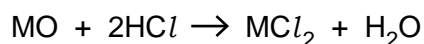


- 1 **P** is an aqueous solution prepared by reacting a metal oxide, **MO**, with an excess of hydrochloric acid, **HCl**. In preparing **P**, 3.36 g of the metal oxide was completely reacted with 1.00 dm³ of 0.200 mol/dm³ hydrochloric acid, an excess.



You are to determine by titration the amount of acid remaining in **P**.

Q is 0.0640 mol/dm³ sodium hydroxide, **NaOH**.

- (a) Put **P** into the burette.

Pipette a 25.0 cm³ (or 20.0 cm³) portion of **Q** into a flask and titrate with **P**, using the indicator provided.

Record your results in the table, repeating the titration as many times as you consider necessary to achieve consistent results.

Results

Burette readings

titration number	1	2	
final reading / cm ³			
initial reading / cm ³			
volume of P used / cm ³			
best titration results (✓)			

Summary

Tick (✓) the best titration results.

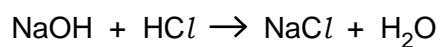
Using these results, the average volume of **P** required was cm³.

Volume of **Q** used was cm³.

[12]

- (b) **Q** is 0.0640 mol/dm^3 sodium hydroxide, NaOH.

Using your results from (a), calculate the concentration, in mol/dm^3 , of hydrochloric acid in **P**.



concentration of hydrochloric acid in **P** mol/dm^3 [2]

- (c) Before reaction with the metal oxide, 1.00 dm^3 of the acid contained 0.200 moles of hydrochloric acid. Using your answer from (b), calculate the number of moles of acid that reacted with 3.36 g of the metal oxide, MO.

moles of hydrochloric acid that reacted with the metal oxide [1]

- (d) Using your answer to (c), deduce the number of moles of metal oxide, MO, that reacted with the hydrochloric acid.

moles of metal oxide that reacted with the hydrochloric acid [1]

- (e) Using your answer to (d) and the mass of metal oxide, 3.36 g, calculate the relative atomic mass of the metal M in the metal oxide, MO.
[Relative atomic mass of oxygen, O, is 16.]

relative atomic mass of M [1]

[Total: 17]

2 You are provided with solid **R** and solution **S**.

Carry out the following tests and record your observations in the table.
You should test and name any gas evolved.

test no.	test	observations
1	Put a small amount of R in a hard-glass test-tube and heat the solid.	
2	To 1 cm depth of aqueous sodium hydroxide in a test-tube, add a small amount of R . Gently warm the mixture.	
3	Dissolve a small amount of R in 2 cm depth of distilled water in a test-tube. To the solution add a few drops of aqueous silver nitrate. Keep this mixture for use in tests 4 and 5.	
4	Transfer about half of the mixture from test 3 to a test-tube and add dilute nitric acid.	
5	To the remainder of the mixture from test 3, add aqueous ammonia until no further change is seen.	
6	To 1 cm depth of S in a test-tube, add aqueous sodium hydroxide until no further change is seen. Allow the final mixture to stand for a few minutes.	

test no.	test	observations
7	<p>(a) To 1 cm depth of S in a test-tube, add an equal volume of aqueous hydrogen peroxide.</p> <p>(b) Pour the mixture from (a) into a boiling tube and then add aqueous sodium hydroxide.</p>	
8	<p>(a) To 1 cm depth of S in a test-tube, add an equal volume of aqueous barium chloride.</p> <p>(b) Add dilute nitric acid to the mixture from (a).</p>	
9	To 1 cm depth of acidified potassium manganate(VII) in a test-tube, add an equal volume of S .	

[19]

ConclusionsThe formulae of two ions in **R** are

and

The formulae of two ions in **S** are

and

[4]

[Total: 23]

QUALITATIVE ANALYSIS NOTES

Tests for anions

<i>anion</i>	<i>test</i>	<i>test result</i>
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
iodide (I^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow ppt.
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide then aluminium foil; warm carefully	ammonia produced
sulfate (SO_4^{2-}) [in solution]	acidify with dilute nitric acid, then add aqueous barium nitrate	white ppt.

Tests for aqueous cations

<i>cation</i>	<i>effect of aqueous sodium hydroxide</i>	<i>effect of aqueous ammonia</i>
aluminium (Al^{3+})	white ppt., soluble in excess giving a colourless solution	white ppt., insoluble in excess
ammonium (NH_4^+)	ammonia produced on warming	–
calcium (Ca^{2+})	white ppt., insoluble in excess	no ppt., or very slight white ppt.
copper(II) (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess giving a dark blue solution
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess giving a colourless solution	white ppt., soluble in excess giving a colourless solution

Tests for gases

<i>gas</i>	<i>test and test result</i>
ammonia (NH_3)	turns damp litmus paper blue
carbon dioxide (CO_2)	turns limewater milky
chlorine (Cl_2)	bleaches damp litmus paper
hydrogen (H_2)	'pops' with a lighted splint
oxygen (O_2)	relights a glowing splint
sulfur dioxide (SO_2)	turns acidified aqueous potassium dichromate(VI) from orange to green