WEIRD CHEMIST

Group 13 Elements — The Boron Family

Chapter: p-Block Elements

DPP-6

Chapter: p-Block Elements (Group 13)

▶ Topic 1 Introduction

(a) Elements of Group 13

Q1. Which of the following is the correct list of all elements belonging to Group 13 of the periodic table?

(1) B, C, N, O, F
(2) B, Al, Ga, In, Tl
(3) Be, Mg, Ca, Sr, Ba
(4) Na, K, Rb, Cs, Fr

(b) Nature — Metal or Non-Metal

Q2. Which of the following correctly describes the variation in metallic character across Group 13 elements?

(1) All five elements are metals
(2) Boron is a non-metal; aluminium, gallium, indium and thallium are metals
(3) Boron and aluminium are non-metals; the rest are metals
(4) All five elements are non-metals

Q3. Boron is described as a "typical non-metal" in NCERT. Which property best justifies this classification?

(1) Boron has a low melting point and soft texture like typical non-metals
(2) Boron is an extremely hard, black coloured solid with a very strong crystalline lattice and does not conduct electricity like a metal
(3) Boron readily forms B^{3+} ions, which is typical of non-metals
(4) Boron is a gas at room temperature, which is characteristic of non-metals

(c) Occurrence

Q4. Boron is a fairly rare element. Which of the following correctly states the abundance of boron in the earth's crust and names its important ores?

(1) Abundance $> 8\%$; ores are bauxite and cryolite
(2) Abundance $< 0.0001\%$ by mass; ores include orthoboric acid (H_3BO_3), borax, kernite and colemanite
(3) Abundance $\approx 27.7\%$; ores include mica and feldspar
(4) Abundance $\approx 8.3\%$; ores include orthoboric acid and borax

Q5. Aluminium is the most abundant metal in the earth's crust. Which of the following correctly states its percentage abundance and names its important minerals?

(1) 45.5% by mass; bauxite ($Al_2O_3 \cdot {}_2H_2O$) and cryolite (Na_3AlF_6)
(2) 8.3% by mass; bauxite ($Al_2O_3 \cdot {}_2H_2O$) and cryolite (Na_3AlF_6)
(3) 27.7% by mass; kernite ($Na_2B_4O_7 \cdot {}_4H_2O$) and borax
(4) 8.3% by mass; orthoboric acid (H_3BO_3) and kernite

▶ Topic 2 Atomic Properties

(a) Electronic Configuration

Q6. The general outer electronic configuration of Group 13 elements is ns^2np^1. Which element has a noble gas core plus 10 d-electrons plus 14 f-electrons plus 10 d-electron cores, making its structure the most complex in the group?

(1) Boron (2) Aluminium (3) Indium (4) Thallium

Q7. The electronic structure of gallium is more complex than that of aluminium. Which statement correctly explains this?

(1) Gallium has a larger atomic radius, making its electron cloud more diffuse and harder to describe
(2) Gallium has a noble gas core plus 10 d-electrons in the inner core, whereas aluminium has only a simple noble gas core
(3) Gallium has more protons, so nuclear charge makes its electron configuration harder to calculate
(4) Gallium belongs to Period 4 and all Period 4 elements are inherently more complex than Period 3 elements

(b) Atomic Radii

Q8. On moving down Group 13, atomic radius is generally expected to increase. However, the atomic radius of gallium (135 pm) is *less* than that of aluminium (143 pm). The best reason for this anomaly is:

(1) Gallium has a higher nuclear charge, which directly pulls the outermost electrons closer inward
(2) The additional 10 d-electrons in gallium's inner core provide poor shielding, so the effective nuclear charge experienced by outer electrons is unexpectedly high

(3) Gallium has a smaller atomic mass than aluminium, which reduces the size of the atom

(4) Gallium belongs to Period 4 and all Period 4 elements have smaller radii than Period 3 elements due to lanthanide contraction

Q9. Which of the following gives the correct order of atomic radii for Group 13 elements?

