Nitrogen (N) – An Essential Element for Life and the Atmosphere

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1. General Information

- Symbol: N
- Atomic Number: 7
- Atomic Mass: 14.01 u
- Group: 15 (Pnictogens)
- Period: 2
- Block: p-block
- Electron Configuration: $1s^2\ 2s^2\ 2p^3$
- Valence Electrons: 5
- Phase at Room Temperature: Gas

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2. Isotopes of Nitrogen

Isotope	Protons	Neutrons	Abundance	Notes
^{14}N	7	7	99.6%	Stable and most common.
^{15}N	7	8	0.4%	Stable, used in research.

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3. Physical Properties

- Color: Colorless
- Odor: Odorless
- Density: 1.25 g/L (at STP)
- Melting Point: -210°C (63 K)
- Boiling Point: -195.8°C (77 K)
- State at STP: Gas
- Non-Metallic and Diatomic: Exists as N_2 molecules.

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4. Chemical Properties

- Inert at Room Temperature – Highly stable and unreactive due to the triple bond in N_2 ($N \equiv N$).
- Reacts at High Temperatures: Combines with hydrogen, oxygen, and metals.
- Essential for Proteins and DNA.
- Forms:
  - Ammonia (NH_3)
  - Nitric acid (HNO_3)
  - Nitrates (NO_3^-)

Reaction with Hydrogen (Haber Process):

$N_2 + 3H_2 \rightarrow 2NH_3$ (Ammonia)

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5. Occurrence and Abundance

- Most abundant gas in Earth’s atmosphere – 78% by volume.
- Found in:
  - Organic Matter – Proteins and nucleic acids.
  - Soil and Water – As nitrates and ammonia.
  - Stars and Interstellar Space – In cosmic dust and gases.

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6. The Nitrogen Cycle

- Essential for Ecosystems – Nitrogen is cycled between the atmosphere, soil, and living organisms.
- Stages:
  1. Nitrogen Fixation: $N_2 \rightarrow NH_3$ (by bacteria or lightning).
  2. Nitrification: $NH_3 \rightarrow NO_3^-$ (nitrates by bacteria).
  3. Assimilation: Plants absorb nitrates to form proteins.
  4. Denitrification: $NO_3^- \rightarrow N_2$ (returns to atmosphere).

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7. Industrial Production of Nitrogen

- Fractional Distillation: Extracted from liquid air.
- Haber Process: Produces ammonia by reacting nitrogen with hydrogen at high pressure and temperature.

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8. Uses of Nitrogen

Application	Description
Fertilizers	Ammonia and nitrates boost plant growth.
Cryogenics	Liquid nitrogen cools medical and industrial equipment.
Food Preservation	Inert atmosphere prevents spoilage.
Electronics	Nitrogen is used to prevent oxidation.

Application	Description
Medical	Used in pharmaceuticals and freezing tissues.
Explosives	Nitrogen compounds like TNT and nitroglycerin.
Welding and Metal Cutting	Provides an inert atmosphere.

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9. Important Nitrogen Compounds

Compound	Formula	Use
Ammonia	NH_3	Fertilizers, cleaners, refrigerants.
Nitric Acid	HNO_3	Explosives, fertilizers.
Nitrogen Dioxide	NO_2	Air pollutant, precursor to acid rain.
Nitrous Oxide	N_2O	Anesthetic (laughing gas).
Nitrates	NO_3^-	Fertilizers, preservatives.

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10. Biological Importance of Nitrogen

- Essential for Life: A key element in amino acids, proteins, and nucleic acids (DNA and RNA).
- Nitrogen Fixation: Bacteria convert atmospheric nitrogen into usable forms for plants.
- Protein Synthesis: Nitrogen is crucial for the growth and repair of cells.

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11. Safety and Toxicity

- Inert Gas Asphyxiation: Displaces oxygen, posing asphyxiation risks in confined spaces.
- Nitrogen Dioxide (NO_2): Toxic and can cause respiratory problems.
- Liquid Nitrogen: Can cause severe frostbite upon contact.

Fun Facts About Nitrogen:

- Nitrogen gas is colorless, odorless, and tasteless.
- Liquid nitrogen can freeze objects instantly.
- Lightning naturally fixes nitrogen by converting N_2 into nitrates.
- DNA, proteins, and chlorophyll all contain nitrogen.