Pearson
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# Examiners' Report
# June 2022

## International GCSE Chemistry 4CH1 2CR

ResultsPlus

## Introduction

The paper contained a range of questions with a mixture of question styles and varying levels of demand, ranging from some designed to be accessible for all candidates, to others meant to be challenging for even the most able. There were opportunities for candidates to show their knowledge, understanding and experience of a wide range of topics including practical work they have carried out as part of their course.

The paper seemed to allow all candidates to show their ability and there was no evidence of any candidates having had any time issues.

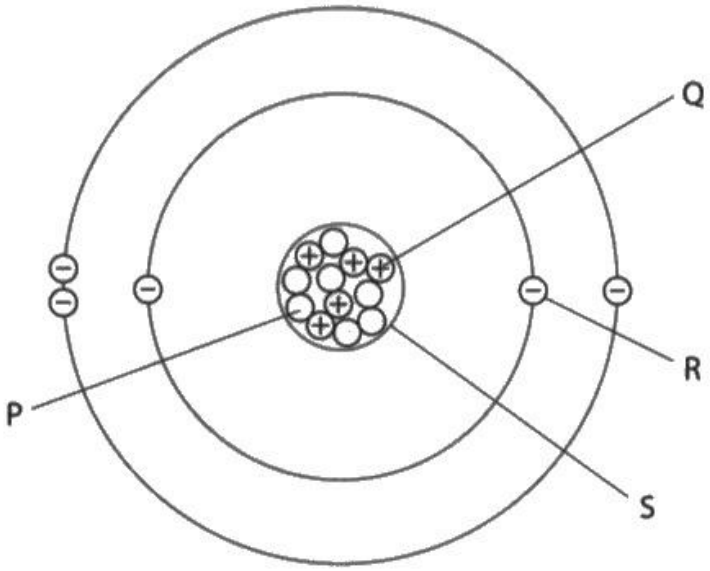
A general comment worth making is that candidates should read all the questions carefully, as they often contain information such as formulae, and other advice to help them in their answers.

This report gives examples of typical responses to questions and some comments on them.

## Question 1 (a)(i)

As expected, most candidates correctly identified the sub-atomic particles in the diagram.

**1** The diagram shows the sub-atomic particles in an atom of an element.




(a) (i) Give the name of each of the sub-atomic particles labelled P, Q and R.

**(3)**

P electron

Q proton

R neutron

**ResultsPlus**
**Examiner Comments**

This candidate has only correctly identified the proton so scores one mark.

## Question 1 (a)(ii)

As anticipated, most candidates identified the nucleus.

(ii) Give the name of the part of the atom labelled S.

**(1)**

Neuclens

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Examiner Comments

Although the spelling is not quite correct this is allowed the mark.

(ii) Give the name of the part of the atom labelled S.

**(1)**

Shell

ResultsPlus
Examiner Comments

This is an example of one of the incorrect suggestions made by a candidate.

## Question 1 (b)

Most candidates were able to count the protons or electrons in the diagram and use the Periodic Table to identify the element as Boron.

(b) Give the name of this element.

**(1)**

Carbon

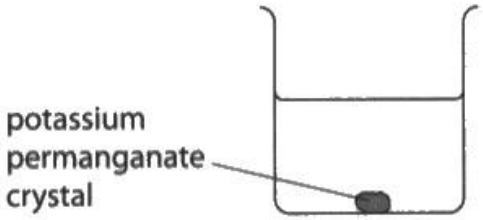
ResultsPlus
Examiner Comments

This is one of the incorrect answers seen.

## Question 2 (a)

Although many candidates correctly named 'dissolving' and 'diffusion' as the two processes, there were a variety of other suggestions often including 'melting' and 'osmosis'.

**2** A potassium permanganate crystal is placed in a beaker of water.




After several days a coloured solution forms.

(a) Give the names of the two processes that cause the coloured solution to form.

**(2)**

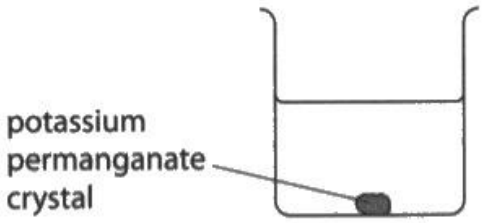
1 Crystalization

2 Evaporation

ResultsPlus
Examiner Comments

Unfortunately this candidate has seemingly misunderstood what was required and did not gain any credit.

**2** A potassium permanganate crystal is placed in a beaker of water.




After several days a coloured solution forms.

(a) Give the names of the two processes that cause the coloured solution to form.

**(2)**

1 diffusion

2 sublimation

**ResultsPlus**
**Examiner Comments**

This scores one mark but also shows another quite common, incorrect answer.

## Question 2 (b)(ii)

Most candidates correctly calculated the relative formula mass of 158. The most common incorrect answer was 76, where candidates had used atomic numbers.

## Question 2 (c)

Many candidates gave a definition of oxidation instead of oxidising agent. However, the mark scheme allowed enough variation for strong candidates to demonstrate their knowledge and understanding.

(c) Potassium permanganate can be used as an oxidising agent.

State what is meant by the term **oxidising agent**.

**(1)**

Oxidising agent tends to make an element lose electrons and gain oxygen.

ResultsPlus
Examiner Comments

This is an example of an acceptable answer.

(c) Potassium permanganate can be used as an oxidising agent.

State what is meant by the term **oxidising agent**.

**(1)**

it is a substance that is reduced in a reaction

ResultsPlus
Examiner Comments

Another example of an acceptable answer.

