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June 2024

GCE Chemistry 9CH0 01

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June 2024

Publications Code 9CH0_01_2406_ER

Introduction

This paper provided candidates with the opportunity to demonstrate their knowledge and understanding of the key concepts in Topics 1 to 8 and 10 to 15 of the A Level specification. This was the third series of Chemistry A Level papers in the June examination series that had been sat by candidates since 2019 due to the impact of the Coronavirus pandemic. These candidates would have been the first to have sat public GCSE examinations since the pandemic in June 2022. The paper proved accessible to all candidates and there was no evidence that any were hindered by not having sufficient time to complete their answers. A number of the questions were found to be demanding and it was pleasing to note that many candidates rose to the challenge and demonstrated their knowledge and understanding of A Level chemistry. There were common errors of exam technique such as failing to double check answers, giving answers to the wrong number of significant figures and not reading the question properly before giving an answer. However, it was clear that many candidates were well prepared and were able to overcome the challenges of the last few years. Nonetheless, there are some key lessons for centres and candidates to learn from the feedback illustrated in the following examples.

Question 1 (a)

This was an introductory question designed to assess the candidates' ability to determine the number of sub-atomic particles in various species of sulfur.

Many fully correct answers were seen.

Common errors included not realising that the number of neutrons needed to change for each isotope and subtracting two from the proton number instead of adding two in the negative ion for the number of electrons.

There were a few instances of candidates using the mass number instead of the atomic number for the number of protons.

Species	Number of protons	Number of neutrons	Number of electrons
^{32}S	16	16	16
^{33}S	16	17	16
$^{34}S^{2-}$	16	18	18

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Examiner Comments

This is an example of a fully correct response scoring all three marks.

Species	Number of protons	Number of neutrons	Number of electrons
^{32}S	16	16	16
^{33}S	16	17	16
$^{34}S^{2-}$	16	18	14

ResultsPlus
Examiner Comments

This response scored two marks.

The first two rows are completed correctly.

In the third row, the candidate has subtracted 2 from the number of protons instead of adding 2 to obtain the correct number of electrons.

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Examiner Tip

Remember that electrons are negatively charged.

Question 1 (b)(i)-(ii)

This question required candidates to calculate a % value and then use that value to calculate the relative atomic mass of sulfur using data from 4 isotopes.

There were a few errors seen in calculating the %. Candidates should check all answers using their calculators. Candidates also lost marks for incorrect rounding of their final answer.

A few candidates lost marks for incorrect units which were penalised if incorrect.

(b) A sample of sulfur was found to contain only four isotopes.

(i) Complete the table to show the percentage abundance of ^{34}S.

(1)

Isotope	^{32}S	^{33}S	^{34}S	^{36}S
Percentage abundance	95.02	0.75	4.21	0.02

(ii) Calculate the relative atomic mass (A_r) of the sulfur in this sample using the data in the table. Give your answer to **two** decimal places.

(2)

$$(32 \times 0.9502) + (33 \times 7.5 \times 10^{-3}) + (34 \times 0.0421) + (36 \times 2 \times 10^{-4}) = 32.0925$$

$$= 32.09$$

ResultsPlus
Examiner Comments

This is an example of a fully correct response.

(b) A sample of sulfur was found to contain only four isotopes.

(i) Complete the table to show the percentage abundance of ^{34}S.

(1)

Isotope	^{32}S	^{33}S	^{34}S	^{36}S
Percentage abundance	95.02	0.75	4.21	0.02

(ii) Calculate the relative atomic mass (A_r) of the sulfur in this sample using the data in the table. Give your answer to **two** decimal places.

(2)

$$\frac{(32 \times 95.02) + (33 \times 0.75) + (34 \times 4.21) + (36 \times 0.02)}{100}$$

$$= 32.10$$

ResultsPlus
Examiner Comments

In this example the calculations are correct but the candidate has incorrectly rounded their final answer.

Question 2 (a)

This question proved challenging with many candidates confusing first electron affinity with first ionisation energy. Many candidates suggested that energy was required for the process, despite the values given in the question being for an exothermic change. There were also a number of candidates who referred to losing an electron instead of gaining it. The last marking point, relating to the effects of shielding and distance from the nucleus outweighing the effect of increased nuclear charge, was rarely awarded.

From chlorine to iodine the first electron affinity value is less negative. Iodine has the biggest ~~distance between outer ele~~ radius. So it is less easier ~~for~~ ~~Iodine~~ to ~~attract~~ add 1 mole of electron to iodine as the attraction between positive nucleus and the add electron decreases. Iodine also has more shielding, these property outweight iodine has more proton.

ResultsPlus
Examiner Comments

This is an example of a fully correct answer.

Marks were awarded for the following:

- M1 for the comment that the values become less negative going down the group.
- M2 for correct reference to the bigger radius of iodine and the effect on that of the attraction between the outer electron and the nucleus.
- M3 for the correct reference to iodine having more shielding.
- M4 for the statement that iodine has more protons but this is outweighed by the increased shielding.

2 This question is about the formation of ions.

(a) Explain the trend in the values of the first electron affinities of the elements shown.

(4)

Element	First electron affinity / kJ mol^{-1}
chlorine	−349
bromine	−325
iodine	−295

The electron affinity decreases down the group because the atoms are getting bigger. as you go down an extra shell is added meaning the ~~ionic~~ ~~atomic~~ ionic radius gets large and also theres more electron shielding from inner electrons. This means the outer electrons are more easily attracted so require less energy.

ResultsPlus
Examiner Comments

This response scored one mark.

The first mark was not awarded as the candidate needed to refer to the value becoming 'less negative' or 'less exothermic' going down the group. In fact, they have made a contradictory statement in their final sentence where they state that more energy would be required.

The second mark was not awarded, as although the candidate has referred to an increase in the number of shells, they have not stated that this would reduce the electrostatic attraction between the nucleus and the incoming electron. Additionally they have referred to 'ionic' radius.

The third mark was awarded for the increased shielding.

There is nothing creditworthy towards the fourth mark.

ResultsPlus
Examiner Tip

Take care to use the correct vocabulary when writing about chemical species. It is important to be accurate and describing atoms as 'ions' will lose marks.

Question 3 (a)(i)

This relatively straightforward question about the method for a flame test yielded many fully correct answers. However a few candidates did not mention the use of HCl, and a few described using a splint instead of a nichrome wire.

3 This question is about compounds and their chemical analysis.

Three containers of soluble white solids have lost their labels but are known to be calcium bromide, calcium iodide and potassium sulfate.

(a) (i) Describe how to carry out a flame test on these samples.

(3)

To begin a flame test use a nichromo wire so it will not react with substance, due to being inert. Dip the nichrome wire into hydrochloric acid and place ~~there~~ into a blue to get rid of any previous samples, until there is no colour. Dip inert wire into solid, place into blue flame and observe the colour produced, ~~repeat these steps~~ repeat the steps for calcium bromide, calcium iodide and potassium sulfate.

ResultsPlus Examiner Comments

This is an example of a fully correct answer with all points being made clearly.

(3)

(aqueous)
- Add nitric acid to ~~a~~ ~~beaker~~ ~~containing~~ each container ~~separate~~ of soluble white solids to remove impurities
- Flame a nichrome/~~or~~ platinum wire
- Dip the nichrome/~~or~~ platinum wire in ~~the~~ a nitric acid solution
- Hold wire over [hot] flame and observe the colour of ~~the~~ the flame.
- Repeat for both other solids.

ResultsPlus
Examiner Comments

This candidate had suggested to use nitric acid rather than hydrochloric acid and so lost a mark.

Two marks awarded.

Question 3 (a)(ii)

This question assesses candidates' knowledge of the colours of the flame tests. Many fully correct responses were seen. However it was clear that some candidates were not familiar with the colours that would be produced.

(ii) Give the expected observation for each of the flame tests.

(2)

calcium bromide

brick red

calcium iodide

brick red

potassium sulfate

lilac

ResultsPlus
Examiner Comments

This scored both marks. The responses are fully correct.

(ii) Give the expected observation for each of the flame tests.

(2)

calcium bromide

~~Gr~~ Pale green.

calcium iodide

Red

potassium sulfate

~~Purple~~ Lilac

ResultsPlus
Examiner Comments

This candidate did not score the first mark, so one mark overall.

