# WEIRD CHEMIST

## Group 14 Elements — The Carbon Family

DPP-7

Chapter: p-Block Elements

**Chapter:** p-Block Elements (Group 14) **Questions:** 50

## TOPIC 1 Introduction

### (a) Elements and Occurrence

**Q1. Carbon is described as the most versatile element in the world. Silicon is the second most abundant element in the earth's crust (27.7% by mass), yet carbon is only the seventeenth most abundant element. Despite this, carbon is far more important to life and industry than silicon. Which of the following best explains carbon's versatility compared to silicon?**

(1) Carbon is more abundant in the free state than silicon, making it more accessible for biological and industrial use

(2) Carbon's ability to form stable covalent bonds with hydrogen, oxygen, nitrogen, chlorine and sulphur, along with its property of catenation, allows formation of an astonishing range of compounds from living tissues to drugs and plastics

(3) Carbon has a higher atomic mass than silicon, which makes its compounds more stable under biological conditions

(4) Silicon is only found in combined form whereas carbon occurs in free form, making silicon less versatile

**Q2. Which of the following correctly identifies all members of Group 14 and their nature (metal, non-metal or metalloid)?**

(1) C and Si are non-metals; Ge is a metalloid; Sn and Pb are metals

(2) C, Si and Ge are non-metals; Sn and Pb are metals

(3) C is a non-metal; Si, Ge, Sn and Pb are metalloids

(4) All five elements are metals

**Q3. A student needs to identify the correct ore of tin and the correct mineral form of silicon from a given list. Which option correctly pairs the element with its ore/occurrence?**

(1) Tin — galena (PbS); Silicon — silica

(2) Tin — cassiterite ($SnO_2$); Silicon — silica and silicates

(3) Tin — $SnO_2$; Silicon — coal and graphite

(4) Tin — PbS; Silicon — diamond

**Q4. The pie chart below shows the percentage abundance of elements in the earth's crust. Segment X = 45.5% (oxygen), Segment Y = 27.7%, Segment Z = 8.3% (aluminium). Based on NCERT data for Group 14, which element does Segment Y represent and what are its important uses?**

(1) Carbon; used as coal, graphite and diamond

(2) Silicon; used in ceramics, glass, cement and as a component of semiconductor devices

(3) Germanium; used to make transistors and semiconductor devices

(4) Tin; found mainly as cassiterite and used in alloys

**Q5. Consider the following statements about Group 14 elements and choose the correct option.**

**I. Carbon has two stable isotopes: $^{12}C$ and $^{13}C$; a third isotope $^{14}C$ is radioactive with half-life 5770 years and is used for radiocarbon dating.**
**II. Silicon is the seventeenth most abundant element by mass in the earth's crust.**
**III. Germanium exists only in traces in nature.**
**IV. Ultrapure germanium and silicon are used to make transistors and semiconductor devices.**

(1) I and II only

(2) I, III and IV only

(3) II and III only

(4) All four statements

## TOPIC 2 Atomic Properties

### (a) Electronic Configuration

**Q6. The general valence shell electronic configuration of Group 14 elements is $ns^2np^2$. Which of the following elements has the electronic configuration [Ar] $3d^{10}4s^24p^2$?**

(1) Carbon (2) Silicon (3) Germanium (4) Tin

**Q7. The inner core electronic configuration differs across Group 14 elements. Which of the following correctly lists the electronic configurations of carbon and tin respectively?**

(1) [He] $2s^22p^2$ and [Kr] $4d^{10}5s^25p^2$

(2) [Ne] $3s^23p^2$ and [Xe] $4f^{14}5d^{10}6s^26p^2$

(3) [He] $2s^22p^2$ and [Ar] $3d^{10}4s^24p^2$

(4) [Ne] $3s^23p^2$ and [Kr] $4d^{10}5s^25p^2$

### (b) Covalent Radius

**Q8. On moving down Group 14, the covalent radius shows an irregular trend. Which of the following correctly describes this trend?**

(1) Covalent radius increases uniformly from C to Pb with equal increments at each step

(2) There is a considerable increase in covalent radius from C to Si, but thereafter from Si to Pb only a small increase is observed

