Cambridge AS & A Level

CHEMISTRY

Paper 1

Topical Past Paper Questions

+ Answer Scheme

2015 - 2021

PapaCambridge

Chapter 4

States of matter

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

167. 9701_m21_qp_12 Q: 6

A solution contains 0.25 g of sulfur dioxide in 1.00 dm^3 of water.

Which volume of sulfur dioxide, measured at 50 °C and a pressure of 1×10^5 Pa, must be added to 1.00 dm^3 of water to produce this solution?

A 0.0162 cm^3 **B** 0.105 cm^3 **C** 16.2 cm^3 **D** 105 cm^3

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168. 9701_s21_qp_11 Q: 8

Which gas would behave most like an ideal gas under room conditions?

A helium

B nitrogen

C ammonia

D krypton

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169. 9701_s21_qp_12 Q: 5

Flask Q contains 5 dm^3 of helium at 12 kPa pressure. Flask R contains 10 dm^3 of neon at 6 kPa pressure.

If the flasks are connected at constant temperature, what is the final pressure?

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

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170. 9701_w21_qp_11 Q: 6

Which substance shows the greatest deviation from the properties of an ideal gas under room conditions?

A $CO_2(g)$ **B** $H_2(g)$ **C** Ne(g) **D** $NH_3(g)$

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171. 9701_w21_qp_12 Q: 8

The general gas equation can be used to calculate the value of the M_r of a gas.

For a sample of a gas of mass m grams, which expression will give the value of M_r?

A $M_r = \frac{mRT}{pV}$ **B** $M_r = \frac{pVRT}{m}$ **C** $M_r = \frac{mpV}{RT}$ **D** $M_r = \frac{pV}{mRT}$

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172. 9701_m20_qp_12 Q: 9

1.8 g of water, heated to 227 °C in a sealed container, turns to steam with a pressure of 200 kPa.

What is the approximate volume of the container?

A $9 \times 10^{-4}\,m^3$ **B** $2 \times 10^{-3}\,m^3$ **C** $2\,m^3$ **D** $8 \times 10^{7}\,m^3$

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173. 9701_s20_qp_11 Q: 9

A sample of argon gas has a mass of 0.20 g, at a pressure of 100 000 Pa and a temperature of 12 °C.

Which volume does the gas occupy?

A $1.2 \times 10^{-4}\,cm^3$

B $5.0\,cm^3$

C $59\,cm^3$

D $119\,cm^3$

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174. 9701_s20_qp_12 Q: 9

The complete combustion of 2 moles of an alkane produces 400 dm^3 of carbon dioxide measured at 301 K and 1×10^5 Pa. Carbon dioxide can be assumed to behave as an ideal gas under these conditions.

What is the formula of the alkane?

A C_8H_{18} **B** $C_{16}H_{34}$ **C** $C_{20}H_{42}$ **D** $C_{40}H_{82}$

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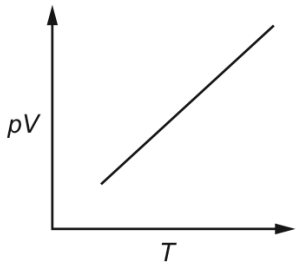
175. 9701_w20_qp_12 Q: 6

A graph of pV against T is shown for a fixed mass of gas. (p = pressure, V = volume and T = temperature in K.)



Which gas gives this graph over the widest range of temperatures and pressures?

A hydrogen, H_2

B hydrogen chloride, HCl

C hydrogen fluoride, HF

D oxygen, O_2

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176. 9701_w20_qp_12 Q: 7

A weather balloon is filled with 12.0 kg helium. The weather balloon reaches a height of 20 km, the pressure inside the balloon is 6000 Pa and the temperature is 216 K.

What is the volume of the weather balloon at this height, correct to three significant figures?

A 897 dm^3 **B** 1790 dm^3 **C** 897 000 dm^3 **D** 1 790 000 dm^3

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177. 9701_m19_qp_12 Q: 6

A sample of gas occupies 240 cm^3 at 37 °C and 100 kPa.

How many moles of gas are present in the sample?

