

Tishk International University  
Faculty of Applied Science  
Department of Nutrition and Dietetics  
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Course Name: General Chemistry /NUT 106

## Lecture 4: **Basic Concepts of Chemical Bonding**

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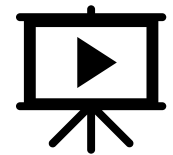


# Objectives

- **CHEMICAL BONDS and LEWIS SYMBOLS**
- **IONIC BONDING**
- **COVALENT BONDING**
- **BOND POLARITY AND ELECTRONEGATIVITY**
- **THE OCTET RULE**
- **RESONANCE STRUCTURES**



- A **chemical bond** is the physical process that causes atoms and molecules to be attracted to each other and held together in more stable chemical compounds.
- Atoms are more **reactive**, and therefore more likely to bond, when their outer electron orbitals are not full. Atoms are less reactive when these outer orbitals contain the maximum number of electrons. This explains why the noble gases do not react.
- **Lewis** notation is one way of representing molecular structure. In Lewis notation, dots and crosses are used to represent the valence electrons around the central atom.
- When atoms bond, electrons are either shared or exchanged.
- [Bonds](#)





## **Electron dot symbols: aka Lewis symbols**

*Lewis dot symbols can be used to predict the number of bonds formed by most elements in their compounds.*

*Lewis electron dot symbols, which consist of the chemical symbol for an element surrounded by dots that represent its valence electrons, grouped into pairs often placed above, below, and to the left and right of the symbol.*

*The structures reflect the fact that the elements in period 2 and beyond tend to gain, lose, or share electrons to reach a total of 8 valence electrons in their compounds.*

## Lewis Dot Symbols of the Main Group Elements

1A 1	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
•H																	He:
•Li	•Be•											•B•	•C•	•N•	•O•	•F•	•Ne•
•Na	•Mg•	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8 9 10			1B 11	2B 12	•Al•	•Si•	•P•	•S•	•Cl•	•Ar•
•K	•Ca•											•Ga•	•Ge•	•As•	•Se•	•Br•	•Kr•
•Rb	•Sr•											•In•	•Sn•	•Sb•	•Te•	•I•	•Xe•
•Cs	•Ba•											•Tl•	•Pb•	•Bi•	•Po•	•At•	•Rn•
•Fr	•Ra•																

Write Lewis dot symbols for the following:

(a) N

(b) S<sup>2-</sup>

(c) K<sup>+</sup>



## Ionic Bonding

*The amount of energy needed to separate a gaseous ion pair is its bond energy. Forming ionic compounds is usually extremely exothermic.*

*The strength of the electrostatic attraction between ions with opposite charges is directly proportional to the magnitude of the charges on the ions and inversely proportional to the internuclear distance.*

