Week 3

IGCSE Chemistry

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

2. Atoms, elements and compounds

Starter Quiz · 课前小测

IGCSE Chemistry Name: _____ Score: _____

1. An element is a substance made of:
   - ☐ only one type of atom
   - ☐ two elements bonded together
   - ☐ a mixture of substances
   - ☐ only compounds
2. Which subatomic particle has a positive charge?
   - ☐ proton
   - ☐ neutron
   - ☐ electron
   - ☐ none of them
3. What is the maximum number of electrons in the first (innermost) shell?

   _____
4. Isotopes are atoms of the same element with different numbers of:
   - ☐ neutrons
   - ☐ protons
   - ☐ electrons
   - ☐ shells
5. When a metal atom forms an ion, it:
   - ☐ loses electrons to form a positive ion
   - ☐ gains electrons to form a negative ion
   - ☐ gains protons
   - ☐ loses protons
6. Ionic compounds form a:
   - ☐ giant lattice of oppositely charged ions
   - ☐ small molecule
   - ☐ sea of electrons
   - ☐ single atom

7. An atom has atomic number 6 and mass number 14. How many neutrons does it have?

   _____
8. Chlorine-37 has 17 protons. How many neutrons does it have?

   _____
9. In a compound, the elements are chemically bonded together.

   ☐ True ☐ False
10. The number of electron shells an atom uses equals its period number.

    ☐ True ☐ False

IGCSE Chemistry

1. **only one type of atom**

   Elements contain a single type of atom.

2. **proton**

   Protons are positive; neutrons neutral; electrons negative.

3. **2**

   The first shell holds up to 2 electrons.

4. **neutrons**

   Isotopes differ only in neutron number.

5. **loses electrons to form a positive ion**

   Metals lose electrons, becoming positive.

6. **giant lattice of oppositely charged ions**

   A giant 3D lattice of ions forms.

7. **8**

   Neutrons = mass number − atomic number = 14 − 6 = 8.

8. **20**

   Neutrons = mass number − protons = 37 − 17 = 20.

9. **True**

   This is what distinguishes a compound from a mixture.

10. **True**

    Period = number of occupied shells.

IGCSE CHEMISTRY • EXERCISE SHEET

2.1 Elements, compounds and mixtures

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

KEY WORDS compound 化合物 • mixture 混合物 • element 元素 • atom 原子 • ion 离子

Objective

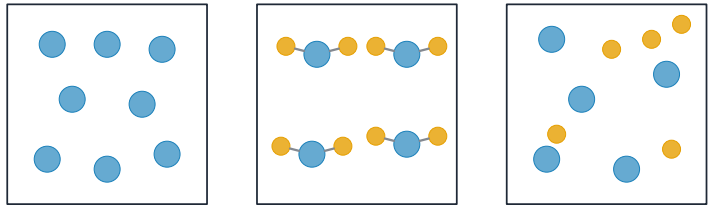
Build the skills to answer exam questions on **elements, compounds and mixtures** 元素、化合物与混合物 — telling them apart and explaining the key difference.

You must be able to:

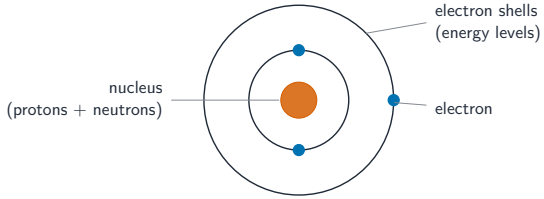
- define element, compound and mixture
- recognise each from a particle diagram
- explain that a compound is bonded (chemical separation) but a mixture is not

1 Worked examples

Three types of substance



Element = one type of atom; compound = different atoms bonded in a fixed ratio; mixture = not bonded



lithium, Li: 3 protons, 4 neutrons
electron configuration 2,1

Atoms are the building blocks of elements and compounds

- **element:** one type of atom (e.g. copper).
- **compound:** elements chemically bonded in a fixed ratio (e.g. water); different properties from its elements.
- **mixture:** not bonded; separated by physical methods (e.g. air).

2 Practice

2.1 Define a compound. [1]

2.2 State how a mixture can be separated. [1]

3 Exam-style questions

3.1 Which is a compound? [1]

- **A** oxygen, O_2
- **B** water, H_2O
- **C** air
- **D** copper

3.2 A particle diagram shows two different atoms always joined together in pairs.

(a) State whether this represents an element, a compound or a mixture. [1]

(b) Explain your answer. [2]

3.3 State the main difference between a compound and a mixture of the same elements. [2]

3.4 Four substances are examined: **W** is made of one kind of atom only; **X** contains two kinds of atom chemically joined in a fixed ratio; **Y** contains two kinds of atom that can be separated by filtering; **Z** is a shiny grey solid that conducts electricity and cannot be broken down.

(a) Classify **W**, **X**, **Y** and **Z** as element, compound or mixture, giving a reason for each. [4]

(b) Explain the difference between a compound and a mixture in terms of how the substances are joined and how they can be separated. [4]

(c) Iron filings and sulfur powder are mixed, then heated strongly to form iron sulfide. Describe how you could show that a chemical change has taken place. [3]

(d) Name a method that would separate the iron from the **mixture** but not from the **compound**, and explain why. [2]

Solutions

2.1 two or more elements chemically joined (bonded) together in a fixed ratio.

2.2 by physical methods (e.g. filtering, distillation).

3.1 B. Water is two elements chemically bonded — a compound.

3.2 (a) a compound.
(b) two different atoms are present, chemically bonded together in a fixed ratio.

3.3 in a compound the elements are chemically bonded and need a chemical reaction to separate; in a mixture they are not bonded and are easily separated by physical means.

3.4 (a) **W** element — only one type of atom. **X** compound — different atoms chemically bonded in a fixed ratio. **Y** mixture — the parts are not chemically joined, so a physical method separates them. **Z** element — it cannot be broken down into anything simpler.
(b) In a compound the atoms are held by **chemical bonds** and are present in a fixed ratio; in a mixture the substances are simply mixed and can be in any proportion. A compound can only be separated by a chemical reaction; a mixture can be separated by physical means such as filtering, distilling or using a magnet.
(c) The mixture is grey with yellow specks and the product is a single black solid, so the appearance changes; heat is given out once the reaction starts and it continues without further heating; the product has different properties from both starting materials, and the change cannot be reversed easily.
(d) A **magnet**. In the mixture the iron is still iron, so it is still attracted; in iron sulfide the iron atoms are chemically bonded to sulfur, so the compound has its own properties and is not magnetic.

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

1 A list of substances is shown.

bauxite **calcium oxide** **ethanol** **graphite** **methane**

nitrogen **oxygen** **propane** **propene** **sulfur dioxide**

Answer the questions using the list of substances.

