CHEMICAL BONDING TUTORIAL

Interatomic Bonding

1 Using the list below, give one example to each of the following solid lattices showing the given properties. Name the structure and type of bonding found in each lattice.

graphite, diamond, copper, iodine, sodium chloride

(a) A hard and brittle solid.
(b) A solid that conducts electricity and melts at 1085 °C.
(c) A solid that cuts through metal and does not conduct electricity.
(d) A substance that sublimates when heated.
(e) A solid that can be used as a lubricant.

2 Which statement(s) are correct?

I HC*l* (g) can conduct electricity.
II Covalent bond is a weak bond compared to ionic bond as boiling point of H_2O is lower than that of MgO.
III Ionic bonds and covalent bonds can both occur in the same compound.
IV Metals can be distinguished from ionic compounds by their electrical conductivity in the solid and liquid state.

A Statements **I** and **III** are correct.
B Statements **II** and **IV** are correct.
C Statement **III** and **IV** are correct.
D Statements **I, III** and **IV** are correct

3 Boron trifluoride and ammonia reacts in a 1:1 mole ratio to form a single compound. Describe the type of bond formed during this reaction.

4 Explain the following observations in terms of structure and bonding.

i. MgO has a higher melting point than NaC*l*.

ii. At room temperature and pressure, CO_2 is a gas, while SiO_2 is a solid of high melting temperature.

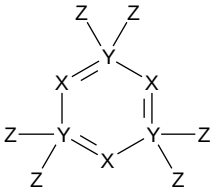
Dot-and-Cross Diagram and VSEPR

5 Fill up the table below for the following compounds:

compound	'dot-and-cross' diagram	(i) **Draw** and **name** the shape of the covalent molecule or polyatomic ion (ii) Indicate the **bond angle** in the diagram	Bonds or intermolecular forces broken during melting or boiling process
(i) Al_2O_3 (m.p. 2072°C) Ionic compound			Ionic bond
(ii) $AlCl_3$ (m.p. 192°C) Covalent molecule			Weak intermolecular forces
(iii) PCl_3 (l)			
(iv) CH_2Cl_2(l)			
(v) PCl_5(s)			
(vi) HCN			

compound	'dot-and-cross' diagram	(i) **Draw** and **name** the shape of the covalent molecule or polyatomic ion (ii) Indicate the **bond angle** in the diagram	Bonds or intermolecular forces broken during melting or boiling process
(vii) SO_2			
(viii) SO_3			
(ix) H_2O_2 (H-O-O-H arrangement)			
(x) $(NH_4)_2SO_4$			Ionic bond

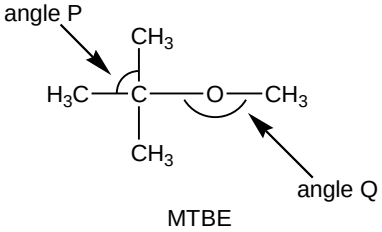
6 A stable molecule containing atoms of the elements, X, Y and Z has the following structure.



Which option is a possible combination of the elements?

	X	**Y**	**Z**
A	N	P	C*l*
B	O	S	C*l*
C	B	N	H
D	P	O	F

7 MTBE is a constituent of petrol.
What are the values of angle P and angle Q in a molecule of MTBE?



MTBE

	angle P	angle Q
A	90°	105°
B	90°	180°
C	109°	105°
D	109°	180°

8 Using VSEPR theory, predict which compound in each of the following pair of molecules has a larger bond angle.

(a) BCl_3 and NCl_3 **(b)** H_2S and PH_3

9 [N10/III/4c]

(a) Draw 'dot-and-cross' diagrams to show the bonding in the molecules of NO_2, O_3 and BF_3.

In the molecule NO_2, the central atom is nitrogen. In each case you should distinguish carefully between electrons originating from the central atom and those from the two outermost atoms. Include all lone pairs in your diagrams.

(b) Suggest a value for the bond angles in each of the three molecules, giving reasons for your choice.

Polarity and Intermolecular Forces

10 **(a)** Classify the following molecules as polar or non-polar.

NH_3, SF_6, $CH_2{=}CH_2$, CH_3OH, ClF_3, CH_3OCH_3

(b) Hence, classify the molecules in **(a)** according to the main type of intermolecular forces present.

