REDSPOT New Solutions . New Minds

About O Level

CHEMISTRY
ALTERNATIVE TO PRACTICAL
(PAPER 4) (YEARLY)

About Thinking Process

When solving problems, we first analyse the questions and then gather relevant information until we are able to determine the answers. But for presentation reason, we need to organise, rearrange and then present ONLY the required workings and solutions.

Thinking process reveals the extra but relevant information which is not required as part of the solutions.

period	**2010 to 2024**
contents	**June & November, Paper 4, Worked Solutions**
form	**Yearly**
compiled for	**O Levels**
special features	**Thinking Process**

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JUNE 2024

Answer **all** questions.

Question 1

(a) A student finds the amount of iron(II) ions in a solution by titration.

The student:

- uses a volumetric pipette to add 25.0 cm^3 of aqueous iron(II) sulfate to a conical flask
- adds approximately 20 cm^3 of dilute sulfuric acid to the flask
- slowly adds aqueous potassium manganate(VII) to the conical flask until the solution just turns pink
- repeats the titration several times.

(i) Fig. 1.1 shows the apparatus the student uses to measure the volume of dilute sulfuric acid.

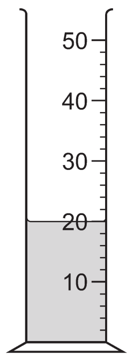


Fig. 1.1

Name the apparatus shown in Fig. 1.1.

.... [1]

(ii) Explain why the student does **not** need to use a volumetric pipette to measure the volume of dilute sulfuric acid.

....

.... [1]

(iii) Describe how the student uses the volumetric pipette to measure 25.0 cm^3 of aqueous iron(II) sulfate safely.

....

.... [1]

(b) Name the apparatus the student uses to add the aqueous potassium manganate(VII) to the flask.

.... [1]

(c) State why the student does **not** need to add an indicator to this titration.

....

.... [1]

(d) Explain how the student knows when they have done enough titrations.

....

.... [1]

[Total: 6]

Question 2

A student investigates the temperature change when a solid completely dissolves in water.

The student:

- measures 25 cm^3 of distilled water and pours it into a beaker
- uses a thermometer to measure the initial temperature of the water in the beaker
- records this temperature in Table 2.1 at time 0 s
- adds a sample of the solid to the beaker and starts a stop-watch
- stirs the mixture and records the temperature and time at 60 s intervals for a total of 300 s.

Some of the results are shown in Table 2.1.

Table 2.1

time / s	temperature / °C
0	19.5
60	13.0
120	
180	14.0
240	14.5
300	

(a) (i) Fig. 2.1 shows the results for 120 s and 300 s.

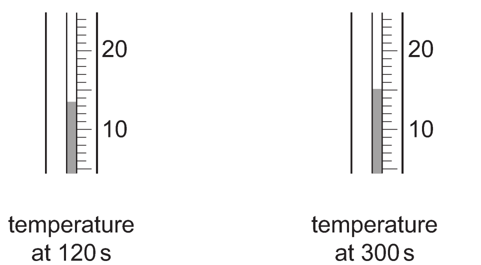


Fig. 2.1

Record the values from Fig. 2.1 to the nearest 0.5 °C in Table 2.1. [3]

(ii) Calculate the maximum temperature change in the investigation.

maximum temperature change .... °C [1]

(iii) Describe the trends shown in the results in Table 2.1.

....

....

.... [2]

(iv) Suggest the temperature of the mixture if it is left for 60 minutes.
Explain your answer.

temperature after 60 minutes .... °C

explanation ....

....
[2]

(b) Describe the energy change when the solid dissolves in water.
Explain how the results in Table 2.1 support your answer.

description ....

explanation ....

....
[2]

(c) Explain why it is important for the student to stir the mixture.

....

.... [1]

(d) The maximum temperature change calculated is **not** the true value for this investigation.
This may be because the volume of water and the temperature are **not** measured precisely.
Explain how to obtain a more precise **temperature** measurement.