A 9.32×10^{-6} **B** 9.32×10^{-3} **C** 0.0781 **D** 78.1

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178. 9701_s19_qp_11 Q: 7

Under which conditions will nitrogen behave most like an ideal gas?

	temperature	pressure
A	low	high
B	high	low
C	low	low
D	high	high

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179. 9701_s19_qp_11 Q: 12

1.15 g of a metallic element needs 300 cm^3 of oxygen for complete reaction, under room conditions, to form an oxide which contains O^{2-} ions.

What could be the identity of this metallic element?

A calcium

B magnesium

C potassium

D sodium

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180. 9701_s19_qp_12 Q: 6

X, Y and Z are all gases that behave ideally and react according to the equation shown.

$$X(g) + 2Y(g) \rightarrow 2Z(g)$$

When 3.0 mol of X and 3.0 mol of Y are placed inside a container with a volume of 1.0 dm^3, they react to form the maximum amount of Z.

The final temperature of the reaction vessel is 120 °C.

What is the final pressure inside the reaction vessel?

A 4.49×10^6 Pa

B 9.80×10^6 Pa

C 1.47×10^7 Pa

D 1.96×10^7 Pa

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181. 9701_s19_qp_13 Q: 7

What changes in conditions or molecular properties make it more likely that gases approach ideal behaviour?

A higher pressure

B lower temperature

C more polar molecules

D weaker intermolecular forces

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182. 9701_w19_qp_12 Q: 5

In this question you should assume the vapour behaves as an ideal gas.

0.175 g of a volatile liquid produces a vapour of volume 4.50×10^{-5} m^3 at 100 °C and pressure of 1.013×10^5 Pa.

What is the M_r of the liquid?

A 31.9 **B** 87.1 **C** 119 **D** 127

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183. 9701_m18_qp_12 Q: 7

The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

0.960 g of oxygen gas is contained in a vessel of volume 7.00×10^{-3} m^3 at a temperature of 30 °C.

Assume that the gas behaves as an ideal gas.

What is the pressure in the vessel?

A 1.07 kPa **B** 2.14 kPa **C** 10.8 kPa **D** 21.6 kPa

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184. 9701_s18_qp_12 Q: 6

Which gas is likely to deviate most from ideal gas behaviour?

A HC*l* **B** He **C** CH_4 **D** N_2

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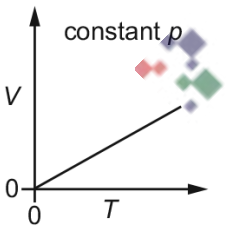
185. 9701_s18_qp_13 Q: 6

Which diagram correctly describes the behaviour of a fixed mass of an ideal gas? (T is measured in K.)

A



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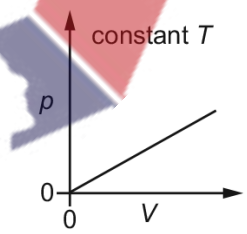

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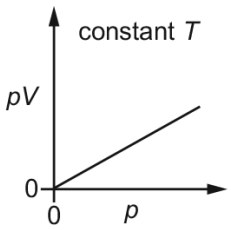

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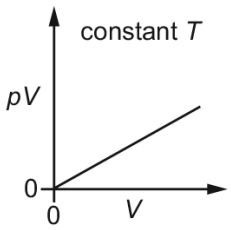

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186. 9701_w18_qp_11 Q: 2

What is a basic assumption of the kinetic theory, as applied to an ideal gas?

A Collisions between gas molecules are elastic.

B Each gas molecule occupies a finite volume.

C Gases consist of particles that experience the force of gravity.

D Gas molecules attract each other with weak intermolecular forces.

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187. 9701_w18_qp_11 Q: 5

In this question you should assume methane behaves as an ideal gas.

The gas laws can be summarised in the ideal gas equation below.

$$pV = nRT$$

The volume of a sample of methane is measured at a temperature of 60 °C and a pressure of 103 kPa. The volume measured is 5.37×10^{-3} m^3.

What is the mass of the sample of methane, given to two significant figures?

A 0.0032 g **B** 0.018 g **C** 3.2 g **D** 18 g

---

188. 9701_w18_qp_12 Q: 6

Exactly 1.00 g of a metallic element reacts completely with 300 cm^3 of oxygen at 298 K and 1 atm pressure to form an oxide which contains O^{2-} ions.

The volume of one mole of gas at this temperature and pressure is 24.0 dm^3.

