Week 7

A-Level Chemistry

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

A-Level Chemistry Name: _____ Score: _____

1. Gas pressure is caused by:
   - ☐ molecules colliding with the walls of the container
   - ☐ molecules joining together
   - ☐ the mass of the gas pulling down
   - ☐ forces between molecules
2. A simple molecular solid (like iodine) has:
   - ☐ strong bonds inside each molecule but weak forces between molecules
   - ☐ a giant lattice of ions
   - ☐ a sea of delocalised electrons
   - ☐ a covalent network of atoms
3. A substance has a high melting point when:
   - ☐ strong forces (ionic, covalent or metallic) must be broken
   - ☐ only weak intermolecular forces break
   - ☐ it is a small molecule
   - ☐ it has no bonds
4. An ideal gas is assumed to have:
   - ☐ particles of zero volume and no forces between them
   - ☐ large particles with strong forces
   - ☐ particles that never move
   - ☐ a fixed shape
5. A giant molecular (giant covalent) structure is:
   - ☐ a huge network of atoms joined by strong covalent bonds
   - ☐ separate small molecules
   - ☐ ions in a lattice
   - ☐ metal ions in an electron sea
6. Diamond and graphite are examples of giant _____ structures.

7. Simple molecular substances have low melting points because the forces between molecules are weak.

   ☐ True ☐ False

8. An ideal gas is assumed to have no forces between its particles and particles of negligible volume; real gases deviate most at high pressure and low temperature.

   ☐ True ☐ False

9. An ionic solid conducts electricity:

   ☐ only when molten or dissolved, so the ions can move

   ☐ when solid

   ☐ never

   ☐ always

10. A real gas behaves LEAST like an ideal gas at:

    ☐ high pressure and low temperature

    ☐ low pressure and high temperature

    ☐ standard conditions only

    ☐ any temperature

4. States of matter

Answers · 答案

A-Level Chemistry

1. **molecules colliding with the walls of the container**

   Each collision with the wall gives a tiny push; the many pushes add up to the pressure.

2. **strong bonds inside each molecule but weak forces between molecules**

   Simple molecular substances are small molecules: strong covalent bonds inside, weak intermolecular forces between.

3. **strong forces (ionic, covalent or metallic) must be broken**

   Breaking strong bonds needs lots of energy, giving a high melting/boiling point; weak forces give a low one.

4. **particles of zero volume and no forces between them**

   The ideal-gas model assumes point particles (zero volume) with no intermolecular forces.

5. **a huge network of atoms joined by strong covalent bonds**

   Diamond, graphite and silicon(IV) oxide are giant covalent networks of atoms.

6. **covalent**

   Networks of covalently bonded atoms.

7. **True**

   The covalent bonds within molecules are strong.

8. **True**

   At high pressure and low temperature the particles are close, so their real volume and attractions matter.

9. **only when molten or dissolved, so the ions can move**

   The ions are fixed in the solid lattice; only when molten or dissolved can they move and carry charge.

10. **high pressure and low temperature**

    At high pressure and low temperature the particles are crowded, so their size and attractions matter.

A-LEVEL CHEMISTRY • EXERCISE SHEET

4.1 The gaseous state: ideal and real gases and pV = nRT

Name: _____ Class: _____ Date: _____ **Total: 23 marks**

KEY WORDS pressure 压强 • ideal gas 理想气体 • ideal gas equation 理想气体方程 • intermolecular forces 分子间作用力 • ion 离子

Objective

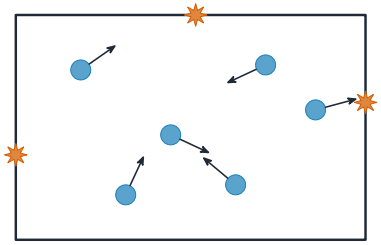
Build the skills to answer exam questions on **the gaseous state** — the origin of gas **pressure** 压强, the **ideal gas** 理想气体 model, and the ideal gas equation $pV = nRT$.