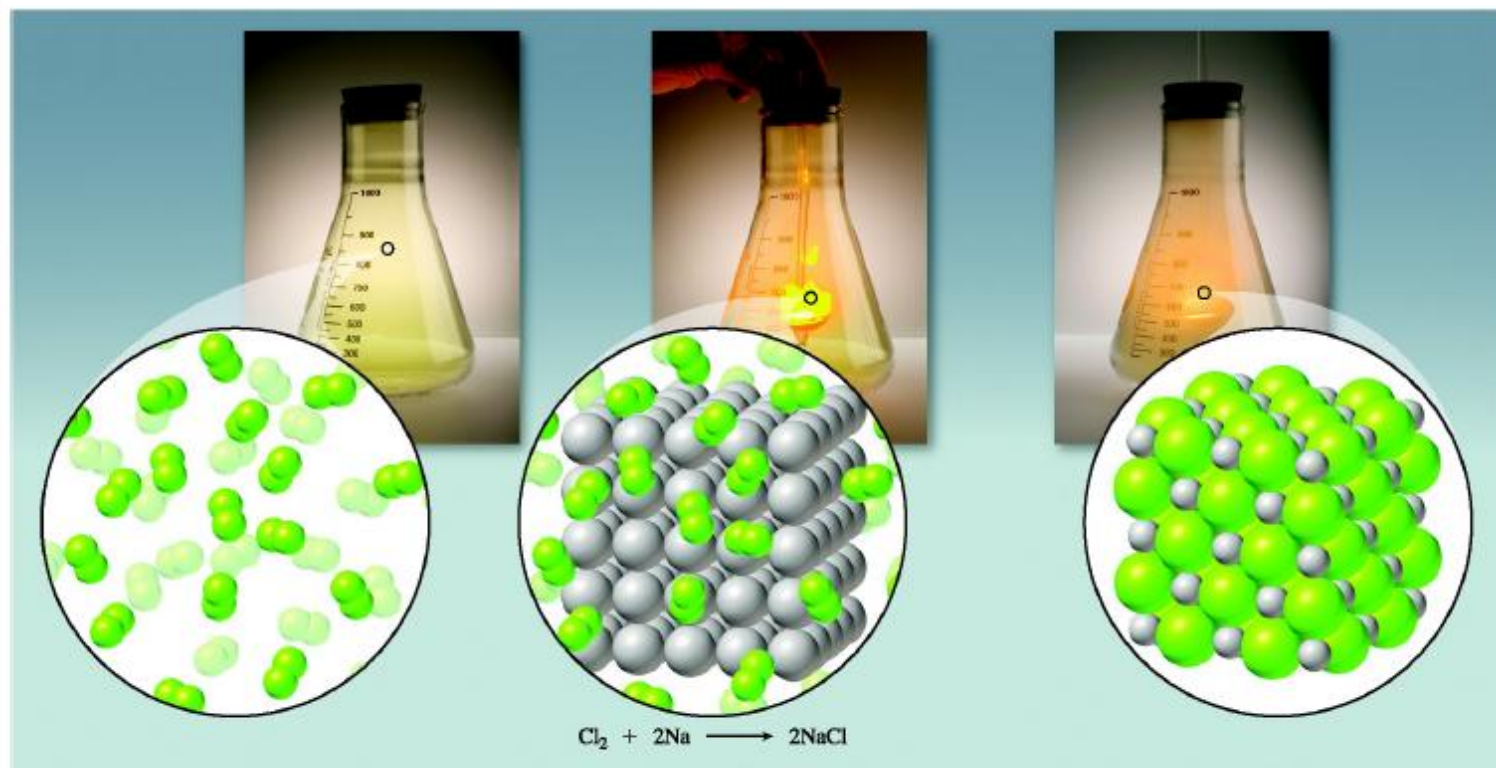
Ionic bond: electrostatic force that holds oppositely charge particles together.

- Formed between cations and anions

Example:



## Microscopic View of NaCl Formation



- An **ionic bond** occurs between atoms where there is a large difference in electronegativity. An exchange of electrons takes place and the atoms are held together by the electrostatic force of attraction between the resulting oppositely-charged ions.
- Ionic solids are arranged in a **crystal lattice** structure.
- Ionic compounds have high melting and boiling points, are brittle in nature, have a lattice structure and are able to conduct electricity when in solution.

## **Energies of Ionic Bond Formation**

The formation of ionic compounds is very exothermic

Removing an electron from an atom, such as Na, is endothermic because energy needs to be used to overcome the attractive forces within the atom. Adding an electron is the opposite process and releases lots of energy

The principal reason that ionic compounds are stable is the attraction between ions of unlike charge. This attraction draws the ions together, releasing energy and causing the ions to form a solid array (lattice)

