Week 27

IGCSE Chemistry

Homework bundle for this week

本周作业合集

exercises.lol

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IGCSE Chemistry Name: _____ Score: _____

1. The independent variable is the one that you:
   - ☐ deliberately change
   - ☐ measure
   - ☐ keep the same
   - ☐ ignore
2. In a titration, the piece of apparatus that delivers an exact, measured volume is the:
   - ☐ burette
   - ☐ beaker
   - ☐ test tube
   - ☐ thermometer
3. Chromatography separates a mixture because its components:
   - ☐ travel at different speeds as the solvent moves
   - ☐ all move at the same speed
   - ☐ react with the paper
   - ☐ evaporate equally
4. Filtration is used to separate:
   - ☐ an insoluble solid from a liquid
   - ☐ two liquids
   - ☐ a dissolved solid
   - ☐ two gases
5. A sodium ion gives which flame colour?
   - ☐ yellow
   - ☐ lilac
   - ☐ red
   - ☐ blue-green
6. How many moles are in 20 cm^3 of acid of concentration 0.5 mol/dm^3? (moles = conc × volume in dm^3)

   _____

7. A spot moves 3 cm; the solvent moves 6 cm. What is the Rf value?

_____

8. Repeating measurements and averaging improves reliability.

☐ True ☐ False

9. If 0.01 mol of alkali is in 25 cm^3, what is its concentration (mol/dm^3)?

_____

10. An Rf value is always between 0 and 1.

☐ True ☐ False

12. Experimental techniques and chemical analysis

Answers · 答案

IGCSE Chemistry

1. **deliberately change**

   You change the independent variable.

2. **burette**

   The burette delivers a precise, variable volume.

3. **travel at different speeds as the solvent moves**

   Different speeds separate the substances.

4. **an insoluble solid from a liquid**

   Filtration removes insoluble solids.

5. **yellow**

   Sodium burns with a yellow flame.

6. **0.01**

   $0.5 \times (20 \div 1000) = 0.01$ mol.

7. **0.5**

   Rf $= 3 \div 6 = 0.5$.

8. **True**

   Repeats reduce the effect of random error.

9. **0.4**

   $0.01 \div (25 \div 1000) = 0.4$ mol/dm^3.

10. **True**

    The spot cannot move further than the solvent.

IGCSE CHEMISTRY • EXERCISE SHEET

12.1 Experimental design

Name: _____ Class: _____ Date: _____ **Total: 7 marks**

KEY WORDS apparatus 仪器 • measuring cylinder 量筒 • burette 滴定管 • stop-watch 秒表 • solution 溶液

Objective

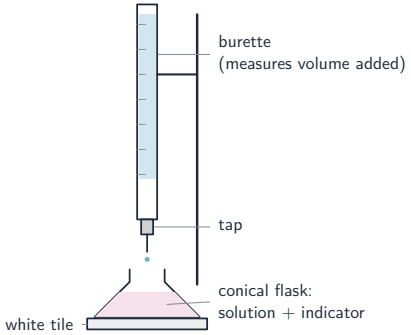
Build the skills to answer exam questions on **experimental design** 实验设计 — choosing **apparatus** 仪器 for each measurement and the key practical words.

You must be able to:

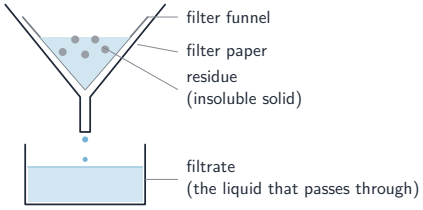
- choose the right apparatus for measuring time, temperature, mass and volume
- define solvent, solute, solution, saturated solution, residue, filtrate
- describe accurate vs rough volume measurement

1 Worked examples

■ **Apparatus and key words**



Accurate volume: burette/pipette; rough volume: measuring cylinder; gas volume: gas syringe



Filtration is a core separation technique

- **solvent** dissolves the **solute** to make a **solution**; **saturated** = max dissolved.
- **residue** = solid left behind; **filtrate** = liquid that passes through a filter.

2 Practice

2.1 Name the apparatus used to measure an accurate volume of a solution. [1]

2.2 Define a saturated solution. [1]

3 Exam-style questions

3.1 Which apparatus measures the volume of a gas produced? [1]

- **A** thermometer
- **B** balance
- **C** gas syringe
- **D** stop-watch

3.2 A student needs to measure exactly 25.0 cm^3 of acid and the temperature of a reaction.

(a) Name the apparatus for each. [2]

(b) State the difference between a residue and a filtrate. [2]

Solutions

2.1 a burette or a (volumetric) pipette.

2.2 a solution holding the maximum amount of solute that will dissolve at that temperature.

3.1 C. A gas syringe measures the volume of gas produced.

3.2 (a) a pipette (or burette) for the acid; a thermometer for the temperature.
(b) the residue is the solid left behind on the filter; the filtrate is the liquid that passes through.

1 Hot concentrated hydrochloric acid reacts with solid manganese(IV) oxide to make chlorine gas. Chlorine gas is toxic and more dense than air. Concentrated hydrochloric acid is corrosive.

Fig. 1.1 shows the apparatus used to make and collect a sample of chlorine gas.

There is **one** error in the way the apparatus has been set up in Fig. 1.1.

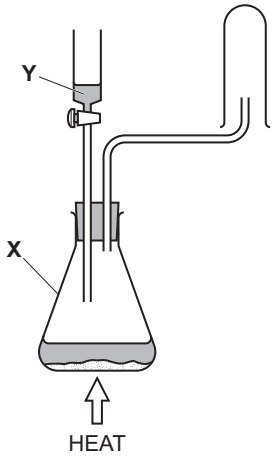


Fig. 1.1

(a) Name the item of apparatus labelled **X** in Fig. 1.1.

..... [1]

(b) Identify the substance labelled **Y** in Fig. 1.1.

..... [1]

(c) Name an item of apparatus that can be used to heat **X** in Fig. 1.1.

..... [1]

(d) There is **one** error in the way the apparatus has been set up.

Describe a change that needs to be made to the apparatus in Fig. 1.1 to correct this error.

.....

..... [1]

(e) Explain why this experiment should be carried out in a fume cupboard.

.....

.... [1]

[Total: 5]

1 Eggshells are made from a mixture of calcium carbonate and other insoluble substances.

Calcium carbonate reacts with dilute hydrochloric acid. The equation for the reaction is shown.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

The other substances in eggshells do **not** react with dilute hydrochloric acid.

A student finds the percentage by mass of calcium carbonate in an eggshell.

Fig. 1.1 shows the first three steps of the method the student uses.

step 1
Grind the eggshell into small pieces.

step 2
Find the mass of the small pieces of eggshell.

step 3
Add the small pieces of eggshell to excess dilute hydrochloric acid and warm the mixture while stirring it with a glass rod.

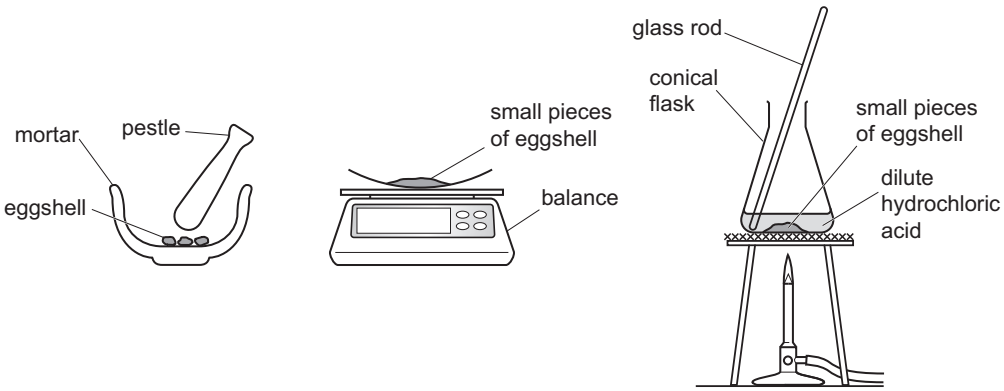


Fig. 1.1

(a) **(i)** Describe what is seen when the calcium carbonate in the eggshell reacts with dilute hydrochloric acid.

