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Examiners' Report
June 2015

IAL Chemistry WCH06 01

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June 2015

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Introduction

There were some very well prepared candidates. Centres can be commended where the practical work is carried out with care and attention to reasons for procedures.

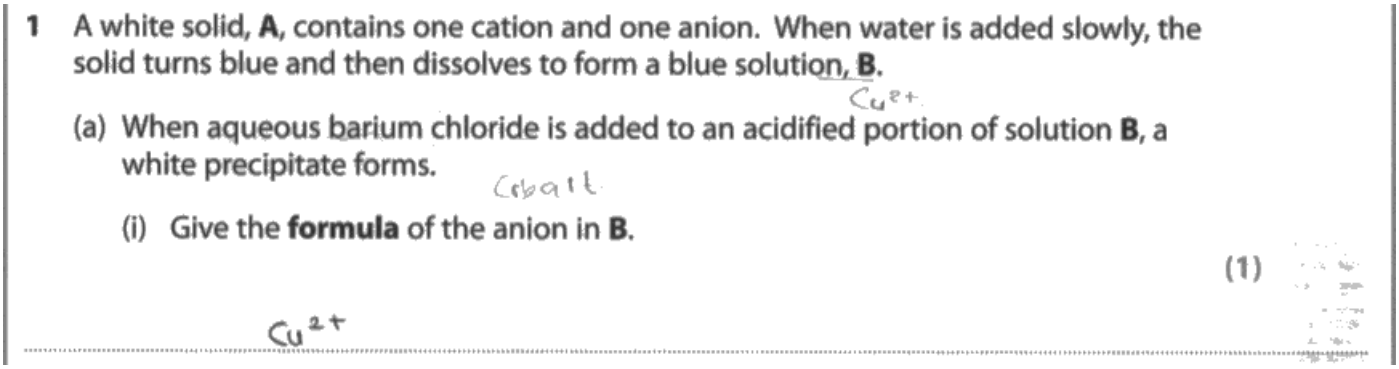
Some candidates seem not to have done many of the practical exercises in the specification.

The full range of marks were seen on this paper. There was no evidence that candidates had insufficient time to complete the paper.

Candidates were good at the calculation aspects, but less good when asked for descriptions or reasons.

Question 1 (a) (i)

This test for the sulfate ion was known by three quarters of the candidates.



1 A white solid, **A**, contains one cation and one anion. When water is added slowly, the solid turns blue and then dissolves to form a blue solution, **B**.

Cu^{2+}

(a) When aqueous barium chloride is added to an acidified portion of solution **B**, a white precipitate forms.

Cobalt

(i) Give the **formula** of the anion in **B**.

(1)

Cu^{2+}

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Examiner Comments

This is an example of someone failing to read the question at the first opportunity or someone who has forgotten the meaning of the term anion.

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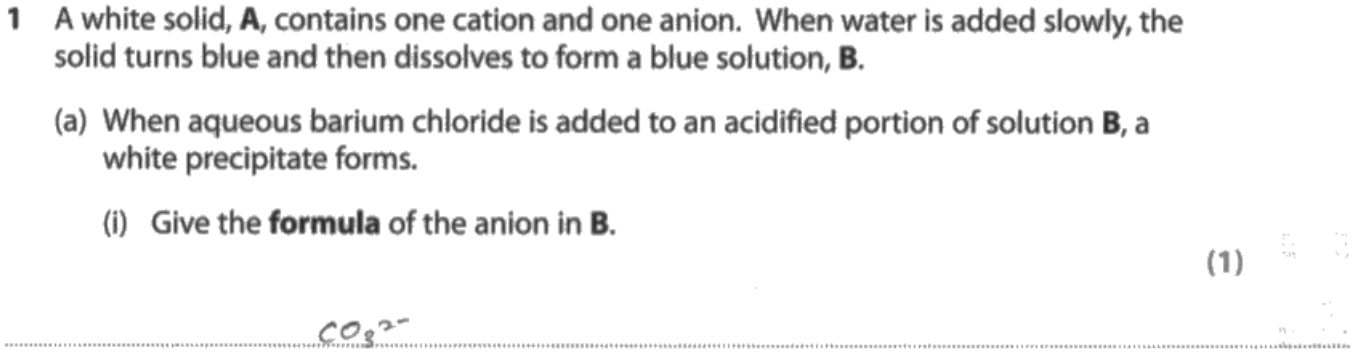
Examiner Tip

Read the question three times: twice before you answer it and once after.

Remember cations are positive, anions are negative - 'Cathy says yes, Ann says no!'



1 A white solid, **A**, contains one cation and one anion. When water is added slowly, the solid turns blue and then dissolves to form a blue solution, **B**.

(a) When aqueous barium chloride is added to an acidified portion of solution **B**, a white precipitate forms.

(i) Give the **formula** of the anion in **B**.

(1)

CO_3^{2-}

ResultsPlus
Examiner Comments

A carbonate would give a white precipitate with barium chloride solution, but not if acid was present.

ResultsPlus
Examiner Tip

Learn the tests for common anions.

Question 1 (a) (ii)

It was disappointing that nearly one quarter of the candidates answered with sulfuric acid.

(ii) Name a suitable acid for acidifying solution **B** in this test.

(1)

HCl

ResultsPlus
Examiner Comments

Though the question asked for the **name** of the acid used, the formula was accepted here. This is not always the case, even on this paper.

ResultsPlus
Examiner Tip

Underline key words in the question as it is read – especially verbal instructions like name, write, draw or calculate.

(ii) Name a suitable acid for acidifying solution **B** in this test.

(1)

~~H_2SO_4~~ Sulfuric acid

ResultsPlus
Examiner Comments

The common wrong response.

ResultsPlus
Examiner Tip

The common wrong response.

Remember the solubilities of common salts.

All nitrates are soluble. Nearly all chlorides are soluble. Some sulfates are insoluble.

Question 1 (b) (i)

This was where many candidates began to make errors in this section with much confusion between ions and substances, and appropriate ligands.

