

## Carbon (C) - The Element of Life and the Backbone of Organic Chemistry

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### Table of Contents



- [1. General Information](#)
- [2. Isotopes of Carbon](#)
- [3. Allotropes of Carbon](#)
- [4. Physical Properties](#)
- [5. Chemical Properties](#)
- [6. Occurrence and Abundance](#)
- [7. The Carbon Cycle](#)
- [8. Industrial Uses of Carbon](#)
- [9. Important Carbon Compounds](#)
- [10. Biological Importance of Carbon](#)
- [11. Safety and Toxicity](#)
  - [Fun Facts About Carbon:](#)

## 1. General Information

- Symbol: C
  - Atomic Number: 6
  - Atomic Mass: 12.01 u
  - Group: 14 (Carbon Group)
  - Period: 2
  - Block: p-block
  - Electron Configuration:  $1s^2 2s^2 2p^2$
  - Valence Electrons: 4
  - Phase at Room Temperature: Solid
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## 2. Isotopes of Carbon

Isotope	Protons	Neutrons	Abundance	Notes
<sup>12</sup> C	6	6	98.9%	Stable (most common).
<sup>13</sup> C	6	7	1.1%	Stable, used in NMR spectroscopy.
<sup>14</sup> C	6	8	Trace	Radioactive (used in carbon dating).

## 3. Allotropes of Carbon

Allotrope	Structure	Properties	Uses
Diamond	Tetrahedral (3D lattice)	Hard, transparent, non-conductive.	Jewelry, cutting tools, electronics.
Graphite	Layered (2D sheets)	Soft, conducts electricity.	Pencils, lubricants, batteries.
Graphene	Single-layer of graphite	Strong, lightweight, conductive.	Electronics, composites.
Fullerenes (C <sub>60</sub> )	Spherical (Buckyballs)	Hollow, high strength.	Nanotechnology, medicine.
Carbon Nanotubes	Cylindrical tubes	Extremely strong and conductive.	Electronics, materials, space tech.
Amorphous Carbon	Disordered structure	Varies in hardness and conductivity.	Activated carbon, carbon black.

## 4. Physical Properties

- Color: Black (graphite), Clear (diamond).
- Density:
  - Diamond: 3.51 g/cm<sup>3</sup>
  - Graphite: 2.26 g/cm<sup>3</sup>
- Melting Point: Sublimes at 3,642°C.
- Boiling Point: 4,827°C.

## 5. Chemical Properties

- Valency: 4 (can form 4 covalent bonds).
- Reactivity:
  - At High Temperatures: Reacts with oxygen, producing CO or CO<sub>2</sub>.
  - Forms Compounds with Hydrogen, Oxygen, and Halogens.
- Combustion:

$C + O_2 \rightarrow CO_2$  (Complete Combustion)

$C + \frac{1}{2}O_2 \rightarrow CO$  (Incomplete Combustion)

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## 6. Occurrence and Abundance

- Fourth most abundant element in the universe.
  - Found in:
    - Atmosphere: As CO<sub>2</sub>.
    - Earth's Crust: In carbonates (limestone).
    - Organic Compounds: In all living organisms (proteins, fats, carbohydrates).
    - Fossil Fuels: Coal, oil, and natural gas.
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## 7. The Carbon Cycle

- Key Process: Movement of carbon between the atmosphere, oceans, plants, animals, and fossil fuels.
  - Stages:
    - Photosynthesis: CO<sub>2</sub> → Glucose (by plants).
    - Respiration: Glucose → CO<sub>2</sub> (by animals/plants).
    - Combustion: Fossil fuels → CO<sub>2</sub>.
    - Decomposition: Organic matter → Carbon in soil.
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## 8. Industrial Uses of Carbon

Application	Description
Steel Production	Carbon is a key component in steel alloys.
Electronics	Graphene and nanotubes in advanced tech.
Energy Storage	Graphite in lithium-ion batteries.
Filtration	Activated carbon for water and air purification.
Fuel	Coal, oil, natural gas.
Medical	Fullerenes and carbon nanotubes for drug delivery.

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## 9. Important Carbon Compounds

Compound	Formula	Use
Carbon Dioxide	CO <sub>2</sub>	Greenhouse gas, used in beverages.
Carbon Monoxide	CO	Poisonous gas, produced by combustion.
Methane	CH <sub>4</sub>	Natural gas, fuel.
Calcium Carbonate	CaCO <sub>3</sub>	Chalk, limestone, antacids.
Carbon Tetrachloride	CCl <sub>4</sub>	Used as a solvent (now restricted).

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## 10. Biological Importance of Carbon

- Basis of Organic Chemistry – Forms the backbone of DNA, proteins, fats, and carbohydrates.
  - Essential for Life – Present in all known life forms.
  - Carbon Bonds: Can form single, double, and triple bonds with other elements.
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## 11. Safety and Toxicity

- Graphite and Diamond – Non-toxic and safe.
- Carbon Monoxide (CO): Highly toxic, binds to hemoglobin and reduces oxygen transport.

- Carbon Dust (Amorphous Carbon): Can cause lung disease if inhaled in large quantities.
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### **Fun Facts About Carbon:**

- Diamonds are formed from carbon under extreme heat and pressure deep within the Earth.
- Graphene is 200 times stronger than steel but incredibly lightweight.
- Carbon dating (using  $^{14}\text{C}$ ) can determine the age of ancient fossils and artifacts.
- All living organisms are carbon-based, making it the building block of life.