....

.... [1]

(e) The maximum temperature change calculated is less than the true value for this investigation.

Suggest a reason for this, other than the precision of measurements.

Describe an improvement to the method which reduces this error.

reason ....

....

improvement ....

.... [2]

[Total: 14]

Question 3

A student does a series of experiments to investigate solution **R**.

(a) (i) The student leaves a wooden splint with one end dipped into **R** for ten minutes. The student then places the damp end of the wooden splint into the flame of a Bunsen burner with the air hole open.

The student concludes that **R** contains sodium ions.

State the observation which allows the student to make this conclusion.

.... [1]

(ii) Explain why the air hole on the Bunsen burner must be open when doing this flame test.

....

.... [1]

(b) (i) The student adds dilute nitric acid to **R**.

The student observes effervescence of a colourless gas which turns limewater milky.

State the conclusions from these observations.

....

.... [2]

(ii) The student adds aqueous barium nitrate to some of the mixture from **(b)(i)**.

The student concludes that **R** contains sulfate ions.

State the observation which allows the student to make this conclusion.

.... [1]

(iii) The student adds aqueous silver nitrate to some of the mixture from **(b)(i)**.

The student observes a colourless solution.

State a conclusion from this observation.

....

.... [1]

(iv) The student adds aqueous sodium hydroxide to **R** and warms the mixture.

Describe a test and observation to show that **R** does **not** contain ammonium ions.

test ....

observation ....

.... [2]

(c) Solution **R** is made from a mixture of two different ionic compounds.

Suggest the names of these **two** compounds.

....

.... [2]

(d) The student tests a different solution, **P**, and finds it difficult to decide whether the solution contains chloride ions or bromide ions.

The student also has aqueous potassium chloride and aqueous potassium bromide.

Suggest how the student could use the aqueous potassium chloride and aqueous potassium bromide to make it easier to decide whether **P** contains chloride ions or bromide ions.

....

....

....

.... [2]

(e) The student adds dilute hydrochloric acid to another solution and a gas is produced. The gas is passed through limewater.

Describe how the gas can be passed through limewater.

You may draw a labelled diagram to help answer the question.

....

....

....

[2]

[Total: 14]

SOLUTIONS - JUNE 2024

Q1 - Solution

(a) (i) Measuring Cylinder

(ii) Volume of the acid used does not need to be very accurate in this experiment.

(iii) The student uses a pipette filler to suck up the liquid up to the mark in the pipette and then place the liquid in the flask.

(b) Burette

(c) The color change of potassium (VII) manganate upon addition to the flask serves as its own indicator, eliminating the need for any additional indicators in this titration.

(d) When two titration results are within 0.2 cm^3 of one another, the student knows that they have done enough titrations.

Q2 - Solution

(a) (i)

time / s	temperature / °C
0	19.5
60	13.0
120	**13.5**
180	14.0
240	14.5
300	**15**

(ii) Maximum temperature change = highest temperature – lowest temperature

= 19.5 °C – 13.0 °C = 6.5 °C

(iii) Initially the temperature decreases in the first 60 s and then increases gradually.

(iv) Temperature after 60 minutes: 19.5

Explanation: The temperature of the mixture returns to its initial value when left for so long.

(b) Description: The energy change is endothermic as the mixture absorbs energy from the surroundings

Explanation: The temperature of the reaction mixture decreases.

(c) To ensure that all solids dissolve completely in the reaction mixture and to maintain a uniform temperature, it is essential to stir the mixture thoroughly.

(d) For more accurate temperature measurements, it is important to use a thermometer with graduations of less than 1 °C intervals.

(e) Reason: There is heat gain from the surroundings.

Improvement: Using a lid or insulation around the beaker can reduce this error.

Q3 - Solution

(a) (i) The student sees a yellow flame.