(b) When aqueous ammonia is added to another portion of solution **B**, a blue precipitate forms. When more aqueous ammonia is added, this precipitate dissolves to form a deep blue solution, **C**.

* (i) Identify, by name or formula, the blue precipitate.

(1)

$[Cu(NH_3)_6]^{2+}$ ~~$Cu(OH)_3$~~ $[Cu(OH)_2(NH_3)_4]$.

ResultsPlus
Examiner Comments

This addition of ammonia to the formula was quite a common error.

ResultsPlus
Examiner Tip

It is always worth remembering that, though a weak alkali, ammonia is ionized in solution to form hydroxide ions, which form a precipitate with copper(II) ions.

(b) When aqueous ammonia is added to another portion of solution **B**, a blue precipitate forms. When more aqueous ammonia is added, this precipitate dissolves to form a deep blue solution, **C**.

(i) Identify, by name or formula, the blue precipitate.

(1)

$[Cu(OH)_2(H_2O)_4]^{2+}$

ResultsPlus
Examiner Comments

The formula is fine, including water as this does but the substance cannot have a charge. A precipitate is not charged.

ResultsPlus
Examiner Tip

The formula is fine, including water as this does but the substance cannot have a charge.

Question 1 (b) (ii)

The ongoing confusion caused by ammonia solution continued. Quite a few candidates gave the correct numbers of ligands but no charge or remarkably, negative charges. It is important to remember that an aqueous solution of ammonia is an equilibrium.$NH_3(aq) + H_2O(l)$ ☐ $NH_4^+(aq) + OH^-(aq)$

At lower concentrations of ammonia solution in a solution containing copper(II) ions the concentration of hydroxide ions is sufficient to form the precipitate, copper(II) hydroxide, which drives the above equilibrium to the right.

As the relative amount of water decreases, because the ammonia solution is more concentrated, this equilibrium is reversed, increasing the concentration of ammonia. This then is removed by reaction with copper ions.

(ii) Give the **formula** of the ion responsible for the deep blue colour of solution **C**.

(1)

$[Cu(NH_3)_4(OH)_2]$

ResultsPlus
Examiner Comments

Here the understanding of more concentrated ammonia solution is insufficient.

There can't be both ammonia and hydroxide ion present in the complex.

ResultsPlus
Examiner Tip

The equilibrium, $NH_3(aq) + H_2O(l)$ ☐ $NH_4^+(aq) + OH^-(aq)$, for ammonia solution makes it clear that there is either higher concentration of ammonia or hydroxide ion.

(ii) Give the **formula** of the ion responsible for the deep blue colour of solution **C**.

(1)

$[Cu(NH_3)_6]^{2+}$

ResultsPlus
Examiner Comments

This contains the wrong number of ammonia ligands.

ResultsPlus
Examiner Tip

It is best to learn that copper is always attached to four ligands in complexes. The extra two waters are further from the copper ion and are best ignored.

Question 1 (c)

There were many answers with incorrect ligands or incorrect charges.

A selection of these are given.

(c) Give the **formula** of the complex ion which gives the blue colour to solution **B**.
Include the ligands in your answer.

(1)

~~[Cu(OH)$_4$]$^{2-}$~~ [Cu(OH)$_2$]

ResultsPlus
Examiner Comments

One of the many incorrect answers.

ResultsPlus
Examiner Tip

One of the many incorrect answers.

The hydroxide concentration in water is insufficient to precipitate copper(II) hydroxide.

(c) Give the **formula** of the complex ion which gives the blue colour to solution **B**.
Include the ligands in your answer.

(1)

[Cu(H$_2$O)$_2$(NH$_3$)$_4$]

ResultsPlus
Examiner Comments

Ammonia is not present in pure water.

ResultsPlus
Examiner Tip

This may be a case of misreading the question – the candidate underlining solution **B** might have helped to focus on the initial solution of **A** in water.

Question 1 (d)

Incorrect formulae for copper(II) sulfate were quite common.

Copper(II) chloride and the tetrachlorocopper(II) ion were also popular.

(d) Give the **formula** of the white solid **A**.

(1)

$CuSO_4$

ResultsPlus
Examiner Comments

An example of incorrect formula for copper(II) sulfate.

ResultsPlus
Examiner Tip

It is important to remember that the blue colour of copper(II) sulfate is due to the water ligands in the aquo complex.

(d) Give the **formula** of the white solid **A**.

(1)

~~$Cu(NH_4)_4$~~ $CuCl_2$

ResultsPlus
Examiner Comments

An example of copper(II) chloride.

ResultsPlus
Examiner Tip

In aqueous solution copper(II) chloride is green, so this cannot be correct.

Question 1 (e)

This either simply wasn't known or the question wasn't understood as there were many very poor answers. It was a good discriminator as only the really good candidates scored both marks.

It was important to realise the role of water ligands in altering the energy levels of d orbitals to differing extents so that 3d to 3d transitions absorb energy from visible light.

Question 2 (a)

Though many know it was the sodium ion, it was a shame how many candidates did not read 'the *formula* of the *ion*'.

2 A salt, **P**, contains carbon, hydrogen, oxygen and one metallic element.

(a) When a flame test is carried out on **P**, a yellow flame results.

Give the **formula** of the metal ion in the salt.

(1)

Na^{2+} sodium

ResultsPlus
Examiner Comments

Though the question has been read correctly the candidate did not know the charge on sodium ions.

ResultsPlus
Examiner Tip

It is easy to learn that Group 1 ions have single positive charges, and Group 2 ions have double positive charges.

2 A salt, **P**, contains carbon, hydrogen, oxygen and one metallic element.

(a) When a flame test is carried out on **P**, a yellow flame results.

Give the **formula** of the metal ion in the salt.

(1)

Sodium . Na

ResultsPlus
Examiner Comments

The candidate has written the name, then wisely given the formula, but failed to give the charge.

Question 2 (b)

(i) It was clear that many candidates had never calibrated a pH meter, though this is essential.