(c) Potassium permanganate can be used as an oxidising agent.

State what is meant by the term **oxidising agent**.

**(1)**

a agent that looses electrons and reacts with oxygen

ResultsPlus
Examiner Comments

This type of incorrect answer was common.

## Question 3 (b)(i)

Many candidates correctly classified the reaction as 'substitution' with 'addition' being the most common incorrect answer.

## Question 3 (b)(ii)

Although correct equations were seen regularly, there were many errors, with $CH_4Br$ being a common product. Some candidates could not give a correct formula for bromine or gave hydrogen as a product.

(ii) Give a chemical equation for this reaction.

**(1)**

$CH_4 + Br_2 \rightarrow Br_2CH_4 + HBr$

**ResultsPlus**
**Examiner Comments**

An incorrect product is given here but if $BrCH_3$ had been given, although in an unusual order, it would have been allowed.

(ii) Give a chemical equation for this reaction.

**(1)**

$CH_3 + Br_2 \longrightarrow CH_2Br + HBr$

**ResultsPlus**
**Examiner Comments**

This was a reasonably common incorrect formula for methane producing an incorrect product.

## Question 3 (c)

Many candidates gave correct responses for part (c)(i) and a good number then went on to correctly answer part (c)(ii). However many candidates could not follow up their correct answers in part (c)(i), often not giving the correct formula of the alkane in part (c)(ii) and instead giving the formula of other organic compounds. Of those candidates that did correctly give $C_5H_{12}$, the most common incorrect value for x was 16, perhaps showing confusion between oxygen atoms and oxygen molecules.

(c) One mole of an alkane burns completely in oxygen.

The equation represents the reaction.

$$\text{alkane} + xO_2 \rightarrow yCO_2 + zH_2O$$

The numbers *x*, *y* and *z* are used to balance the equation.

(i) The complete combustion of one mole of the alkane produces 220 g of carbon dioxide and 108 g of water.

Calculate the values of *y* and *z*.

[$M_r$ of $CO_2 = 44$ $M_r$ of $H_2O = 18$]

**(2)**

*y* = 5

*z* = 6

(ii) Determine the molecular formula of the alkane and the value of *x*.

**(2)**

molecular formula = .....

*x* = .....

**ResultsPlus**
**Examiner Comments**

This candidate, although not showing any working, gained two marks for the correct values of *y* and *z* but then was unable to continue any further.

(c) One mole of an alkane burns completely in oxygen.

The equation represents the reaction.

$$\text{alkane} + xO_2 \rightarrow yCO_2 + zH_2O$$

5 6

The numbers *x*, *y* and *z* are used to balance the equation.

(i) The complete combustion of one mole of the alkane produces 220 g of carbon dioxide and 108 g of water.

Calculate the values of *y* and *z*.

[$M_r$ of $CO_2 = 44$ $M_r$ of $H_2O = 18$]

**(2)**

220/44 108/18

5 6

1 12 ×10

10/2 12/2

5 6

*y* = 5

*z* = 6

(ii) Determine the molecular formula of the alkane and the value of *x*.

**(2)**

$C_5H_{12} + 16O_2 \Rightarrow 5CO_2 + 6H_2O$

molecular formula = $C_5H_{12}$

*x* = 16

**ResultsPlus**
**Examiner Comments**

This candidate, like many others, having given correct answers in part (c)(i) and a correct molecular formula in part (c)(ii) then made a balancing error and so gained three of the four marks.

## Question 3 (d)

The majority of candidates identified carbon monoxide as the product of incomplete combustion and then went on to give a correct explanation in terms of the oxygen carrying capacity of blood. However, some answers were incorrect due to candidates getting confused in their explanations involving haemoglobin.

(d) When an alkane burns in a limited supply of air, incomplete combustion occurs.

Explain why incomplete combustion of an alkane could be harmful to humans.

**(2)**

Incomplete combustion creates carbon monoxide which is harmful to breathe in.

**ResultsPlus**
**Examiner Comments**

One mark is gained for carbon monoxide but the explanation involving harmful is insufficient for the second mark.

(d) When an alkane burns in a limited supply of air, incomplete combustion occurs.

Explain why incomplete combustion of an alkane could be harmful to humans.

**(2)**

If we get an incomplete combustion of [redacted] alkane, [redacted] soot will then be released and soot is harmful to humans.

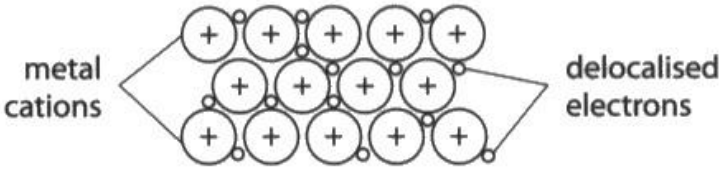
**ResultsPlus**
**Examiner Comments**

This was one of the minority of candidates who did not answer in terms of carbon monoxide. They gained one mark for suggesting soot as the product but again the explanation was insufficient for a second mark.

## Question 4 (a)

As expected, there was a good spread of marks in this question. Most candidates identified that copper is a good electrical conductor and is malleable/ductile. There were some excellent explanations for conductivity, although some candidates failed to mention that the delocalised electrons can move and some mentioned ions moving. Explanations of copper being malleable/ductile were also usually good. High melting point was suggested less often and the explanations were not always good enough. Many candidates suggested that copper is shiny, cheap and unreactive, all of which was ignored.

**4** (a) The diagram represents the structure of copper metal.




Explain three properties of copper that make it a suitable metal to use in electrical wiring.

