Bonding

The nature of chemical bonds

Covalent dot and cross

Draw dot and cross diagrams to illustrate the bonding in the following covalent compounds. If you wish you need only draw the outer shell electrons;

(2 marks for each correct diagram)

1. Water, H_2O

2. Carbon dioxide, CO_2

3. Ethyne, C_2H_2

4. Phosphoryl chloride, $POCl_3$

5. Sulfuric acid, H_2SO_4

Draw dot and cross diagrams to illustrate the bonding in the following ionic compounds.

(2 marks for each correct diagram)

1. Lithium fluoride, LiF

2. Magnesium chloride, $MgCl_2$

3. Magnesium oxide, MgO

4. Lithium hydroxide, LiOH

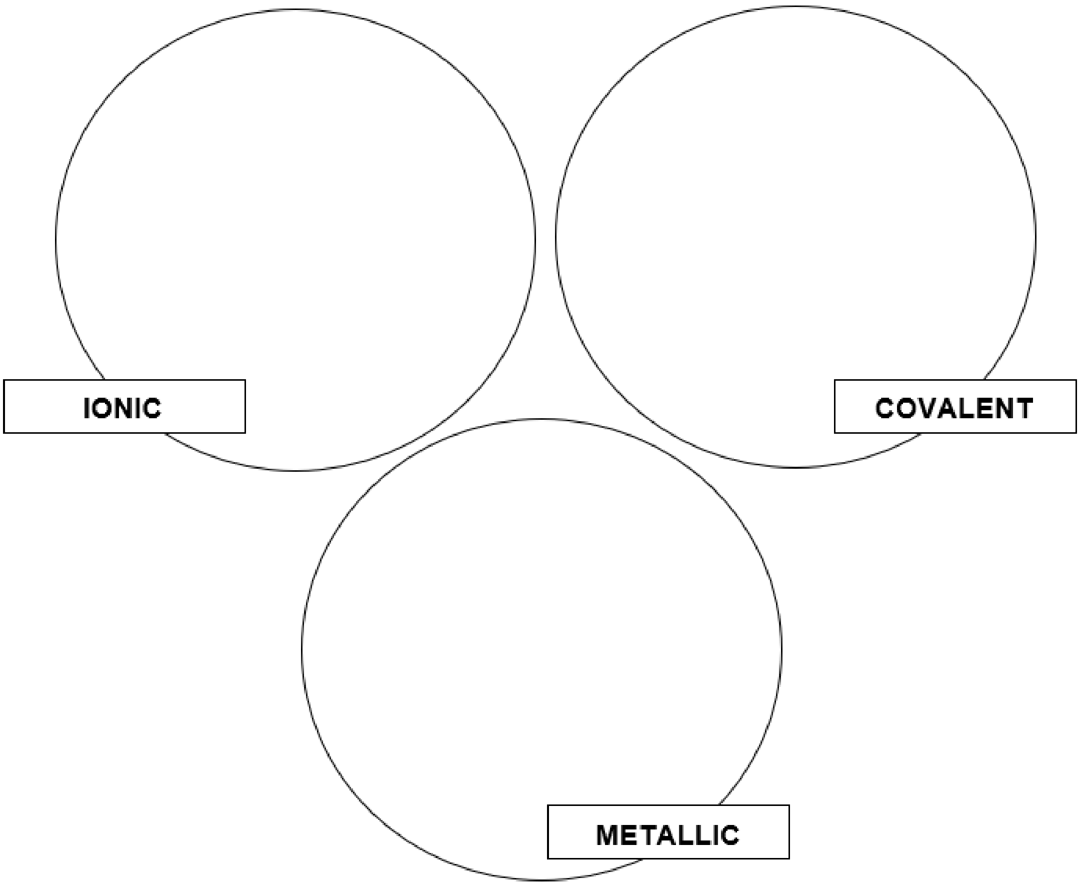
5. Sodium cyanide, NaCN

Which type of chemical bond

There are three types of strong chemical bonds; **ionic**, **covalent** and **metallic**.