It is normal to use two buffer solutions of known pH, one alkaline and one acidic.

(ii) To show the pH of a solution universal indicator solution or universal indicator paper must be used.

This was rarely given – acid base indicators suitable for titrations were the common responses.

(iii) A pH meter measures precisely to one decimal place. Universal indicator changes colour over a range of pH values, as do other acid base indicators.

(b) **P** dissolves in water to form a weakly alkaline solution, **Q**, with pH 8.1.

The pH of **Q** can be measured by using a calibrated pH meter or an indicator.

(i) Describe how to calibrate a pH meter.

(2)

Get the incubator

(ii) Name a suitable indicator you could use and state the colour you would expect to observe.

(2)

universal indicator.

(iii) Which of the two methods will give the more accurate value for the pH of **Q**? Justify your answer.

(1)

pH meter is more accurate.

ResultsPlus
Examiner Comments

This is a fairly typical response.

(i) It is clear the candidate has never done this experiment.

(ii) The candidate is fortunate to receive a mark as strictly the word solution or paper should be added. There is no mention of colour.

(iii) This answer restates the question without further justification.

The candidate has not read the full question in both (ii) and (iii).

ResultsPlus
Examiner Tip

(i) Carry out all experiments related to the specification.

(ii) Read the question and underline key words.

(b) **P** dissolves in water to form a weakly alkaline solution, **Q**, with pH 8.1.

The pH of **Q** can be measured by using a calibrated pH meter or an indicator.

(i) Describe how to calibrate a pH meter.

(2)

By putting the pH meter into a strong acid and label as ~~PH~~ pH 1 and then putting it into a strong alkali. ~~and~~ and labelling as pH 14

(ii) Name a suitable indicator you could use and state the colour you would expect to observe.

(2)

Methyl orange.

Orange to yellow

(iii) Which of the two methods will give the more accurate value for the pH of **Q**? Justify your answer.

(1)

PH meter. Because you can identify the ~~exact~~ exact pH ~~PH~~ from the pH meter.

ResultsPlus
Examiner Comments

(i) Though this is not best practice, it was accepted on this occasion.

(ii) This gets a 'rescue' mark for an indicator with the correct alkaline colour.

(iii) This is fine as per the mark scheme.

ResultsPlus
Examiner Tip

This is a good example of a candidate who has the good sense to apply what they know to the question, even though they are on unfamiliar ground.

Question 2 (c) (i)

It was surprising that so few candidates seemed to be familiar with this common test for an ester.

The purpose of the sodium carbonate solution is to neutralise the carboxylic acid which often has a stronger (and often unpleasant) smell than the ester.

Many answers referred to the solid dissolving or disappearing, confusing the test with adding sodium to an alcohol.

This was probably why so many candidates gave a white solid forming.

primary alcohol / aldehyde

(c) Some of the solution **Q** is acidified with concentrated hydrochloric acid.

carboxylic

An organic compound, **R**, forms in the solution.

ester

Methanol is added and the mixture warmed, forming a new organic compound **S**.

This mixture is added to sodium carbonate solution in an evaporating basin.
A fruity smell is detected.

(i) Describe and explain what you would **see** as the mixture is added to the sodium carbonate solution.

(2)

Efferversence as CO_2 is released

The mixture goes clear

A precipitate is formed

ResultsPlus
Examiner Comments

This is a typical answer illustrating the confusion with reaction of sodium with an alcohol.

The first line would have gained full marks.

ResultsPlus
Examiner Tip

Inorganic salts of carboxylic acids are ionic so usually more soluble than the acids.

(c) Some of the solution **Q** is acidified with concentrated hydrochloric acid.

An organic compound, **R**, forms in the solution.

Methanol is added and the mixture warmed, forming a new organic compound **S**.

This mixture is added to sodium carbonate solution in an evaporating basin.
A fruity smell is detected.

(i) Describe and explain what you would **see** as the mixture is added to the sodium carbonate solution.

(2)

white misty fumes of HCl

effervescence. CO_2 gas is ~~evolved~~ given off.

ResultsPlus
Examiner Comments

The candidate just manages to save their marks.

ResultsPlus
Examiner Tip

It is best to fully cross out parts of answers which you do not wish to have marked.

Question 2 (c) (ii)

Three quarters of candidates did recognise the test for an ester.

(ii) What type of compound is **S**?

(1)

carboxylic acid.

ResultsPlus
Examiner Comments

The typical incorrect answer.

ResultsPlus
Examiner Tip

The formation of the fruity smell is usually the give away for an ester.

(ii) What type of compound is **S**?

(1)

Alcohol

ResultsPlus
Examiner Comments

This was the other common incorrect answer.

ResultsPlus
Examiner Tip

Esters are used for their sweet or fruity smells.

Question 2 (d)

This question was another good discriminator – often if they could answer they gave R as an acyl chloride.

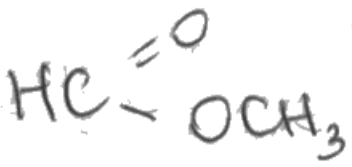
For P, too many drew a covalent bond between O and Na, some even gave the charges and still drew in the bond.

(d) The high resolution proton nuclear magnetic resonance (nmr) spectrum of **S** has only two peaks which are both singlets and have the same area.

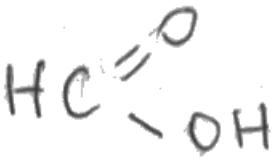
Deduce the structural formulae of **S**, **R**, and **P**.

(3)

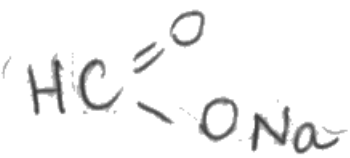
S



R



P



ResultsPlus
Examiner Comments

This is an instructive example. The candidate has found an ester which would give two singlet peaks in the NMR spectrum, but has failed to realise the significance of the same areas.

The second and third structures are acceptable transferred errors.

ResultsPlus
Examiner Tip

Always consider all the information in the stem of a question.