You must be able to:

- explain the origin of pressure in terms of collisions with the container walls
- state the assumptions of an ideal gas
- use $pV = nRT$ in calculations, including finding M_r

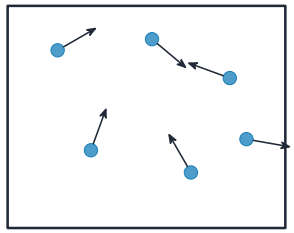
1 Worked examples

■ Gas pressure and the ideal gas

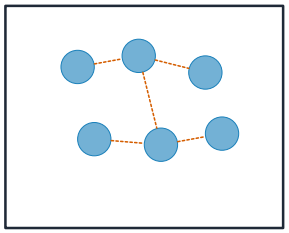


fast particles collide with the walls; the many pushes make the **pressure**

Pressure comes from the many collisions of fast gas molecules with the container walls



ideal gas (model)
point particles, *no* forces



real gas: high p, low T
real size + attractions (dashed)

An ideal gas has zero particle volume and no intermolecular forces — real gases obey it best at low pressure, high temperature

■ The ideal gas equation

$$pV = nRT$$

(p in Pa, V in m^3, T in K, $R = 8.31$ J $K^{-1}mol^{-1}$). **Convert first:** °C → K (+273); $cm^3/dm^3 \rightarrow m^3$.

Example. Volume of 0.50 mol at 27 °C, 100 kPa: $T = 300$ K, $p = 1.00 \times 10^5$ Pa; $V = nRT/p = (0.50 \times 8.31 \times 300)/(1.00 \times 10^5) = 0.0125$ m^3.

Finding M_r. Since $n = m/M$: $M = \dfrac{mRT}{pV}$.

2 Practice

2.1 State the **two** assumptions made about an ideal gas. [2]

2.2 Convert 25 °C to kelvin. [1]

3 Exam-style questions

3.1 A real gas behaves **most** like an ideal gas at: [1]

- **A** high pressure and low temperature
- **B** low pressure and high temperature
- **C** high pressure and high temperature
- **D** low pressure and low temperature

3.2 In the equation $pV = nRT$, the temperature T must be in: [1]

- **A** °C
- **B** kelvin
- **C** °F
- **D** joules

3.3 Calculate the volume, in m^3, of 2.0 mol of an ideal gas at 127 °C and a pressure of 2.0×10^5 Pa. ($R = 8.31$). [3]

3.4 A gas of mass 1.32 g occupies 750 cm^3 at 100 kPa and 27 °C. Calculate its molar mass. ($R = 8.31$). [3]

3.5 A 250 cm^3 glass vessel is evacuated, sealed and weighed. It is then filled with an unknown gas **G** at 101 kPa and 25 °C and reweighed; the mass rises by 0.286 g. ($R = 8.31\ J\,K^{-1}mol^{-1}$)

(a) Calculate the amount, in mol, of **G** in the vessel. [3]

(b) Hence calculate the relative molecular mass of **G** and suggest its identity. [3]

(c) State **two** assumptions of the ideal gas model, and explain which is more likely to fail if the measurement is repeated at 500 kPa. [4]

(d) State and explain the effect on the calculated M_r if the vessel had not been fully evacuated first. [2]

Solutions

2.1 the particles have zero volume; there are no intermolecular forces of attraction.

2.2 $25 + 273 = 298$ K.

3.1 B. Low pressure and high temperature (particles far apart, forces negligible).

3.2 B. Temperature must be in kelvin.

3.3 $T = 400$ K; $V = nRT/p = (2.0 \times 8.31 \times 400)/(2.0 \times 10^5) = 0.0332$ m^3.

3.4 convert: $V = 7.50 \times 10^{-4}$ m^3, $T = 300$ K, $p = 1.00 \times 10^5$ Pa; $M = \dfrac{mRT}{pV} = \dfrac{1.32 \times 8.31 \times 300}{(1.00 \times 10^5)(7.50 \times 10^{-4})} = 43.9$ g mol^{-1}.

3.5 (a) $V = 250 \times 10^{-6}$ m^3, $T = 298$ K, $p = 1.01 \times 10^5$ Pa; $n = \dfrac{pV}{RT} = \dfrac{1.01 \times 10^5 \times 2.50 \times 10^{-4}}{8.31 \times 298}$ $= 1.02 \times 10^{-2}$ mol.
(b) $M_r = \dfrac{m}{n} = \dfrac{0.286}{1.02 \times 10^{-2}} = 28.0$; so **G** could be nitrogen, N_2, or carbon monoxide, CO.
(c) The molecules themselves occupy a negligible fraction of the container's volume; there are no attractive forces between them. At 500 kPa the molecules are five times closer together, so it is the **no-attraction** assumption that fails first — the attractions pull the molecules together, so the real gas is more compressible than $pV = nRT$ predicts.
(d) Air left behind means the measured mass increase is less than the true mass of **G**, while n is still calculated from the full pressure — so the M_r comes out **too low**.

