

HOLIDAY HOMEWORK 假期作业

IGCSE Chemistry

Exercise sheets and past-paper practice, topic by topic.

每个单元：练习卷 + 历年真题。

For class or self-study • no answer keys included.

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1 States of matter – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
particles	粒子	_____	_____	_____
kinetic theory	粒子动理论	_____	_____	_____
solid	固体	_____	_____	_____
liquid	液体	_____	_____	_____
gas	气体	_____	_____	_____
regular	规则	_____	_____	_____
vibrate	振动	_____	_____	_____
melting	融化	_____	_____	_____
freezing	凝固	_____	_____	_____
boiling	沸腾	_____	_____	_____
evaporating	蒸发	_____	_____	_____
condensing	凝结	_____	_____	_____
melting point	熔点	_____	_____	_____
boiling point	沸点	_____	_____	_____

Recall

Everything is made of tiny **particles** 粒子 that are always moving. This is the **kinetic particle theory** 粒子动理论. How close the particles are, and how they move, decides the **state** of matter.

- The three states are **solid** 固体, **liquid** 液体 and **gas** 气体.
- Heating and cooling change one state into another.

Nothing here is hard — it just adds the particle picture.

New ideas

Read these first, then do the Practice.

1 The three states

	Solid	Liquid	Gas
shape	fixed	takes the container's shape	fills the container
separation	touching, very close	close	far apart
arrangement	regular 规则	random	random
motion	vibrate 振动 in place	slide past each other	move fast, random



solid



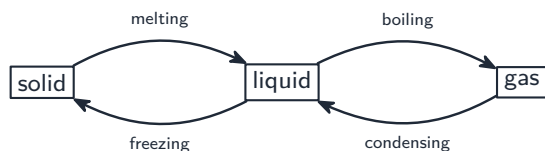
liquid



gas

2 Changes of state

Change	Name
solid → liquid	melting 融化
liquid → solid	freezing 凝固
liquid → gas	boiling 沸腾 / evaporating 蒸发
gas → liquid	condensing 凝结



A pure solid melts at one fixed **melting point** 熔点; a pure liquid boils at one fixed **boiling point** 沸点.

■ 3 Energy and changes of state

While a substance **melts or boils**, the temperature **stays the same** — the energy goes into breaking the forces between particles, not into speeding them up.

Watch out: a **pure** substance has one sharp melting point; an impurity lowers it and spreads it over a range. And while a substance melts or boils its temperature is **constant** — the energy breaks forces, it does not raise the temperature.

Practice

Try these in order.

1.1 In which state are the particles (a) far apart and fast, (b) in a fixed regular pattern?[2]

1.2 Name the change of state from (a) solid to liquid, (b) gas to liquid. [2]

1.3 Why can a gas be compressed (squeezed smaller) but a solid cannot? [2]

1.4 What name is given to the fixed temperature at which a pure liquid boils? [1]

1.5 Explain why the temperature stays the same while a solid is melting. [2]

1.6 **Challenge.** A pure solid is heated steadily until it has all melted. Describe what happens to its temperature (a) before it melts, (b) while it is melting, (c) after it has all melted. [3]

3 Which atom has an equal number of protons, neutrons and electrons?

- A** $^{40}_{18}\text{Ar}$ **B** ^1_1H **C** $^{23}_{11}\text{Na}$ **D** $^{14}_7\text{N}$

4 The only naturally occurring isotopes in a sample of europium are ^{151}Eu and ^{153}Eu . This sample of europium has a relative atomic mass, A_r , of 152.

What is the percentage of ^{151}Eu present in this sample to three significant figures?

- A** 0.987% **B** 50.0% **C** 76.0% **D** 98.7%

5 Which statement about potassium chloride is correct?

- A** It has a high melting point because it is a giant structure with strong covalent bonds.
B It conducts electricity when solid because of its oppositely charged ions.
C It conducts electricity when molten because its ions can move.
D It is insoluble in water because of its strong bonding.

3 Which atom has twice as many neutrons as protons?

- A** ^1_1H **B** ^2_1H **C** ^3_1H **D** ^4_2He

4 What is the nucleon number of an atom?

- A** the number of electrons, neutrons and protons in the nucleus
B the number of neutrons and protons in the nucleus
C the number of neutrons in the nucleus
D the number of protons in the nucleus

1 Gases and diffusion – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
gas	气体	_____	_____	_____
pressure	压强	_____	_____	_____
kinetic energy	动能	_____	_____	_____
Diffusion	扩散	_____	_____	_____
concentration	浓度	_____	_____	_____
relative molecular mass	相对分子质量	_____	_____	_____

Recall

From Part 1 you know a **gas** 气体 is far-apart, fast-moving particles. Here we see how a gas responds to **heat** and **pressure**, and how particles **spread out** by diffusion.

- Gas particles hit the container walls — this is **pressure** 压强.
- Particles spread from crowded to spread-out places.

Nothing here is hard — it just follows the particles.

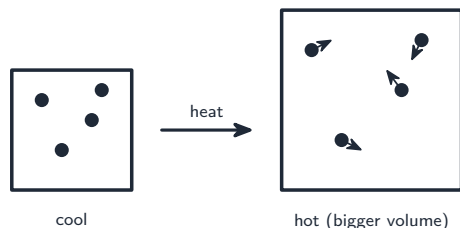
New ideas

Read these first, then do the Practice.

■ 1 Heating a gas

Heating gives the particles more **kinetic energy** 动能, so they move faster and hit the walls harder and more often:

- at **constant pressure** → the gas takes up **more space** (volume increases).
- at **constant volume** (a sealed rigid container) → the **pressure rises**.



■ 2 Squeezing a gas

Increasing the **pressure** at constant temperature pushes the particles closer, so the **volume decreases**.

■ 3 Diffusion

Diffusion 扩散 is the spreading of particles from high **concentration** 浓度 to low concentration, because particles move randomly. It happens in gases and liquids, not solids.

Lighter particles move faster, so a gas with a smaller **relative molecular mass** 相对分子质量 diffuses faster.



Watch out: when heating a gas, say what is fixed — in a *sealed rigid* container the pressure rises (volume fixed); at *constant pressure* the volume rises instead. In diffusion the **lighter** gas (smaller M_r) always travels faster.

Practice

Try these in order.

1.1 What causes the pressure of a gas on its container? [1]

1.2 A gas in a sealed rigid container is heated. Explain why its pressure rises. [2]

1.3 What is *diffusion*? [1]

1.4 Why does diffusion happen in gases and liquids but not in solids? [1]

1.5 Ammonia ($M_r = 17$) and hydrogen chloride ($M_r = 36.5$) diffuse from opposite ends of a tube. Which travels further, and why? [2]

1.6 **Challenge.** Two gases, X ($M_r = 2$) and Y ($M_r = 32$), are released together from the same place. Which spreads through the room faster, and why? [2]

2 Which gas diffuses most quickly at room temperature and pressure?

- A** CH₄ **B** C₂H₆ **C** CO **D** SO₂

3 Samples of four gases are released in a room at the same time.

The gases are carbon dioxide, CO₂, hydrogen chloride, HCl, hydrogen sulfide, H₂S, and nitrogen dioxide, NO₂.

Which gas diffuses fastest?

- A** carbon dioxide
B hydrogen chloride
C hydrogen sulfide
D nitrogen dioxide

2 Atoms and elements – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
atom	原子	_____	_____	_____
element	元素	_____	_____	_____
compound	化合物	_____	_____	_____
mixture	混合物	_____	_____	_____
nucleus	原子核	_____	_____	_____
protons	质子	_____	_____	_____
neutrons	中子	_____	_____	_____
Electrons	电子	_____	_____	_____
shells	电子层	_____	_____	_____
proton number	质子数	_____	_____	_____
mass number	质量数	_____	_____	_____
Isotopes	同位素	_____	_____	_____

Recall

All substances are built from about 100 simple building blocks. Sorting them into three groups, and looking inside the **atom** 原子, is where the IGCSE course begins.

- Everything is made of **atoms**.
- Atoms join together in different ways.

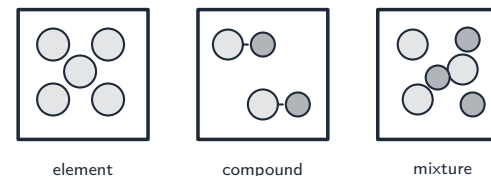
Nothing here is hard — it just sorts and names things.

New ideas

Read these first, then do the Practice.

■ 1 Element, compound, mixture

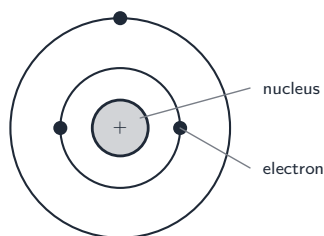
- an **element** 元素 has only **one** type of atom (e.g. copper, oxygen).
- a **compound** 化合物 is two or more elements **chemically joined** (bonded) in a fixed ratio (e.g. water).
- a **mixture** 混合物 is substances just **mixed**, not bonded, and easy to separate (e.g. air).



■ 2 Inside the atom

The tiny **nucleus** 原子核 holds **protons** 质子 (charge +1) and **neutrons** 中子 (charge 0). **Electrons** 电子 (charge -1) move in **shells** 电子层 around it.

Particle	Relative mass	Relative charge
proton	1	+1
neutron	1	0
electron	≈ 0	-1



lithium (2,1)

The **proton number** 质子数 names the element. The **mass number** 质量数 is protons + neutrons.

■ 3 Isotopes

Isotopes 同位素 are atoms of the **same** element (same protons) with **different** numbers of neutrons. They have the **same chemical properties** (chemistry depends on electrons).

Watch out: the **proton number** names the element; the **mass number** is protons + neutrons, so neutrons = mass number – proton number (not just the mass number). Isotopes react the same because chemistry depends on the *electrons*, which are unchanged.

Practice

Try these in order.

2.1 Define an *element* and a *compound*. [2]

2.2 State the charge on (a) a proton, (b) a neutron, (c) an electron. [3]

2.3 An atom has 11 protons and 12 neutrons. Give its (a) proton number, (b) mass number. [2]

2.4 Write the electronic configuration of sodium (11 electrons). [1]

2.5 What are isotopes? [2]

2.6 **Challenge.** Chlorine has two isotopes, chlorine-35 and chlorine-37 (both with proton number 17). State how many neutrons each has, and explain why they react in exactly the same way. [3]

4 Which row describes elements, compounds and mixtures?

	elements	compounds	mixtures
A	all the atoms are the same type	contain different atoms chemically joined together	can be separated using physical processes
B	all the atoms are the same type	can be separated into new substances using chemical processes	contain different atoms chemically joined together
C	can be separated into new substances using chemical processes	all the atoms are the same type	contain different atoms chemically joined together
D	contain different atoms chemically joined together	all the atoms are the same type	can be separated using physical processes

5 Symbols representing four particles are shown.

The letters are **not** the chemical symbols.

Which particles have the same number of neutrons?

- A** W and X^{2+} **B** W and Z **C** X^{2+} and Y **D** Y and Z

5 Which statement about atoms or ions is correct?

- A** The mass number of an atom is the total number of nucleons and protons.
B The electronic configuration of an aluminium ion, Al^{3+} , is 2,8,3.
C Hydrogen is the only atom that has an incomplete first electron shell.
D Most of the volume of an atom is taken up by its nucleus.

3 Which statement defines nucleon number?

- A** It is the total number of protons in the nucleus of an atom.
B It is the total number of electrons surrounding the nucleus of an atom.
C It is the total number of neutrons in the nucleus of an atom.
D It is the total number of protons and neutrons in the nucleus of an atom.

6 A sample of copper has a relative atomic mass of 63.5.

What are the relative abundances of the isotopes in this sample of copper?

- A** 25% ^{63}Cu and 75% ^{65}Cu
- B** 50% ^{63}Cu and 50% ^{65}Cu
- C** 75% ^{63}Cu and 25% ^{65}Cu
- D** 90% ^{63}Cu and 10% ^{65}Cu

5 Element T has two isotopes, $^{12}_6\text{T}$ and $^{14}_6\text{T}$.

Which statement about these isotopes is correct?

- A** They have different chemical properties because they have different numbers of neutrons.
- B** They have the same chemical properties because they have the same number of outer shell electrons.
- C** They have the same nucleon number because the sum of the number of protons and electrons is the same.
- D** They have different positions in the Periodic Table because they have different numbers of neutrons.

2 Chemical bonding – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
electrons	电子	_____	_____	_____
bonding	化学键	_____	_____	_____
ions	离子	_____	_____	_____
ionic bond	离子键	_____	_____	_____
lattice	晶格	_____	_____	_____
molten	熔融	_____	_____	_____
covalent bond	共价键	_____	_____	_____
diamond	金刚石	_____	_____	_____
graphite	石墨	_____	_____	_____
metallic bonding	金属键	_____	_____	_____
delocalised electrons	离域电子	_____	_____	_____

Recall

From Part 1 you know atoms have **electrons** 电子 in shells. Atoms join up to fill their outer shell — this is **bonding** 化学键. Here we meet the three types.

- Atoms bond to reach a full outer shell (like a noble gas).
- The type of bond decides the substance's properties.

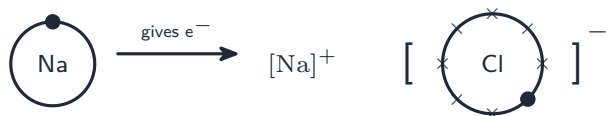
Nothing here is hard — it just compares three bonds.

New ideas

Read these first, then do the Practice.

■ 1 Ionic bonding (metal + non-metal)

A metal atom **gives** electrons to a non-metal atom, making charged **ions** 离子. An **ionic bond** 离子键 is the strong attraction between the opposite charges.



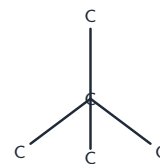
Ionic compounds form a giant **lattice** 晶格. They have **high melting points** and conduct only when **molten** 熔融 or dissolved (the ions can then move).

■ 2 Covalent bonding (non-metal + non-metal)

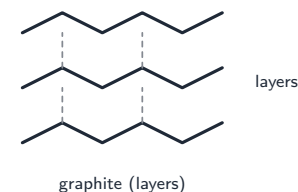
A **covalent bond** 共价键 is a **shared** pair of electrons between two non-metal atoms. Small molecules (like H₂O) have **low** melting points (the forces **between** molecules are weak) and do not conduct.