They have given two different colours for the calcium compounds and one is incorrect.

The potassium colour of lilac is correct.

Question 3 (b)

This question was about the analysis of halide ions. Many candidates knew the colour of the precipitates formed with silver nitrate, but on occasion the formulae were incorrect, with $AgBr_2$ / AgI_2 being common wrong answers. Most candidates knew that adding ammonia would cause a change to the precipitate, but not all candidates were able to describe this correctly.

(b) Separate aqueous solutions of calcium bromide and of calcium iodide reacted with acidified silver nitrate to produce a precipitate.
Concentrated aqueous ammonia was added to each precipitate.

Complete the table.

(2)

Solution	Formula of precipitate with silver nitrate	Colour of precipitate with silver nitrate	Observation with concentrated aqueous ammonia
calcium bromide(aq)	$AgBr_{(s)}$	cream	AgBr solid dissolves
calcium iodide(aq)	$AgI_{(s)}$	yellow	AgI does not dissolve

ResultsPlus
Examiner Comments

This is a fully correct answer scoring both marks.

Solution	Formula of precipitate with silver nitrate	Colour of precipitate with silver nitrate	Observation with concentrated aqueous ammonia
calcium bromide(aq)	$AgBr_2$	cream	dissolves
calcium iodide(aq)	AgI_2	yellow	dissolves

ResultsPlus
Examiner Comments

This response did not score. The candidate has given the incorrect formula for the precipitate, the colours are correct, but then the observations with concentrated ammonia are wrong.

ResultsPlus
Examiner Tip

Learn the charges of the cations and anions in the specification.

Question 3 (c)

This question required candidates to recall a chemical test for sulfate ions. Many correct answers were seen, although some candidates did not specify the acid that would need to be added to the barium chloride to give a white precipitate specific for sulfate ions. A few candidates wrote the formula for barium chloride as BaCl instead of $BaCl_2$ and so were not credited.

(c) Describe a chemical test for the sulfate ion giving the positive result.

$BaCl_2$

(2)

Use hydrochloric acid to get rid of carbonate ions, then use $BaCl_2$ positive test would produce white precipitate of $BaSO_4$.

ResultsPlus
Examiner Comments

This is a fully correct answer scoring both marks.

Add 1cm³ of BaCL to 1g of your metal compound. A positive result will ~~see~~ show a white precipitate forming.

ResultsPlus
Examiner Comments

This did not score. Although the candidate had identified that barium chloride needed to be used, the formula was incorrect and they had omitted to add HCl or HNO_3.

Question 4 (a)

This was a straightforward question, and many correct answers were seen. A few candidates wrote the definition of a base and some gave an incorrect answer as an 'electron donor'.

Acids and alkalis are formed from their ~~[illegible]~~ conjugate base pairs

ResultsPlus
Examiner Comments

This response did not score as it did not answer the question.

Question 4 (c)

This question challenged the candidates' ability to interpret data on the pH of various acids of the same concentration. Many answers that scored three marks were seen as candidates correctly identified hydrochloric acid as a strong acid, sulfuric acid as a diprotic acid, and propanoic acid as a weak acid.

The third marking point was rarely scored as candidates did not make the connection that the pH value in the table for the sulfuric acid was not as low as expected for full dissociation of both protons and that therefore the second ionisation of sulfuric acid was suppressed by the first.

A few candidates wrote that propanoic acid was a weak acid and then contradicted themselves with an equation showing the dissociation with a forward arrow, rather than reversible arrows.

(c) Some information about acids in aqueous solution is given.

Comment on these pH values. No calculations are required.

* There fore is a strong acid

(4)

Name of acid	Formula of acid	pH of a solution of $0.100\,mol\,dm^{-3}$ acid
hydrochloric acid	HCl	1.00
sulfuric acid	H_2SO_4	0.98
propanoic acid	CH_3CH_2COOH	2.94

A pH of exactly 1.00 means HCl fully disassociates in aqueous solution. * H_2SO_4 is a diprotic acid so has two equilibria to consider. $H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$ ~~fully~~ is completely to the RHS. However, $HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$ does occur but not ~~fully~~ to completion, therefore its pH is slightly less than 1.00. Propanoic acid is a weak acid therefore most of the molecules stays as CH_3CH_2COOH rather than donating a proton. Thats why its pH is the highest because this means its $[H^+]$ is the lowest.

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Examiner Comments

This is a fully correct response. The candidate has identified that HCl fully dissociates and that H_2SO4 is diprotic. They have also realised that the second dissociation of H_2SO4 is incomplete and given a correct equation. Finally, they have described propanoic acid as a weak acid for the final mark.

Hydrochloric acid is a strong acid because it can dissosiate completely and give One mole of H^+ for each mole of acid.
Sulfuric acid can dissociate but not completly, but still it is stronger acid then HCl because it have two protons and can donate 1 or 2 H^+ per acid
Propanoic acid is a weak acid because it is an organic compound. It is more stable in aqueous solution and given 1 or 0 H^+ per acid.

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Examiner Comments

This is an example of a response that scored marks 1, 2 and 4, but the candidate did not explain in enough detail the reason why sulfuric acid could not dissociate completely.

ResultsPlus
Examiner Tip

Use all of the data in the question in your answer.

Question 4 (d)

The first part of this question required candidates to write the correct expression for the acid dissociation constant of carbonic acid and was generally well-answered.

The second part of the question required candidates to rearrange their expression to determine the concentration of hydrogen ions and then to calculate the pH.

For those candidates that did not rearrange the expression for K_a correctly, there was a mark available for working out a pH value from their concentration of hydrogen ions.

Candidates were generally familiar with the required calculation methods, but there were a few calculator errors seen and candidates should be encouraged to check their work as they go.

(d) One of the systems controlling the pH of blood is the carbonic acid–hydrogencarbonate buffer system.

$Ka = \frac{}{[HA]}$

$\frac{Ka \times HA}{A^-}$

$$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

(i) Write the expression for the acid dissociation constant, K_a, for carbonic acid. State symbols are not required.

(1)

$$Ka = \frac{[H^+][HCO_3^-]}{[H_2CO_3]}$$

(ii) A blood sample taken from an individual was analysed.

Calculate the pH of the blood sample.

Use your expression for K_a and the values shown.

K_a for carbonic acid $= 4.50 \times 10^{-7}\,mol\,dm^{-3}$

$[HCO_3^-] = 0.0240\,mol\,dm^{-3}$ $\quad$ $[H_2CO_3] = 0.00200\,mol\,dm^{-3}$

(3)

$$[H^+] = \frac{Ka\,[H_2CO_3]}{[HCO_3^-]}$$

$$= \frac{(4.5 \times 10^{-7})(0.002)}{0.024}$$

$$= 3.75 \times 10^{-8}$$

$$pH = -\log(3.75 \times 10^{-8})$$

$$= 7.43 \text{ (3sf)}.$$

ResultsPlus
Examiner Comments

This is an example of a fully correct response, scoring all available marks (1,3).

(d) One of the systems controlling the pH of blood is the carbonic acid–hydrogencarbonate buffer system.

$$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

(i) Write the expression for the acid dissociation constant, K_a, for carbonic acid. State symbols are not required.

(1)

$$Ka = \frac{[H^+][HCO_3^-]}{[H_2CO_3]}$$

(ii) A blood sample taken from an individual was analysed.

Calculate the pH of the blood sample.

Use your expression for K_a and the values shown.

K_a for carbonic acid = 4.50×10^{-7} mol dm^{-3}

$[HCO_3^-] = 0.0240$ mol dm^{-3} $[H_2CO_3] = 0.00200$ mol dm^{-3}

(3)

$$\frac{Ka \times [H_2CO_3]}{[HCO_3^-]} = H^+$$

$$\frac{(4.5 \times 10^{7})(0.002)}{0.0240} = 3.75 \times 10^{-8}$$

$$10^{-3.75 \times 10^{-8}} = 1 \ (3.s.f)$$

ResultsPlus
Examiner Comments

This response scored 1,2.

The expression for the acid dissociation constant is correct.

They have also scored the first two marks for the third part, but their pH calculation is incorrect.

ResultsPlus
Examiner Tip

Check all answers with your calculator.

Question 4 (e)

This question was about regulation of the pH of the blood.