Name: A-Level Chemistry: **w25 11**

11 1.00 g of nitrogen gas is stored in a 2.00 dm^3 vessel at 40.0 °C.

What is the pressure in the vessel?

A 5940 Pa **B** 11 900 Pa **C** 46 400 Pa **D** 92 900 Pa

A-Level Chemistry: **w25 12**

8 A pure sample of a gas has a density of 2.62 g dm^{-3} at 101 000 Pa and 25 °C. The gas behaves ideally under these conditions.

Which expression gives the M_r of the gas?

A $\dfrac{101000 \times 0.001}{2.62 \times 8.31 \times 25}$

B $\dfrac{101000 \times 0.001}{2.62 \times 8.31 \times 298}$

C $\dfrac{2.62 \times 8.31 \times 25}{101000 \times 0.001}$

D $\dfrac{2.62 \times 8.31 \times 298}{101000 \times 0.001}$

2 Effusion is the process in which a gas escapes through a small hole.

A student investigates the relationship between rate of effusion and relative molar mass of a gas using the apparatus shown in Fig. 2.1.

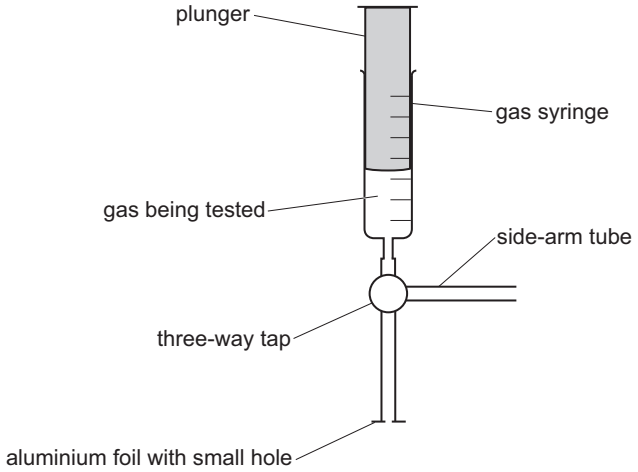


Fig. 2.1

The following method is used:

step 1 Turn the tap and remove any gas from the syringe through the side-arm tube, by pushing in the plunger.

step 2 Add 50 cm^3 of the gas being tested to the syringe through the side-arm tube.

step 3 Remove the gas from the syringe, through the side-arm tube, by pushing in the plunger.

step 4 Add 70 cm^3 of the gas being tested to the syringe through the side-arm tube.

step 5 Turn the tap to connect the syringe to the tube with the aluminium foil and small hole.

step 6 Allow the syringe plunger to fall and start a timer when the volume of gas in the syringe reaches 60 cm^3.

step 7 Stop the timer when the volume of gas in the syringe reaches 10 cm^3. Record the time taken.

step 8 Repeat steps 1 to 7 with different gases.

(a) Suggest why the student adds 50 cm^3 of the gas being tested to the syringe in step 2 and then removes this gas in step 3.

.....

..... [1]

(b) The student's results are shown in Table 2.1.

Table 2.1

gas	hydrogen, H_2	helium, He	neon, Ne	argon, Ar	krypton, Kr
relative molar mass, M	2.0	4.0	20.2	39.9	83.8
$\sqrt{\frac{1}{M}}$					
time taken / s	10.8	15.3	34.5	39.7	70.4
rate of effusion / $cm^3 s^{-1}$					

$$\text{rate of effusion} = \frac{\text{volume of gas}}{\text{time taken}}$$

(i) Complete Table 2.1.

Give the values for $\sqrt{\frac{1}{M}}$ to **three** significant figures.

Give the values for rate of effusion to **two** decimal places. [2]

(ii) Identify the dependent variable in this experiment.

..... [1]

(iii) Identify a variable, other than temperature, that is controlled when carrying out this experiment.

..... [1]

(c) Plot a graph on the grid in Fig. 2.2 to show the relationship between rate of effusion and $\sqrt{\frac{1}{M}}$.
Use a cross (×) to plot each data point. Draw a suitable line of best fit.