Each substance may be used once, more than once, or not at all.

State which of the substances:

(a) is a basic oxide

..... [1]

(b) contains carbon atoms only

..... [1]

(c) is manufactured by fermentation

..... [1]

(d) is produced by the decomposition of vegetation

..... [1]

(e) contains aluminium oxide

..... [1]

(f) causes acid rain

..... [1]

(g) is a simple molecule with 11 atoms

..... [1]

(h) is produced when limestone thermally decomposes in the blast furnace

..... [1]

(i) is a gas that is approximately 21% of clean, dry air

..... [1]

(j) is a monomer in addition polymerisation.

..... [1]

[Total: 10]

IGCSE CHEMISTRY • EXERCISE SHEET

2.2 Atomic structure and the Periodic Table

Name: _____ Class: _____ Date: _____ **Total: 30 marks**

KEY WORDS electron 电子 • proton 质子 • neutron 中子 • charge 电荷 • electronic configuration 电子排布

Objective

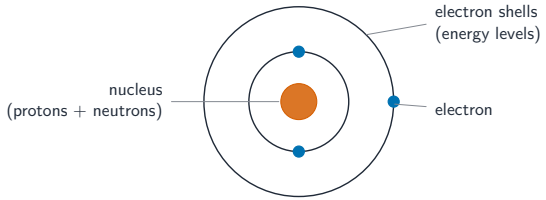
Build the skills to answer exam questions on **atomic structure and the Periodic Table** 原子结构与周期表 — sub-atomic particles, **proton/mass number** 质子数/质量数, and **electronic configuration** 电子排布.

You must be able to:

- give the relative mass and charge of protons, neutrons, electrons
- find protons, neutrons and electrons from proton and mass numbers
- write electronic configurations and link them to Group and Period

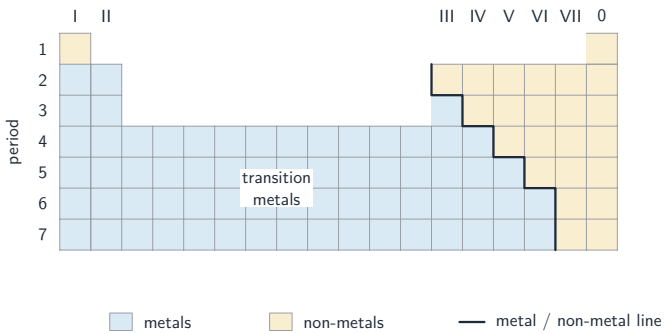
1 Worked examples

Configuration and the Periodic Table



lithium, Li: 3 protons, 4 neutrons
electron configuration 2,1

Electrons fill shells from the inside: 2, then 8, then 8 (first 20 elements)



Electron arrangement explains an element place in the Periodic Table

- **proton +1, neutron 0, electron −1**; neutrons = mass number − proton number.
- **Group** = outer-shell electrons; **Period** = number of shells.
- e.g. sodium $2, 8, 1 \rightarrow$ Group I, Period 3.

Reading an atom, and reading the Periodic Table from it

Particle	Relative mass	Relative charge	Where
proton 质子	1	+1	nucleus
neutron 中子	1	0	nucleus
electron 电子	$\frac{1}{1840}$ (negligible)	−1	shells around the nucleus

Proton number (atomic number) is the number of protons and defines the element. **Nucleon number** (mass number) is protons + neutrons, so **neutrons = nucleon number − proton number**. In a neutral atom, electrons = protons; in an **ion**, subtract the charge: an Al^{3+} ion has 13 protons but 10 electrons.

Filling the shells (first 20 elements): 2, then 8, then 8. Calcium, proton number 20, is $2, 8, 8, 2$.

The configuration tells you the position, and that is the marked step:

- **Group number = number of outer-shell electrons.** $2, 8, 7$ has 7 outer electrons $\rightarrow$ **Group VII**.
- **Period number = number of occupied shells.** $2, 8, 7$ has 3 shells $\rightarrow$ **Period 3**.

So $2, 8, 7$ is chlorine. Reading it the other way is equally examinable: an element in Group II, Period 4 has 2 outer electrons and 4 shells, so $2, 8, 8, 2$ — calcium.

Isotopes 同位素 are atoms of the same element with the **same proton number but different numbers of neutrons**. They have identical chemical properties, because

chemistry depends on the electrons and isotopes have the same electron arrangement; only physical properties that depend on mass, such as density, differ.

Worked example. An atom is written $^{37}_{17}\mathrm{Cl}$. Give its numbers of protons, neutrons and electrons, its electronic configuration, and its group and period.

1. Protons = 17 (the lower number); electrons = 17 (neutral atom).
2. Neutrons = $37 - 17 = 20$.
3. Configuration: $2, 8, 7$.
4. Seven outer electrons → Group VII; three shells → Period 3.

2 Practice

2.1 State the relative charge of a neutron. [1]

2.2 Write the electronic configuration of calcium (proton number 20). [1]

2.3 An ion is $^{27}_{13}\mathrm{Al}^{3+}$. State its numbers of protons, neutrons and electrons, and explain why the last two numbers are not equal. [4]

2.4 Deduce the group and period of an element with configuration $2, 8, 3$. [2]

2.5 Explain why two isotopes of the same element have identical chemical properties. [2]

3 Exam-style questions

3.1 An atom has the configuration $2, 8, 7$. It is in: [1]

- **A** Group II, Period 7
- **B** Group VII, Period 3
- **C** Group VII, Period 2
- **D** Group III, Period 7

3.2 An atom of aluminium has proton number 13 and mass number 27.

(a) State the number of protons, neutrons and electrons. [3]

(b) Write its electronic configuration. [1]

3.3 Explain why an atom has no overall electric charge. [2]

3.4 The table shows information about four particles.

Particle	Proton number	Nucleon number	Charge
W	11	23	0
X	11	24	0
Y	17	35	1−
Z	12	24	2+

(a) Complete a table of the number of protons, neutrons and electrons in each particle. [4]

(b) State which two particles are isotopes of each other, and explain your answer. [2]

(c) Give the electronic configuration of particle W, and deduce its group and period. [3]

(d) Explain why particle Z has a charge of 2+. [2]

(e) Explain why W and X have identical chemical properties despite their different masses. [2]

Solutions

2.1 0 (neutral).

2.2 $2, 8, 8, 2$.

2.3 13 protons — the proton number never changes; $27 - 13 = 14$ neutrons; $13 - 3 = 10$ electrons; the 3+ charge means the atom has **lost** three electrons, so it now has three fewer electrons than protons.

2.4 Three outer-shell electrons → Group III; three occupied shells → Period 3.

2.5 Chemical properties depend on the arrangement of electrons; isotopes have the same proton number and therefore the same number and arrangement of electrons.