The first part required candidates to explain the effect on the two equilibria involved after vigorous exercise.

Candidates generally answered this well in terms of the effect on the equilibria, but the second mark was often not awarded as the candidates just stated that the amount of H^+ ions would increase, rather than the concentration. A few candidates stated incorrectly that an increased hydrogen ion concentration would increase the pH.

The second part of the question was about how the buffer system in the blood works. Candidates found this more difficult to answer.

Good answers mentioned the large reservoir of hydrogen carbonate ions that would react with the H^+ ions.

(e) The relevant equilibria that maintain the pH of blood are shown.

Equilibrium **1** $CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$

Equilibrium **2** $H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$

(i) When a person exercises vigorously the concentration of carbon dioxide (aq) in the blood increases.

Explain how this increase in the concentration of carbon dioxide affects the pH of the blood.
Refer to the equilibria in your answer. No calculation is required.

(2)

if the
~~the~~ concentration CO_2 increases, the equilibrium in equilibrium ~~a~~ 1 shifts to the right to produce more H_2CO_3 (carbonic acid)
This increase in concentration of H_2CO_3 means Equilibrium 2 shifts to the right and
~~Equilibrium 2 shifts to the right &~~
more H^+ are produced.
~~more H^+ are produced.~~ ~~H^+ react with the reservoir of HCO_3^-~~
→ pH of blood decreases, as $[H^+]$ increases

(ii) Explain how the carbonic acid–hydrogencarbonate buffer system in Equilibrium **2** acts to restore the pH of the blood after a person has exercised.

(2)

~~the $[H^+]$ more H^+ are formed due to increase~~
H^+ react with the large reservoir of HCO_3^- to form carbonic acid H_2CO_3
the equilibrium 2 shifts to the left as H^+ are removed
$[H_2CO_3]$ and $[H^+]$ do not significantly change

ResultsPlus
Examiner Comments

This is an example of a fully correct response to both parts of the question, scoring all of the marks (2,2).

For the first part, the candidate has referred correctly to both equilibria moving to the right and they have made a correct statement linking the increased $[H^+]$ to the reduced pH.

For the second part, the candidate has correctly referenced the large reservoir of hydrogen carbonate ions which react with the H^+ ions.

(e) The relevant equilibria that maintain the pH of blood are shown.

Equilibrium **1** $CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$

Equilibrium **2** $H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$

(i) When a person exercises vigorously the concentration of carbon dioxide (aq) in the blood increases.

Explain how this increase in the concentration of carbon dioxide affects the pH of the blood.
Refer to the equilibria in your answer. No calculation is required.

(2)

The increase in CO_2 will shift Equillibrium 1 to the right to balance it out. this will increase the H_2CO_3 causing Equillibrium 2 to shift to the right as well causing an increas in $[H^+]$ causing an ~~decrease~~ increase in PH of the blood.

(ii) Explain how the carbonic acid–hydrogencarbonate buffer system in Equilibrium **2** acts to restore the pH of the blood after a person has exercised.

(2)

As the concentration of H^+ increase so does the conentration of HCO_3^- Meaning they are able to neutralise one another and keep the PH constant.

ResultsPlus
Examiner Comments

This response scored just one mark overall (1,0).

For the first part, the candidate had correctly referenced the effect of exercise on both equilibria.

However they had linked an increase in hydrogen ion concentration to an increase, rather than a decrease, in pH.

For the second part, although the candidate knew that hydrogen carbonate ions were involved, they had not fully explained their role in regulating blood pH after exercise.

ResultsPlus
Examiner Tip

Remember that a high concentration of H^+ ions is linked to a low pH.

Question 5 (a)

The question required the calculation of an enthalpy change using bond energy data.

While many correct answers of –1276 were seen, a few candidates subtracted the energy change for the bonds forming from the energy change for the bonds breaking and so gained an answer of +1276, scoring two of the three marks.

Many candidates did not check their answers to ensure that they had taken account of all of the bonds being broken or made, and a few calculator errors were seen.

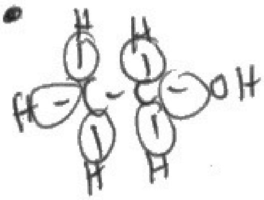
5 This question is about 'Direct Ethanol Fuel Cells' which are being developed to power small electronic devices.

The overall reaction in these fuel cells is shown.

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 3H_2O(l) + 2CO_2(g)$$

(a) Calculate the enthalpy change for the reaction using the mean bond enthalpy data.

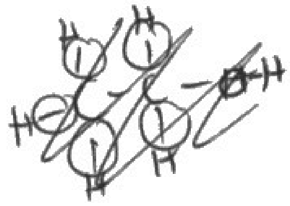
(3)



$5(413) + 347$
$+ 358 + 464$

• $3\ O=O$
$= 3(498)$

Bond	Mean bond enthalpy / $kJ\,mol^{-1}$
C—C	347
C—H	413
C—O	358
O—H	464
O=O	498
C=O	805



• $O-H-O$
$3(2 \times 464)$

• $O=C=O$
$2(2 \times 805)$

HRP

$\Delta H = R - P$ · ΔH = Reactants − products
bonds broken − bonds made.

• Reactants $= 5(413) + 347 + 358 + 464 + 3(498)$
$= 4728$

• products $= 3(2 \times 464) + 2(2 \times 805)$
$= 2784 + \cancel{322} \; 3220$
6004

• $\Delta H = 4728 - 6004$
$= -1276$

Enthalpy change = −1276 $kJ\,mol^{-1}$

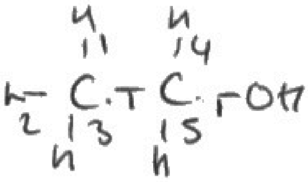
ResultsPlus
Examiner Comments

This is a fully correct answer where the candidate has taken care to include all of the bonds and has also circled their answers so that they can keep track of their progress.

ResultsPlus
Examiner Tip

Write out all expressions for bond energy and check your calculations.

C_2H_5OH + $3O_2$



$O=O$

$\left.\right\}$ $498 \times 3 =$ 495

$C-H = 413 \times 5$
$C-C = 347 \times 1$
$C-O = 358 \times 1$
$OH = 464 \times 1$

$3234 + 495 = \boxed{3729}$

PRODUCTS:

$2\ O-H = (464 \times 2) \times 3$ 2784

$= \boxed{6004 =}$

$O=C=O$

$2\ C=O = (805 \times 2) \times 2$ 3220

$6004 - 3729 = 2275$

Enthalpy change = (+)2275 kJ mol^{-1}

ResultsPlus Examiner Comments

This response scored one mark overall. The enthalpy change for the bonds being made was calculated correctly, but the enthalpy change for the bonds breaking was incorrect. The candidate could still have scored the third mark for overall enthalpy change, but they have done the subtraction the wrong way round (bonds made – bonds broken, instead of bonds broken – bonds made).

ResultsPlus Examiner Tip

Remember breaking bonds is endothermic (+) and making bonds is exothermic (-).

Question 5 (b)

This question required candidates to complete an enthalpy cycle and then to use their cycle to calculate the enthalpy change in the Direct Ethanol Fuel Cell.

