

**Practical Guide**

# Chemistry

for 'O' Level  
Practical  
Assessment






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**HODDER  
EDUCATION**

AN HACHETTE SINGAPORE COMPANY

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# Acids, bases and salts

## Acid

An acid is a substance which produces  $\text{H}^+$  ions in aqueous solution.

Strong acids completely ionize in water to give high concentration of  $\text{H}^+$  ions in aqueous solution.

Weak acids partially ionize in water to give low concentration of  $\text{H}^+$  ions in aqueous solution.

## Common acids

Name	Formula	Strength
Hydrochloric acid	HCl	Strong
Sulfuric acid	$\text{H}_2\text{SO}_4$	Strong
Nitric acid	$\text{HNO}_3$	Strong
Ethanoic acid	$\text{CH}_3\text{COOH}$	Weak

## Properties

- Sour taste
- pH less than 7
- Turns blue litmus paper red

## Chemical reactions

Acid + base  $\rightarrow$  salt + water (neutralisation)

Acid + metal  $\rightarrow$  salt + hydrogen gas

Acid + carbonate  $\rightarrow$  salt + water + carbon dioxide gas

## Tests for gases

Gas	Test	Result
Hydrogen	Lighted splint	Extinguish with a "pop" sound
Carbon dioxide	Limewater	White ppt

## Base

A base is a substance which reacts with acid to produce salt and water only.

- Bases include metal oxides, metal hydroxides and aqueous ammonia.
- Bases can be soluble or insoluble in water.
- Alkalis are soluble bases.

## Alkali

An alkali is a substance which produces  $\text{OH}^-$  ions in aqueous solution.

Strong alkalis completely ionize in water to give high concentration of  $\text{OH}^-$  ions in aqueous solution.

Weak alkalis partially ionize in water to give low concentration of  $\text{OH}^-$  ions in aqueous solution.

## Common alkalis

Name	Formula	Strength
Sodium hydroxide	NaOH	Strong
Potassium hydroxide	KOH	Strong
Calcium hydroxide	$\text{Ca}(\text{OH})_2$	Weak
Aqueous ammonia	$\text{NH}_3$	Weak

## Properties

- Bitter taste
- pH more than 7
- Turns red litmus paper blue

## Chemical reactions

Base/ Alkali + acid  $\rightarrow$  salt + water (neutralisation)

