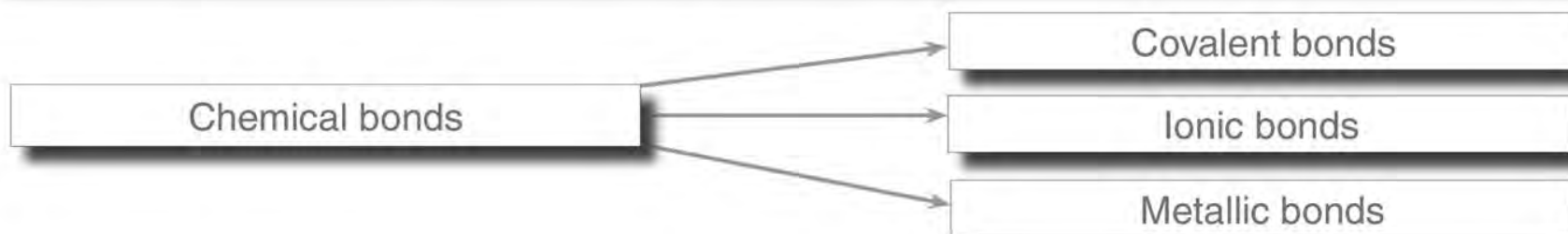




KNOWLEDGE AREA: MATTER AND MATERIALS

UNIT 5

CHEMICAL BONDS



Three bonding models

covalent bonds: between non-metals.

ionic bonds: between metals and non-metals.

metallic bonds: between metals.

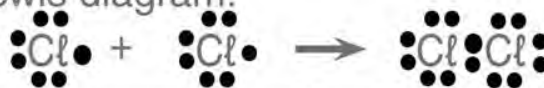


Lewis diagrams

Examples of Lewis diagrams for period 2

| Group 1 (i) | Group 2 (ii) | Group 13 (iii) | Group 14 (iv) | Group 15 (v) | Group 16 (vi) | Group 17 (vii) | Group 18 (viii) |
|----------------|-----------------|-------------------|------------------|------------------|------------------|-------------------|--------------------|
| Li • | Be •• | B •• • | • C • • | •• • N • • | •• • O • • | •• • F • •• | •• • Ne • •• |

Bonds can be illustrated with a Lewis diagram.



5.1 Covalent bonds

- Bond between non-metal atoms
- Orbitals with half-filled orbitals overlap and electrons are shared.
- Smallest particle is a molecule.



- Atoms have some half-filled orbitals.
- The half-filled orbitals overlap to form a new filled orbital.
- Atoms' electronegativity must be the same or have an electronegativity difference of less than 1,9.
- Polar or non-polar covalent bonds are formed.
- Non-polar covalent bonds: atoms attract the shared pair of electrons equally.
- Polar covalent bond: One atom attracts the shared pair of electrons more than the other.
- Bonds can be one of the following:
single
double
triple

| Formula | Lewis diagram | Single/ double/triple bond | Polar or non-polar bond |
|----------------------------|----------------------------|----------------------------------|-------------------------------|
| H ₂ Hydrogen | H ● H | Single | Non-polar |
| F ₂ Fluorine | ●●●● ● F ● F ●● ●●●● | Single | Non-polar |



| Formula | Lewis diagram | Single/ double/triple bond | Polar or non-polar bond |
|----------------------------|---------------|----------------------------------|-------------------------------|
| H ₂ O Water | | Single | Polar |
| NH ₃ Ammonia | | Single | Polar |
| CH ₄ Methane | | Single | Non-polar |
| O ₂ Oxygen | | Double | Non-polar |
| N ₂ Nitrogen | | Triple | Non-polar |
| HCl Hydrogen chloride | | Single | Polar |

Exercise 8: Page 105

1. Draw a Lewis diagram for each of the following elements.

| | | | | | |
|-----|-----|-------|-------|-------|-------|
| Ar | H • | Ca •• | Hg • | Zn •• | Fe •• |
| K • | Cl | Na • | Au •• | Mg •• | S |
| Si | Al | P | Ag • | He •• | Pb •• |