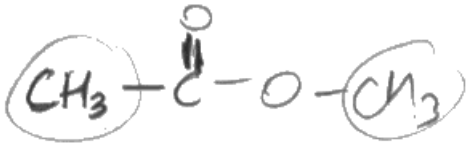
(d) The high resolution proton nuclear magnetic resonance ~~(nmr)~~ spectrum of **S** has only two peaks which are both singlets and have the same area.

Deduce the structural formulae of **S**, **R**, and **P**.

(3)

S

CH_3COOCH_3



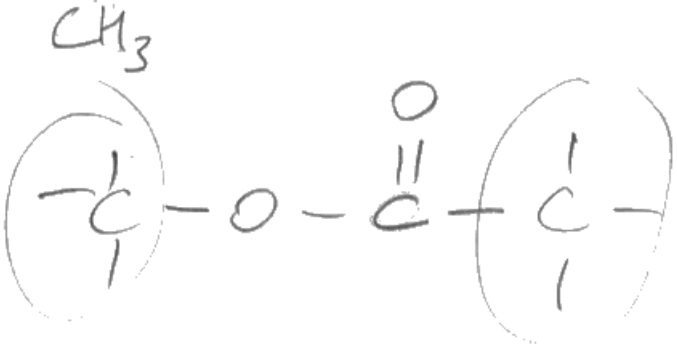
R

CH_3COCl

P

$CH_3CO^-Na^+$

$Na_2CO_3 + CH_3COCl$



CH_3COOCH_3

ResultsPlus
Examiner Comments

This was a common error in **R**. It is difficult to make an acyl chloride from an ester.

Then a subscript 2 in lost from the formula for **P**.

ResultsPlus
Examiner Tip

Always check each carbon has four bonds.

Question 3 (a)

It is rarely correct to add water to concentrated acid because of the risk of a violent reaction.

3 Cupronickel is an alloy of copper and nickel. It is used to make 'silver' coins.

A coin is analysed by the following method.

Step 1 It is weighed on a balance which reads to two decimal places and found to have mass 4.00 g.

Step 2 Water is added to the coin in a beaker. Concentrated nitric and sulfuric acids are added and the coin dissolves.

Step 3 When the coin is completely dissolved, the solution is neutralized.

Step 4 The neutral solution is transferred, with the washings, to a 100 cm^3 volumetric flask, made up to the mark with water and mixed thoroughly.

Step 5 10 cm^3 samples of the solution are taken and an excess of potassium iodide is added, producing iodine.

Step 6 The iodine is titrated with 0.200 mol dm^{-3} sodium thiosulfate solution.

(a) Why, in **Step 2**, is water added before, rather than after, the acids?

(1)

To cool down the ~~air~~ solution, Reduce the temperature as addition of concentrated acid is highly volatile and vigorous reactions can occur. As it is an exothermic reaction water is added

ResultsPlus
Examiner Comments

Although the first sentence is incorrect, the candidate recognises the consequences of adding water to acid.

ResultsPlus
Examiner Tip

When doing experiments ask why each step is done and consider the order in which chemicals are added.

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Step 5 10 cm^3 samples of the solution are taken and an excess of potassium iodide is added, producing iodine.

Step 6 The iodine is titrated with 0.200 mol dm^{-3} sodium thiosulfate solution.

(a) Why, in **Step 2**, is water added before, rather than after, the acids?

(1)

To provide a medium for the neutralization reaction to take place.

ResultsPlus
Examiner Comments

It is true that water is often the solvent for a reaction but here that does not answer the question about the step in which it is added.

ResultsPlus
Examiner Tip

Read the question more carefully.

Question 3 (b)

It was common to see the colour of iodine in starch solution given here.

(b) What is the colour of an aqueous iodine solution?

(1)

blue black Solution.

ResultsPlus
Examiner Comments

The common incorrect answer.

ResultsPlus
Examiner Tip

Another case of misreading the question - aqueous, and iodine solution are all important.

(b) What is the colour of an aqueous iodine solution?

(1)

Yle Orange

ResultsPlus
Examiner Comments

This is a more instructive error - the only common solution described as orange is sodium or potassium dichrolmate(VI).

ResultsPlus
Examiner Tip

Learn the colours of aqueous halogen solutions.

Iodine is red-brown unless it is very dilute when it is yellow.

Question 3 (c) (i)

This was the easiest question on the paper.

(c) (i) To make the end point of the titration more obvious, an indicator is added just before the colour of the iodine disappears.

Name this indicator.

(1)

Methyl orange.

ResultsPlus
Examiner Comments

Methyl orange is an acid-alkali indicator.

ResultsPlus
Examiner Tip

Indicators depend on the titration involved.

(c) (i) To make the end point of the titration more obvious, an indicator is added just before the colour of the iodine disappears.

Name this indicator.

(1)

Phenophthalein.

ResultsPlus
Examiner Comments

Another acid-base indicator.

ResultsPlus
Examiner Tip

Careful reading of the stem of a question will often point to the correct answer as it does here.

Question 3 (c) (ii)

It was pleasing to see how many candidates were aware that if added to early a stable iodine-starch complex forms.

(ii) Suggest why the indicator is not added to the iodine solution earlier in the titration.

(1)

Starch forms an insoluble blueblack complex in high concentrations of iodine.

ResultsPlus
Examiner Comments

This was sufficient. Detail of the nature of the complex was not required on this occasion.

ResultsPlus
Examiner Tip

Always answer the question as fully as possible.

(ii) Suggest why the indicator is not added to the iodine solution earlier in the titration.

(1)

~~starch becomes~~ end point colour will be reached, before ~~the~~ ~~titre~~ solution reacts with iodine.

ResultsPlus
Examiner Comments

Though this is true – the titre will be too small – it does not explain why.

ResultsPlus
Examiner Tip

Again, always answer the question as fully as possible.

Question 3 (c) (iii)

The common error was to fail to give the starting colour.

(iii) Give the colour change at the end point when the indicator is used in this titration.

