Allotropes of Carbon

Source: TH

Why in News?

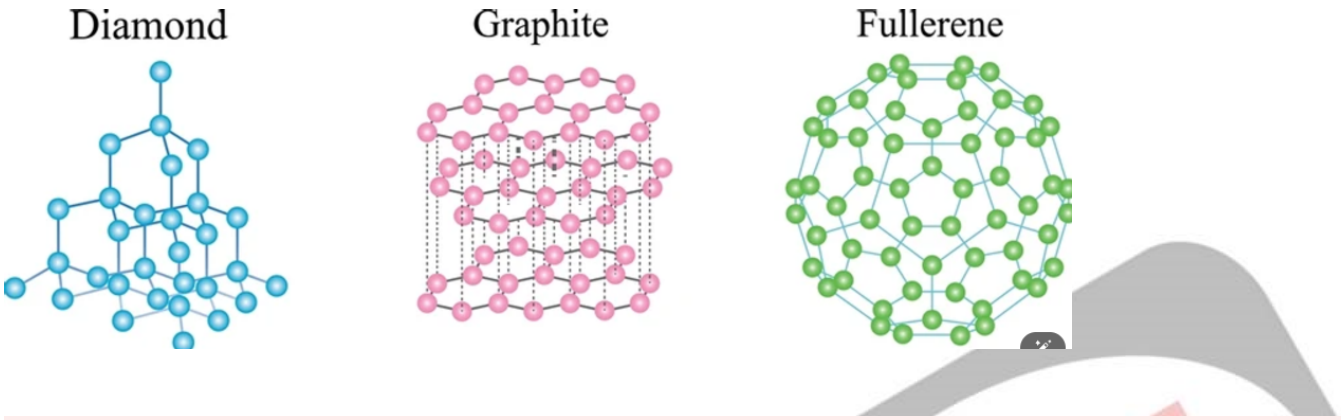
Carbon and its allotropes remain in news due to its varied **physical and chemical properties.**

- Allotrope refers to one or more forms of a **chemical element** that occur in the **same physical state.**
- **Carbon has four main allotropes** namely Diamond, Graphite, Fullerenes, and Graphene.
    - Additionally, **carbon nanotubes** and **amorphous carbon** (like charcoal) are also considered forms of carbon, but they are less commonly classified as primary allotropes.

What are the Allotropes of Carbon?

- **Graphite:** In graphite, each carbon atom forms bonds with **three other carbon atoms**, creating **two-dimensional sheets**. It is made up of layers of Carbon atoms arranged in **hexagonal arrays.**
    - **Electricity Conduction:** Graphite is a **good conductor of electricity** due to the existence of **delocalised electrons** within its layers.
    - **Lubricant:** Its layers can **easily slide** over each other, making it suitable as a **solid lubricant.**
    - **Hardness:** Graphite is the **softest** carbon allotrope.
    - **Graphene:** Graphene is a single, **one atom thick** layer of graphite. It has vast potential in **electronics, energy storage, sensors, coatings, composites**, and biomedical devices.
        - Its **high surface area** and biocompatibility make it ideal for **drug delivery and tissue engineering.**
- **Diamond:** It is made up of a **three-dimensional** network of Carbon atoms arranged in a **tetrahedral structure**, where each carbon atom is bonded to other **four carbon atoms.**
    - **Hardness:** It is recognized as the **hardest naturally** occurring material due to its strong covalent bonds, making it suitable fo**r industrial cutting, drilling, and grinding applications.**
    - **Transparency:** Some diamonds exhibit **high transparency** in the visible spectrum, making them valuable in **jewellery.**
    - **Thermal Conductivity:** Diamonds possess excellent **thermal conductivity,** making them useful in heat sinks.
    - **Electricity Conduction:** It **lacks electrical conductivity** in its pure form as it has **no free electrons or "charge carriers"** available to conduct electricity.
    - **Lab-grown Diamonds (LGDs): LGDs** are **identical to natural diamonds** in terms of physical properties such as **hardness, sparkle, and durability** but are created artificially in laboratories using **Graphite as a diamond seed**.
- **Fullerene: Buckminsterfullerene** is a type of **fullerene** with the formula **C60** and is characterised by its distinctive **cage-like structure** resembling a football.
    - **Applications:** Fullerenes and their compounds have potential applications as **semiconductors, superconductors, lubricants, catalysts**, electric wires, and plastic reinforcing fibres.

- **Carbon Nanotubes:** They are **cylindrical structures** made of rolled-up **graphene sheets.**
  - They are used in electronics, **materials science, energy storage,** medical applications, sensors, **water purification**, **drug delivery**, aerospace, and **nanotechnology**.
  - They can be used as **carriers of drugs and antigens** in the human body and **biochemical sensors.**
  - They are **biodegradable in nature.**
- **Amorphous Carbon:** It refers to various forms of carbon **lacking a crystalline structure**, such as **charcoal, soot, and activated carbon.**



UPSC Civil Services Examination, Previous Year Questions (PYQs)

Prelims

Q.With reference to carbon nanotubes, consider the following statements: (2020)

1. They can be used as carriers of drugs and antigens in the human body.
2. They can be made into artificial blood capillaries for an injured part of human body.
3. They can be used in biochemical sensors.
4. Carbon nanotubes are biodegradable.

Which of the statements given above are correct?

(a) 1 and 2 only

(b) 2, 3 and 4 only

(c) 1, 3 and 4 only

(d) 1, 2, 3 and 4

Ans: (c)

Q. Graphene is frequently in news recently. What is its importance? (2012)

1. It is a two-dimensional material and has good electrical conductivity.
2. It is one of the thinnest but strongest materials tested so far.
3. It is entirely made of silicon and has high optical transparency
4. It can be used as ‘conducting electrodes’ required for touch screens, LCDs and organic LEDs.

Which of the statements given above are correct?

(a) 1 and 2 only

(b) 3 and 4 only

(c) 1, 2 and 4 only

(d) 1, 2, 3 and 4

Ans: (c)