■ 3 Giant covalent and metallic

- **diamond** 金刚石 — each carbon bonds to **four** others → very hard.
- **graphite** 石墨 — carbon in flat **layers** that slide (a lubricant); spare electrons let it **conduct**.



diamond (network)



graphite (layers)

- **metallic bonding** 金属键 — positive metal ions in a “sea” of **delocalised electrons** 离域电子. This is why metals **conduct** and can be hammered into shape.

Watch out: ionic bonding **transfers** electrons (metal → non-metal); covalent bonding **shares** them (non-metal + non-metal) — don't confuse the two. An ionic solid conducts only when **molten or dissolved**, never as a solid (the ions must be free to move).

Practice

Try these in order.

2.1 What type of elements form (a) an ionic bond, (b) a covalent bond? [2]

2.2 Define an *ionic bond*. [2]

2.3 Why does an ionic compound conduct electricity when molten but not when solid? [2]

2.4 What is a *covalent bond*?

[1]

2.5 Explain why graphite can conduct electricity but diamond cannot.

[2]

2.6 Challenge. Sodium chloride has a high melting point, but methane (a small covalent molecule) has a very low one. Explain this difference.

[2]

Name: _____

IGCSE Chemistry: **w25 21**

6 Which statement describes the formation of bonds in lithium bromide?

- A** A lithium atom donates one electron to a bromine atom.
- B** A bromine atom donates one electron to a lithium atom.
- C** A lithium atom shares a pair of electrons with a bromine atom.
- D** A bromine atom donates a pair of electrons to a lithium atom.

IGCSE Chemistry: **w25 22**

7 Which statement describes the structure of sodium chloride?

- A** a lattice of alternating positive and negative ions
- B** a lattice of positive ions surrounded by a 'sea' of delocalised electrons
- C** a mixture of sodium and chlorine atoms
- D** a regular lattice of sodium and chlorine atoms

IGCSE Chemistry: **w25 23**

5 Which statement describes all positive ions?

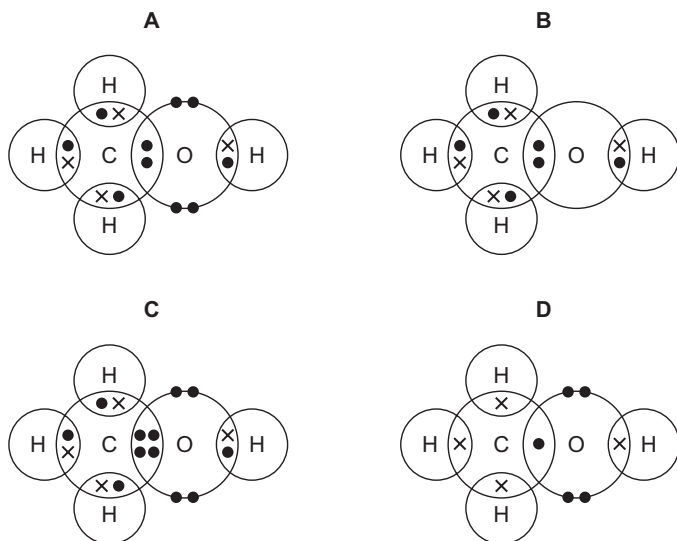
- A** Positive ions have more electrons than neutrons.
- B** Positive ions have more protons than neutrons.
- C** Positive ions have more electrons than protons.
- D** Positive ions have more protons than electrons.

IGCSE Chemistry: **s25 23**

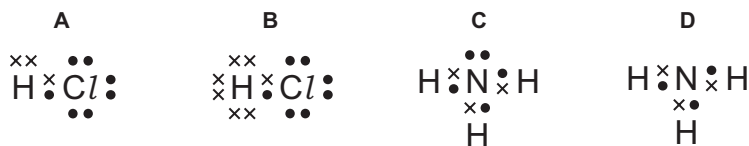
6 Which statement about ionic compounds is correct?

- A** Giant lattices are formed when ionic compounds crystallise from solution.
- B** In all ionic compounds, the metal ions have fewer electrons than the non-metal ions.
- C** In a giant lattice, ions of the same charge are closer together than ions of opposite charge.
- D** When ionic compounds melt, strong intermolecular forces are broken.

7 Which diagram shows the outer shell electron arrangement for a molecule of methanol, CH_3OH ?



7 For which covalent compound does the dot-and-cross diagram correctly show the outer shell electrons?



8 Graphite and diamond are both forms of the element carbon.

Which row shows the number of other carbon atoms that each carbon atom is covalently bonded to in graphite and in diamond?

	graphite	diamond
A	3	3
B	3	4
C	4	3
D	4	4

6 Which statement about silicon(IV) oxide, SiO_2 , is correct?

- A** It conducts electricity because it contains delocalised electrons.
- B** It has a giant covalent structure with each silicon atom bonded to four oxygen atoms.
- C** It is a simple covalent molecule.
- D** Its structure is similar to that of graphite.

7 Which statement explains why solid magnesium is a good conductor of electricity?

- A** Magnesium has delocalised electrons that can move through the lattice.
- B** Magnesium has strong attractions between ions.
- C** Magnesium consists of a giant lattice of anions in a 'sea' of delocalised electrons.
- D** Magnesium consists of metal ions that move through the lattice.

9 Which row describes the structure and bonding in cobalt?

	structure	bonding
A	giant	ionic
B	simple	ionic
C	giant	metallic
D	simple	metallic

8 Which row identifies the positive and the negative particles present in a giant metallic lattice?

	positive particles	negative particles
A	anions	cations
B	anions	delocalised electrons
C	cations	anions
D	cations	delocalised electrons

3 Formulae and equations – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
Stoichiometry	化学计量	_____	_____	_____
formulae	化学式	_____	_____	_____
equations	化学方程式	_____	_____	_____
molecular formula	分子式	_____	_____	_____
empirical formula	实验式	_____	_____	_____
ratio	比例	_____	_____	_____
ionic compound	离子化合物	_____	_____	_____
symbol equation	化学方程式	_____	_____	_____
balanced	配平	_____	_____	_____
state symbols	状态符号	_____	_____	_____
aqueous	水溶液	_____	_____	_____

Recall

Stoichiometry 化学计量 is about the **amounts** of substances in a reaction. It starts with writing **formulae** 化学式 and balancing **equations** 化学方程式.

- A formula shows which atoms are in a substance, and how many.
- An equation shows reactants changing into products.

Nothing here is hard — it just needs careful counting.

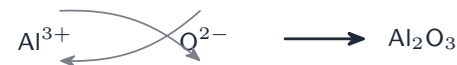
New ideas

Read these first, then do the Practice.

■ 1 Formulae

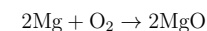
- the **molecular formula** 分子式 gives the actual number of each atom (glucose: $\text{C}_6\text{H}_{12}\text{O}_6$).
- the **empirical formula** 实验式 gives the simplest **ratio** 比例 (glucose: CH_2O).

For an **ionic compound** 离子化合物, balance the charges so the compound is neutral — the charges **cross over** to become the numbers.



■ 2 Balancing equations

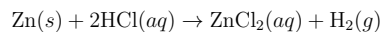
A **symbol equation** 化学方程式 must be **balanced** 配平 — the **same number of each atom** on both sides:



left:	2 Mg, 2 O	balanced
right:	2 Mg, 2 O	

■ 3 State symbols

Add **state symbols** 状态符号 in brackets: (*s*) solid, (*l*) liquid, (*g*) gas, (*aq*) **aqueous** 水溶液.



Watch out: when balancing you may change only the **big numbers in front** (coefficients) — never the small subscripts inside a formula, as that would change the substance. For an ionic formula the charges **cross over** to become the subscripts.

Practice

Try these in order.

3.1 State the difference between a *molecular* and an *empirical* formula. [2]

3.2 Work out the formula of the compound of Mg^{2+} and Cl^- . [2]

3.3 Balance this equation: $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$. [2]

3.4 What does the state symbol (*aq*) mean? [1]

3.5 Write the symbol equation (with state symbols) for solid zinc reacting with hydrochloric acid to give zinc chloride solution and hydrogen gas. [2]

3.6 Challenge. Balance this equation: $\text{Fe} + \text{O}_2 \rightarrow \text{Fe}_2\text{O}_3$. [2]

9 Which compound has an empirical formula that is the same as its molecular formula?

- A** butane
B but-1-ene
C butanoic acid
D butan-1-ol

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8 A compound is analysed and found to contain 85.7% carbon and 14.3% hydrogen only.

What is its empirical formula?

- A** CH **B** CH₂ **C** C₂H₄ **D** C₆H

IGCSE Chemistry: **m25 22**

9 Which formula for the named compound is correct?

- A** calcium oxide, CaO
B cobalt(II) chloride, Co₂Cl
C sulfur dioxide, S₂O₂
D anhydrous copper(II) sulfate, Cu(SO₄)₂

11 An organic compound, Q, contains carbon, hydrogen and oxygen only.

Q contains 40.0% carbon and 6.7% hydrogen by mass.

What is the empirical formula of Q?

- A** CHO **B** CH₂O **C** C₂HO₂ **D** C₃H₆O₃

3 The mole – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)
mole	摩尔	_____
relative atomic mass	相对原子质量	_____
relative molecular mass	相对分子质量	_____
particles	粒子	_____
Avogadro constant	阿伏伽德罗常数	_____
molar mass	摩尔质量	_____

Recall

From Part 1 you can write a balanced equation. Now we count the **amounts**: how much reacts and how much is made, using the **mole** 摩尔.

- Atoms are far too light to weigh one at a time.
- The mole lets us count particles by weighing.

Nothing here is hard — it just needs one equation.

New ideas

Read these first, then do the Practice.

■ 1 Relative masses

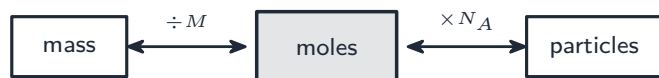
- the **relative atomic mass** 相对原子质量 (A_r) is the average mass of an element's atoms.
- the **relative molecular mass** 相对分子质量 (M_r) is the sum of the A_r values in a molecule.

$$M_r(\text{H}_2\text{O}) = (2 \times 1) + 16 = 18$$

■ 2 The mole

One **mole** 摩尔 contains 6.02×10^{23} **particles** 粒子 (the **Avogadro constant** 阿伏伽德罗常数). The **molar mass** 摩尔质量 (in g/mol) has the same number as A_r or M_r . The key equation:

$$\text{amount (mol)} = \frac{\text{mass (g)}}{\text{molar mass (g/mol)}}$$



Worked example. Moles in 36 g of water ($M_r = 18$): $n = 36/18 = 2$ mol.

■ 3 Reacting masses

A balanced equation gives the **ratio** of the amounts. To find a reacting mass: mass → moles → (use the ratio) → moles → mass.



Watch out: apply the equation ratio to **moles**, not to masses — always convert mass → moles **first**. The molar mass (g/mol) has the same number as A_r or M_r .

Practice

Try these in order. Use A_r : H = 1, C = 12, O = 16, Na = 23.

3.1 Calculate the relative molecular mass, M_r , of (a) CO_2 , (b) H_2O . [2]

3.2 State the value of the Avogadro constant. [1]

3.3 How many moles are in 46 g of sodium ($A_r = 23$)? [2]

3.4 How many moles are in 88 g of CO_2 ($M_r = 44$)? [2]

3.5 How many particles are in 2 mol of a substance? [1]

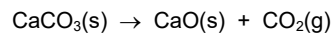
3.6 Challenge. Magnesium burns: $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$. What mass of magnesium oxide forms from 48 g of magnesium? (A_r : Mg = 24, O = 16.) [3]

11 How many atoms are present in 1.00 mol of argon?

- A** 2.06×10^{23} **B** 3.02×10^{26} **C** 6.02×10^{23} **D** 6.32×10^{20}

IGCSE Chemistry: **w25 23**

12 Calcium carbonate decomposes when heated strongly.



How many gaseous molecules are produced when 10.0 g of calcium carbonate is completely decomposed?

- A** 1.00×10^{22} **B** 1.20×10^{23} **C** 6.02×10^{22} **D** 6.02×10^{23}

IGCSE Chemistry: **s25 22**

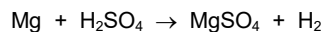
9 The concentration of a solution of aqueous sodium hydroxide is 0.50 mol/dm^3 .

Which mass of sodium hydroxide is used to make 500 cm^3 of this solution?

- A** 10 g **B** 20 g **C** 40 g **D** 160 g

IGCSE Chemistry: **m25 22**

10 The equation for the reaction of magnesium with dilute sulfuric acid is shown.



[M_r : MgSO_4 , 120]

Which mass of magnesium sulfate is formed when 12 g of magnesium completely reacts with dilute sulfuric acid?

- A** 5 g **B** 10 g **C** 60 g **D** 120 g

12 The value of the Avogadro constant is 6.02×10^{23} .

What is the total number of atoms in 2.00 mol of ammonia gas?

- A** 1.20×10^{24} **B** 2.41×10^{24} **C** 4.82×10^{24} **D** 2.89×10^{25}

4 Electrolysis – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
Electrolysis	电解	_____	_____	_____
ionic compound	离子化合物	_____	_____	_____
electric current	电流	_____	_____	_____
molten	熔融	_____	_____	_____
ions	离子	_____	_____	_____
electrodes	电极	_____	_____	_____
electrolyte	电解质	_____	_____	_____
anode	阳极	_____	_____	_____
cathode	阴极	_____	_____	_____
inert	惰性	_____	_____	_____
metals	金属	_____	_____	_____
hydrogen	氢气	_____	_____	_____
non-metals	非金属	_____	_____	_____
reduction	还原	_____	_____	_____
oxidation	氧化	_____	_____	_____

Recall

Electrolysis 电解 breaks down an **ionic compound** 离子化合物 by passing an **electric current** 电流 through it (when it is **molten** 熔融 or dissolved).

- It works only when the **ions** 离子 are free to move.
- A solid ionic compound cannot be electrolysed (its ions are locked in place).

Nothing here is hard — it just names the parts.

New ideas

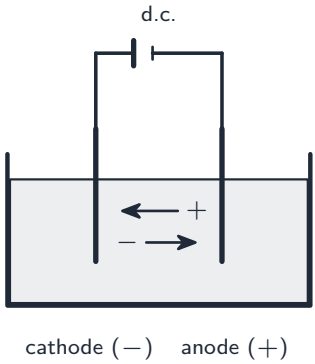
Read these first, then do the Practice.