1. Sort the compounds below into groups within the circles below according to their chemical bonding;

sodium chloride, NaCl	magnesium, Mg	magnesium oxide, MgO
methane, CH_4	oxygen, O_2	barium iodide, BaI_2
aluminium, Al	ammonia, NH_3	caesium, Cs



2. For each of the types of compound, indicate if you would expect them to;
(a) have a high or a low melting point
(b) conduct electricity

Bonding summary

A student has written the revision cards below to help her prepare for the exam. However she has made a number of mistakes. Can you correct her cards to make sure she has accurate information to revise from;

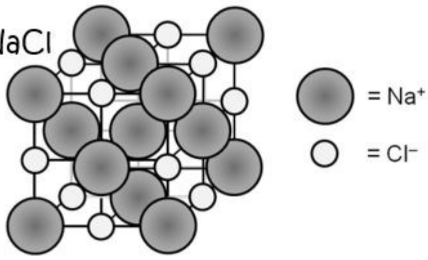
(1 mark for each correct correction made)

Ionic bonding

Between a metal and a non-metallic atom, e.g. NaCl

Electrons are shared between the atoms

The molecules have high melting points owing to the strong electrostatic attraction between the ions



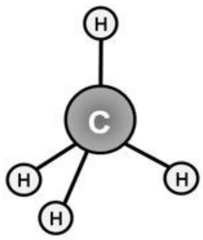
Ionic compounds do not conduct electricity at all as the ions that carry the current are held in a fixed position in the lattice structure

Covalent bonding

Between two non-metallic atoms, e.g. CO_2

Electrons are transferred between the atoms

Covalent molecules have high melting points because of the strong covalent bonds which must be broken



Covalent compounds do not conduct electricity at all as there are no free electrons

Metallic bonding

In metallic bonding, the outer electrons from the metal atoms merge to produce a lattice of negative metal ions in a sea of delocalised electrons

The strength of the metal depends on two things;
- the charge on the metal ion
- the size of the metal ion

Therefore sodium is stronger than magnesium

Metals have low melting points because of the repulsive forces between the negative electrons which need little energy to be broken

Metals conduct electricity because of the sea of delocalised electrons which can move through the structure to carry the charge

Co-ordinate bonding

By drawing dot and cross diagrams, decide which of the species below contain a co-ordinate or dative covalent bond in which both electrons in one of the covalent bonds is provided by a single atom.

1. H_2S (2 marks)

2. NH_4^+ (2 marks)

3. H_3NBF_3 (2 marks)

4. CO (2 marks)

5. PF_3 (2 marks)

Electronegativity and polarity

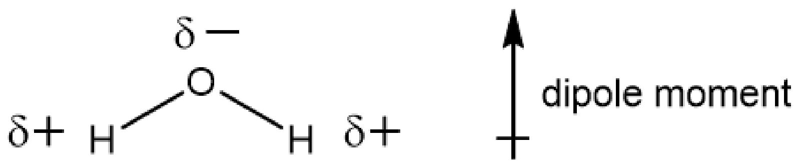
A **polar bond** is a bond in which the electrons between the atoms that are bonded together covalently are shared unequally. The unequal share of electrons is usually shown by a δ+ and a δ– sign. If a molecule contains more than one polar bond, the effect of the polarity of all the bonds in the molecule may result in the molecule having a **dipole moment**.

Use the table of the Pauling electronegativity of different elements to identify any polar bonds in the molecules below. Then use these polar bonds to decide if the molecule has a dipole moment (this can be shown by an arrow with a line through it $\longrightarrow$; the head of the arrow points towards the negative end.)