(3) Covalent radius decreases from C to Si due to increased nuclear charge, then increases from Si to Pb

(4) Covalent radius remains nearly constant from Si to Pb because all heavier elements have similar atomic sizes

**Q9. The small increase in covalent radius observed from Si to Pb in Group 14 (compared to the large jump from C to Si) is best explained by:**

(1) The heavier members Ge, Sn and Pb have completely filled $d$ and $f$ orbitals in their inner core, which offer poor shielding, increasing the effective nuclear charge and counteracting the expected increase in size

(2) The heavier elements have fewer electrons in their valence shell, making the atoms smaller than expected

(3) From Si to Pb, the nuclear charge decreases, which pulls the electron cloud inward and reduces the covalent radius

(4) The presence of $d$ and $f$ orbitals in heavier members expands the valence shell, causing a uniform large increase in radius from Si to Pb

### (c) Ionisation Enthalpy

**Q10. Which of the following correctly compares the first ionisation enthalpy of Group 14 members with Group 13 members of the same period?**

(1) First ionisation enthalpy of Group 14 members is lower than the corresponding Group 13 members because Group 14 has more electrons to shield the nucleus

(2) First ionisation enthalpy of Group 14 members is higher than the corresponding Group 13 members due to the influence of inner core electrons

(3) First ionisation enthalpy of Group 14 and Group 13 members are equal because they belong to the same period

(4) First ionisation enthalpy of Group 14 members is lower than Group 13 because the extra $p$ electron in Group 14 is easily removed

**Q11. On moving down Group 14, the ionisation enthalpy shows an irregular trend. A small decrease in $\Delta_i H$ is observed from Si to Ge to Sn, but a slight increase from Sn to Pb. Which of the following correctly explains the increase from Sn to Pb?**

(1) Pb has a smaller atomic size than Sn, which increases the attraction of the nucleus for outer electrons

(2) The poor shielding effect of intervening $d$ and $f$ orbitals in Pb increases the effective nuclear charge experienced by valence electrons, combined with the increase in atomic size, results in a slight increase in ionisation enthalpy

(3) Pb has more protons than Sn, so the direct nuclear charge increase dominates and raises the ionisation enthalpy

(4) The inert pair effect in Pb makes the $6s^2$ electrons completely non-participatory, so the ionisation enthalpy refers only to the $6p$ electrons which are harder to remove

### (d) Electronegativity

**Q12. Which of the following correctly describes the electronegativity trend in Group 14 elements compared to Group 13 elements?**

(1) Group 14 elements are slightly less electronegative than Group 13 elements because they have more electrons in the valence shell

(2) Group 14 elements are slightly more electronegative than Group 13 elements due to their smaller atomic size

(3) Group 14 and Group 13 elements have identical electronegativity values since they belong to the same period

(4) Group 14 elements are much more electronegative than Group 13 elements because they have a higher nuclear charge

**Q13. The electronegativity values of Group 14 elements are: C = 2.5, Si = 1.8, Ge = 1.8, Sn = 1.8, Pb = 1.9. Which of the following conclusions is correct based on this data?**

(1) Electronegativity decreases uniformly from C to Pb, showing a smooth periodic trend down the group

(2) Carbon has a significantly higher electronegativity than the rest; from Si to Pb the values are almost the same, with a very slight increase at Pb

(3) Silicon is the most electronegative element in Group 14 because it is the second most abundant element in the earth's crust

(4) Electronegativity increases steadily from C to Pb due to the increase in nuclear charge down the group

## TOPIC 3 Physical Properties

### (a) Physical State at Room Temperature

**Q14. Which of the following correctly describes the physical state and nature of all Group 14 elements at room temperature?**

(1) All are gases; carbon and silicon are non-metals, germanium is a metalloid, tin and lead are metals

(2) All are solids; carbon and silicon are non-metals, germanium is a metalloid, tin and lead are soft metals with low melting points