(ii) When the air hole is open, the bunsen flame is blue color. During this flame test, it is important that the bunsen flame do not mask the flame color.

(b) (i) The gas present is carbon dioxide which means that **R** contains carbonate ions (CO_3^{2-}).

(ii) The student observes white precipitates.

(iii) As a colorless solution is observed, this ensures that no chloride, bromide or iodide ions are present in the mixture.

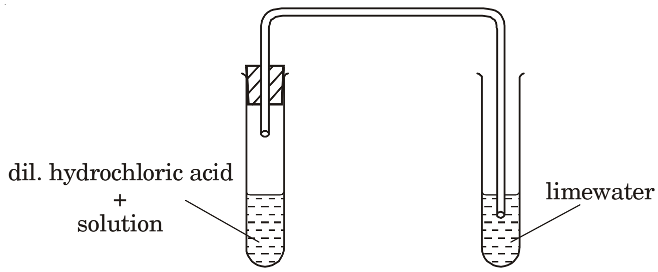
(iv) Test: The gas is tested with damp red litmus paper.

Observation: The red litmus paper does not change color as **R** does not contain ammonium ions

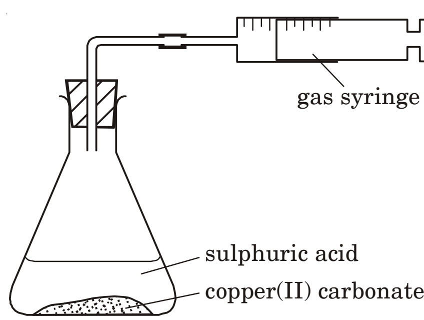
(c) Sodium Sulfate and Sodium Carbonate.

(d) The student should do a halide test with silver nitrate on aqueous potassium chloride and potassium bromide and then compare the results with that of solution **P**. This way the student can judge whether chloride or bromide ions are present in **P** or not.

(e) By using a delivery tube from the reaction vessel, the gas can be bubbled through limewater.



Q4 - Solution



The student should begin the experiment by accurately preparing the two reagents. This involves using a weighing balance to measure a precise mass of copper(II) carbonate and then using a measuring cylinder to dispense an excess amount of dilute sulfuric acid. Next, the student should position the conical flask on a stable surface and attach one end of the delivery tube to it, ensuring that the other end is securely connected to a gas syringe. Rubber stoppers should be used where necessary to prevent any gas from escaping. Once the apparatus is set up, the student should pour the measured dilute sulfuric acid into the conical flask containing copper(II) carbonate. Immediately after pouring, they should seal the flask with a stopper and start timing using a stopwatch. The student should observe as carbon dioxide gas is produced during this reaction; it will flow through the delivery tube into the gas syringe. They should continue monitoring until bubbling ceases, at which point they can carefully read and record the volume of carbon dioxide collected in the gas syringe.

To enhance accuracy in their results, student is advised to repeat this experiment multiple times under consistent conditions, using exactly the same mass of copper(II) carbonate each time, and calculate an average volume from these trials. This systematic approach will help ensure reliable data regarding how much carbon dioxide is generated during each reaction.

NONEMBER 2024

Answer **all** questions.

Question 1

A student does an experiment to make pure hydrated copper(II) sulfate crystals, $CuSO_4 \cdot 5H_2O$.

(a) The student makes aqueous copper(II) sulfate by reacting a dilute acid with excess copper(II) oxide. Name the acid.

.... [1]

(b) Fig. 1.1 shows the apparatus the student uses to crystallise the aqueous copper(II) sulfate.