H 2.1							He
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne
Na 0.9	Mg 1.2	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar

(2 marks per molecule)

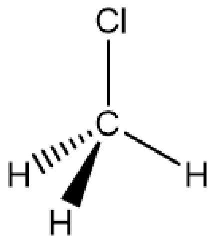
e.g. H_2O



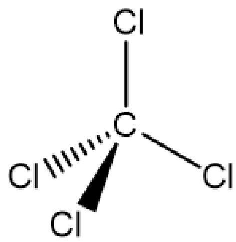
1. HCl

2. CO_2

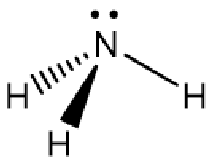
3. CH_3Cl



4. CCl_4



5. NH_3



Intermolecular forces

Molecules are attracted to each other by weak intermolecular forces. There are three types of intermolecular force;

- Van der Waal's forces
- Dipole-dipole forces
- Hydrogen bonding

For each group of molecules below, identify the strongest type of intermolecular force present in each molecule (1 mark) and then use this information to order the molecules according to their boiling point, from lowest to highest (1 mark).

1. CH_4 SiH_4 SnH_4

2. NH_3 PH_3 AsH_3

3. HF HCl HBr

4. CH_3F CH_3Cl CH_4

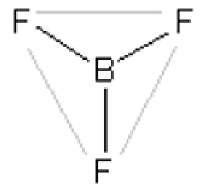
5. HF H_2O NH_3

Shapes of molecules

For this activity you need to work with a partner. The diagrams below show the 3 dimensional shapes of some different molecules. Your job is to describe the diagrams to your partner such that they can draw exact copies without seeing the original diagram. Good luck!

(2 marks awarded for each diagram your partner draws)

1.



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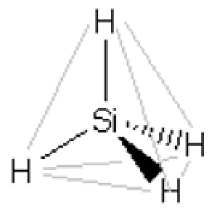
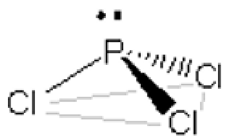
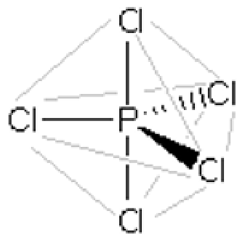


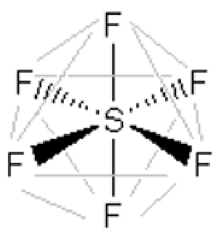
3.



4.



5.



Properties and bonding

Match the compound on the left to its correct structure from the middle bank of statements and one or more statements from the column on the right. Aluminium has been done for you.

Compound	Structure	
aluminium	metal	Weak intermolecular forces are broken when it boils
		High melting point
diamond	simple covalent molecule	Conducts electricity when molten
		Conducts electricity when in solution
iodine	ionic compound	Conducts electricity when solid
chlorine	molecular crystal	Low melting point
		An ionic bond is broken when it melts
potassium fluoride	macromolecular crystal	A covalent bond must be broken to melt it

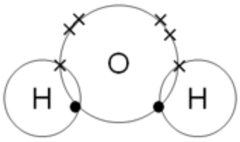
BONUS MARK Sketch the arrangement of molecules in a crystal of iodine

Bonding – Answers

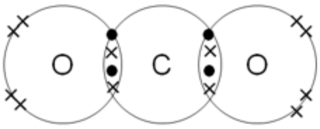
The nature of chemical bonds

Covalent dot and cross

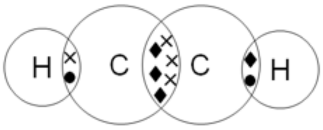
1.



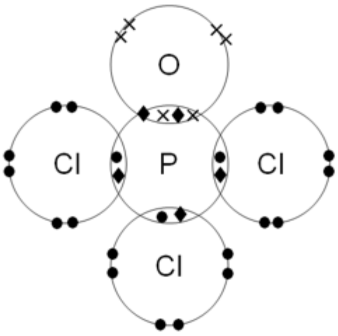
2.



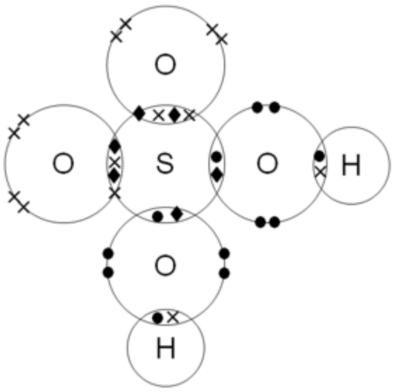
3.