(3) Carbon is a gas, silicon is a liquid; germanium, tin and lead are solids

(4) All are solids and all are metals with high melting points

### (b) Boiling Point Order

**Q15. The boiling points of Group 14 elements are: Si = 3550 K, Ge = 3123 K, Sn = 2896 K, Pb = 2024 K; carbon's boiling point is not listed. The bar chart represents these values. Which conclusion is *correctly* drawn from this data?**

(1) Boiling point increases smoothly from Si to Pb down the group

(2) Boiling point decreases from Si to Pb, and since carbon has the highest melting point (4373 K) among all Group 14 elements, it is expected to have the highest boiling point as well

(3) Lead has the highest boiling point because it is the densest Group 14 element

(4) Silicon has a lower boiling point than germanium based on the data

### (c) Melting Point Order

**Q16. Melting and boiling points of Group 14 elements are much higher than those of corresponding Group 13 elements. A student argues this is because Group 14 elements form stronger interatomic bonds. Which of the following data from the table best supports this argument?**

(1) Carbon melting point (4373 K) vs boron melting point (2450 K); the higher value for carbon supports stronger bonding in Group 14

(2) Lead melting point (600 K) is lower than aluminium melting point (933 K), which contradicts the general trend

(3) Silicon boiling point (3550 K) is lower than silicon melting point (1693 K), which shows the data is inconsistent

(4) Density of germanium (5.32 g $cm^{-3}$) is lower than tin (7.26 g $cm^{-3}$), proving Group 14 bonds are weaker

**Q17. Consider the following statements about physical properties of Group 14 elements and select the correct combination.**

**I. All Group 14 members are solids at room temperature.**
**II. Carbon and silicon are non-metals; germanium is a metalloid; tin and lead are soft metals with low melting points.**
**III. Melting points and boiling points of Group 14 elements are much higher than those of corresponding Group 13 elements.**
**IV. Among Group 14 elements, tin has a higher melting point than lead.**

(1) I and III only

(2) I, II and III only

(3) I, II, III and IV only

(4) II and IV only

### (d) Density

**Q18. Using the data given below, a student needs to select the Group 14 element with the *lowest* melting point and the element with the *highest* density. Which option correctly identifies both?**

| Element | Melting point / K | Density / g cm$^{-3}$ |
|---|---|---|
| C | 4373 | 3.51 |
| Si | 1693 | 2.34 |
| Ge | 1218 | 5.32 |
| Sn | 505 | 7.26 |
| Pb | 600 | 11.34 |

(1) Lowest MP: Ge; Highest density: Pb
(2) Lowest MP: Sn; Highest density: Pb
(3) Lowest MP: Pb; Highest density: Sn
(4) Lowest MP: Sn; Highest density: Ge

## TOPIC 4 Chemical Properties

### (a) Oxidation States

**Q19. In Group 14, the stability of the +2 oxidation state increases down the group in the sequence Ge < Sn < Pb, while carbon and silicon mostly show the +4 state. A student claims that lead compounds in the +4 state are strong oxidising agents. Which of the following correctly supports this claim?**

(1) Lead prefers the +4 state because it has more electrons than tin; the +4 state is therefore more stable and non-oxidising
(2) The inability of the $ns^2$ electrons of Pb to participate in bonding (inert pair effect) makes $Pb^{4+}$ unstable; it readily accepts electrons to revert to the more stable $Pb^{2+}$, making Pb(IV) compounds strong oxidising agents
(3) Lead in the +4 state is stable because $d$ orbitals are available, so it cannot act as an oxidising agent
(4) Lead compounds in +4 state are oxidising agents only in acidic medium and are reducing agents in alkaline medium

**Q20. The common oxidation states of Group 14 elements are +4 and +2. Which of the following statements about these oxidation states is correct?**

(1) Compounds in +4 state are generally ionic because the sum of the first four ionisation enthalpies is very low
(2) Compounds in +4 state are generally covalent because the sum of the first four ionisation enthalpies is very high; in heavier members the +2 state becomes more stable due to the inert pair effect
(3) Both +4 and +2 states form ionic compounds equally throughout the group
(4) The +2 state is more stable than the +4 state for all Group 14 elements including carbon and silicon