3.1 B. Outer shell 7 → Group VII; three shells → Period 3.

3.2 (a) protons = 13; neutrons = $27 - 13 = 14$; electrons = 13.
(b) $2, 8, 3$.

3.3 it has equal numbers of protons (+1) and electrons (−1); so the positive and negative charges cancel.

3.4 (a) W: 11 protons, 12 neutrons, 11 electrons. X: 11 protons, 13 neutrons, 11 electrons. Y: 17 protons, 18 neutrons, 18 electrons. Z: 12 protons, 12 neutrons, 10 electrons.
(b) W and X; they have the same proton number, 11, but different nucleon numbers and so different numbers of neutrons.
(c) $2, 8, 1$; one outer-shell electron → Group I; three occupied shells → Period 3.
(d) Z is a magnesium atom that has lost two electrons; it now has 12 protons but only 10 electrons, so there are two more positive charges than negative.
(e) Chemical properties are determined by the outer-shell electrons; W and X have the same electronic configuration, $2, 8, 1$, and differ only in neutrons, which take no part in bonding.

3 The table shows information about four different particles.

particle	nucleon number	number of protons	number of neutrons	number of electrons
Na	23	11	W	11
Na^+	23	11	12	X
O	16	8	Y	8
O^{2-}	16	8	8	Z

What are the values of W, X, Y and Z?

	W	X	Y	Z
A	11	10	10	8
B	11	11	8	10
C	12	10	8	10
D	12	11	10	8

5 Symbols representing four particles are shown.

$^{40}_{20}W$ $^{41}_{20}X^{2+}$ $^{37}_{18}Y$ $^{37}_{17}Z$

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.

1 Protons, neutrons and electrons are particles found in atoms.

(a) Complete Table 1.1 to show the relative mass and relative charge of a proton, a neutron and an electron.

Table 1.1

particle	relative mass	relative charge
proton		+1
neutron		
electron	$\frac{1}{1840}$	

[2]

(b) Some elements have many isotopes.

(i) Define the term isotopes.

.....

.....

..... [2]

(ii) Explain why all isotopes of the same element have the same chemical properties.

.....

..... [1]

(c) Complete Table 1.2.

Table 1.2

atom or ion	number of protons	number of neutrons	number of electrons
$^{40}_{18}Ar$	18		18
$^{32}_{16}S^{2-}$		16	
	22	28	20

[5]

(d) The term mass number is defined as the total number of protons and neutrons in the nucleus of an atom.

State the name of **one other** term which is defined as the total number of protons and neutrons in the nucleus of an atom.

..... [1]

(e) Calculate the number of atoms in 2.00 g of argon.

Give your answer in standard form.

number of atoms = ... [2]

[Total: 13]

3 Which row gives the number of protons, electrons and neutrons in an atom of zinc?

	protons	electrons	neutrons
A	30	30	35
B	30	35	35
C	35	30	30
D	35	35	30

4 Which particles have the electronic configuration 2,8,8?

1 an argon atom, Ar

2 an aluminium ion, Al^{3+}

3 a sodium ion, Na^{+}

4 a chloride ion, Cl^{-}

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

2 Atoms are made of electrons, neutrons and protons.

(a) Complete Table 2.1.

Table 2.1

particle	relative charge	relative mass
electron		$\frac{1}{1840}$
neutron	0	
proton		

[2]

(b) Atoms of the same element are known as isotopes.

$^{39}_{19}K$ and $^{41}_{19}K$ are isotopes of potassium.

(i) Complete Table 2.2 to show the number of electrons, neutrons and protons in one atom or ion of these isotopes.

Table 2.2

isotope	electrons	neutrons	protons
$^{39}_{19}K$			
$^{41}_{19}K^+$			

[3]

(ii) Table 2.3 shows the relative masses and the percentage abundances of the two isotopes in a sample of potassium.

Table 2.3

relative mass of isotope	percentage abundance of isotope
39	90
41	10

Calculate the relative atomic mass of this sample of potassium to **one** decimal place.

relative atomic mass = [2]

(iii) An isotope of aluminium has a nucleon number of 27.

Aluminium has a relative atomic mass of 27.

State what conclusion can be made from this information.

.....

..... [1]

(c) A calcium atom has the electronic configuration of 2,8,8,2.

Give the formula of one atom and one negative ion that has the same electronic configuration as Ca^{2+}.

- atom .....
- negative ion .....

[2]

[Total: 10]

4 Sulfur atoms can form the negative ion S^{2-}.

Three other atoms or ions are listed.

- argon, Ar
- calcium, Ca
- oxide, O^{2-}

How many of these atoms or ions have the same electronic configuration as S^{2-}?

A 0 **B** 1 **C** 2 **D** 3

IGCSE CHEMISTRY • EXERCISE SHEET

2.3 Isotopes

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

KEY WORDS isotopes 同位素 • relative atomic mass 相对原子质量 • abundance 丰度 • electronic configuration 电子排布 • atom 原子

Objective

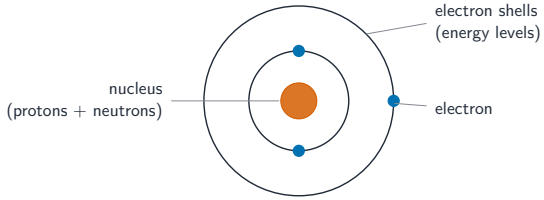
Build the skills to answer exam questions on **isotopes** 同位素 — what they are, why they share chemical properties, and calculating **relative atomic mass** 相对原子质量.

You must be able to:

- define isotopes (same protons, different neutrons)
- explain why isotopes have the same chemical properties
- calculate A_r from isotope masses and abundances

1 Worked examples

Relative atomic mass



lithium, Li: 3 protons, 4 neutrons
electron configuration 2,1

Isotopes have the same protons (same element) but different numbers of neutrons

$$A_r = \frac{\sum(\text{isotope mass} \times \text{abundance})}{100}$$

Chlorine, 75% ^{35}Cl, 25% ^{37}Cl: $A_r = \dfrac{(35 \times 75) + (37 \times 25)}{100} = 35.5.$

2 Practice

2.1 Define isotopes. [1]

2.2 State why isotopes of an element have the same chemical properties. [1]

3 Exam-style questions

3.1 Two isotopes of an element differ in their number of: [1]

- **A** protons
- **B** electrons
- **C** neutrons
- **D** protons and electrons

3.2 Boron has two isotopes: ^{10}B (20%) and ^{11}B (80%).

(a) Calculate the relative atomic mass of boron. [3]

(b) State the number of neutrons in an atom of ^{11}B (proton number 5). [1]

3.3 Explain, in terms of electrons, why isotopes react in the same way. [2]

Solutions

2.1 atoms of the same element with the same number of protons but different numbers of neutrons.

