IONIC BOND

Electrovalent Bond

The electrovalent bond, also known as an ionic or polar bond, arises when two or more atoms engage in a chemical interaction that involves the transfer of electrons from an electropositive atom to an electronegative one.

This electron transfer process leads to the creation of two distinct types of ions:

(i) cations (ii) anions

Cations are ions with a positive charge, while anions carry a negative charge.

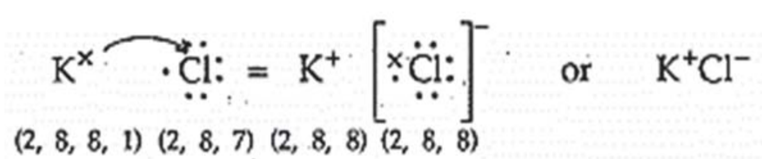
The attraction between these oppositely charged ions facilitates the formation of a bond between them. This bond, alternatively referred to as an ironic, electrovalent, or polar bond, is essentially the result of the electrostatic attraction between the positively charged cations and the negatively charged anions. Specifically, the term "ionic bond" is often used to describe this type of bond.

Compounds that exhibit the presence of ionic bonds are categorized as ionic, electrovalent, or polar compounds. In essence, the nature of the electrovalent bond is defined by the transfer of electrons, the generation of charged ions, and the subsequent attraction between these ions, culminating in the formation of a distinct type of chemical bond with specific properties

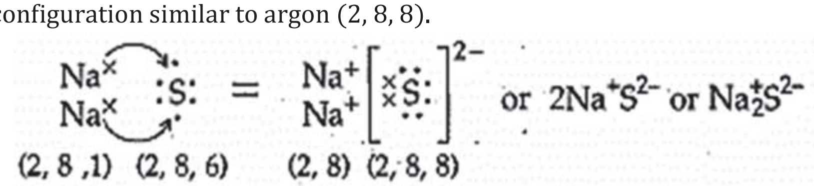
[**Note:** Electrovalent bond is not possible between similar atoms. This type of bonding requires two atoms of different nature, one atom should have the tendency to lose electron or electrons, i.e., electropositive in nature and the other atom should have the tendency to accept electron or electrons, i.e., electronegative in nature. Actually, ionic bond is not a true bond but just electrostatic attraction between closely packed ions. It is non directional in nature.]

Examples

(i) **Potassium chloride:** The unbound potassium atom possesses a single valency electron with an electronic configuration of 2, 8, 8, 1 ($4s^1$), while the chlorine atom carries seven valency electrons with an electronic configuration of 2, 8, 7 ($3s^2\ 3p^5$). In the process of forming an ionic bond, the potassium atom releases its valency electron, which is then accepted by the chlorine atom. Consequently, potassium attains the noble gas configuration of argon (2, 8, 8), transforming into a positively charged ion (K^+). Simultaneously, chlorine achieves the noble gas configuration of argon (2, 8, 8), acquiring a negative charge (Cl^-). The interaction between the potassium ion and chloride ion is characterized as an ionic bond. An expedient representation of the potassium chloride formation from potassium and chlorine atoms involves the utilization of electron dot symbols.



(ii) **Sodium sulfide:** Sodium undergoes a chemical union with sulfur, resulting in the creation of sodium sulfide, Na2S. In this process, two sodium atoms relinquish their valency electrons, transforming into sodium ions with a configuration reminiscent of neon (2, 8). On the other hand, sulfur, with an initial configuration of 2, 8, 6 in its valency shell, gains two electrons. This electron acquisition enables sulfur to attain a configuration similar to argon (2, 8, 8).



Net Reaction

The chemical equation provided represents the formation of sodium chloride (NaCl) through the combination of solid sodium (Na) and half a mole of gaseous chlorine (Cl_2):

$$Na(s) + \frac{1}{2} Cl_2(g) \rightarrow NaCl(s)$$

The net enthalpy change for this reaction is calculated by summing the enthalpies of various steps involved in the process. In this case, it is determined by summing the enthalpies of formation for the reactants and products, taking into account the stoichiometric coefficients of each substance. The enthalpies of formation are often tabulated values representing the heat change associated with the formation of one mole of a substance from its elements in their standard states.

For the given reaction, the net enthalpy change (ΔH) is calculated as follows:

$$\Delta H = \text{Enthalpy of Na} + \text{Enthalpy of } \frac{1}{2} Cl_2 + \text{Enthalpy of NaCl}$$

Substituting the known values:

$$\Delta H = 108.5 kJ/mol + 121.5 kJ/mol + 495.2 kJ/mol + (-348.3) kJ/mol + (-758.7) kJ/mol$$

After calculation, the net enthalpy change (ΔH) is found to be -381.8 kJ/mole. The negative sign indicates that the reaction is exothermic, meaning it releases energy to the surroundings.