**Q21. In tetravalent state, the number of electrons around the central atom in a molecule such as $CCl_4$ is eight, making them *electron precise* molecules. However, other Group 14 elements (Si, Ge, Sn) can form complexes like $SiF_6^{2-}$, $[GeCl_6]^{2-}$ and $[Sn(OH)_6]^{2-}$. Which of the following correctly explains why carbon cannot form similar complexes?**

(1) Carbon has too many electrons and cannot accept any more from donor species

(2) Carbon cannot exceed a covalence of 4 due to the absence of $d$ orbitals, whereas Si, Ge and Sn have accessible $d$ orbitals that allow expansion of the coordination sphere beyond 4

(3) Carbon forms only ionic compounds and ionic compounds do not form complexes

(4) The C–F bond is too weak to allow formation of $[CF_6]^{2-}$ under normal conditions

**Q22. The diagram below shows the hybridisation in $[SiF_6]^{2-}$, $[GeCl_6]^{2-}$ and $[Sn(OH)_6]^{2-}$ as $sp^3d^2$. Carbon cannot form the analogous $[CF_6]^{2-}$. Based on this, what can be concluded about the geometry of these complexes and why carbon is excluded?**

(1) The complexes are tetrahedral ($sp^3$); carbon is excluded because it is too small to accommodate six ligands

(2) The complexes are octahedral ($sp^3d^2$); carbon is excluded because it lacks $d$ orbitals and cannot expand its covalence beyond 4

(3) The complexes are square planar ($dsp^2$); carbon is excluded because it forms only two bonds in the +4 state

(4) The complexes are trigonal bipyramidal ($sp^3d$); carbon is excluded because its electronegativity is too high

**Q23. Consider the following statements about oxidation states of Group 14 elements and select the correct combination.**

**I. Carbon also exhibits negative oxidation states in addition to +4 and +2.**
**II. Tin in the +2 state is a reducing agent.**
**III. Lead compounds in the +2 state are stable whereas lead in the +4 state is a strong oxidising agent.**
**IV. Germanium forms stable compounds in the +4 state and only a few compounds in the +2 state.**

(1) I and II only
(2) I, II and IV only
(3) III and IV only
(4) All four statements are correct

**(b) Reactivity Towards Oxygen (Air)**

**Q24. The dioxides $CO_2$, $SiO_2$ and $GeO_2$ are acidic, whereas $SnO_2$ and $PbO_2$ are amphoteric. Among monoxides, CO is neutral, GeO is distinctly acidic, whereas SnO and PbO are amphoteric. A student concludes that the acidic character of oxides *decreases* down Group 14. Which of the following observations best supports this conclusion?**

(1) $CO_2$ is acidic while $SnO_2$ and $PbO_2$ are amphoteric, showing that oxides become less acidic and more amphoteric as we go down the group

(2) CO is neutral while SnO is amphoteric, showing that acidic character increases down the group

(3) All dioxides of Group 14 are equally acidic regardless of the position of the element in the group

(4) SiO exists only at high temperature, proving that lighter elements form more stable monoxides

**Q25. Oxides in higher oxidation states of Group 14 elements are generally more acidic than those**

**in lower oxidation states. Which of the following correctly applies this principle to germanium oxides?**

(1) $GeO_2$ is neutral; GeO is acidic
(2) $GeO_2$ is acidic; GeO is distinctly acidic but less so than $GeO_2$
(3) $GeO_2$ is amphoteric; GeO is basic
(4) $GeO_2$ is basic; GeO is neutral

**Q26. A chemistry student tests four oxides of Group 14 elements with both dilute NaOH and dilute HCl solutions. Which of the following oxides would react with *both* acid and alkali, confirming its amphoteric nature?**

(1) $CO_2$ and $SiO_2$
(2) $SnO_2$ and $PbO_2$
(3) CO and GeO
(4) $CO_2$ and CO

**Q27. The chart below classifies Group 14 oxides by their acidic/basic nature:**

| Oxide | Type | Oxide | Type |
|---|---|---|---|
| $CO_2$ | Acidic | CO | Neutral |
| $SiO_2$ | Acidic | GeO | Acidic |
| $GeO_2$ | Acidic | SnO | Amphoteric |
| $SnO_2$ | Amphoteric | PbO | Amphoteric |
| $PbO_2$ | Amphoteric | | |