■ 1 The electrolytic cell

Two **electrodes** 电极 dip into the **electrolyte** 电解质 (the molten/dissolved substance):

- the **anode** 阳极 is the **positive** (+) electrode.
- the **cathode** 阴极 is the **negative** (–) electrode.

The electrodes are often **inert** 惰性 (carbon or platinum). Positive ions move to the cathode; negative ions move to the anode.



■ 2 What forms at each electrode

A simple rule:

- **metals** 金属 or **hydrogen** 氢气 form at the **cathode** (–).
- **non-metals** 非金属 (other than hydrogen) form at the **anode** (+).

cathode (–) $\longrightarrow$ metal or hydrogen

anode (+) $\longrightarrow$ non-metal

Example. Molten lead(II) bromide $\rightarrow$ **lead** at the cathode, **bromine** at the anode.

■ 3 Reduction and oxidation

- at the cathode, positive ions **gain** electrons — this is **reduction** 还原.
- at the anode, negative ions **lose** electrons — this is **oxidation** 氧化.

Watch out: remember **PANIC** — Positive Anode, Negative Is Cathode. Positive ions go to the cathode and **gain** electrons (reduction); negative ions go to the anode and **lose** electrons (oxidation).

Practice

Try these in order.

4.1 Why must an ionic compound be molten or dissolved to be electrolysed? [2]

4.2 State which electrode is (a) the positive one, (b) the negative one. [2]

4.3 What forms at (a) the cathode, (b) the anode (give the rule)? [2]

4.4 Molten lead(II) bromide is electrolysed. Name the product at (a) the cathode, (b) the anode. [2]

4.5 Is gaining electrons oxidation or reduction? [1]

4.6 Challenge. Molten aluminium oxide is electrolysed. Name the product at (a) the cathode and (b) the anode, and state which product's ions are *reduced*. [3]

12 Aqueous copper(II) sulfate is electrolysed using copper electrodes.

Which statement is correct?

- A** Oxygen gas is produced at the positive electrode.
- B** The blue colour of the solution gradually fades.
- C** The concentration of copper ions in the solution stays the same.
- D** The mass of the negative electrode decreases.

10 Which particles are responsible for the transfer of charge in the external circuit during the electrolysis of molten lead(II) bromide?

- A** anions
- B** atoms
- C** cations
- D** electrons

13 Three aqueous solutions, L, M and N, are electrolysed using inert electrodes.

L is concentrated hydrochloric acid.

M is concentrated aqueous sodium chloride.

N is dilute aqueous sodium chloride.

Which solutions produce a pale yellow-green gas at the anode?

- A** L and M **B** L only **C** M and N **D** N only

4 Electroplating and fuel cells – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)
fuel cell	燃料电池	_____
Electroplating	电镀	_____
corrosion	腐蚀	_____

Recall

From Part 1 you know electrolysis splits a compound at two electrodes. Here we use it to **coat metals** (electroplating) and meet the **fuel cell** 燃料电池.

- Electroplating puts a thin metal layer on an object.
- A fuel cell makes electricity from hydrogen and oxygen.

Nothing here is hard — it just applies the idea.

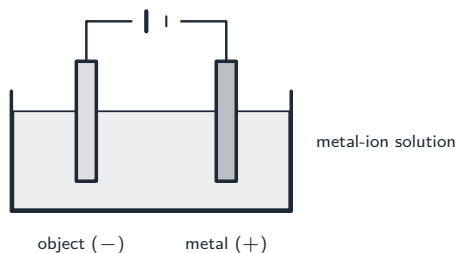
New ideas

Read these first, then do the Practice.

■ 1 Electroplating

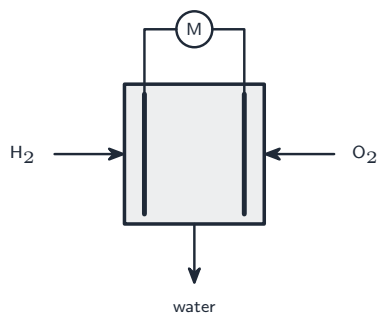
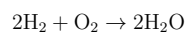
Electroplating 电镀 covers a metal object with a thin layer of another metal (to look better and resist **corrosion** 腐蚀). To electroplate:

- make the **object** the **cathode** (–).
- make the **plating metal** the **anode** (+).
- use an electrolyte containing **ions of the plating metal**.



■ 2 The hydrogen–oxygen fuel cell

A **fuel cell** 燃料电池 makes electricity directly from hydrogen and oxygen. The **only product is water**:



- **advantage** — the only product is water, so it does not pollute the air.
- **disadvantage** — hydrogen is hard and dangerous to store, and making it can still use fossil fuels.

Watch out: when electroplating, the **object** to be coated is the **cathode** (–) and the **plating metal** is the **anode** (+); the electrolyte must contain **ions of the plating metal**. A fuel cell's only product is water.

Practice

Try these in order.

4.1 What is *electroplating*, and why is it done? [2]

4.2 When electroplating, which electrode is (a) the object, (b) the plating metal? [2]

4.3 Write the overall equation for the hydrogen–oxygen fuel cell. [1]

4.4 What is the only chemical product of a hydrogen–oxygen fuel cell? [1]

4.5 State one advantage and one disadvantage of a fuel cell compared with a petrol engine. [2]

4.6 **Challenge.** A steel spoon is to be electroplated with silver. State (a) which electrode the spoon should be, and (b) a suitable electrolyte. [2]

12 Which equation represents the overall reaction in a hydrogen–oxygen fuel cell?

- A** $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$
- B** $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$
- C** $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}_2$
- D** $\text{H}_2\text{O}_2 \rightarrow \text{H}_2 + \text{O}_2$

12 Hydrogen–oxygen fuel cells can be used to power vehicles.

Which statement about hydrogen–oxygen fuel cells is correct?

- A** The equation for the overall reaction is $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}_2$.
- B** The only chemical products are water and carbon dioxide.
- C** Chemical energy in the fuel is converted into electrical energy.
- D** The hydrogen used in hydrogen–oxygen fuel cells is a fossil fuel.

15 Which statements about hydrogen–oxygen fuel cells are correct?

- 1 They convert chemical energy into electrical energy.
- 2 Hydrogen is reduced in the fuel cells.
- 3 They do **not** produce any atmospheric pollutants.

- A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

5 Energetics – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)
energy	能量	_____
exothermic	放热	_____
endothermic	吸热	_____
thermal energy	热能	_____
combustion	燃烧	_____
neutralisation	中和	_____
decomposition	分解	_____
enthalpy change	焓变	_____
activation energy	活化能	_____

Recall

Every chemical reaction transfers **energy** 能量. The reaction is either **exothermic** 放热 or **endothermic** 吸热, depending on which way the heat moves.

- An exothermic reaction **gives out** heat (warms the surroundings).
- An endothermic reaction **takes in** heat (cools the surroundings).

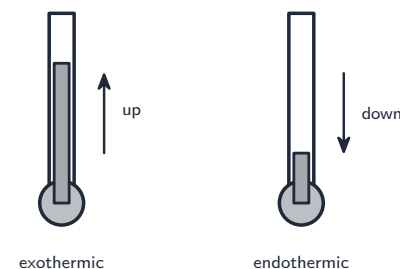
Nothing here is hard — it just adds a symbol and a diagram.

New ideas

Read these first, then do the Practice.

■ 1 Exothermic and endothermic

- **exothermic** 放热反应 — gives out **thermal energy** 热能, so the surroundings warm **up**. Examples: **combustion** 燃烧, **neutralisation** 中和.
- **endothermic** 吸热反应 — takes in thermal energy, so the surroundings cool **down**. Example: thermal **decomposition** 分解.



■ 2 Enthalpy change, ΔH

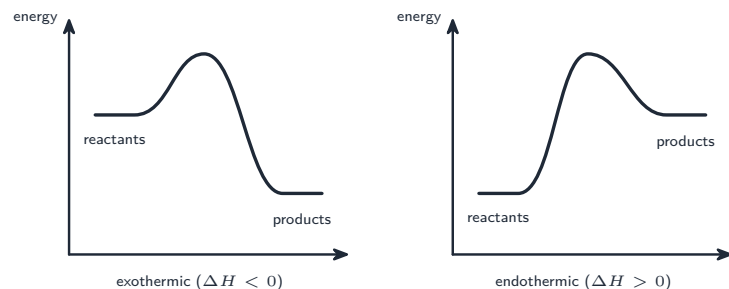
The thermal energy transferred is the **enthalpy change** 焓变, ΔH :

- ΔH is **negative** for exothermic (energy leaves the chemicals).
- ΔH is **positive** for endothermic (energy is taken in).

■ 3 Reaction pathway diagrams

The **activation energy** 活化能 (E_a) is the least energy colliding particles need to react — a "hill" they must get over.

- **exothermic** — products **lower** than reactants ($\Delta H < 0$).
- **endothermic** — products **higher** than reactants ($\Delta H > 0$).



Watch out: match the sign to the direction — exothermic **gives out** heat so ΔH is **negative** (products lower); endothermic **takes in** heat so ΔH is **positive** (products higher). The activation energy is a *hill* every reaction must climb, exo or endo.

Practice

Try these in order.

5.1 What happens to the temperature of the surroundings in (a) an exothermic, (b) an endothermic reaction? [2]

5.2 Give the sign of ΔH for (a) an exothermic, (b) an endothermic reaction. [2]

5.3 Give one example of an exothermic reaction. [1]

5.4 What is meant by the *activation energy*? [1]

5.5 On a reaction pathway diagram, where are the products (compared with the reactants) for an exothermic reaction? [1]

5.6 Challenge. On a pathway diagram the products lie **above** the reactants. State (a) whether the reaction is exothermic or endothermic, (b) the sign of ΔH , and (c) what the surroundings do. [3]

5 Bonds and energy – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)
bond breaking	断键	_____
bond making	成键	_____
bond energy	键能	_____

Recall

From Part 1 you know ΔH is the energy change. Where does that energy come from? It comes from **breaking** and **making** bonds during the reaction.

- Breaking bonds **takes in** energy.
- Making bonds **gives out** energy.

Nothing here is hard — it just adds one calculation.

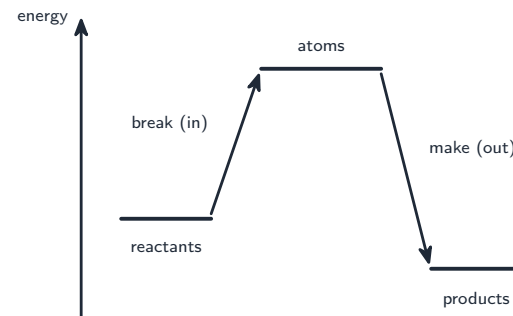
New ideas

Read these first, then do the Practice.

■ 1 Bonds and energy

A reaction breaks the bonds in the reactants and makes new bonds in the products:

- **bond breaking** 断键 takes in energy (endothermic step).
- **bond making** 成键 gives out energy (exothermic step).



■ 2 Calculating ΔH from bond energies

The **bond energy** 键能 is the energy to break one mole of a bond.

$$\Delta H = (\text{bonds broken}) - (\text{bonds made})$$

If more energy is given out making bonds than taken in breaking them, the reaction is **exothermic** (ΔH negative).

Worked example. $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$. Bond energies: $\text{H-H} = 436$, $\text{Cl-Cl} = 242$, $\text{H-Cl} = 431$. broken = $436 + 242 = 678$; made = $2 \times 431 = 862$; $\Delta H = 678 - 862 = -184$ kJ/mol (exothermic).

Watch out: bond **breaking** takes energy *in*; bond **making** gives energy *out*. Use $\Delta H = (\text{bonds broken}) - (\text{bonds made})$ — a **negative** answer means exothermic.

Practice

Try these in order.

5.1 Does breaking a bond take in or give out energy? [1]

5.2 Does making a bond take in or give out energy? [1]

5.3 Write the equation for ΔH in terms of bonds broken and bonds made. [1]

5.4 Use bond energies to find ΔH for $\text{H}_2 + \text{Br}_2 \rightarrow 2\text{HBr}$. Bond energies: $\text{H-H} = 436$, $\text{Br-Br} = 193$, $\text{H-Br} = 366$. [3]

5.5 Is the reaction in 5.4 exothermic or endothermic? [1]

5.6 Challenge. Use bond energies to find ΔH for $\text{H}_2 + \text{F}_2 \rightarrow 2\text{HF}$. Bond energies: $\text{H-H} = 436$, $\text{F-F} = 158$, $\text{H-F} = 568$. Is it exothermic? [3]

14 The average bond energy for the C–H bond is 413 kJ/mol.

What is the enthalpy change when 1.0 mol of methane molecules is formed from carbon and hydrogen atoms?

- A –1652 kJ B –413 kJ C +413 kJ D +1652 kJ

11 Two statements about hydrogen are listed.

- 1 Hydrogen is used as a fuel.
- 2 When hydrogen burns in the air to form water, thermal energy is produced.

Which conclusion about these statements is correct?

- A Both statements are correct, and statement 2 explains statement 1.
B Both statements are correct, but statement 2 does **not** explain statement 1.
C Statement 1 is correct, but statement 2 is **not** correct.
D Statement 2 is correct, but statement 1 is **not** correct.

13 Which row describes an exothermic reaction?

	sign of enthalpy change, ΔH	temperature of the surroundings
A	positive	decreases
B	positive	increases
C	negative	decreases
D	negative	increases

6 Rate of reaction – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)
rates	速率	_____
chemical change	化学变化	_____
physical change	物理变化	_____
collide	碰撞	_____
activation energy	活化能	_____
rate	速率	_____
concentration	浓度	_____
surface area	表面积	_____
temperature	温度	_____
catalyst	催化剂	_____

Recall

Some changes make a **new substance**; others just change shape or state. And reactions can go at different **rates** 速率.

- A **chemical change** 化学变化 makes a new substance (e.g. burning, rusting).
- A **physical change** 物理变化 does not (e.g. melting, dissolving).

Nothing here is hard — it just adds the collision idea.

New ideas

Read these first, then do the Practice.

■ 1 Physical vs chemical change

Physical change	Chemical change
no new substance	new substance(s) made
easy to reverse	usually hard to reverse
e.g. melting, dissolving	e.g. burning, rusting

■ 2 Collision theory

For a reaction, particles must **collide** 碰撞 with enough energy (the **activation energy** 活化能). A faster **rate** 速率 means more successful collisions each second.