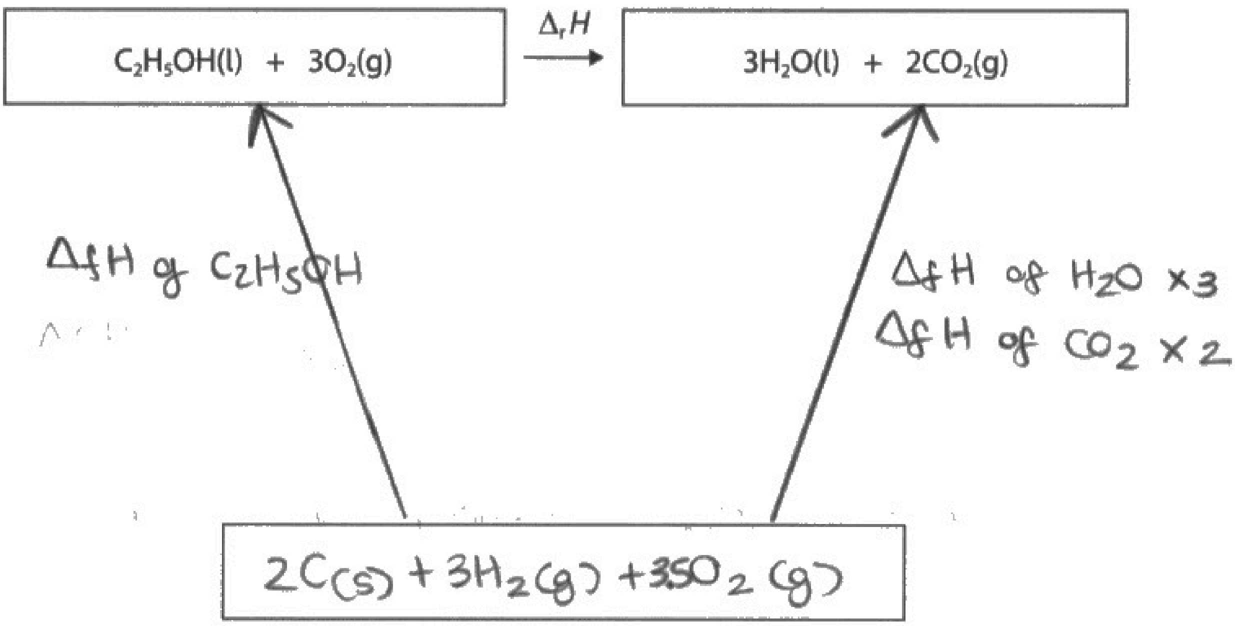
The first mark, for completion of the cycle, was awarded more frequently than the second. Candidates were sometimes unsure which substances to place in the bottom box, with marks lost for unbalanced oxygen and for incorrect state symbols.

Many correct answers were seen for the value of the enthalpy change, but some candidates did not take into account the moles of water and carbon dioxide and a few obtained an incorrect answer of +1369 instead of –1369, having used their cycle incorrectly.

(b) (i) Complete the enthalpy cycle for the overall reaction in the Direct Ethanol Fuel Cell. Include labels.

(2)

Substance	$\Delta_f H^\ominus$ / kJ mol^{-1}
$C_2H_5OH(l)$	−277
$CO_2(g)$	−394
$H_2O(l)$	−286



(ii) Calculate a value for the enthalpy change of the Direct Ethanol Fuel Cell reaction, using your cycle.

(1)

$277 + (-394 \times 2) + (-286 \times 3)$

$= -1369$

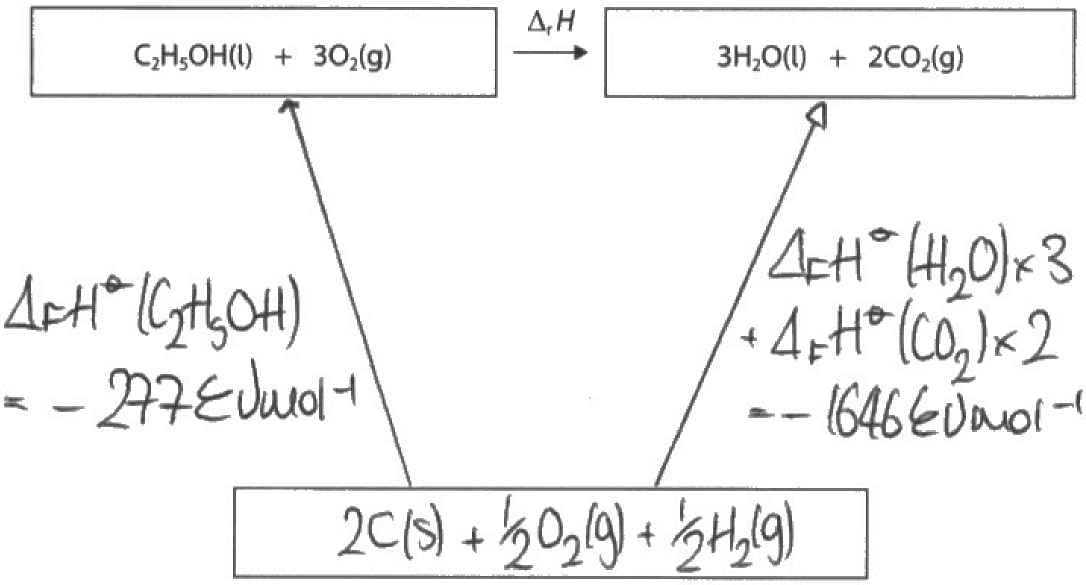
Enthalpy change = −1369 kJ mol^{-1}

ResultsPlus
Examiner Comments

This is a fully correct response, scoring 2,1.

ResultsPlus
Examiner Tip

Clear diagrams help to ensure that calculated answers are correct.



(ii) Calculate a value for the enthalpy change of the Direct Ethanol Fuel Cell reaction, using your cycle.

(1)

$\Delta_r H = 277 - 1646$

$= -1369$ kJ mol^{-1}

Enthalpy change = -1369 kJ mol^{-1}

ResultsPlus
Examiner Comments

This candidate scored the first mark for the cycle but the oxygens and the hydrogens are unbalanced in the box.

Their calculation is correct.

Score 1,0.

ResultsPlus
Examiner Tip

Check that the amounts of all substances are correctly balanced.

Question 5 (c)

This question required candidates to give the reasons for differences between the values for the enthalpy change of reaction calculated using bond energy values and by using values for standard enthalpies of formation.

The majority of candidates who were awarded at least one mark for this question realised that mean bond energies were used in the calculations, which would not be the specific value for the bond in the molecules in the question.

The second mark was for stating that the bond energy values given were for substances in the gas state and that water and ethanol are liquids. This was awarded less often, with a common insufficient answer being that the standard enthalpies of formation were under standard conditions.

(c) Give **two** reasons for the difference between your calculated values in (a) and (b).

(2)

~~d)~~ • value in (a) assumes all bonds are in gaseous state wheras in (b) it consides the fact that ethanol is in liquid state

• value (a) uses mean bond enthalpy which is different to the specific bond enthalpies of the reactants and products which is considered in (b)

ResultsPlus
Examiner Comments

This response scored two marks.

The second mark was awarded for the first sentence. The candidate has identified ethanol as being in the liquid state but it was sufficient to mention that the bond enthalpy values are given for the substances in the gas state without mention of ethanol or water specifically to score the mark.

• Mean bond enthalpy data is an average so will not be specific to the bond in context of the molecule.

• Mean bond enthalpy data isn't from bonds under standard conditions like in the ~~fuel cell.~~ enthalpies of formation.

ResultsPlus
Examiner Comments

This response scored one overall.

The first mark was awarded for the statement about the mean bond enthalpies being used.

The second mark was not awarded as the reference to standard conditions was not sufficient for this mark.

Question 5 (d)

The question was about the reactions at the electrodes in the Direct Ethanol Fuel Cell.

Candidates were asked to write balanced ionic equations for both the oxidation and reduction reactions.

The reduction half-equation was more often awarded than the oxidation equation.

(d) In the Direct Ethanol Fuel Cell under acidic conditions, at one electrode the ethanol is oxidised in the presence of water to produce carbon dioxide, hydrogen ions and electrons. loss

At the other electrode, the hydrogen ions and electrons combine with oxygen to form water.

Write the two ionic half-equations for this process.
State symbols are not required.

(2)

Oxidation half-equation OIL

$C_2H_5OH + 3H_2O \rightarrow 2CO_2 + 12H^+ + 12e^-$

Reduction half-equation RIG

$2H^+ + \frac{1}{2}O_2 + 2e^- \rightarrow H_2O$

ResultsPlus
Examiner Comments

This is a fully correct response scoring both marks.

Oxidation half-equation

$C_2H_5OH + H_2O \rightarrow CO_2 + H^+$

Reduction half-equation

$2H^+ + 2e^- + O_2 \rightleftharpoons H_2O$

ResultsPlus
Examiner Comments

This response did not score. The first equation is incorrect and the second equation is not balanced.

ResultsPlus
Examiner Tip

Check that equations are balanced.

Question 6

This extended response question was about d-block elements and the colours formed in aqueous solution.

Many candidates started their responses by giving the electron configurations of copper, iron and zinc.

While many correct electron configurations were given there were some that incorrectly included 4s electrons in the electron configurations of the ions.