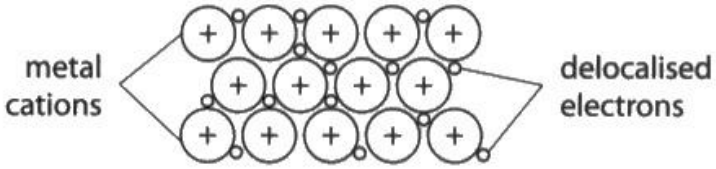
**(5)**

Copper is malleable and ductile so it can be bend into any shape and can be turned into a wire.
Copper has delocalised electrons that are free to move which means it can conduct electricity.
Copper is not too reactive so it is safe to use in electrical wiring.

**ResultsPlus**
**Examiner Comments**

This candidate scores 3 marks. The answer mentions copper is malleable/ductile but without an explanation. It does state copper conducts electricity and there is a suitable explanation of this property.

**4** (a) The diagram represents the structure of copper metal.




Explain three properties of copper that make it a suitable metal to use in electrical wiring.

**(5)**

Copper has delocalised electrons. This means that they can flow as charge, so therefore, copper can conduct electricity. The structure of copper means that it is ductile. This means that it can be drawn into wires because when a force is applied, the layers slide over each other. Copper is also a good conductor of heat, so it can withstand the heat caused by charge passing through the wires.

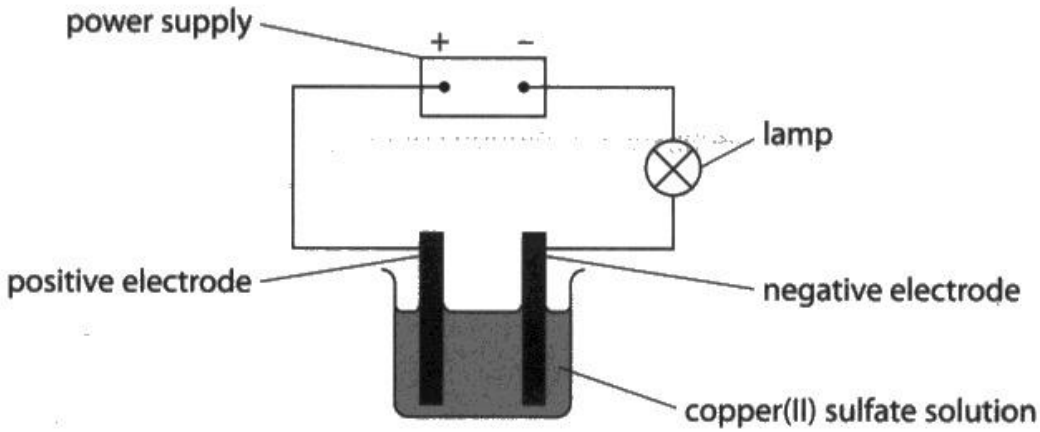
**ResultsPlus**
**Examiner Comments**

This answer is worth four marks. It scores one mark for copper can conduct electricity and one for its explanation. Similarly one mark for it being ductile and one for the explanation.

## Question 4 (b)(i)

Many candidates did not score the mark in this question, usually because they gave incorrect charges on the ions or very often they put $S^{2-}$ rather than $SO_4^{2-}$.

(b) The diagram shows the electrolysis of copper(II) sulfate solution, using graphite electrodes.




Copper forms at the negative electrode and oxygen forms at the positive electrode.

(i) Give the formula of the copper ion and the formula of the sulfate ion in copper(II) sulfate.

**(1)**

copper ion

$Cu^{2+}$

sulfate ion

$SO_4^-$

**ResultsPlus**
**Examiner Comments**

Although the copper ion is correct the charge on the sulfate ion is not so it is not awarded the mark.

## Question 4 (b)(ii)

Most candidates scored a mark for bubbles or fizzing. Although told in the question that oxygen forms at the positive electrode, many candidates stated that brown or orange copper solid would be seen.

Candidates are also reminded that an observation has to be something seen, so 'gas produced' would not score.

(ii) State what would be seen at the positive electrode.

**(1)**

Gas released

**ResultsPlus**
**Examiner Comments**

This is not an observation as the gas cannot be seen.

## Question 4 (b)(iii)

A surprisingly large number of candidates did not score the mark for the test for oxygen. The most common incorrect answers did not contain the key word 'glowing' but instead suggested 'extinguished' or 'put out' splint. Many candidates gave the test for hydrogen or even carbon dioxide on occasions.

(iii) Give a test for oxygen.

**(1)**

burning splint, it will relight

ResultsPlus
Examiner Comments

This answer suggests using a burning rather than a glowing splint so does not score the mark.

(iii) Give a test for oxygen.

**(1)**

pop sound test

ResultsPlus
Examiner Comments

This candidate is mixing up the test for hydrogen with the test for oxygen.

## Question 4 (b)(iv)

The ionic half-equation for the formation of oxygen proved too difficult for all but the strongest candidates. Many candidates gave a half-equation starting from oxide ions. In general, candidates either knew the answer for two marks, starting from hydroxide ions, or got it completely wrong with only a few candidates scoring one mark as the balancing was incorrect.

(iv) Give an ionic half-equation for the formation of oxygen at the positive electrode.

**(2)**

$2O^{2-} + 4e^-$ $2O^{2-} \longrightarrow 4e^- + 2O$ $4OH^- \longrightarrow 4e^- + 2H_2O + 2O_2$

**ResultsPlus**
**Examiner Comments**

All the formulae are correct but the half-equation is not balanced so this scores one mark.

