CHEMISTRY OF CARBON COMPOUNDS

16. VERSATILE NATURE OF CARBON

SOLUTIONS

TEACHING TASK

JEE MAIN LEVEL QUESTIONS

1. Which property of carbon is primarily responsible for the existence of millions of organic compounds?

A) Allotropy B) Catenation C) Isomerism D) Tetravalency

Answer:B

Solution:Catenation is the ability of carbon to form long chains or rings by bonding with itself — the main reason for the huge variety of organic compound.

2. The maximum chain length (number of carbon atoms) known in stable catenated carbon compounds is close to: **(FA & SA- 3 Marks/ 4 Marks)**

A) 30 B) 60 C) 100 D) > 100

Answer:D

Solution:Carbon can form long stable chains of more than 100 atoms (e.g. polymers, long-chain hydrocarbons.

3. The ability of carbon to form $p\pi-p\pi$ multiple bonds with itself and other atoms is mainly due to:

A) Small atomic size B) High electronegativity

C) High ionization energy D) Availability of vacant d-orbitals

Answer:A

Solution:Carbon's small atomic size allows for effective overlap of its p orbitals with the p orbitals of other atoms, enabling the formation of $p\pi-p\pi$ multiple bonds.

4. The total number of structural isomers possible for C_4H_8 (both chain and ring isomers) is: **(FA & SA- 5 Marks/8 Marks)**

A) 4 B) 5 C) 6 D) 7

Answer:C

Solution:Alkenes:But-1-ene,But-2-ene (cis & trans are stereoisomers, structural = 1), 2-Methylprop-1-ene,2-Methylprop-2-ene (same as isobutylene)
Cycloalkanes:Cyclobutane,Methylcyclopropane
Total = 6 structural isomers.

5. Which of the following carbon allotropes is an example of a zero-dimensional

nanostructure? **(FA & SA- 2 Marks)**

A) Diamond B) Graphite C) Fullerene (C_{60}) D) Graphene

Answer:C

Solution:Fullerene C_{60} is a closed cage, zero-dimensional.

6. Which pair of hybridizations is observed simultaneously in allene (C_3H_4)?

A) sp and sp^2 B) sp^2 and sp^3 C) sp and sp^3 D) sp^2 and sp^2

Answer:A

Solution:In allene, the central carbon is sp-hybridized, and the two terminal carbons are sp^2-hybridized.

7. The unique property of carbon to form a large number of compounds by different arrangements of atoms, but with the same molecular formula, is known as:

A) Hybridisation B) Isomerism C) Aromaticity D) Allotropy

Answer:B

Solution: The unique property of carbon to form a large number of compounds by different arrangements of atoms, but with the same molecular formula, is known as Isomerism.

8. The high melting point and hardness of diamond is due to:

A) Covalent bonding throughout B) van der Waals interactions

C) Metallic bonding D) Ionic interactions

Answer:A

Solution:Each carbon atom in diamond is tetrahedrally bonded to four others by strong covalent bonds in a 3D network.

9. Which of the following explains the versatility of carbon in organic chemistry?

A) Catenation B) Tetravalency

C) Multiple bonding ability D) All of the above

Answer:D

Solution:Carbon shows catenation, tetravalency, and multiple bonding — all contribute to its versatility.

10. Which of the following is NOT a reason for the versatile bonding nature of carbon?

A) Tetravalency B)Small atomic size

C)Presence of d-orbitals for bonding D)Catenation

Answer:C

Solution:Carbon lacks d-orbitals (only 1s, 2s, 2p) — so this is NOT a factor in its bonding versatility.

JEE ADVANCED LEVEL QUESTIONS

Multicorrect Answer Type :

11. Which of the following statements are correct about graphite?

A) Each carbon atom is bonded to three others in a hexagonal layer.
B) Layers are held together by weak van der Waals forces.
C) Good electrical conductor due to delocalised electrons.
D) Hybridisation of carbon is sp^3.

Answer:A,B,C

Solution:A) Each carbon atom is bonded to three others in a hexagonal layer $\rightarrow$ True (trigonal planar).
B) Layers held by weak van der Waals forces $\rightarrow$ True.
C) Good electrical conductor due to delocalised p electrons $\rightarrow$ True.
D) Hybridisation of carbon is sp^3 $\rightarrow$ False, it's sp^2.