A general understanding of how the colours arise was shown, but candidates lost marks for not mentioning that it is the ligand that splits the d-subshell and that the energy gap between the split d-orbitals is linked to the colour seen.

Some candidates said that the colour arose when light was emitted when an electron dropped back down, but this would be for a flame test, rather than for an aqueous solution where the colour seen is the complementary colour of the light absorbed during the d-d transition.

There was, on occasion, careless use of the words 'subshell' and 'orbital' which some candidates used interchangeably. The incorrect mention of a single d-orbital instead of 'd-orbitals' or 'd-subshell' was penalised by the loss of a mark.

*6 Explain why aqueous solutions of Cu^{2+} ions and Fe^{2+} ions are coloured but have different colours, whereas aqueous solutions of Zn^{2+} ions are colourless. Include any relevant electronic configurations.

(6)

-> Cu^{2+} and Fe^{2+} are transition metal ions, so have an incomplete d sub shell ~~orbital~~ ~~ie Cu^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$~~

ie $Cu^{2+}: 1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ ~~Fe^{2+} $1s^2 2s^2 2s^2$~~

$Fe^{2+}: 1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

-> A full d sub shell ~~orbital~~ $= 3d^{10}$, $\therefore$ Cu^{2+} + Fe^{2+} both have incomplete ~~comp~~ d subshells.

-> In aqueous solution ~~the~~ the ions form a ~~complex~~ a complex ie $[Cu(H_2O)_6]^{2+}$ and $[Fe(H_2O)_6]^{2+}$, and the water ligands cause ~~the~~ splitting of the 3d subshell into 2 energy levels. As the subshell is incomplete, when light is incident, light photons with ~~the~~ ~~a~~ the energy equal to the energy difference in the split d energy levels are absorbed to cause an electron to transition from the ~~lower~~ lower to higher energy level. ~~and~~ The wavelengths of light which are not absorbed are reflected, and these wavelengths of light are the colour produced.

Cu^{2+} and Fe^{2+} ions produce different colours as they have a different energy gap between the two split d orbitals, therefore light with a different wavelength is needed and absorbed to cause electron transitions, so different wavelengths of light are reflected and seen.

-> Zn^{2+} ions are colourless as Zn^{2+} ions ~~have a~~ do not have an incomplete d subshell ~~or~~, it has a full d subshell.

$Zn^{2+}: 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$

Therefore, no electron transitions can occur from the lower energy level to the higher energy level, so no light is ~~absorbed~~, absorbed and all wavelengths are ~~p~~ reflected.

ResultsPlus
Examiner Comments

This response scored all six marks.

IP1 – was awarded for the correct electron configurations of Cu^{2+} and Fe^{2+} at the start of the response.
IP2 – in the second paragraph there is a statement about the ligand splitting the d-subshell.
IP3 – although this is alluded to in the second paragraph this would be insufficient for the mark as it does not make a link between the energy gap and the different colours. There is a detailed correct explanation in the penultimate paragraph which scores this mark.
IP4 – is scored in the second paragraph
IP5 – is also scored in the second paragraph.
IP6 – for the correct electron configuration of Zn^{2+} given at the bottom of the response, together with a comment that its d-subshell is full.

***6** Explain why aqueous solutions of Cu^{2+} ions and Fe^{2+} ions are coloured but have different colours, whereas aqueous solutions of Zn^{2+} ions are colourless.
Include any relevant electronic configurations.

(6)

Because Cu and Fe are transition metals.
Transition metals are metals that can form ions with a partially filled d-subshell.
Transition metals are able to form coloured compounds, have various oxidation numbers and form complexes.

$Cu^{2+} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^9$

$Fe^{2+} = 1s^2, 2^2, 2p^6, 3s^2, 3p^6, 3d^6$

$Zn^{2+} = 1s^2, 2s^2, 2p^6, 3s^2, 3d^6, 3d^{10}$

1s
2s 2p
3s 3p 3d
4s 4p 4d 4f
2 6 10 14

24

Cu^{2+} and Fe^{2+} have incomplete d-subshells so they are transition metals and hence are able to form different colours.

Zn^{2+} however, although it is in the d-block of the periodic table, it is not a transition metal because it forms an ion with a complete d-subshell / $3d^{10}$ hence its appearance is colourless.

Cu^{2+} is green. Fe^{2+} is pale green.

ResultsPlus
Examiner Comments

This response scores two marks.

IP1 – is scored for the correct electron configurations of Cu^{2+} and Fe^{2+}.

IP6 – is scored for the correct electron configurations of Zn^{2+} and the comment that the 3d-subshell is full.

There is nothing else creditworthy in this response.

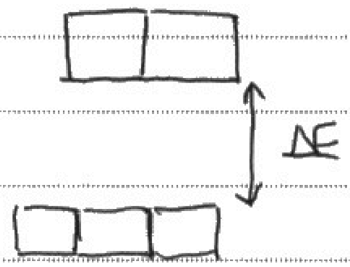
Cu^{2+} is [Ar] $4s^0 3d^9$

Fe^{2+} is [Ar] $4s^0 3d^6$

Zn^{2+} is [Ar] $4s^0 3d^{10}$

A transition metal form a stable ion with a partially filled d subshell. So Cu and Fe are transition metals but Zn is not as Zn^{2+} has ~~a~~ fully filled d-orbital.

When Cu^{2+} and Fe^{2+} complexes form the ligand causes ~~d~~ the d-orbital to split into two different energy levels.



ΔE is different for both Cu^{2+} and Fe^{2+}. Different amounts of energy are required to promote and eletron to a higher energy level, and the energy left is transmitted as color.

Zn^{2+} is colorless because there is no free orbital for the electron to be promoted to so no energy is absorbed hence there is no energy left to be transmitted as color

ResultsPlus
Examiner Comments

This could have scored 5 marks, but the overall score is 4 due to incorrect use of 'orbital', 'orbitals' and 'subshell'.

IP1 – is scored for the correct electron configurations of Cu^{2+} and Zn^{2+}.

IP2 – is not awarded as although the candidate has stated that the ligand would split the d-orbital this is incorrect use of language and they are penalised for not referring to the ligand splitting the d-subshell or the d-orbitals.

IP3 – is awarded for an explanation of the different energy differences in Cu^{2+} and Fe^{2+} and relating this to the colour seen.

IP4 – is not awarded as although the candidate has mentioned the electron being promoted, they have not mentioned light energy.

IP5 – is awarded for the energy left being transmitted as colour.

IP6 – is awarded, as although the candidate has described Zn^{2+} as having a fully filled d-orbital instead of subshell, this error has already been penalised and the electron configuration of Zn^{2+} is correct.

ResultsPlus
Examiner Tip

Take great care with the use of 'orbital', 'orbitals' and 'subshell'.

Question 7 (b)

This question required candidates to write two equations to show the catalytic activity of vanadium pentoxide (V_2O_5).

Some correct answers were seen, but also many unbalanced equations and some equations which did not include any vanadium compounds.

(b) Write **two** equations that show the conversion of SO_2 and O_2 into SO_3 by using V_2O_5 as the catalyst.
State symbols are not required.

(2)

$$V_2O_5 + SO_2 \cancel{+O_2} \rightarrow V_2O_4 + SO_3$$

$$V_2O_4 + \frac{1}{2}O_2 \rightarrow V_2O_5$$

ResultsPlus
Examiner Comments

This is an example of a fully correct answer scoring two marks.

(2)

$$SO_2 + \frac{1}{2}O_2 + V_2O_5 \rightleftharpoons SO_3 + V_2O_5$$

ResultsPlus
Examiner Comments

This response did not score.

The equation is an attempt to show the overall reaction to form SO_3 from SO_2.

There is no change in the oxidation state of vanadium and only one equation has been given.

Question 8 (a)

This question required candidates to draw dot-and-cross diagrams of the ions in magnesium hydroxide.

Whilst most candidates drew ions, there were a significant number of candidates who drew covalent bonding diagrams.