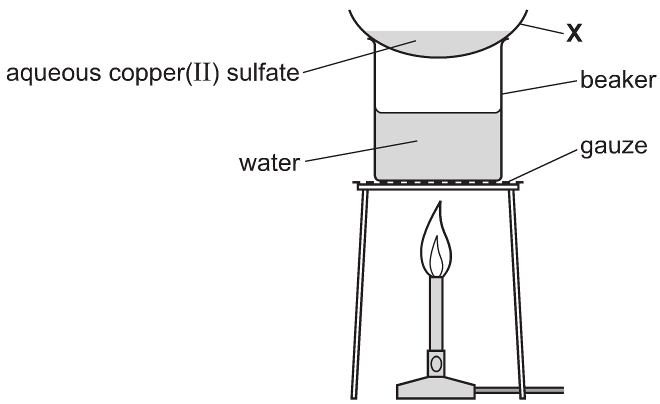


Fig. 1.1

(i) Name apparatus **X**.

.... [1]

(ii) Describe how the student decides when to stop heating the aqueous copper(II) sulfate.

....

.... [1]

(iii) Suggest why apparatus **X** is heated with a water bath and **not** heated directly using the Bunsen burner.

....

....

.... [2]

(iv) Describe the final step needed to produce pure hydrated copper(II) sulfate crystals.

.... [1]

[Total: 6]

Question 2

A student titrates four samples of aqueous sodium carbonate with 0.500 mol / dm^3 dilute hydrochloric acid, HC*l* (aq).

In titration 1 the student:

- rinses and fills a burette with 0.500 mol / dm^3 HC*l*(aq)
- adds 25.0 cm^3 of aqueous sodium carbonate to a conical flask
- adds methyl orange indicator to the conical flask
- adds HC*l*(aq) from the burette while swirling the flask, adding drop by drop near the end-point, until the solution just changes colour.

The student repeats the titration three more times.

(a) Fig. 2.1 shows the burette readings for two of the titrations.

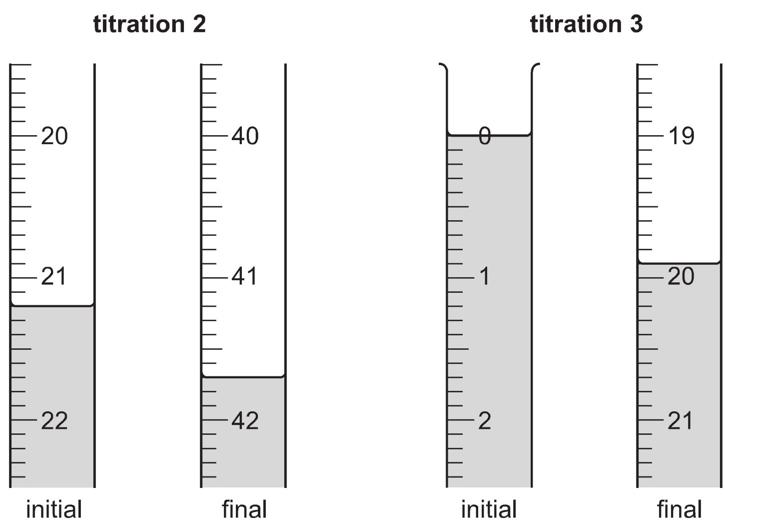


Fig. 2.1

Record the burette readings in Table 2.1.

Complete Table 2.1.

Table 2.1

	titration number			
	1	2	3	4
final burette reading / cm^3	21.1			40.4
initial burette reading / cm^3	0.2			20.3
volume of HC*l*(aq) used / cm^3	20.9			
best titration results (✓)				

[3]

(b) Tick (✓) the two best titration results in Table 2.1. [1]

(c) Use the ticked (✓) titration results in Table 2.1 to calculate the average volume of HC*l*(aq) needed to neutralise 25.0 cm^3 of the aqueous sodium carbonate.

volume .... cm^3 [1]

(d) Use your answer from **(c)** to calculate the number of moles of HC*l* in the average volume of HC*l*(aq) needed to neutralise 25.0 cm^3 of the aqueous sodium carbonate.

number of moles .... [1]

(e) The equation for the reaction between hydrochloric acid and sodium carbonate is:

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$$

Use your answer from **(d)** to calculate the concentration of the aqueous sodium carbonate.

