2S.3 Chemical bonding and structure

1) An atom undergoes chemical bonding to achieve the **noble gas configuration/stable electronic configuration** to make them more chemically stable
    - Octet configuration – 8 electrons in the valence shell
    - Duplet configuration – 2 electrons in the valence shell (helium)
2) **Ionic bonds**:
    - **Electrostatic Force of attraction** between positively and negatively charged ions
    - Formed between a metal and a non-metal (metal – anion, non-metal – cation)
    - The ions are packed into a **giant lattice structure** (have straight sides)
    - When an atom loses an electron, it has a positive charge, and it is called a **cation**
    - When an atom gains an electron, it has a negative charge, and it is called an **anion**
    - These forms when an atom gains or loses an electron/electrons so as to **achieve noble gas configuration**
    - The electron that is lost by a cation is not necessarily transferred to the anion that it bonds with
    - Are usually formed between ions from group I, II, III and group V, VI, VII
    - Group IV atoms usually do not form ions
3) Properties of ionic compounds:
    - Hard and crystalline solids at r.t.p. (Most of the time – Ammonium nitrate (NH_4NO_3) boiling point at 170°C)
    - **High melting and boiling points**
    - Explanation: Ionic compounds are held together in fixed positions in a giant lattice structure by strong ionic bonds, thus a lot of energy is required to overcome these strong electrostatic forces of attraction
    - Do not conduct electricity in the solid state, but **can conduct electricity in molten or aqueous state**
    - Explanation: In the solid state, ionic compounds are held in fixed positions by strong ionic bonds, therefore, the ions are unable to move freely to conduct electricity as they cannot carry the electrical charges. However, in molten or aqueous state, the ions can move freely and therefore can conduct electricity by carrying the electrical charges.
    - Ionic compounds are **soluble in water** but **insoluble in organic compounds** (Most of the time – Lead (II) sulfate (($PbSO_4$) is insoluble in water)
    - Explanation: The ions attract the water molecules, which disrupts the crystal structure, causing the ions to separate and go into the solution. They do not attract the molecules of organic compounds.

- Basic particle – ion
- Examples – Sodium Chloride, Magnesium Oxide, Calcium Chloride, etc.
- Note: The explanations are model answers for related questions

4) Covalent bonds

- Formed by the sharing of electrons between 2 atoms of non-metal elements
- Can exist as simple covalent molecules or giant covalent structures
- Simple covalent molecules have a simple molecular structure
- Giant covalent structure have a large network of atoms held together by strong covalent bonds

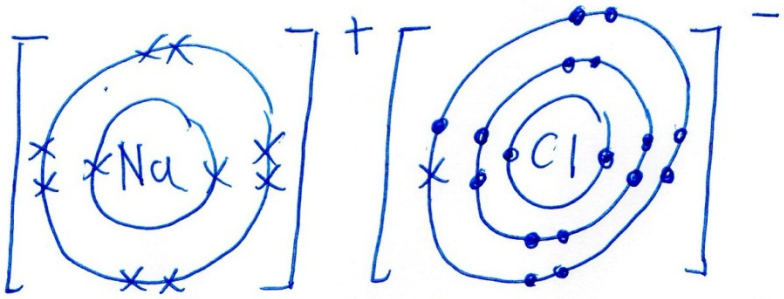
5) Properties of simple molecular compounds (covalent)

- Liquids or gases at r.t.p (Mostly – iodine and sulfur are solids)
- **Low boiling and melting points**
- Explanation: Molecules are held together by weak intermolecular forces of attraction (van der Waals' forces), so very little energy is needs to overcome the weak intermolecular forces of attraction (the weak intermolecular forces are considered chemical bonds)
- Note: The covalent bonds are not broken in state change, it is the force between the covalent molecules that are broken
- **Do not conduct electricity in any states**
- Explanation: There are no free-moving charged particles (ions or electrons) in covalent substances to conduct electricity (or rather no charged particles at all)
- Insoluble in water (Mostly – sugar, hydrogen chloride and alcohol are soluble in water), but soluble in organic solvents
- Basic particle – molecule (A molecule is made up of 2 or more atoms held together by covalent bonds)
- Examples – Carbon Dioxide, Oxygen, Methane, Sulfur, etc.
- Note: The explanations are model answers for related questions

