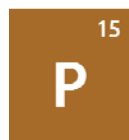


## Stable Isotopes of Phosphorus

Isotope	Z(p)	N(n)	Atomic Mass	Natural Abundance	Half-life	Nuclear Spin
P-31	15	16	30.9737620	100.00%	Stable	1/2+



Phosphorus was discovered in 1669 by Hennig Brand. Its name originates from the Greek word *phosphoros*, which means “bringer of light.” Elemental phosphorus in its solid phase exists in three major allotropic forms:

*White or yellow phosphorus* is a white, soft, wax-like, transparent mass which often acquires a yellow appearance due to impurities, especially traces of red phosphorus. It has a garlic-like odor. It is made up of cubic crystals, has a density of 1.82 g/cm<sup>3</sup>, and melts at 44.10 °C to a colorless or yellowish liquid. When cooled below -76.90 °C, the cubic alpha form converts to a hexagonal beta modification with a density of 1.88 g/cm<sup>3</sup>.

*Red phosphorus* is obtained from white phosphorus by heating it to 230-240 °C, allowing complete conversion to occur in about 48 hours. Conversion is catalyzed by sulfur, iodine and selenium. Red phosphorus exhibits three important modifications: an amorphous form at ordinary temperatures, a triclinic crystalline form (probably most stable), and a hexagonal or tetragonal form that may prevail at higher temperatures. Red phosphorus has a density of 2.00-2.31 g/cm<sup>3</sup> and melts at 590 °C.

*Black phosphorus* occurs in two forms: an amorphous modification having a lamellar structure similar to graphite, and an orthorhombic crystalline form. The density of black phosphorus may vary between 2.20 and 2.69 g/cm<sup>3</sup>. Black phosphorus is obtained from white phosphorus by heating the latter to 220 °C under an extremely high pressure of about 10,000 atm.

When solid phosphorus of any form — white, red or black — is melted, it forms the same liquid phosphorus. Vapors condense rapidly and convert to white phosphorus. Both red and black phosphorus are nonflammable. The latter is difficult to ignite. White phosphorus is soluble in a number of organic solvents, highly soluble in carbon disulfide and moderately soluble in benzene, but exhibits lower solubility in ether. Red and black phosphorus are insoluble in organic solvents.

White phosphorus is a highly toxic substance, considered both an acute and a chronic toxicant. Chronic exposure to its vapors can cause necrosis of the jaw, bronchopneumonia, bone changes, anemia or weight loss. Ingestion can cause nausea, vomiting, abdominal pain, diarrhea or coma. Skin contact can cause severe burns. Contact with the eyes damages vision. Red phosphorus is much less toxic than its white allotrope.

## Properties of Phosphorus

<b>Name</b>	Phosphorus
<b>Symbol</b>	P
<b>Atomic number</b>	15
<b>Atomic weight</b>	30.9737616
<b>Standard state</b>	Solid at 298 °K
<b>CAS Registry ID</b>	7723-14-0
<b>Group in periodic table</b>	15
<b>Group name</b>	Pnictogen
<b>Period in periodic table</b>	3
<b>Block in periodic table</b>	p-block
<b>Color</b>	Colorless or red or silvery white
<b>Classification</b>	Nonmetallic
<b>Melting point</b>	44.20 °C
<b>Boiling point</b>	277.00 °C
<b>Thermal conductivity</b>	0.236 W/(m·K)
<b>Electrical resistivity</b>	About $10 \times 10^{-8} \Omega\text{m}$
<b>Electronegativity</b>	2.19
<b>Heat of vaporization</b>	$12.40 \text{ kJ}\cdot\text{mol}^{-1}$
<b>Heat of fusion</b>	$0.64 \text{ kJ}\cdot\text{mol}^{-1}$
<b>Density of solid</b>	$1.82 \text{ g/cm}^3$
<b>Density of liquid</b>	$1.74 \text{ g/cm}^3$
<b>Electron configuration</b>	$[\text{Ne}]3s^23p^3$
<b>Atomic radius</b>	1.10 Å
<b>Oxidation states</b>	-3, +3, +5