**Which of the following conclusions is *incorrect* based on this chart?**

(1) The acidic character of dioxides decreases down Group 14 from $CO_2$ to $PbO_2$
(2) Among monoxides, CO is neutral whereas GeO is acidic and SnO, PbO are amphoteric
(3) All monoxides and dioxides of Group 14 are acidic in nature
(4) Higher oxidation state oxides are generally more acidic than lower oxidation state oxides of the same element

**Q28. Consider the following statements about reactivity of Group 14 elements towards oxygen and select the correct combination.**

**I. All Group 14 members form oxides when heated in oxygen; the two main types are monoxide (MO) and dioxide ($MO_2$).**
**II. SiO exists only at high temperature.**
**III. $CO_2$, $SiO_2$ and $GeO_2$ are acidic; $SnO_2$ and $PbO_2$ are amphoteric.**
**IV. Among monoxides, CO is amphoteric, GeO is neutral, and SnO and PbO are acidic.**

(1) I and IV only
(2) I, II and III only
(3) II and III only
(4) All four statements

**(c) Reactivity Towards Water**

**Q29. Which of the following correctly summarises the reactivity of Group 14 elements towards water?**

(1) All Group 14 elements react vigorously with water to form their respective oxides and dihydrogen gas

(2) Carbon, silicon and germanium are unaffected by water; tin decomposes steam to form $SnO_2$ and $H_2$; lead is unaffected due to a protective oxide film

(3) Carbon reacts with cold water while silicon and germanium react with hot water; tin and lead are completely inert

(4) Tin reacts with cold water while lead reacts with steam; carbon, silicon and germanium are inert towards water

**Q30. Lead is unaffected by water despite being a reactive metal. Which of the following correctly explains this behaviour?**

(1) Lead reacts with water to form PbO which dissolves readily, so no protective layer is formed

(2) A protective oxide film forms on the surface of lead, preventing further reaction with water

(3) Lead is a noble metal and is chemically inert towards all reagents including water

(4) Lead reacts with water only at very high temperatures to give $PbO_2$ and $H_2$

### (d) Reactivity Towards Halogens

**Q31. Except $CCl_4$, other tetrachlorides of Group 14 are easily hydrolysed by water. $SiCl_4$ undergoes hydrolysis by initially accepting a lone pair from the oxygen of water into the $d$ orbitals of Si, finally forming $Si(OH)_4$ (silicic acid). Which of the following best explains why $CCl_4$ resists hydrolysis?**

(1) Carbon is more electronegative than silicon, making the C–Cl bond stronger and resistant to attack by water

(2) Carbon has no vacant $d$ orbitals to accept the lone pair from the oxygen of water, so the first step of hydrolysis cannot occur

(3) $CCl_4$ is ionic in nature and ionic compounds do not undergo hydrolysis

(4) Carbon forms only two bonds in $CCl_4$ so there is no scope for water to attack the central atom

**Q32. $PbI_4$ does not exist, whereas $PbCl_4$ and $PbBr_4$ exist but are unstable. Which of the following correctly explains the non-existence of $PbI_4$?**

(1) Pb–I bond is too strong, making $PbI_4$ overly stable and unable to release iodine during reactions

(2) The Pb–I bond initially formed during the reaction does not release enough energy to unpair the $6s^2$ electrons and excite one of them to a higher orbital to give four unpaired electrons around the lead atom

(3) Iodine is too large to bond with lead in the +4 oxidation state due to steric repulsion between four large iodine atoms

(4) Lead does not react with iodine under any condition because the inert pair effect completely prevents +4 state formation with all halogens

**Q33. Group 14 elements can form halides of formula $MX_2$ and $MX_4$ (where X = F, Cl, Br, I). The central metal atom in $MX_4$ halides undergoes $sp^3$ hybridisation. Which of the following correctly states the geometry of these $MX_4$ halides and identifies the exceptions that are ionic?**

(1) Tetrahedral geometry; $SnF_4$ and $PbF_4$ are exceptions that are ionic in nature