Structure and Physical Properties

11 The boiling points of four compounds are given in the table below.

Compound	Boiling point/ °C
H_2O	100
CH_3OH	65
SiH_4	–107
CH_4	−164

Explain the differences in boiling point between

(a) CH_4 and SiH_4

(b) H_2O and CH_3OH

12 The boiling points of three organic compounds are given in the table below.

Compound	Molecular formula	M_r	Boiling point/°C
A	$CH_3CH_2OCH_2CH_3$	74	35
B	$CH_3CH_2CH_2CH_2OH$	74	118
C	$(CH_3)_3COH$	74	83

Explain the differences in boiling point between

(a) **A** and **B**

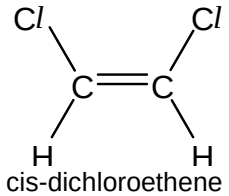
(b) **B** and **C**

13 Referring to table in question **5**, explain the following observations.

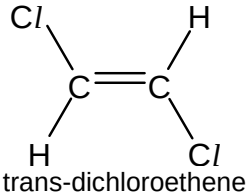
(i) Al_2O_3 conducts electricity in molten state while $AlCl_3$ in molten state does not.

(ii) Difference in physical state of PCl_3 and PCl_5.

14 **(a)** The boiling point of cis-dichloroethene is 333 K, whereas that of trans-dichloroethene is 321 K.

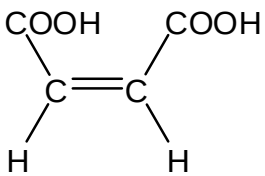


cis-dichloroethene

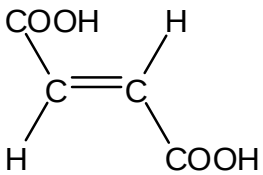


trans-dichloroethene

(b) The boiling point of **R** is higher than **Q**.



Q



R

Solubility

15 Predict with explanations whether or not

(a) CH_3CH_2OH is soluble in H_2O

(b) NH_4NO_3 is soluble in benzene, C_6H_6.

16 Ammonia and hydrogen chloride gases are soluble in water because they interact with the solvent.

$$HCl(g) + aq \rightarrow H^+(aq) + Cl^-(aq)$$
$$NH_3(g) + aq \rightarrow NH_3(aq)$$

Use suitable diagrams to illustrate all the possible interactions between the dissolved gas and **a water molecule**.

Application questions

17 Provide an explanation for the following observations.

(a) Ice is less dense than water.

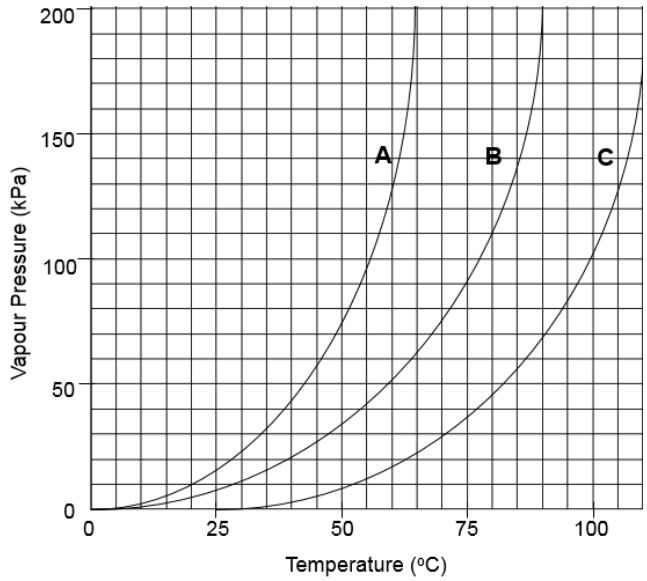
(b) The relative molecular mass of ethanoic acid is 120 in benzene, C_6H_6.

18 Vaporization occurs when some molecules in a liquid possesses enough kinetic energy to escape from the surface of the liquid at a given temperature.

Saturated vapour pressure is the pressure on the walls of the container exerted by the gas molecules vaporized from the surface of the liquid in a closed container when the rates of condensation and evaporation are equal.

Boiling occurs when the vapour pressure is equal to the external pressure which is usually the atmospheric pressure (101 kPa).

The graph below shows the vapour pressures of three liquids at varying temperatures.



(a) The identities for liquids **A** and **B** could be ethanol (CH_3CH_2OH) and propanone (CH_3COCH_3). Based on the graph, identify liquids **A** and **B** and explain your reasoning. [4]

(b) Suggest a possible identity for **C**.