Alkali + ammonium salt  $\rightarrow$  salt + water + ammonia gas

## Test for gas

Gas	Test	Result
Ammonia	Damp red litmus paper	Turns blue

# Salt

## Solubility

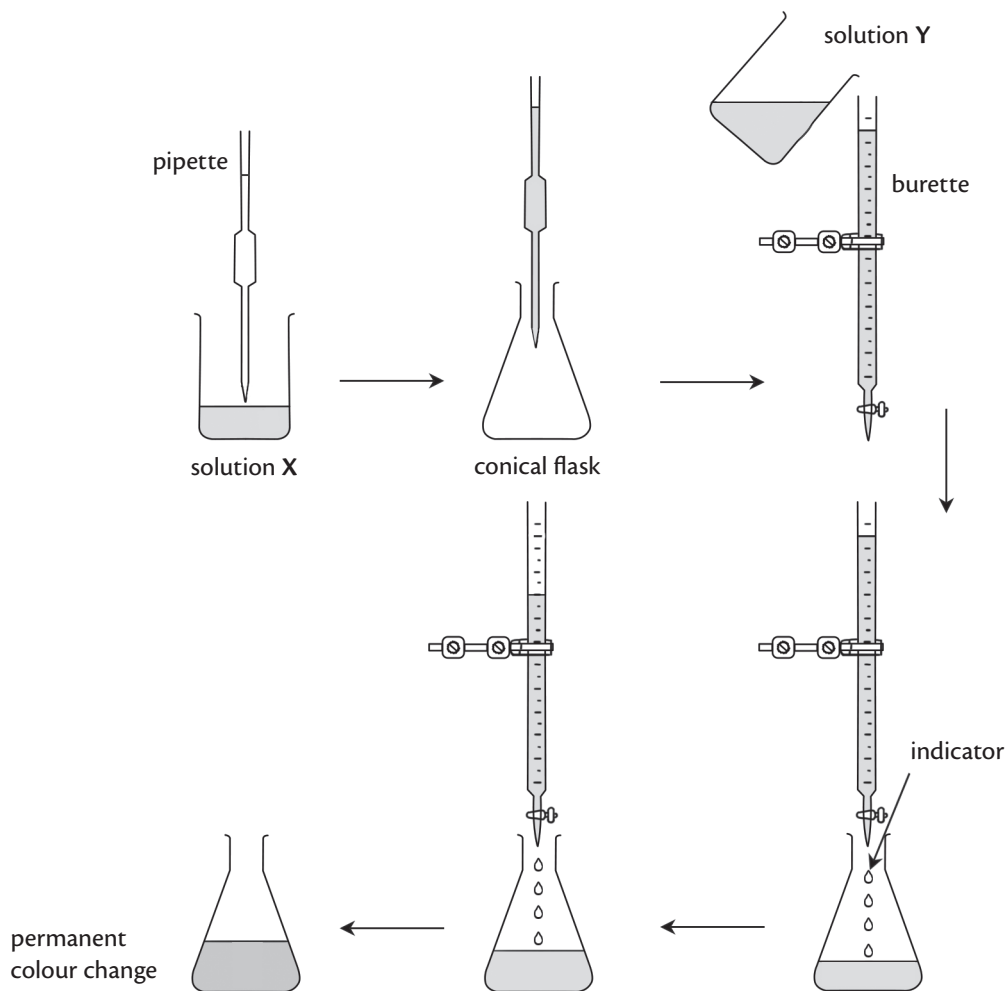
Soluble
Sodium (all)
Potassium (all)
Ammonium (all)
Nitrate (all)
Chloride (most) except silver, lead (II)
Sulfate (most) except barium, lead (II)

Insoluble
Carbonate (most)

## Salt preparation

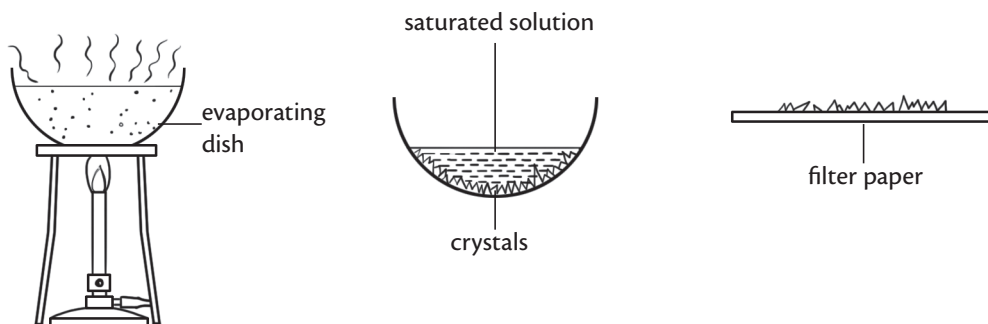
Solubility of salt	Method	Separation technique
Soluble	Titration	Crystallization
	Acid + excess insoluble solid (base, metal, carbonate)	Filtration, then crystallization
Insoluble	Precipitation	Filtration

