

# Pabna University of Science and Technology



## Faculty of Engineering and Technology Department of Information and Communication Engineering **Assignment**

Course Code: **CHEM-2201**

Course title: **Chemistry**

Submitted By:	Submitted To:
<p><b>Name:</b> Shahriyar <b>Roll:</b> 220616 <b>Reg:</b> 1065463 <b>Session:</b> 2021-2022 2<sup>nd</sup> Year 2<sup>nd</sup> semester Department of Information and Communication Engineering, Pabna University of Science and Technology, Pabna.</p>	<p><b>Abrar Yasir Abir</b> Lecturer, Department of Chemistry, Pabna University of Science and Technology, Pabna.</p>

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## 1. Defects of Rutherford's Model of Atom and Bohr's Improvements

Defects of Rutherford's Model:

- **Atomic Collapse Problem:**  
According to classical electromagnetic theory, a moving electron should emit radiation, lose energy, and spiral into the nucleus, making the atom unstable. But atoms are stable.
- **No Explanation for Line Spectra:**  
Rutherford's model could not explain why atoms emitted light at specific wavelengths, seen as discrete lines in an atomic emission spectrum (like hydrogen's Balmer series).
- **Lack of Quantization:**  
The model did not incorporate any idea of quantized energy levels.

**Bohr's Modifications:**

- **Stable Orbits:**  
Electrons revolve around the nucleus in stable orbits called "stationary states" without radiating energy.
- **Quantized Energy Levels:**  
Each orbit has a definite, fixed energy level. Electrons can only exist in these allowed orbits.
- **Emission/Absorption of Radiation:**  
Energy is absorbed or emitted when an electron jumps from one orbit to another, explaining discrete spectral lines.
- **Formula Introduced:**  
Bohr introduced formulas linking energy levels and emission frequencies using Planck's quantum theory.

## 2. Quantum Numbers and Their Importance

### Definition:

Quantum numbers specify the properties and behavior of atomic orbitals and the electrons inside them.

The Four Quantum Numbers:

Quantum Number	Symbol	What it Represents	Allowed Values	Example
Principal	n	Energy level, size	1, 2, 3, 4...	n=1 for 1st shell
Azimuthal	l	Shape of orbital	0 to (n-1)	l=0 (s), 1 (p), 2 (d)
Magnetic	m	Orientation	-l to +l	For l=1: m=-1, 0, +1
Spin	s	Electron spin direction	+ $\frac{1}{2}$ or - $\frac{1}{2}$	

Significance:

- Defines the energy, shape, orientation, and spin of an electron.
- No two electrons in the same atom can have identical values of all four quantum numbers (Pauli's Exclusion Principle).

## 3. Comparison Between Ionic and Covalent Compounds

Properties of Ionic Compounds:

- Formed by transfer of electrons from metal to non-metal.
- Strong electrostatic force between oppositely charged ions.
- High melting and boiling points.
- Conduct electricity in molten or aqueous state.
- Generally soluble in water but insoluble in organic solvents.

Examples:

Sodium chloride (NaCl), Calcium chloride (CaCl<sub>2</sub>)

Properties of Covalent Compounds:

- Formed by sharing of electrons between non-metal atoms.
- Weak intermolecular forces (except network solids like diamond).
- Low melting and boiling points (except for giant molecules like SiO<sub>2</sub>).
- Poor conductors of electricity.
- Soluble in organic solvents, insoluble in water (mostly).

Examples:

Methane ( $\text{CH}_4$ ), Carbon dioxide ( $\text{CO}_2$ )

#### 4. Coordinate Covalent Bond

##### Definition:

A type of covalent bond where both electrons shared in the bond originate from the same atom.

How Different from a Normal Covalent Bond:

- Normal Covalent Bond: Each atom contributes one electron.
- Coordinate Covalent Bond: One atom donates both electrons.

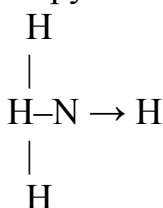
Example:

In ammonium ion ( $\text{NH}_4^+$ ), nitrogen donates a lone pair to a proton ( $\text{H}^+$ ).