2.2 they have the same number of electrons / the same electronic configuration.

3.1 C. Isotopes differ in the number of neutrons.

3.2 (a) $A_r = \frac{(10 \times 20) + (11 \times 80)}{100} = \frac{200 + 880}{100}; = 10.8.$
(b) $11 - 5 = 6$ neutrons.

3.3 chemical reactions only involve the electrons; isotopes have the same number of electrons / configuration, so they react identically.

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6 Which two values are used to calculate the relative atomic mass of a sample of boron?

	value 1	value 2
A	the total number of boron isotopes	the total number of boron atoms
B	the relative abundance of each boron isotope in the sample	the relative mass of each boron isotope
C	the relative abundance of each boron isotope in the sample	the total number of boron atoms
D	the total number of boron isotopes	the relative mass of each boron isotope

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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

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5 A sample of element Q has two isotopes.

Their relative masses and abundances are shown.

relative mass of isotope	abundance / %
238	66
244	34

What is the relative atomic mass of this sample of Q to three significant figures?

A 240 **B** 241 **C** 242 **D** 243

2 Atoms are made of electrons, neutrons and protons.

(a) State which of these particles are found in the nucleus of an atom.

..... [1]

(b) Atoms of the same element are known as isotopes.

$^{32}_{16}S$ and $^{34}_{16}S$ are isotopes of sulfur.

(i) Complete Table 2.1 to show the number of electrons, neutrons and protons in one atom or ion of these isotopes.

Table 2.1

isotope	electrons	neutrons	protons
$^{34}_{16}S$			
$^{32}_{16}S^{2-}$			

[3]

(ii) Table 2.2 shows the relative masses and the percentage abundances of the two isotopes in a sample of sulfur.

Table 2.2

relative mass of isotope	percentage abundance of isotope
32	95
34	5

Calculate the relative atomic mass of this sample of sulfur to **one** decimal place.

relative atomic mass = ... [2]

(iii) The relative atomic masses of all elements are compared to one atom of an isotope.

Identify this isotope.

..... [1]

(c) Ions are atoms or groups of atoms that have gained or lost one or more electrons.

An oxygen atom has the electronic configuration of 2,6.

Give the formula of **one** atom and **one** positive ion that has the same electronic configuration as O^{2-}.

- atom .....
- positive ion .....

[2]

[Total: 9]

5 Element T has two isotopes, $^{12}_{6}T$ and $^{14}_{6}T$.

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.

6 Lithium is in Group I of the Periodic Table. Nitrogen is in Group V of the Periodic Table.

Lithium reacts with nitrogen to form the ionic compound lithium nitride, Li_3N.

What happens to the electrons when lithium atoms and nitrogen atoms form ions?

	lithium	nitrogen
A	each lithium atom loses one electron to form an Li^+ ion	each nitrogen atom gains three electrons to form an N^{3-} ion
B	each lithium atom loses one electron to form an Li^+ ion	each nitrogen atom gains five electrons to form an N^{5-} ion
C	each lithium atom gains one electron to form an Li^- ion	each nitrogen atom loses three electrons to form an N^{3+} ion
D	each lithium atom gains one electron to form an Li^- ion	each nitrogen atom loses five electrons to form an N^{5+} ion

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2.4 Ions and ionic bonds

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS cation 阳离子 • ionic compound 离子化合物 • molten 熔融 • melting point 熔点 • metal 金属

Objective

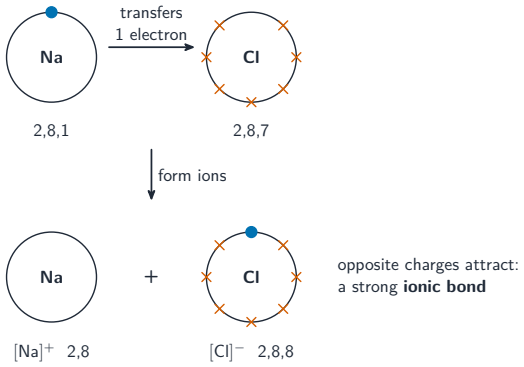
Build the skills to answer exam questions on **ions and ionic bonds** 离子与离子键 — ion formation, the **ionic bond** 离子键, the giant **lattice** 晶格, and the properties of ionic compounds.

You must be able to:

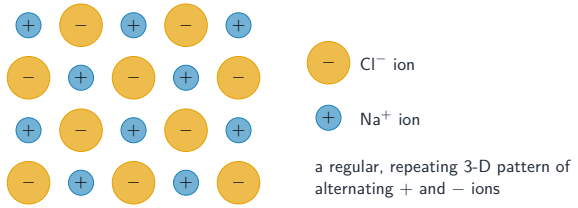
- explain how metals/non-metals form ions (to gain a full outer shell)
- describe ionic bonding (electron transfer; electrostatic attraction)
- explain the properties of ionic compounds from their structure

1 Worked examples

■ Ionic bonding and lattice



A metal gives electron(s) to a non-metal; both reach full outer shells and the opposite charges attract



Ions pack into a giant lattice of alternating + and − ions

- **ionic compounds:** high melting point; conduct only when molten/aqueous (ions free to move).

2 Practice

2.1 State the charge on an ion formed when a metal atom loses electrons. [1]

2.2 Define an ionic bond. [1]

3 Exam-style questions

3.1 Ionic compounds conduct electricity when: [1]

- **A** solid
- **B** molten or in solution
- **C** never
- **D** only as a gas

3.2 Sodium $(2, 8, 1)$ reacts with chlorine $(2, 8, 7)$ to form sodium chloride.

(a) Describe what happens to the electrons, and give the charges of the two ions. [3]

(b) Explain why sodium chloride has a high melting point. [2]

3.3 Explain why solid sodium chloride does not conduct electricity but molten sodium chloride does. [2]

Solutions

2.1 a positive charge (a cation).

2.2 the strong electrostatic attraction between oppositely charged ions.

3.1 B. Ionic compounds conduct when molten or in solution.

3.2 (a) sodium gives its one outer electron to chlorine; sodium becomes Na^+ and chlorine becomes Cl^-; both then have full outer shells.
(b) there is strong electrostatic attraction between the oppositely charged ions in the lattice; a lot of energy is needed to break it.

3.3 in the solid the ions are fixed in place and cannot move; when molten the ions are free to move and carry charge.

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.

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

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.

2 Table 2.1 shows the melting points, boiling points and electrical conductivities of seven substances, **A**, **B**, **C**, **D**, **E**, **F** and **G**.

Table 2.1

substance	melting point / °C	boiling point / °C	electrical conductivity when solid	electrical conductivity when molten
A	1600	2230	poor	poor
B	–219	–183	poor	poor
C	770	1420	poor	good
D	–39	357	good	good
E	–7	58	poor	poor
F	44	280	poor	poor
G	1085	2562	good	good

(a) Identify which substance, **A**, **B**, **C**, **D**, **E**, **F** or **G**, is:

(i) a gas at 25 °C

..... [1]

(ii) a solid consisting of simple molecules at 25 °C

..... [1]

(iii) a metal which is liquid at 25 °C.