..... [1]

(ii) Describe what the student should do to make sure the acid is in excess and all of the calcium carbonate has reacted.

.....

.....

..... [2]

(b) After **step 3**, the student filters the mixture to obtain the unreacted solid left from the eggshell.

(i) Draw a labelled diagram of the apparatus the student should use to filter the mixture.

[2]

(ii) After the filtration, the student washes the residue.

Identify the **two** substances removed from the residue by washing.

substance 1 .....

substance 2 .....

[2]

(iii) After washing the residue, the student dries the residue in an oven.
The student then measures the mass of the dry residue.

The masses the student records are shown in Table 1.1.

Table 1.1

mass of small pieces of eggshell / g	2.00
mass of dry residue after filtration / g	0.11

Use the data in Table 1.1 to calculate the percentage by mass of calcium carbonate in the eggshell.

percentage of calcium carbonate = ... [2]

[Total: 9]

1 A student uses the apparatus in Fig. 1.1 to show that water is formed as one of the products when a fuel is burned. The gases produced when the fuel is burned are passed through the apparatus using a suction pump.

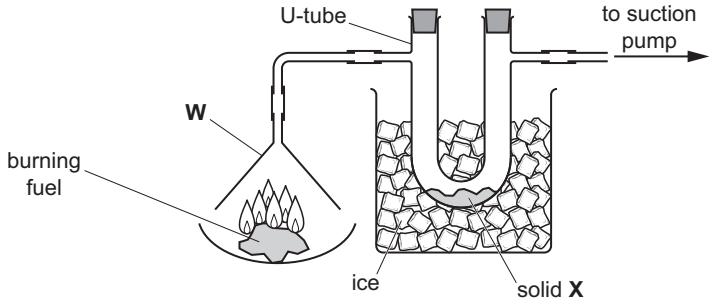


Fig. 1.1

(a) Identify the item of apparatus labelled **W** in Fig. 1.1.

..... [1]

(b) When the fuel is burned, the steam produced passes into the U-tube.

Suggest why the U-tube is surrounded by ice.

..... [1]

(c) Water causes solid **X** in the U-tube to change colour.

Name solid **X** and state the colour change seen.

solid **X** .....

colour change from ..... to .....

[2]

.

The student tries to use the apparatus in Fig. 1.2 to pass the gases produced through acidified aqueous potassium manganate(VII).

There is an error in the apparatus in Fig. 1.2 so that the gases produced will **not** pass through the acidified aqueous potassium manganate(VII).

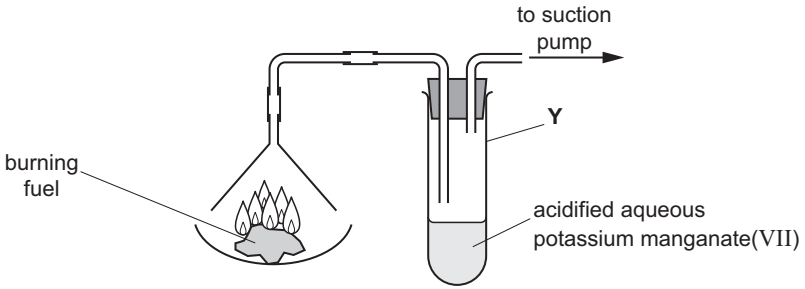


Fig. 1.2

(d) Identify the item of apparatus labelled **Y** in Fig. 1.2.

..... [1]

(e) **On Fig. 1.2**, draw a circle around the error in the apparatus. [1]

(f) The error in the apparatus in Fig. 1.2 is corrected.
The student observes that the acidified aqueous potassium manganate(VII) changes colour from purple to colourless.

Suggest why this colour change occurs.

.....

..... [1]

[Total: 7]

1 When heated, magnesium reacts with steam to make magnesium oxide and hydrogen gas.

Fig. 1.1 shows the apparatus a teacher uses to react clean magnesium ribbon with steam and collect the hydrogen gas produced.

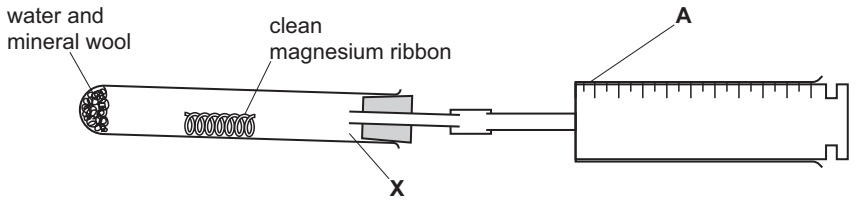


Fig. 1.1

(a) Name the item of apparatus labelled **A** in Fig. 1.1.

..... [1]

(b) Suggest how the magnesium ribbon should be cleaned before use.

.....

..... [1]

(c) State the purpose of the mineral wool.

.....

..... [1]

(d) Draw **two** arrows on Fig. 1.1 to show the **two** places where the apparatus should be heated. [2]

(e) During the reaction a colourless liquid collects at the point marked **X** on Fig. 1.1.

Suggest the identity of liquid **X**.

..... [1]

(f) The gas collected in **A** is **not pure** hydrogen.

Suggest why the gas collected is **not pure**.

.....

..... [1]

[Total: 7]

1 Fermentation is a process in which yeast is used to convert aqueous glucose to ethanol and carbon dioxide. Fermentation takes place at a temperature of between 25 °C and 35 °C.

$$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

A student uses the apparatus shown in Fig. 1.1 to make carbon dioxide by fermentation.

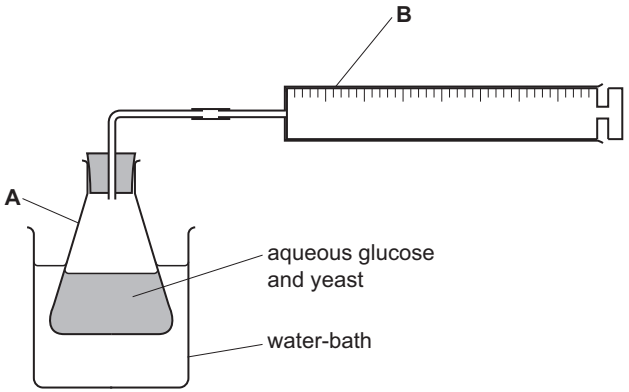


Fig. 1.1

(a) Name the items of apparatus labelled **A** and **B** in Fig. 1.1.

A .....

B .....
[2]

(b) Suggest why a water-bath is used.

.....

..... [1]

(c) The student measures the volume of gas that is collected every 10 minutes for 90 minutes.

Their results are shown in Fig. 1.2.

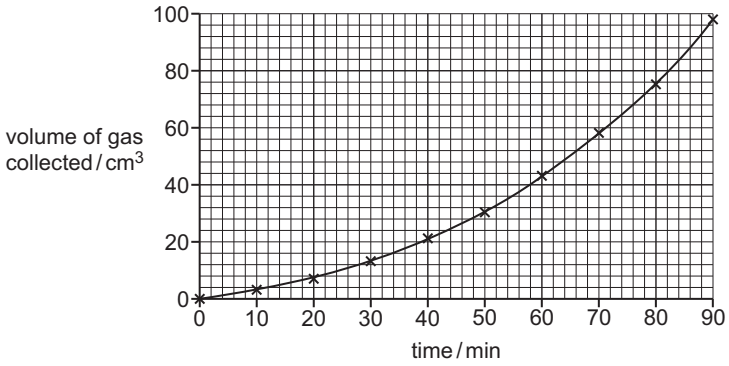


Fig. 1.2

Describe how the results in Fig. 1.2 show that the fermentation is **not** complete after 90 minutes.

..... [1]

(d) The student repeats the experiment using the apparatus shown in Fig. 1.3.