Give your answer to **three** significant figures.

concentration .... mol / dm^3 [3]

(f) The student is provided with 150 cm^3 of the aqueous sodium carbonate.

Use your answer to **(e)** to calculate the mass of Na_2CO_3 in 150 cm^3 of this solution.

[A_r: C, 12; O, 16; Na, 23]

mass .... g [3]

(g) State why the conical flask is swirled while HC*l*(aq) is added from the burette.

.... [1]

(h) State why the HC*l*(aq) is added drop by drop near the end-point.

.... [1]

[Total: 14]

Question 3

A student investigates solution **P** and solution **Q**.

(a) Solution **P** is colourless and contains sodium ions.

(i) Describe how to do a flame test on solution **P** to confirm the identity of this cation.

....

....

....

.... [3]

(ii) Solution **P** contains an anion composed of nitrogen and oxygen.

Describe a test to identify the anion in solution **P**.

test ....

....

....

observations ....

....

identity of anion ....

[6]

(b) The tests the student does on solution **Q** are shown in Table 3.1.

Some of the observations for these tests are also shown.

Table 3.1

	tests on solution **Q**	observations
1	Add drops of aqueous ammonia to solution **Q** until a change is seen. Then add excess aqueous ammonia.	green precipitate insoluble in excess
2	Add drops of aqueous sodium hydroxide to solution **Q** until a change is seen. Then add excess aqueous sodium hydroxide.	green precipitate soluble in excess, giving a green solution
3	Add aqueous silver nitrate to solution **Q**.	white precipitate
4	Add dilute nitric acid to solution **Q**. Then add aqueous barium nitrate.	

(i) Identify the cation in solution **Q** using the observations from tests 1 **and** 2.

.... [1]

(ii) Test 3 is incomplete.

Describe what else must be done in test 3 to ensure that the white precipitate observed leads to a valid conclusion about the anion in solution **Q**.

.... [1]

(iii) The student completes test 3 correctly. The observation remains the same.

Identify an anion in solution **Q**.

.... [1]

(iv) The ion identified in **(iii)** is the only anion in solution **Q**.

Describe the expected observation from test 4.

.... [1]

(v) Solution **Q** is acidic.

Describe the observation when solution **Q** is added to sodium carbonate.

.... [1]

[Total: 14]

Question 4

Muntz metal is an alloy that contains zinc and copper.

Zinc reacts with dilute sulfuric acid. Copper does **not** react with dilute sulfuric acid.

Plan an investigation to find the percentage by mass of zinc in a powdered sample of Muntz metal which contains only zinc and copper.

Your plan must include the use of common laboratory apparatus, Muntz metal and dilute sulfuric acid. No other chemicals should be used.

Your plan must include:

- the apparatus needed
- the method to use and the measurements to take
- procedures to ensure that the percentage determined is as accurate as possible
- how the measurements are used to determine the percentage by mass of zinc in the sample of Muntz metal.

You may draw a diagram to help answer the question.

....

....

....

....

....

....

....

SOLUTIONS - NOVEMBER 2024

Q1 - Solution

(a) Dilute sulfuric acid.

(b) **(i)** Evaporating dish.

(ii) When crystals begin to form, the student decides to stop heating the copper(II) sulfate further.

(iii) The water bath provides a gentle heating method for the solution, effectively preventing any solids from splattering and ensuring that the water of crystallization remains intact.

(iv) The crystals must be left to dry.