..... [1]

(b) (i) Identify which substance, **A**, **B**, **C**, **D**, **E**, **F** or **G**, has a giant covalent structure.

Use the information in Table 2.1 to give **two** reasons for your choice.

substance .....

reason 1 .....

reason 2 .....

[3]

(ii) Identify which substance, **A**, **B**, **C**, **D**, **E**, **F** or **G**, is an ionic compound.

Use the information in Table 2.1 to give **one** reason for your choice.

substance .....

reason .....

[2]

[Total: 8]

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.

2 This question is about ionic compounds.

(a) State what is meant by the term ionic bond.

.....

..... [2]

(b) Potassium sulfide, K_2S, is an ionic compound.

Complete the dot-and-cross diagram in Fig. 2.1 of the ions in potassium sulfide.

Show the charges on the ions.

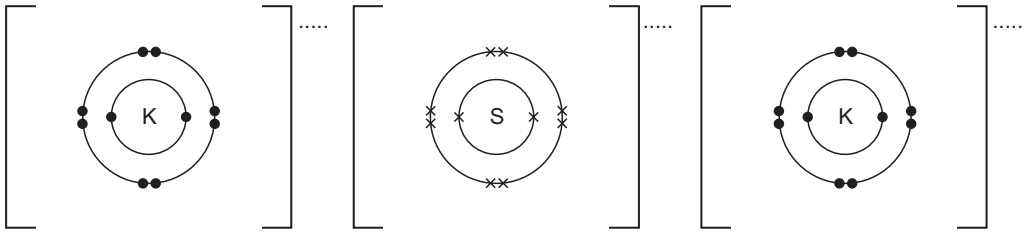


Fig. 2.1

[3]

(c) Ionic compounds form giant ionic lattices.

(i) Fig. 2.2 shows part of the giant ionic lattice structure of sodium chloride.

Complete the diagram in Fig. 2.2 to show the ions present. Use '+' for sodium ions and '–' for chloride ions. One chloride ion has been completed for you.

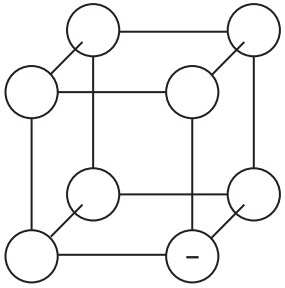


Fig. 2.2

[2]

(ii) State the name given to any positive ion.

..... [1]

(d) Ionic compounds can be decomposed by the passage of an electric current using inert electrodes.

(i) State the name of this process.

..... [1]

(ii) Write the ionic half-equation for the reaction which takes place at the anode when **molten** potassium bromide, KBr, is decomposed by the passage of an electric current.

..... [2]

(iii) Name the products and state the observations at the negative and positive electrodes when **dilute aqueous** potassium bromide, KBr, is decomposed by the passage of an electric current.

product at the negative electrode

.....

observations at the negative electrode

.....

products at the positive electrode

..... and .....

observations at the positive electrode

.....

[5]

IGCSE CHEMISTRY • EXERCISE SHEET

2.5 Simple molecules and covalent bonds

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

KEY WORDS covalent bond 共价键 • intermolecular forces 分子间作用力 • ion 离子 • electrons 电子 • atom 原子

Objective

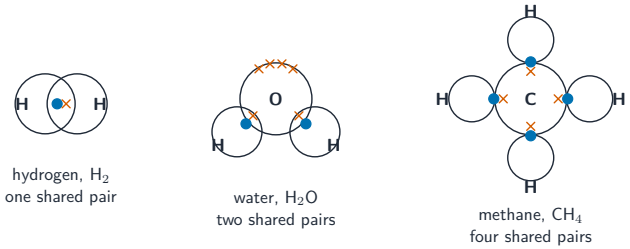
Build the skills to answer exam questions on **simple molecules and covalent bonds** 简单分子与共价键 — sharing electrons, dot-and-cross diagrams, and the properties of simple molecular substances.

You must be able to:

- describe a covalent bond (a shared pair of electrons between non-metals)
- draw/interpret dot-and-cross diagrams (H_2, H_2O, CH_4, etc.)
- explain why simple molecular substances have low melting points and don't conduct

1 Worked examples

■ Covalent bonding



Atoms share pairs of electrons so each reaches a full outer shell

- **covalent bond:** a shared pair of electrons (between non-metals).
- **low melting point:** weak intermolecular forces between molecules (the bonds inside are strong).
- **poor conductor:** no free electrons or ions to carry charge.

2 Practice

2.1 Define a covalent bond. [1]

2.2 State how many shared pairs of electrons there are in a molecule of methane, CH_4. [1]

3 Exam-style questions

3.1 Simple molecular substances have low melting points because: [1]

- **A** the covalent bonds are weak
- **B** the forces between molecules are weak
- **C** they contain ions
- **D** they have delocalised electrons

3.2 Water, H_2O, is a simple molecule.

(a) Describe how the bonds in a water molecule form. [2]

(b) Explain why water does not conduct electricity (when pure). [2]

3.3 Explain why chlorine, Cl_2, has a low boiling point. [2]

Solutions

2.1 a shared pair of electrons between two (non-metal) atoms.

2.2 four shared pairs.

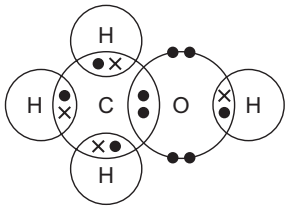
3.1 B. The forces between molecules (intermolecular forces) are weak.

3.2 (a) the oxygen atom shares one pair of electrons with each of the two hydrogen atoms; so each atom reaches a full outer shell.
(b) the molecules have no overall charge and there are no free electrons or ions; so there is nothing to carry the charge.

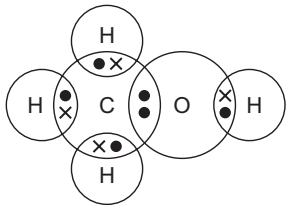
3.3 chlorine is made of simple molecules with weak intermolecular forces; little energy is needed to separate them, so the boiling point is low.

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

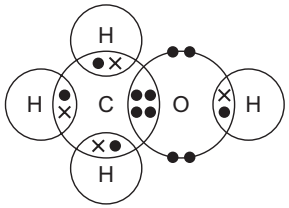
A



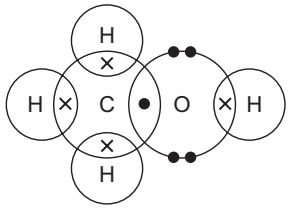
B



C



D



4 This question is about chlorine and compounds of chlorine.

(a) Gaseous chlorine reacts with gaseous phosphorus(III) chloride to form gaseous phosphorus(V) chloride. The reaction is a reversible reaction.