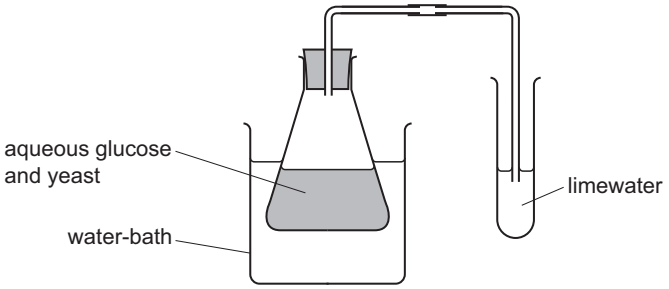


Fig. 1.3

(i) State what happens to the appearance of the limewater during fermentation.

..... [1]

(ii) State **one** observation the student would make that shows that fermentation is complete.

.....

..... [1]

(e) State the method the student should use to obtain ethanol from the fermentation mixture.

..... [1]

[Total: 7]

IGCSE CHEMISTRY • EXERCISE SHEET

12.2 Acid-base titrations

Name: _____ Class: _____ Date: _____ **Total: 7 marks**

KEY WORDS indicator 指示剂 • end-point 终点 • titration 滴定 • acid–base titrations 酸碱滴定 • solution 溶液

Objective

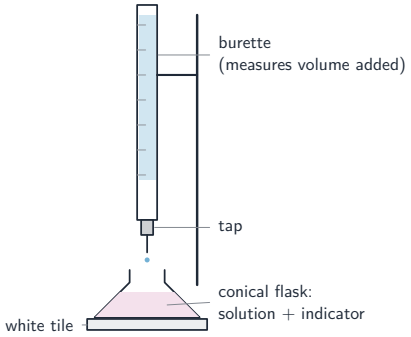
Build the skills to answer exam questions on **acid–base titrations** 酸碱滴定 — the method, the **end-point** 终点, and reading the burette.

You must be able to:

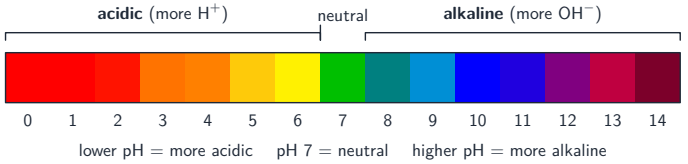
- describe the titration method (pipette, indicator, burette)
- explain the end-point
- relate the procedure to an accurate result

1 Worked examples

The titration method



Run solution from the burette into the flask until the indicator just changes colour



A titration tracks the change in pH

- pipette a fixed volume of one solution into a flask; add indicator.
- add the other solution from the burette slowly until the colour just changes (end-point).
- read the burette to find the volume added.

2 Practice

2.1 Name the apparatus used to measure the fixed volume into the flask. [1]

2.2 State what the end-point of a titration shows. [1]

3 Exam-style questions

3.1 The solution added from the burette is run in: [1]

- **A** all at once
- **B** slowly, until the indicator just changes colour
- **C** until the flask overflows
- **D** without an indicator

3.2 A student titrates sodium hydroxide against hydrochloric acid.

(a) Describe how they would carry out the titration. [3]

(b) Explain why a few drops of indicator are added. [1]

Solutions

2.1 a (volumetric) pipette.

2.2 the reaction is exactly complete (the acid and alkali have reacted).

3.1 B. The solution is added slowly until the indicator just changes colour.

3.2 (a) pipette a fixed volume of sodium hydroxide into the flask and add indicator; add acid from the burette slowly, swirling; stop when the indicator just changes colour and read the burette.
(b) to show the end-point by changing colour.

39 Which item of apparatus is used to measure 13.7 cm^3 of dilute hydrochloric acid?

A a balance

B a burette

C a conical flask

D a volumetric pipette

2 A student investigates the reaction between dilute hydrochloric acid and aqueous sodium hydroxide.

The student does five experiments.

Experiment 1

- Fill a burette with aqueous sodium hydroxide.
- Run some of the aqueous sodium hydroxide out of the burette so that the level of the aqueous sodium hydroxide is on the burette scale.
- Record the initial burette reading.
- Use a volumetric pipette to add 25.0 cm^3 of dilute hydrochloric acid to a conical flask.
- Stand the conical flask on a white tile.
- Add five drops of thymolphthalein indicator to the conical flask.
- Slowly add aqueous sodium hydroxide from the burette to the conical flask, while swirling the flask, until the solution just changes colour. This is the end-point.
- Record the final burette reading.

Experiment 2

- Empty the conical flask and rinse it with distilled water.
- Refill the burette with aqueous sodium hydroxide.
- Run some of the aqueous sodium hydroxide out of the burette so that the level of the aqueous sodium hydroxide is on the burette scale.
- Record the initial burette reading.
- Use the volumetric pipette to add 25.0 cm^3 of dilute hydrochloric acid to the conical flask.
- Add 0.25 g of sodium hydrogencarbonate to the conical flask and swirl the flask.
- Stand the conical flask on the white tile.
- Add five drops of thymolphthalein indicator to the conical flask.
- Slowly add aqueous sodium hydroxide from the burette to the conical flask, while swirling the flask, until the solution just changes colour. This is the end-point.
- Record the final burette reading.

Experiment 3

- Repeat Experiment 2 using 0.50 g of sodium hydrogencarbonate instead of 0.25 g.

Experiment 4

- Repeat Experiment 2 using 1.00 g of sodium hydrogencarbonate instead of 0.25 g.

Experiment 5

- Repeat Experiment 2 using 1.50 g of sodium hydrogencarbonate instead of 0.25 g.

(a) Use the information in the descriptions of Experiments 1 to 5 and the burette diagrams in Fig. 2.1 and Fig. 2.2 to complete Table 2.1.

Experiment 1

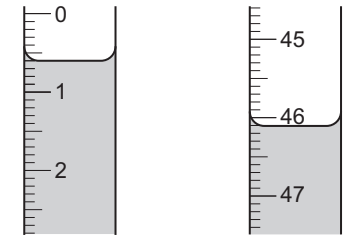


Fig. 2.1

Experiment 2

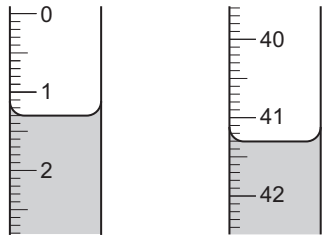


Fig. 2.2

Table 2.1

	Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
volume of dilute hydrochloric acid / cm^3					
mass of sodium hydrogencarbonate / g	0.00	0.25	0.50	1.00	1.50
final burette reading / cm^3			36.0	24.1	13.5
initial burette reading / cm^3			1.4	0.3	0.5
volume of aqueous sodium hydroxide added to reach the end-point / cm^3					13.0

[5]

(b) Complete a suitable scale on the *y*-axis and plot the results from Experiments 1 to 5 in Table 2.1 on Fig. 2.3. Draw a straight line of best fit.

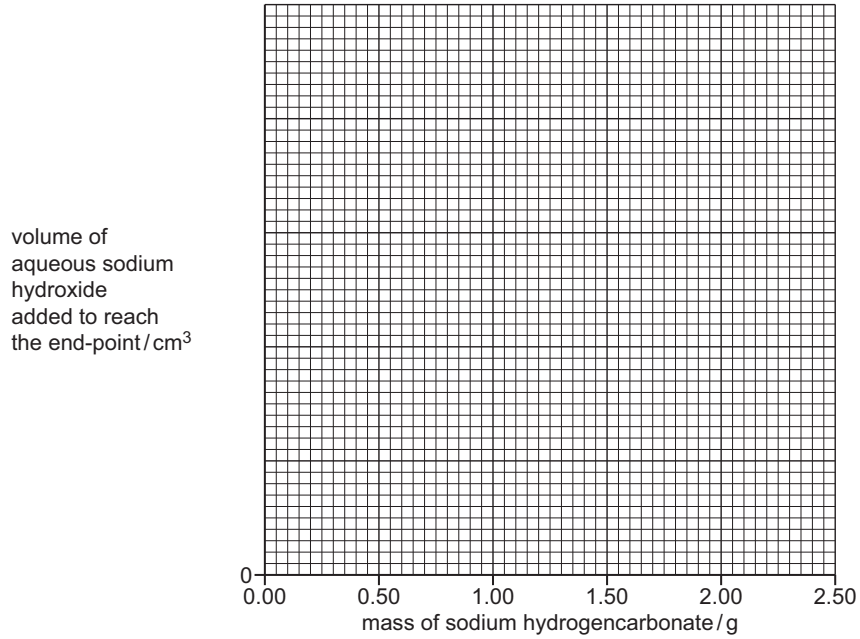


Fig. 2.3

[4]

(c) The sodium hydrogencarbonate added in Experiments 2 to 5 neutralises some of the dilute hydrochloric acid in the conical flask. The sodium hydroxide used in the titration neutralises the remaining dilute hydrochloric acid.

