Bonding Revision

Bold italic = Paper 2 only

Some useful phrases:

Strong electrostatic forces of attraction between oppositely-charged ions require a lot of energy to break

Weak intermolecular forces of attraction require little energy to break

Giant lattice of positive ions in a sea of delocalized electrons

Electrostatic attraction between positive ions and delocalized electrons

Layers of positive ions slide over each other

Strong electrostatic attraction between a shared ***pair*** of electrons and the nuclei of ***both*** atoms making up the bond

Don't get mixed up:

Ionic substances conduct electricity when molten/in aqueous solution because IONS are free to move

Metals conduct electricity because delocalized ELECTRONS are free to move

Graphite conducts electricity because delocalized ELECTRONS are free to move

Do not:

- Mention the words *molecules/intermolecular* forces when talking about ionic compounds
- Get mixed up between *ammoni**a*** (NH_3 – a covalent molecule) and *ammoni**um*** (NH_4^+ an ion)
- Get mixed up between sulfide (S^{2-}) and sulfate (SO_4^{2-}) or between nitride (N^{3-}) and nitrate (NO_3^-)
- Mention the word 'electrons' when explaining why ionic compounds conduct electricity

Remember:

Intermolecular forces are between *molecules*   Covalent bonds are between *atoms*.

When a covalent molecular substance melts/boils only the weak intermolecular forces of attraction are broken – this does not require much energy.

If a compound contains a metal it is almost certainly ionic (exceptions will be things like ammonium chloride)

Diamond and graphite have giant structures but C_{60} fullerene has a simple molecular structure

Covalent molecular substances with higher relative molecular masses usually have higher melting/boiling points because the intermolecular forces are stronger.

Bonding Revision

1 Complete the sentences:

positive ions are formed when atoms …LOSE electrons

negative ions are formed when atoms …GAIN…. electrons

2 Give the charges on the ions followed by the following atoms:

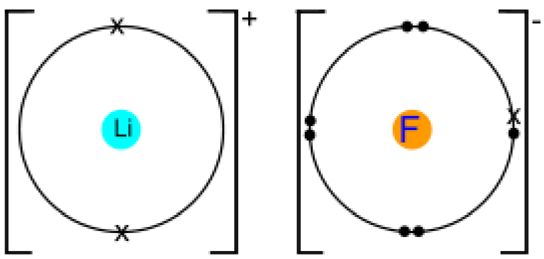
K	Al	Cl	S	Ca	N
K^{+}	Al^{3+}	Cl^{-}	S^{2-}	Ca^{2+}	N^{3-}

3 Give the formulae of the following ions:

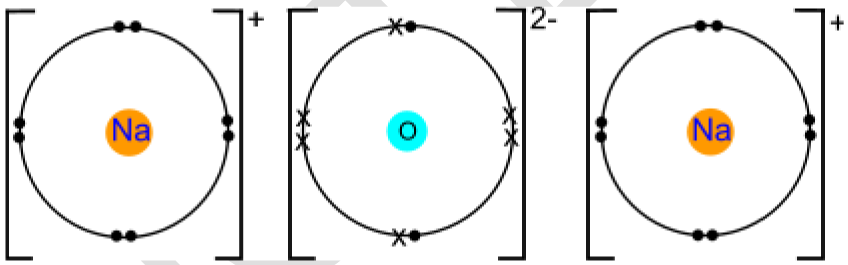
Hydroxide	Nitrate	Sulfate	Carbonate	Ammonium	Silver	iron(II)	Zinc	lead(II)
OH^{-}	NO_3^{-}	SO_4^{2-}	CO_3^{2-}	NH_4^{+}	Ag^{+}	Fe^{2+}	Zn^{2+}	Pb^{2+}

4 Draw dot and cross diagrams showing the ions present in each of the following – you only need to show outer shell electrons