(1) $r_{\mathrm{B}} < r_{\mathrm{Al}} < r_{\mathrm{Ga}} < r_{\mathrm{In}} < r_{\mathrm{Tl}}$

(2) $r_{\mathrm{B}} < r_{\mathrm{Ga}} < r_{\mathrm{Al}} < r_{\mathrm{In}} < r_{\mathrm{Tl}}$

(3) $r_{\mathrm{Tl}} < r_{\mathrm{In}} < r_{\mathrm{Ga}} < r_{\mathrm{Al}} < r_{\mathrm{B}}$

(4) $r_{\mathrm{B}} < r_{\mathrm{Al}} < r_{\mathrm{In}} < r_{\mathrm{Ga}} < r_{\mathrm{Tl}}$

(c) Ionisation Enthalpy

Q10. The ionisation enthalpy does not decrease smoothly down Group 13. Discontinuities are observed between Al & Ga, and between In & Tl. Which of the following correctly explains the discontinuity between In and Tl?

(1) Thallium has a larger atomic radius, which should lower ionisation enthalpy, but lanthanide contraction reverses this

(2) The 10 d-electrons and 14 f-electrons in thallium's core provide poor shielding, so outer electrons experience a higher effective nuclear charge than expected

(3) Thallium has a lower nuclear charge than indium, making its ionisation enthalpy unexpectedly high

(4) The inert pair effect makes the $6s$ electrons of thallium harder to remove than the $5s$ electrons of indium

Q11. The order of the first three successive ionisation enthalpies ($\Delta_i H_1$, $\Delta_i H_2$, $\Delta_i H_3$) for Group 13 elements is:

(1) $\Delta_i H_1 > \Delta_i H_2 > \Delta_i H_3$

(2) $\Delta_i H_1 < \Delta_i H_2 < \Delta_i H_3$

(3) $\Delta_i H_1 = \Delta_i H_2 = \Delta_i H_3$

(4) $\Delta_i H_2 < \Delta_i H_1 < \Delta_i H_3$

Q12. The decrease in ionisation enthalpy from B to Al is associated with an increase in size. From Al to Ga, the ionisation enthalpy does not decrease as expected. Which is the correct reason?

(1) Poor screening by the 10 d-electrons in gallium's core increases effective nuclear charge, resisting the expected decrease

(2) Gallium has a lower atomic mass than expected, making removal of electrons easier

(3) The inert pair effect in gallium stabilises the $4s$ electrons, making them harder to remove

(4) All Group 13 elements have identical ionisation enthalpies because they share the same group oxidation state

(d) Electronegativity

Q13. On moving down Group 13, the electronegativity values show an irregular trend. Which of the following correctly describes this trend?

(1) Electronegativity increases steadily from B to Tl as atomic size increases down the group

(2) Electronegativity decreases steadily from B to Tl because nuclear charge increases down the group

(3) Electronegativity first decreases from B to Al and then increases marginally down the group due to discrepancies in atomic size

(4) Electronegativity first increases from B to Al and then decreases marginally due to the inert pair effect

▶ Topic 3 Physical Properties

(a) Physical State at Room Temperature

Q14. Which of the following correctly states the physical state of all Group 13 elements at room temperature (298 K)?

(1) All are solids

(2) Boron and aluminium are solids; gallium is liquid; indium and thallium are gases

(3) All are solids except gallium, which has an unusually low melting point (303 K) and melts just above room temperature

(4) Boron is a gas; the rest are solids

(b) Boiling Point Order

Q15. From the boiling point data of Group 13 elements (B = 3923 K, Al = 2740 K, Ga = 2676 K, In = 2353 K, Tl = 1730 K), which of the following correctly arranges them in *decreasing* order of boiling point?

(1) B > Al > Ga > In > Tl

(2) Tl > In > Ga > Al > B

(3) Al > B > Ga > In > Tl

(4) B > Ga > Al > In > Tl

(c) Melting Point Order

Q16. Boron has an unusually high melting point compared to the rest of Group 13 elements. Which of the following correctly explains this and identifies the element with the *lowest* melting point in the group?