Q2 - Solution

(a) & (b)

	titration number			
	1	2	3	4
final burette reading / cm^3	21.1	**41.7**	**19.9**	40.4
initial burette reading / cm^3	0.2	**21.2**	**0.0**	20.3
volume of HC*l*(aq) used / cm^3	20.9	**20.5**	**19.9**	**20.1**
best titration results (✓)			✓	✓

(c) Average volume of HC*l* $= \frac{(19.9+20.1)}{2} = 20\ cm^3$

(d) Concentration of HC*l* $= 0.500\ mol/dm^3$

Number of moles of HC*l* = volume × concentration

$$= 0.500 \times \frac{20}{1000} = 0.01 \text{ moles.}$$

(e) Molar ratio between HC*l* and $Na_2CO_3 = 2:1$

$\therefore$ Moles of $Na_2CO_3 = \frac{0.01}{2} = 0.005$ mol

Concentration $= \frac{0.005}{\frac{25}{1000}}$

$$= 0.005 \times \frac{1000}{25} = 0.2\ mol/dm^3$$

(f) M_r of $Na_2CO_3 = (23\times2)+12+(16\times3) = 106$

Moles of Na_2CO_3 in 150 $cm^3 = 0.2 \times \frac{150}{1000} = 0.03$

Mass of Na_2CO_3 in 150 $cm^3 = 0.03 \times 106 = 3.18$ g

(g) The conical flask is swirled to mix all the reactants and ensure reaction.

(h) Hydrochloric acid is added gradually, drop by drop, to ensure that the endpoint is accurately reached and the volume of the reacted solution is precise.

Q3 - Solution

(a) (i) Use a clean platinum or nichrome wire loop and dip it into solution **P** to collect a small amount of the solution. Hold the wire loop with the sample in the non-luminous flame of the Bunsen burner. Sodium ions will produce a bright yellow-orange flame. This distinct color confirms the presence of sodium ions in solution **P**.

(ii) Test: Add a few drops of aqueous sodium hydroxide to a test tube containing solution **P**. Cut a small piece of aluminium foil and add it to the test tube and gently warm the mixture in the test tube.

Observation: Ammonia gas will be released during the reaction. Test the gas by bringing damp red litmus paper close to the mouth of the test tube. If ammonia is present, it will turn the damp red litmus paper blue, indicating a basic solution.

Identity of anion: Nitrate ions NO_3^-

(b) (i) Chromium, Cr^{3+}

(ii) Dilute nitric acid must be added to complete the test.

(iii) Chloride ion Cl^-

(iv) There will be no precipitate formed so no observable change is expected.

(v) Effervescence and fizzing is observed.

Q4 - Solution

Apparatus Needed:

1. Balance: To weigh the powdered Muntz metal sample.
2. Beaker + Conical flask: To contain the dilute sulfuric acid and the Muntz metal sample.
3. Burette: To accurately measure and dispense dilute sulfuric acid.
4. Pipette: For transferring a specific volume of dilute sulfuric acid.
5. Stirring rod: To mix the solution.
6. Filter paper and funnel: To separate undissolved copper from the solution.
7. Evaporating dish: To evaporate water from the zinc sulfate solution to obtain solid zinc sulfate

Method:

Accurately weigh a sample of powdered Muntz metal using the balance. Record the mass (m) of the sample. Then prepare a known concentration of dilute sulfuric acid in a beaker. Place the powdered Muntz metal sample into a clean conical flask.

Use a pipette or graduated cylinder to measure a specific volume of dilute sulfuric acid and add it into the conical flask containing the Muntz metal. Stir the mixture gently with a stirring rod to ensure complete reaction between zinc and sulfuric acid.

Observe the reaction until no more gas bubbles are produced, indicating that all zinc has reacted. After the reaction is complete, set up a funnel with filter paper over another conical flask. Pour the mixture through the filter paper to separate any undissolved copper from the zinc sulfate solution. Measure and record the mass of copper collected over the filter paper. The amount of zinc that reacted can be calculated based on stoichiometry using the balanced equation for the reaction between zinc and sulfuric acid:

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

$$\text{Percentage of zinc} = \frac{\text{mass of Muntz metal} - \text{mass of copper}}{\text{mass of Muntz metal}} \times 100$$

To ensure precision in the investigation, calibrated equipment should be used for measuring volumes and masses. Multiple trials with different samples should be conducted to obtain an