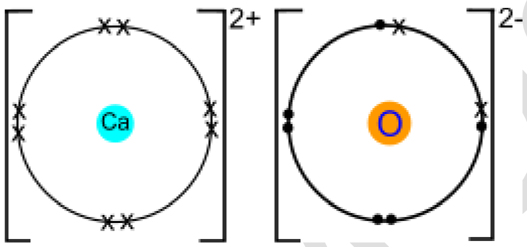
Lithium fluoride



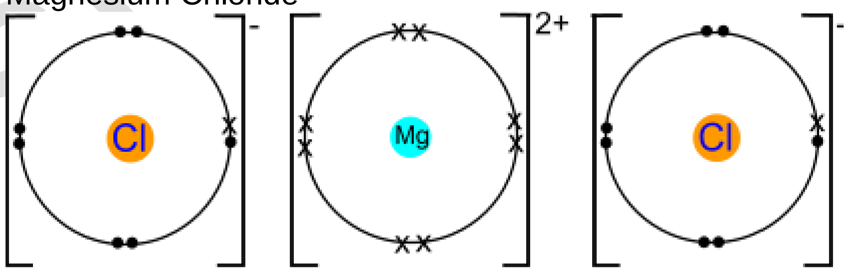
sodium oxide



Calcium Oxide



Magnesium Chloride



5 Work out the formulae of the following compounds:

Potassium oxide	Calcium chloride	Magnesium hydroxide	Barium nitrate	Ammonium sulfate	Sodium carbonate
K_2O	$CaCl_2$	$Mg(OH)_2$	$Ba(NO_3)_2$	$(NH_4)_2SO_4$	Na_2CO_3
Copper(II) sulfate	Lead(II) nitrate	Silver bromide	Zinc sulfate	iron(II) hydroxide	iron(III) chloride
$CuSO_4$	$Pb(NO_3)_2$	AgBr	$ZnSO_4$	$Fe(OH)_2$	$FeCl_3$

6 Fill in the gaps:

(a) Ionic bonding is a …STRONG… electrostatic attraction between OPPOSITELY-CHARGED ions

(b) An ionic crystal is a GIANT three-dimensional LATTICE structure held together by the attraction between OPPOSITELY-CHARGED IONS

Bonding Revision

7 Explain the following in terms of structure and bonding:

(a) ionic compounds have high melting points

Strong electrostatic forces of attraction between oppositely-charged ions throughout the giant structure require a lot of energy to overcome

(b) ionic compounds conduct electricity only when molten or in solution

In solid state – ions held tightly in place in the lattice structure – cannot move (other than vibrate)
Molten/in solution – ions free to move

8 Use the following words to fill in the gaps. Each word may be used once, more than once or not at all.

electrons	*nuclei*	*electrostatic*	*sharing*	*both*	*transfer*
pair	*shared*	*electromagnetic*	*ions*	*molecule*	*weak*

Ionic bonding involves the …… *transfer* ……….. of electrons from one atom to

another. Covalent bonding involves the … *sharing* ……of a … *pair*.. of … *electrons* …

The atoms in a covalent bonds are held together by the …… *electrostatic* …….. attraction

between the … *nuclei* …… of …… *both* …. atoms making up the bond and the

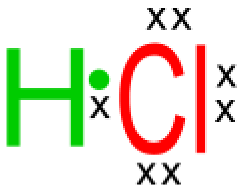
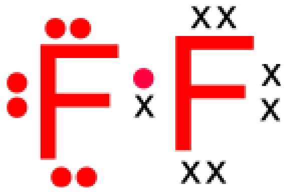
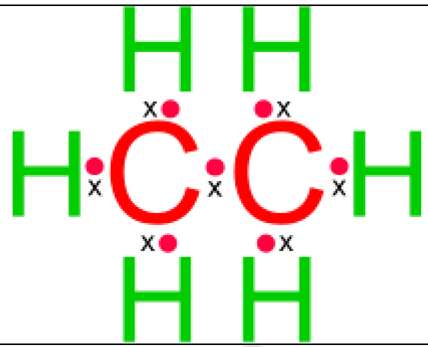
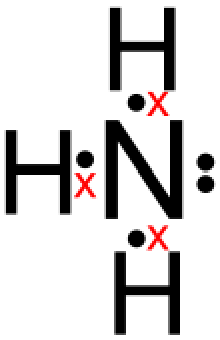
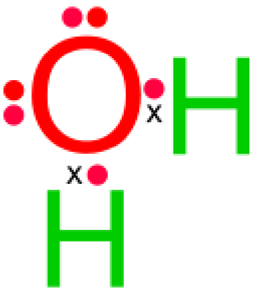
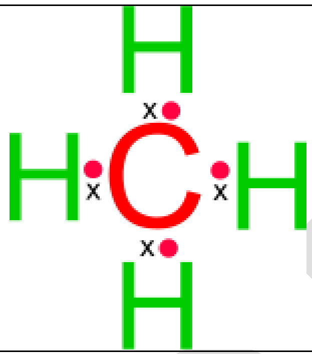
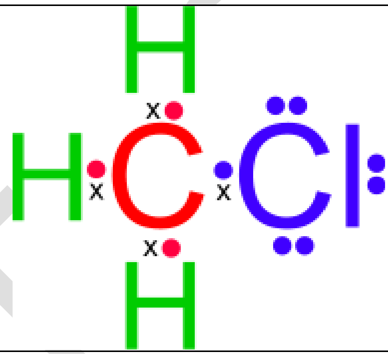
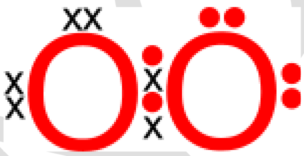
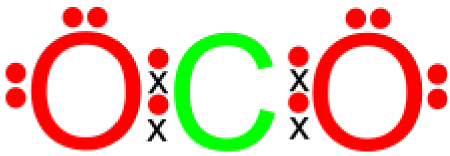
… *shared* …..   …… *pair* ….. of …… *electrons* …….