## Question 4 (b)(v)

A pleasing number of candidates correctly suggested that the hydroxide ions came from water, with good descriptions of the dissociation of water.

(v) Suggest why the copper(II) sulfate solution contains some $OH^-$ ions. **(1)**

Because it is an ~~aguest~~ aqueos solution that contains water which are broken into $H^+$ ions and $OH^-$ ions

**ResultsPlus**
**Examiner Comments**

This is a good answer and is worth the mark.

## Question 5 (a)(i)

The most common incorrect answers in word equations for fermentation included water as a product. Although the question asked for a word equation, a number of candidates decided to try to give a balanced chemical equation. This more difficult option was allowed to score the mark as long as the equation was fully correct including balancing.

**5** This question is about alcohols, carboxylic acids and esters.

(a) Ethanol can be manufactured by the fermentation of a solution of glucose.

(i) Write a word equation for this reaction.

**(1)**

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

**ResultsPlus**
**Examiner Comments**

This candidate, although asked for a word equation, gave a chemical equation which, as it is fully correct including balancing, was awarded the mark.

## Question 5 (a)(ii)

Most candidates scored a mark here for yeast. The most common incorrect answer was 'zymase' which would not be added on its own.

(ii) State the substance that needs to be added for the reaction to occur.

**(1)**

phosphoric acid

ResultsPlus
Examiner Comments

This candidate seems to have confused fermentation with a different process.

(ii) State the substance that needs to be added for the reaction to occur.

**(1)**

enzymes

ResultsPlus
Examiner Comments

This is not an acceptable answer but enzymes in yeast would be.

## Question 5 (a)(iii)

Most candidates gave at least one correct condition for fermentation with many giving both. Some candidates thought that yeast was a condition and unfortunately some gave industrial conditions for ethanol production from ethene rather than fermentation as required by the question.

(iii) State two conditions needed for this reaction.

**(2)**

1 30°C

2 60-70 atmospheric pressure.

**ResultsPlus**
**Examiner Comments**

Although the temperature is acceptable this candidate, like others, has given a pressure related to a different process.

## Question 5 (b)(ii)

Most candidates knew that esters have a sweet or pleasant smell and scored a mark. Some also added that an ester would be seen as an oily layer which was not worth credit on its own, as other organic compounds would produce an oily layer.

(ii) State how you would know that an ester has formed.

**(1)**

There would be a sweet / fruity ~~smell~~ smell.

**ResultsPlus**
**Examiner Comments**

This was the most common correct answer.

## Question 5 (b)(iii)

Most candidates were able to give a use of esters with perfume by far the most common answer. Some suggested food colouring rather than flavouring whilst others put polyesters.

(iii) Give one use of an ester.

(1)

food flavouring

**ResultsPlus**
**Examiner Comments**

A common correct answer.

## Question 5 (c)(i)

Many candidates gave definitions of a homologous series rather than a functional group whilst others gave an example of a functional group instead of a definition.

Pleasingly, there were some very good answers but also some confused attempts with candidates seeming to know what a functional group was but not quite able to describe it correctly, possibly due to language skills letting them down.

(c) Aspirin is a compound used to reduce pain.

Aspirin contains a carboxylic acid functional group and an ester functional group.

(i) State what is meant by the term **functional group**.

**(1)**

An atom or group of atoms that determine the chemical properties of a hydrocarbon molecule

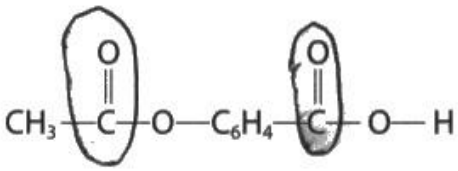
**ResultsPlus**
**Examiner Comments**

This is an example of an acceptable answer.

## Question 5 (c)(ii)

This question was generally poorly answered. Many candidates circled the ester linkage rather than the carboxylic acid functional group. Others circled more that the carboxylic acid group.

(ii) This is the structural formula of aspirin.



Draw a circle around the carboxylic acid functional group.

**(1)**

**ResultsPlus**
**Examiner Comments**

This is an example of one of many incorrect responses.

## Question 5 (c)(iii)

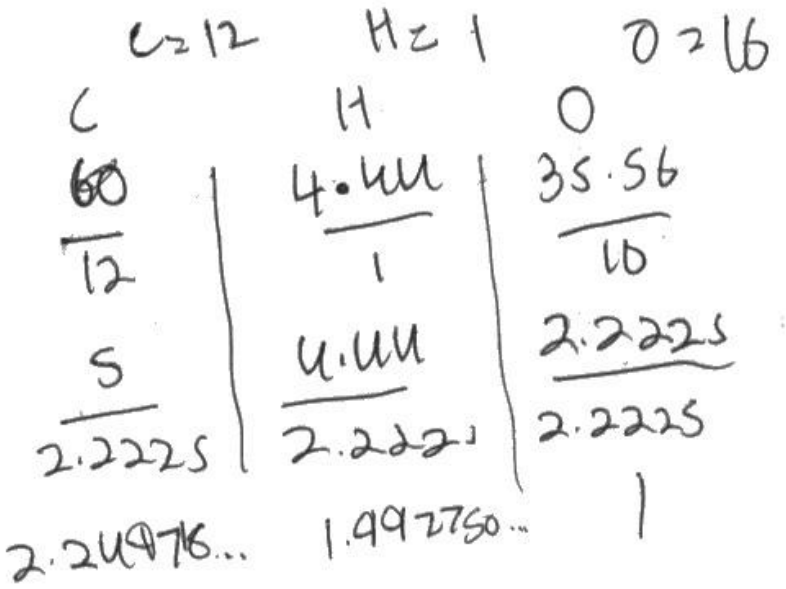
The calculation proving the empirical formula of aspirin was often well done. However some candidates missed out the last step or did not make it clear what they were doing.