(1) Boron has the highest melting point due to ionic bonding; aluminium has the lowest melting point

(2) Boron has the highest melting point due to its strong crystalline lattice; gallium (303 K) has the lowest melting point in the group

(3) All Group 13 elements have similar melting points as they are all soft metals

(4) Thallium has the highest melting point and boron has the lowest melting point due to non-metallic character

Q17. Consider the following statements about melting and boiling points of Group 13 elements:

I. Boron has a very high melting point due to strong crystalline lattice.
II. Gallium has an unusually low melting point of 303 K, allowing it to exist as liquid in summer.
III. Gallium's high boiling point (2676 K) makes it useful for measuring high temperatures.
IV. The melting points of all Group 13 elements increase smoothly going down the group.

Which of the above statements are correct?

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

(d) Density

Q18. A scientist arranges samples of B, Al, Ga, In and Tl in order of *increasing* density. Which order is correct?

(1) Tl < In < Ga < Al < B
(2) B < Al < In < Ga < Tl
(3) B < Al < Ga < In < Tl
(4) Al < B < Ga < In < Tl

Q19. Which of the following correctly describes the trend in density and electrical conductivity for Group 13 elements (excluding boron)?

(1) Density decreases down the group; all members are poor conductors of electricity
(2) Density increases from boron to thallium; aluminium, gallium, indium and thallium are soft metals with high electrical conductivity
(3) Density remains nearly constant; only aluminium is a good conductor of electricity
(4) Density decreases from boron to thallium; all members are good conductors of electricity

▶ Topic 4 Chemical Properties

(a) Oxidation States

Q20. Boron forms only covalent compounds and cannot form B^{3+} ions. Which of the following best explains this?

(1) Boron has a lower nuclear charge than aluminium, making it harder to attract electrons for ionic bonding
(2) The sum of the first three ionisation enthalpies of boron is very high due to its small size, making B^{3+} formation energetically unfavourable

(3) Boron has more electrons than aluminium, so it prefers covalent bonding
(4) Aluminium is a non-metal and therefore more likely to form ionic compounds than boron

Q21. The inert pair effect is responsible for the stability of the +1 oxidation state in heavier Group 13 elements. Which of the following correctly explains the inert pair effect?

(1) The ns electrons in heavier elements are lost first because they are the outermost electrons
(2) Poor shielding by intervening d and f orbitals increases the effective nuclear charge on ns electrons, making them reluctant to participate in bonding
(3) The inert pair effect arises because heavier elements have larger atomic radii, making it easier to retain ns electrons
(4) The ns electrons form a stable pair that participates preferentially in covalent bonding in heavier elements

Q22. Which of the following correctly states the trend in relative stability of the +1 oxidation state down Group 13?

(1) Al > Ga > In > Tl
(2) Tl > In > Ga > Al
(3) Ga > In > Tl > Al
(4) All elements equally stable in +1 state

Q23. In thallium, the +1 oxidation state is predominant whereas the +3 oxidation state is highly oxidising. This can be explained by:

(1) The large atomic radius of thallium makes the +3 state more stable than the +1 state
(2) The inert pair effect makes the $6s^2$ electrons of thallium reluctant to participate in bonding, stabilising Tl^+ over Tl^{3+}
(3) Thallium has fewer electrons than indium and therefore prefers the lower oxidation state
(4) The +3 state in thallium is stable because thallium is a typical metal

Q24. Consider the following statements about oxidation states of Group 13 elements:

I. Thallium predominantly shows +1 oxidation state and its +3 state is highly oxidising in character.
II. Compounds in +1 oxidation state are more ionic than those in the +3 oxidation state.
III. In BF_3, boron has 8 electrons around it and is therefore not a Lewis acid.
IV. The relative stability of +1 oxidation state increases for heavier Group 13 elements: Al < Ga < In < Tl.

Which combination of statements is correct?

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

Q25. The standard electrode potential E° for Al^{3+}/Al is -1.66 V and for Tl^{3+}/Tl is $+1.26$ V. Which of the following conclusions is correct based on these values?