These all make a reaction **faster**:

Change	Why (collisions)
higher concentration 浓度	more particles in a volume → collide more often
larger surface area 表面积 (a powder)	more particles exposed → collide more often
higher temperature 温度	particles move faster → collide more often, with more energy
a catalyst 催化剂	lowers the activation energy



low concentration

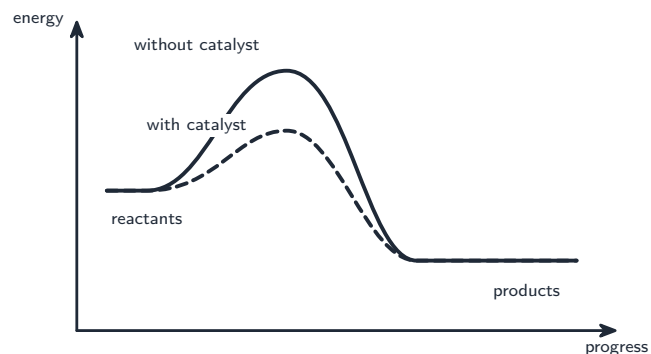


high concentration

more collisions

■ 3 Catalysts

A **catalyst** 催化剂 speeds up a reaction but is **not used up**. It lowers the **activation energy**, so more collisions succeed (it does **not** change ΔH).



Watch out: a catalyst speeds a reaction by **lowering the activation energy**, but it is **not used up** and does **not** change ΔH . Higher concentration, smaller pieces and higher temperature all work by giving **more successful collisions per second**.

Practice

Try these in order.

6.1 State two differences between a physical and a chemical change. [2]

6.2 What two things must particles do to react (collision theory)? [2]

6.3 Explain why a powdered solid reacts faster than a single lump. [2]

6.4 Explain why raising the temperature speeds up a reaction. [2]

6.5 Does a catalyst get used up in a reaction? [1]

6.6 Challenge. Marble chips react with acid. State **two** changes that would make the reaction faster, and explain each one using collision theory. [4]

16 Which statement about reactions is correct?

- A** A reaction that is vigorous at room temperature has a high activation energy.
- B** If ΔH for a reaction is positive, bond making in the formation of the products is endothermic.
- C** In an exothermic reaction, the energy required to break bonds is less than the energy released to make bonds.
- D** Reactions with a positive enthalpy change always transfer thermal energy to the surroundings.

IGCSE Chemistry: **s25 23**

27 A sample of calcium carbonate is heated strongly, and substances U and V are formed.

Substance U is a white solid. Substance V is a colourless gas.

What are substances U and V?

	U	V
A	calcium chloride	oxygen
B	calcium hydroxide	carbon dioxide
C	calcium oxide	carbon dioxide
D	calcium sulfate	oxygen

IGCSE Chemistry: **m25 22**

18 Which change is a physical change?

- A** cracking an alkane
- B** evaporating ethanol
- C** fermenting glucose
- D** neutralising an acid

15 Which statement describes the effect of adding a catalyst to a chemical reaction?

- A** The activation energy, E_a , of the reaction is increased.
- B** The enthalpy change, ΔH , of the reaction stays unchanged.
- C** The frequency of collisions between the particles is decreased.
- D** The kinetic energy of the particles is increased.

IGCSE Chemistry: **s25 23**

15 The rate of reaction between magnesium and dilute hydrochloric acid is increased by increasing the concentration of the acid.

How does this affect the reacting particles?

	collision rate of particles	proportion of particles with sufficient energy to react
A	increases	increases
B	increases	stays the same
C	stays the same	increases
D	stays the same	stays the same

IGCSE Chemistry: **m25 22**

19 Which statements explain why increasing the temperature in a reaction involving gases increases the rate of reaction?

- 1 It increases the collision frequency between the gas particles.
- 2 It lowers the activation energy.
- 3 It increases the kinetic energy of the gas particles.
- 4 It increases the number of gas particles per unit volume.

- A** 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

6 Reversible reactions and redox – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)
reversible	可逆	_____
oxidation	氧化	_____
reduction	还原	_____
redox	氧化还原	_____
reversible reaction	可逆反应	_____
hydrated	水合	_____
anhydrous	无水	_____
closed system	密闭系统	_____
equilibrium	平衡	_____
oxidising agent	氧化剂	_____
reducing agent	还原剂	_____

Recall

Some reactions can go **both ways** — they are **reversible** 可逆. And **oxidation** 氧化 and **reduction** 还原 always happen together in a **redox** 氧化还原 reaction.

- A reversible reaction is shown by $\rightleftharpoons$.
- “Redox” is short for reduction–oxidation.

Nothing here is hard — it just adds the right words.

New ideas

Read these first, then do the Practice.

■ 1 Reversible reactions

A **reversible reaction** 可逆反应 can go forwards and backwards. A good example:

- blue **hydrated** 水合 copper(II) sulfate, when heated, loses its water $\rightarrow$ white **anhydrous** 无水 copper(II) sulfate.
- adding water turns it **blue** again (this is a test for water).

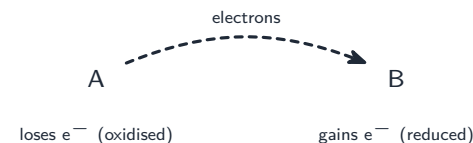


In a **closed system** 密闭系统, a reversible reaction reaches **equilibrium** 平衡 when the **forward** and **reverse** rates are equal.

■ 2 Redox: OIL RIG

- **oxidation** 氧化 is **loss** of electrons.
- **reduction** 还原 is **gain** of electrons.

Remember **OIL RIG**: Oxidation Is Loss, Reduction Is Gain.



- an **oxidising agent** 氧化剂 oxidises another substance (and is itself reduced).

- a **reducing agent** 还原剂 reduces another substance (and is itself oxidised).

Watch out: OIL RIG — Oxidation Is Loss of electrons, Reduction Is Gain. The **oxidising agent** is itself *reduced* (it takes the electrons); the **reducing agent** is itself *oxidised*. At equilibrium the forward and reverse rates are equal — the reaction has **not** stopped.

Practice

Try these in order.

6.1 What symbol shows a reversible reaction? [1]

6.2 Heating blue hydrated copper(II) sulfate gives a white solid. Name the change and the white solid. [2]

6.3 How could you turn the white solid blue again, and what does this test for? [2]

6.4 What does OIL RIG stand for? [2]

6.5 An oxidising agent oxidises another substance. What happens to the oxidising agent itself? [1]

6.6 **Challenge.** In the reaction $\text{Zn} + \text{CuSO}_4 \rightarrow \text{ZnSO}_4 + \text{Cu}$, zinc gives electrons to the copper ions. State which substance is **oxidised** and which is the **oxidising agent**. [2]

17 Which equation represents one of the reactions in the Contact process?

- A $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$
 B $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{aq})$
 C $2\text{SO}_3(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_4(\text{aq})$
 D $2\text{SO}_3(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_4(\text{g})$

17 Which statement about the conditions used in the Haber process and in the Contact process is correct?

- A The typical pressure used in the Haber process is similar to that used in the Contact process.
 B The typical temperature used in the Haber process is similar to that used in the Contact process.
 C The Haber process uses a vanadium(V) oxide catalyst, and the Contact process uses an iron catalyst.
 D Both processes produce an acidic gas.

20 Which row identifies the conditions used to make sulfur trioxide in the Contact process?

	pressure / kPa	catalyst
A	200	iron
B	200	vanadium(V) oxide
C	20 000	iron
D	20 000	vanadium(V) oxide

19 What is the oxidation number of chromium in the $\text{Cr}_2\text{O}_7^{2-}$ ion?

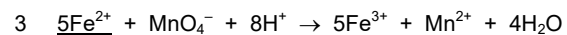
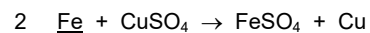
- A** -2 **B** -1 **C** +6 **D** +12

18 Zinc reacts with dilute hydrochloric acid.

Which statement about the particles in the reaction is correct?

- A** Increasing the concentration of dilute hydrochloric acid increases the collision rate but has **no** effect on the activation energy.
- B** Increasing the concentration of dilute hydrochloric acid increases the collision rate and the activation energy.
- C** Increasing the temperature of the reaction increases the activation energy.
- D** Increasing the temperature of the reaction causes all collisions to lead to a reaction.

17 Which equations show the underlined species acting as a reducing agent?

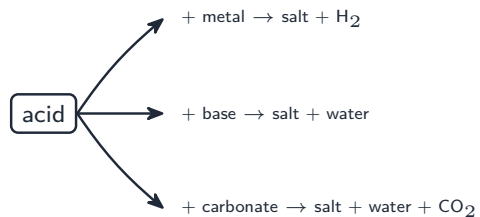


- A** 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

Vocabulary 词汇

English	中文	Write it 3 times (English)		
acids	酸			
alkalis	碱			
bases	碱			
metal	金属			
salt	盐			
hydrogen	氢气			
base	碱			
carbonate	碳酸盐			
carbon dioxide	二氧化碳			
indicator	指示剂			
Litmus	石蕊			
Universal indicator	通用指示剂			
acidic	酸性			
neutral	中性			
alkaline	碱性			

$$\text{H}^+(aq) + \text{OH}^-(aq) \rightarrow \text{H}_2\text{O}(l)$$



Watch out: an **alkali** is a base that *dissolves* in water — every alkali is a base, but not every base is an alkali. On the pH scale, below 7 is acidic, exactly 7 is neutral, above 7 is alkaline.

Practice

Try these in order.

7.1 What ion do all acids form in water? [1]

7.2 Name the products of (a) acid + metal, (b) acid + carbonate. [2]

7.3 What colour is litmus in (a) an acid, (b) an alkali? [2]

7.4 What colour does universal indicator show at pH 7, and what is that called? [2]

7.5 Write the ionic equation for neutralisation. [1]

7.6 Challenge. Write the **word** equation for dilute hydrochloric acid reacting with calcium carbonate, and name the gas given off. [3]

20 Which statement describes a property of ethanoic acid?

- A** It does **not** produce carbon dioxide when added to sodium carbonate.
- B** It does **not** produce hydrogen when added to magnesium.
- C** It only donates some of its protons when added to excess aqueous sodium hydroxide.
- D** It only partially dissociates when added to water.

21 Which statement describes a base?

- A** It reacts with ammonium chloride to produce ammonia gas.
- B** It reacts with calcium carbonate to produce carbon dioxide gas.
- C** It reacts with copper to produce hydrogen gas.
- D** It turns blue litmus red.

34 Which statement about aqueous ethanoic acid is correct?

- A** It reacts with magnesium to form oxygen gas.
- B** It reacts with sodium carbonate to form carbon dioxide gas.
- C** It turns red litmus paper blue.
- D** It turns methyl orange yellow.

7 Strong/weak acids and salts – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)
salt	盐	_____
dissociates	电离	_____
strong acid	强酸	_____
weak acid	弱酸	_____
excess	过量	_____
filter	过滤	_____
evaporate	蒸发	_____
crystallise	结晶	_____
precipitation	沉淀	_____

Recall

From Part 1 you know acids form H^+ ions. Here we sort acids into **strong** and **weak**, and learn how to make a **salt** 盐.

- “Strong/weak” is about how fully an acid splits into ions.
- A salt is what forms when an acid is neutralised.

Nothing here is hard — it just adds the methods.

New ideas

Read these first, then do the Practice.

■ 1 Strong and weak acids

This is about how fully the acid **dissociates** 电离 (splits into ions) in water:

- a **strong acid** 强酸 is **fully** dissociated (e.g. hydrochloric acid).
- a **weak acid** 弱酸 is only **partly** dissociated (e.g. ethanoic acid).



strong (all ions)



weak (mostly HA)

(“Strong/weak” is **not** the same as concentrated/dilute.)

■ 2 Making a soluble salt

React an acid with an **excess** 过量 of an insoluble base, metal or carbonate, then:



filter 过滤 off the leftover solid → **evaporate** 蒸发 some water → **crystallise** 结晶.

■ 3 Making an insoluble salt

Make it by **precipitation** 沉淀: mix two solutions that each carry one of the needed ions, and the insoluble salt forms as a solid. Then filter, wash and dry it.

Watch out: **strong/weak** is about how *fully* an acid splits into ions; **concentrated/dilute** is about how *much* acid is in the water — they are different ideas. A *soluble* salt is made with **excess** insoluble solid then filtering; an *insoluble* salt by **precipitation**.

Practice

Try these in order.

7.1 What is the difference between a *strong* and a *weak* acid?

[2]

7.2 Is hydrochloric acid strong or weak?

[1]

7.3 Does “strong” mean the same as “concentrated”?

[1]

7.4 List the steps to make a soluble salt from an acid and an excess of an insoluble base.[3]

7.5 How is an insoluble salt made?

[1]

7.6 **Challenge.** Lead nitrate solution is mixed with potassium iodide solution and a yellow solid forms. Name this method of making a salt, and state the two steps after mixing to obtain the dry solid.

[3]

25 Which metal oxide reacts with aqueous sodium hydroxide to form a salt and water?

- A** calcium oxide
- B** copper(II) oxide
- C** sodium oxide
- D** aluminium oxide

IGCSE Chemistry: **s25 22**

20 Which three oxides are **all** acidic?

- A** CaO, NO₂, SO₂
- B** CaO, CO₂, Na₂O
- C** CO₂, NO₂, SO₂
- D** CO₂, Na₂O, SO₂

IGCSE Chemistry: **s25 23**

20 Which row identifies an acidic oxide, a basic oxide and an amphoteric oxide?

	acidic	basic	amphoteric
A	ZnO	SO ₂	Al ₂ O ₃
B	SO ₂	Al ₂ O ₃	Na ₂ O
C	ZnO	Al ₂ O ₃	SO ₂
D	SO ₂	Na ₂ O	Al ₂ O ₃

20 Which method is used to prepare a pure, dry sample of lead(II) chloride?

- A** mix aqueous lead(II) nitrate and dilute hydrochloric acid → filter → crystallise and dry the filtrate
- B** mix aqueous lead(II) nitrate and dilute hydrochloric acid → filter → wash and dry the residue
- C** mix solid lead(II) hydroxide and aqueous sodium chloride → filter → crystallise and dry the filtrate
- D** mix solid lead(II) hydroxide and aqueous sodium chloride → filter → wash and dry the residue

IGCSE Chemistry: **w25 23**

11 Which statement describes a saturated solution?

- A** It is a solution that contains the maximum concentration of solute.
- B** It is a solution that contains the maximum amount of solvent.
- C** It is a hydrocarbon that contains both double and single bonds.
- D** It is a hydrocarbon that contains only single bonds.