12. Which of the following statements are correct about fullerenes (C_{60})?
A) Molecule has 12 pentagons and 20 hexagons.
B) Each carbon atom is sp^2 hybridised.
C) Behaves like a spherical cage structure.
D) Used as a semiconductor only, not as a superconductor.

Answer:A,B,C

Solution:A) Molecule has 12 pentagons and 20 hexagons $\rightarrow$ True (Euler's formula: V - E + F = 2).
B) Each carbon atom is sp^2 hybridised $\rightarrow$ True (but slightly curved due to pentagons, nearly sp^2).
C) Behaves like a spherical cage structure $\rightarrow$ True.
D) Used as a semiconductor only, not as a superconductor $\rightarrow$ False: Doped C_{60} can be a superconductor at low temperatures.

Assertion and Reason Type:

A) Both (A) and (R) are true and (R) is the correct explanation of (A)
B) Both (A) and (R) are true and (R) is not the correct explanation of (A)
C) (A) is true but (R) is false
D) (A) is false but (R) is true

13. **Assertion** : Fullerenes (C_{60}) can act as superconductors when doped with alkali metals.
Reason : Delocalised π-electrons in the spherical structure contribute to conduction.

Answer:B

Solution:
Assertion (A): True (e.g., K_3C_{60} becomes superconducting around 18 K)
Reason (R): True
Partial contribution, but superconductivity arises mainly due to electron–phonon interactions, not only because of π-electron delocalization.
So R is true but not the correct explanation for superconductivity.

14. **Assertion** : Silicon shows catenation but to a lesser extent than carbon.
Reason : Larger atomic size of silicon reduces effective orbital overlap required for stable Si–Si bonds.

Answer:A

Solution:Assertion: Silicon shows catenation but to a lesser extent than carbon →True (Si–Si bonds weaker than C–C).
Reason: Larger atomic size of silicon reduces effective orbital overlap required for stable Si–Si bonds →True (larger size → longer bonds → weaker overlap, less catenation).
Reason correctly explains Assertion.

Comprehension Type:

One of the most interesting carbon molecules having 60 to 120 atoms are called **fullerenes**. In 1985, three scientists H.W. Kroto, Smalley and Robert Curt made C_{60} as a result of laser beam on a sample of graphite and named it as 'Buckminsterfullerene'. They named it so after an American architect Buckminsterfuller, who designed domes that had hexagons and pentagons. Buckminsterfullerene is made from interlocking hexagonal and pentagonal rings of carbon atoms. Its structure is similar to soccer ball and commonly called buckyballs. It has been found that some fullerene based compounds of helium, neon, argon are superconductors, i.e., they conduct electricity without any resistance.

15. Fullerenes are carbon molecules containing:
A) 20 to 40 carbon atoms B) 60 to 120 carbon atoms
C) 150 to 200 carbon atoms D) Only 60 carbon atoms

Answer:B

Solution:Fullerenes exist in many sizes, but C_{60}–C_{120} are the most common stable ones

16. The molecule C_{60}, discovered in 1985, was named Buckminsterfullerene after:
A) An American scientist who discovered graphite
B) An American architect who designed geodesic domes
C) A German chemist who worked on allotropy
D) A British physicist who studied carbon allotropes

Answer:B

Solution:C_{60} resembles a geodesic dome designed by the American architect Buckminster Fuller.

17. The structure of Buckminsterfullerene resembles:
A) A cube B) A pyramid C) A soccer ball D) A cylinder

Answer:C

Solution: Its structure is similar to soccer ball and commonly called buckyballs.

18. Some fullerene compounds with helium, neon, or argon are:
A) Good insulators B) Semiconductors
C) Superconductors D) Dielectrics

Answer:C

Solution:When encapsulated (endohedral fullerenes), they can exhibit superconducting behavior when doped.
Most commonly: alkali-metal-doped fullerenes like K_3C_{60} are superconductors.
Since helium/neon/argon inside also stabilize structure → used in

superconducting materials.