Factors Affecting the Formation of Ionic Bond

Conditions for Forming Electrovalent or Ionic Bond

Conditions that promote the formation of an electrovalent bond are as follows:

(i) **Number of valency electrons:** For an electrovalent bond to occur, one atom should possess 1, 2, or 3 valency electrons, typically belonging to group IA, IIA, or IIIA and exhibiting metallic or electropositive characteristics. The other atom, transitioning into an anion, should possess 5, 6, or 7 electrons in the valency shell, typically belonging to group VA, VIA, or VIIA and demonstrating non-metallic or electronegative properties. Transition metal atoms can also form cations by losing electrons but do not consistently attain inert gas configuration.

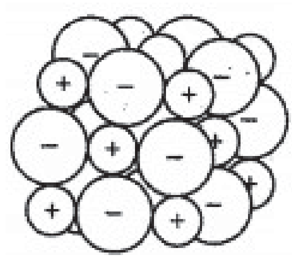
(ii) **Difference in electronegativity:** The ease of forming an electrovalent bond is enhanced when there is a significant difference in electronegativities between the two atoms. A difference of approximately 2 is necessary for electrovalent bond formation. For instance, sodium with an electronegativity of 0.9 and fluorine with an electronegativity of 4.0 readily form an electrovalent bond due to a difference of 3.1.

(iii) **Overall decrease in energy:** The formation of an electrovalent bond requires a net decrease in energy, resulting in energy release. Various energy changes occur in this process:

(a) **Ionisation energy:** The neutral isolated gaseous atom is converted into a cation by requiring energy equivalent to ionisation energy, as depicted in the equation A + ionisation energy = A^+ + e-.

(b) **Electron affinity:** An electron is added to a neutral isolated gaseous atom to form a univalent anion, releasing energy equivalent to electron affinity, as illustrated by the equation $B + e^- = B^-$ + electron.

(c) **Lattice energy:** The electrostatic force of attraction between cations and anions contributes to lattice energy, forming a molecule A^+B^-



Crystals of ionic compounds are characterized by the arrangement of positive and negative ions in a systematic manner within a crystal lattice. The electrostatic field of a charged particle, such as a positive ion, extends in all directions, leading to its surrounded by numerous negatively charged ions. Similarly, a negative ion is surrounded by a number of positive ions. The cations and anions align in an alternating pattern within the crystal lattice, contributing to the overall structure.

This formation of a crystal lattice enhances the force of attraction between ions, resulting in a decrease in potential energy. The process involves the systematic clustering of ions, further strengthening the electrostatic interactions.

The energy released during the condensation of the requisite number of positive and negative ions into a crystal lattice to form one mole of the compound is termed lattice energy (III step). The ease of forming an ionic compound is directly proportional to the magnitude of lattice energy, with higher lattice energy indicating a greater likelihood of compound formation.

Characteristics of ionic Bond

Properties of Ionic or Electrovalent bond

(i) The ionic bond is fundamentally electrostatic in its nature.

(ii) The factors facilitating its formation include:

  (a) A low ionization potential (I.P.) of the element that transforms into a cation through electron loss, requiring the element to be metallic or electropositive.

  (b) A high electron affinity (E.A.) of the element that transforms into an anion through electron gain, necessitating the element to be non-metallic or electronegative.

  (c) High lattice energy (L.E.): The energy released during the crystallization of isolated ions. The value of lattice energy is contingent on the charges of the ions and the distance between them, being higher when charges are elevated, and ionic radii are small.

  (d) The combined sum of these three energies should be negative, indicating energy release: I.P. + E.A. + L.E. = negative.

(iii) Elements highly electropositive from groups I and II combine with highly electronegative elements from VI and VII (or 16th and 17th) groups, leading to the formation of electrovalent or ionic compounds. Ionic compounds, such as halides, oxides, sulphides, nitrides, and hydrides of alkali and alkaline earth metals, are typically observed.

(iv) The probability of ionic bond formation increases with a greater difference in electronegativity between two atoms.

(v) Electro-valency, the capacity of an element to form an electrovalent or ionic bond, is measured in terms of electrons lost or accepted. Electrovalence of an element is equivalent to the number of electrons lost or gained by an atom of the element to attain an inert gas configuration. Elements losing electrons exhibit positive electro valency, while those gaining electrons display negative electro valency. Generally, positive and negative signs are omitted in practice, and only the numerical value represents electrovalence.

Element	No: of electrons lost or gained by an atom	Electro-valency	Change in electronic configuration
Na	1 (lost)	1 (Monovalent)	2,8,1 to 2,8(Na^+)
K	1 (lost)	1 (Monovalent)	2,8,8,1 to 2,8,8 (N^+)
Mg	2 (lost)	2 (Divalent)	2,8,2 to 2,8(Mg^{++})
Ca	2 (lost)	2 (Divalent)	2,8,8,2 to 2,8,8(Ca^{++})
Al	3 (lost)	3 (Trivalent)	2,8,3 to 2,8(Al^{+++})
F	1 (gained)	1 (Monovalent)	2,7 to 2,8(F^-)
Cl	1 (gained)	1 (Monovalent)	2,8,7 to 2,8,8(Cl^-)
O	2 (gained)	2 (Divalent)	2,6 to 2,8(O^{-7})
S	2 (gained)	2 (Divalent)	2,8,6 to 2,8,8 (S^-)
N	3 (gained)	3 (Trivalent)	2,5 to 2,8(N^{--})