4.



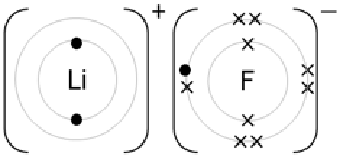
5.



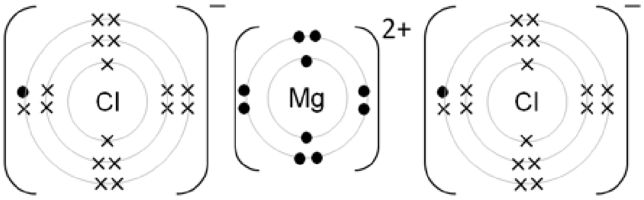
(2 marks for each diagram)

Ionic dot and cross

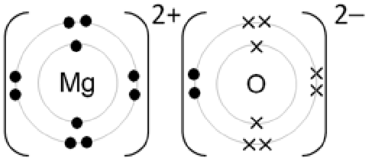
1.



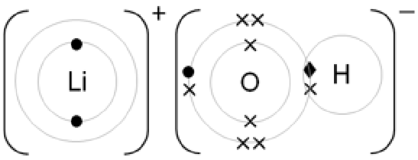
2.



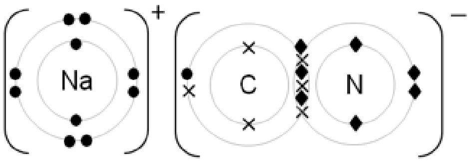
3.



4.

