3. Chemical bonding

3.6 Intermolecular forces

Paper 1

Question Paper

1 Why does ICl have a higher boiling point than Br_2?

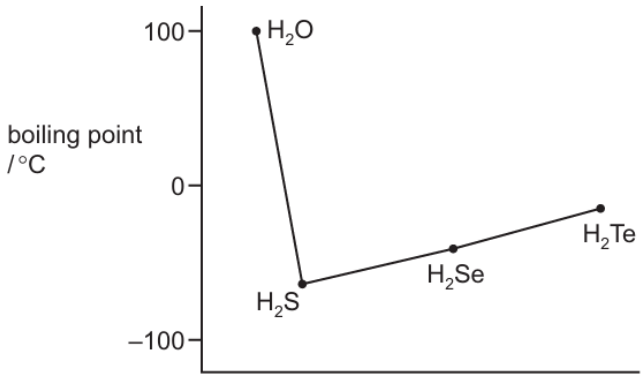
A because of the difference in the bond energies of the covalent bonds within ICl and Br_2

B because of the difference in the polar nature of ICl and Br_2

C because of the difference in the number of electrons contained within ICl and Br_2

D because of the difference in the relative molecular mass of ICl and Br_2

2 The graph shows the boiling points of the hydrogen compounds of Group 16 elements.



Which statement correctly explains why water does **not** fit the trend of the other compounds?

A There are fewer electrons in the oxygen atoms so there is less shielding of the nuclear charge.

B There are strong hydrogen bonds in water but **not** in the other compounds.

C The covalent bonds in water are much stronger than in the other compounds.

D The water molecules are smaller and so have stronger van der Waals' forces.

3 Consider the following four compounds.

1 $(CH_3)_3CH$

2 $CH_3CH_2CH_2OH$

3 $CH_3CH_2CH_2SH$

4 $CH_3CH_2CH_2CH_3$

What is the order of increasing boiling point of the compounds (lowest first)?

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

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

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

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

4 Nitrogen, N_2, and carbon monoxide, CO, both have $M_r = 28$.

The boiling point of N_2 is 77 K.

The boiling point of CO is 82 K.

What could be responsible for this difference in boiling points?

A CO molecules have a permanent dipole; the N_2 molecules are **not** polar.

B N_2 has σ and π bonding; CO has σ bonding only.

C N_2 has a strong N≡N bond; CO has a C=O bond.

D The CO molecule has more electrons than the N_2 molecule.

5 The boiling points of Br_2, IC*l* and IBr are given in the table.

	Br_2	IC*l*	IBr
boiling point / °C	59	97	116

Which row explains:

- why the boiling point of IC*l* is greater than Br_2
- why the boiling point of IBr is greater than IC*l*?

	boiling point of IC*l* is greater than Br_2	boiling point of IBr is greater than IC*l*
A	IC*l* has stronger instantaneous dipole-induced dipoles	IBr has stronger instantaneous dipole-induced dipoles
B	IC*l* has permanent dipoles	IBr has stronger instantaneous dipole-induced dipoles
C	IC*l* has stronger instantaneous dipole-induced dipoles	IBr has stronger permanent dipoles
D	IC*l* has permanent dipoles	IBr has stronger permanent dipoles

6 For which pair is the boiling point of the first compound **higher** than the boiling point of the second compound?

A CH_3CH_2OH and CH_3CH_2SH

B $CH_3CO_2CH_3$ and $CH_3CH_2CO_2H$

C CH_3OCH_3 and CH_3CH_2OH

D CH_3CH_2CHO and $CH_3CH_2CO_2H$

7 Which type of interaction exists between water molecules and metal cations in aqueous solution?

A dipole-dipole interactions

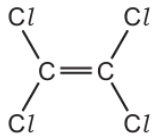
B hydrogen bonds

C ion-dipole interactions

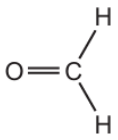
D ionic bonds

8 Which molecule has the largest overall dipole?

A



B



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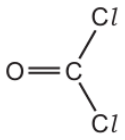


D

9 The strength of hydrogen bonding increases as the electronegativity of the element bonded to hydrogen increases.

Some information for a range of hydrides is given.

hydride	boiling point /K
PH_3	185
HCl	188
HF	293
H_2O	373

Which statement and reason about these hydrides is correct?

A The boiling point of PH_3 is much lower than the boiling point of H_2O because PH_3 does not form hydrogen bonds or instantaneous dipole-induced dipole forces between its molecules.

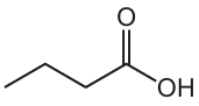
B The boiling point of HF is higher than the boiling point of HCl because the bond energy of H–F is greater than the bond energy of H–Cl.

C The boiling point of H_2O is higher than the boiling point of HF because each hydrogen bond between the H_2O molecules is stronger than each hydrogen bond between HF molecules.

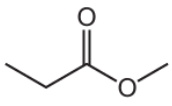
D The boiling points of PH_3 and HCl are similar because the molecules of PH_3 and HCl have the same number of electrons and similar intermolecular forces.

10 The structures represent three compounds, each with four carbon atoms per molecule.

X



Y



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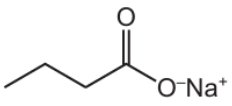

Which row is correct?

	lowest boiling point	→	highest boiling point
A	X	Y	Z
B	Y	X	Z
C	Z	X	Y
D	Z	Y	X

11 In which of the following, when in liquid form, are there only intermolecular forces based on temporary dipoles between the particles?

A bromine

B ethanol

C hydrogen chloride

D water

12 When aqueous bromine is shaken with cyclohexane and allowed to stand, two layers form. The top cyclohexane layer is coloured and the bottom aqueous layer is almost colourless.

What is the most likely explanation for this observation?

A Bromine is reduced to bromide ions in the bottom layer.

B Bromine molecules are non-polar.

C Bromine reacts with water but cannot react with cyclohexane.

D The product of the reaction between bromine and cyclohexane is coloured.

13 In which change are **only** temporary dipole-induced dipole forces overcome?

A $C_2H_5OH(l) \rightarrow C_2H_5OH(g)$

B $H_2O(s) \rightarrow H_2O(l)$

C $O_2(s) \rightarrow O_2(l)$

D $C_4H_{10}(l) \rightarrow C_4H_{10}(s)$

14 Which statement explains why iodine is less volatile than chlorine?

A Chlorine is more electronegative than iodine and so has more repulsion between its molecules.

B The greater number of electrons in iodine leads to larger temporary dipole-induced dipole forces.

C The I–I bond energy is smaller than the Cl–Cl bond energy.

D The iodine molecules have stronger permanent dipole-permanent dipole forces.

15 Ethanal, CH_3CHO, ethanol, C_2H_5OH, and methoxymethane, CH_3OCH_3, are three organic compounds.

Which compound has the highest boiling point and what is the interaction that causes this boiling point to be the highest?

	highest boiling point	interaction
A	methoxymethane	permanent dipole-dipole forces
B	ethanal	hydrogen bonds
C	ethanol	hydrogen bonds
D	ethanal	permanent dipole-dipole forces

16 Which compound has a boiling point that is influenced by hydrogen bonding?

A CH_3CHO **B** CH_3OCH_3 **C** HCO_2CH_3 **D** HCO_2H

17 Which molecule has no overall dipole?

A CH_3Cl **B** CH_2Cl_2 **C** $CHCl_3$ **D** CCl_4

18 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