As expressed on the front cover, candidates should be encouraged to show all working to demonstrate how they arrive at the empirical formulae.

(iii) Aspirin has this percentage composition by mass.

C = 60.00%  H = 4.44%  O = 35.56%

Show by calculation that the empirical formula of aspirin is $C_9H_8O_4$ (3)




ResultsPlus
Examiner Comments

This candidate has started the calculation well but has not completed the final step of multiplying by four, so gains two marks.

## Question 6 (a)

Many candidates knew that concordant results were within 0.2 $cm^3$ or less of other result but other candidates stated they were the same or gave imprecise statements such as similar to each other.

**6** A student uses this method to do a titration.

- use a measuring cylinder to obtain 25 $cm^3$ of sodium hydroxide solution
- transfer the solution to a conical flask
- add a few drops of universal indicator to the flask
- fill a burette with dilute sulfuric acid and record the initial burette reading
- add the acid to the flask, swirling the flask continuously
- add the acid slowly near the end-point
- record the final burette reading at the end-point

The student repeats the titration until at least two concordant results are obtained.

(a) State what is meant by concordant results.

**(1)**

concordant results are results that are with 0.20 $cm^3$ of each other.

ResultsPlus
Examiner Comments

A common correct answer.

## Question 6 (b)

The explanations of improvements to the method were generally good, with candidates often gaining at least two marks by suggesting a different indicator with a good reason. Some candidates just repeated aspects of the given method, such as repetition to obtain more concordant results.

(b) Explain two improvements to the student's method so that more accurate results are obtained.

**(4)**

Use a pipette to obtain the 25cm3 because a pipette can obtain exactly 25 cm3 (more accurate) than a measuring cylinder)

Use methyl orange indicator instead of the universal indicator because the universal indicator doesn't have a sharp color change at the end point while methyl orange does have.

~~A white tile can be placed under the conical flask~~ A white tile can also be used to see the color change easily.

ResultsPlus
Examiner Comments

A good answer worth four marks.

(b) Explain two improvements to the student's method so that more accurate results are obtained.

**(4)**

First the student should use a pipette ~~ist~~ instead of measuring cylinder because it is more accurate than measuring cylinder. The student should repeat the expirement for more accurate results. He should add a few drops of the universal indicator after filling the burette with dilute sulphuric acid and measuring the reading.

**ResultsPlus**
**Examiner Comments**

This answer is given two marks for one improvement with a reason.

## Question 6 (c)

It was pleasing to see many candidates gaining the full three marks in this titration calculation. Others did not appreciate the molar ratio involved and ended up with an answer of 62.5 or 125 but the use of ECF (error carried forward) in the mark scheme allowed these candidates to gain two marks.

(c) The student makes the improvements and repeats the titration.

The sulfuric acid has a concentration of 0.600 mol/dm$^3$.

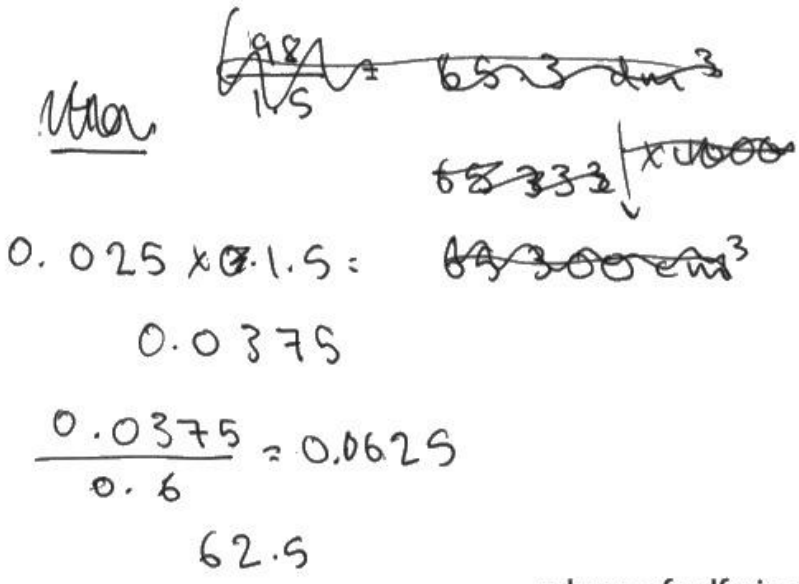
The sodium hydroxide solution has a concentration of 1.50 mol/dm$^3$.

This is the equation for the reaction.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the volume, in cm$^3$, of sulfuric acid that the student needs to completely react with 25.0 cm$^3$ of the sodium hydroxide solution.

**(3)**




volume of sulfuric acid = 62.5 cm$^3$

**ResultsPlus**
**Examiner Comments**

This candidate failed to use the molar ratio in the equation so their answer was twice as large as it should have been. With the use of ECF (error carried forward) it was able to score two marks.

(c) The student makes the improvements and repeats the titration.

The sulfuric acid has a concentration of 0.600 mol/dm$^3$.

The sodium hydroxide solution has a concentration of 1.50 mol/dm$^3$.