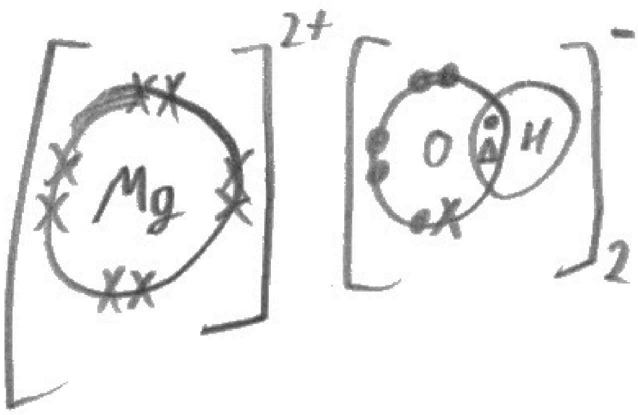
The Mg^{2+} ion was generally drawn correctly, with most of the errors seen being with the hydroxide ion. On occasion the charges were omitted and some candidates only gave one hydroxide ion instead of two.

8 This question is about ionic compounds.

(a) Draw dot-and-cross diagrams of the ions in magnesium hydroxide, showing the outer shell electrons only.

Use × for magnesium electrons, ● for oxygen electrons and △ for each hydrogen electron.

(2)

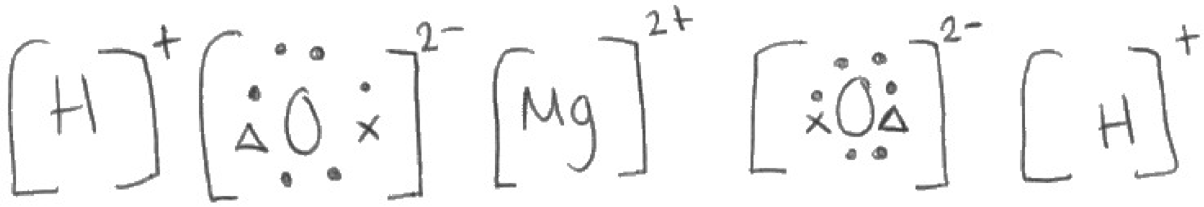


ResultsPlus
Examiner Comments

This is a fully correct response showing a correct Mg^{2+} ion and two correct OH^- ions.

hydrogen electron.

$Mg(OH)_2$ **(2)**



ResultsPlus
Examiner Comments

This response scored one mark.

The structure of the Mg^{2+} ion is correct.

However, although the candidate has recognised that there should be two hydroxide ions, the structures are not correct.

Question 8 (c)(i)-(ii)

This question required candidates to complete a Born-Haber cycle for MgF_2 and calculate the standard enthalpy of formation.

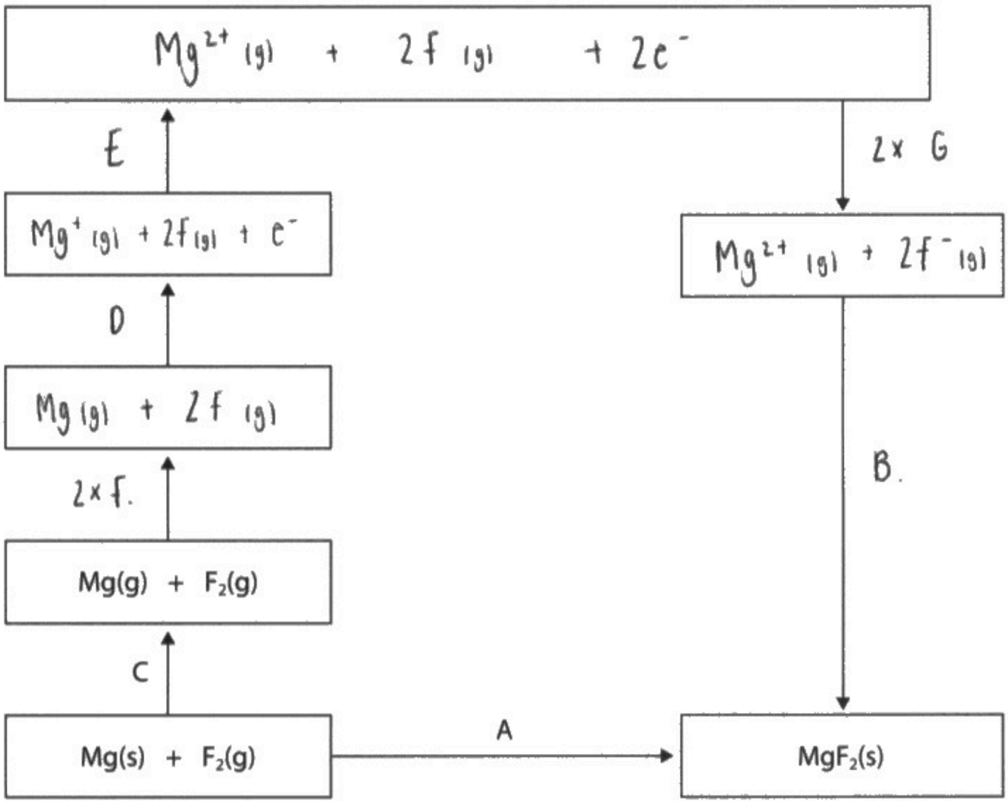
Four marks were allocated for the completion of the cycle and one for the calculation.

Most candidates scored the first mark for adding the labels in the correct places and many realised that they would need to double the enthalpy change of atomisation of fluorine and first electron affinity of fluorine.

Some candidates failed to write the correct species in the boxes, in particular when converting F_2 to 2F, and on occasion the electrons and state symbols were missing.

(i) Complete the Born–Haber cycle for magnesium fluoride with formulae, state symbols, electrons and correctly labelled arrows.
The cycle is not drawn to scale.

(4)



(ii) Calculate the value of $\Delta_f H^\ominus$ [$MgF_2(s)$].

(1)

$\Delta_f H^\ominus [MgF_2(s)] = C + 2F + D + E + 2G + B.$

$= 148 + 2(79) + 738 + 1451 + 2(-328) + (-2957).$

= ~~+2069 kJmol~~.

1118

$= -1118 \text{ kJ mol}^{-1}$

ResultsPlus Examiner Comments

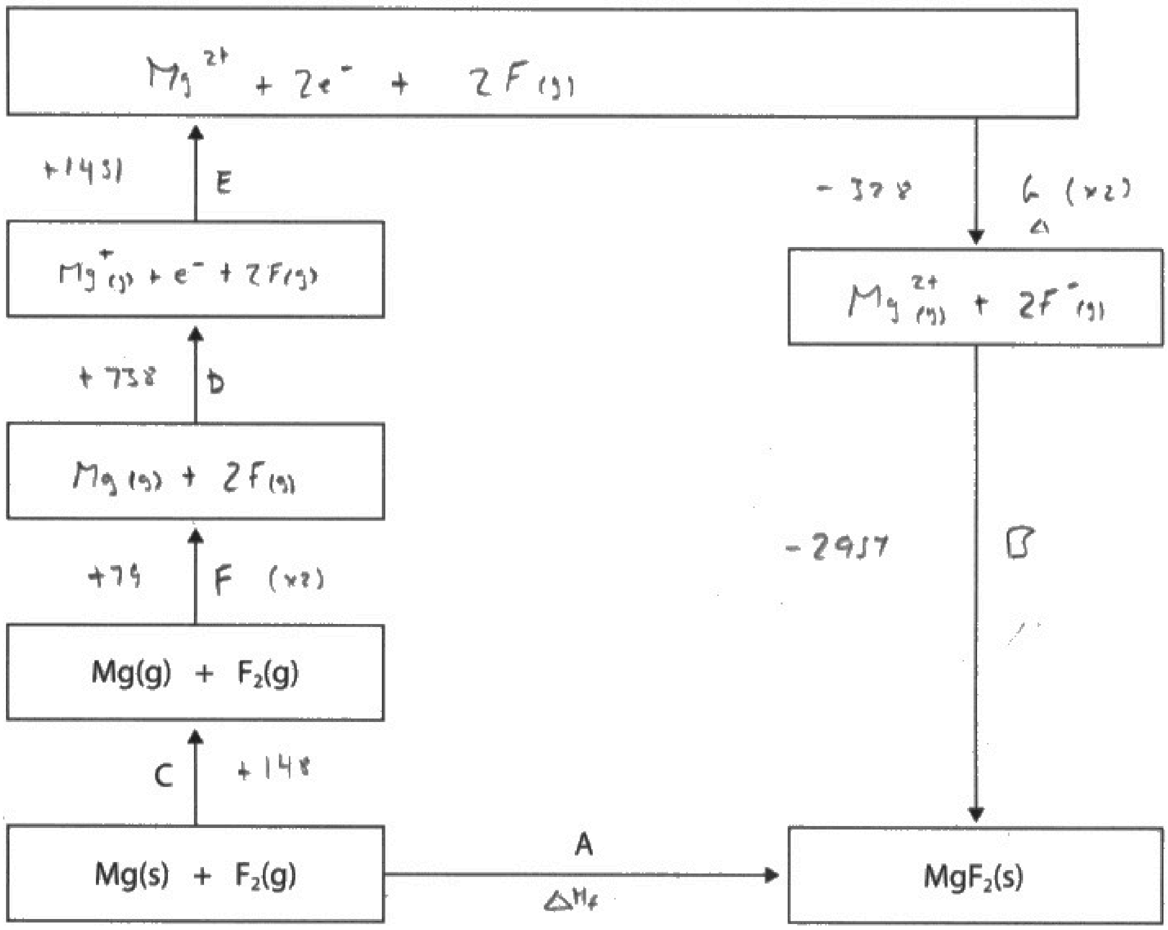
This is an example of a fully correct answer, scoring 4,1.