What could be the identity of the metal?

A calcium

B magnesium

C potassium

D sodium

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189. 9701_m17_qp_12 Q: 6

Which gas sample contains the **fewest** molecules?

A 1.00 dm^3 of carbon dioxide at 27 °C and 2.0 kPa

B 1.00 dm^3 of hydrogen at 100 °C and 2.0 kPa

C 1.00 dm^3 of nitrogen at 300 °C and 4.0 kPa

D 1.00 dm^3 of oxygen at 250 °C and 3.0 kPa

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190. 9701_s17_qp_12 Q: 5

At a temperature of 2500 K and a pressure of 1.00×10^{-4} Pa a sample of 0.321 g of sulfur vapour has a volume of 2.08×10^{6} m^3.

What is the molecular formula of sulfur under these conditions?

A S **B** S_2 **C** S_4 **D** S_8

---

191. 9701_s17_qp_13 Q: 5

All gases listed are at the same pressure.

Which gas will most closely approach ideal behaviour?

A ammonia at 100 K

B ammonia at 500 K

C neon at 100 K

D neon at 500 K

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192. 9701_w17_qp_11 Q: 5

A fluorescent light tube has an internal volume of 400 cm^3 and an internal pressure of 200 kPa.

It is filled with 0.03 moles of an ideal gas.

What is the temperature of the gas inside the fluorescent light tube?

A 3.21×10^{-1} K

B 3.21×10^{2} K

C 3.21×10^{5} K

D 3.21×10^{8} K

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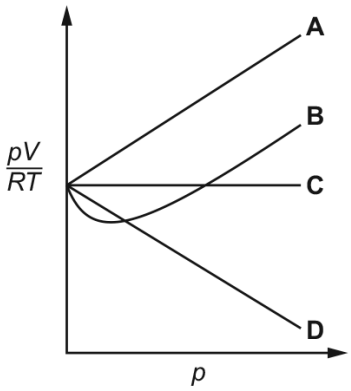
193. 9701_w17_qp_12 Q: 5

A sample of an ideal gas is contained at a constant temperature of 300 K in a gas syringe.

The pressure is increased and a graph of $\frac{pV}{RT}$ against pressure is plotted.

Which graph correctly represents the results?



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194. 9701_m16_qp_12 Q: 7

What is the volume of steam produced when 1.00 g of ice is heated to 323 °C at a pressure of 101 kPa?

A 0.27 dm^3 **B** 1.3 dm^3 **C** 2.7 dm^3 **D** 48 dm^3

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195. 9701_s16_qp_12 Q: 6

Argon is a gas used to fill electric light bulbs.

Under which conditions of pressure and temperature will argon behave most like an ideal gas?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

---

196. 9701_s16_qp_12 Q: 7

0.10 g of the volatile liquid X formed 0.025 dm^3 of vapour at 100 °C and atmospheric pressure.

1 mol of vapour occupies 22.4 dm^3 at 0 °C and atmospheric pressure.

What is the relative molecular mass of X?

A $\frac{0.025 \times 273 \times 22.4}{0.10 \times 373}$

B $\frac{0.025 \times 373 \times 22.4}{0.10 \times 273}$

C $\frac{0.10 \times 273 \times 22.4}{0.025 \times 373}$

D $\frac{0.10 \times 373 \times 22.4}{0.025 \times 273}$

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197. 9701_s16_qp_13 Q: 2

What will make it more likely that a gas will approach ideal behaviour?

A higher pressure

B lower temperature

C more polar molecules

D weaker intermolecular forces

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198. 9701_w16_qp_11 Q: 2

In the ideal gas equation, $pV = nRT$, what are the units of n and T?

	n	T
A	no units	°C
B	no units	K
C	mol	°C
D	mol	K

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199. 9701_w16_qp_11 Q: 7

The approximate percentage composition of the atmospheres on four different planets is given in the table below.

Which mixture of gases has the greatest density?

	planet	major gases / % by number of molecules		
		H_2	He	CH_4
A	Jupiter	89.8	10.2	0.0
B	Neptune	80.0	19.0	1.0
C	Saturn	96.3	3.3	0.4
D	Uranus	82.5	15.2	2.3

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200. 9701_w16_qp_12 Q: 8

In an experiment, a sample of a pure gas is put into a gas syringe at a temperature of 300 K and pressure of 16 kPa. The gas is compressed until the volume occupied by the gas is halved.