Extrapolate the line on your graph in Fig. 2.3 and deduce the mass of sodium hydrogencarbonate needed to neutralise **all** of the dilute hydrochloric acid in the conical flask.

Show clearly **on Fig. 2.3** how you worked out your answer.

mass of sodium hydrogencarbonate = ...

[3]

(d) **(i)** Explain why a volumetric pipette is used rather than a measuring cylinder to measure the volume of dilute hydrochloric acid used in each experiment.

.....

..... [1]

(ii) Explain why it is **not** possible to use a volumetric pipette instead of the burette to measure the volume of aqueous sodium hydroxide added in each experiment.

.....

..... [1]

(e) The conical flask is placed on a white tile to make the colour change of the indicator at the end-point more visible.

Explain why universal indicator is **not** a suitable indicator for this titration.

.....

.....

.....

..... [2]

(f) Draw a line **on Fig. 2.3** to show the results you would expect if the investigation was repeated using aqueous sodium hydroxide with twice the concentration.

Label your line **F**. [2]

[Total: 18]

2 A student investigates the reaction between acidic solution **B** and two different solutions of aqueous sodium hydroxide, solution **C** and solution **D**, using two different indicators.

The student does two experiments.

Experiment 1

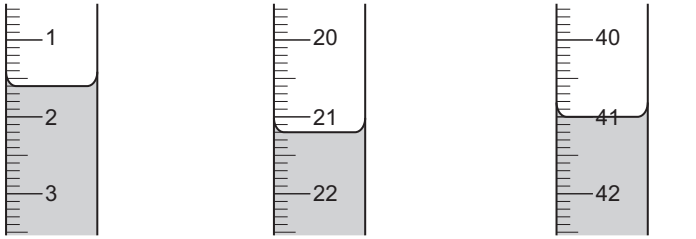
- Rinse a burette with distilled water and then with solution **C**.
- Fill the burette with solution **C**. Run some of solution **C** out of the burette so that the level of the solution is on the burette scale.
- Record the initial burette reading.
- Use a measuring cylinder to pour 25 cm^3 of solution **B** into a conical flask.
- Add five drops of methyl orange indicator **and** five drops of thymolphthalein indicator to the conical flask.
- Stand the conical flask on a white tile.
- Slowly add solution **C** from the burette to the conical flask, while swirling the flask, until the solution changes colour from red to orange. This is the first end-point.
- Record the burette reading at the first end-point.
- Continue to add solution **C** from the burette to the conical flask while swirling the flask. The solution changes colour from orange to yellow.
- Continue to add solution **C**, while swirling the flask, until the solution changes colour from yellow to green. This is the second end-point.
- Record the burette reading at the second end-point.

Experiment 2

- Empty the conical flask and rinse it with distilled water.
- Repeat Experiment 1 using solution **D** instead of solution **C**.

(a) Use the burette diagrams in Fig. 2.1 and Fig. 2.2 to record the readings for Experiment 1 and Experiment 2 in Table 2.1. Complete Table 2.1.

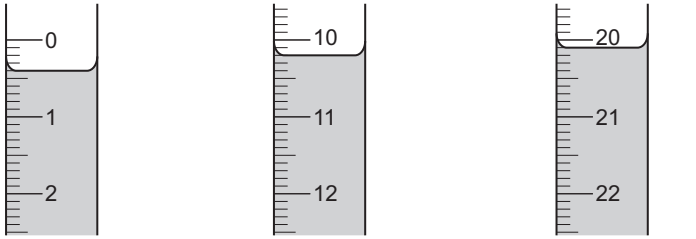
Experiment 1



initial burette reading | burette reading at first end-point | burette reading at second end-point

Fig. 2.1

Experiment 2



initial burette reading | burette reading at first end-point | burette reading at second end-point

Fig. 2.2

Table 2.1

	Experiment 1 using solution **C**	Experiment 2 using solution **D**
burette reading at first end-point / cm^3		
burette reading at second end-point / cm^3		
initial burette reading / cm^3		
volume added from burette to reach first end-point / cm^3		
total volume added from burette to reach second end-point / cm^3		

[5]

(b) **(i)** Explain why the conical flask is rinsed with distilled water at the start of Experiment 2.

.....

..... [1]

(ii) At the start of Experiment 1, the burette is rinsed with distilled water and then with solution **C**.

Explain how the volume added from the burette to reach the first end-point would be different if the burette was **not** rinsed with solution **C**.

.....

.....

.....

..... [2]

(iii) Explain why the conical flask is placed on a white tile during the titration.

.....

..... [1]

(c) Compare the concentration of solution **C** used in Experiment 1 with the concentration of solution **D** used in Experiment 2.

Explain your answer.

.....

.....

.....

..... [3]

(d) **(i)** Deduce the volume of solution **C** required to reach the **first** end-point if Experiment 1 is repeated using 50 cm^3 of solution **B** instead of 25 cm^3.

volume of solution **C** = ... [2]

(ii) State why using 50 cm^3 of solution **B** would cause a problem when finding the volume of solution **C** needed to reach the **second** end-point in Experiment 1.

.....

..... [1]

(e) A student repeats Experiment 2.

The student warms solution **B** in the conical flask before carrying out the titration.

State the effect, if any, on the volume of solution **D** required to reach the **second** end-point in Experiment 2.

Explain your answer.

effect on volume of solution **D** .....

explanation .....

.....

[2]

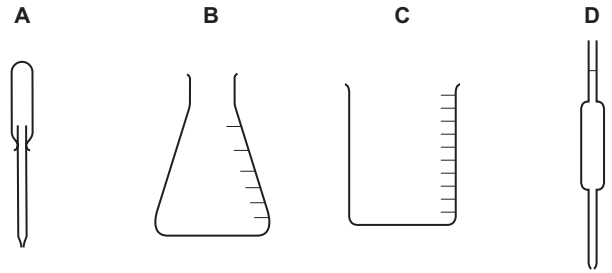
(f) State **one** change to the **apparatus** that will improve the accuracy of the results.

..... [1]

[Total: 18]

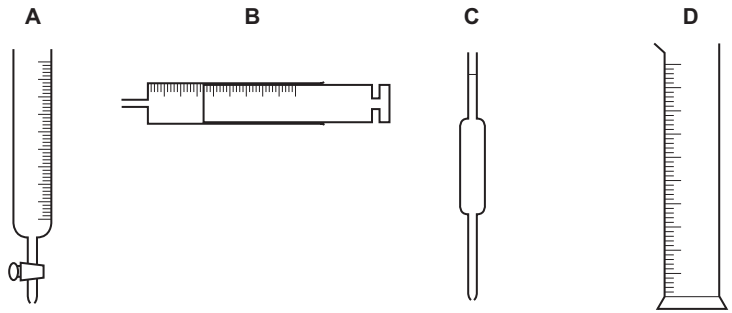
IGCSE Chemistry: **s25 21**

38 Which item of apparatus is used to measure 25.0 cm^3 of aqueous sodium hydroxide?



IGCSE Chemistry: **s25 22**

38 Which item of apparatus is used to measure exactly 26.3 cm^3 of a liquid?



IGCSE CHEMISTRY • EXERCISE SHEET

12.3 Chromatography

Name: _____ Class: _____ Date: _____ **Total: 6 marks**

KEY WORDS chromatography 色谱法 • paper chromatography 纸色谱法 • value 比移值 • chromatogram 色谱图 • locating agent 显色剂

Objective

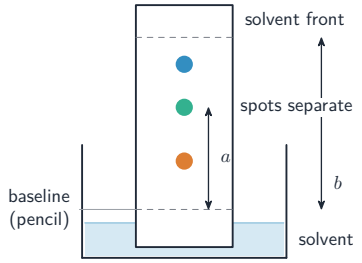
Build the skills to answer exam questions on **chromatography** 色谱法 — separating a mixture, the R_f **value** 比移值, and using a **chromatogram** 色谱图.