(1) Tl is more electropositive than Al because its electrode potential is positive

(2) Al is more electropositive than Tl; Al readily forms Al^{3+} ions in solution, whereas Tl^{3+} is unstable and a powerful oxidising agent, making Tl^{+} the more stable ion in solution

(3) Both Al and Tl have equal tendency to form M^{3+} ions since both belong to Group 13

(4) Tl^{3+} is more stable than Tl^{+} in solution because the +3 state is the group oxidation state

Q26. Compounds of Group 13 elements in the +1 oxidation state are described as more ionic than those in the +3 oxidation state. Which of the following best explains this observation?

(1) In the +1 state, only the p electron is lost, giving a larger ion with lower charge density that favours ionic bonding

(2) In the +3 state, all three valence electrons are removed, giving a smaller, highly charged ion with high polarising power that favours covalent bonding

(3) Both (1) and (2) together correctly explain why +1 state compounds are more ionic than +3 state compounds

(4) The +1 state is more ionic because the elements prefer to retain their ns^2 electrons rather than participate in bonding

(b) Reactivity Towards Air

Q27. Boron is unreactive in crystalline form, yet amorphous boron reacts with air on heating to form B_2O_3. Aluminium reacts with air to form Al_2O_3, but does not corrode further. Which of the following correctly explains why aluminium is protected?

(1) Aluminium reacts with nitrogen in air to form a nitride layer impermeable to oxygen

(2) Aluminium forms a very thin but tough Al_2O_3 layer on its surface that acts as a protective barrier against further reaction

(3) Aluminium becomes completely unreactive once it loses its surface lustre on exposure to air

(4) The oxide layer on aluminium is basic and neutralises acids in the atmosphere, preventing corrosion

Q28. When Group 13 elements are heated in air, they form oxides and at high temperatures also react with dinitrogen. Which pair of equations correctly represents both reactions for a Group 13 element E?

(1) $2\mathrm{E}(s) + 3\mathrm{O_2}(g) \xrightarrow{\Delta} 2\mathrm{E_2O_3}(s)$ and $2\mathrm{E}(s) + \mathrm{N_2}(g) \xrightarrow{\Delta} 2\mathrm{EN}(s)$

(2) $4\mathrm{E}(s) + 3\mathrm{O_2}(g) \xrightarrow{\Delta} 2\mathrm{E_2O_3}(s)$ and $\mathrm{E}(s) + \mathrm{N_2}(g) \xrightarrow{\Delta} \mathrm{EN_2}(s)$

(3) $2\mathrm{E}(s) + \mathrm{O_2}(g) \xrightarrow{\Delta} 2\mathrm{EO}(s)$ and $\mathrm{E}(s) + \mathrm{N_2}(g) \xrightarrow{\Delta} \mathrm{EN}(s)$

(4) $\mathrm{E}(s) + \mathrm{O_2}(g) \xrightarrow{\Delta} \mathrm{EO_2}(s)$ and $3\mathrm{E}(s) + \mathrm{N_2}(g) \xrightarrow{\Delta} \mathrm{E_3N_2}(s)$

Q29. The nature of oxides of Group 13 elements varies down the group. Which of the following correctly describes this variation?

(1) B_2O_3 is basic; Al_2O_3 and Ga_2O_3 are acidic; oxides of In and Tl are amphoteric

(2) B_2O_3 is acidic; Al_2O_3 and Ga_2O_3 are amphoteric; oxides of In and Tl are basic

(3) All Group 13 oxides are amphoteric in nature

(4) B_2O_3 is neutral; Al_2O_3 is acidic; oxides of Ga, In and Tl are basic

Q30. Boron trioxide (B_2O_3) is acidic in nature. Which of the following correctly describes how B_2O_3 reacts with a basic metallic oxide?

