

Carbon (C) Student Datasheet

Atomic structure · allotropes · bonding · isotopes · uses · carbon cycle

6

C

Carbon · 12.011

QUICK FACTS

Atomic number	6	Group / Period / Block	14 / 2 / p
Classification	Nonmetal	Electron configuration	1s ² 2s ² 2p ²
Shells	2 · 4	Valence electrons	4
Electronegativity	2.55 (Pauling)	1st ionization energy	1086.454 kJ/mol

WHY CARBON IS SPECIAL

Carbon has four valence electrons and forms strong covalent bonds with itself and many other elements. That lets it build chains, rings, sheets and three-dimensional networks - the structural basis of organic chemistry and life.

Key idea: same element, different structure very different material properties.

ALLOTROPES AT A GLANCE

Diamond	sp ³ · 3D network · hard · insulating
Graphite	sp ² · layered · soft · conductive
Graphene	sp ² · one-atom-thick sheet
Fullerenes	curved carbon cages such as C ₆₀

ATOMIC + ISOTOPE REFERENCE

¹² C	stable	dominant natural isotope; mass exactly 12 u
¹³ C	stable	about 1% in normal materials; isotope tracer
¹⁴ C	radioactive	half-life 5730 years; radiocarbon dating

Standard atomic weight: [12.0096, 12.0116] (CIAAW 2024)

Carbon: learn the patterns, not just the numbers

BONDING PATTERNS

sp³	Tetrahedral	diamond; four σ -bond directions
sp²	Trigonal planar	graphite/graphene; π system
sp	Linear	triple-bonded carbon in molecules

PHYSICAL PROPERTIES

Diamond density	3.513 g/cm³
Graphite density	2.2 g/cm³
Sublimation reference	4098 K
Covalent radius	75 pm
Electron affinity	121.776 kJ/mol

CARBON CYCLE

Atmosphere

CO₂ and CH₄

Biosphere

living organic carbon

Ocean

dissolved inorganic +
organic carbon

Rocks + sediments

largest long-term reservoir

REAL-WORLD USES

- Graphite: pencils, electrodes, lubricants, furnace applications
- Diamond: cutting, drilling, abrasives and wear-resistant surfaces
- Activated carbon: adsorption, purification and filtration
- Carbon fibre: strong, lightweight composite reinforcement
- Coke + carbon control: central to iron and steel production

REVISION QUESTIONS

1. Why do diamond and graphite have different properties?
2. Why does carbon commonly form four covalent bonds?
3. What does $1s^2 2s^2 2p^2$ tell you about valence electrons?
4. Why is ¹⁴C useful for dating once-living material?
5. Name four major reservoirs in the carbon cycle.

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