**Lattice energy:** energy required to separate completely a mole of a solid ionic compounds into its gaseous ions

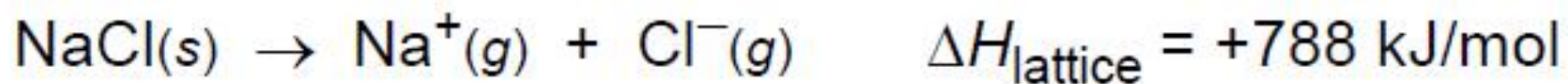
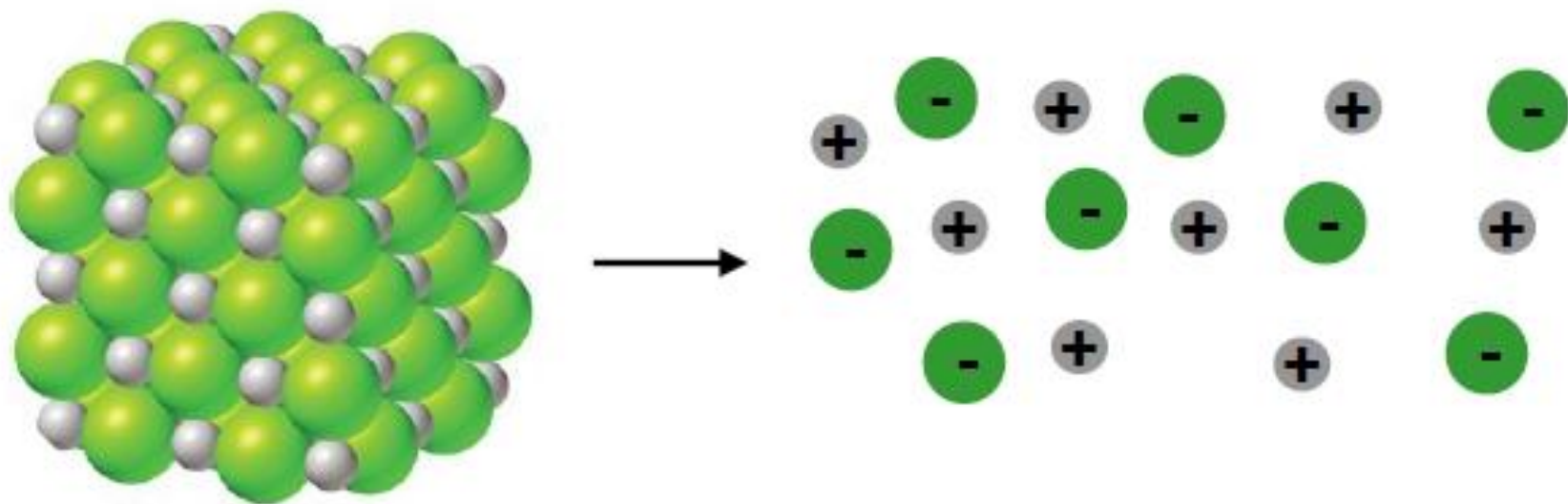
Large values of lattice energy mean that the ions are strongly attracted to one another

Energy released by the attraction between the ions of unlike charges more than makes up for the endothermic nature of ionization energies, making the formation of ionic compounds an exothermic process

$$E = k \frac{Q_1 Q_2}{d}$$

- $E$  = potential energy of two interacting charged particles
- $Q_1$  and  $Q_2$  = charges on the particles
- $D$  = distance between the particles
- $K$  = constant;  $8.99 \times 10^9 \text{ Jm/C}^2$

For a given arrangement of ions, the lattice energy increases as the charges of ions increase and as their radii decrease. The magnitude of lattice energies depends primarily on the ionic charges because ionic radii do not vary over a wide range.



Because they are defined as an *amount* of energy, lattice energies are always positive.

## COVALENT BONDING

*The strength of a covalent bond depends on the overlap between the valence orbitals of the bonded atoms. Bond order is the number of electron pairs that hold two atoms together.*

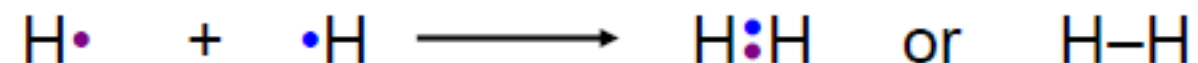
*Single bonds have a bond order of one, and multiple bonds with bond orders of two (a double bond) and three (a triple bond) are quite common. In closely related compounds with bonds between the same kinds of atoms, the bond with the highest bond order is both the shortest and the strongest.*

Ionic substances are usually brittle with high melting points. They are usually crystalline, meaning that they have flat surfaces that make characteristic angles with one another.

- **Covalent bond:** chemical bond formed by sharing a pair of electrons.

**Covalent bonding** occurs between the atoms of non-metals and involves a sharing of electrons so that the orbitals of the outermost energy levels in the atoms are filled.

