Topic 4 Chemical bonding and structure (SL)

Syllabus:

4.1 Ionic bonding and structure

Cations form by metals losing valence electrons

Anions form by non-metals gaining electrons

No. of electrons lost or gained is determined by the electron configuration of the atom

Ionic bond is due to the electrostatic attraction between oppositely charged ions

Ionic compounds are solid lattice structure under normal conditions.

Deduce the formula and the name of ionic compounds

Physical properties of ionic compounds

4.2 Covalent bonding

A covalent bond is formed by the electrostatic attraction between a shared pair of electrons and the positively charged nuclei.

Single, double and triple covalent bonds involve one, two and three standard pairs of electrons respectively

Bond length decreases and bond strength increases

Polar bond is due to the difference in electronegativities of the bonded atoms

4.3 Covalent structure

Drawing Lewis structures

"Octet rule" refers to the tendency of atoms to have 8 valence electrons

Be and B can form stable compounds with incomplete octets of electrons

Resonance structures occur when there is more than one possible position for a double bond in a molecule

VSEPR theory determines the shaped of species

C and Si form giant covalent structure

Explanation of the properties of giant covalent compounds in terms of their structures

4.4 Intermolecular forces

Intermolecular forces include London (dispersion) forces, dipole-dipole forces and hydrogen bonding

Strength: London (dispersion) forces < dipole-dipole forces < hydrogen bonding

Explain the physical properties of the covalent compounds in terms of their structure and intermolecular forces

4.5 Metallic bonding

Metallic bond is the electrostatic attraction between a lattice of positive ions and delocalized electrons

Charge of ions and the radius of metal ion affect the strength of metallic bond

Alloys usually contain more than one metal and have enhanced properties

4.1 Ionic bonding and structure

- Ionic bond are formed when one or more electrons are transferred from metal atom to non-metal atom.
- Ionic bond is the electrostatic attraction between the oppositely charged ions.
- The metal ion and non-metal have the noble gas electron configuration.
- Cations (positively charged ions) form by metals losing valence electrons. (Na^+, Mg^{2+}, Al^{3+})
- Anions (negatively charged ions) form by non-metals gaining electrons. (F^-, O^{2-}, N^{3-})
- Polyatomic ions are those ions consisting of more than one atom. (CO_3^{2-}, OH^-, NH_4^+)

Cations			Cations		
Charge	Name	Formula	Charge	Name	Formula
1+	Lithium ion	Li^+	2+	Magnesium ion	Mg^{2+}
	Sodium ion	Na^+		Calcium ion	Ca^{2+}
	Potassium ion	K^+		Barium ion	Ba^{2+}
	Silver ion	Ag^+		Zinc ion	Zn^{2+}
	Hydrogen ion	H^+		Iron (II) ion	Fe^{2+}
	Ammonium ion	NH_4^+		Copper (II) ion	Cu^{2+}
	Hydronium ion	H_3O^+		Lead (II) ion	Pb^{2+}
3+	Aluminium ion	Al^{3+}	4+	Lead (IV) ion	Pb^{4+}
	Iron (III) ion	Fe^{3+}			
	Chromium (III) ion	Cr^{3+}			

Anions			Anions		
Charge	Name	Formula	Charge	Name	Formula
1–	Fluoride ion	F^-	2–	Oxide ion	O^{2-}
	Chloride ion	Cl^-		Sulphide ion	S^{2-}
	Bromide ion	Br^-		Sulphate ion	SO_4^{2-}
	Iodide ion	I^-		Carbonate ion	CO_3^{2-}
	Hydroxide ion	OH^-		Dichromate ion	$Cr_2O_7^{2-}$
	Nitrate ion	NO_3^-		Thiosulphate ion	$S_2O_3^{2-}$
	Hydrogen carbonate ion	HCO_3^-		Chromate ion	CrO_4^{2-}
	Hydrogen sulphate ion	HSO_4^-	3–	Nitride ion	N^{3-}
	Permanganate ion	MnO_4^-		Phosphate ion	PO_4^{3-}
	Cyanide ion	CN^-			
	Ethanoate ion	CH_3COO^-			