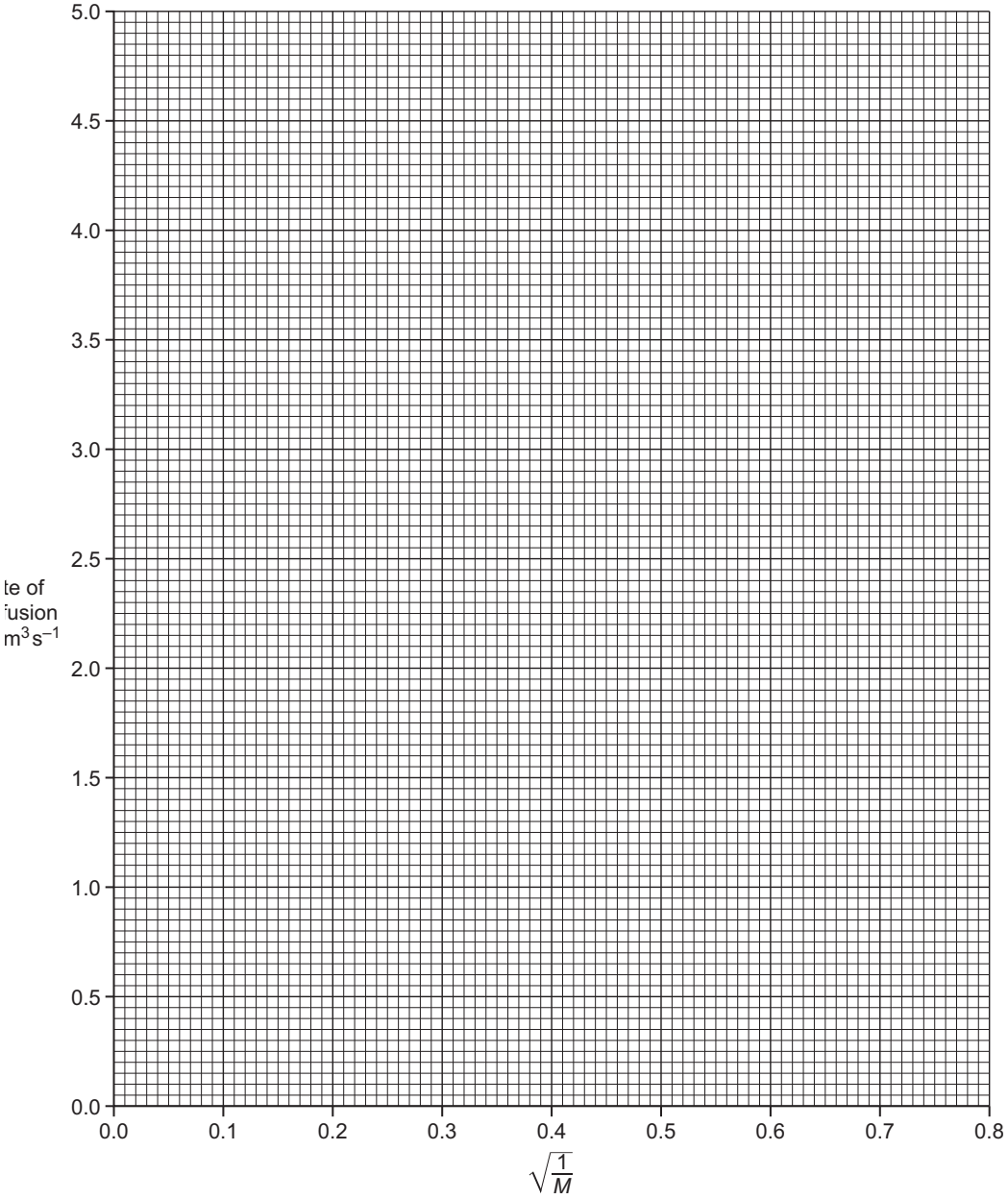


Fig. 2.2

[2]

(d) Circle **one** point on the graph in Fig. 2.2 which you consider to be most anomalous.

Suggest **one** reason for this anomaly. Assume there is no error in $\sqrt{\frac{1}{M}}$.

.....

..... [1]

(e) Graham's law of effusion can be expressed as:

the rate of effusion of a gas is proportional to $\sqrt{\frac{1}{M}}$.

State whether or not the student's results support Graham's law of effusion.

Explain your answer, using the graph in Fig. 2.2.

.....

..... [1]

(f) Suggest how the position of the plotted points relative to the line of best fit in Fig. 2.2 is related to the reliability of the results.

.....

..... [1]

(g) The student then repeats this method to determine the value of M of a sample of natural gas.

The time recorded in step 7 is 31.6 s.

(i) Use the graph in Fig. 2.2 and the student's result to calculate the value of M for this sample.