All of the labels are correct, including a clear indication of doubling F and G.

The species are correct, as are the state symbols and electrons and the final calculation is correct.

(i) Complete the Born–Haber cycle for magnesium fluoride with formulae, state symbols, electrons and correctly labelled arrows.
The cycle is not drawn to scale.

(4)



(ii) Calculate the value of $\Delta_f H^\ominus[MgF_2(s)]$.

(1)

$\Delta H_f = -\Delta H_{latt} - 2(\Delta H_{ea} F) - \Delta H_{1st\ IE} - \Delta H_{2nd\ IE} - \Delta H_{a}\,Mg - 2(\Delta H_a F)$

$-(-2957) - 2(-328) - (1451) - (738) - 2(79) - (148)$

$= +1118\ kJ\ mol^{-1}$

ResultsPlus
Examiner Comments

This response scored 3 in total (3,0).

The labels and species were correct, but a state symbol had been missed from the Mg^{2+} in the top box.

The calculation had yielded +1118 instead of –1118 kJ mol^{-1} and so was not awarded.

ResultsPlus
Examiner Tip

Check Born-Haber cycles for consistency so that minor errors do not creep in.

Question 8 (c)(iii)

Candidates were required to evaluate data on the theoretical and experimental lattice energies of two compounds.

Candidates were generally able to make a link between the data and the bonding in the compounds, with many candidates realising that MgI_2 would have some covalent character thus scoring the second mark.

Some candidates clearly understood that the MgF_2 would be almost 100% ionic, but just stated that MgF_2 had less covalent character than MgI_2 and so did not score M1.

Candidates sometimes did not score M3 due to careless slips when describing species. Examples included describing the ionic lattice as a 'molecule' and referring to iodine atoms or molecules being more polarisable.

Very few candidates were awarded M4 as they were focused on the differences between the experimental and theoretical lattice energies in their answers and so did not compare the values for MgF_2 and MgI_2.

(iii) The experimental and theoretical values of the lattice energy for MgF_2 and MgI_2 are given in the table.

Explain the differences in these values.

(4)

Compound	Experimental lattice energy / kJ mol^{-1}	Theoretical lattice energy / kJ mol^{-1}
MgF_2	−2957	−2913
MgI_2	−2327	−1944

• MgI_2 has a larger difference in experimental and theoretical lattice energies compared to MgF_2.

• This is because I^- has a much larger ionic radius than F^-.

• So Mg^{2+} is able to polarise the I^- ion more than F^- distorting its electron cloud.

• This introduces covalent character in MgI_2 which makes the ~~Mg I~~ Mg−I bond stronger

• So more energy is ~~for~~ released when MgI_2 formed than predicted

• Less polarisation in MgF_2 so ~~for~~ almost 100% ionic character.

ResultsPlus
Examiner Comments

This response scored three marks, M1, M2 and M3.

MgF_2 is described as being ionic and MgI_2 as having covalent character.

The description of the iodide ion being polarised by the Mg^{2+} ion is correct.

Nothing creditworthy for M4.

Question 9 (a)-(b)

This question was about entropy and Gibbs free energy and required candidates to determine the minimum required temperature for a chemical reaction from given data.

Part (a)

For the first mark the candidates needed to calculate the entropy change of the system. Many correct answers were seen.

For the second part the candidates needed to calculate the Gibbs free energy and comment on why the reaction was not feasible.

Candidates needed to convert both the entropy and the enthalpy change of the reaction so that both were in J or kJ and then calculate the Gibbs free energy change.

The most frequent mark that was lost was for not giving the correct units for Gibbs free energy that would be consistent with their calculation.

The third mark proved accessible with many correct responses noting that the reaction would not be feasible at 298K as the Gibbs free energy change was positive.

Part (b)

Candidates needed to rearrange the Gibbs free energy equation to calculate a feasible temperature in K.

They then needed to convert this to °C for the final answer.

There was an alternative route to the same answer via a total entropy change of 0. Few candidates opted for this method.

Many fully correct answers were seen, with a few candidates adding 273 instead of subtracting it to convert from K to °C.

9 Sodium hydrogencarbonate is used as a raising agent in baking as carbon dioxide gas is released when it undergoes thermal decomposition.

(a) Show that this reaction is **not** feasible at 298 K by calculating ΔG.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l) \qquad \Delta_r H = +91.6\,kJ\,mol^{-1}$$

(3)

Compound	$NaHCO_3(s)$	$Na_2CO_3(s)$	$CO_2(g)$	$H_2O(l)$
Standard molar entropy / $J K^{-1} mol^{-1}$	101.7	135.0	213.6	69.9

$\Delta S_{system} = (69.9 + 213.6 + 135) - (101.7 \times 2)$

$= +215.1\ J\ K^{-1}\ mol^{-1}$

~~ΔG~~ $\Delta G = \Delta H - T\Delta S$

$= +91.6 - 298 \times \frac{215.1}{1000}$

$= +27.5\ kJ\ mol^{-1}$

Since ΔG is positive, this reaction is not feasible at 298 K.

(b) Calculate the minimum temperature, in degrees Celsius (°C), at which an oven should be set for this reaction to be thermodynamically feasible.

(2)

$\Delta H - T\Delta S = 0.$

$91.6 - T \times 0.2151 = 0$

~~T~~ $0.2151\,T = 91.6$

$T = \frac{91.6}{0.2151}$

$= 425.8\ K$

$= 152.8\ °C$

Minimum temperature = 152.8 °C

ResultsPlus Examiner Comments

This is a fully correct answer scoring all five marks (3,2).

The calculation of the entropy change of the system, change in Gibbs free energy and the comment about feasibility are all correct.

Their calculation for part (b) is also correct via the Gibbs free energy route.

$$\Delta G = \Delta H - 298\,\Delta S_{\cancel{total}\ system}$$

$$\Delta S_{system} = ((69.9) + 213.6 + 135) - (2 \times 101.7)$$

$$= \frac{837}{2} - 2(101.7)$$

$$= 215.1\ \text{JK}^{-1}\text{mol}$$

$$\Delta G = 91.6 - 298\left(\frac{215.1}{1000}\right) = \Delta G = +27.5002$$

$$= +27.5$$

ΔG is positive ~~so~~ (+ve) and so reaction is not feasible at 298 K

ResultsPlus Examiner Comments

This is part (a) of the candidate's answer and they have been awarded two marks.

They have not given a unit for their change in Gibbs free energy.

ResultsPlus Examiner Tip

Check that you have added units and that they are correct.

Question 10 (a)

This question required candidates to give a detailed method for producing a solution of a vitamin C tablet.

Although many correct answers were seen, some candidates omitted to specify that distilled or deionised water should be used. There were a few candidates who did not reference using a volumetric flask, with a conical flask being the most common alternative.

A few candidates omitted transferring the washings and a few did not state that the solution needed to be mixed once it was made up to the mark on the volumetric flask.

10 Vitamin C has the molecular formula $C_6H_8O_6$.

The label on a bottle of vitamin C tablets stated that a 2.50 g tablet contained 6% of vitamin C by mass. The tablet was analysed to check the accuracy of the label. The procedure involved a series of steps.