(1) B_2O_3 donates oxide ions to the basic metallic oxide to form a salt and water

(2) B_2O_3 reacts with basic metallic oxides (e.g., CaO) to form metal borates (e.g., $Ca(BO_2)_2$), because an acidic oxide reacts with a basic oxide to form a salt

(3) B_2O_3 does not react with basic metallic oxides because it is a non-metallic oxide and non-metallic oxides are chemically inert

(4) B_2O_3 acts as a base and reacts with acidic metallic oxides to form metal borates

Q31. Consider the following statements about reactivity of Group 13 elements towards air:

I. B_2O_3 is acidic and reacts with basic metallic oxides to form metal borates.
II. Oxides of indium and thallium are amphoteric in nature.
III. Aluminium and gallium oxides are amphoteric in nature.
IV. At high temperature, Group 13 elements react with dinitrogen to form nitrides of formula EN.

Which combination of statements is correct?

(1) I and II only

(2) I, III and IV only

(3) II and III only

(4) I, II and III only

(c) Reactivity Towards Acids and Alkalies

Q32. Aluminium dissolves readily in dilute HCl but concentrated HNO_3 renders aluminium passive. Which of the following correctly explains the passivation by concentrated HNO_3?

(1) Concentrated HNO_3 reacts violently with aluminium releasing so much heat that the metal becomes non-reactive

(2) Concentrated HNO_3 forms a thin, tough protective oxide layer on the surface of aluminium, preventing further reaction

(3) Concentrated HNO_3 converts aluminium into $Al(NO_3)_3$ which coats the surface and blocks further attack

(4) Aluminium is a noble metal and does not react with any concentrated acid

Q33. Aluminium shows amphoteric character. Which of the following pair of reactions correctly demonstrates this property?

(1) Reacts with HCl to give $AlCl_3$ and with NaOH to give $Na[Al(OH)_4]$, liberating H_2 in both cases

(2) Reacts with HCl to give $AlCl_3$ but does not react with NaOH at all

(3) Reacts with NaOH to give $Na[Al(OH)_4]$ but does not react with any acid

(4) Reacts with H_2SO_4 to give $Al_2(SO_4)_3$ and with NaOH to give $NaAlO_2$ but liberates no gas in either reaction

Q34. A student adds excess aqueous NaOH to aluminium metal. What are the products formed and what is the IUPAC name of the aluminium-containing product?

(1) Al_2O_3 and H_2O; aluminium oxide

(2) $Na[Al(OH)_4]$ and H_2; sodium tetrahydroxoaluminate(III)

(3) $AlCl_3$ and H_2; aluminium chloride

(4) $NaAlO_2$ and H_2O; sodium meta-aluminate

Q35. Which of the following balanced equations correctly represents the reaction of aluminium with dilute hydrochloric acid?

(1) $\text{Al}(s) + \text{HCl}(aq) \rightarrow \text{AlCl}(aq) + \frac{1}{2}\text{H}_2(g)$

(2) $2\text{Al}(s) + 6\text{HCl}(aq) \rightarrow 2\text{Al}^{3+}(aq) + 6\text{Cl}^-(aq) + 3\text{H}_2(g)$

(3) $\text{Al}(s) + 3\text{HCl}(aq) \rightarrow \text{AlCl}_3(aq) + \text{H}_3(g)$

(4) $4\text{Al}(s) + 12\text{HCl}(aq) \rightarrow 4\text{AlCl}_2(aq) + 6\text{H}_2(g)$

Q36. Consider the following statements about reactivity of Group 13 elements towards acids and alkalies:

I. Boron does not react with acids and alkalies even at moderate temperature.
II. Aluminium dissolves in dilute HCl liberating dihydrogen.
III. Concentrated HNO_3 reacts vigorously with aluminium and dissolves it completely.
IV. The product formed when aluminium reacts with aqueous NaOH is sodium tetrahydroxoaluminate(III).

Which combination is correct?

(1) I, II and III only

(2) I, II and IV only

(3) II, III and IV only

(4) All four statements

(d) Reactivity Towards Halogens

Q37. Group 13 elements react with halogens to form trihalides (except Tl). Which of the following correctly states what thallium forms with halogens and why?