(1)

colourless

ResultsPlus
Examiner Comments

The most common error.

ResultsPlus
Examiner Tip

Always give colour changes as from… to….

(iii) Give the colour change at the end point when the indicator is used in this titration.

(1)

orange to green

ResultsPlus
Examiner Comments

A curious confusion with dichromate(VI).

Question 3 (d) (i-iv)

(i) This was rarely incorrect.

(ii) This was another good discriminator as the weaker candidates gave 2, 3 and 4.

Several candidates weren't precise enough with their explanation for their correct choice e.g. closer or smallest distance, rather than not concordant.

(iii) Again rarely incorrect with transferred error allowed from (ii).

(iv) Here, the most common error was to forget the factor of 10.

Candidates either knew what to do or didn't know where to start!

They need to be encouraged to write chemical statements to explain their maths in order to gain credit for their working, as this was essential to gain credit for an incorrect final answer.

(d) The results for the titrations are shown below.

Titration number	1	2	3	4
Burette reading (final) / cm^3	24.10	47.90	23.55	47.00
Burette reading (initial) / cm^3	0.00	24.10	0.00	23.55
Titre / cm^3	24.10	23.8	23.55	23.45

(i) Complete the table.

(1)

(ii) Which titres should be used to calculate the mean? Explain your choice.

(1)

3 and 4

* ~~be c~~ because other titres (1 and 2) has ~~gr~~ greater value than ± 0.2

(iii) Calculate the mean titre.

(1)

$$\frac{23.55 + 23.45}{2}$$

$$= 23.5 \text{ cm}^3$$

(iv) Calculate the percentage by mass of copper in the coin.

Use the equations below.

$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$

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

(5)

moles of $S_2O_3^{2-}$

$0.200 \longrightarrow 1000cm^3$

$x \longrightarrow 23.5cm^3$

$x = 4.7 \times 10^{-3}$ moles

moles of I_2

2 : 1

$4.7 \times 10^{-3} : x$

$x = 2.35 \times 10^{-3}$ moles

moles of Cu^{2+}

1 : 2

$2.35 \times 10^{-3} : x$

~~$x = 4.7 \times 10^{-3}$ moles~~

$x = 4.7 \times 10^{-3}$ moles

mass of Cu^{2+}

mass $= 4.7 \times 10^{-3} \times 63.5$

$= 0.298$ g

% by mass of copper

$\frac{0.298}{4} \times 100$

$= 7.45\%$

ResultsPlus
Examiner Comments

This is fine till the final part when the factor of ten is omitted.

ResultsPlus
Examiner Tip

There is nearly always a dilution factor in repeated titrations.

Question 3 (d) (v)

The factor of 2 was often omitted in the burette calculation.

(v) The uncertainty in each burette reading is ±0.05 cm^3 and the uncertainty in each reading of the balance is ±0.005 g.

Calculate the percentage uncertainty in the third titre value and in the mass measurement. Use your results to decide whether using a balance that weighs to three decimal places would significantly improve the accuracy of the result.

(2)

burette

$\% U = \frac{0.05}{23.55} \times 100$

$= 0.21\%$

balance

$\frac{0.005}{4.00} \times 100$

0.13%

$\% U \frac{0.005}{4.004} \times 100$

$= 0.12\%$

% uncertainty in 4.004 less than % uncertainty 4.00 therefore balance that reads 3 d.p will improve the accuracy

ResultsPlus
Examiner Comments

The balance uncertainty is fine.

The burette calculation has omitted the factor of 2.

ResultsPlus
Examiner Tip

A titration involves two readings, one before and the other after the titration.

Question 4 (a)

It was disappointing to see how many candidates did not appreciate that bromine is a diatomic molecule.

This was the most common method of losing a mark.

4 Bromobenzene can be prepared from benzene by the following steps.

Step 1 Reflux 20.0 cm^3 of benzene with 6.0 cm^3 of bromine and about 10 g of iron filings, by heating on a water bath at 50 °C.

Step 2 After the reaction has finished, remove the water bath and heat to boiling until no bromine vapour can be seen.

Step 3 Cool the mixture and add 25 cm^3 of ethoxyethane (diethyl ether) to extract the bromobenzene.

Step 4 Wash the ethoxyethane layer with aqueous sodium hydroxide. Separate the ethoxyethane layer.

Step 5 Wash the ethoxyethane layer with water and repeat the separation.

Step 6 Dry the ethoxyethane layer with a suitable drying agent.

Step 7 Decant the dried solution.

Step 8 Distil the separated solution, collecting the fraction boiling around the boiling temperature of bromobenzene, 156 °C.

(a) Calculate the number of moles of bromine, Br_2, used in the experiment.

[Density of bromine 3.1 g cm^{-3}]

(2)

Density = m/v

3·1 = 79·9 / x

x = 79·9 / 3·1

x = 25·77

Volume = 25·77 cm^3

n = C V

= 6·0 × 25·77 / 1000

= 0·155 moles.

ResultsPlus
Examiner Comments

This answer illustrates two common problems.

First, insufficient practice in calculations involving density.

Second, confusion between moles of solids and solutions.

ResultsPlus
Examiner Tip

Practise density calculations connecting moles and volumes.

4 Bromobenzene can be prepared from benzene by the following steps.

Step 1 Reflux 20.0 cm^3 of benzene with 6.0 cm^3 of bromine and about 10 g of iron filings, by heating on a water bath at 50 °C.

Step 2 After the reaction has finished, remove the water bath and heat to boiling until no bromine vapour can be seen.

Step 3 Cool the mixture and add 25 cm^3 of ethoxyethane (diethyl ether) to extract the bromobenzene.

Step 4 Wash the ethoxyethane layer with aqueous sodium hydroxide. Separate the ethoxyethane layer.

Step 5 Wash the ethoxyethane layer with water and repeat the separation.

Step 6 Dry the ethoxyethane layer with a suitable drying agent.

Step 7 Decant the dried solution.

Step 8 Distil the separated solution, collecting the fraction boiling around the boiling temperature of bromobenzene, 156 °C.