(a) Step **1** Dissolving the tablet.

A 2.50 g vitamin C tablet was crushed and dissolved to make an aqueous solution of volume 250.0 cm^3.

Describe how to make this solution from the crushed tablet.

(3)

Pour crushed tablet into a beaker. Add about 100 cm^3 distilled water. Stir to dissolve tablet (use stirring rod). Pour this beaker's contents down the rod into a volumetric flask (250 cm^3). Rinse washings of beaker into flask to ensure all traces of tablet go into flask. Fill rest of flask until 250 cm^3 mark with distilled water. Place on lid, invert to mix.

ResultsPlus
Examiner Comments

This response scored all three marks with a clear reference to each marking point.

Crush tablet and transfer to beaker
Add distilled water to beaker to dissolve tablet and stir
Pour solution into volumetric flask using funnel
Rinse beaker with distilled water and pour washings into volumetric flask
Make up to the mark of volumetric flask with distilled water

ResultsPlus
Examiner Comments

This response scored two marks.

The candidate described the method correctly but did not mention mixing the solution once it was made.

Question 10 (b)(i)

This was generally well-answered with many fully balanced equations seen.

Some errors included unbalanced water molecules or adding electrons instead of water.

(b) Step **2** Producing a known amount of iodine.

Iodine was produced by reacting 25.0 cm^3 of 0.0100 mol dm^{-3} potassium iodate with excess potassium iodide and hydrochloric acid in a conical flask.

(i) Complete the ionic equation for the formation of the iodine from 1 mol of IO_3^- ions.

(1)

$$IO_3^- + \ldots 5 \ldots I^- + \ldots 6 \ldots H^+ \rightarrow 3I_2 + \ldots 3H_2O \ldots$$

ResultsPlus
Examiner Comments

This is a fully correct response scoring the mark.

$$IO_3^- + \ldots 6 \ldots I^- + \ldots\ldots H^+ \rightarrow 3I_2 + \ldots 6e^- \ldots$$

ResultsPlus
Examiner Comments

This candidate had interchanged the numbers for the I^- and the H^+. They also added electrons at the end instead of water molecules and so did not score the mark.

Question 10 (b)(ii)

This was an accessible question towards the end of the paper and as such, was well-answered.

Nevertheless a few candidates did not make it clear how they had reached the final answer by multiplying their first answer by 3 and lost the mark. A few candidates gave the wrong 'power of 10' to their first answer, for example, 2.3×10^{-3} was seen relatively often in responses that did not score.

(ii) Show, by calculation, that 7.50×10^{-4} moles of iodine were produced in the flask.

(2)

$25 cm^3 \div 1000 = 0.025 dm^3$

$0.025 dm^3 \times 0.01 mol dm^{-3} = 2.5 \times 10^{-4}$ mol of IO_3^-

1 : 3 molar ratio

$2.5 \times 10^{-4} \times 3 = 7.5 \times 10^{-4}$ mol of I_2 as shown.

ResultsPlus
Examiner Comments

This candidate has made it clear how they calculated their final value and therefore this scores the full two marks.

(2)

$n(IO_3^-) = \frac{25}{1000} \times 0.01$

$= 0.025$ ~~$\times 3 = 7.50 \times 10^{-8}$~~

$0.025 \times 3 = n(I_2) = 7.50 \times 10^{-8}$

ResultsPlus
Examiner Comments

This response did not score as they had shown the moles of potassium iodate to be 0.025 instead of 0.00025.

Question 10 (c)(i)

This question required the candidates to determine which was the most appropriate indicator for a redox titration involving iodine and then to describe the colour change at the end-points.

The indicator was frequently correctly identified as starch, but the candidates found it more difficult to give the correct colour change.

Where a wrong indicator was given, it was frequently phenolphthalein.

(c) Step **3** Titrating with sodium thiosulfate solution.

$10.0\,cm^3$ of the vitamin C tablet solution from Step **1** was added to the conical flask from Step **2** to react with the iodine produced, as shown in the equation.

$$C_6H_8O_6(aq) + I_2(aq) \rightarrow C_6H_6O_6(aq) + 2HI(aq)$$

The unreacted iodine in the conical flask was titrated with a solution of $0.100\,mol\,dm^{-3}$ sodium thiosulfate, $Na_2S_2O_3(aq)$.

The mean titre was $14.40\,cm^3$.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

(i) State the indicator used in this titration, giving the colour change that would be observed at the end-point.

(2)

starch, blue/black to colourless

ResultsPlus
Examiner Comments

This response is fully correct and scored two marks.

- Starch indicator
- change goes from orange to blue black

ResultsPlus
Examiner Comments

This response scored one mark for the correct indicator. The colour change is incorrect as it should be from blue-black to colourless.

ResultsPlus
Examiner Tip

Look carefully at the equation used for a titration to work out the colour change.

Question 10 (c)(ii)

Many candidates were able to work their way through this redox titration calculation logically and gain all or most of the marks. Common errors included failing to carry out the step to determine the moles of iodine that reacted or making an error in the calculation of the relative formula mass of ascorbic acid.

(ii) **Deduce, by calculation, whether the label on the bottle of vitamin C tablets is correct.**

(6)

mean titre $14.4 cm^3$

$[Na_2S_2O_3] = 0.1 mol/dm^3$

Then $n_{S_2O_3^{2-}} = \frac{14.4 cm^3}{1000 cm^3/dm^3} \cdot 0.1 mol/dm^3 = 1.44 \times 10^{-3}$ mol

Because $n_{S_2O_3^{2-}} : n_{I_2} = 2:1$,

$n_{I_2} = 7.2 \times 10^{-4}$ mol left

There were originally 7.5×10^{-4} mol I_2,

so $0.3 \times 10^{-4} = 3 \times 10^{-5}$ mol used up

Now $n_{I_2} : n_{VitC} = 1:1$ so there is 3×10^{-5} mol of $C_6H_8O_6$ in the solution. ($10 cm^3$ of soln.)

Then in total there is $\frac{250}{10} \cdot 3 \times 10^{-5}$ mol

$= 7.5 \times 10^{-4}$ mol

The molar mass is 176g/mol

so mass 0.132g

$\frac{0.132g}{2.5g} \cdot 100\% = 5.28\%$

So because $5.28\% < 6\%$, the label is incorrect

ResultsPlus
Examiner Comments

This is a fully correct response scoring all six marks.

The candidate has laid their work out clearly and logically, helping them keep track of this multi-step calculation.

ResultsPlus
Examiner Tip

When working through a multi-step calculation, lay your work out clearly so that you keep track of what you have done.

(ii) Deduce, by calculation, whether the label on the bottle of vitamin C tablets is correct.

(6)

6% of 2.50 = 0.15 g of $C_6H_8O_6$

n of $Na_2S_2O_3$:

$n = 0.1 \times \frac{14.40}{1000} = 1.44 \times 10^{-3}$ mol

n of I_2:

2 : 1 $\frac{1.44 \times 10^{-3}}{2} = 7.2 \times 10^{-4}$ mol

difference in n of I_2:

$(7.5 \times 10^{-4}) - (7.2 \times 10^{-4}) = 3 \times 10^{-5}$ mol

$n = \frac{m}{Mr}$ $M = 3 \times 10^{-5} \times (126.9 \times 2)$

$= 7.614 \times 10^{-3}$ g

ResultsPlus
Examiner Comments

This response scored three marks. The first three steps were correct, but then the candidate calculated the relative atomic mass for iodine instead of calculating the relative formula mass of ascorbic acid and lost their way.

Paper Summary

Based on their performance on this paper, candidates should

- Ensure that they can explain differences in electron affinity clearly without confusing with first ionisation energy.
- Be able to describe the experimental procedures in the core practicals.
- Be able to explain how a buffer solution works.
- Check all calculations and do not leave expressions unevaluated.
- Use correct vocabulary when describing species (atom, ion, molecule etc).
- Understand how to derive the correct electron configurations for transition metals and their ions.
- Be able to explain differences in bonding in ionic compounds using given data.
- Ensure they are clear on units for entropy and Gibbs free energy.
- Learn which indicators are used for which type of experiment.
- Set out working for multi-step calculations clearly.

Grade boundaries

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

https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html

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