Integer Type:

19. Number of pentagons present in a C_{60} Buckminsterfullerene molecule is _____

Answer:12

Solution:A C_{60} Buckminsterfullerene has a truncated icosahedron structure. It consists of 12 pentagons and 20 hexagons.

Matrix Matching Type:

20.

Column I	**Column II**
1) Carbon nanotubes	(P) High tensile strength and used in nanotechnology
2) Fullerene (C_{70})	(Q) Hardest natural material, 3D covalent network
3) Diamond	(R) Molecular cage structure with 70 carbon atoms
4) Graphene	(S) Single layer of carbon atoms arranged in hexagonal lattice

Answer:1-P, 2-R, 3-Q, 4-S

Solution:

1) Carbon nanotubes	(P) High tensile strength and used in nanotechnology
2) Fullerene (C_{70})	(R) Molecular cage structure with 70 carbon atoms
3) Diamond	(Q) Hardest natural material, 3D covalent network
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LEARNERS TASK

CONCEPTUAL UNDERSTANDING QUESTIONS (CUQ's)

1. Which of the following is NOT true for carbon?

A) Forms catenated chains B) Exhibits allotropy
C) Forms ionic compounds easily D) Forms compounds with multiple bonds

Answer:C

Solution:Carbon usually forms covalent bonds, not ionic.

2. Carbon atoms in graphene are arranged in:

A) Linear chains B) Hexagonal planar sheets
C) Tetrahedral network D) Cubic lattice

Answer:B

Solution:Hexagonal planar sheets (sp^2 hybridized).

3. Buckminsterfullerene (C_{60}) is also called:

A) Buckyball B) Nanotube C) Diamondoid D) Graphite

Answer:A

Solution:C_{60} is commonly called a buckyball (Buckminsterfullerene.

4. Which property of carbon is primarily responsible for the formation of millions of organic compounds?

A) Small atomic size
B) Catenation
C) Ionic bonding
D) Metallic character

Answer:B

Solution:Catenation — Ability to bond to itself to form long chains/rings creates enormous variety

5. The hybridisation of carbon in diamond is:
A) sp
B) sp^2
C) sp^3
D) sp^3d

Answer:C

Solution:Each carbon in diamond is tetrahedrally sp^3-hybridized.

6. Which of the following statements is CORRECT about carbon nanotubes?
A) Exhibit very high tensile strength
B) Can act as superconductors when doped
C) Each carbon atom is sp^3 hybridised
D) All of the above

Answer:A,B

Solution:A) Exhibit very high tensile strength – True;
B also true for doped fullerenes not necessarily all nanotubes,
C is false (sp^2 hybridized).

7. The main reason carbon shows allotropy is:
A) Different arrangements of carbon atoms in the lattice
B) Presence of free electrons
C) Ability to form ionic compounds
D) Different isotopes of carbon

Answer:A

Solution: The main reason carbon shows allotropy is Different arrangements of carbon atoms in the lattice.

8. Which of the following organic compounds was first synthesized artificially from an inorganic substance?
A) Urea
B) Methane
C) Ethanol
D) Formic acid

Answer:A

Solution:Urea — Wöhler's synthesis (1828) made urea from inorganic salts — first organic synthesis from inorganic

9. Which of the following statements about carbon compounds is FALSE?
A) Generally covalent
B) Show isomerism
C) Mostly ionic in nature
D) Can form long chains and rings

Answer:C

Solution:C) Mostly ionic in nature — False; carbon compounds are generally covalent

10. The ability of carbon to form multiple bonds (double and triple) with itself and other elements is due to:
A) Small size and effective orbital overlap
B) High metallic character
C) Presence of d-orbitals
D) High electronegativity alone

Answer:A

Solution:Small size and effective orbital overlap.

JEE MAINS LEVEL QUESTIONS

11. Silicon forms fewer compounds than carbon primarily because:
A) Tetravalency is absent B) Catenation is less favorable
C) Forms mostly ionic compounds D) Presence of d-orbitals

Answer:B

Solution:Silicon has a larger atomic size, leading to weak Si–Si bonds $\rightarrow$ less catenation.

12. The distance between two layers in graphene sheets is approximately:
A) 0.34 nm B) 0.24 nm C) 0.35 nm D) 0.64 nm

Answer:A

Solution:Interlayer spacing in graphite; graphene itself is a single layer but distance between stacked graphene sheets is ~0.34 nm.