(1) Thallium forms TlX_3 like all other Group 13 elements because the inert pair effect is not strong enough with halogens

(2) Thallium forms TlX (monohalide) instead of TlX_3 because the +1 oxidation state is predominant due to the inert pair effect

(3) Thallium does not react with halogens at all as it is the heaviest Group 13 element

(4) Thallium forms TlX_2 because it shows a +2 oxidation state preferentially

Q38. The general reaction of Group 13 elements with halogens is $2\mathbf{E}(s) + 3\mathbf{X}_2(g) \xrightarrow{\Delta} 2\mathbf{EX}_3(s)$ (where X = F, Cl, Br, I). White fumes are observed around an open bottle of anhydrous aluminium chloride. Which of the following correctly explains this observation?

(1) Anhydrous $AlCl_3$ sublimes at room temperature and vapours appear white in air
(2) Anhydrous $AlCl_3$ is partially hydrolysed by atmospheric moisture to liberate HCl gas, which appears white as moist HCl in air
(3) Anhydrous $AlCl_3$ reacts with oxygen to form white Al_2O_3 powder around the bottle
(4) Anhydrous $AlCl_3$ absorbs CO_2 from air and forms a white carbonate layer on the surface

Q39. Which of the following is the correct product when aluminium reacts with chlorine gas?

(1) AlCl (2) $AlCl_2$ (3) $AlCl_3$ (4) Al_2Cl_3

▶ Topic 5 Anomalous Behaviour of the First Element — Boron

Important Trends and Anomalous Properties of Boron

Q40. Certain important trends can be observed in Group 13 elements. The tri-chlorides of all Group 13 elements except boron undergo hydrolysis in water to give species like $[M(H_2O)_6]^{3+}$ and $[M(OH)_4]^-$. Which of the following pairs of species are formed during hydrolysis of $AlCl_3$ in water?

(1) Tetrahedral $[Al(OH)_4]^-$ and HCl
(2) Octahedral $[Al(H_2O)_6]^{3+}$ and HCl
(3) Linear $[AlCl_2(OH)_2]^-$ and HCl
(4) Square planar $[AlCl_4]^-$ and H_2O

Q41. Tri-chlorides, bromides and iodides of all Group 13 elements are covalent and hydrolysed in water to form $[M(OH)_4]^-$ and $[M(H_2O)_6]^{3+}$ species. However, boron is an exception and does NOT form these species in aqueous medium. Which of the following best explains this anomaly?

(1) Boron is a non-metal and non-metals never form ionic species in aqueous medium
(2) Boron lacks d orbitals, so its maximum covalence is limited to 4; it cannot expand its coordination number to form tetrahedral $[B(OH)_4]^-$ or octahedral $[B(H_2O)_6]^{3+}$ like other Group 13 elements
(3) Boron trichloride is not hydrolysed in water because the B–Cl bond is extremely strong and resists hydrolysis
(4) Boron has the smallest atomic radius in Group 13 and therefore cannot accommodate water molecules around it

Q42. The maximum covalence of boron is 4, while for aluminium and heavier Group 13 elements it can exceed 4. Which statement correctly explains this?

(1) Boron has a higher nuclear charge than aluminium, limiting the number of bonds it can form

(2) Boron does not have d orbitals available for bonding, restricting its maximum covalence to 4, whereas Al and heavier elements have accessible d orbitals allowing expansion beyond 4

(3) Boron forms only ionic compounds which always have a maximum coordination number of 4

(4) Aluminium has a smaller atomic radius than boron, allowing it to accommodate more bonds

Q43. Boron is unable to form BF_6^{3-} ion, whereas aluminium readily forms AlF_6^{3-}. The correct reason for boron's inability is:

(1) Boron has very high electronegativity and repels fluoride ions, preventing formation of BF_6^{3-}

(2) Due to non-availability of d orbitals, boron cannot expand its octet and its maximum covalence cannot exceed 4

(3) Boron is a non-metal and non-metals never form anionic complex species with fluorine

(4) The B–F bond is too strong to allow additional fluoride ions to coordinate beyond BF_4^-

Q44. The monomeric trihalides of Group 13 are electron deficient and act as Lewis acids. BF_3 easily reacts with NH_3 to complete boron's octet. Which of the following correctly describes the change in geometry of boron in this reaction?