(2) Square planar geometry; $SnCl_4$ and $PbCl_4$ are ionic

(3) Trigonal pyramidal geometry; all $MX_4$ halides are covalent

(4) Tetrahedral geometry; all $MX_4$ halides are covalent without exception

**Q34. The stability of dihalides ($MX_2$) increases down Group 14 from Ge to Pb. Considering thermal and chemical stability, which of the following correctly compares $GeX_4$ vs $GeX_2$, and $PbX_2$ vs $PbX_4$?**

(1) $GeX_4$ is more stable than $GeX_2$; $PbX_2$ is more stable than $PbX_4$

(2) $GeX_2$ is more stable than $GeX_4$; $PbX_4$ is more stable than $PbX_2$

(3) Both $GeX_4$ and $PbX_4$ are more stable than their respective dihalides throughout

(4) Both $GeX_2$ and $PbX_2$ are less stable than their respective tetrahalides throughout

**Q35. A student carries out hydrolysis of $SiCl_4$ with water. The reaction proceeds stepwise, first accepting a lone pair from water's oxygen into Si's $d$ orbital, then losing HCl, and finally forming silicic acid. What is the final product of complete hydrolysis of $SiCl_4$?**

(1) $SiO_2$ and HCl

(2) $Si(OH)_4$ (silicic acid) and HCl

(3) $SiH_4$ and $Cl_2$

(4) $SiCl_2(OH)_2$ and $H_2$

**Q36. Carbon does not react directly with halogens under normal conditions. All other Group 14 members react with halogens under suitable conditions to form halides. A student wants to prepare $SnF_4$ and $PbF_4$. Which of the following statements about these compounds is correct?**

(1) Both $SnF_4$ and $PbF_4$ are covalent with tetrahedral geometry like most $MX_4$ halides

(2) $SnF_4$ and $PbF_4$ are exceptions among $MX_4$ halides as they are ionic in nature

(3) $SnF_4$ is ionic but $PbF_4$ is covalent because lead prefers the +2 oxidation state

(4) Both $SnF_4$ and $PbF_4$ do not exist because Sn and Pb only show the +2 oxidation state with fluorine

**Q37. The NCERT diagram for hydrolysis of $SiCl_4$ shows: Step 1: $SiCl_4 + H_2O \rightarrow$ intermediate (Si accepts lone pair from O into $d$ orbital) $-$ HCl; Step 2: Intermediate $+ 3H_2O \rightarrow Si(OH)_4$ (silicic acid) $-$ 3HCl. Based on this diagram, what type of bond is formed in Step 1 between Si and the oxygen of water?**

(1) An ionic bond formed by complete transfer of electrons from oxygen to silicon

(2) A coordinate (dative) bond where oxygen donates its lone pair into the vacant $d$ orbital of silicon

(3) A hydrogen bond between the Cl atoms of $SiCl_4$ and the H atoms of water

(4) A pi bond formed by sideways overlap of $p$ orbitals of Si and O

**Q38. The stability trend of dihalides in Group 14 can be shown as: Ge dihalide $<$ Sn dihalide $<$ Pb dihalide (increasing stability). A student draws the reverse trend for tetrahalides: $GeX_4 > SnX_4 > PbX_4$ (decreasing stability going down). Which conclusion is correctly drawn from both trends together?**

(1) For all Group 14 elements, the tetrahalide is always more stable than the dihalide, regardless of position in the group

(2) As we go down Group 14, the +2 state becomes progressively more stable (dihalide stability increases) while the +4 state becomes progressively less stable (tetrahalide stability decreases), consistent with the inert pair effect

(3) Stability of both dihalides and tetrahalides increases uniformly from Ge to Pb down the group

(4) The trends are unrelated to oxidation states and depend only on the size of the halogen atom

**Q39. Consider the following statements about reactivity of Group 14 elements towards halogens and select the correct combination.**

**I. Carbon does not react directly with halogens; all other Group 14 members do under suitable conditions.**
**II. Most $MX_4$ halides are covalent and tetrahedral; $SnF_4$ and $PbF_4$ are exceptions that are ionic.**
**III. $PbI_4$ does not exist because the Pb–I bond energy is insufficient to unpair the $6s^2$ electrons.**
**IV. Except $CCl_4$, all other Group 14 tetrachlorides are easily hydrolysed by water.**

