

Structure of Atoms

Comprehensive lecture notes on subatomic particles, atomic models, electronic configurations, and isotopes.

Discovery of Subatomic Particles

Unveiling the fundamental building blocks inside the atom through historic experiments.

CATHODERAYS (1895)

Electron (J.J. Thomson)

Discovered via discharge tube experiments. Rays deflected toward positive plate, proving negative charge. Mass-to-charge ratio determined.

CANAL RAYS (1886)

Proton (E. Goldstein)

Observed using perforated cathode tubes. Positive rays traveling in opposite direction to cathode rays, yielding positively charged protons.

BERYLLIUM BOMBARDMENT (1932)

Neutron (James Chadwick)

Bombarded Be-9 with alpha particles. Emitted highly penetrating neutral radiation with mass nearly equal to proton.

Properties of Subatomic Particles

Comparative analysis of charge, mass, and location inside the atom.

Particle	Symbol	Relative Charge	Absolute Mass (g)	Location
Proton	p ⁺	+1	1.673 × 10 ⁻²⁴ g	Nucleus
Neutron	n ⁰	0 (Neutral)	1.675 × 10 ⁻²⁴ g	Nucleus
Electron	e ⁻	-1	9.109 × 10 ⁻²⁸ g	Extra-nuclear space

Early Atomic Models

Evolution of atomic structure from plum pudding to nuclear planetary model.

PLUM PUDDING MODEL (1904)

J.J. Thomson

Atom is a sphere of positive charge with negative electrons embedded inside like plums in a pudding.

Limitation: Failed to explain scattering experiments.

PLANETARY MODEL (1911)

Rutherford's Gold Foil

Alpha particle scattering proved atom has a dense, positively charged nucleus surrounded by orbiting electrons.

Limitation: According to classical physics, revolving electrons should radiate energy and spiral into the nucleus.

Rutherford's Scattering Experiment

Experimental setup, observations, and revolutionary conclusions.

Key Observations

- **Most particles** passed straight through gold foil without any deflection.
- **Few particles** deflected slightly at small angles.
- **Very few (1 in 20,000)** bounced straight back or rebounded at large angles.

Major Conclusions

- **Atom is mostly empty space** (explaining why most rays pass undeflected).
- **Nucleus is dense & positive** (deflecting positive alpha particles).
- **Nucleus is extremely small** compared to total atomic volume.

Bohr's Atomic Theory

Resolving classical physics instability via quantized energy levels.

Stationary Orbits

Electrons revolve around nucleus in circular paths called orbits or shells, possessing fixed energy.

Quantized Energy

As long as an electron stays in its orbit, it does not radiate or absorb energy. Energy is quantized.

Quantum Jump

Energy is emitted or absorbed only when an electron jumps from one orbit to another ($\Delta E = h\nu$).

Comparison: Rutherford vs. Bohr Model

Contrasting classical nuclear model with quantum shell theory.

Feature	Rutherford's Model	Bohr's Model
Path of Electrons	Continuous spiral orbit without fixed radii.	Fixed circular orbits (shells K, L, M, N).
Energy Emission	Continuous radiation leading to atomic collapse.	No emission while in orbit; only on jumping.
Spectrum Explanation	Should produce continuous spectrum.	Successfully explains atomic line spectra.

Electronic Configuration Rules

Distributing electrons into K, L, M, N shells using the $2n^2$ rule.

Maximum Capacity ($2n^2$)

Where **n** is the principal quantum number (shell number).

- **K Shell (n=1):** $2(1)^2 = 2$ electrons
- **L Shell (n=2):** $2(2)^2 = 8$ electrons
- **M Shell (n=3):** $2(3)^2 = 18$ electrons
- **N Shell (n=4):** $2(4)^2 = 32$ electrons

Key Principles

- Shells are filled in order of increasing energy (K first, then L, then M).
- **Octet Rule:** The outermost valence shell can hold a maximum of 8 electrons for chemical stability.
- An atom with 8 valence electrons is chemically inert (Noble Gases).

Electronic Configuration Examples

Step-by-step shell distribution for elements 1 through 18.

Z=1

Hydrogen (H)

K: 1

Valence electron = 1

Z=6

Carbon (C)

K: 2, L: 4

Valence electrons = 4

Z=11

Sodium (Na)

K: 2, L: 8, M: 1

Valence electron = 1

Z=18

Argon (Ar)

K: 2, L: 8, M: 8

Valence octet complete

Isotopes & Hydrogen Isotopes

Atoms of the same element with identical atomic number but different mass numbers.

Definition

Isotopes have identical chemical properties because they have the same number of valence electrons, differing only in neutron count.

Examples: Carbon-12 & Carbon-14, Chlorine-35 & Chlorine-37.

Three Isotopes of Hydrogen

- **Protium (${}^1_1\text{H}$):** 1 p⁺, 0 n⁰ (Abundance: 99.98%)
- **Deuterium (${}^2_1\text{H}$):** 1 p⁺, 1 n⁰ (Heavy water component)
- **Tritium (${}^3_1\text{H}$):** 1 p⁺, 2 n⁰ (Radioactive isotope)

Applications of Isotopes

Crucial practical uses in medicine, agriculture, and power generation.



Medical Diagnosis

Iodine-131 used for diagnosis and treatment of thyroid gland disorders; Cobalt-60 for radiotherapy in cancer.



Nuclear Power

Uranium-235 undergoes controlled nuclear fission in nuclear reactors to generate electricity on a large scale.



Radiocarbon Dating

Carbon-14 is used to determine the age of ancient fossils, archaeological artifacts, and historical wood samples.

KARACHI EDU COACHING

Chapter 2 Complete

You have mastered atomic structure, electronic configurations, and isotope applications for your board exams.

 Excellence in Education