When the three gases are in a closed container the system reaches equilibrium.

$$Cl_2(g) + PCl_3(g) \rightleftharpoons PCl_5(g)$$

(i) Describe a reversible reaction at equilibrium in terms of:

- the rate of the forward reaction and the rate of the reverse reaction

.....

- the concentrations of reactants and products.

.....

[2]

(ii) Complete Table 4.1 using only the words **increases**, **decreases** or **no change**.

Table 4.1

change to condition	effect on the rate of the forward reaction	effect on the equilibrium concentration of PCl_5
the pressure is decreased		
a catalyst is added	increases	

[3]

(iii) When the temperature of the equilibrium mixture is increased, the equilibrium concentration of PCl_5 decreases.

State what conclusion about the forward reaction can be made from this information.

..... [1]

(b) Ethene, C_2H_4, reacts with chlorine, Cl_2, to form 1,2-dichloroethane, CH_2ClCH_2Cl.

The equation for this reaction can be represented as shown.

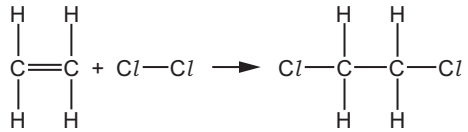


Table 4.2 shows some bond energies.

Table 4.2

bond	bond energy in kJ / mol
C–C	350
C=C	610
C–H	410
Cl–Cl	240
C–Cl	340

Use the bond energies in Table 4.2 to calculate the enthalpy change, in kJ / mol, of the reaction.

Use the following steps.

- Calculate the total energy needed to break the bonds in C_2H_4 and Cl_2.

..... kJ

- Calculate the total energy released when the bonds form in CH_2ClCH_2Cl.

..... kJ

- Calculate the enthalpy change of the reaction.
  Your answer should include a sign.

..... kJ / mol
[3]

(c) Chlorine reacts with nitrogen to form nitrogen trichloride, NCl_3.

Complete the dot-and-cross diagram in Fig. 4.1 of a molecule of NCl_3.

Show outer shell electrons only.

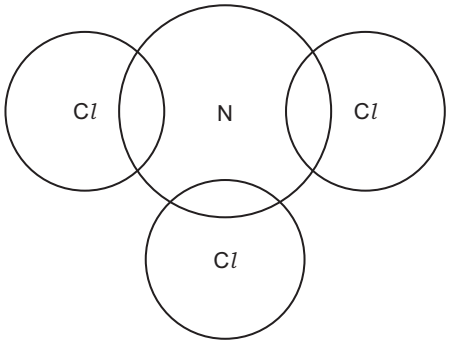


Fig. 4.1

[3]

(d) When solid magnesium carbonate, $MgCO_3$, is added to dilute hydrochloric acid, HCl, a chemical reaction occurs. The equation for the reaction is shown.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$$

(i) Give **two** observations when solid magnesium carbonate is added to dilute hydrochloric acid.

1 .....

2 .....
[2]

(ii) Calculate the volume, in cm^3, of $CO_2(g)$ that is produced at room temperature and pressure (r.t.p.) when 50.0 cm^3 of 0.100 mol / dm^3 HCl reacts with excess $MgCO_3$.

The volume of 1 mol of any gas is 24 000 cm^3 at r.t.p.

Use the following steps.

- Calculate the number of moles of HCl in 50.0 cm^3 of 0.100 mol / dm^3 HCl.

..... mol

- Deduce the number of moles of $CO_2(g)$ produced.

..... mol

- Calculate the volume, in cm^3, of $CO_2(g)$ produced at r.t.p.

..... cm^3
[3]

[Total: 17]

4 This question is about nitrogen and its compounds.

Nitrogen contains molecules with the formula N_2.

(a) Complete the dot-and-cross diagram in Fig. 4.1 to show the electronic configuration in a nitrogen molecule. Show outer-shell electrons only.

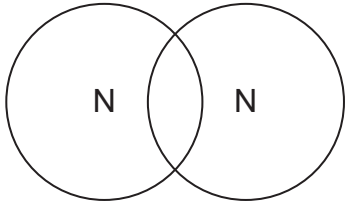


Fig. 4.1

[2]

(b) Ammonia, NH_3, is manufactured by reacting nitrogen with hydrogen, H_2, in the Haber process.

(i) State **three** typical conditions for the reaction between nitrogen and hydrogen in the Haber process.

1 .....

2 .....

3 .....

[3]

(ii) Write the symbol equation for the chemical reaction in the Haber process.

..... [1]

(c) Ammonia is converted into nitric acid in a two-step process.

In step 1, ammonia and oxygen are passed over a catalyst.

(i) Balance the symbol equation for this reaction.

$$4NH_3 + ...O_2 \rightleftharpoons .....NO + ...H_2O$$

[1]

(ii) Give the oxidation number of nitrogen in:

- NH_3 .....
- NO. .....

[2]

(iii) Define oxidation in terms of oxidation number.

..... [1]

(iv) In step 2, oxygen and water react with NO to produce nitric acid as the only product.

Write a symbol equation for this chemical reaction.

..... [2]

(d) Ammonia is converted into ammonium sulfate, $(NH_4)_2SO_4$.

$$2NH_3(g) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(s)$$

360 dm^3 of ammonia gas, measured at r.t.p., reacts with excess sulfuric acid.

Calculate the mass of ammonium sulfate produced, using the following steps.

- Calculate the number of moles of $NH_3(g)$ in 360 dm^3.

  One mole of any gas occupies 24 dm^3 at r.t.p.

  ..... mol

- Calculate the number of moles of $(NH_4)_2SO_4$ produced.

  ..... mol

- Calculate the mass of $(NH_4)_2SO_4$ produced.

  The M_r of $(NH_4)_2SO_4$ is 132.

  ..... g

[3]

[Total: 15]

2 This question is about covalent compounds.

(a) State what is meant by a covalent bond.

.....

..... [2]

(b) Chlorine(I) oxide, Cl_2O, is a simple molecule with covalent bonds.

(i) State what is meant by (I) in the name chlorine(I) oxide.

..... [2]

(ii) Complete the dot-and-cross diagram in Fig. 2.1 of a molecule of chlorine(I) oxide.

Show outer electrons only.