- **Example: Sodium Chloride (NaCl)**

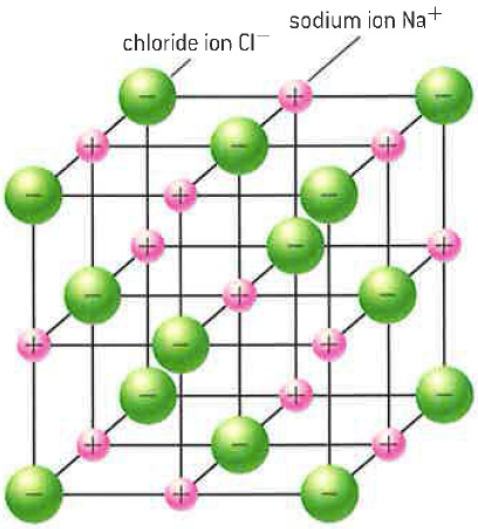
  Na transfers the valence electron to Cl.

  $Na \rightarrow Na^+ + e^-$

  Electron arrangement of Na^+: 2, 8 (octet)

  $Cl + e^- \rightarrow Cl^-$

  Electron arrangement of Cl^-: 2, 8, 8 (octet)



- **Formula of ionic compound (Cross method)**

  Cation is always on the RHS

  The formula shows the ratio of cation and anion.

  Na^{1+} and Cl^{1-} → NaCl (One Na^+ and One Cl^-)

  Mg^{2+} and Cl^{1-} → $MgCl_2$ (One Mg^{2+} and Two Cl^-)

  Al^{3+} and O^{2-} → Al_2O_3 (Two Al^{3+} and Three O^{2-})

- **Name of ionic compound (Cation first and then Anion)**

  NaCl: Sodium chloride

  Al_2O_3 : Aluminium oxide

  Na_2SO_4: Sodium sulphate

  NH_4Cl: Ammonium chloride

- **Properties of ionic compound**
  1. Ionic compounds are usually solids with lattice structure.
  2. High melting point (NaCl is 800°C) and boiling point (NaCl is 1413°C)
  3. It doesn't conduct electricity in solid state because the ions occupy fixed position in lattice structure.
  4. It conducts electricity in molten state and aqueous state (dissolved in water) because there are mobile ions.
  5. It is soluble in polar solvents such as water because the ions can form interaction with water molecule, but it is soluble in non-polar solvents.

MCQ

1. What is the formula of magnesium fluoride?

   A. Mg_2F_3
   B. Mg_2F
   C. Mg_3F_2
   D. MgF_2

2. Which properties do typical ionic compounds have?

	Melting point	Conductivity of solid
A.	High	Good
B.	Low	Good
C.	High	Poor
D.	Low	Poor

3. What are the correct formulas of the following ions?

	Nitrate	Sulfate	Phosphate	Hydrogencarbonate
A.	NO_3^-	SO_4^{2-}	PO_4^{3-}	HCO_3^-
B.	NO_3^-	SO_4^{2-}	PO_3^{3-}	HCO_3^{2-}
C.	NO_2^-	SO_4^-	PO_4^{3-}	HCO_3^-
D.	NO_2^-	SO_3^{2-}	PO_3^{3-}	HCO_3^{2-}

4. Which statement best describes ionic bonding?

   A. It is the electrostatic attraction between positive ions and delocalized electrons and occurs by the transfer of electrons.
   B. It is the electrostatic attraction between positive ions and negative ions and occurs by the transfer of electrons.
   C. It is the electrostatic attraction between positive ions and negative ions and occurs by the sharing of electrons.
   D. It is the electrostatic attraction between positive nuclei and electrons and occurs by the sharing of electrons.

5. The formula of cerium(III) sulfate is $Ce_2(SO_4)_3$. What is the correct formula of cerium(II) phosphate?

   A. CeP
   B. $Ce_2(PO_4)_3$
   C. $Ce_3(PO_4)_2$
   D. $CePO_4$