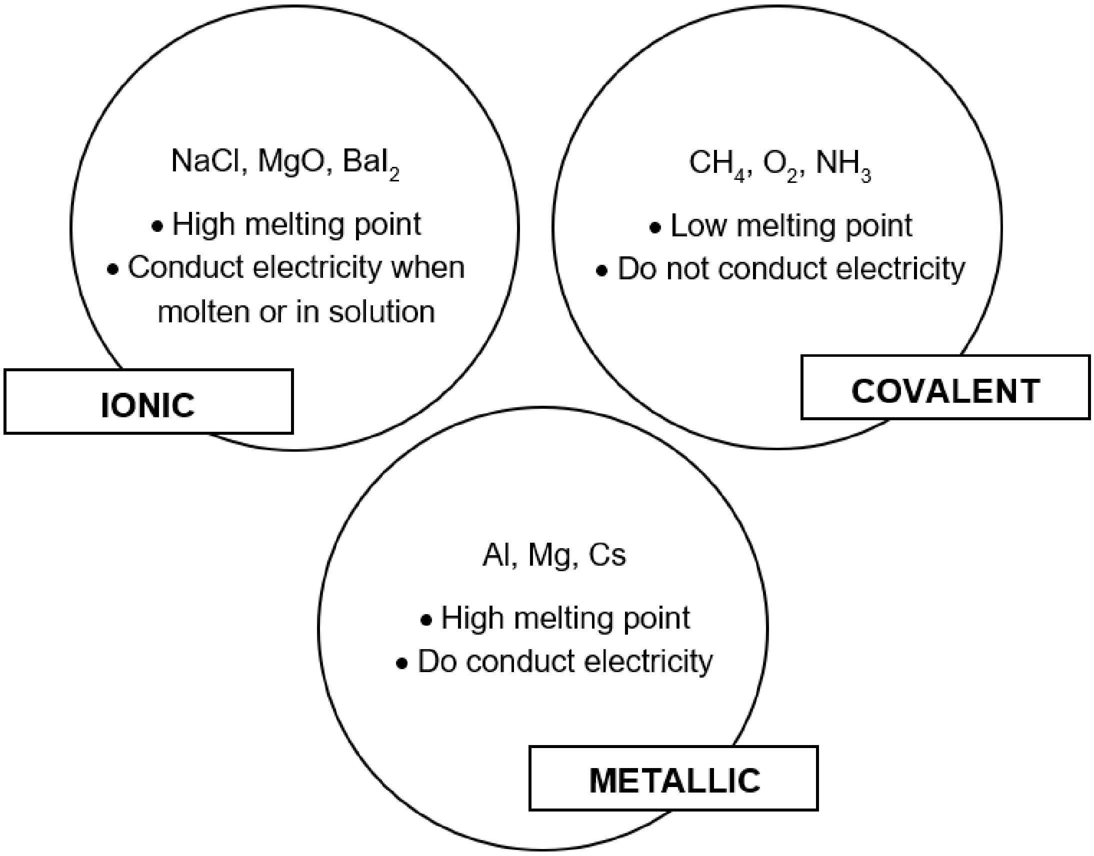


5.



(2 marks for each diagram)

Types of chemical bond



(1 mark for all three of each type correctly identified;
1 mark for each of the six comments relating to melting point / conductivity;
1 bonus mark for clarifying that ionic compounds only conduct when molten or in solution)

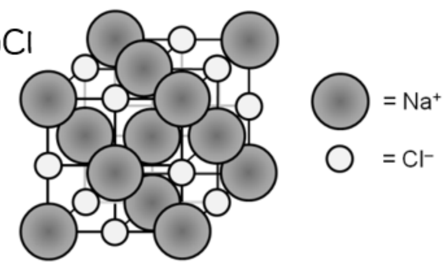
Bonding summary

Ionic bonding

Between a metal and a non-metallic atom, e.g. NaCl

Electrons are shared between the atoms

The molecules have high melting points owing to the strong electrostatic attraction between the ions



Ionic compounds do not conduct electricity at all as the ions that carry the current are held in a fixed position in the lattice structure

Corrections;

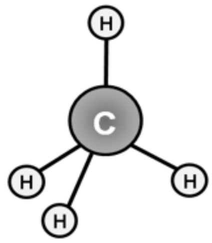
(1 mark) In the diagram the Na$^+$ ion should be smaller than the Cl$^-$ ion
(1 mark) Electrons are not shared but transferred between the atoms
(1 mark) Ionic compounds are NOT molecules
(1 mark) Ionic compounds can conduct electricity when molten or in solution

Covalent bonding

Between two non-metallic atoms, e.g. CH_4

Electrons are transferred between the atoms

Covalent molecules have high melting points because of the strong covalent bonds which must be broken



Covalent compounds do not conduct electricity at all as there are no free electrons

Corrections;
(1 mark) Electrons are shared between atoms not transferred
(1 mark) Covalent molecules have low melting points because……
(1 mark) Only weak intermolecular forces need to be broken (clarification of correction above)

Metallic bonding

In metallic bonding, the outer electrons from the metal atoms merge to produce a lattice of negative metal ions in a sea of delocalised electrons

The strength of the metal depends on two things;
- the charge on the metal ion
- the size of the metal ion
Therefore sodium is stronger than magnesium

Metals have low melting points because of the repulsive forces between the negative electrons which need little energy to be broken

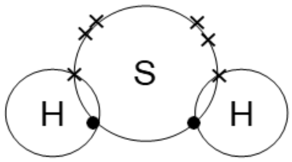
Metals conduct electricity because of the sea of delocalised electrons which can move through the structure to carry the charge

Corrections;
(1 mark) The metal ions are positive not negative
(1 mark) Sodium is weaker than magnesium (following on from the points raised)
(1 mark) Metals have high melting points because of the attractive forces between the positive metal ions and the delocalised sea of electrons.

Covalent bonding

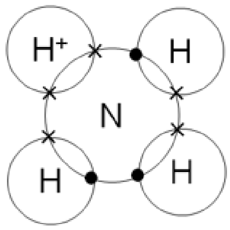
Coordinate bonding

1.



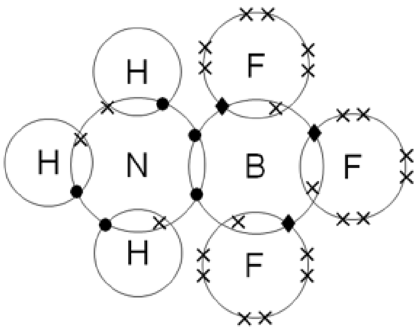
No coordinate bonds

2.