13. A pure sample of diamond is transparent to: **(FA & SA- 2 Marks)**
A) Visible light only B) X-rays only
C) Both X-rays and visible light D) Infrared rays

Answer:C

Solution:Both X-rays and visible light.

14. Which statement is correct regarding amorphous carbon (coke)?
A) Chemically more active than graphite
B) Graphite is more chemically active than coke
C) Both are equally active
D) Coke is completely inert

Answer:A

Solution:Graphite is more stable; coke reacts more easily.

15. Graphene acts as a good conductor of electricity because:
(FA & SA- 3 Marks/4 Marks)
A) Delocalised electrons are present
B) Electrons are tightly held
C) Each carbon is sp^3 hybridised
D) Layered van der Waals bonding

Answer:A

Solution: Due to sp^2 π-electron cloud.

16. Which of the following is insoluble in ordinary solvents but can dissolve in CS_2? **(FA & SA- 5 Marks/8 Marks)**
A) Graphite B) Diamond C) Fullerene (C_{60}) D) Bone charcoal

Answer:C

Solution: Fullerene (C60) – Dissolves in CS_2 (molecular solid).

17. Catenation occurs primarily between:
A) Carbon atoms only
B) Silicon atoms only
C) Carbon with other elements as well
D) Both 1 and 3

Answer:D

Solution:Carbon catenates strongly with itself and forms chains with other elements (e.g., C–O, C–N).

18. Molecular formula of Hexane is:
A) C_6H_{14} B) C_6H_{12} C) C_5H_{12} D) C_4H_{10}

Answer:A

Solution:C_6H_{14} – Hexane is an alkane.

19. The radioactive isotope of carbon used for radiocarbon dating is:
A) C-12 B) C-13 C) C-14 D) C-15

Answer:C

Solution: C-14 – Used in radiocarbon dating.

20. Allotropes of phosphorus show:
A) Same physical and chemical properties
B) Different physical properties but similar chemical properties
C) Different physical and chemical properties
D) None of the above

Answer:B

Solution:Allotropy is the phenomenon due to which an element exhibits different physical forms, which have same chemical properties.

JEE ADVANCED LEVEL QUESTIONS

Multicorrect Answer Type :

21. Which of the following statements are correct about carbon allotropes?
A) Diamond is sp^3 hybridised and forms a 3D network.
B) Graphite is sp^2 hybridised and conducts electricity.
C) Fullerene (C_{60}) is composed entirely of hexagonal rings .
D) Carbon nanotubes have high tensile strength and sp^2 hybridised carbon atoms.

Answer:A,B,D

Solution:A) Diamond is sp^3 hybridised and forms a 3D network $\rightarrow$ True.
B) Graphite is sp^2 hybridised and conducts electricity $\rightarrow$ True (due to delocalized π electrons).

C) Fullerene (C60) is composed entirely of hexagonal rings →False (has 12 pentagons and 20 hexagons).

D) Carbon nanotubes have high tensile strength and sp^2 hybridised carbon atoms → True.

22. Which of the following statements are correct regarding chemical reactivity of carbon allotropes?

A) Diamond is chemically inert due to strong covalent bonds in a 3D network.

B) Graphite reacts more readily with halogens than diamond.

C) Amorphous carbon (coke) is more reactive than graphite.

D) Fullerenes can form addition reactions at the double bonds.

Answer:A,B,C,D

Solution:A) Diamond is chemically inert due to strong covalent bonds in a 3D network →True.

B) Graphite reacts more readily with halogens than diamond→ True (graphite has delocalized p bonds that can react under certain conditions).

C) Amorphous carbon (coke) is more reactive than graphite → True (disordered structure has more reactive sites).

D) Fullerenes can form addition reactions at the double bonds → True (e.g., with halogens).

Assertion and Reason Type:

A) Both (A) and (R) are true and (R) is the correct explanation of (A)

B) Both (A) and (R) are true and (R) is not the correct explanation of (A)

C) (A) is true but (R) is false

D) (A) is false but (R) is true

23. **Assertion** : Diamond is extremely hard and has a very high melting point.
Reason : Each carbon atom in diamond is sp^3 hybridised and forms a strong 3D covalent network.