## Titration



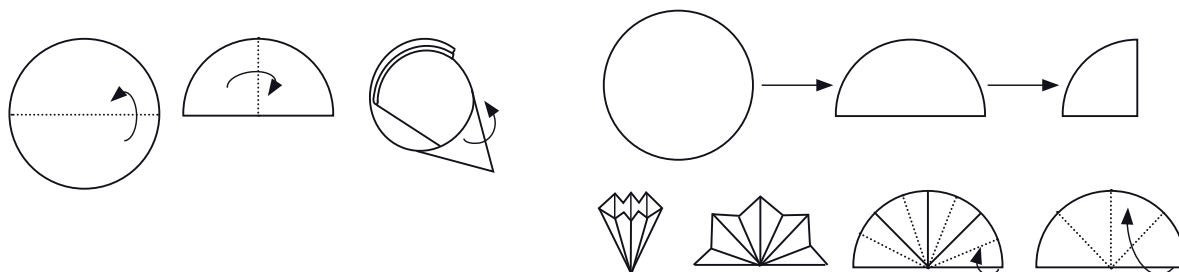
1. Pipette  $25.0 \text{ cm}^3$  of acid / base into a clean conical flask.
2. Rinse and fill the burette with base / acid.
3. Add 2 to 3 drops of pH indicator into the conical flask.
4. Titrate until end-point when the colour of the pH indicator changes permanently.
5. Repeat titration until consistent results are obtained (difference in the titre volumes within  $0.20 \text{ cm}^3$ ).

## Crystallization

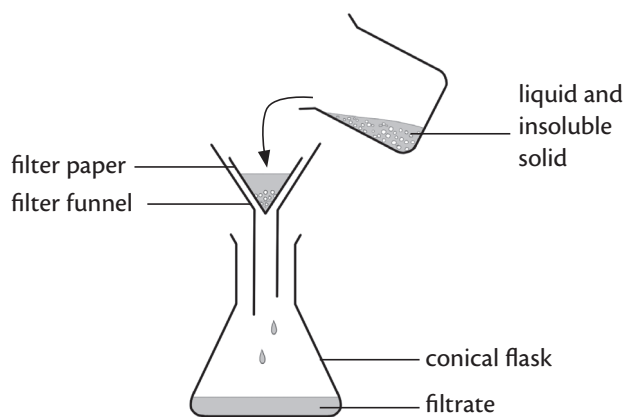


1. Put the solution into an evaporating dish.
2. Heat solution until saturated.
3. Leave to cool until crystals form.
4. Filter out crystals.
5. Rinse crystals with a small volume of cold distilled water.
6. Dry crystals with clean filter paper.

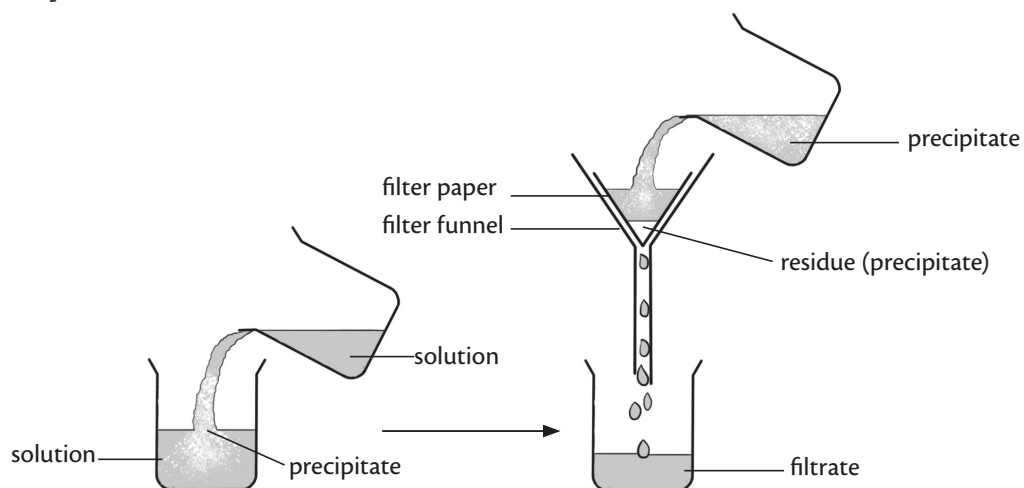
## Filtration



1. Place folded filter paper into filter funnel.
2. Pour mixture into filter funnel with filter paper.
3. Wait for all filtrate to be collected in conical flask.