You must be able to:

- describe paper chromatography and the use of a locating agent
- calculate an R_f value
- use a chromatogram to identify substances and check purity

1 Worked examples

■ Chromatography and Rf



$$R_f = \frac{a}{b} = \frac{\text{spot}}{\text{solvent}}$$

Substances travel different distances as the solvent rises; $R_f = \dfrac{\textit{spot distance}}{\textit{solvent distance}}$

- **colourless** substances need a **locating agent** to show the spots.
- a **pure** substance gives only one spot.

2 Practice

2.1 State what a single spot on a chromatogram tells you about a substance. [1]

2.2 State why a locating agent is sometimes needed. [1]

3 Exam-style questions

3.1 The R_f value of a spot is the distance moved by the spot divided by the distance moved by the: [1]

- **A** paper
- **B** solvent
- **C** baseline
- **D** beaker

3.2 On a chromatogram, a spot moves 3.0 cm while the solvent moves 12.0 cm.

(a) Calculate the R_f value. [2]

(b) State how a chromatogram can be used to identify an unknown substance. [1]

Solutions

2.1 it is pure (a single substance).

2.2 to make colourless spots show up.

3.1 B. $R_f = \dfrac{\text{distance moved by the spot}}{\text{distance moved by the solvent}}$.

3.2 (a) $R_f = \dfrac{3.0}{12.0} = 0.25$.
(b) compare its spot/R_f with those of known substances run alongside.

40 Chromatography is used to separate and analyse mixtures of soluble substances.

The first steps of the process are listed.

- apply sample to baseline
- develop chromatogram in solvent

What is the next step in the process to detect soluble **colourless** substances?

A calculate the R_f values

B compare the results with known substances

C count the number of spots

D use a suitable locating agent

The Periodic Table of Elements

Group I	II	III	IV	V	VI	VII	VIII
							2 He helium 4
3 Li lithium 7	4 Be beryllium 9	5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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Key

atomic number
atomic symbol
name
relative atomic mass

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

40 A colourless mixture is separated by paper chromatography.

The steps below describe the method. These steps are **not** in the correct order.

1 Remove the chromatography paper from the solvent when the solvent front is near the top of the paper.

2 Place the chromatography paper in the solvent.

3 Spray the chromatography paper with a locating agent.

4 Place a spot of the mixture on the pencil line.

5 Draw a pencil line at the bottom of the chromatography paper.

6 Draw a pencil line to mark the position of the solvent front.

What is the correct order for these steps?

A $3 \rightarrow 5 \rightarrow 6 \rightarrow 4 \rightarrow 2 \rightarrow 1$

B $5 \rightarrow 4 \rightarrow 3 \rightarrow 2 \rightarrow 1 \rightarrow 6$

C $3 \rightarrow 5 \rightarrow 4 \rightarrow 1 \rightarrow 2 \rightarrow 6$

D $5 \rightarrow 4 \rightarrow 2 \rightarrow 1 \rightarrow 6 \rightarrow 3$

The Periodic Table of Elements

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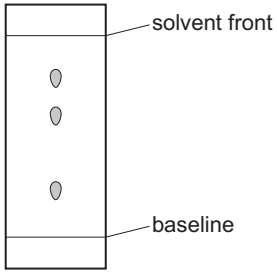
The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

40 A mixture of four different colourless amino acids is analysed by paper chromatography.

The final chromatogram is shown.



Why does the chromatogram only show three spots?

A A locating agent is **not** used.

B One of the amino acids is insoluble in the solvent.

C The solvent front is too near the top of the paper.

D Two of the amino acids have the same R_f value.

The Periodic Table of Elements

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																	2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
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The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

40 In paper chromatography, what is the equation for the R_f value?

A $R_f = \dfrac{\text{distance travelled by solvent}}{\text{distance travelled by substance}}$

B $R_f = \dfrac{\text{distance travelled by locating agent}}{\text{distance travelled by substance}}$

C $R_f = \dfrac{\text{distance travelled by substance}}{\text{distance travelled by locating agent}}$

D $R_f = \dfrac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$

The Periodic Table of Elements

Group

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The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

40 A mixture of soluble substances can be separated by paper chromatography. Each substance can be identified using its R_f value.

Which formula shows how the R_f value is calculated?

A $R_f = \dfrac{\text{distance travelled by solvent}}{\text{distance travelled by substance}}$

B $R_f = \dfrac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$

C R_f = distance travelled by solvent – distance travelled by substance

D R_f = distance travelled by solvent × distance travelled by substance

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The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

IGCSE CHEMISTRY • EXERCISE SHEET

12.4 Separation and purification

Name: _____ Class: _____ Date: _____ **Total: 28 marks**

KEY WORDS filtration 过滤 • boiling point 沸点 • melting point 熔点 • distillation 蒸馏 • crystallisation 结晶

Objective

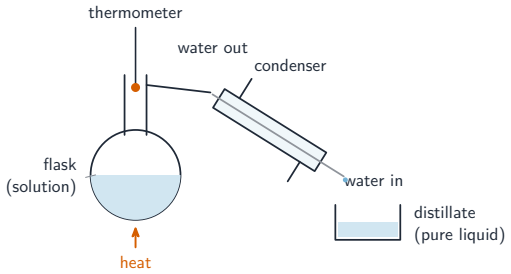
Build the skills to answer exam questions on **separation and purification** 分离与提纯 — choosing **filtration** 过滤, **crystallisation** 结晶, **distillation** 蒸馏, and checking purity.

You must be able to:

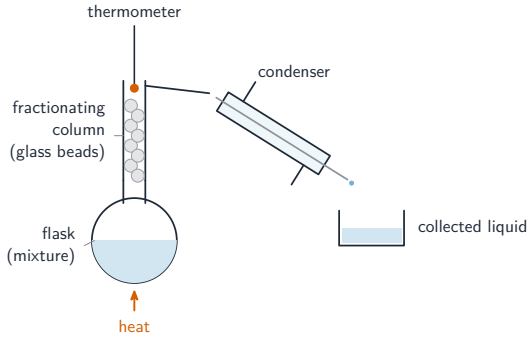
- choose the right method for a given mixture
- describe simple and fractional distillation
- check purity using melting and boiling points

1 Worked examples

Distillation methods



Simple distillation separates a solvent from a solution



Fractional distillation separates liquids with different boiling points

- filtration: insoluble solid from a liquid; crystallisation: soluble solid from solution.

Choosing the technique from what you are separating

Read the mixture, not the apparatus — the exam gives you a mixture and expects the method plus a reason.

You want to separate	Method	Why it works
an insoluble solid from a liquid	**filtration** 过滤	the solid is too large to pass through the filter paper's pores; the **residue** stays, the **filtrate** passes
a dissolved solid from its solution, keeping the solid	**crystallisation** 结晶	evaporate to the point of crystallisation, cool, then filter and dry — gentle enough not to decompose the solid
a solvent from a solution, keeping the liquid	**simple distillation** 蒸馏	the solvent boils, is condensed and collected; the solute stays behind
two miscible liquids with different boiling points	**fractional distillation** 分馏	the fractionating column lets the lower-boiling liquid pass while the higher-boiling one condenses and runs back
coloured or soluble substances in a mixture	**chromatography** 色谱法	each substance has a different attraction to the paper and the solvent, so each moves a different distance

Fractional distillation, in the order the marks come: heat the mixture; the liquid with the **lower boiling point** vaporises first; its vapour rises up the column

while any higher-boiling vapour condenses and falls back; the vapour passes into the condenser, is cooled and is collected as the first fraction; the temperature then rises and the second liquid distils.