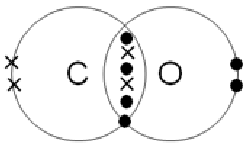
One coordinate bond in which both electrons are donated from the N atom to the H

3.



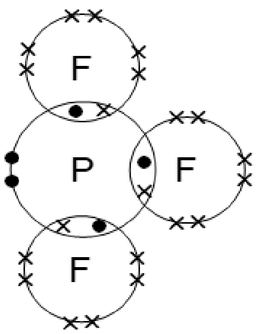
One coordinate bond in which both electrons are donated from the N atom to the B atom

4.



One coordinate bond in which both electrons are donated from the O atom to the C atom

5.



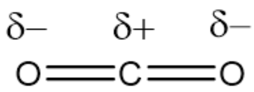
No coordinate bonds

(1 mark for each correct dot and cross diagram;
1 mark for correct identification of the coordinate bond or the lack of coordinate bond)

Electronegativity and polarity

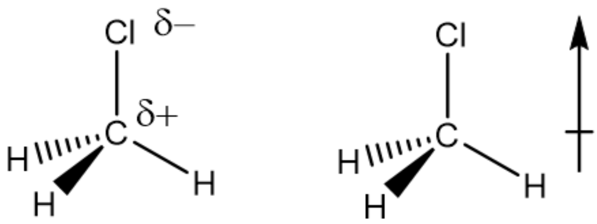
1.

2.

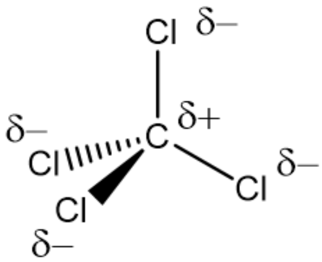


no dipole moment

3.

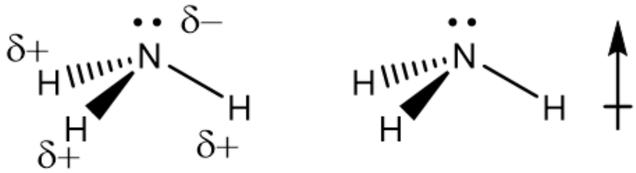


4.



no dipole moment

5.



(1 mark for the correct placement of the δ+ and δ–;
1 mark for correct identification of the dipole moment)