## Precipitation



1. Mix the two solutions together in a beaker.
2. Filter the mixture.
3. Rinse the residue (precipitate) with distilled water.
4. Dry the precipitated salt with clean filter paper.

## Experiments on acids, bases and salts

Experiments may include titration, salt preparation and moles calculations. Unfamiliar acids, bases and indicators may be used.



## Planning

- Identify the independent variable (the variable that is changed or varied during the experiment) from the aim.
- Suggest a minimum of five different values of the independent variable with regular intervals: e.g. 20°C, 30°C, 40°C, 50°C, 60°C.
- Identify the dependent variable (the variable to measure under investigation) from the aim.
- Suggest how to measure the dependent variable: e.g. measure time taken for colour to change, count the number of bubbles, measure volume of gas, measure mass etc.
- Identify at least 2 fixed or controlled variables, which can affect the results of the experiment, to be measured and kept constant.
- Draw a labelled diagram of the set up needed or describe any modifications to the original set up which should be made.
- Write down the name of the apparatus used to make each measurement. Apparatus used in the main experiment may be used.
- Steps and details depend on the aim of the experiment. Steps from the main experiment may be used with modifications.
- State the safety precautions.
- Repeat the experiment and calculate the average results for reliability.
- State the expected results if the question requires you to do so.

Key marking points for planning:

- Appropriate variables identified: independent, dependent and fixed or controlled variables
- Drawing or description of the set up needed
- Steps of the experiment
- Expected results (if required)

### *Sample planning questions*

1. Plan an experiment to prepare clean dry crystals of sodium chloride.
2. Describe a suitable method to prepare a clean dry sample of barium sulfate.
3. Outline the steps to determine the water of crystallization in a sample of hydrated copper (II) sulfate.



## Experiment 1.1

**X** contains dilute hydrochloric acid and dilute sulfuric acid.

You are to determine the concentration of hydrogen ions in **X**, by performing a titration using aqueous sodium carbonate.

**Read all the instructions below carefully before starting the experiment.**

### *Instructions*

**X** is an aqueous solution of hydrogen ions. The solution was made by mixing unknown concentrations of dilute hydrochloric acid and dilute sulfuric acid.

**Y** is  $0.225 \text{ mol/dm}^3$  sodium carbonate.

(a) Put **X** into the burette.

Pipette  $25.0 \text{ cm}^3$  of **Y** into a flask and titrate with **X**, using the indicator provided.

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

### **Results [5]**

(b) From your titration results, obtain an average volume of **X** to be used in your calculations. Show clearly how you obtained this volume. [1]

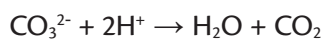
Average volume of **X**: \_\_\_\_\_

- (c) Y is 0.225 mol/dm<sup>3</sup> sodium carbonate.

Calculate the number of moles of sodium carbonate present in 25.0 cm<sup>3</sup> of Y. [1]

Number of moles of Y: \_\_\_\_\_

- (d) Using your results from (b) and the equation below, calculate the concentration of hydrogen ions in X. [2]



Concentration of hydrogen ions in X: \_\_\_\_\_

X contains dilute hydrochloric acid and dilute sulfuric acid.

The concentration of hydrochloric acid in X is 0.100 mol/dm<sup>3</sup>.

- (e) Using your answer from (d), calculate the concentration of sulfuric acid in X. [2]

Concentration of sulfuric acid in X: \_\_\_\_\_

- (f) X was made by mixing equal volumes of dilute hydrochloric acid and dilute sulfuric acid.  
Calculate the concentrations of the dilute hydrochloric acid and dilute sulfuric acid used to make X. [2]

Concentration of dilute hydrochloric acid used to make X: \_\_\_\_\_

Concentration of dilute sulfuric acid used to make X: \_\_\_\_\_

- (g) Without doing any further calculations, state and explain which acid has a higher percentage by mass in X. [2]

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- (h) X can be used to make lead (II) sulfate.

