Boron (B) – A Versatile Metalloid Essential for Industrial and Biological Applications

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1. General Information

- Symbol: B
- Atomic Number: 5
- Atomic Mass: 10.81 u
- Group: 13 (Metalloids)
- Period: 2
- Block: p-block
- Electron Configuration: $1s^2\ 2s^2\ 2p^1$
- Valence Electrons: 3
- Phase at Room Temperature: Solid

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2. Isotopes of Boron

Isotope	Protons	Neutrons	Abundance
^{10}B	5	5	19.9%
^{11}B	5	6	80.1%

- ^{10}B is important for nuclear shielding due to its ability to absorb neutrons.

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3. Physical Properties

- Color: Black (Crystalline) or Brown (Amorphous)
- Density: 2.34 g/cm³
- Melting Point: 2,076°C
- Boiling Point: 3,927°C
- State at STP: Solid
- Hardness: Second hardest element (next to diamond, in crystalline form).

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4. Chemical Properties

- Reacts with Oxygen: Forms boron oxide (B_2O_3) at high temperatures.
- Inert at Room Temperature – Does not react easily with air or water.
- Combines with Metals – Forms borides, which are extremely hard.
- Forms Covalent Compounds – Such as boric acid (H_3BO_3) and borates.

Reaction with Oxygen:

$4B + 3O_2 \rightarrow 2B_2O_3$

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5. Occurrence and Abundance

- Rare in Earth’s Crust: 0.001% by weight.
- Found in:
  - Borax ($Na_2B_4O_7 \cdot 10H_2O$)
  - Kernite ($Na_2B_4O_6(OH)_2 \cdot 3H_2O$)
  - Tourmaline (Borosilicate mineral)
- Largest Deposits: Turkey, USA, and South America.

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6. Production and Extraction

Source	Method
Borax and Kernite	Dissolved in water and refined to boric acid.
Electrolysis	Produces pure boron from boron halides.

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7. Uses of Boron

Application	Description
Glass and Ceramics	Borosilicate glass (heat-resistant).
Detergents	Borax is a key ingredient in cleaning products.
Fertilizers	Boron is essential for plant growth.
Nuclear Reactors	^{10}B absorbs neutrons, preventing radiation.
Aerospace and Defense	Boron fibers reinforce aircraft and armor.
Medicinal Uses	Boric acid is used as an antiseptic.
Semiconductors	Boron is used to dope silicon in electronics.

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8. Unique Properties of Boron

- Metalloid: Exhibits properties of both metals and non-metals.
- Extreme Hardness: Crystalline boron is as hard as diamond.
- Neutron Absorption: Essential for nuclear technology.

- Lightweight and Strong: Used in high-strength materials and aerospace.

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9. Boron Compounds

Compound	Formula	Use
Boric Acid	H_3BO_3	Antiseptic, insecticide, eyewash.
Borax	$Na_2B_4O_7 \cdot 10H_2O$	Detergents, ceramics, glass.
Boron Nitride	BN	Lubricants, coatings, cutting tools.
Boron Carbide	B_4C	Armor, bulletproof vests.
Boron Trifluoride	BF_3	Catalyst in organic reactions.

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10. Biological Importance

- Essential for Plants: Boron helps in cell wall formation and pollination.
- Trace Element for Humans: Supports bone health, but excess can be toxic.
- Deficiency in Plants: Leads to poor growth and weak cell walls.

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11. Boron in Technology

- Boron Fibers: Lightweight and used in aerospace.
- Doping Agent: Used in semiconductors to alter electrical properties.
- Boron Alloys: Used in lightweight, high-strength materials.

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12. Safety and Toxicity

- Low Toxicity in Small Amounts: Essential for plants and trace for humans.
- Toxic in High Doses: Can cause nausea, vomiting, and skin irritation.
- Inhalation Risk: Boron dust can irritate the respiratory system.

Fun Facts About Boron:

- Boron is found in stars and is created by cosmic ray spallation.
- Borosilicate glass (Pyrex) resists heat and thermal shock.
- Tourmaline gemstones contain boron and are prized for their colors.
- The hardness of boron carbide makes it the material of choice for tank armor and bulletproof vests