After compression, the temperature of the gas in the syringe is 375 K and the pressure is 40 kPa.

Which statement is correct?

A Intermolecular forces between the gas molecules are significant.

B It is possible to calculate the number of moles of gas present using these data alone.

C The gas is behaving ideally.

D The pressures used are too high for ideal gas behaviour.

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201. 9701_s15_qp_11 Q: 3

Use of the Data Booklet is relevant to this question.

1.00 g of carbon is combusted in a limited supply of pure oxygen. 0.50 g of the carbon combusts to form CO_2 and 0.50 g of the carbon combusts to form CO.

The resultant mixture of CO_2 and CO is passed through excess NaOH(aq) and the remaining gas is then dried and collected.

What is the volume of the remaining gas? (All gas volumes are measured at 25 °C and 1 atmosphere pressure.)

A 1 dm^3 **B** 1.5 dm^3 **C** 2 dm^3 **D** 3 dm^3

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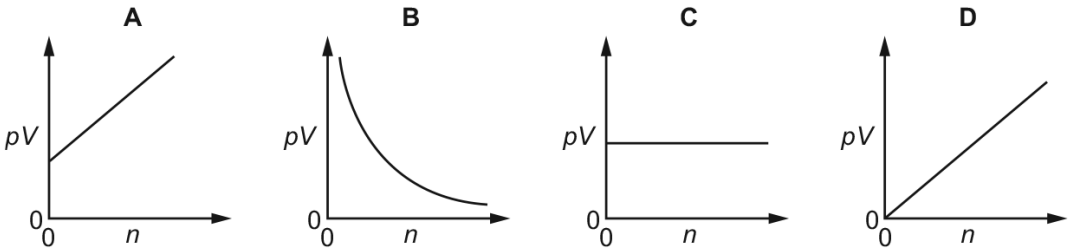
202. 9701_s15_qp_13 Q: 2

Which diagram shows the correct graph of *pV* against *n* for an ideal gas at constant temperature?



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203. 9701_s15_qp_13 Q: 11

Use of the Data Booklet is relevant to this question.

The gas laws can be summarised in the ideal gas equation below.

$$pV = nRT$$

When an evacuated tube of volume 400 cm^3 is filled with gas at 300 K and 101 kPa, the mass of the tube increases by 0.65 g.

Assume the gas behaves as an ideal gas.

What could be the identity of the gas?

A argon

B helium

C krypton

D neon

---

204. 9701_w15_qp_12 Q: 19

Use of the Data Booklet is relevant to this question.

4.70 g of an ammonium salt is heated with excess aqueous sodium hydroxide. The volume of ammonia gas given off, measured at room temperature and pressure, is 1.41 dm^3.

Which ammonium salt was used?

A ammonium bromide (M_r = 97.9)

B ammonium carbonate (M_r = 96)

C ammonium nitrate (M_r = 80)

D ammonium sulfate (M_r = 132.1)

4.2 Bonding and structure

205. 9701_m22_qp_12 Q: 7

Elements X, Y and Z are all in the first two periods of the Periodic Table.

Their Pauling electronegativity values, E_N, are shown.

element	E_N
X	1.0
Y	2.1
Z	4.0

Substances exist with formulae XZ, YZ and Z_2.

Which row puts these substances in order of increasing melting point?

	lowest melting point	→	highest melting point
A	XZ	YZ	Z_2
B	XZ	Z_2	YZ
C	Z_2	YZ	XZ
D	Z_2	XZ	YZ

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206. 9701_s21_qp_12 Q: 6

Sodium chloride, water and air represent three states of matter – solid, liquid and gas.

Which row is correct?

	sodium chloride	water	air
A	particles held in rigid structure	can easily be compressed	can easily be compressed
B	particles stationary	particles move	cannot easily be compressed
C	particles stationary	particles stationary	particles move
D	resistant to change of shape	cannot easily be compressed	can easily be compressed

---

207. 9701_s20_qp_11 Q: 19

What is the order of increasing melting point of the three chlorides shown?