Starting from X, describe a method that can be used to make a pure, dry sample of lead (II) sulfate.

You are given a solution of lead (II) nitrate. You can assume that all the apparatus and reagents normally found in a school laboratory are available. [5]

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**[Total: 20]**

# Answers

## Experiment 1.1

X contains dilute hydrochloric acid and dilute sulfuric acid.

You are going to determine the concentration of hydrogen ions in X by performing a titration using aqueous sodium carbonate.



### Thought Process

Acid + carbonate → salt + water + carbon dioxide

Hydrochloric acid + sodium carbonate → sodium chloride + water + carbon dioxide

Sulfuric acid + sodium carbonate → sodium sulfate + water + carbon dioxide

Carbon dioxide gas results in effervescence of colourless, odourless gas

Read all the instructions below carefully before starting the experiment.

### Instructions

X is an aqueous solution of hydrogen ions. The solution was made by mixing unknown concentrations of dilute hydrochloric acid and dilute sulfuric acid.

Y is 0.225 mol/dm<sup>3</sup> sodium carbonate.

- (a) Put X into the burette.

Pipette 25.0 cm<sup>3</sup> of Y into a flask and titrate with X, using the indicator provided.

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

### Results [5]

Titration number	1	2
Final reading/ cm <sup>3</sup>	25.10	25.30
Initial reading/ cm <sup>3</sup>	0.00	0.00
Volume of X used/ cm <sup>3</sup>	25.10	25.30
Best titration results	✓	✓

- (b) From your titration results, obtain an average volume of X to be used in your calculations. Show clearly how you obtained this volume. [1]

$$\text{Average volume of X} = \frac{25.10 + 25.30}{2} = 25.20 \text{ cm}^3 \text{ (25.00 cm}^3 \text{ - 25.40 cm}^3\text{)}$$

### Skill Tip ✓

Titrate until permanent colour change of the indicator.

### Skill Tip ✓

Consistent results are achieved when 2 titre volumes are within 0.20 cm<sup>3</sup> of each other.



### Marking

Readings [1]: recorded to 2 d.p.

Calculation [1]: correct subtraction

Accuracy [2]: within 0.20 cm<sup>3</sup> of examiner's value

Concordant results [1]: within 0.20 cm<sup>3</sup>



### Thought Process

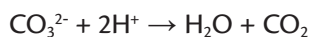
Choose the 2 closest values (within 0.20 cm<sup>3</sup>).

- (c) Y is 0.225 mol/dm<sup>3</sup> sodium carbonate.

Calculate the number of moles of sodium carbonate present in 25.0 cm<sup>3</sup> of Y. [1]

$$\text{Number of moles of Y} = \frac{25.0}{1000} \times 0.225 = 0.00563 \text{ mol}$$

- (d) Using your results from (b) and the equation below, calculate the concentration of hydrogen ions in X. [2]



$$\text{Number of moles of H}^+ = 2 \times 0.005625 = 0.01125 \text{ mol}$$

$$\text{Concentration of hydrogen ions in X} = \frac{0.01125}{25.20 \div 1000} = 0.446 \text{ mol/dm}^3$$

(0.443 mol/dm<sup>3</sup> – 0.450 mol/dm<sup>3</sup>)

X contains dilute hydrochloric acid and dilute sulfuric acid.

The concentration of hydrochloric acid in X is 0.100 mol/dm<sup>3</sup>.