Chromatography and R_f. Draw the pencil baseline **above** the solvent level, or the spots dissolve away. Then

$$R_f = \frac{\text{distance moved by the spot}}{\text{distance moved by the solvent front}}$$

R_f has **no units** and is always **less than 1**. Two substances with the same R_f in the same solvent are likely to be the same substance; a colourless spot is revealed with a **locating agent** or UV light.

Worked example. A spot moves 3.6 cm while the solvent front moves 8.0 cm. Find R_f, and state what it means if a known sample gives 0.45 on the same paper. $R_f = \dfrac{3.6}{8.0} = 0.45$. The two have the same R_f under the same conditions, so the unknown is likely to be that substance.

2 Practice

2.1 Name the method to separate an insoluble solid from a liquid. [1]

2.2 State how impurities affect the melting point of a substance. [1]

2.3 Name the method used to obtain pure water from sea water, and state the principle it relies on. [2]

2.4 Explain why the baseline in chromatography is drawn in pencil and above the solvent level. [2]

2.5 A spot travels 2.7 cm and the solvent front 9.0 cm. Calculate the R_f value. [2]

3 Exam-style questions

3.1 To separate two liquids with different boiling points, you would use: [1]

- **A** filtration
- **B** crystallisation
- **C** fractional distillation
- **D** chromatography

3.2 A student wants pure water from salty water.

(a) Name the method to use. [1]

(b) Describe how it separates the water from the salt. [2]

3.3 Explain how you could check that a sample of a solid is pure. [2]

3.4 A student is given a mixture of sand, salt and water, and separately a mixture of ethanol (b.p. 78 °C) and water.

(a) Name the method used to remove the sand, and state which part of the apparatus retains it. [2]

(b) Describe how the student would obtain solid salt from the remaining solution, and explain why crystallisation is preferred to boiling the solution dry. [3]

(c) Name the method used to separate the ethanol from the water, and describe how it works. [4]

(d) State which liquid is collected first and explain why. [2]

(e) The student also uses chromatography on a food dye. One spot moves 4.4 cm while the solvent front moves 8.0 cm. Calculate the R_f value and state what could be concluded if a known dye gives the same value. [3]

Solutions

2.1 filtration.

2.2 impurities lower the melting point.

2.3 Simple distillation; the water boils, is condensed and collected, while the dissolved salts remain behind because their boiling points are far higher.

2.4 Pencil, because ink would itself dissolve and separate in the solvent; above the solvent level, so the spots are not washed off into the solvent instead of travelling up the paper.

2.5 $R_f = \dfrac{2.7}{9.0} = 0.30$.

3.1 **C**. Fractional distillation separates liquids with different boiling points.

3.2 (a) simple distillation.
(b) the water boils off and is cooled back to a liquid in the condenser; the salt is left behind in the flask.

3.3 measure its melting (or boiling) point; a pure substance melts at a sharp, fixed temperature, while impurities lower it / give a range.

3.4 (a) Filtration; the sand is left in the filter paper as the residue.
(b) Heat the solution to evaporate some of the water until the point of crystallisation, then leave it to cool so crystals form, and filter and dry them; crystallisation is preferred because boiling dry can decompose the solid or leave impurities behind with it.
(c) Fractional distillation; the mixture is heated and the ethanol, which has the lower boiling point, vaporises first; its vapour passes up the fractionating column while any water vapour condenses and runs back down; the ethanol vapour is then cooled in the condenser and collected.
(d) Ethanol, because its boiling point of 78 °C is lower than water's 100 °C, so it vaporises and distils over first.
(e) $R_f = \dfrac{4.4}{8.0} = 0.55$; if a known dye gives the same R_f under the same conditions, the unknown is likely to be that same dye.

40 Ethanol can be made by fermentation of sugar, using yeast.

This produces a mixture of ethanol and water.

How is ethanol separated from this mixture?

A distilling the mixture using a fractionating column

B filtering the mixture

C heating to evaporate most of the water, and allowing the ethanol to crystallise

D heating to evaporate the water

The Periodic Table of Elements

Key: atomic number / atomic symbol / name / relative atomic mass

Group I	Group II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

3 A student prepares a sample of the insoluble salt barium sulfate, $BaSO_4$.
The student adds aqueous sodium sulfate, $Na_2SO_4(aq)$, to aqueous barium chloride, $BaCl_2(aq)$.

The student carries out the following steps.

step 1 Dissolve 0.100 moles of solid $BaCl_2$ in 100 cm^3 of distilled water in a beaker to form $BaCl_2(aq)$.

step 2 Add an aqueous solution which contains 0.100 moles of $Na_2SO_4(aq)$ to the beaker containing the $BaCl_2(aq)$ from **step 1**.

step 3 Stir the mixture and then filter it.

step 4 Dry the solid left in the filter paper.

(a) Complete the symbol equation for the reaction. Include state symbols.

$$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(.....) + ...(.....)$$

[2]

(b) Calculate the mass of solid $BaCl_2$ dissolved in **step 1**.

mass = ... g [2]

(c) The concentration of $Na_2SO_4(aq)$ in **step 2** is 1.25 mol/dm^3.

Calculate the volume, in cm^3, of 1.25 mol/dm^3 $Na_2SO_4(aq)$ added in **step 2** which contains 0.100 moles of Na_2SO_4.

volume = ... cm^3 [1]

(d) State the colour of the solid formed in **step 2**.

..... [1]

(e) The mixture is filtered in **step 3**.

State the general term given to a solid left in the filter paper after filtration.

..... [1]

(f) The actual mass of dry $BaSO_4$ collected in **step 4** is greater than the expected mass. This is because the student should do an additional step between **step 3** and **step 4**.

Suggest what the student should do in this additional step, and explain why the actual mass collected is greater than the expected mass.

.....

.....

.....

..... [2]

(g) State the name of this method of salt preparation.

..... [1]

(h) State the name of a different:

- barium salt that can be used in place of $BaCl_2$ .....
- sulfate salt that can be used in place of Na_2SO_4 .....
- barium salt that can be made by this method. .....

[3]

[Total: 13]

39 Which method is used to obtain copper(II) sulfate crystals from an aqueous solution of copper(II) sulfate?

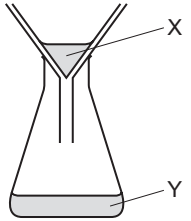
A chromatography

B condensation

C evaporation

D filtration

39 A mixture containing an aqueous salt and an insoluble salt is filtered.



Which row describes X and Y?

	X	Y
A	solute	pure water
B	solute	filtrate
C	residue	pure water
D	residue	filtrate

40 Pure ethanol has a melting point of –114 °C and a boiling point of 78 °C.

What are the melting and boiling points of a sample of ethanol with glucose dissolved in it?

	melting point / °C	boiling point / °C
A	–116	77
B	–116	79
C	–112	77
D	–112	79

The Periodic Table of Elements

Group	I	II											III	IV	V	VI	VII	VIII
																		2 He helium 4
													5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
													13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
													31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
													49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
													81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
													113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –
	1 H hydrogen 1																	
	3 Li lithium 7	4 Be beryllium 9																
	11 Na sodium 23	12 Mg magnesium 24																
	19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65						
	37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112						
	55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201						
	87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –						

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

38 The steps used to separate a mixture of a soluble solid and an insoluble solid are listed.

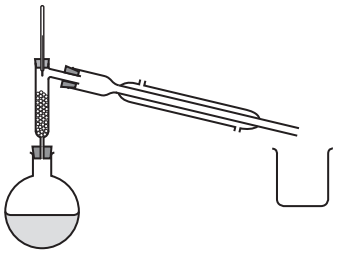
- A solution is made by adding the mixture to a suitable .....1..... .
- The mixture is stirred and then poured through a filter funnel lined with filter paper.
- The insoluble solid is collected on the filter paper as the .....2..... .

Which words complete gaps 1 and 2?