Answer:A

Solution:

Assertion: Diamond is extremely hard and has a very high melting point → True.

Reason: Each carbon atom in diamond is sp^3 hybridised and forms a strong 3D covalent network → True, and explains hardness and high melting point.

24. **Assertion** : Fullerene (C_{60}) can form addition reactions.
Reason : The carbon atoms in fullerene are sp^2 hybridised, and double bonds are present in the cage structure.

Answer:A

Solution:Assertion: Fullerene (C_{60}) can form addition reactions → True (e.g., with bromine or hydrogen).

Reason: The carbon atoms in fullerene are sp^2 hybridised, and double bonds are present in the cage structure → True (π-bonds allow addition reactions). Reason explains Assertion.

Comprehension Type:

Allotropy is the phenomenon due to which an element exhibits different physical forms, which have same chemical properties. The various physical forms of an element that exhibit allotropy are called as allotropes. The main reason behind allotropy is different arrangement of atoms in the molecule of each allotrope. Examples of some elements exhibiting allotropy are:
Sulphur : rhombic, monoclinic and plastic.
Phosphorus : red and yellow

25. Allotropy refers to:
A) An element forming compounds with different elements
B) An element exhibiting different physical forms with same chemical properties
C) A compound showing different physical forms
D) A substance changing its physical state

Answer:B

Solution:Allotropy = Same element in the same physical state showing different structural forms (with different physical properties but same chemical composition).

26. Which of the following is an example of allotropy?
A) Sulphur: rhombic, monoclinic, and plastic
B) Carbon: C-12, C-13, C-14
C) Water: ice, liquid, steam
D) Sodium: metal, ion

Answer:A

Solution:Sulphur: rhombic, monoclinic, and plastic – These are allotropes of sulfur. (B is isotopes, C is states of matter, D is chemical states)

Integer Type:

27. Bond angle in diamond (in degrees) = _____

Answer:109^0 28'

Solution:The bond angle in diamond is 109^0 28'

28. Distance between two adjacent layers in graphite (in A^0)_____

Answer:3.35

Solution: Distance between two adjacent layers in graphite is 3.35 Å.

Matrix Matching Type:

29.

Column I	**Column II**
1) Fullerene	(P) Spherical cage structure of carbon atoms
2) Graphene	(Q) Single layer of carbon atoms in hexagonal lattice
3) Diamond	(R) 3D tetrahedral network of sp^3 carbon atoms
4) Carbon nanotubes	(S) Cylindrical tube made of sp^2 carbon atoms

A) 1–P, 2–Q, 3–R, 4–S
B) 1–S, 2–Q, 3–P, 4–R
C) 1–Q, 2–P, 3–S, 4–R
D) 1–P, 2–S, 3–R, 4–Q

Answer:A

Solution:

1) Fullerene (P) Spherical cage structure of carbon atoms
2) Graphene (Q) Single layer of carbon atoms in hexagonal lattice
3) Diamond (R) 3D tetrahedral network of sp^3 carbon atoms
4) Carbon nanotubes (S) Cylindrical tube made of sp^2 carbon atoms

KEY

				TEACHING TASK					
			JEE MAIN LEVEL QUESTIONS						
1	2	3	4	5	6	7	8	9	10
B	D	A	C	C	A	B	A	D	C
			JEE ADVANCED LEVEL QUESTIONS						
11	12	13	14	15	16	17	18	19	
A,B,C	A,B,C	B	A	B	B	C	C	12	
20									
1-P, 2-R, 3-Q, 4-S									
				LEARNERS TASK					
			CONCEPTUAL UNDERSTANDING QUESTIONS (CUQ's)						
1	2	3	4	5	6	7	8	9	10
C	B	A	B	C	A,B	A	A	C	A
			JEE MAIN LEVEL QUESTIONS						
11	12	13	14	15	16	17	18	19	20
B	A	C	A	A	C	D	A	C	B
			JEE ADVANCED LEVEL QUESTIONS						
21	22	23	24	25	26	27	28	29	
A,B,D	A,B,C,D	A	A	B	A	109	3.35	A	