- (e) Using your answer from (d), calculate the concentration of sulfuric acid in X. [2]

$$\text{Concentration of hydrogen ions from sulfuric acid} = 0.446 - 0.100 = 0.346 \text{ mol/dm}^3$$

$$(0.343 \text{ mol/dm}^3 - 0.350 \text{ mol/dm}^3)$$

$$\text{Concentration of sulfuric acid in X} = \frac{0.346}{2} = 0.173 \text{ mol/dm}^3$$

$$(0.171 \text{ mol/dm}^3 - 0.175 \text{ mol/dm}^3)$$

- (f) X was made by mixing equal volumes of dilute hydrochloric acid and dilute sulfuric acid.

Calculate the concentrations of the dilute hydrochloric acid and dilute sulfuric acid used to make X. [2]

$$\text{Concentration of dilute hydrochloric acid used to make X} = 0.100 \times 2 = 0.200 \text{ mol/dm}^3$$

$$\text{Concentration of dilute sulfuric acid used to make X} = 0.173 \times 2 = 0.346 \text{ mol/dm}^3$$

(0.343 mol/dm<sup>3</sup> – 0.350 mol/dm<sup>3</sup>)

- (g) Without doing any further calculations, state and explain which acid has a higher percentage by mass in X. [2]

X contains a higher percentage by mass of sulfuric acid.

Sulfuric acid has a higher concentration than hydrochloric acid in X.

Sulfuric acid has a higher molecular mass than hydrochloric acid.



**Thought Process**  
number of moles =  
concentration  $\times$  volume

**Answering Skill**

Must change volume in cm<sup>3</sup> to dm<sup>3</sup> for correct answer.



**Thought Process**  
1:2 ratio of carbonate and hydrogen ions. Number of moles of hydrogen ions should be double the number of moles of carbonate.



**Thought Process**  
Concentration of hydrogen ions in X is sum of concentration of sulfuric acid and concentration of hydrochloric acid.



**Thought Process**  
Initial concentration of acids should be double. Concentrations of acids becomes halved when equal volumes are mixed together.



**Thought Process**  
What is the difference in concentration and molecular mass between sulfuric acid and hydrochloric acid?



**Marking**  
Calculations and workings will not be accepted.  
Both points present together [1]  
1 point missing [0]



(h) X can be used to make lead (II) sulfate.

Starting from X, describe a method that can be used to make a pure, dry sample of lead (II) sulfate.

You are given a solution of lead (II) nitrate. You can assume that all the apparatus and reagents normally found in a school laboratory are available. [5]

### Precipitation of lead (II) nitrate

1. Add an excess of aqueous silver nitrate to X.



#### Thought Process

Excess silver nitrate needed to precipitate as much chloride as possible.

Silver chloride will be formed. Silver chloride is insoluble.

Aqueous barium nitrate should not be used as insoluble barium sulfate will be formed.

2. Filter the mixture.



#### Thought Process

Residue is silver chloride, filtrate contains silver ions, sulfate ions and nitrate ions.

3. Keep the filtrate.

4. Add an excess of aqueous lead (II) nitrate to the filtrate.



#### Thought Process

Insoluble lead (II) sulfate will be formed. The remaining solution contains silver ions, lead (II) ions and nitrate ions.

5. Filter the mixture.

6. Keep the residue.



#### Thought Process

Residue is lead (II) sulfate, filtrate contains lead (II) ions, silver ions and nitrate ions.

### Purification of lead (II) nitrate

1. Rinse the residue with a small volume of cold distilled water.

2. Dry the residue between pieces of clean dry filter papers.



#### Thought Process

Salt preparation: What method is suitable to prepare this salt? Is this salt soluble in water or not?

Need to use separation techniques to purify the salt.

Use clean dry filter paper to dry the sample.



#### Marking

Any methods using sulfuric acid directly will not be accepted.

Preparation of salt [3]

Purification of salt [2]



#### Marking

Correct reagents [1]

Correct separation technique [1]

Correct order of steps [1]



#### Thought Process

Wash to remove any solution and ions stuck to the residue.



#### Marking

Wash [1]

Dry [1]

[Total: 20]