Intermolecular forces

1. CH_4 – VdW's SiH_4 – VdW's SnH_4 – VdW's

∴ B.p. $CH_4 < SiH_4 < SnH_4$

2. NH_3 – Hydrogen bonding PH_3 – VdW's AsH_3 – VdW's

∴ B.p. $PH_3 < AsH_3 < NH_3$ – Hydrogen bonding

3. HF – Hydrogen bonding HCl – dipole dipole HBr – dipole dipole

∴ B.p. HBr < HCl < HF

4. CH_3F – dipole dipole CH_3Cl – dipole dipole CH_4 – VdW's

∴ B.p. $CH_4 < CH_3F < CH_3Cl$

5. HF – Hydrogen bonding H_2O – Hydrogen bonding NH_3 – Hydrogen bonding

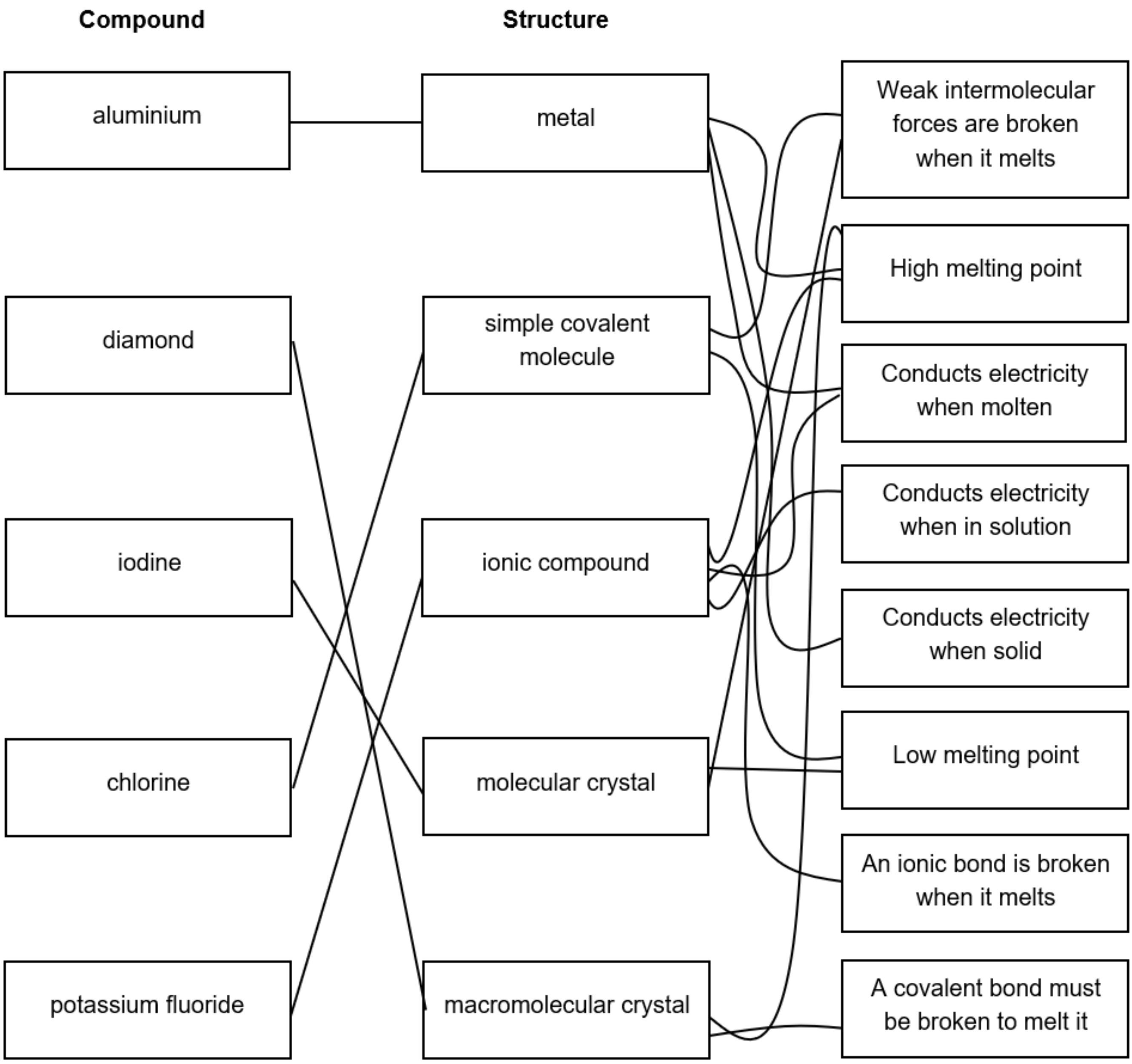
∴ B.p. $NH_3 < HF < H_2O$

(1 mark for correct identification of strongest intermolecular force in all three molecules;
1 mark for the correctly predicting the correct order of the molecules based on their boiling points)

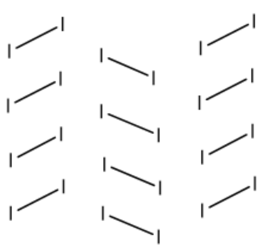
Shapes of molecules

2 marks allocated for the drawing of each molecule.

Properties and bonding



4 marks for the correct identification of the structure of each compound
5 marks for the correct statements (1 mark each for the correct identification of 2 correct statements for diamond, iodine and chlorine, 2 marks for the 4 correct statements for potassium fluoride)



1 Bonus mark;