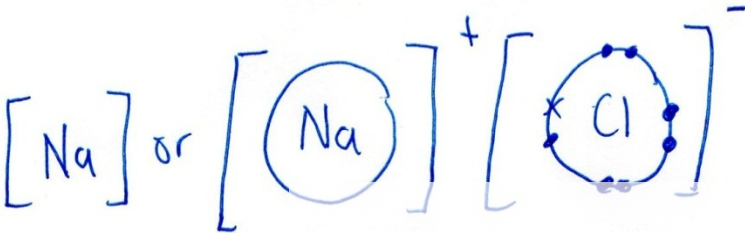
6) Drawing of the formation of ionic compounds

- When atoms lose electrons
  - They have 1, 2 or 3 valence electrons only
  - When drawing electronic structure
    - Write the symbol on the middle (if the element is unknown and named "X", use "X" as the symbol)
    - Bracket the whole electronic structure and write the charge at the top right corner
    - The charge would be:
      - "+" when 1 electron is lost
      - "2+" when 2 electrons are lost
      - "3+" when 3 electrons are lost

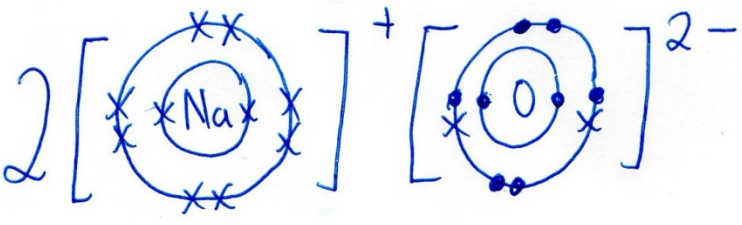
        - When drawing only valence electrons, positive ions must be drawn with only the symbol in the bracket or with an empty shell (not needed for full structure)
- When atoms gain electrons
    - They have 5, 6 or 7 valence electrons only
    - When drawing electronic structure
        - Write the symbol on the middle (if the element is unknown and named "X", use "X" as the symbol)
        - Bracket the whole electronic structure and write the charge at the top right corner
        - The charge would be:
            - " - " when 1 electron is gained
            - "2 -" when 2 electrons are gained
            - "3 -" when 3 electrons are gained
        - Use a different symbol (dot or cross) for the electrons gained to show that it is from another atom
        - When drawing valence electrons, no change
- When the ratio of ions is not 1:1, write a large numeral to in front of the ion to represent the ratio.(E.g. calcium chloride – [Ca]2[Cl])
- Use cross for ions which have larger proton numbers