IGCSE Chemistry: **s25 21**

19 Lead(II) sulfate is an insoluble salt.

Which process is **not** used to prepare a pure sample of this salt?

- A** crystallisation
- B** drying
- C** filtration
- D** precipitation

8 The Periodic Table – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
Periodic Table	周期表	_____	_____	_____
elements	元素	_____	_____	_____
proton number	质子数	_____	_____	_____
periods	周期	_____	_____	_____
groups	族	_____	_____	_____
period	周期	_____	_____	_____
metals	金属	_____	_____	_____
non-metals	非金属	_____	_____	_____
group	族	_____	_____	_____
alkali metals	碱金属	_____	_____	_____
soft	柔软	_____	_____	_____
reactivity	活泼性	_____	_____	_____
melting point	熔点	_____	_____	_____
density	密度	_____	_____	_____

Recall

The **Periodic Table** 周期表 arranges all the **elements** 元素 in order of **proton number** 质子数. It is the chemist's map.

- The rows are **periods** 周期; the columns are **groups** 族.
- Elements in the same group behave alike.

Nothing here is hard — it just reads the table.

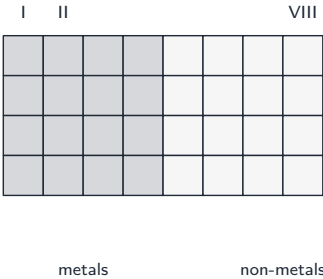
New ideas

Read these first, then do the Practice.

■ 1 The layout

- across a **period** 周期 (a row): **metals** 金属 on the left → **non-metals** 非金属 on the right.
- in a **group** 族 (a column): elements have the **same number of outer electrons**, so they react in similar ways.

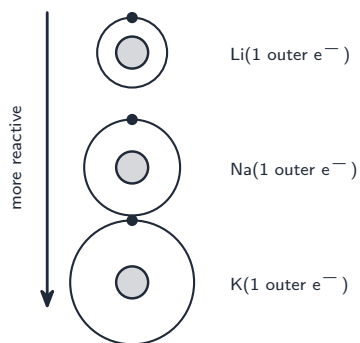
The **group number** equals the charge of the ions: Group I → +1, Group II → +2, Group VII → -1.



■ 2 Group I — the alkali metals

The **alkali metals** 碱金属 (lithium, sodium, potassium) are **soft** 柔软 metals with **one** outer electron. Going **down** the group:

Property	Trend down the group
reactivity 活泼性	increases
melting point 熔点	decreases
density 密度	increases



Watch out: elements in a group share properties because they have the **same number of outer electrons** (the group number), not the same total. Group I gets **more** reactive *down* the group — the opposite of Group VII.

Practice

Try these in order.

8.1 In what order are the elements arranged in the Periodic Table? [1]

8.2 What are (a) the rows, (b) the columns called? [2]

8.3 Why do elements in the same group have similar chemical properties? [2]

8.4 What charge of ion does a Group I element form? [1]

8.5 State the trend in reactivity going down Group I. [1]

8.6 Challenge. Potassium is below sodium in Group I. Predict whether potassium is more or less reactive than sodium, and explain why in terms of the outer electron. [3]

21 The properties of the elements change from left to right across the Periodic Table.

Which statement describes how the properties change across Period 3?

- A** Elements change from gases to solids.
- B** Elements change from non-conductors to electrical conductors.
- C** Elements change from metal to non-metal.
- D** Elements have a decreasing number of electron shells.

_____ IGCSE Chemistry: **s25 23** _____

22 Element X is in the same group of the Periodic Table as silicon.

An atom of element X has more protons than a silicon atom.

Which element could be X?

- A** aluminium
- B** carbon
- C** germanium
- D** phosphorus

_____ IGCSE Chemistry: **m25 22** _____

25 The elements oxygen and sulfur are in the same group of the Periodic Table.

Which statement about oxygen and sulfur is **not** correct?

- A** They are non-metals.
- B** They have giant covalent structures.
- C** They have six electrons in the outer electron shells of their atoms.
- D** They react together to form an acidic oxide.

24 Which properties decrease down the group of alkali metals?

- 1 melting point
- 2 density
- 3 reactivity

- A** 1 and 2 **B** 1 only **C** 2 and 3 **D** 3 only

_____ IGCSE Chemistry: **w25 22** _____

23 Which statement about the elements in Group I is correct?

- A** Hydrogen is produced when Group I elements react with water.
- B** Ions of Group I elements have a 1– charge.
- C** Sodium is more reactive than potassium.
- D** Solid sodium is a poor electrical conductor.

_____ IGCSE Chemistry: **s25 22** _____

22 Sodium is a Group I metal.

What is a physical property of sodium?

- A** non-conductor of electricity
- B** high melting point
- C** high density
- D** malleable

8 Groups and trends – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)
Group VII	第七族	_____
transition elements	ele- 过渡元素	_____
noble gases	稀有气体	_____
halogens	卤素	_____
diatomic	双原子	_____
coloured compounds	com- 有色化合物	_____
catalysts	催化剂	_____
monatomic	单原子	_____

Recall

From Part 1 you know Group I gets more reactive down the group. Here we look at **Group VII** 第七族 (the opposite trend), the **transition elements** 过渡元素, and the **noble gases** 稀有气体.

- Group VII = the **halogens** 卤素.
- The transition metals sit in the middle of the table.

Nothing here is hard — it just compares groups.

New ideas

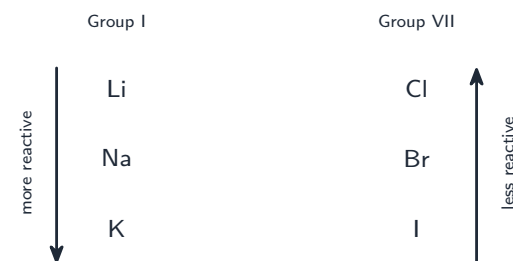
Read these first, then do the Practice.

■ 1 Group VII — the halogens

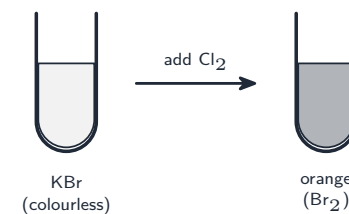
The **halogens** 卤素 (chlorine, bromine, iodine) are **diatomic** 双原子 non-metals:

Halogen	At room temperature
chlorine	pale yellow-green gas
bromine	red-brown liquid
iodine	grey-black solid

Going **down** Group VII, **reactivity decreases** — the **opposite** of Group I.



A more reactive halogen **displaces** a less reactive one from its salt:



■ 2 Transition elements and noble gases

- **transition elements** 过渡元素 (middle of the table) have **high melting points**, form **coloured compounds** 有色化合物, are good **catalysts** 催化剂, and have **variable oxidation numbers** (e.g. iron(II) and iron(III)).
- **noble gases** 稀有气体 (Group VIII) are **unreactive**, **monatomic** 单原子 gases — they already have a **full outer shell**.

Watch out: Group VII (halogens) gets **less** reactive *down* the group — the opposite of Group I. A more reactive halogen **displaces** a less reactive one from its salt. Noble gases are unreactive because their outer shell is already **full**.

Practice

Try these in order.

8.1 Give the colour and state of (a) chlorine, (b) iodine. [2]

8.2 State the trend in reactivity going down Group VII. [1]

8.3 Write the equation for chlorine reacting with potassium bromide, and state the colour change. [2]

8.4 State two properties of the transition elements. [2]

8.5 Why are the noble gases unreactive? [1]

8.6 **Challenge.** Will bromine displace chlorine from potassium chloride solution? Explain your answer. [2]

22 Which property decreases down Group VII of the Periodic Table, from chlorine to iodine?

- A atomic number
- B density
- C reactivity
- D melting point

24 When chlorine is bubbled into aqueous sodium bromide, a displacement reaction occurs.

Which description of this reaction is correct?

- A Chloride displaces bromide.
- B Chlorine displaces bromine.
- C Chloride displaces bromine.
- D Chlorine displaces bromide.

26 Tennessine, Ts, is at the bottom of Group VII of the Periodic Table.

What are the predicted properties of tennessine at room temperature?

- A a black solid, more dense than iodine
- B a black solid, more reactive than iodine
- C a colourless gas, less dense than chlorine
- D a colourless gas, less reactive than chlorine

26 Which row identifies a transition element?

	melting point	density at r.t.p.
A	high	high
B	high	low
C	low	high
D	low	low

23 Some properties of elements are listed.

- 1 They have good electrical conductivity.
- 2 They have high melting points.
- 3 They are malleable.
- 4 They have ions with variable oxidation numbers.

Which properties are correct for **both** iron and lithium?

A 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

24 Which element is a transition element?

	melting point in °C	density at r.t.p. in g/cm ³	colour of oxide at r.t.p.
A	98	1.0	white
B	328	11.3	yellow
C	651	1.7	white
D	1907	7.2	green

25 Part of the Periodic Table is shown.

Which element is an inert gas?

A simplified periodic table with 18 columns and 4 rows. The columns are grouped into four sets of three. Element A is in the top row, second column of the second set. Element B is in the second row, second column of the fourth set. Element C is in the third row, third column of the fourth set. Element D is in the third row, second column of the third set.

24 Two statements about noble gases are listed.

- 1 Noble gases are reactive, monatomic gases.
- 2 Noble gases all have a full outer shell of electrons.

Which statements about noble gases are correct?

A Both statements are correct, and statement 2 explains statement 1.

B Both statements are correct but statement 2 does **not** explain statement 1.

C Statement 1 is correct but statement 2 is **not** correct.

D Statement 2 is correct but statement 1 is **not** correct.

23 Which statement about the elements in Group VIII is correct?

- A** They all form diatomic molecules.
- B** They all have eight electrons in their outer electron shells.
- C** They all react with oxygen to form oxides.
- D** They all are gases at room temperature.

9 Metals and alloys – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
Metals	金属	_____	_____	_____
non-metals	非金属	_____	_____	_____
alloy	合金	_____	_____	_____
malleable	可锻	_____	_____	_____
ductile	可延	_____	_____	_____
brittle	易碎	_____	_____	_____
mixture	混合物	_____	_____	_____
brass	黄铜	_____	_____	_____
steel	钢	_____	_____	_____
layers	层	_____	_____	_____
reactivity series	金属活动性顺序	_____	_____	_____

Recall

Metals 金属 behave very differently from **non-metals** 非金属, and we can order them by how reactive they are.

- Metals conduct heat and electricity and can be shaped.
- An **alloy** 合金 is a metal mixed with other elements.

Nothing here is hard — it just organises the properties.

New ideas

Read these first, then do the Practice.

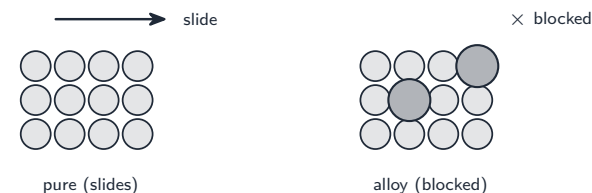
■ 1 Metals vs non-metals

Property	Metals	Non-metals
conducting heat and electricity	good	poor
malleable 可锻 / ductile 可延	yes	brittle 易碎 (snap)
melting point	usually high	usually low

■ 2 Alloys

An **alloy** 合金 is a **mixture** 混合物 of a metal with other elements (e.g. **brass** 黄铜 = copper + zinc; **steel** 钢 = iron + carbon).

Alloys are **harder** than pure metals: in a pure metal the same-size atoms let the **layers** 层 slide, but in an alloy the different-sized atoms **block** the sliding.



■ 3 The reactivity series

The **reactivity series** 金属活动性顺序 lists metals from most to least reactive (carbon and hydrogen are included for comparison):

	K	most reactive
	Na	
	Ca	
	Mg	
	Al	
	C (carbon)	
	Zn	
	Fe	
	H (hydrogen)	
	Cu	
	Ag	
	Au	least reactive

less reactive



A more reactive metal **displaces** a less reactive one from a solution of its ions.

Watch out: an alloy is **harder** than the pure metal because its different-sized atoms **block the layers from sliding** — pure metals are softer, not harder. A more reactive metal **displaces** a less reactive one from a solution of its ions.

Practice

Try these in order.

9.1 State two physical properties of metals. [2]

9.2 What is an *alloy*? Give one example. [2]

9.3 Explain why an alloy is harder than the pure metal. [2]

9.4 In the reactivity series, which is more reactive — magnesium or copper? [1]

9.5 Zinc is more reactive than copper. What will zinc do to copper(II) sulfate solution? [1]

9.6 **Challenge.** Iron is more reactive than copper but less reactive than magnesium. Predict what happens when (a) magnesium is added to iron(II) sulfate solution, (b) copper is added to iron(II) sulfate solution. [2]

5 This question is about metallic compounds.

(a) Insoluble metal salts, such as lead(II) sulfate, are made by precipitation.

When aqueous lead(II) ions react with aqueous sulfate ions, a precipitate of lead(II) sulfate forms.

A sample of pure lead(II) sulfate can be obtained from the precipitate formed.

(i) Write an ionic equation for this precipitation reaction. Include state symbols.

..... [3]

(ii) State the name of an aqueous solution containing lead(II) ions.

..... [1]

(iii) State the name of an aqueous solution containing sulfate ions.

..... [1]

(iv) The lead(II) sulfate precipitate is separated from the rest of the reaction mixture by filtration. The impure lead(II) sulfate remains on the filter paper.

State the general term given to an insoluble substance that remains on the filter paper during filtration.

..... [1]

(v) Describe how the lead(II) sulfate is purified after filtration.

.....

..... [2]

(b) Copper is a transition element.

A list of properties of copper is shown.

- It has good electrical conductivity.
- It has variable oxidation states.
- It forms soluble salts.
- It forms coloured compounds.
- It forms basic oxides.
- It acts as a catalyst.

(i) Give **two** properties from the list that show how copper is similar to metals in Group I of the Periodic Table.

1

2

[2]

(ii) Give **two** properties from the list that show how copper is different from metals in Group I of the Periodic Table.

1

2

[2]

[Total: 12]

25 Which statement about the properties and uses of copper is correct?

- A** It is used in electrical wiring, and it is ductile.
- B** It is mixed with tin to make the alloy brass.
- C** It is used in overhead electrical cables because it has a low density.
- D** It is used in takeaway food containers because of its resistance to corrosion.