2 Complete the following table.

| | Formula and name | Lewis diagrams | Single/double/triple | Polar/non-polar |
|-----|---------------------------------------|---|----------------------|-----------------|
| 2.1 | H ₂ S Hydrogen sulphide | $2\text{H}\cdot + \cdot\ddot{\text{S}}\cdot \rightarrow \text{H}:\ddot{\text{S}}:\text{H}$ | Enkel | Polêr |
| 2.2 | CO Carbon monoxide | $\cdot\ddot{\text{C}}\cdot + \cdot\ddot{\text{O}}\cdot \rightarrow \cdot\ddot{\text{C}}::\ddot{\text{O}}\cdot$ | Dubbel | Polêr |
| 2.3 | Cl ₂ Chlorine gas | $\cdot\ddot{\text{Cl}}\cdot + \cdot\ddot{\text{Cl}}\cdot \rightarrow \cdot\ddot{\text{Cl}}:\ddot{\text{Cl}}\cdot$ | Enkel | Nie-polêr |
| 2.4 | HBr Hydrogen bromide | $\text{H}\cdot + \cdot\ddot{\text{Br}}\cdot \rightarrow \text{H}:\ddot{\text{Br}}\cdot$ | Enkel | Polêr |

5.2 Ionic bonds

- Bonds between metals and non-metals
- Electron transfer
- Positive ions and negative ions attract each other.
- Atoms' electronegativity must differ by more than 1,9.

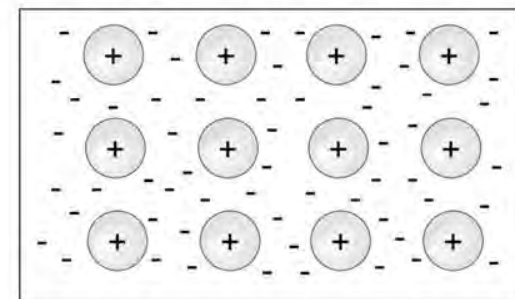
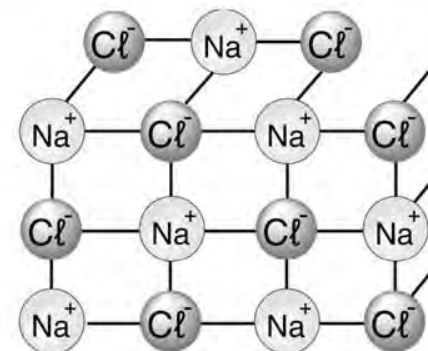


- One atom must have a low first ionization energy.
- Metals tend to give away electrons.
- There must be an atom with a high electron affinity.
- Non-metals tend to accept electrons.
 - Smallest particle is an ion.
 - Ionic bonds form a crystal lattice in the solid phase.
 - Example of an ionic bond:



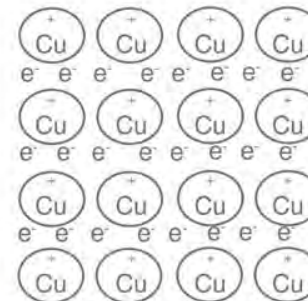
5.3 Metallic bonds

- Bonds between atoms of metals.
- Atoms are closely packed
- Valence electrons are delocalised.





- Positive core ions form a compact crystal lattice.
- Smallest particle is a positive core ion.
- The following are required for a metallic bond:
 - Low ionisation energy
 - Atoms must have empty valence orbitals so that the delocalised electrons can move into them.



Practical activity 6: Page 107

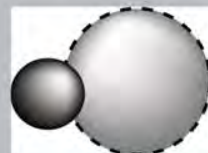
Work together in small groups.