Full Electronic Structure of Sodium Chloride

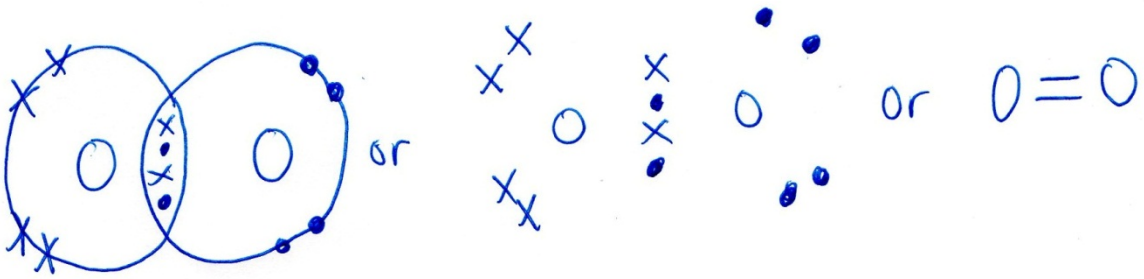


Sodium Chloride Showing Only Valence Electrons

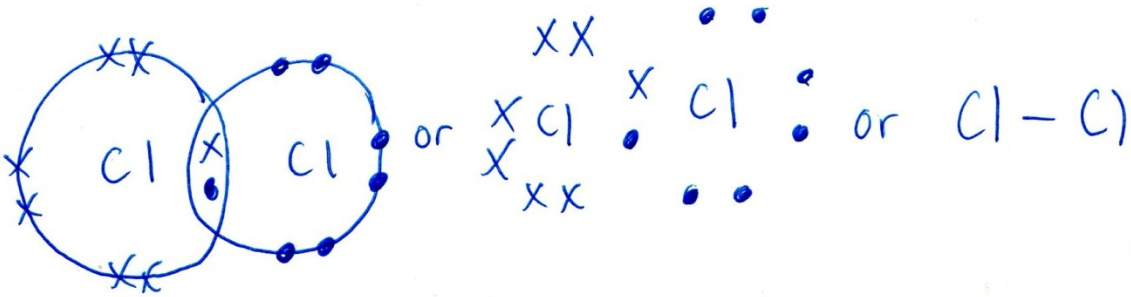


Full Electronic Structure of Sodium Oxide

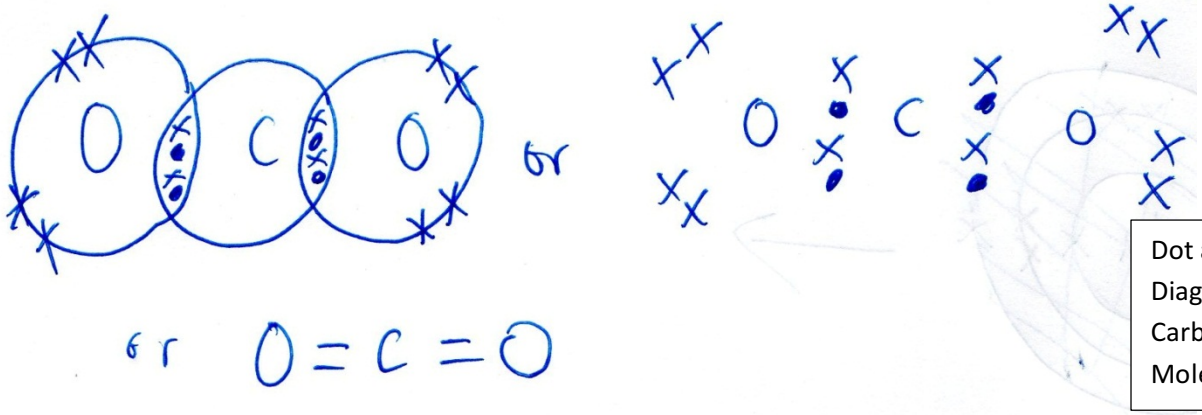
7) Drawing of the formation of covalent compounds
    - Only the valence electrons are involved so usually only the valence electrons are drawn
    - The two atoms are joined like a Venn diagram, with the electrons only inside the "shared" area (more than one pair can be inside
    - Write the symbol on the middle of atom (if the element is unknown and named "X", use "X" as the symbol)
    - 2 separate atoms have their electrons represented by different symbols
    - If there are more than 2 atoms, alternate the symbols (no 2 atoms joined together can have the same symbols)
    - Valence electrons can be drawn with the electron shell or without
    - Structural formula (as compared to the "dot-and-cross" diagram) is shown by drawing a line between the symbols of different atoms to represent 1 pair of shared electrons. More than one pair is represented by more than 1 line
8) Note: Polyatomic structures with charges are also bracketed (the whole molecule). They can form ionic compounds



Dot and Cross Diagram of an Oxygen Molecule



Dot and Cross Diagram of a Chlorine Molecule



Dot and Cross Diagram of a Carbon Dioxide Molecule