(1) I and II only
(2) I, II and IV only
(3) II and III only
(4) All four statements are correct

**Q40. A student is given five statements about Group 14 halides and must identify all correct ones in under 90 seconds.**

**I. Heavier members Ge to Pb can form dihalides of formula $MX_2$.**
**II. The stability of dihalides *decreases* down the group from Ge to Pb.**
**III. $GeX_4$ is more stable than $GeX_2$ thermally and chemically.**
**IV. $SiCl_4$ undergoes hydrolysis by accepting a lone pair from water into Si's $d$ orbitals, ultimately giving silicic acid.**

(1) I and II only
(2) I, III and IV only
(3) II and III only
(4) All four statements

## TOPIC 5 Anomalous Behaviour of the First Element — Carbon

**Important Trends and Anomalous Properties of Carbon**

**Q41. Carbon differs from the rest of Group 14 members due to its smaller size, higher electronegativity, higher ionisation enthalpy and unavailability of $d$ orbitals. The bond enthalpies of homoatomic single bonds are: C–C = 348, Si–Si = 297, Ge–Ge = 260, Sn–Sn = 240 kJ mol$^{-1}$. A student concludes that catenation tendency decreases down Group 14. Which of the following best supports this conclusion?**

(1) The C–C bond enthalpy (348 kJ mol$^{-1}$) is the highest, making carbon–carbon chains the most stable; as bond enthalpy decreases down the group, the tendency to form chains decreases in the order C $>>$ Si $>$ Ge $=$ Sn

(2) The C–C bond is the weakest because carbon is the smallest atom, and weak bonds favour catenation

(3) Lead shows the highest catenation because it has the largest atomic size and most electrons to share

(4) Bond enthalpy has no relationship with catenation tendency; only atomic size determines chain formation

**Q42. Heavier Group 14 elements (Si, Ge, Sn, Pb) do not form $p\pi$–$p\pi$ multiple bonds with themselves or with other elements. Carbon, however, readily forms C=C, C≡C, C=O, C=S and C≡N bonds. Which of the following correctly explains why heavier members cannot form $p\pi$–$p\pi$ bonds?**

(1) Heavier elements have too few electrons to participate in $\pi$ bonding

(2) The atomic orbitals of heavier elements are too large and diffuse to have effective sideways ($p\pi$–$p\pi$) overlapping, making multiple bond formation ineffective

(3) Heavier elements prefer ionic bonding over covalent bonding and hence cannot form multiple bonds

(4) The electronegativity of heavier elements is too high, preventing effective $\pi$ overlap

**Q43. Carbon has a maximum covalence of 4 while other Group 14 members can exceed 4. Which of the following correctly explains this difference?**

(1) Carbon has more electrons than silicon, which prevents it from forming more than four bonds

(2) In carbon, only $s$ and $p$ orbitals are available for bonding, limiting it to four pairs of electrons around it; other members have accessible $d$ orbitals allowing expansion of covalence beyond 4

(3) Carbon forms only ionic bonds and ionic compounds cannot exceed a coordination number of 4

(4) Carbon has a higher atomic mass than silicon, which limits the number of bonds it can form

**Q44. Catenation is the ability of atoms to link with one another through covalent bonds to form chains and rings. Which of the following correctly states the order of catenation tendency in Group 14 and the reason for lead's position in this order?**

(1) Order: Pb $>$ Sn $>$ Ge $>$ Si $>$ C; lead shows the highest catenation because it is the heaviest element

(2) Order: C $>>$ Si $>$ Ge $=$ Sn; lead does not show catenation because as atomic size increases and electronegativity decreases down the group, the tendency to catenate decreases significantly

(3) Order: C $=$ Si $=$ Ge $=$ Sn $=$ Pb; all Group 14 elements show equal catenation tendency

(4) Order: Si $>$ C $>$ Ge $>$ Sn; carbon does not catenate because its bonds are too strong to form chains