Atoms share electrons to form covalent bonds.



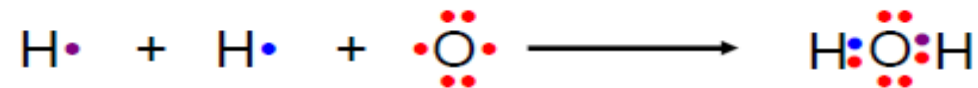
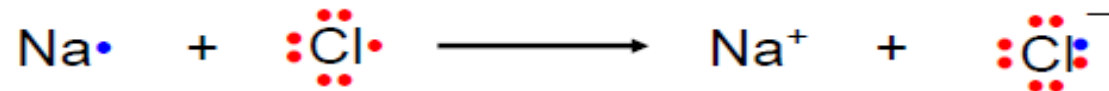
In forming the bond the atoms achieve a more stable electron configuration.

- The **valency** is the number of electrons in the outer shell of an atom which are able to be used to form bonds with other atoms.
- Covalent compounds have lower melting and boiling points than ionic compounds. Covalent compounds are also generally flexible, are generally not soluble in water and do not conduct electricity.

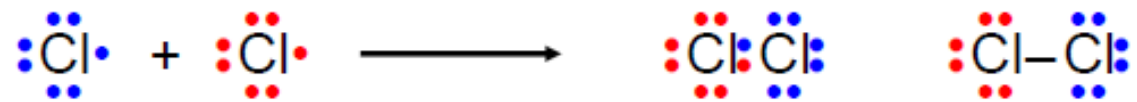
- A **metallic bond** is the electrostatic attraction between the positively charged nuclei of metal atoms and the delocalised electrons in the metal.
- Metals are able to conduct heat and electricity, they have a metallic lustre (shine), they are both malleable (flexible) and ductile (stretchable) and they have a high melting point and density.
- We can work out the relative molecular mass for covalent compounds and the formula mass for ionic compounds and metals.

- **Octet rule:** atoms tend to lose or gain electrons until they are surrounded by 8 valence electrons
  - Octet: Eight is a “magic” number of electrons.
  - Octet Rule: Atoms will gain, lose, or share electrons to acquire eight valence electrons

Examples:



## •Lewis Structures



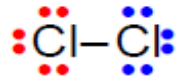
Shared electrons  $\Rightarrow$  Bonds

Non-bonding valence electrons  $\Rightarrow$  Lone pairs

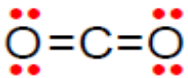
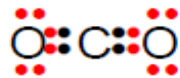
## Multiple Bonds:

A **double** or **triple bond** occurs if there are two or three electron pairs that are shared between the same two atoms.

- The number of shared electron pairs is the number of bonds.



Single Bond



Double Bond



Triple Bond

## **STRENGTHS OF COVALENT BONDS**

*Bond order is the number of electron pairs that hold two atoms together.*

*Single bonds have a bond order of one, and multiple bonds with bond orders of two (a double bond) and three (a triple bond) are quite common.*

*The bond with the highest bond order is both the shortest and the strongest. In bonds with the same bond order between different atoms, trends are observed that, with few exceptions, result in the strongest single bonds being formed between the smallest atoms.*

**Bond dissociation energy:** aka **bond energy**; enthalpy change,  $\Delta H$ , required to break a particular bond in a mole of gaseous substance.

For polyatomic molecules, we must often utilize average bond energies.

Bond energy is *always* positive, the *greater* the bond energy, the *stronger* the bond

A molecule with strong bonds generally has less tendency to undergo chemical change than does one with weak bonds.

### **Bond Strength and Bond Length**

As the number of bonds between a given element increase, the bond energy increases and the bond length decreases. Hence, the atoms are held more tightly and closely together. In general, *as the number of bonds between two atoms increases, the bond grows shorter and stronger.*

- Bond strength and bond length

bond strength            single < double < triple

bond length             single > double > triple

	N–N	N=N	N≡N
Bond Strength	163 kJ/mol	418 kJ/mol	941 kJ/mol
Bond Length	1.47 Å	1.24 Å	1.10 Å