25 Brass is an alloy of copper.

Which statement about brass or copper is correct?

- A** Brass does **not** conduct electricity because it is a compound.
- B** Copper conducts electricity because its atoms are free to move.
- C** Brass is harder than copper because its layers of atoms **cannot** easily slide over each other.
- D** Copper is stronger than brass because it is a pure metal.

26 Brass is a mixture of copper and zinc.

Which statement describes and explains the relative strength of brass compared to copper?

- A** Brass is stronger than copper because the layers of atoms in brass **cannot** easily slide over each other.
- B** Brass is stronger than copper because the intermolecular forces are greater in brass than in copper.
- C** Brass is weaker than copper because the layers of atoms slide more easily over each other in brass than in copper.
- D** Brass is weaker than copper because the intermolecular forces are weaker in brass than in copper.

28 Which statement about alloys is correct?

- A** Alloys are harder than pure metals because they contain strong intermolecular forces.
- B** Brass is an alloy containing mainly copper and tin.
- C** The different-sized atoms in an alloy mean that the layers **cannot** easily slide over each other.
- D** There are no alloys containing carbon because carbon is a non-metal.

9 Rusting and extraction – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
reactivity series	金属活动性顺序	_____	_____	_____
rusts	生锈	_____	_____	_____
extract	提取	_____	_____	_____
ores	矿石	_____	_____	_____
Rusting	生锈	_____	_____	_____
oxygen	氧气	_____	_____	_____
barrier methods	隔离法	_____	_____	_____
galvanising	镀锌	_____	_____	_____
sacrificial protection	牺牲保护	_____	_____	_____
blast furnace	高炉	_____	_____	_____
electrolysis	电解	_____	_____	_____

Recall

From Part 1 you know the **reactivity series** 金属活动性顺序. It explains why iron **rusts** 生锈 and how we **extract** 提取 metals from their **ores** 矿石.

- Rusting is the corrosion of iron.
- A metal's place in the series decides how it is extracted.

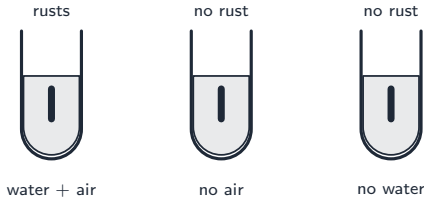
Nothing here is hard — it just applies the order.

New ideas

Read these first, then do the Practice.

■ 1 Rusting

Rusting 生锈 is the corrosion of iron. It needs **two** things: **oxygen** 氧气 (from the air) **and** water.



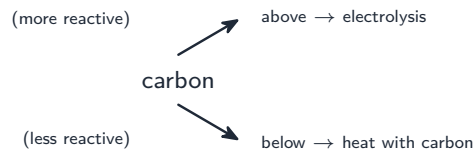
Stopping rust:

- **barrier methods** 隔离法 — paint, oil/grease or plastic keep out air and water.
- **galvanising** 镀锌 — coat with **zinc**; the zinc also gives **sacrificial protection** 牺牲保护 (being more reactive, it corrodes instead of the iron).

■ 2 Extracting metals

How a metal is taken from its ore depends on its reactivity:

- metals **below carbon** in the series → heat the ore **with carbon** (carbon removes the oxygen). Iron is made this way in a **blast furnace** 高炉.
- metals **above carbon** are too reactive → extracted by **electrolysis** 电解. Aluminium is made this way.



Watch out: rusting needs **both** oxygen **and** water — remove either and iron will not rust. A metal **below** carbon is extracted by heating its ore *with carbon*; one **above** carbon is too reactive and needs **electrolysis**.

Practice

Try these in order.

9.1 What two substances are needed for iron to rust? [2]

9.2 Name the rust formed (its chemical name). [1]

9.3 Galvanising protects iron in two ways. State them. [2]

9.4 Why does the more reactive zinc protect the iron, even if the surface is scratched? [2]

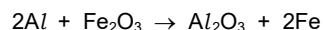
9.5 How is (a) iron, (b) aluminium extracted from its ore? [2]

9.6 Challenge. Aluminium is above carbon in the reactivity series, but iron is below it. Explain why aluminium must be extracted by electrolysis while iron can be extracted with carbon. [3]

26 What is the correct order of reactivity of the following metals, from least reactive to most reactive?

- A** calcium → magnesium → zinc → copper
B copper → zinc → magnesium → calcium
C copper → zinc → calcium → magnesium
D zinc → copper → magnesium → calcium

27 The equation for the reaction between aluminium and iron(III) oxide is shown.



Which statement about this reaction is correct?

- A** The aluminium acts as an oxidising agent.
B It shows that iron is more reactive than aluminium.
C The oxidation number of the aluminium decreases during the reaction.
D It shows that aluminium has a greater tendency to form ions than iron.

29 Separate pieces of aluminium foil and copper foil are heated in air.

The copper foil reacts to give a black solid.

The aluminium foil does **not** react.

Which statement explains these observations?

- A** Aluminium has an unreactive layer, but copper does **not**.
B Aluminium is below copper in the reactivity series.
C Copper reacts with moisture in the air, but aluminium does **not**.
D Copper reacts with nitrogen in the air, but aluminium does **not**.

28 Which row identifies methods used to prevent iron from rusting?

	greasing	painting	washing with distilled water	key ✓ = yes X = no
A	✓	X	✓	
B	X	✓	✓	
C	✓	✓	X	
D	✓	✓	✓	

29 Galvanising prevents iron from rusting.

Which statements about galvanising are correct?

- Galvanising involves coating the iron with silver.
- Galvanising prevents oxygen and water from coming into contact with the iron.
- Galvanising works because the metal coating loses electrons more readily than iron.

- A** 1, 2 and 3 **B** 1 and 3 only **C** 2 and 3 only **D** 2 only

27 An example of sacrificial protection is the fitting of zinc blocks to the outside of a ship's steel hull.

Which statement explains why zinc is used to protect the iron in the steel from rusting?

- A** Zinc is more reactive than iron so it loses electrons more easily.
B Zinc is less reactive than iron so it loses electrons more easily.
C Zinc is more reactive than iron so it gains electrons more easily.
D Zinc is less reactive than iron so it gains electrons more easily.

29 Which statement about the extraction of aluminium by electrolysis is correct?

- A** Aluminium oxide is dissolved in molten cryolite to increase its melting point.
- B** At the cathode, oxygen ions lose electrons to form oxygen gas.
- C** The carbon in the graphite anode reacts with oxygen gas forming carbon dioxide.
- D** The reaction at the anode is $\text{Al}^{3+} + 3\text{e}^{-} \rightarrow \text{Al}$.

28 Which process is used in the extraction of iron from hematite?

- A** electrolysis
- B** precipitation
- C** reduction
- D** fractional distillation

28 Which equation represents a reaction that occurs in a blast furnace during the extraction of iron from hematite?

- A** $\text{Ca} + \text{CO}_2 \rightarrow \text{CaO} + \text{CO}$
- B** $\text{Fe}_2\text{O}_3 + 3\text{Ca} \rightarrow 2\text{Fe} + 3\text{CaO}$
- C** $\text{Ca}(\text{OH})_2 \rightarrow \text{CaO} + \text{H}_2\text{O}$
- D** $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$

10 Water — Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
Water	水	_____	_____	_____
anhydrous	无水	_____	_____	_____
sedimentation	沉降	_____	_____	_____
filtration	过滤	_____	_____	_____
carbon	碳	_____	_____	_____
chlorination	氯消毒	_____	_____	_____
microbes	微生物	_____	_____	_____
Fertilisers	肥料	_____	_____	_____
nitrogen	氮	_____	_____	_____
phosphorus	磷	_____	_____	_____
potassium	钾	_____	_____	_____

Recall

Water 水 is everywhere in chemistry. We need ways to **test** for it, and to make natural water **safe to drink**.

- Pure water melts at 0 °C and boils at 100 °C.
- Natural water is not pure — it has dissolved substances.

Nothing here is hard — it just lists the tests and steps.

New ideas

Read these first, then do the Practice.

■ 1 Testing for water

Two tests show water is **present**:

- **anhydrous** 无水 cobalt(II) chloride turns **blue** → **pink**.
- anhydrous copper(II) sulfate turns **white** → **blue**.

To show water is **pure**, check it melts at 0 °C and boils at 100 °C (any dissolved substance changes these).

■ 2 Treating drinking water

Natural water has solids, microbes and dissolved substances. To make it safe:



- **sedimentation** 沉降 and **filtration** 过滤 remove solids.
- passing through **carbon** 碳 removes tastes and smells.
- **chlorination** 氯消毒 kills harmful **microbes** 微生物.

■ 3 Fertilisers

Fertilisers 肥料 help plants grow. **NPK fertilisers** contain the three key elements: **nitrogen** 氮, **phosphorus** 磷 and **potassium** 钾.

Watch out: the two water tests give *different* colours — anhydrous copper(II) sulfate goes white → **blue**, while anhydrous cobalt(II) chloride goes blue → **pink**. These show water is *present*; the 0/100 °C check shows it is *pure*.

Practice

Try these in order.

10.1 What colour change shows water using anhydrous copper(II) sulfate? [1]

10.2 Pure water melts and boils at what temperatures? [2]

10.3 Name the step in water treatment that kills harmful microbes. [1]

10.4 What does carbon do in water treatment? [1]

10.5 What three elements do NPK fertilisers provide? [3]

10.6 **Challenge.** A sample of water is found to boil at 103°C. State, with a reason, whether it is pure. [2]

30 Which flow chart describes the correct treatment sequence of the domestic water supply?

- A filtration → chlorination → sedimentation
- B sedimentation → chlorination → filtration
- C chlorination → filtration → sedimentation
- D sedimentation → filtration → chlorination

28 A sample of water taken from a river contains harmful microbes.

What is a source of harmful microbes in the river water?

- A sewage
- B fertilisers
- C detergents
- D plastics

32 Which statements about the treatment of domestic water supplies are correct?

- 1 The water undergoes sedimentation to remove dissolved solids.
- 2 The water is filtered to remove insoluble solids.
- 3 The water is treated with carbon to improve the taste.
- 4 The water is chlorinated to decrease the pH.

- A 1 and 2 B 1 and 4 C 2 and 3 D 3 and 4

10 Air and climate – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
air	空气	_____	_____	_____
pollutants	污染物	_____	_____	_____
nitrogen	氮气	_____	_____	_____
oxygen	氧气	_____	_____	_____
carbon dioxide	二氧化碳	_____	_____	_____
carbon monoxide	一氧化碳	_____	_____	_____
sulfur dioxide	二氧化硫	_____	_____	_____
oxides of nitrogen	氮氧化物	_____	_____	_____
Greenhouse gases	温室气体	_____	_____	_____
methane	甲烷	_____	_____	_____
global warming	全球变暖	_____	_____	_____

Recall

The **air** 空气 around us is a mixture of gases. Burning fuels adds **pollutants** 污染物 that harm the air and the climate.

- Clean dry air is mostly nitrogen and oxygen.
- Some gases trap heat and warm the Earth.

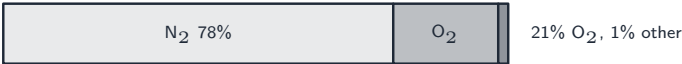
Nothing here is hard — it just lists the gases and effects.

New ideas

Read these first, then do the Practice.

■ 1 What is in clean air

Gas	Amount
nitrogen 氮气	about 78%
oxygen 氧气	about 21%
noble gases + carbon dioxide	about 1%

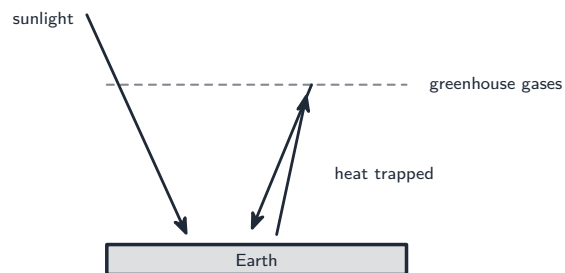


■ 2 Air pollutants

Pollutant	Source	Problem
carbon dioxide 二氧化碳	burning fuels	greenhouse gas → global warming
carbon monoxide 一氧化碳	incomplete combustion	toxic
sulfur dioxide 二氧化硫	fuels with sulfur	acid rain
oxides of nitrogen 氮氧化物	car engines	acid rain

■ 3 The greenhouse effect

Greenhouse gases 温室气体 (CO₂, **methane** 甲烷) let sunlight through, but they **absorb** the heat the warm Earth gives off and send some back down — so the Earth warms up (**global warming** 全球变暖).



Watch out: keep the two problems apart — **carbon dioxide** and methane cause **global warming**; **sulfur dioxide** and oxides of nitrogen cause **acid rain**. And carbon *monoxide* is toxic, while carbon *dioxide* is the greenhouse gas.

Practice

Try these in order.

10.1 What are the two main gases in clean, dry air, and their approximate percentages?^[2]

10.2 Name a pollutant that causes (a) acid rain, (b) global warming.^[2]

10.3 Why is carbon monoxide dangerous?^[1]

10.4 Explain how greenhouse gases warm the Earth.^[3]

10.5 State two ways to slow climate change.^[2]

10.6 Challenge. A car engine burns petrol. (a) Name a pollutant it makes that causes acid rain. (b) Name the toxic gas formed when the fuel burns in too little oxygen, and explain why it forms.^[3]

30 Nitrogen, phosphorus and potassium are essential elements for improved plant growth.

Which mixture provides all **three** essential elements?

	mixture	formulae
A	ammonium phosphate + potassium chloride	$(\text{NH}_4)_3\text{PO}_4$ + KCl
B	ammonium phosphate + ammonium nitrate	$(\text{NH}_4)_3\text{PO}_4$ + NH_4NO_3
C	ammonium phosphate + ammonium chloride	$(\text{NH}_4)_3\text{PO}_4$ + NH_4Cl
D	ammonium nitrate + potassium chloride	NH_4NO_3 + KCl

18 A farmer incorrectly adds two substances to the soil at the same time.

They react together to form a gas which turns damp red litmus paper blue.

What are the two substances?

- A** a basic oxide and a potassium salt
- B** a basic oxide and an ammonium salt
- C** an acidic oxide and a potassium salt
- D** an acidic oxide and an ammonium salt

32 The exhaust gases from cars contain oxides of nitrogen.

How are these oxides of nitrogen formed?

