reactants but the product has a five bond carbon and a three bond carbon.

ResultsPlus
Examiner Tip

Always check the number of bonds formed by each carbon in organic formulae.

Question 20 (d)

Ethane is produced in a number of oil refinery processes and is then cracked producing high percentages of ethene and hydrogen. There were many correct answers. Even though candidates may have been unfamiliar with this starting material for cracking, many candidates applied their knowledge that ethane is always one of the products of cracking. Methane is also a product of this cracking so the equation for its formation with ethene was acceptable.

Weaker candidates lost atoms in the equation forming methane and hydrogen, or failed to produce stable compounds giving two methyl groups or even methane and CH_2.

(d) Ethane can be cracked in industry. Write an equation for the cracking of ethane.

(1)

$$C_2H_6 \xrightarrow{\text{Heat.}} C_2H_4 + H_2.$$

ResultsPlus
Examiner Comments

The addition of the word heat above the arrow in the correct equation is fine, as it is true.

ResultsPlus
Examiner Tip

It is a good idea to give extra relevant information providing it is correct.

(d) Ethane can be cracked in industry. Write an equation for the cracking of ethane.

(1)

$$CH_3CH_{3(g)} \rightarrow CH_{3(g)} + CH_{3(g)}$$

ResultsPlus
Examiner Comments

A typical incorrect response.

ResultsPlus
Examiner Tip

Always check that carbon has formed four bonds.

Question 20 (e)

Clear appreciation of why cracking of larger alkane molecules is carried out was needed here. Candidates were prone to rather vague reasons like 'more uses for the products' (which fails to say which products) or 'to form alkenes' (without reference to why alkenes are important). With this type of question it is important that candidates make a response of A level quality, expressing as much as they should know, for example 'Short chain alkenes are produced from which many other useful chemicals like poyalkenes are made'. It is also essential that candidates make their writing clear. Benefit of the doubt cannot be given to candidates where alk**A**nes could not be distinguished from alk**E**nes.

(e) Suggest **two** reasons why cracking of larger alkane molecules is important in industry.

(2)

Reason 1: because large alkenes arent very useful but smaller chain alkanes are have a variety of uses

Reason 2: produce useful alkenes

ResultsPlus
Examiner Comments

The first reason is just acceptable for one mark, though it would have been better if it had ended '...are used as fuels like petrol'.

The second is insufficient.

ResultsPlus
Examiner Tip

Always relate as much as you know which is relevant to the question.

(e) Suggest **two** reasons why cracking of larger alkane molecules is important in industry.

(2)

Reason 1: more demand for lighter fractions of crude oil

Reason 2: make more products including plastics.

ResultsPlus
Examiner Comments

The first reason is just acceptable but would have been much better if the reason for the higher demand had been given mentioning petrol for internal combustion engines.

The second reason would have been sufficient if alkenes had been mentioned, though the use of the term plastic is not strictly appropriate. Plastic is a property of a material (that allows its shape to be permanently changed when a stress is applied). The correct term here is polymer.

ResultsPlus
Examiner Tip

Be very careful to use scientific terms correctly.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice

- Write clearly, taking particular care to state symbols like (g) and (s).
- Learn the important practical techniques covered in this unit, including hazards associated with commonly used chemicals.
- Learn detail of the organic reactions of both the alkanes and the alkenes with their equations using the different types of formulae.
- Try as many calculations involving amounts and equations, and enthalpy changes as you can.

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