9 State the type of structure and bonding for each of the following by putting ticks in boxes

SUBSTANCE	IONIC	COVALENT	SIMPLE MOLECULAR	GIANT
Potassium chloride	✓			✓
Water		✓	✓	
Ammonia		✓	✓	
Magnesium oxide	✓			✓
Sulfur dioxide		✓	✓	
Diamond		✓		✓
Graphite		✓		✓
C_{60} fullerene		✓	✓	

Bonding Revision

10 Draw dot and cross diagrams (showing outer shells only) for the following:

			
H_2	**HCl**	**F_2**	**C_2H_6**
			
NH_3	**H_2O**	**CH_4**	**CH_3Cl**
			
N_2	**C_2H_4**	**O_2**	**CO_2**

11 Methane, CH_4, has a simple molecular structure. Explain whether you would expect it to have a high or low melting/boiling point?

Melting/boiling point: High (Low) *circle the correct answer*

Explanation: only weak intermolecular forces of attraction must be broken
These require little energy to overcome

12 The boiling point of the halogens are shown in the table.

	Boiling point / ^{o}C
Fluorine, F_2	-188
Chlorine, Cl_2	-34
Bromine, Br_2	59
Iodine, I_2	184

(a) State the type of structure and bonding in these substances:

Structure: simple molecular Bonding:…covalent

(b) Explain the trend in boiling point in terms of structure and bonding

intermolecular forces of attraction must be broken
these increase in strength as relative molecular mass increases
therefore I_2 has stronger intermolecular forces of attraction than F_2 and so more energy must be supplied to overcome them

13 Diamond has a giant covalent structure. Explain whether you would expect it to have a high or low melting/boiling point?

Melting/boiling point: High Low *circle the correct answer*

Explanation: strong covalent bonds throughout the giant structure must be broken
This requires a large amount of energy

14 Complete the table by putting ticks in the appropriate boxes.

	Structure		Melting point		Hardness		Electrical conductivity	
SUBSTANCE	**SIMPLE MOLECULAR**	**GIANT**	**High**	**Low**	**Hard**	**Soft**	**Good**	**Poor**
Diamond		✓	✓		✓			✓
Graphite		✓	✓			✓	✓	
C_{60} fullerene	✓			✓		✓		✓

15 Explain why fullerene, C_{60}, has a lower melting point than diamond

C_{60} has a simple molecular structure but diamond has a giant structure

C_{60} only weak intermolecular forces of attraction must be broken - these require little energy to overcome

Diamond: strong covalent bonds throughout the giant structure must be broken - this requires a large amount of energy

16 Delete words as appropriate to make the following paragraph correct.

Covalent compounds are usually ***poor*** conductors of electricity. This is because

they ***don't*** contain charged particles that are ***free*** to move

Extension Question

17 A student gives the following answer in an exam:

I would expect ethene (C_2H_4) to have a higher boiling point than ethane (C_2H_6) because there is a double bond between the carbon atoms in ethane but only a single bond between the carbon atoms in ethane. A double bond is stronger than a single bond, therefore more energy is needed to break it and therefore ethane has a higher boiling point.

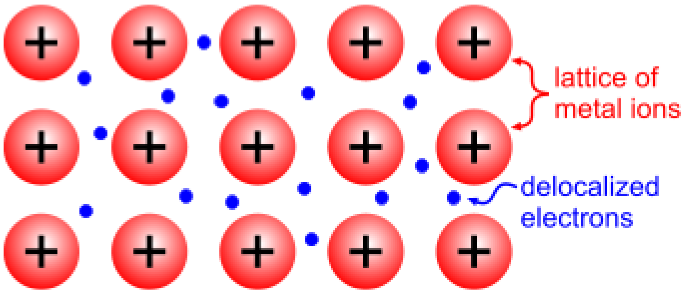
Discuss the student's answer

This is incorrect because ethane and ethane are both covalent molecular substances;
only intermolecular forces of attraction are broken when they boil and not covalent bonds;
therefore it makes no difference whether there are double bonds between the C atoms or single bonds;

The boiling point is determined by the strength of the intermolecular forces;
Ethene has a higher relative molecular mass than ethane and so it could have a higher boiling point than ethane;
because intermolecular forces get stronger as relative molecular mass increases (although other factors can also play a role);

Metallic Bonding – Paper 2 only

18 Draw a labelled 2D diagram to show the structure of a metal and describe its structure.

Diagram	Description
	Giant lattice structure of positive ions in a sea of delocalised electrons.

19 Complete the following sentence by inserting appropriate words in the spaces.

Metallic bonding is the ELECTROSTATIC attraction between POSITIVE IONS

and DELOCALISED ELECTRONS

20 Explain the following in terms of structure and bonding:

(a) metals are malleable

Layers of positive ions
slide over each other

(b) metals are good conductors of electricity

Delocalised electrons
are free to move