(a) Calculate the number of moles of bromine, Br_2, used in the experiment.

[Density of bromine 3.1 g cm^{-3}]

(2)

$d = \frac{m}{v}$

$m = v \times d$

$= 6.0 \times 3.1$

$= 18.6\ g$

$n = \frac{mass}{RMM}$

$= \frac{18.6}{79.9}$

$= 0.233\ mol\,dm^3$

ResultsPlus
Examiner Comments

The typical error.

ResultsPlus
Examiner Tip

Remember most non-metallic elements consist of diatomic molecules.

Question 4 (b)

Many knew the first step but balancing of this equation was poor.

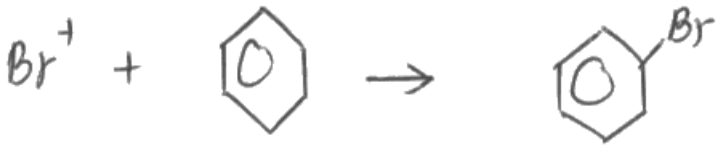
In the second step – far too many didn't know it or produced Br^-.

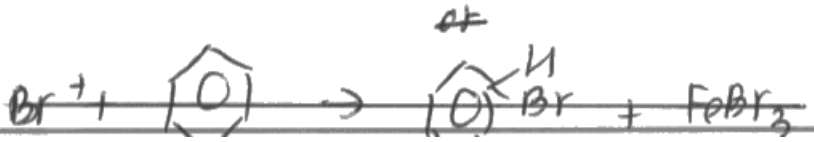
(b) Bromine reacts with iron to form iron(III) bromide, which reacts with bromine to produce the attacking electrophile in **Step 1**.

Write the chemical equations for these reactions.

(2)

$$Br_2 + FeBr_3 \longrightarrow FeBr_4^- + Br^+$$





ResultsPlus
Examiner Comments

An instructive error. The candidate has assumed the formation of iron(III) bromide. As a result they have given the correct second equation and even given the next equation correctly.

ResultsPlus
Examiner Tip

A check after answering on the question might have helped the candidate realise that they had not answered the question asked.

(b) Bromine reacts with iron to form iron(III) bromide, which reacts with bromine to produce the attacking electrophile in **Step 1**.

Write the chemical equations for these reactions.

(2)

~~$3Br_2 + 2Fe \longrightarrow 2Fe(Br)_3$~~

~~$Fe(Br)_3$~~

$3Br_2 + 2Fe \longrightarrow 2FeBr_3$

$FeBr_3 + Br_2 \longrightarrow FeBr_2 + 3Br$

ResultsPlus
Examiner Comments

The first equation is correct.

ResultsPlus
Examiner Tip

The key here is realising the attacking electrophile is Br^+.

Learn the attacking electrophiles in arene reactions.

Question 4 (c)

(c) Why is the ethoxyethane layer washed with sodium hydroxide solution in **Step 4**?

(1)

To remove the impurities present.

ResultsPlus
Examiner Comments

This answer is insufficient.

ResultsPlus
Examiner Tip

Answer the question as fully as possible - what might the impurities be?

(c) Why is the ethoxyethane layer washed with sodium hydroxide solution in **Step 4**?

(1)

Sodium hydroxide is added to remove HBr which dissolved in the ethoxyethane layer.

ResultsPlus
Examiner Comments

The fully correct answer, even mentioning where the HBr is dissolved.

ResultsPlus
Examiner Tip

Advanced level answers should be detailed like this.

Question 4 (d)

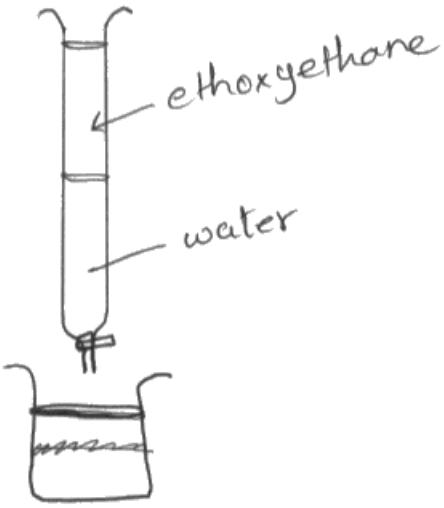
Some very poor drawings were seen here. The narrow neck and/or the tap was missed.

It was rare to see the layers the wrong way round which suggested the density information had been ignored.

(d) Draw a diagram of the apparatus used to separate the ethoxyethane layer from the aqueous layer in **Step 5**. Clearly label the ethoxyethane layer.

[Densities: water 1.0 g cm^{-3}, ethoxyethane 0.7 g cm^{-3}]

(2)



ResultsPlus
Examiner Comments

Though the layers are correct, this is quite clearly a burette.

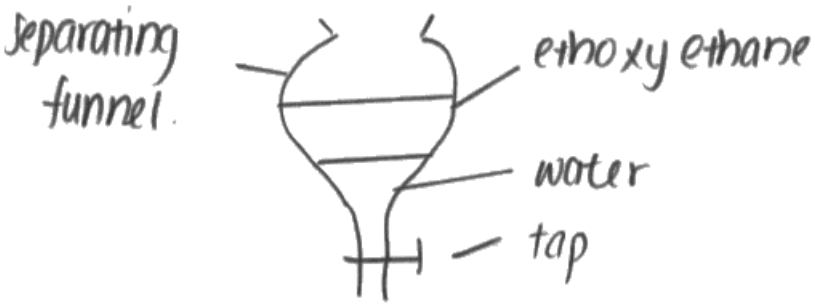
ResultsPlus
Examiner Tip

Be familiar with common apparatus like a separating funnel.

(d) Draw a diagram of the apparatus used to separate the ethoxyethane layer from the aqueous layer in **Step 5**. Clearly label the ethoxyethane layer.

[Densities: water 1.0 g cm^{-3}, ethoxyethane 0.7 g cm^{-3}]

(2)



ResultsPlus
Examiner Comments

A perfect answer.