This is the equation for the reaction.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the volume, in cm$^3$, of sulfuric acid that the student needs to completely react with 25.0 cm$^3$ of the sodium hydroxide solution.

**(3)**

$n = 0.025 \times 1.50 = 0.0375$ mol of NaOH

2 mol of NaOH → 1 mol of $H_2SO_4$

0.0375 → $x$

$x = \frac{0.0375}{2} = 0.01875$ mol

vol of $H_2SO_4 = 0.01875 \times 24000$

$= 450$

volume of sulfuric acid = 450 cm$^3$

**ResultsPlus**
**Examiner Comments**

This candidate started off well by completing the first two steps in the calculation. However, they then involved the molar gas volume. They scored two marks.

## Question 6 (d)

Many candidates unnecessarily gave a method for making sodium sulfate solution prior to starting their method for obtaining the crystals. Many candidates gained MP1 and MP2 on the mark scheme but often then did not gain MP3 as they went straight to filtering without cooling or leaving the solution. Some candidates missed out the steps in MP3 and MP4 completely and went straight to drying crystals. Weaker candidates muddled the order of the steps and so often scored few marks.

(d) The student plans to obtain pure dry crystals of hydrated sodium sulfate.

They add the calculated volume of sulfuric acid to 25.0 $cm^3$ of the sodium hydroxide solution to form sodium sulfate solution.

Describe what the student should do to obtain pure dry crystals of hydrated sodium sulfate from the solution.

(4)

In order to obtain pure dry crystals of hydrated sodium sulfate, the student should heat the sodium sulfate solution until all the water is evaporated and the impurities are left, then the student should filter out the dry crystals from the impurities and then dry the crystals with a towel or in the oven and in the end dry crystals are obtained.

**ResultsPlus**
**Examiner Comments**

In this answer the candidate scores one mark for heating the solution but evaporates all the water so gains no other marks.

(d) The student plans to obtain pure dry crystals of hydrated sodium sulfate.

They add the calculated volume of sulfuric acid to 25.0 $cm^3$ of the sodium hydroxide solution to form sodium sulfate solution.

Describe what the student should do to obtain pure dry crystals of hydrated sodium sulfate from the solution.

**(4)**

after ~~&~~ collecting the ~~hydrated~~ sodium sulfate solution place it in an evaporating dish and place over a bunsen burner using a tryped. once you see crystals begin to form you may take the evaporating dish off the bunsen burner and leave to cool. As the solution ~~cools~~ cools more crystals will form (Precipitate). you may then ~~filter the~~ seperate the crystals from the solution using the filtration method. Place some filter paper in a funnel which is placed over a beaker. Then proceed to empty the solution through the funnel. Place the crystals collected and leave them to dry of any remaining solution.

**(Total for Question 6 = 12 marks)**

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Examiner Comments

This candidate gives a good description and gains four marks.

## Question 7 (a)(i)

Most candidates correctly identified the reversible reaction symbol.

**7** In the presence of an iron catalyst, nitrogen reacts with hydrogen to form ammonia.

The reaction conditions used are a temperature of 450 °C and a pressure of 200 atmospheres.

This is the equation for the reaction.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \qquad \Delta H = -92\,kJ/mol$$

(a) (i) State what the symbol $\rightleftharpoons$ represents.

**(1)**

Reversesible. Dynamic ~~equ~~ equilibrium

ResultsPlus
Examiner Comments

This candidate refers to equilibrium which is ignored but has not mentioned reversible so does not gain the mark.

## Question 7 (a)(ii)

The vast majority of candidates knew that a catalyst increases the rate of reaction. Some went on to describe how a catalyst works which was not required and so was ignored.

(ii) Give the reason for using a catalyst.

**(1)**

Using a ~~to~~ catalyst will alter the rate of reaction.

**ResultsPlus**
**Examiner Comments**

Unfortunately this candidate refers to altering not increasing the rate of reaction so did not gain the mark.

## Question 7 (b)(i)

Many candidates who correctly stated the yield would decrease with increased temperature then went on to state that the equilibrium position would move in the endothermic direction but did not state which direction that was. Weaker candidates confused yield and rate and the position of equilibrium.

(b) (i) The reaction mixture is kept at a pressure of 200 atmospheres, but the temperature is increased to 550 °C.

Explain the effect of this change on the yield of ammonia at equilibrium.

**(2)**

This will decrease the yield as the position of equilibria will shift to the left as the backward reaction is endothermic

**ResultsPlus**
**Examiner Comments**

A good answer worth two marks.

pathway with a lower activation energy

(b) (i) The reaction mixture is kept at a pressure of 200 atmospheres, but the temperature is increased to 550 °C.

Explain the effect of this change on the yield of ammonia at equilibrium.

**(2)**

The yield of ammonia decreases so lower yield of ammonia. The position of equilibrium shifts to the left because the forward reaction is exothermic

ResultsPlus
Examiner Comments

A different way of gaining two marks.

(b)(i) The reaction mixture is kept at a pressure of 200 atmospheres, but the temperature is increased to 550 °C.

Explain the effect of this change on the yield of ammonia at equilibrium.

**(2)**

The equilibrium will ~~stay~~ shift to reactants side, the yield of ammonia will decrease

ResultsPlus
Examiner Comments

The candidate has correctly stated the yield decreases but without a suitable reason, so they only score one mark.

## Question 7 (b)(ii)

There were many excellent answers but some candidates did not identify which side had the fewer moles even though they made statements such as 'it moves to the side with fewer moles'. Sometimes yield and rate were confused and some weaker candidates thought the answer involved the exothermic nature of the reaction.