	1	2
A	solute	filtrate
B	solute	residue
C	solvent	filtrate
D	solvent	residue

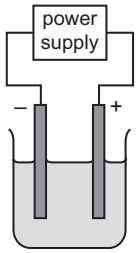
39 Which items of apparatus are used to separate a mixture of liquids with different boiling points?

A

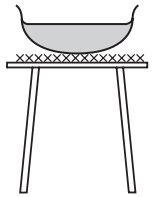


B

C



D



IGCSE CHEMISTRY • EXERCISE SHEET

12.5 Identification of ions and gases

Name: _____ Class: _____ Date: _____ **Total: 21 marks**

KEY WORDS sodium 钠 • nitrate 硝酸盐 • barium 钡 • sodium hydroxide 氢氧化钠 • nitric acid 硝酸

Objective

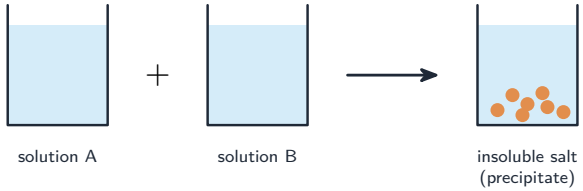
Build the skills to answer exam questions on the **identification of ions and gases** 离子与气体检验 — tests for **anions** 阴离子, **cations** 阳离子, gases, and **flame tests** 焰色试验.

You must be able to:

- give the test and result for common anions (carbonate, halides, sulfate, nitrate)
- give the cation tests with sodium hydroxide / aqueous ammonia
- give the gas tests and flame-test colours

1 Worked examples

Key tests



Many ion tests give a coloured precipitate

- **chloride:** dilute HNO_3 + silver nitrate → white precipitate.
- **sulfate:** dilute HNO_3 + barium nitrate → white precipitate.
- **CO_2:** turns limewater milky. **H_2:** squeaky pop. **O_2:** relights a glowing splint.
- **flame:** Li red, Na yellow, K lilac, Cu blue-green.

2 Practice

2.1 Give the test and result for carbon dioxide gas. [2]

2.2 State the flame colour given by a potassium ion. [1]

3 Exam-style questions

3.1 A white precipitate forms when dilute nitric acid and silver nitrate are added. The ion present is: [1]

- **A** sulfate
- **B** carbonate
- **C** chloride
- **D** nitrate

3.2 A solution gives a light blue precipitate with sodium hydroxide that dissolves in excess aqueous ammonia to a deep blue solution.

(a) Name the cation present. [1]

(b) Describe the test for a sulfate ion and its result. [2]

3.3 Describe the test for hydrogen gas and its positive result. [2]

3.4 An unknown white solid **S** dissolves in water. Three tests are carried out.

- Adding dilute nitric acid then silver nitrate gives a **cream** precipitate.
- Adding aqueous sodium hydroxide and warming gives a gas that turns damp red litmus **blue**.
- Adding dilute hydrochloric acid gives **no** effervescence.

(a) Identify the anion and the cation present in **S**, and name the compound. [3]

(b) Name the gas produced in the second test and give the equation for its formation from the ion present. [2]

(c) Explain what the third test rules out, and why. [2]

(d) Describe the tests for carbon dioxide, hydrogen and oxygen, giving the positive result in each case. [3]

(e) Explain why the nitric acid is added before the silver nitrate. [2]

Solutions

2.1 bubble it through limewater; the limewater turns milky.

2.2 lilac (purple).

3.1 C. Silver nitrate (with nitric acid) gives a white precipitate with chloride.

3.2 (a) copper(II), Cu^{2+}.
(b) add dilute nitric acid then barium nitrate; a white precipitate confirms a sulfate.

3.3 hold a lighted splint at the mouth of the tube; a 'squeaky pop' shows hydrogen.

3.4 (a) The cream precipitate with silver nitrate shows **bromide**, Br^-; the gas turning damp red litmus blue is ammonia, so the cation is **ammonium**, NH_4^+; **S** is ammonium bromide, NH_4Br.
(b) **Ammonia**, NH_3; $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$.
(c) It rules out **carbonate**; a carbonate would fizz with dilute acid, giving carbon dioxide, and no gas was seen.
(d) Carbon dioxide — bubble through limewater, which turns milky. Hydrogen — a lighted splint gives a squeaky pop. Oxygen — a glowing splint relights.
(e) The acid removes carbonate ions, which would themselves form a precipitate with silver nitrate; without it a carbonate would give a false positive for a halide.

39 The results of flame tests on three metal salts, X, Y and Z, are shown.

metal salt	flame test colour
X	yellow
Y	lilac
Z	blue-green

Which row identifies the cations present in X, Y and Z?

	X	Y	Z
A	potassium	sodium	calcium
B	potassium	sodium	copper
C	sodium	potassium	calcium
D	sodium	potassium	copper

39 Substance X contains one cation.

Two tests are completed on aqueous X.

test 1 flame test

test 2 addition of aqueous sodium hydroxide dropwise and then in excess

Which row shows a possible combination of observations for the tests?

	observation for test 1	observation for test 2
A	yellow flame	white ppt., insoluble in excess
B	blue-green flame	light blue ppt., insoluble in excess
C	light green flame	green ppt., soluble in excess
D	red flame	red-brown ppt., insoluble in excess

3 A student tests two solids: solid **J** and solid **K**.

Tests on solid J

Solid **J** is lithium chloride.

Record the expected observations.

(a) The student carries out a flame test on solid **J**.

(i) State the colour the Bunsen burner flame becomes during the flame test.

..... [1]

(ii) The student uses a roaring Bunsen burner flame to carry out the flame test.

State why a yellow Bunsen burner flame is **not** suitable for a flame test.

.....

..... [1]

(b) The student dissolves the remaining solid **J** in distilled water to form solution **J**.

The student divides solution **J** into two portions.

(i) To the first portion of solution **J**, the student adds about 1 cm^3 of dilute nitric acid followed by a few drops of aqueous silver nitrate.

observations .....

..... [1]

(ii) To the second portion of solution **J**, the student adds aqueous sodium hydroxide until it is in excess.

observations .....

..... [1]

Tests on solid K

Table 3.1 shows the tests and the student's observations for solid **K**.

Table 3.1

tests	observations
test 1 Heat about half of solid **K** in a boiling tube until there is no further change. Hold anhydrous cobalt(II) chloride paper at the mouth of the boiling tube.	condensation forms at the top of the boiling tube the anhydrous cobalt(II) chloride paper changes colour from blue to pink
test 2 The remaining solid **K** is dissolved in distilled water to form solution **K**. Solution **K** is divided into three portions. To the first portion of solution **K**, add aqueous ammonia dropwise and then in excess.	a green precipitate forms the precipitate remains when excess aqueous ammonia is added
test 3 To the second portion of solution **K**, add 1 cm^3 of dilute nitric acid followed by a few drops of aqueous barium nitrate.	a white precipitate forms
test 4 To the third portion of solution **K**, add 3 cm^3 of aqueous sodium carbonate. Test any gas given off.	effervescence is seen and a green precipitate forms the gas turns limewater milky

(c) State the conclusion that can be made from the observations in **test 1**.

..... [1]

(d) Two different cations can give the observations in **test 2**.

(i) Identify the **two** possible cations that the observations in **test 2** show could be in solid **K**.

.....

..... [2]

(ii) Describe an additional test that can be carried out on solution **K** to confirm which of the two cations you have identified in **(d)(i)** is in solid **K**.

Explain how the result of this test shows which of these two cations is in solid **K**.

test .....

.....

explanation .....

.....

[2]

(e) Identify the gas given off in **test 4**.

..... [1]

(f) Identify the anion in solid **K**.

..... [1]

[Total: 11]

3 A student tests two solids: solid **E** and solid **F**.

Tests on solid E

Solid **E** is ammonium sulfate.

Record the expected observations.

The student dissolves solid **E** in distilled water to form solution **E**. The student divides solution **E** into three approximately equal portions.

(a) **(i)** To the first portion of solution **E**, the student adds about 2 cm^3 of aqueous sodium hydroxide. The student warms the mixture gently and tests any gas produced.

observations .....

