BONDING & STRUCTURE Core (SL & HL)

1. (a) Select the substance with the highest boiling point in each of the following pairs. Explain your reasoning.

(i) Ethane (C_2H_6) and butane (C_4H_{10})

[2]

(Butane has the higher boiling point) stated or implied. AND
because it has a greater mass/number of electrons ✓
so more/stronger London dispersion forces ✓
(allow "intermolecular") forces

(ii) Ethanol (CH_3CH_2OH) and methoxymethane (CH_3OCH_3)

[2]

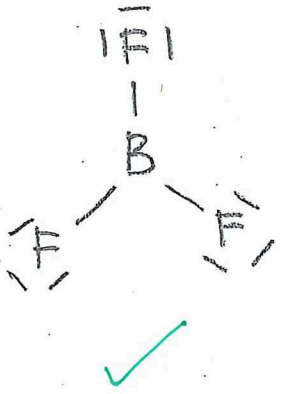
(Ethanol has the higher boiling point) stated or implied AND
because it has hydrogen bonding between molecules ✓
(as well as LDF & dipole-dipole) which are stronger ✓
than the LDForces and dipole-dipole forces in CH_3OCH_3.

(b) Boron trifluoride (BF_3) and nitrogen trifluoride (NF_3) are both covalent molecules.

(i) Draw Lewis (electron dot) structures to represent boron trifluoride and nitrogen trifluoride.

[2]

allow any combination of lines/dots/crosses.



✓

✓

(ii) State the shape and bond angles in boron trifluoride and nitrogen trifluoride.

[2]

BF_3 : trigonal planar, angles 120° ✓

NF_3 : trigonal pyramidal, angles 107° ✓
(electron domains are tetrahedral) (allow ~109.5°)

(iii) Predict and explain whether BF_3 and NF_3 have polar **bonds**. State and explain whether they are polar **molecules**.

[3]

Bonds in BF_3 and NF_3 will be polar as fluorine has a higher electronegativity than B or N. ✓
BF_3 will be a non-polar molecule as dipoles cancel / it is symmetrical. ✓
NF_3 will be polar, as it is not symmetrical. ✓

2. (a) Refractory tiles for furnaces may be made from magnesium oxide.

(i) Describe the bonding in magnesium oxide.

[2]

the bonding in MgO is ionic ✓
The bonds will be the electrostatic attraction between oppositely charged ions, ✓
(in this case Mg^{2+} and O^{2-} ions)

(ii) Describe the structure of magnesium oxide and explain why it has a very high melting point.

[2]

MgO has a giant structure / lattice of regularly arranged ions. ✓
Ionic bonds are strong / require a lot of energy to break. ✓

(b) Magnesium has typical metallic properties. Outline why metals, like magnesium, can conduct electricity and are malleable.

[2]

Metals have (a sea of) delocalised electrons that are mobile (and can carry charge). ✓

the metal ions/atoms (in the metal lattice) are in layers that can slide over one-another ✓ (whilst maintaining attraction).

(c) Explain why magnesium has a higher melting point than sodium.

[2]

✓ (Magnesium forms a 2+ ion / donates 2 electrons to the sea of electrons (as opposed to sodiums 1+/1) ✓ So the metal bonds / attraction in the lattice is greater / requires more energy to break.

3. (a) Sodium carbonate is a white solid. The carbonate ion (CO_3^{2-}) is a compound ion.

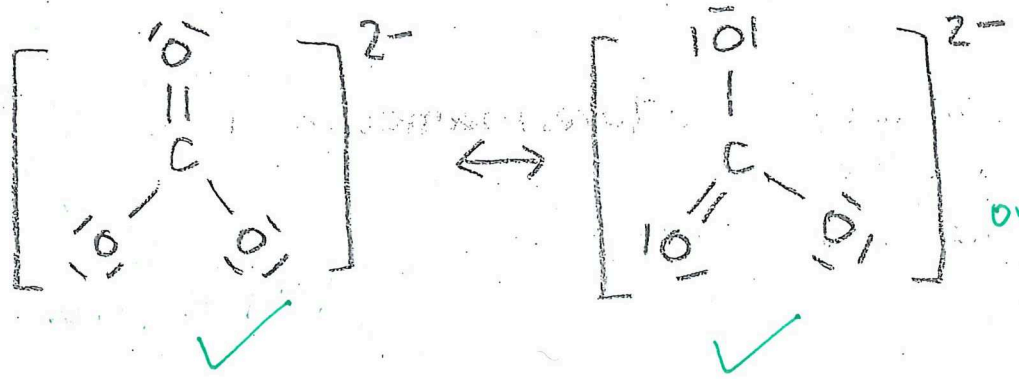
(i) Write the formula for sodium carbonate.

[1]

Na_2CO_3 ✓

(ii) Draw a Lewis (electron dot) structure to represent a carbonate ion. Draw a second **resonance structure** for the carbonate ion.

[2]



✓ ✓ or double bond bottom right.

(iii) The bonds between the carbon and oxygen atoms in the carbonate ion are covalent. Describe the attraction in a covalent bond.

[2]

The electrostatic attraction between the shared pair of electrons ✓ and the nuclei of the two atoms. ✓

(iv) Explain why sodium carbonate does not conduct electricity when solid but does conduct when dissolved in water.

[2]

when solid the ions cannot move, ✓ but when dissolved in water the ions can move ✓ (and carry charge)

4. Elemental carbon has several allotropic forms, including diamond and graphite. Explain, in terms of bonding and structure, why carbon (diamond) is a very hard substance and does not conduct electricity, but carbon (graphite) is soft and can conduct electricity.

[6]

Both diamond and graphite have a giant covalent/ macromolecular structure. ✓

Diamond's carbon atoms form four bonds to each other in a tetrahedral arrangement ✓

Diamond has strong bonds in a rigid structure ✓

Diamond has no mobile electrons ✓

Graphite's carbon atoms form three bonds to each other in a trigonal planar shape ✓

(This forms) layers which can slide over one-another as there are only weak London dispersion forces between the layers. ✓

Graphite has mobile electrons. ✓

ANY 6 max

Total Marks 32 (48 minutes)