ResultsPlus
Examiner Tip

Practise drawing items of apparatus.

Question 4 (e)

Omissions of one or other acid were common, as were omission of the word 'concentrated'.

So only about half the candidates gained this mark.

(e) The bromobenzene formed in this reaction can be nitrated to make 2,4-dinitrobromobenzene.

Identify, by name or formula, the chemicals needed for this reaction.

(1)

eg concentrated hydrochloric acid and

concentrated ~~sodium hydroxide~~ hydroe sulfuric acid

ResultsPlus
Examiner Comments

This mixture tends to spit or explode!

ResultsPlus
Examiner Tip

Learn the meaning of 'nitration'.

(e) The bromobenzene formed in this reaction can be nitrated to make 2,4-dinitrobromobenzene.

Identify, by name or formula, the chemicals needed for this reaction.

(1)

concentrated HNO_3

ResultsPlus
Examiner Comments

An instructive omission.

Nitric acid alone will nitrate a phenol but not benzene.

ResultsPlus
Examiner Tip

This is easy to remember - it is the only time that a mixture of concentrated acids is used!

Question 4 (f)

This was a good question for the better candidates. Weaker candidates found the mean of the three values, instead of multiplying them together appropriately.

(f) 2,4-dinitrobromobenzene reacts with hydrazine hydrate to make 2,4-dinitrophenylhydrazine crystals.

The percentage yields for the reactions are:

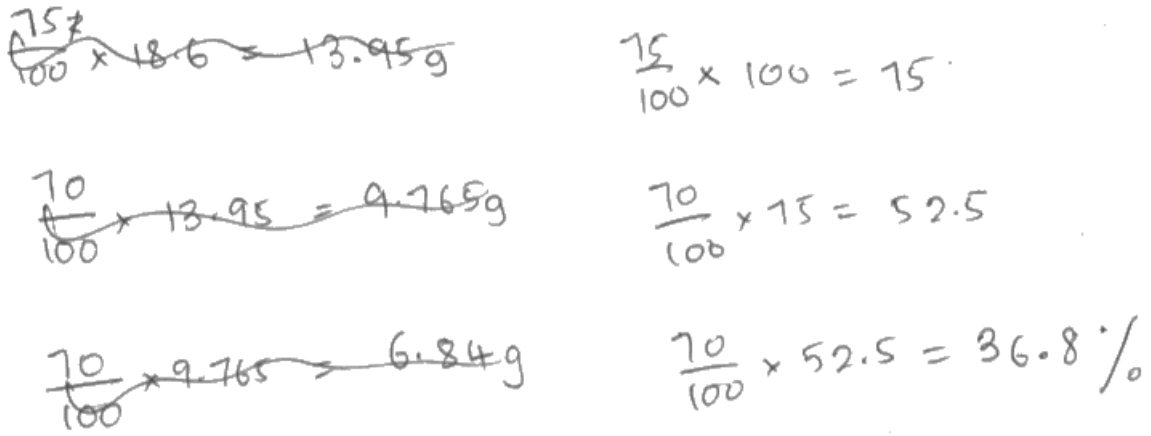
75% for the formation of bromobenzene from benzene

70% for the formation of 2,4-dinitrobromobenzene from bromobenzene

70% for the formation of 2,4-dinitrophenylhydrazine from 2,4-dinitrobromobenzene

Calculate the overall percentage yield of 2,4-dinitrophenylhydrazine from benzene, for this series of reactions.

(1)



ResultsPlus
Examiner Comments

The correct answer, clearly reasoned.

ResultsPlus
Examiner Tip

Always show your reasoning in calculations.

(f) 2,4-dinitrobromobenzene reacts with hydrazine hydrate to make 2,4-dinitrophenylhydrazine crystals.

The percentage yields for the reactions are:

75% for the formation of bromobenzene from benzene 79.5

70% for the formation of 2,4-dinitrobromobenzene from bromobenzene

70% for the formation of 2,4-dinitrophenylhydrazine from 2,4-dinitrobromobenzene 38.95

55.65

Calculate the overall percentage yield of 2,4-dinitrophenylhydrazine from benzene, for this series of reactions.

(1)

% yield = $\frac{\text{actual yield}}{\text{theoretical yield}}$ x 100

= $\frac{38.96}{106}$ x100

= 36.8%

ResultsPlus
Examiner Comments

The fully correct answer.

ResultsPlus
Examiner Tip

Always show reasoning fully in calculations, as it is here.

(f) 2,4-dinitrobromobenzene reacts with hydrazine hydrate to make 2,4-dinitrophenylhydrazine crystals.

The percentage yields for the reactions are:

75% for the formation of bromobenzene from benzene

70% for the formation of 2,4-dinitrobromobenzene from bromobenzene

70% for the formation of 2,4-dinitrophenylhydrazine from 2,4-dinitrobromobenzene

Calculate the overall percentage yield of 2,4-dinitrophenylhydrazine from benzene, for this series of reactions.

(1)

70 +25

= 95 %

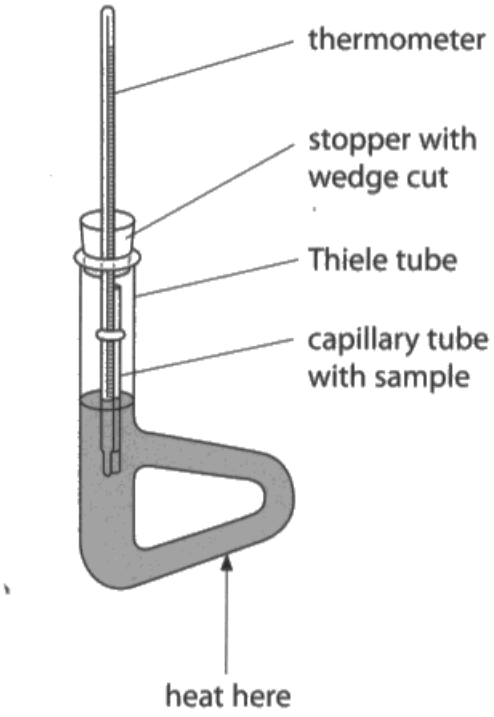
ResultsPlus
Examiner Comments

Notice how the incorrect answer is given with no reasoning.