**Q45. Carbon is able to show allotropic forms due to its property of catenation and $p\pi$–$p\pi$ bond formation. Which of the following is a direct consequence of these two unique properties of carbon?**

(1) Formation of $CO_2$ and CO as gaseous oxides
(2) Formation of allotropes like diamond, graphite and fullerenes
(3) Resistance to hydrolysis shown by $CCl_4$
(4) Formation of ionic compounds in the +2 oxidation state

**Q46. A researcher wants to synthesise a compound involving $p\pi$–$p\pi$ multiple bonding between two Group 14 elements and a small, highly electronegative atom. Which of the following combinations is feasible based on NCERT principles?**

(1) Sn=O (tin forms a double bond with oxygen using $p\pi$–$p\pi$ overlap)
(2) C=O (carbon forms a double bond with oxygen; both are small atoms with compact orbitals allowing effective $p\pi$–$p\pi$ overlap)
(3) Pb=S (lead forms a double bond with sulphur using large, diffuse orbitals)
(4) Ge=N (germanium forms a double bond with nitrogen due to its large atomic size)

**Q47. The table below shows bond enthalpies of homoatomic bonds in Group 14:**

| Bond | Bond Enthalpy / kJ mol$^{-1}$ |
|---|---|
| C–C | 348 |
| Si–Si | 297 |
| Ge–Ge | 260 |
| Sn–Sn | 240 |

**Which of the following conclusions is *correctly* drawn from this data?**

(1) Bond enthalpy increases down the group from C to Sn, explaining why heavier elements show more catenation
(2) Bond enthalpy decreases from C to Sn, meaning C–C bonds are the strongest; this explains why carbon has the greatest tendency to catenate while lead does not catenate at all
(3) All Group 14 homoatomic bonds have equal enthalpy, showing no trend with atomic size
(4) Ge–Ge bond is stronger than Si–Si bond because germanium has more electrons

**Q48. Carbon forms $p\pi$–$p\pi$ multiple bonds shown as: C=C, C≡C, C=O, C=S, C≡N. Heavier elements like Si, Ge, Sn do not form such bonds. A student draws a diagram showing that Si orbitals are large and diffuse compared to C orbitals, resulting in poor sideways overlap. Which conclusion follows from this diagram?**

(1) Si can form $p\pi$–$p\pi$ bonds more effectively than C because larger orbitals give better overlap
(2) Effective $p\pi$–$p\pi$ overlap requires compact orbitals of similar size; since Si orbitals are too large and diffuse, sideways overlap is ineffective and multiple bonds are not formed

(3) Si forms $\sigma$ bonds only because it has fewer electrons than carbon

(4) Carbon cannot form $p\pi$–$p\pi$ bonds with nitrogen because carbon orbitals are too small

**Q49. Consider the following statements about anomalous behaviour of carbon and select the correct combination.**

**I. Carbon differs from other Group 14 members due to its smaller size, higher electronegativity, higher ionisation enthalpy and absence of $d$ orbitals.**
**II. Carbon can form $p\pi$–$p\pi$ multiple bonds with itself and with atoms of small size and high electronegativity such as O, N and S.**
**III. Heavier Group 14 members form $p\pi$–$p\pi$ bonds more easily than carbon because their orbitals are larger.**
**IV. Due to catenation and $p\pi$–$p\pi$ bond formation, carbon is able to show allotropic forms.**

(1) I and III only
(2) I, II and IV only
(3) II and III only
(4) All four statements

**Q50. A student must evaluate four statements about catenation in under 90 seconds and pick the correct set.**

**I. Catenation is the tendency of atoms to link with one another through covalent bonds to form chains and rings.**
**II. C–C bond enthalpy (348 kJ mol$^{-1}$) is the highest among Group 14 homoatomic bonds, making carbon's catenation tendency the greatest.**
**III. The order of catenation is C $>>$ Si $>$ Ge $=$ Sn; lead does not show catenation.**
**IV. Catenation tendency increases down Group 14 as atomic size increases and bond enthalpy decreases.**

(1) I, II and III only
(2) II and IV only
(3) I and IV only
(4) All four statements

**— END OF ASSIGNMENT —**