CCl_4 $MgCl_2$ PCl_5

	lowest melting point	→	highest melting point
A	CCl_4	PCl_5	$MgCl_2$
B	$MgCl_2$	CCl_4	PCl_5
C	$MgCl_2$	PCl_5	CCl_4
D	PCl_5	CCl_4	$MgCl_2$

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208. 9701_s20_qp_12 Q: 1

In which carbon allotrope are all electrons localised?

A buckminsterfullerene

B diamond

C graphite

D graphene

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209. 9701_s20_qp_13 Q: 3

Solid carbon dioxide, CO_2, is similar to solid iodine, I_2, in its structure.

Which statement about solid CO_2 and solid SiO_2 is correct?

A Both solid CO_2 and solid SiO_2 exist in a lattice structure.

B Both solid CO_2 and solid SiO_2 have a simple molecular structure.

C Both solid CO_2 and solid SiO_2 have atoms joined by single covalent bonds.

D Both solid CO_2 and solid SiO_2 change spontaneously to gas at s.t.p..

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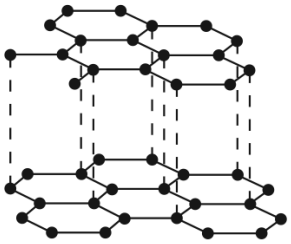
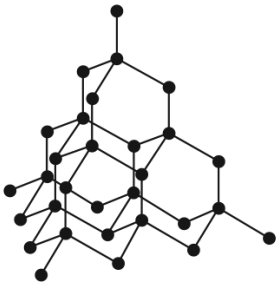
210. 9701_m19_qp_12 Q: 7

P, Q and R represent three different structures of an element.

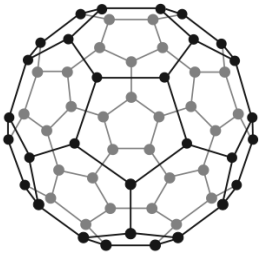
P



Q



R



Which structures are giant molecular?

A P, Q and R

B P and Q only

C P and R only

D Q and R only

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211. 9701_s19_qp_12 Q: 5

The table shows some properties of four substances.

Which substance could be potassium iodide?

	melting point of solid / °C	electrical conductivity when molten
A	–66	poor
B	–39	good
C	680	good
D	1600	poor

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212. 9701_s19_qp_12 Q: 7

Which pair of substances are both simple molecular?

A C_{60} and graphene

B C_{60} and iodine

C graphene and graphite

D graphite and iodine

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213. 9701_s19_qp_13 Q: 4

Element W is in period three of the Periodic Table and has a solid, white oxide, X. X is thermally stable and has a very high melting point.

X is slightly soluble in water.

Which row describes the structure and bonding of X?

	structure	bonding
A	giant three dimensional lattice	covalent
B	strong double bonds within small molecules	covalent
C	giant three dimensional lattice	ionic
D	strong ionic bonds within small molecules	ionic

---

214. 9701_s19_qp_13 Q: 5

Ethane, CH_3CH_3, and fluoromethane, CH_3F, have the same number of electrons in their molecules.

Their boiling points are given.

CH_3CH_3	184.5 K
CH_3F	194.7 K

What is responsible for this difference in boiling points?

A CH_3F has a larger M_r than CH_3CH_3.

B CH_3F has a permanent dipole, CH_3CH_3 does not.

C CH_3F has a strong C–F bond, CH_3CH_3 does not.

D Hydrogen bonding occurs in CH_3F, but not in CH_3CH_3.

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215. 9701_s18_qp_11 Q: 6

Which solid contains more than one type of bonding?

A iodine

B silicon dioxide

C sodium chloride

D zinc

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216. 9701_s18_qp_12 Q: 3

In which pair does the second substance have a **lower** boiling point than the first substance?

A C_2H_6 and C_2H_5Cl

B CH_3OCH_3 and C_2H_5OH

C Ne and Ar

D CH_3NH_2 and C_2H_6

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217. 9701_s18_qp_12 Q: 9

Materials can be classified by their chemical structures. Four common types of structure are metallic, ionic, simple molecular and giant molecular.

Some physical properties of four substances are shown in the table.