Method 1:

| Formula and name | Schematic diagram |
|------------------|-------------------|
| CH ₄ | |
| HBr | |



Method 2:



Method 3:

Fig. 1A

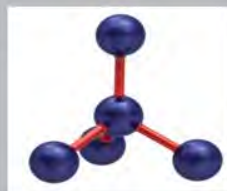
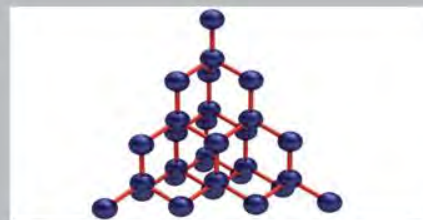


Fig. 1B



**Exercise 9: Page 108**

1 Predict what type of bond will form in the following cases.

| | Substances | Type of bond |
|------|---|---------------------|
| 1.1 | Between copper atoms | Metallic |
| 1.2 | Between sodium and sulphate ions | Ionic |
| 1.3 | Between hydrogen and carbonate ions | Covalent |
| 1.4 | Between carbon and oxygen | Covalent |
| 1.5 | Between mercury and oxygen | Ionic |
| 1.6 | Between iodine and hydrogen | Covalent |
| 1.7 | Between zinc atoms | Metallic |
| 1.8 | Between sulfur and hydrogen | Covalent |
| 1.9 | Between potassium and permanganate ions | Ionic |
| 1.10 | Inside diatomic molecules | Covalent |

Revise cations, anions and the naming of different compounds.

2 Complete the following table, by writing the formula of the substance made up of the two ions.



| | Sodium ion | Magnesium ion | Al³⁺ | Ca²⁺ |
|----------------|--|---|--|---|
| Nitrite ion | 2.1 NaNO₂ | 2.2 Mg(NO₂)₂ | 2.3 Al(NO₂)₃ | 2.4 Ca(NO₂)₂ |
| Dichromate ion | 2.5 Na₂Cr₂O₇ | 2.6 MgCr₂O₇ | 2.7 Al₂(Cr₂O₇)₃ | 2.8 CaCr₂O₇ |
| Sulphite ion | 2.9 Na₂SO₃ | 2.10 MgSO₃ | 2.11 Al₂(SO₃)₃ | 2.12 CaSO₃ |
| Chlorate ion | 2.13 NaClO₃ | 2.14 Mg(ClO₃)₂ | 2.15 Al(ClO₃)₃ | 2.16 Ca(ClO₃)₂ |





3 Complete the table.

| Formula | Chemical name | General name | Type of bond |
|------------------------------------|-------------------------------|--|---------------------|
| 3.1 H₂O | Hydrogen oxide | 3.2 Water | 3.3 Covalent |
| H₂SO₄ | 3.4 Hydrogen sulphate | 3.5 Sulfuric acid/ battery acid | 3.6 Covalent |
| CH₃COOH | 3.7 Ethanoic acid | 3.8 Acetic acid | 3.9 Covalent |
| 3.10 KNO₃ | 3.11 Potassium nitrate | Saltpetre | 3.12 Ionic |
| 3.13 CaCO₃ | Calcium carbonate | 3.14 Marble/chalk | 3.15 Ionic |



| Formula | Chemical name | General name | Type of bond |
|----------------------|--|-------------------------|----------------------|
| 3.16 CO_2 | 3.17 Carbon dioxide/ carbon(IV) oxide | Carbon dioxide | 3.18 Covalent |
| 3.19 CuSO_4 | 3.20 Copper sulphate | Blue vitriol | 3.21 Ionic |
| CH_4 | 3.22 Methane | 3.23 Natural gas | 3.24 Covalent |

4 Draw the following Lewis structures.

| | Compound | Lewis structure | | Compound | Lewis structure |
|-----|----------------|---|-----|--------------------|--|
| 4.1 | Lithium iodide |  | 4.3 | Aluminium chloride |  |
| 4.2 | PH_3 |  | 4.4 | BeO |  |



5 Compare the following types of bonds.

| Property | Ionic bond | Covalent bond | Metallic bond |
|-------------------------|----------------------------------|---------------------------------|--|
| Smallest particle | 5.1 Ion | 5.2 Molecule | 5.3 Atom |
| Types of elements | 5.4 Metals and non-metals | 5.5 Non-metals | 5.6 Metals |
| How is the bond formed? | 5.7 Electron transfer | 5.8 Sharing of electrons | 5.9 Positive atomic cores with sea of delocalised electrons |