- A** Nitrogen and oxygen from the air react together at the high temperatures in the engine.
- B** Nitrogen and oxygen from the petrol react together in the car exhaust.
- C** Nitrogen from the petrol reacts with oxygen at the high temperatures in the engine.
- D** Nitrogen reacts with oxygen from the air in the catalytic converter.

30 Which gas contributes to increased global warming?

- A** argon
- B** carbon dioxide
- C** nitrogen
- D** oxygen

31 Which statement describes how greenhouse gases increase global warming?

- A** Greenhouse gases absorb thermal energy from the Sun, reducing the Earth's temperature.
- B** Greenhouse gases reflect thermal energy back into space, cooling the Earth's surface.
- C** Greenhouse gases absorb and re-emit thermal energy radiated from the Earth's surface.
- D** Greenhouse gases release thermal energy from the Earth into space.

11 Hydrocarbons and fuels – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)
Organic chemistry	有机化学	_____
hydrocarbon	碳氢化合物	_____
Petroleum	石油	_____
homologous series	同系物	_____
alkanes	烷烃	_____
saturated	饱和	_____
alkenes	烯烃	_____
unsaturated	不饱和	_____
fractions	馏分	_____
fractional distillation	分馏	_____
volatility	挥发性	_____
Cracking	裂化	_____
catalyst	催化剂	_____
Combustion	燃烧	_____
bromine water	溴水	_____

Recall

Organic chemistry 有机化学 is the chemistry of carbon compounds. A **hydrocarbon** 碳氢化合物 is a compound made of hydrogen and carbon only.

- **Petroleum** 石油 (crude oil) is a mixture of many hydrocarbons.
- Carbon is special: it joins to other carbon atoms to make long chains.

Nothing here is hard — it just gives names to families of molecules.

New ideas

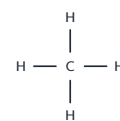
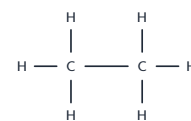
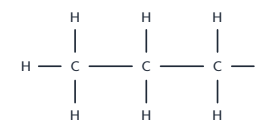
Read these first, then do the Practice.

■ 1 Two families of hydrocarbon

A **homologous series** 同系物 is a family of compounds with similar chemical properties and the same general formula. Two to know:

Family	Bonds	General formula
alkanes 烷烃	single C–C only (saturated 饱和)	C_nH_{2n+2}
alkenes 烯烃	one C=C double bond (unsaturated 不饱和)	C_nH_{2n}

The start of the name gives the number of carbons (*meth-* = 1, *eth-* = 2, *prop-* = 3); the ending gives the family (*-ane* or *-ene*).

methane CH_4 ethane C_2H_6 propane C_3H_8

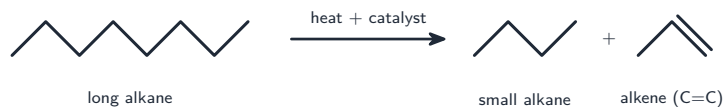
■ 2 Fractional distillation

Petroleum is separated into useful **fractions** 馏分 by **fractional distillation** 分馏. The oil is heated; the gases rise up a tall column that is hot at the bottom and cool at the top, so each fraction turns back to liquid at a different height.

Going up the column the molecules get smaller, with lower boiling points and higher **volatility** 挥发性 (they turn to gas more easily).

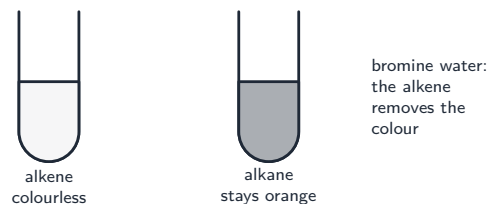
■ 3 Cracking

Long alkane molecules are not very useful. **Cracking** 裂化 breaks them into smaller, more useful molecules — a smaller alkane plus an alkene — using a high temperature and a **catalyst** 催化剂.



■ 4 Two reactions to know

- **Combustion 燃烧:** hydrocarbons burn in plenty of oxygen to give carbon dioxide and water.
- **Test for a C=C:** shake the compound with orange **bromine water 溴水**. An alkene turns it colourless; an alkane leaves it orange.



Watch out: **alkanes** are *saturated* (single bonds only, C_nH_{2n+2}); **alkenes** are *unsaturated* (one C=C, C_nH_{2n}). Only an **alkene** decolourises bromine water — that is the test for the C=C double bond.

Practice

Try these in order.

11.1 What is a *hydrocarbon*? [1]

11.2 Give the general formula of (a) the alkanes and (b) the alkenes. [2]

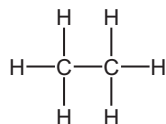
11.3 Name the process used to separate petroleum into fractions. [1]

11.4 What does *cracking* do, and why is it useful? [2]

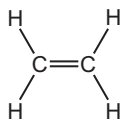
11.5 Describe the test that tells an alkene from an alkane, and the result for each. [2]

11.6 **Challenge.** Propene is an alkene with 3 carbon atoms. Write its molecular formula, and state what you would see when it is shaken with bromine water. [3]

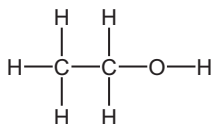
37 The structures of four compounds are shown.



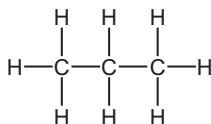
1



2



3



4

Which compounds are members of the same homologous series?

- A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 4 **D** 2 and 4

IGCSE Chemistry: s25 21

33 The structural formula of methyl ethanoate is $\text{CH}_3\text{COOCH}_3$.

Which compounds are structural isomers of methyl ethanoate?

- 1 $\text{HCOOCH}_2\text{CH}_3$
2 $\text{CH}_3\text{CH}_2\text{COOH}$
3 $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{OH}$

- A** 1, 2 and 3 **B** 1 and 2 only **C** 2 and 3 only **D** 3 only

IGCSE Chemistry: s25 23

34 Which row describes two characteristics of members of the same homologous series?

	characteristic 1	characteristic 2
A	same functional group	trend in physical properties
B	same physical properties	same functional group
C	same general formula	different chemical properties
D	differing from one member to the next by a CH_3 unit	similar chemical properties

32 Petroleum is separated by fractional distillation.

Which statement about the fractions produced is correct?

- A** Bottled gas for heating and cooking is obtained from the naphtha fraction.
B Diesel oil is used as a fuel for jet aircraft.
C Substances used to make polishes are obtained from the lubricating fraction.
D The kerosene fraction contains many useful waxes.

IGCSE Chemistry: w25 22

36 Which row shows the products obtained by the cracking of a large alkane?

	alkene	hydrogen	water	
A	✓	✓	✓	key ✓ = yes ✗ = no
B	✓	✓	✗	
C	✓	✗	✓	
D	✗	✓	✓	

IGCSE Chemistry: s25 22

34 Petroleum can be separated into useful fractions by fractional distillation.

Which row shows a correct use of the named fraction?

	fraction	use
A	bitumen	lubricant
B	naphtha	fuel for home heating
C	kerosene	jet fuel
D	refinery gas	making chemicals

31 Which type of reaction takes place when methane reacts with chlorine in the presence of ultraviolet light?

- A** addition
- B** cracking
- C** polymerisation
- D** substitution

IGCSE Chemistry: **s25 21**

34 What is the **total** number of covalent bonds in one molecule of propane?

- A** 8
- B** 9
- C** 10
- D** 11

IGCSE Chemistry: **s25 22**

35 Ethane reacts with chlorine in the presence of ultraviolet light.

Which products are formed?

- A** $\text{ClCH}_2\text{CH}_2\text{Cl}$ and H_2
- B** $2\text{CH}_3\text{Cl}$ and H_2
- C** $\text{C}_2\text{H}_5\text{Cl}$ and HCl
- D** $\text{CH}_2=\text{CH}_2$ and 2HCl

IGCSE Chemistry: **s25 23**

35 Compound W is a hydrocarbon that contains single bonds only.

Which homologous series contains W?

- A** alkenes
- B** alkanes
- C** carboxylic acids
- D** alcohols

11 Alcohols, acids and polymers – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
functional group	官能团	_____	_____	_____
alcohols	醇	_____	_____	_____
carboxylic acids	羧酸	_____	_____	_____
ethanol	乙醇	_____	_____	_____
fermentation	发酵	_____	_____	_____
yeast	酵母	_____	_____	_____
glucose	葡萄糖	_____	_____	_____
hydration	水合	_____	_____	_____
solvent	溶剂	_____	_____	_____
Ethanoic acid	乙酸	_____	_____	_____
metals	金属	_____	_____	_____
carbonates	碳酸盐	_____	_____	_____
bases	碱	_____	_____	_____
oxidation	氧化	_____	_____	_____
ester	酯	_____	_____	_____

English	中文	Write it 3 times (English)
polymer	聚合物	
monomers	单体	
addition polymerisation	加聚	
poly(ethene)	聚乙烯	
repeat unit	重复单元	
plastics	塑料	
landfill	填埋	

Recall

A **functional group** 官能团 is the part of a molecule that gives it its reactions. Two families share the spotlight here:

- **alcohols** 醇 have the -OH group;
- **carboxylic acids** 羧酸 have the -COOH group.

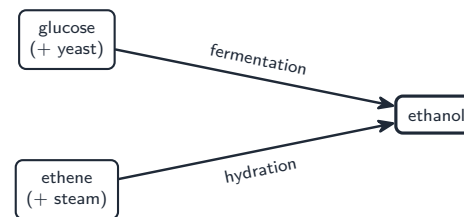
New ideas

Read these first, then do the Practice.

■ 1 Alcohols

The alcohol to know is **ethanol** 乙醇. There are two ways to make it:

Method	What happens	Note
fermentation 发酵	yeast 酵母 turns glucose 葡萄糖 into ethanol + CO_2	renewable sugar; slow
hydration 水合 of ethene	steam adds to ethene (acid catalyst)	fast and pure; uses petroleum



Ethanol is used as a **fuel** (it burns well) and as a **solvent** 溶剂 (it dissolves many things).

■ 2 Carboxylic acids

Ethanoic acid 乙酸 is the one to know. Like other acids, it reacts with:

- **metals** 金属 $\rightarrow$ salt + hydrogen;
- **carbonates** 碳酸盐 $\rightarrow$ salt + water + carbon dioxide;
- **bases** 碱 $\rightarrow$ salt + water.

It is made by the **oxidation** 氧化 of ethanol. When a carboxylic acid reacts with an alcohol (acid catalyst), it makes an **ester** 酯.



■ 3 Polymers

A **polymer** 聚合物 is a very large molecule built from many small **monomers** 单体. In **addition polymerisation** 加聚, many unsaturated monomers (with $\text{C}=\text{C}$) join up with no other product. Many ethene monomers join to make **poly(ethene)** 聚乙烯. The small part that repeats along the chain is the **repeat unit** 重复单元.



Many **plastics** 塑料 do not break down, so they build up in **landfill** 填埋 sites and harm sea life — a real environmental problem.

Watch out: fermentation (yeast on glucose) is renewable but slow; **hydration of ethene** (steam + catalyst) is fast and pure but uses petroleum — know one advantage of each. In **addition polymerisation** the monomers must have a $C=C$, and there is **no** other product.

Practice

Try these in order.

11.6 Name the functional group in (a) an alcohol and (b) a carboxylic acid. [2]

11.7 Name the two methods used to make ethanol. [2]

11.8 Give two uses of ethanol. [2]

11.9 Ethanoic acid reacts with magnesium carbonate. Name the three products. [2]

11.10 Many ethene monomers join together. Name the product and the process. [2]

11.11 Challenge. Ethene (C_2H_4) undergoes addition polymerisation. Name the polymer formed, and explain why ethane (C_2H_6) cannot be used to make a polymer this way. [3]

36 Ethene reacts with hydrogen in an addition reaction to form ethane.

Which catalyst is used for this reaction?

- A** iron
- B** nickel
- C** vanadium(V) oxide
- D** yeast

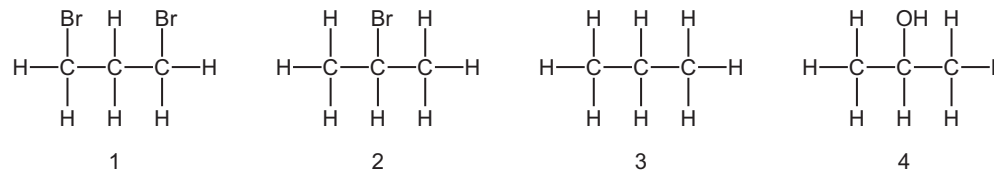
32 The alkenes are a homologous series.

Which statement about the members of the homologous series of the alkenes is correct?

- A** They have the same functional group.
- B** They have the same relative molecular mass.
- C** They have different chemical properties.
- D** They have different general formulae.

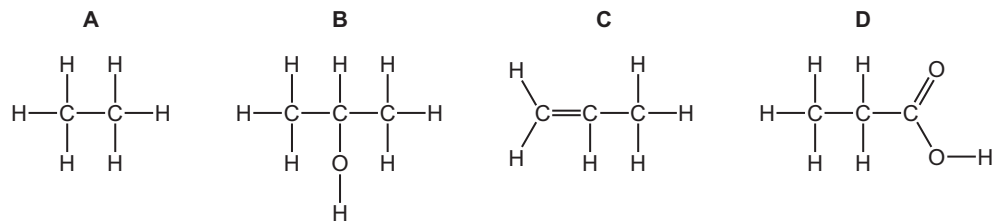
36 Propene undergoes addition reactions with bromine, hydrogen and steam.

Which structures represent a product of these reactions?



- A** 1 and 3
- B** 1 and 4
- C** 2 and 3
- D** 3 and 4

33 Which structure represents a compound in the alcohol homologous series?

IGCSE Chemistry: **s25 22**

32 What is the structural formula of butan-2-ol?

- A** $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
B $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$
C $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
D $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$

IGCSE Chemistry: **m25 22**

37 Which statements describe disadvantages of manufacturing ethanol by fermentation?

- 1 The process uses a renewable resource.
- 2 The process produces impure ethanol.
- 3 The process requires a high temperature.
- 4 The process is slow.