(ii) The reaction mixture is kept at a temperature of 450 °C, but the pressure is increased to 300 atmospheres.

Explain the effect of this change on the yield of ammonia at equilibrium.

**(2)**

The ~~yield~~ yield of ammonia increases since the equilibrium shifts to the right.

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The candidate has correctly stated that the yield increases but has not given a reason involving moles of gas so scores just one mark.

(ii) The reaction mixture is kept at a temperature of 450 °C, but the pressure is increased to 300 atmospheres.

Explain the effect of this change on the yield of ammonia at equilibrium.

**(2)**

The yield of ammonia will increase as their are fewer ~~gas~~ molecules on the right hand side.

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Molecules was allowed for moles, so this candidate scored two marks.

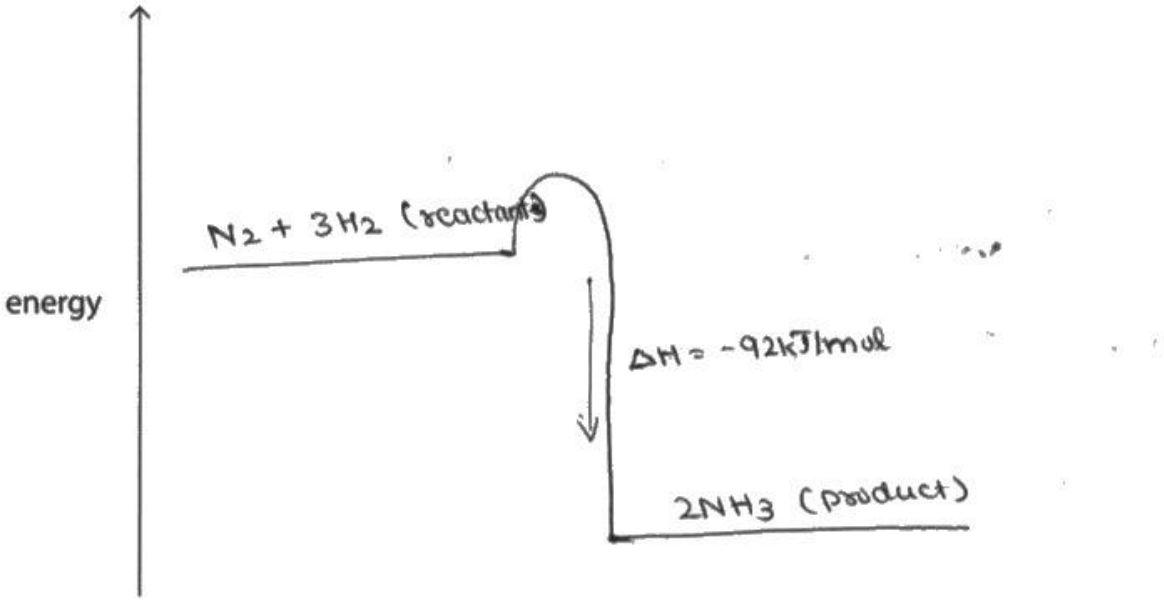
## Question 7 (c)

Although not asked for, many candidates included activation energy in their diagrams, perhaps suggesting they do not know the difference between an energy level diagram and a reaction profile. Some of the lines indicating the enthalpy change were a bit imprecise, often not quite reaching the reactant or product horizontal lines making it difficult to award marks.

(c) Draw an energy level diagram for the reaction between nitrogen and hydrogen.

Include the reactants, products and $\Delta H$ in your diagram.

**(3)**

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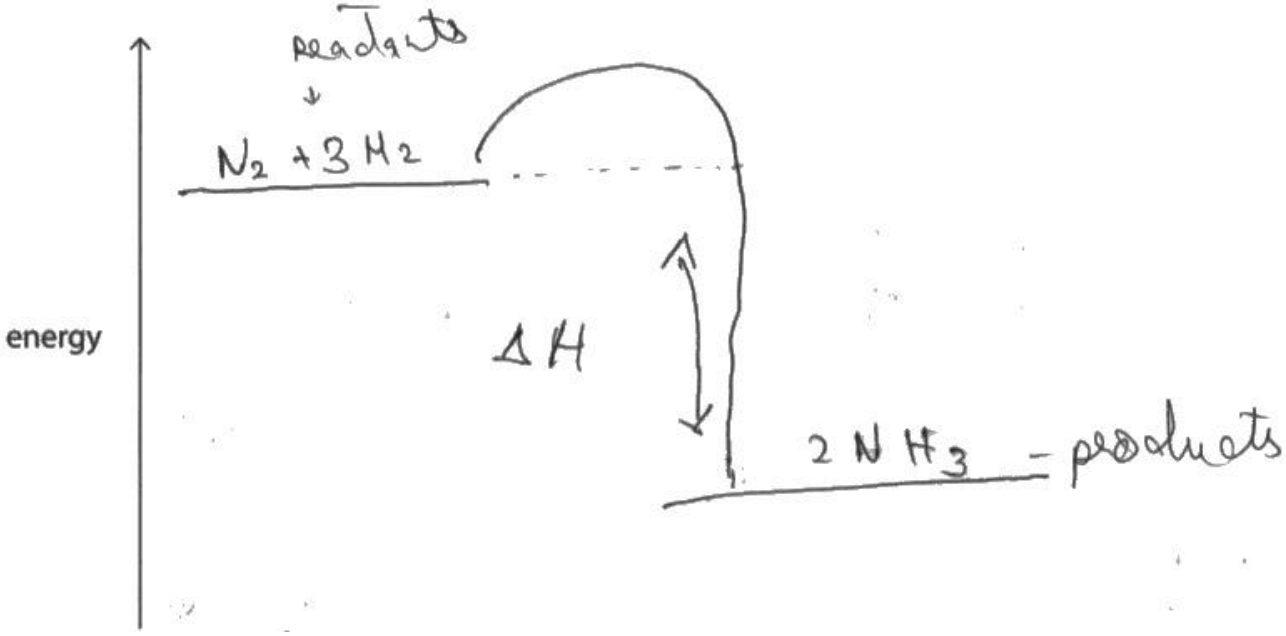
**Examiner Comments**

This candidate scores the first two marks but not the third as the arrow indicating the enthalpy change does not end at the level of the products.