Question 4 (g) (i)

Very few candidates seemed familiar with this, though it is a standard procedure to melt one end of the tube in a hot Bunsen flame.

(g) The purity of the 2,4-dinitrophenylhydrazine crystals can be checked by carrying out a melting temperature determination using the Thiele tube apparatus shown below.



(i) The capillary tube must be sealed at one end. Describe how this is done.

(1)

By using a stopper.

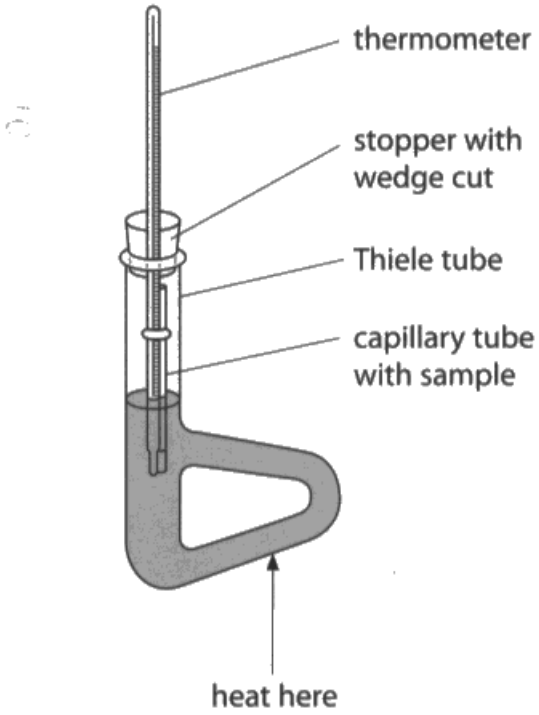
ResultsPlus
Examiner Comments

This was the common wrong response.

ResultsPlus
Examiner Tip

Practise practical techniques, then you will remember them.

(g) The purity of the 2,4-dinitrophenylhydrazine crystals can be checked by carrying out a melting temperature determination using the Thiele tube apparatus shown below.



(i) The capillary tube must be sealed at one end. Describe how this is done.

(1)

The end that is to be sealed is heated above a (in the blue part of the flame) bunsen burner to melt it together.

ResultsPlus
Examiner Comments

An excellent answer.

Question 4 (g) (ii)

Again, very few candidates seem to have done this. Often the use of wires or rods were suggested.

Many heated the tube!

(ii) When crystals are placed in the capillary tube they often stick in the top. Describe how to ensure the crystals reach the bottom of the capillary tube.

(1)

Shake the capillary tube vigorously to ensure the crystals reach bottom.

ResultsPlus
Examiner Comments

Though this has some merit, the crystals would most likely spill out.

(ii) When crystals are placed in the capillary tube they often stick in the top. Describe how to ensure the crystals reach the bottom of the capillary tube.

(1)

Shake the capillary tube and lightly tap the outside of the tube with a stirrer to make them fall.

ResultsPlus
Examiner Comments

This gained the mark – though a stirrer seems a strange device to use.

ResultsPlus
Examiner Tip

It is unwise to suggest more than one thing.

Question 4 (g) (iii)

Weaker candidates managed to get the first mark for high boiling temperature. Only more able candidates were able to get the second mark. The better candidates saying that the solvent must not decompose at high temperature.

(iii) Dibutyl phthalate is often used as the liquid in the Thiele tube.

Suggest **two** properties of dibutyl phthalate that make it a suitable liquid for this purpose.

(2)

higher boiling point.

high specific heat capacity.

ResultsPlus
Examiner Comments

Though arguably both of these reasons are correct, the second is a physical property and this is a chemical examination.

ResultsPlus
Examiner Tip

Always give chemical reasons first, in this type of question.

(iii) Dibutyl phthalate is often used as the liquid in the Thiele tube.

Suggest **two** properties of dibutyl phthalate that make it a suitable liquid for this purpose.

(2)

It must be having a boiling temperature higher than that of the sample.

It ~~should~~ must be a clear liquid, so that ~~then~~ any changes to the sample won't be obscured by the liquid.

ResultsPlus
Examiner Comments

The high boiling temperature is fine.

The clarity of the liquid was deemed just sufficient - especially with the reason given.

ResultsPlus
Examiner Tip

Always answer questions as fully as possible.

Question 4 (g) (iv)

Answers here showed the lack of practical experience of many candidates. The word 'range' in the question was often ignored.

Values were often ridiculous.

(iv) The melting temperature for crystals of 2,4-dinitrophenylhydrazine is 201°C.

Suggest the temperature **range** over which you would expect the crystals to melt before and after purification by recrystallization.

(2)

Before recrystallization 150°C - 250°C 170°C - 220°C

After recrystallization 199°C - 203°C

ResultsPlus
Examiner Comments

The first range is far too large.

The second is just acceptable - though it is unlikely that crystals will melt above their melting temperature.

ResultsPlus
Examiner Tip

Remember what you found when finding a melting temperature in the laboratory.

(iv) The melting temperature for crystals of 2,4-dinitrophenylhydrazine is 201°C.

Suggest the temperature **range** over which you would expect the crystals to melt before and after purification by recrystallization.

(2)

Before recrystallization 180°C

After recrystallization 203°C

ResultsPlus
Examiner Comments

The word 'range' has not been read.

ResultsPlus
Examiner Tip

Read the question three times.

Twice before answering and then afterwards to check you have answered it.

Paper Summary

To improve on this paper candidates should:

- Treat practical work seriously
- Constantly be considering the reasons for all the procedures that they use
- Record and remember observations that they make during experiments
- Practise drawing fully labelled diagrams of apparatus.

Grade Boundaries

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