Table of Contents

1. General Information

- Symbol: P
- Atomic Number: 15
- Atomic Mass: 30.97 u
- Group: 15 (Pnictogens)
- Period: 3
- Block: p-block
- Electron Configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$
- Valence Electrons: 5
- Phase at Room Temperature: Solid

---

2. Isotopes of Phosphorus

Isotope	Protons	Neutrons	Abundance	Notes
^{31}P	15	16	100%	Only stable isotope.
^{32}P	15	17	Trace	Radioactive, used in medicine.

---

3. Physical Properties

- Color/Allotropes:
  - White Phosphorus (Waxy, Yellow): Highly reactive and toxic.
  - Red Phosphorus: Stable, non-toxic, used in safety matches.
  - Black Phosphorus: Conductive, layered structure.
- Odor: Odorless (except white phosphorus, which smells like garlic).
- Density: ~1.82 g/cm³ (white phosphorus)
- Melting Point: 44.1°C (white phosphorus)
- Boiling Point: 280°C
- State at STP: Solid

---

4. Chemical Properties

- Highly Reactive (White Phosphorus):
  - Ignites spontaneously in air.
  - Stored underwater to prevent oxidation.
- Red and Black Phosphorus are less reactive.
- Forms Covalent Compounds:
  - Bonds with oxygen, hydrogen, halogens, and metals.

Reaction with Oxygen:

$P_4 + 5O_2 \rightarrow P_4O_{10}$ (Phosphorus Pentoxide)

Reaction with Halogens:

$2P + 3Cl_2 \rightarrow 2PCl_3$ (Phosphorus Trichloride)

---

5. Occurrence and Abundance

- 11th most abundant element in Earth’s crust.
- Not found in free state – Present in minerals.
- Common Minerals:
  - Apatite ($Ca_5(PO_4)_3(F,Cl,OH)$)
  - Phosphorite (Sedimentary rock containing phosphorus).

---

6. Industrial Production of Phosphorus

- Thermal Process (from Phosphate Rock):

  $$Ca_5(PO_4)_3F + C + SiO_2 \rightarrow P_4 + CO + CaSiO_3$$

- Electric Arc Furnace reduces phosphate rock to white phosphorus.

---

7. Uses of Phosphorus

Application	Description
Fertilizers	Phosphates (P_2O_5) promote plant growth.
Matches and Fireworks	Red phosphorus used in match tips and fireworks.
Detergents	Phosphates soften water and remove stains.
Steel Production	Phosphorus improves strength and hardness.
Pesticides and Herbicides	Organophosphates control pests.
LEDs and Semiconductors	Phosphorus used in electronics.

---

8. Important Phosphorus Compounds

Compound	Formula	Use
Phosphoric Acid	H_3PO_4	Fertilizers, soft drinks.
Phosphorus Pentoxide	P_4O_{10}	Drying agent, desiccant.

Compound	Formula	Use
Phosphorus Trichloride	PCl_3	Chemical synthesis, pesticides.
Calcium Phosphate	$Ca_3(PO_4)_2$	Fertilizers, animal feed.
Sodium Triphosphate	$Na_5P_3O_{10}$	Water softener in detergents.

---

9. Biological Importance of Phosphorus

- Essential for Life:
  - Key component of DNA, RNA, and ATP (energy molecule).
  - Present in bones and teeth as calcium phosphate.
- Cell Membranes: Phospholipids form cellular membranes.
- Nutrient for Plants: Supports root development and flowering.

---

10. Phosphorus in Environmental Chemistry

- Phosphorus Cycle:
  - Cycles through soil, plants, animals, and water.
  - Excess phosphorus from fertilizers can cause eutrophication (algal blooms).
- Soil Enrichment: Phosphorus fertilization increases crop yields.

---

11. Safety and Hazards

- White Phosphorus:
  - Highly Toxic and Flammable.
  - Can cause severe burns upon contact.
  - Exposure to Air: Ignites at ~30°C.
- Red Phosphorus:
  - Stable and non-toxic but can ignite under friction.
- Inhalation of Phosphorus Vapors can lead to “phossy jaw” (bone decay).

Handling Precautions:

- Store white phosphorus underwater or inert gas.
- Use protective gloves and goggles when handling phosphorus.

Fun Facts About Phosphorus:

- Discovered in 1669 by Hennig Brand while distilling urine.
- Phosphorescence is not caused by phosphorus, despite the name.
- White phosphorus glows in the dark (chemiluminescence).
- Essential for agriculture, yet overuse can harm water ecosystems.