(c) Draw an energy level diagram for the reaction between nitrogen and hydrogen.

Include the reactants, products and $\Delta H$ in your diagram.

**(3)**




**ResultsPlus**
**Examiner Comments**

This candidate also scores the first two marks but not the third as the arrow indicating the enthalpy change does not start at the level of the reactants or end at the level of the products.

## Question 7 (d)

As expected, weaker candidates found this calculation very challenging and often did not attempt it. Some tried unsuccessfully to use masses. However, many candidates were able to make good attempts at part (d)(i) often gaining the first two marks. Some candidates also gained the third mark with a variety of acceptable methods, although others did not convincingly show that nitrogen was in excess.

There were a lot of blanks in part (d)(ii) and only the strongest candidates were able to score full marks. However a good number of candidates did manage two marks for obtaining 80 $dm^3$ but then failed to use the information that the yield was 20%.

(d) At the start of the reaction, 48 $dm^3$ of nitrogen is added to 120 $dm^3$ of hydrogen at rtp.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

[molar volume of any gas at rtp = 24 $dm^3$]

(i) Show by calculation that the nitrogen is in excess.

(3)

~~volume = molar volume × no of moles~~

~~no of moles = molar volume × volume~~

volume = molar volume × no of moles

$\frac{120}{24}$ = no of moles of hydrogen

5 = no of moles of hydrogen

∴ 5 ÷ 3

= 1.66 moles of nitrogen

volume of nitrogen = 24 × 1.66

= 40 $dm^3$ needed

∴ 48 > 40, therefore nitrogen is in excess.

(ii) The yield of ammonia at equilibrium is 20%.

Calculate the volume, in $dm^3$, of ammonia formed from 120 $dm^3$ of hydrogen.

(3)

$\frac{120}{24} = 5$

$(5 \div 3) \times 2$

= 3.33 mols of ammonia

volume = ~~molar volume~~ × no of mol

volume of ammonia = 3.33 × 24

= 80 dm3

At 20%:

∴ $80 \times \frac{20}{100}$

= 16 ~~moles of~~ dm3 of ammonia

volume of ammonia = 16 $dm^3$

**(Total for Question 7 = 15 marks)**

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As indicated in the mark scheme alternative methods other than the expected one were accepted. This shows one of them and the candidate gained full marks.

(d) At the start of the reaction, 48 $dm^3$ of nitrogen is added to 120 $dm^3$ of hydrogen at rtp.

$$\underset{48\,dm^3}{N_2} + \underset{120\,dm^3}{3H_2} \rightleftharpoons 2NH_3$$

[molar volume of any gas at rtp = 24 $dm^3$]

(i) Show by calculation that the nitrogen is in excess.

**(3)**

$V = n \times 24\ dm^3$

$3H_2$

$120\,dm^3 = n \times 24$

$n = 5$ moles $\longrightarrow$ to react need 1·6 mole of $N_2$

| $N_2$ | : | $H_2$ |
|---|---|---|
| 1 | : | 3 |
| 1·6 | : | 5 |

$N_2$ $48\,dm^3 = n \times 24$

$n = \frac{48}{24}$

$= 2$ moles.

$2 > 1.6$ thus $N_2$ is in access.

(ii) The yield of ammonia at equilibrium is 20%.

Calculate the volume, in $dm^3$, of ammonia formed from 120 $dm^3$ of hydrogen.

**(3)**

$n = \frac{V}{24\,dm^3}$

$3H_2$ $n = \frac{120\,dm^3}{24\,dm^3} = 5$

$H_2 : NH_3$ 3 : 2

5 :

3 : 2

1 : 2/3

5 :

$n\,2NH_3 = \frac{5}{3} \times 2 = 1.67$

~~$n\,2NH_3$ 3 5 2 2~~

$V = \frac{10}{3} \times 24 = 80$

~~$V\,2NH_3 = 1 \cdot 2 \times 24\ dm^3$~~

~~$= 28.8$~~

volume of ammonia = ~~28.8~~ 80 $dm^3$

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Examiner Comments

Three marks were awarded in part (d)(i) but in part (d)(ii) the candidate did not use the information about 20% yield so only scored two marks.

## Paper Summary

Based on their performance on this paper, candidates should:

- increase their familiarity with pieces of apparatus used in the laboratory and their purpose.
- have as much practical experience as possible to improve understanding of methods used in practical situations.
- read questions carefully to both be clear what is being asked and to be aware that useful information to help in the answer is sometimes provided.
- learn tests for gases.
- practise writing formulae and equations, including those involved in organic chemistry.
- practise all types of calculations, including titrations and show all working.
- improve understanding of terms such as 'oxidation' and 'oxidising agent'.
- be clear in which direction a reaction is exothermic or endothermic or which side of the equation has more or less moles of gas.