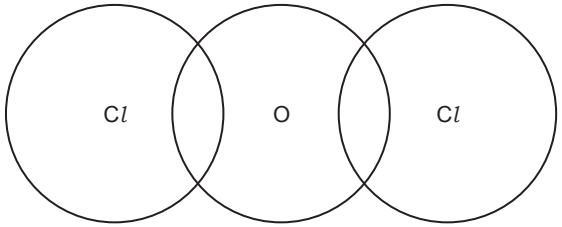


Fig. 2.1

[3]

(iii) Explain, in terms of structure and bonding, why Cl_2O boils at a low temperature and does **not** thermally decompose into its constituent elements, Cl_2 and O_2.

.....

.....

.....

..... [3]

(iv) Give **two** reasons why liquid Cl_2O is a poor conductor of electricity.

1 .....

2 .....

[2]

(c) Carbon and silicon(IV) oxide both exist as giant covalent structures.

(i) Name a giant covalent structure of carbon which conducts electricity.

..... [1]

(ii) Identify the particles responsible for the conduction of electricity in this covalent structure of carbon.

..... [1]

(iii) Silicon(IV) oxide contains silicon atoms, Si, and oxygen atoms, O.

Fig. 2.2 shows part of the giant covalent structure of silicon(IV) oxide.

Complete the diagram in Fig. 2.2 by adding the symbol for each of the 9 atoms shown.

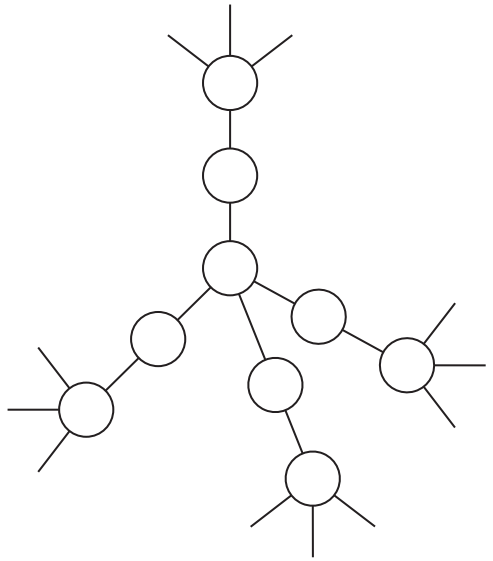


Fig. 2.2

[2]

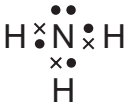
[Total: 16]

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

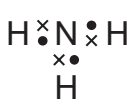
A

B

C



D



IGCSE CHEMISTRY • EXERCISE SHEET

2.6 Giant covalent structures

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

KEY WORDS silicon(iv) oxide 二氧化硅 • graphite 石墨 • giant covalent structure 巨型共价结构 • diamond 金刚石 • lubricant 润滑剂

Objective

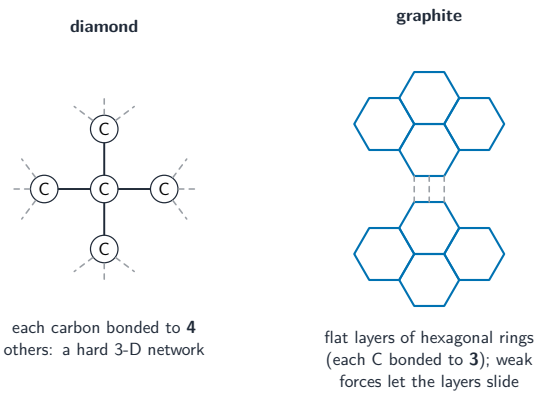
Build the skills to answer exam questions on **giant covalent structures** 巨型共价结构 — **diamond** 金刚石, **graphite** 石墨 and silicon(IV) oxide, and how structure explains their properties.

You must be able to:

- describe the bonding in diamond and graphite
- link structure to properties (hardness, conductivity, lubrication)
- describe silicon(IV) oxide as a giant covalent structure

1 Worked examples

Diamond vs graphite



Diamond: each C bonded to 4 others (hard). Graphite: flat layers with weak forces between (slippery)

- **diamond:** rigid 3-D network → very hard → cutting tools.

- **graphite:** layers slide (lubricant); one free electron per C → conducts (electrodes).
- **SiO_2:** giant covalent like diamond → very hard, very high melting point.

2 Practice

2.1 State how many carbon atoms each carbon is bonded to in diamond. [1]

2.2 State one use of graphite. [1]

3 Exam-style questions

3.1 Graphite conducts electricity because: [1]

- **A** it contains ions
- **B** each carbon has a free (delocalised) electron
- **C** the layers are strongly bonded
- **D** it is a metal

3.2 Diamond and graphite are both forms of carbon.

(a) Explain why diamond is very hard. [2]

(b) Explain why graphite is a good lubricant. [2]

3.3 Explain why both diamond and graphite have very high melting points. [2]

Solutions

2.1 four.

2.2 as a lubricant (or as an electrode).

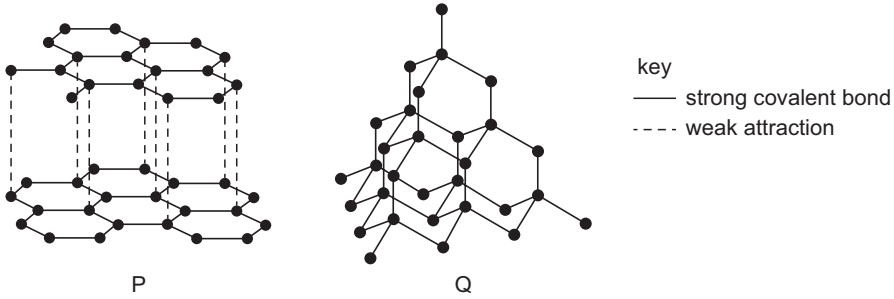
3.1 B. Each carbon has one free (delocalised) electron that can move.

3.2 (a) each carbon is bonded to four others by strong covalent bonds; forming a rigid 3-D network, so it is very hard.
(b) graphite has layers held by weak forces; the layers can slide over each other.

3.3 they are giant covalent structures with many strong covalent bonds; a lot of energy is needed to break them, so the melting point is very high.

4 Substances with giant covalent structures can be used as lubricants and as cutting tools for hard materials.

The diagrams show how the atoms are arranged in two giant covalent substances, P and Q.



Which statement is correct?

A Only P is used as a cutting tool and only Q is used as a lubricant.

B Only P is used as a lubricant and only Q is used as a cutting tool.

C P and Q are both used as cutting tools.

D P and Q are both used as lubricants.

IGCSE Chemistry: **w25 22**

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

8 Rescuers are drilling through fallen rock in order to rescue some people trapped in a cave. The drill needs lubricating from time to time.

Four statements are made about the materials used for the drill tip and the lubricant to explain the reasons for their use.

1 Diamond is used for the drill tip as it does **not** conduct electricity.

2 Diamond is used for the drill tip as it is very hard.

3 Graphite is used as the lubricant as it conducts electricity.

4 Graphite is used as the lubricant as it is soft and slippery.

Which statements are correct?