M = ... [2]

(ii) Natural gas is a mixture of mainly methane, CH_4, with small amounts of other gases.

Suggest what your calculated value of the M of natural gas in **(g)(i)** tells you about the other gases in the mixture.

.....

..... [1]

(h) The experiment described in **(g)** is repeated at a higher temperature.

Suggest how the rate of effusion for this sample of natural gas would change, if at all.

Explain your answer.

effect on the rate of effusion .....

explanation .....

.....

[1]

[Total: 14]

Important values, constants and standards

molar gas constant	$R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4\,\text{C mol}^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23}\,\text{mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\,\text{C}$
molar volume of gas	$V_m = 22.4\,\text{dm}^3\,\text{mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,\text{dm}^3\,\text{mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,\text{mol}^2\,\text{dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

The Periodic Table of Elements

Group 1	2												13	14	15	16	17	18
								1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0												5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3												13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	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 –

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	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 –

A-LEVEL CHEMISTRY • EXERCISE SHEET

4.2 Bonding and structure

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

KEY WORDS melting point 熔点 • lattice 晶格 • crystalline solid 晶体 • solubility 溶解度 • diamond 金刚石

Objective

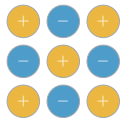
Build the skills to answer exam questions on **bonding and structure** — the four lattice structures of crystalline solids and how structure decides physical properties.

You must be able to:

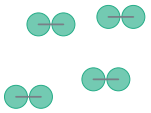
- describe giant ionic, simple molecular, giant molecular and giant metallic structures
- relate structure and bonding to melting point, conductivity and solubility
- deduce the structure of a substance from its properties

1 Worked examples

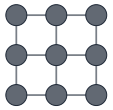
The four structures



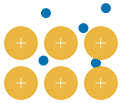
giant ionic
NaCl: high m.p.,
conducts when molten



simple molecular
I_2, ice: low m.p.,
weak forces between



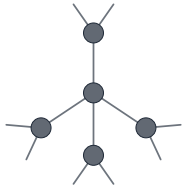
giant covalent
diamond, SiO_2: very
high m.p., insulating



giant metallic
copper: high m.p.,
conducts (solid + molten)

The structure decides melting point, conductivity and solubility

- **giant ionic** 离子晶体 — a lattice of ions (NaCl, MgO).
- **simple molecular** 分子晶体 — small molecules with weak forces between them (I_2, C_{60}, ice).
- **giant molecular** 原子晶体 — a covalent network (silicon(IV) oxide, graphite, diamond).
- **giant metallic** 金属晶体 — metal ions in an electron sea (copper).



diamond
every C bonded to 4:
rigid 3D network, very hard

graphite
layers slide; spare
electrons let it conduct

Diamond is a hard 3D network; graphite has sliding layers and delocalised electrons (so it conducts)

Properties from structure

structure	m.p./b.p.	conducts?	soluble in water?
giant ionic	high	when molten/dissolved	usually yes
simple molecular	low	no	usually low
giant molecular	very high	no (graphite yes)	no
giant metallic	high	yes (solid + molten)	no

2 Practice

2.1 Name the type of structure in (a) diamond and (b) copper. [2]

2.2 State why simple molecular solids have low melting points. [1]

3 Exam-style questions

3.1 Which structure conducts electricity when **solid**? [1]

- **A** giant ionic
- **B** simple molecular
- **C** giant metallic
- **D** giant molecular (diamond)

3.2 Why does graphite conduct electricity but diamond does not? [1]

- **A** graphite has ions
- **B** graphite has delocalised electrons between its layers
- **C** diamond is a metal
- **D** diamond is molecular

3.3 A solid X has a very high melting point, does not conduct electricity, and is insoluble in water.

(a) Deduce the type of structure and bonding in X. [2]

(b) Give an example of such a substance. [1]

3.4 Explain why sodium chloride conducts electricity when molten or dissolved, but not when solid. [2]

Solutions

2.1 (a) giant molecular (giant covalent); (b) giant metallic.

2.2 only weak intermolecular forces are broken on melting.

3.1 **C**. Giant metallic conducts when solid (delocalised electrons).

3.2 **B**. Graphite has delocalised electrons between its layers.

3.3 (a) giant molecular (giant covalent) structure with covalent bonding.
(b) e.g. diamond / silicon(IV) oxide.

3.4 when molten or dissolved the ions are free to move and carry charge; in the solid the ions are fixed in the lattice, so they cannot move.