- A** 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

37 What is produced by the bacterial oxidation of ethanol?

- A** ethene
B sodium ethanoate
C ethyl ethanoate
D vinegar

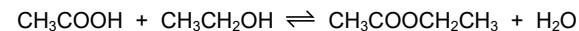
IGCSE Chemistry: **w25 23**

38 Which statement about ethanoic acid is correct?

- A** Ethanol is reduced by bacteria to produce ethanoic acid.
B Ethanoic acid reacts with magnesium to produce a salt of formula CH_3COOMg .
C Ethanoic acid and methanol react in the presence of an acid catalyst to produce ethyl methanoate.
D Ethanol reacts with acidified aqueous potassium manganate(VII) to produce ethanoic acid.

IGCSE Chemistry: **s25 21**

14 The equation represents the reaction between ethanoic acid and ethanol.



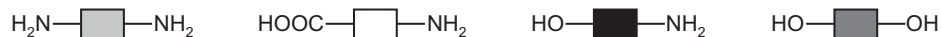
Which type of reaction does this show?

- A** addition
B neutralisation
C reduction
D reversible

38 Which statement about addition polymers or condensation polymers is correct?

- A** Addition polymers only contain carbon and hydrogen atoms.
- B** One of the monomers used to make a polyester is a diamine.
- C** Addition polymers contain carbon–carbon double bonds in the main chain.
- D** Water is an additional product in the formation of a protein from amino acids.

35 The diagrams represent four monomers.



The monomers each react in a 1 : 1 ratio with the dicarboxylic acid shown.



How many of the four monomers shown can react with the dicarboxylic acid to form a polymer?

- A** 1 **B** 2 **C** 3 **D** 4

38 Nylon is made in a polymerisation reaction.

Which row describes the type of polymerisation and identifies the other product of the reaction?

	type of polymerisation	other product
A	addition	water
B	addition	none
C	condensation	water
D	condensation	none

12 Separating and purifying – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
solute	溶质	_____	_____	_____
solvent	溶剂	_____	_____	_____
solution	溶液	_____	_____	_____
residue	残渣	_____	_____	_____
filtrate	滤液	_____	_____	_____
titration	滴定	_____	_____	_____
pipette	移液管	_____	_____	_____
indicator	指示剂	_____	_____	_____
burette	滴定管	_____	_____	_____
end-point	终点	_____	_____	_____
filtration	过滤	_____	_____	_____
crystallisation	结晶	_____	_____	_____
simple distillation	蒸馏	_____	_____	_____
fractional distillation	分馏	_____	_____	_____
Paper chromatography	纸色谱法	_____	_____	_____

English	中文	Write it 3 times (English)		
R value	比移值	_____	_____	_____
Impurities	杂质	_____	_____	_____
melting point	熔点	_____	_____	_____
boiling point	沸点	_____	_____	_____

Recall

These words come up in every practical:

- A **solute** 溶质 dissolves in a **solvent** 溶剂 to make a **solution** 溶液.
- The **residue** 残渣 is the solid left on the filter paper; the **filtrate** 滤液 is the liquid that passes through.

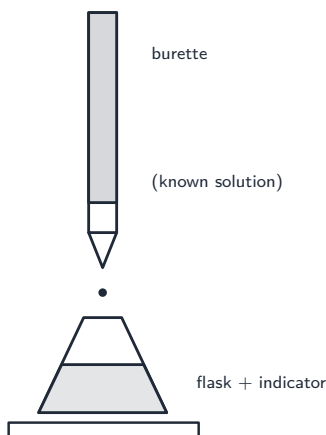
New ideas

Read these first, then do the Practice.

■ 1 Titration

A **titration** 滴定 finds the exact volume of one solution that reacts with another.

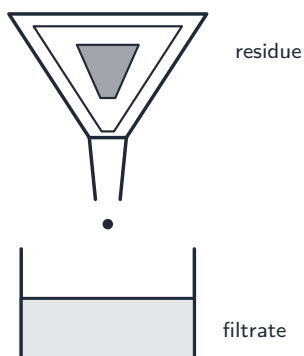
- Measure a fixed volume of one solution into a flask with a **pipette** 移液管, and add a few drops of **indicator** 指示剂.
- Run the other solution in from a **burette** 滴定管 until the colour just changes — the **end-point** 终点.



■ 2 Separating mixtures

Choose the method to match the mixture:

Method	Separates
filtration 过滤	an insoluble solid from a liquid
crystallisation 结晶	a soluble solid from its solution
simple distillation 蒸馏	a solvent (liquid) from a solution
fractional distillation 分馏	two liquids with different boiling points

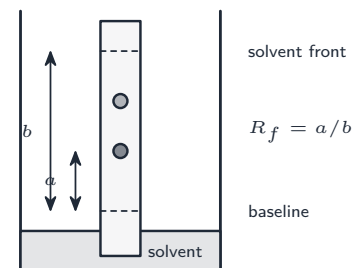


■ 3 Chromatography

Paper chromatography 纸色谱法 separates a mixture of soluble, coloured substances. A spot of the mixture is placed on a pencil baseline; as the solvent rises up the paper, each substance travels a different distance and so separates.

The spots are compared using the **R_f value** 比移值:

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



■ 4 Checking purity

A pure substance melts and boils at sharp, fixed temperatures. **Impurities** 杂质 lower the **melting point** 熔点 and raise the **boiling point** 沸点 — so a thermometer can check purity.

Watch out: match the method to the mixture — **filtration** (insoluble solid from a liquid), **crystallisation** (soluble solid from solution), **distillation** (a liquid from a solution / two liquids). The R_f value is *substance distance* ÷ *solvent distance*, so it is always **less than 1**.

Practice

Try these in order.

12.1 Name the apparatus used to measure a fixed, accurate volume of solution into a flask. [1]

12.2 In a titration, what is the *end-point*? [1]

12.3 Which method would separate an insoluble solid from a liquid? [1]

12.4 In a chromatography run, a spot moves 4 cm while the solvent moves 8 cm. Work out the R_f value. [1]

12.5 How does the melting point change if a substance is impure? [1]

12.6 Challenge. In a chromatogram, substance A moves 3 cm and substance B moves 6 cm while the solvent moves 8 cm. Calculate the R_f of each, and state which travelled further. [3]

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.

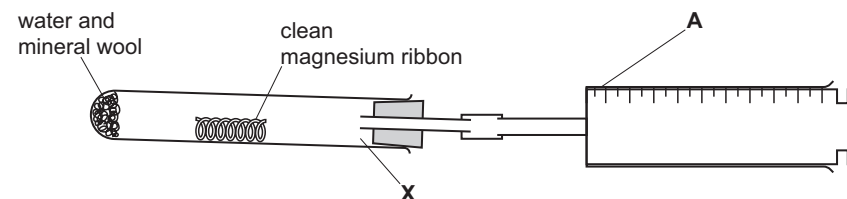


Fig. 1.1

- (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]

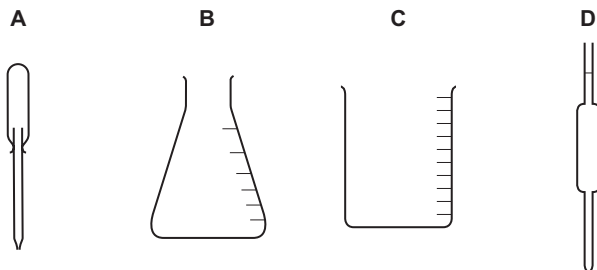
[Total: 7]

39 Which item of apparatus is used to measure 13.7 cm³ of dilute hydrochloric acid?

- A a balance
- B a burette
- C a conical flask
- D a volumetric pipette

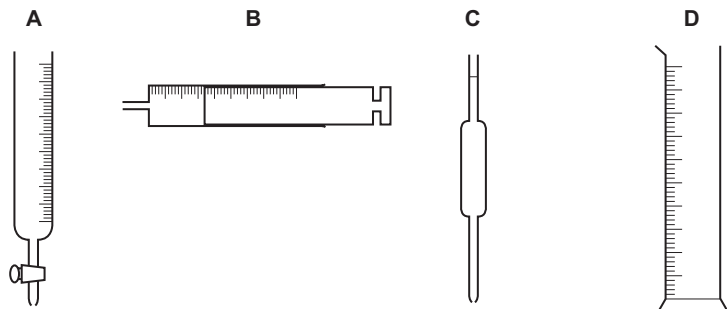
IGCSE Chemistry: s25 21

38 Which item of apparatus is used to measure 25.0 cm³ of aqueous sodium hydroxide?



IGCSE Chemistry: s25 22

38 Which item of apparatus is used to measure exactly 26.3 cm³ of a liquid?



12 Identifying ions and gases – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)
ion	离子	_____
cation	阳离子	_____
anion	阴离子	_____
precipitate	沉淀	_____
hydrogen	氢气	_____
pop	爆鸣声	_____
oxygen	氧气	_____
carbon dioxide	二氧化碳	_____
limewater	石灰水	_____
ammonia	氨气	_____
litmus	石蕊	_____
chlorine	氯气	_____
flame test	焰色试验	_____
lithium	锂	_____
sodium	钠	_____

English	中文	Write it 3 times (English)
potassium	钾	
copper(II)	铜	
sodium hydroxide	氢氧化钠	
iron(II)	铁	
calcium	钙	
carbonate	碳酸盐	
chloride	氯化物	
silver nitrate	硝酸银	

Recall

An **ion** 离子 is a charged particle:

- a **cation** 阳离子 is positive (e.g. Na^+);
- an **anion** 阴离子 is negative (e.g. Cl^-).

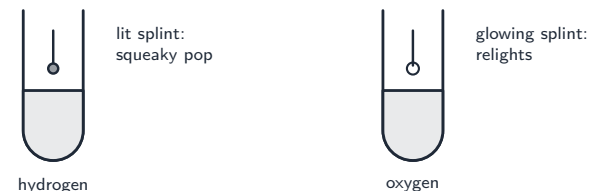
Many tests work by forming a coloured **precipitate** 沉淀 (an insoluble solid).

New ideas

Read these first, then do the Practice.

■ 1 Tests for gases

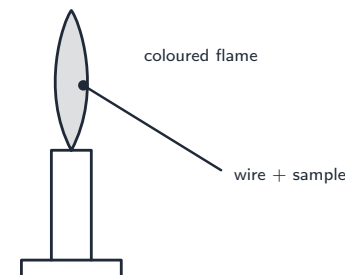
Gas	Test	Result
hydrogen 氢气	a lit splint	squeaky pop 爆鸣声
oxygen 氧气	a glowing splint	it relights
carbon dioxide 二氧化碳	bubble through limewater 石灰水	turns milky
ammonia 氨气	damp red litmus 石蕊 paper	turns blue
chlorine 氯气	damp litmus paper	bleached white



■ 2 Flame tests

A **flame test** 焰色试验 identifies some metal cations by the colour they give a flame:

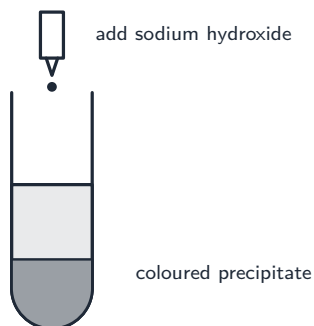
Cation	Flame colour
lithium 锂 (Li^+)	red
sodium 钠 (Na^+)	yellow
potassium 钾 (K^+)	lilac (purple)
copper(II) 铜 (Cu^{2+})	blue-green



■ 3 Tests for cations

Add aqueous **sodium hydroxide** 氢氧化钠 and look at the precipitate that forms:

Cation	Precipitate with sodium hydroxide
copper(II) (Cu^{2+})	light blue
iron(II) 铁 (Fe^{2+})	green
iron(III) (Fe^{3+})	red-brown
calcium 钙 (Ca^{2+})	white



■ 4 Two anion tests

- **carbonate** 碳酸盐: add dilute acid → it fizzes and gives carbon dioxide.
- **chloride** 氯化物: add dilute nitric acid, then **silver nitrate** 硝酸银 → a white precipitate.

Watch out: keep the gas tests apart — hydrogen → a **lit** splint pops; oxygen → a **glowing** splint relights; carbon dioxide → limewater turns **milky**. In a flame test, sodium is **yellow** and potassium is **lilac** — don't confuse them.

Practice

Try these in order.

12.6 Describe the test for hydrogen gas, and its result. [2]

12.7 A compound gives a yellow flame in a flame test. Which metal ion does it contain? [1]

12.8 Sodium hydroxide solution is added to an unknown solution and a red-brown precipitate forms. Name the ion present. [1]

12.9 Describe the test for the chloride ion (Cl^-), and the result. [2]

12.10 How would you show that a gas is carbon dioxide? [1]

12.11 **Challenge.** An unknown solution gives a **green** precipitate with sodium hydroxide, and a **white** precipitate when dilute nitric acid then silver nitrate are added. Name the cation and the anion present. [2]

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

- A $R_f = \frac{\text{distance travelled by solvent}}{\text{distance travelled by substance}}$
- B $R_f = \frac{\text{distance travelled by locating agent}}{\text{distance travelled by substance}}$
- C $R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by locating agent}}$
- D $R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$

The Periodic Table of Elements

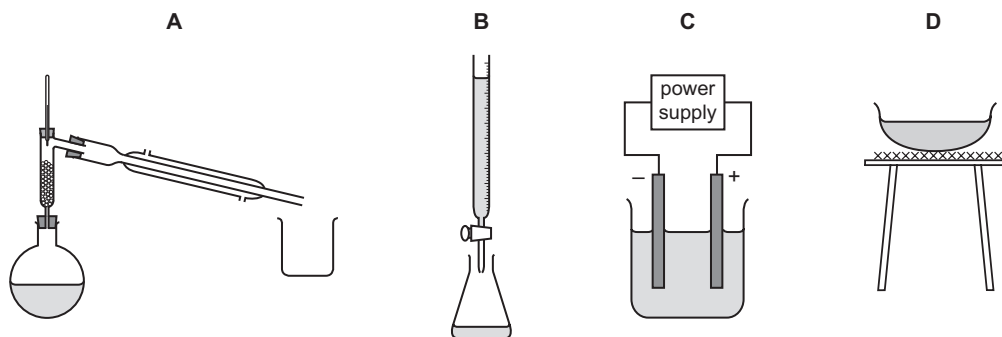
Group																		
I	II	Key										III	IV	V	VI	VII	VIII	
		atomic number atomic symbol name relative atomic mass										1 H hydrogen 1						
3 Li lithium 7	4 Be beryllium 9																	
11 Na sodium 23	12 Mg magnesium 24																	
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 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	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 88	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 dm³ at room temperature and pressure (r.t.p.).

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



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

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+}