Diagram:

yaml

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(Arrow shows coordinate bond.)

#### 5. Hydrogen Bonding and Water's High Boiling Point

##### Definition:

Attractive force between a hydrogen atom covalently bonded to a highly electronegative atom (N, O, or F) and another electronegative atom.

Types of Hydrogen Bonding:

- Intermolecular Hydrogen Bonding:  
e.g.,  $\text{H}_2\text{O}$  molecules bonding with each other.
- Intramolecular Hydrogen Bonding:  
e.g., o-nitrophenol, hydrogen bonding within a single molecule.

Why Water Has a High Boiling Point:

- Extensive hydrogen bonding between water molecules requires significant energy to break.
- This strong intermolecular force leads to a much higher boiling point compared to other similar-sized molecules like  $\text{H}_2\text{S}$ .

## 6. Bond Angles of H<sub>2</sub>O and NH<sub>3</sub> and Explanation

Bond Angles:

- H<sub>2</sub>O (Water): 104.5°
- NH<sub>3</sub> (Ammonia): 107°

Why They Differ:

- Both oxygen and nitrogen atoms are sp<sup>3</sup> hybridized.
- In water (H<sub>2</sub>O):
  - Oxygen has two lone pairs.
  - Lone pair-lone pair > lone pair-bond pair > bond pair-bond pair repulsions.
  - This causes compression of bond angle to 104.5°.
- In ammonia (NH<sub>3</sub>):
  - Nitrogen has only one lone pair, so the bond angle remains larger at 107°.

Diagram:

- H<sub>2</sub>O: Bent shape.
- NH<sub>3</sub>: Trigonal pyramidal shape.

## 7. Ionization Potential of an Element

### Definition:

The minimum amount of energy required to remove an electron from a gaseous atom or ion.

First vs Second Ionization Potential:

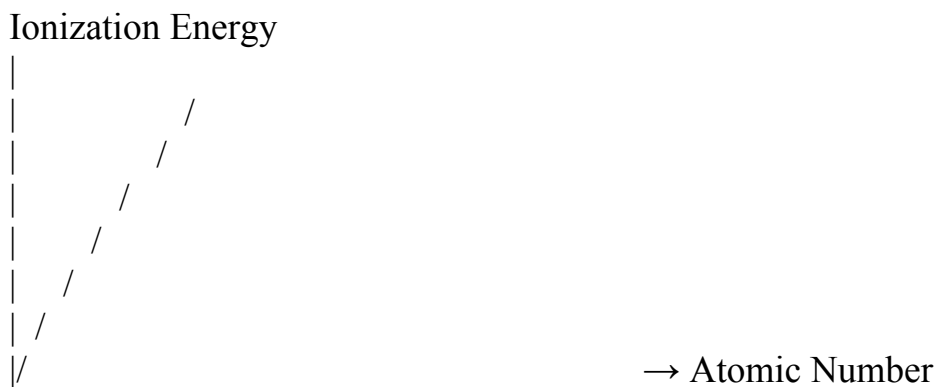
- First Ionization Potential: Energy to remove the first electron.
- Second Ionization Potential: Higher, because removing an electron from a positively charged ion is more difficult due to stronger nuclear attraction.

Variation with Atomic Volume:

- Down a Group:
  - Atomic radius increases.
  - Valence electrons are farther from the nucleus.
  - Ionization energy decreases.
- Across a Period:

- Nuclear charge increases.
- Atomic radius decreases.
- Ionization energy increases.

Graph:



## 8. f-Block Elements and Inner Transition Elements

Definition of f-Block Elements:

- Elements where the last electron enters an f-orbital.
- Include Lanthanides (58-71) and Actinides (90-103).

Characteristics:

- Show variable oxidation states.
- Have high melting and boiling points.
- Most lanthanides are silvery-white metals.
- Actinides are mostly radioactive.

Why Called Inner Transition Elements:

- They involve the filling of  $(n-2)f$  orbitals.

- Transition occurs in the inner orbitals, not the outermost ones, differentiating them from d-block transition metals.

Examples:

- Lanthanides: Cerium (Ce), Neodymium (Nd)
- Actinides: Uranium (U), Thorium (Th)