

Acid-base and redox reaction – 2021/20 GCE Chemistry A Component 01**1. Nov/2021/Paper_H432/01/No.18(a _ c)**

A student carries out an experiment to determine the percentage by mass of copper in an ore containing copper in its +2 oxidation state.

The student is provided with a sample of the copper ore, 1 mol dm^{-3} potassium iodide, KI(aq) , and $0.0200 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

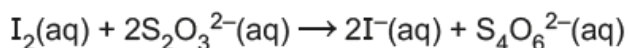
The student's method is outlined below.

Step 1 Add an excess of warm nitric acid to 2.50 g of the ore.
The copper(II) compounds in the ore react, forming aqueous copper(II) nitrate.

Step 2 Filter the mixture to remove the unreacted rock. Neutralise the filtrate.

Step 3 Add an excess of aqueous potassium iodide, KI(aq) .
A precipitate of copper(I) iodide and a solution of iodine, $\text{I}_2(\text{aq})$, forms.

Step 4 Titrate the mixture from **Step 3** using $0.0200 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$ in the burette.



26.55 cm^3 of $0.0200 \text{ mol dm}^{-3}$ $\text{Na}_2\text{S}_2\text{O}_3$ are required to reach the end point.

(a) In **Step 1**, the student observed that bubbles of gas were produced.

Suggest the formula of the copper(II) compound which reacted with HNO_3 to form the gas, and write a full equation for the reaction.

Formula:

Equation: [2]

(b) Write an **ionic** equation, including state symbols, for the reaction in **Step 3**.

..... [1]

(c) Suggest a suitable indicator for this titration and state the colour change at the end point in **Step 4**.

Indicator:

Colour from to [1]

2. Nov/2020/Paper_H432/01/No.1

Several students titrate 25.00 cm^3 of the same solution of sodium hydroxide, NaOH(aq) with hydrochloric acid, HCl(aq) .

One student obtains a smaller titre than the other students.

Which procedure explains the smaller titre?

- A** The burette readings are taken from the top of the meniscus instead of the bottom of the meniscus.
- B** The conical flask is rinsed with water before carrying out the titration.
- C** An air bubble is released from the jet of the burette during the titration.
- D** The pipette is rinsed with water before filling with NaOH(aq) .

Your answer

[1]

3. Nov/2020/Paper_H432/01/No.4

Phosphoric acid is a tribasic acid.

What is the mass of Ca(OH)_2 that completely neutralises 100 cm^3 of 0.100 mol dm^{-3} phosphoric acid?

- A** 0.49g
- B** 0.74g
- C** 1.11g
- D** 2.22g

Your answer

[1]

4. Nov/2020/Paper_H432/03/No.4

A student carries out an investigation to identify two metals, **M** and **X**, by two different methods.

(a) The student is provided with a sample of metal **M**.

The student analyses metal **M** using a 'back-titration' technique:

- The metal is reacted with excess acid.
- The resulting solution is titrated to determine the amount of acid remaining after the reaction.

Stage 1

The student adds 100 cm³ of 2.10 mol dm⁻³ HCl(aq) to 6.90 g of **M**.

An excess of HCl(aq) has been used to ensure that all of metal **M** reacts.

A redox reaction occurs, forming a solution containing **M** in the +2 oxidation state.

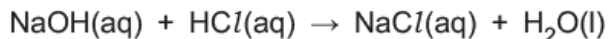
Stage 2

The resulting solution from **Stage 1** is made up to 250.0 cm³ with distilled water.

Stage 3

A 25.00 cm³ sample of the diluted solution from **Stage 2** is titrated with 0.320 mol dm⁻³ NaOH(aq).

The NaOH(aq) reacts with excess HCl(aq) that remains in **Stage 1**:



The student repeats the titration to obtain concordant titres.

Titration results (The trial titre has been omitted.)

The burette readings have been recorded to the nearest 0.05 cm³.

	1	2	3
Final reading / cm ³	27.80	37.55	32.20
Initial reading / cm ³	0.50	10.00	5.00

- (i) In **Stage 1**, a redox reaction takes place between **M** and HCl(aq), forming hydrogen and a solution containing **M** in the +2 oxidation state.

Write an overall equation, with state symbols, for this reaction. Write half-equations for the oxidation and reduction processes.

Overall equation

Oxidation half-equation

Reduction half-equation

[3]

(ii) In **Stage 1**, suggest **two** observations that would confirm that all of metal **M** has reacted.

1

.....

2

.....

[2]

(iii) In **Stage 3**, write the ionic equation for the reaction taking place in the titration.

..... [1]

(iv) Metal **M** can be identified following the steps below.

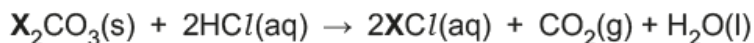
1. The amount, in mol, of excess HCl(aq) that remains after the reaction of **M** with HCl(aq) .
2. The amount, in mol, of HCl(aq) that reacted with **M**.
3. The identity of metal **M**.

Analyse the results to identify metal **M**.

Metal **M** = [6]

- (b) The student is provided with the carbonate of an unknown metal, X_2CO_3 .

The student measures the mass loss when the X_2CO_3 is reacted with an **excess** of hydrochloric acid. The equation is shown below.



The reaction is carried out using this method:

- Step 1** Add 100 cm³ HCl(aq) to a conical flask and weigh.
- Step 2** Add X_2CO_3 to the conical flask and immediately reweigh.
- Step 3** After 5 minutes, reweigh the conical flask and contents.

Results

Mass of conical flask + HCl(aq)	172.93 g
Mass of conical flask + X_2CO_3 + HCl(aq) before reaction	187.50 g
Mass of conical flask + contents after 5 minutes	184.75 g

- (i) Calculate the amount, in mol, of CO_2 released in the reaction.

Amount of CO_2 = mol [1]

- (ii) Calculate the molar mass of X_2CO_3 and identify metal X.

Molar mass of X_2CO_3 = g mol⁻¹ Metal X = [3]

- (c) After analysing the results, the student was told that their molar mass of X_2CO_3 was incorrect.

The student evaluated the experiment for possible reasons for the incorrect result.

- (i) The student wondered whether the reaction was complete when the mass was recorded after 5 minutes (**Step 3**).

How could the student modify the experimental procedure to be confident that the reaction was complete?

.....
.....
..... [1]

- (ii) The student finds out that carbon dioxide is slightly soluble in water.

State and explain how the solubility of CO_2 would affect the calculated molar mass of X_2CO_3 .

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.....
.....
..... [2]