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

IGCSE Chemistry: **s25 21**

7 Which statement about silicon(IV) oxide is correct?

A It contains silicon ions and oxide ions arranged in a giant lattice.

B It is used in electrical circuits because it can conduct electricity.

C Its bonds each contain one shared pair of electrons.

D Its atoms are arranged in the same way as the atoms in graphite.

IGCSE Chemistry: **s25 22**

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.

IGCSE CHEMISTRY • EXERCISE SHEET

2.7 Metallic bonding

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

KEY WORDS delocalised electrons 离域电子 • malleability 展性 • metallic bonding 金属键 • ion 离子 • metal 金属

Objective

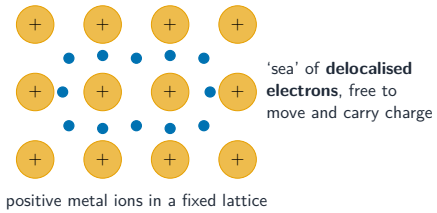
Build the skills to answer exam questions on **metallic bonding** 金属键 — the 'sea' of **delocalised electrons** 离域电子, and how it explains conductivity and **malleability** 展性.

You must be able to:

- describe metallic bonding (positive ions in a sea of delocalised electrons)
- explain why metals conduct electricity
- explain why metals are malleable and ductile

1 Worked examples

The metallic 'sea' of electrons



A metal is positive ions in a sea of delocalised electrons that are free to move

- **metallic bond:** electrostatic attraction between positive ions and the sea of electrons.
- **conducts:** the delocalised electrons are free to move and carry charge.
- **malleable/ductile:** layers of ions can slide without breaking the bond.

2 Practice

2.1 Define metallic bonding. [1]

2.2 State what carries the electric charge in a metal. [1]

3 Exam-style questions

3.1 A metal can be hammered into a sheet because: [1]

- **A** the bonds are weak
- **B** layers of ions can slide over each other
- **C** it contains molecules
- **D** the electrons are fixed

3.2 A piece of copper conducts electricity and can be drawn into a wire.

(a) Explain why copper conducts electricity. [2]

(b) Explain why copper is ductile (can be pulled into a wire). [2]

3.3 State why metals generally have high melting points. [2]

Solutions

2.1 the electrostatic attraction between positive metal ions and a sea of delocalised electrons.

2.2 the delocalised (free) electrons.

3.1 **B**. Layers of positive ions can slide over each other.

3.2 (a) it has delocalised electrons that are free to move; they carry charge through the metal.
(b) the layers of positive ions can slide over each other without breaking the metallic bonding, so the metal changes shape instead of breaking.

3.3 there is strong electrostatic attraction between the positive ions and the delocalised electrons; a lot of energy is needed to overcome it.

Name:

IGCSE Chemistry: **w25 21**

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.

IGCSE Chemistry: **w25 22**

9 Which row describes the structure and bonding in cobalt?

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

3 This question is about copper and compounds of copper.

(a) **(i)** Describe the bonding in a metallic element such as copper.

.....

.....

.....

.....

..... [3]

(ii) Explain how solid copper conducts electricity.

..... [1]

(b) Copper is in alloys such as brass.

(i) State **one** reason why alloys are more useful than pure metals.

..... [1]

(ii) Name the substance that is present in brass, other than copper.

..... [1]

(c) Copper(II) sulfate crystals are made by the reaction between copper(II) carbonate and dilute sulfuric acid, using the following steps.

The sulfuric acid has a concentration of 0.100 mol / dm^3.

step 1 Powdered copper(II) carbonate is added to dilute sulfuric acid. The mixture is stirred. A reaction occurs.

step 2 More copper(II) carbonate is added, with stirring, until the reaction stops.

step 3 Unreacted copper(II) carbonate is separated from aqueous copper(II) sulfate by filtration.

step 4 Aqueous copper(II) sulfate is heated until some of the water evaporates.

step 5 The remaining solution is allowed to cool and crystallise.

step 6 The crystals are removed and dried.

(i) Give **two** observations in **step 1**.

1 .....

2 .....
[2]

(ii) State why the reaction stops in **step 2**.

..... [1]

(iii) Name the residue in **step 3**.

..... [1]

(iv) Name a substance, other than copper(II) carbonate, that can be added to dilute sulfuric acid to produce aqueous copper(II) sulfate.

..... [1]

(v) The solution at the end of **step 4** contains the maximum amount of copper(II) sulfate that will dissolve at that temperature.

State the term used to describe this type of solution.

..... [1]

(vi) **Step 1** is repeated using sulfuric acid of concentration 0.200 mol / dm^3 instead of 0.100 mol / dm^3.

All other conditions are the same.

The rate of reaction increases.

Explain why the rate of reaction increases. Give your answer in terms of particles.

.....

.....

..... [2]

(vii) Copper(II) sulfate crystals have the formula $CuSO_4 \cdot 5H_2O$.

State the term used to describe a substance that is chemically combined with water.

..... [1]

[Total: 15]

3 This question is about zinc and compounds of zinc.

(a) Zinc is held together by electrostatic forces of attraction between particles.

(i) Name the type of bonding in zinc.

..... [1]

(ii) Name the **two** types of particles held together by the bonding in **(a)(i)**.

1 .....

2 .....
[2]

(iii) Name the type of particle whose movement allows zinc to conduct electricity.

..... [1]

(b) Zinc is present in alloys such as brass.

(i) State the meaning of the term alloy.

..... [1]

(ii) Name the substance that is present in brass, other than zinc.

..... [1]

(c) Zinc sulfate crystals are made by the reaction between zinc carbonate and dilute sulfuric acid, using the following steps.

step 1 An excess of powdered zinc carbonate is added to dilute sulfuric acid.

step 2 Excess zinc carbonate is separated from aqueous zinc sulfate by filtration.

step 3 Aqueous zinc sulfate is heated until a saturated solution is formed.

step 4 The saturated solution is allowed to cool and crystallise.

step 5 The crystals are removed and dried.

(i) Give **two** observations which show that the zinc carbonate is in excess in **step 1**.

1 .....

2 .....
[2]

(ii) Name the filtrate in **step 2**.

..... [1]

(iii) Name a compound, other than zinc carbonate, that can be added to dilute sulfuric acid to produce aqueous zinc sulfate in **step 1**.

..... [1]

(iv) State what is meant by the term saturated solution.

.....

..... [2]

(v) **Step 1** is repeated using large pieces of zinc carbonate instead of powdered zinc carbonate.

All other conditions are the same.

The rate of reaction decreases.

Explain why the rate of reaction decreases. Give your answer in terms of particles.

.....

.....

..... [2]

(vi) Hydrated crystals form in **step 4**.

State what is meant by the term hydrated.

..... [1]

[Total: 15]

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