Which substance has a simple molecular structure?

	melting point / °C	effect of adding water	electrical conductivity
A	64	reacts	good when solid
B	113	insoluble	always poor
C	767	soluble	good when solid
D	1600	insoluble	always poor

---

218. 9701_s18_qp_13 Q: 1

Why is the boiling point of ammonia, NH_3, higher than the boiling point of phosphine, PH_3?

A Ammonia molecules are polar; phosphine molecules are not.

B Ammonia molecules have significant hydrogen bonding; phosphine molecules do not.

C N–H covalent bonds are stronger than P–H covalent bonds.

D There is one lone pair in each ammonia molecule but no lone pair in each phosphine molecule.

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219. 9701_w18_qp_11 Q: 14

Which row describes the structure and bonding of SiO_2 and $SiCl_4$?

	SiO_2		$SiCl_4$	
	bonding	structure	bonding	structure
A	covalent	giant	covalent	giant
B	covalent	giant	covalent	simple
C	ionic	giant	covalent	giant
D	ionic	giant	covalent	simple

---

220. 9701_m17_qp_12 Q: 4

The boiling points of methane, ethane, propane and butane are given.

compound	CH_4	CH_3CH_3	$CH_3CH_2CH_3$	$CH_3CH_2CH_2CH_3$
boiling point/K	112	185	231	273

Which statement explains the increase in boiling point from methane to butane?

A Closer packing of molecules results in stronger van der Waals' forces.

B More covalent bonds are present and therefore more energy is required to break the bonds.

C More electrons in the molecules results in stronger van der Waals' forces.

D More hydrogen atoms in the molecules results in stronger hydrogen bonding.

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221. 9701_w17_qp_11 Q: 4

In the sodium chloride lattice the number of chloride ions that surround each sodium ion is called the *co-ordination number* of the sodium ions.

What are the co-ordination numbers of the sodium ions and the chloride ions in the sodium chloride lattice?

	sodium ions	chloride ions
A	4	6
B	6	4
C	6	6
D	8	6

---

222. 9701_m16_qp_12 Q: 8

Solid carbon dioxide, CO_2, is similar to solid iodine, I_2, in its structure and properties. Carbon is in Group 14. Silica, SiO_2, is a Group 14 compound.

Which statement about solid CO_2 and solid SiO_2 is correct?

A Both solids exist in a lattice structure.

B Both solids have a simple molecular structure.

C Both solids have atoms joined by single covalent bonds.

D Both solids change spontaneously to gas at s.t.p.

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223. 9701_m16_qp_12 Q: 9

An article in a science magazine contains the following statement.

'It is lighter than a feather, stronger than steel, yet incredibly flexible and more conductive than copper.'

Which form of carbon is being described?

A buckminsterfullerene

B diamond

C graphene

D graphite

---

224. 9701_s15_qp_12 Q: 4

Which solid has a simple molecular lattice?

A calcium fluoride

B nickel

C silicon(IV) oxide

D sulfur

---

225. 9701_s15_qp_13 Q: 14

The compound $(CH_3)_3NAlCl_3$ has a simple molecular structure.

Which statement about $(CH_3)_3NAlCl_3$ is correct?

A $(CH_3)_3NAlCl_3$ molecules attract each other by hydrogen bonds.

B The Al atom has an incomplete valance shell of electrons.

C The bonds around the Al atom are planar.

D The molecules contain coordinate and covalent bonding

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226. 9701_w15_qp_11 Q: 5

Some car paints contain small flakes of silica, SiO_2.

In the structure of solid SiO_2

- each silicon atom is bonded to **x** oxygen atoms,
- each oxygen atom is bonded to **y** silicon atoms,
- each bond is a **z** type bond.

What is the correct combination of **x**, **y** and **z** in these statements?

	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic

---

227. 9701_w15_qp_12 Q: 3

Three substances have the physical properties shown in the table.

substance	melting point /°C	boiling point /°C	conductivity (solid)	conductivity (liquid)	conductivity (aqueous)
U	420	907	good	good	insoluble
V	993	1695	poor	good	good
W	–70	58	poor	poor	hydrolyses, resulting solution conducts well

What could be the identities of **U**, **V** and **W**?

	U	V	W
A	Na	KCl	$SiCl_4$
B	Na	NaF	C_2H_5Br
C	Zn	KCl	HCl
D	Zn	NaF	$SiCl_4$