..... [1]

(ii) Identify the gas given off in **(a)(i)**.

..... [1]

(b) To the second portion of solution **E**, the student adds about 1 cm^3 of dilute nitric acid followed by a few drops of aqueous barium nitrate.

observations .....

..... [1]

(c) To the third portion of solution **E**, the student adds a few drops of acidified aqueous potassium manganate(VII).

observations .....

..... [1]

Tests on solid F

Table 3.1 shows the tests and the student's observations for solid **F**.

Table 3.1

tests	observations
test 1 Carry out a flame test on solid **F**.	yellow flame
test 2 Dissolve the remaining solid **F** in distilled water to form solution **F**. Divide solution **F** into three portions. To the first portion of solution **F**, add about 1 cm^3 of dilute nitric acid followed by a few drops of aqueous silver nitrate.	yellow precipitate forms
test 3 To the second portion of solution **F**, add aqueous sodium hydroxide dropwise until in excess.	white precipitate forms the precipitate dissolves in excess aqueous sodium hydroxide to form a colourless solution
test 4 To the third portion of solution **F**, add aqueous ammonia dropwise until in excess.	white precipitate forms the precipitate dissolves in excess aqueous ammonia to form a colourless solution

(d) Identify the **three** ions in solid **F**.

.....

.....

..... [3]

[Total: 7]

3 A student tests two substances: solution **A** and solid **B**.

Tests on solution A

Solution **A** is aqueous iron(III) nitrate.

Record the expected observations.

The student divides solution **A** into three approximately equal portions.

(a) To the first portion of solution **A**, the student adds aqueous ammonia dropwise and then in excess.

observations when added dropwise .....

observations in excess .....
[2]

(b) **(i)** To the second portion of solution **A**, the student adds excess aqueous sodium hydroxide.

observations .....

..... [1]

(ii) To the product from **(b)(i)**, the student adds a small piece of aluminium foil. The student gently warms the mixture formed and tests any gas produced.

observations .....

..... [1]

(iii) Identify the gas produced in **(b)(ii)**.

..... [1]

(c) To the third portion of solution **A**, the student adds about 1 cm^3 of dilute nitric acid followed by a few drops of aqueous barium nitrate.

observations .....

..... [1]

Tests on solid B

Table 3.1 shows the tests and the student's observations for solid **B**.

Table 3.1

tests	observations
test 1 Do a flame test on solid **B**.	light green flame colour
test 2 Add the remaining solid **B** to dilute hydrochloric acid. Test any gas produced.	effervescence and a colourless solution forms limewater turns milky

(d) Identify the gas produced in **test 2**.

..... [1]

(e) Identify solid **B**.

.....

..... [2]

[Total: 9]

3 A student tests two solids: solid **F** and solid **G**.

Tests on solid F

Solid **F** is calcium carbonate.

(a) The student adds about 15 cm^3 of dilute hydrochloric acid to the sample of solid **F** in a boiling tube and tests any gas produced.

observations .....

.....

..... [2]

(b) The student filters the product from **(a)** to obtain solution **H** as the filtrate.
The student divides solution **H** into three approximately equal portions in three test-tubes.

(i) To the first portion of solution **H**, the student adds about 1 cm depth of dilute nitric acid followed by a few drops of aqueous barium nitrate.

observations .....

..... [1]

(ii) To the second portion of solution **H**, the student adds aqueous sodium hydroxide dropwise and then in excess.

observations when added dropwise .....

observations in excess .....
[2]

(iii) To the third portion of solution **H**, the student adds about 1 cm depth of dilute nitric acid followed by a few drops of aqueous silver nitrate.

observations .....

..... [1]

Tests on solid G

Table 3.1 shows the tests and the student's observations for solid **G**.

Table 3.1

tests	observations
test 1 Do a flame test on solid **G**.	lilac coloured flame
test 2 Dissolve the remaining solid **G** in water to form solution **G**. Divide solution **G** into three portions. To the first portion of solution **G**, add about 1 cm^3 of aqueous chlorine.	orange solution forms
test 3 To the second portion of solution **G**, add about 1 cm^3 of aqueous sodium hydroxide.	remains colourless
test 4 To the third portion of solution **G**, add about 1 cm^3 of dilute nitric acid followed by a few drops of aqueous silver nitrate.	cream precipitate forms

(c) Identify solid **G**.

.....

..... [2]

[Total: 8]

3 A student tests two solids: solid **J** and solid **K**.

Tests on solid J

Solid **J** is iron(II) iodide.

The student dissolves solid **J** in water to form solution **J**. Solution **J** is divided into four portions.

(a) To the first portion of solution **J**, the student adds aqueous sodium hydroxide dropwise and then in excess.

observations when added dropwise .....

observations when added in excess .....

[2]

(b) To the second portion of solution **J**, the student adds 1 cm^3 of dilute nitric acid followed by a few drops of aqueous barium nitrate.

observations .....

..... [1]

(c) To the third portion of solution **J**, the student adds 1 cm^3 of dilute nitric acid followed by a few drops of aqueous silver nitrate.

observations .....

..... [1]

(d) To the fourth portion of solution **J**, the student adds 1 cm^3 of aqueous chlorine.

observations .....

..... [1]

Tests on solid K

Table 3.1 shows the tests and the student's observations for solid **K**.

Table 3.1

tests	observations
test 1 Carry out a flame test on solid **K**.	lilac coloured flame
test 2 The remaining solid **K** is dissolved in water to form solution **K**. Solution **K** is divided into two portions. To the first portion of solution **K** in a boiling tube, add 1 cm^3 aqueous sodium hydroxide. Warm the product and hold damp red litmus paper at the mouth of the boiling tube.	the damp red litmus paper remains red
test 3 To the second portion of solution **K** in a boiling tube, add about 1 cm^3 of aqueous sodium hydroxide and a piece of aluminium foil. Warm the mixture and test any gas given off.	effervescence is seen damp red litmus paper turns blue

(e) State the conclusion about solid **K** that can be made from the observations in **test 2**.

..... [1]

(f) Identify the gas given off in **test 3**.

..... [1]

(g) Identify solid **K**.

.....

..... [2]

[Total: 9]

3 A student tests two solids: solid **L** and solid **M**.

Tests on solid L

Solid **L** is hydrated aluminium chloride.

The student dissolves solid **L** in distilled water to form solution **L**. Solution **L** is divided into four approximately equal portions.

(a) To the first portion of solution **L**, the student adds aqueous sodium hydroxide dropwise and then in excess.

observations when added dropwise .....

observations in excess .....
[2]

(b) To the second portion of solution **L**, the student adds aqueous ammonia dropwise and then in excess.

observations when added dropwise .....

observations in excess .....
[2]

(c) To the third portion of solution **L**, the student adds about 1 cm^3 of dilute nitric acid followed by a few drops of aqueous silver nitrate.

observations .....

..... [1]

(d) To the fourth portion of solution **L**, the student adds about 1 cm^3 of dilute nitric acid followed by a few drops of aqueous barium nitrate.

observations .....

..... [1]

Tests on solid M

Table 3.1 shows the tests and the student's observations for solid **M**.

Table 3.1

tests	observations
test 1 Do a flame test on solid **M**.	light green coloured flame
test 2 Dissolve the remaining solid **M** in water to form solution **M**. Divide solution **M** into three portions. To the first portion of solution **M**, add about 1 cm^3 of aqueous sodium hydroxide.	no visible change
test 3 To the second portion of solution **M**, add about 1 cm^3 of aqueous sodium hydroxide and a piece of aluminium foil. Warm the mixture and test any gas given off.	effervescence is seen; damp red litmus paper turns blue
test 4 To the third portion of solution **M**, add about 1 cm^3 of dilute sulfuric acid.	white precipitate forms

(e) Identify the gas given off in **test 3**.

..... [1]

(f) Identify solid **M**.

.....

..... [2]

[Total: 9]

39 Which ion forms a green precipitate with aqueous sodium hydroxide that dissolves in an excess of aqueous sodium hydroxide?

A Ca^{2+} **B** Cr^{3+} **C** Cu^{2+} **D** Fe^{2+}