(1) Boron changes from tetrahedral to planar; BF_3 is electron-rich and donates electrons to NH_3

(2) Boron changes from planar (sp^2) to tetrahedral (sp^3); BF_3 is electron-deficient with only 6 electrons around boron, so it accepts a lone pair from NH_3

(3) Boron remains planar throughout; BF_3 accepts a proton from NH_3

(4) Boron changes from linear to planar; the reaction occurs because nitrogen is more electronegative than boron

Q45. The monomeric trihalides of Group 13 elements are electron deficient. Which of the following correctly states the number of electrons around the central atom in BCl_3 and $AlCl_3$ respectively, and identifies them as Lewis acids?

(1) 8 electrons in both; they are Lewis bases because they have a complete octet

(2) 6 electrons in both; they are electron deficient and hence act as Lewis acids by accepting lone pairs from donors

(3) 10 electrons in BCl_3 and 6 electrons in $AlCl_3$; only $AlCl_3$ is a Lewis acid

(4) 4 electrons in BCl_3 and 8 electrons in $AlCl_3$; only BCl_3 is a Lewis acid

Q46. Most metal halides of Group 13 (e.g., $AlCl_3$) exist as dimers (Al_2Cl_6) through halogen bridging. In the dimer, the bridging Al–Cl bond (221 pm) is longer than the terminal Al–Cl bond (206 pm). Which of the following correctly explains why the bridging bond is weaker?

(1) The bridging Cl donates its lone pair to two Al atoms simultaneously, reducing the bond order per Al and making the bridging bond longer and weaker

(2) The terminal Cl is further from the Al nucleus and experiences less nuclear attraction, forming a weaker bond

(3) Both bonds are coordinate bonds, so they must be equal in strength regardless of bond length

(4) The bridging bond is ionic while the terminal bond is covalent, making the bridging bond longer

Q47. Which of the following correctly explains why $AlCl_3$ dimerises to form Al_2Cl_6 but BF_3 does NOT dimerize through halogen bridging?

(1) BF_3 is more electronegative than $AlCl_3$ and electronegative compounds never form dimers

(2) Boron's small size and absence of d orbitals limit its maximum covalence to 4; it prefers to complete its octet by acting as a Lewis acid towards external donors like NH_3 rather than by bridging

(3) BF_3 already has 8 electrons around boron due to back-bonding with F, so dimerisation is unnecessary

(4) Fluorine is too small to act as a bridging atom between two boron centres, whereas chlorine is large enough to bridge two aluminium atoms

Q48. The product formed when BF_3 reacts with NH_3 is $F_3B \longleftarrow NH_3$. What type of bond is formed between B and N in this adduct?

(1) A covalent bond formed by sharing of one electron each from B and N; called a normal covalent bond

(2) A coordinate bond (dative bond) formed by donation of a lone pair from N to the empty orbital of B; called a Lewis acid-base interaction

(3) An ionic bond formed by complete transfer of electrons from N to B; called an electrovalent bond

(4) A hydrogen bond between the F atoms of BF_3 and the H atoms of NH_3

Q49. In acidified aqueous solution, $AlCl_3$ forms the complex ion $[Al(H_2O)_6]^{3+}$. What is the hybridisation of Al in this complex ion?

(1) sp^3 (2) sp^3d^2 (3) sp^2 (4) sp^3d

Q50. Consider the following statements about anomalous properties of boron and Group 13 trends:

I. Tri-chlorides, bromides and iodides of all Group 13 elements are covalent and hydrolysed in water.
II. Species like $[M(OH)_4]^-$ and $[M(H_2O)_6]^{3+}$ exist for all Group 13 elements including boron.
III. BF_3 acts as a Lewis acid and reacts with NH_3 to complete boron's octet.
IV. Most metal halides of Group 13 dimerise through halogen bridging where the metal accepts electrons from halogen to complete its octet.

Which combination of statements is correct?

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

— END OF ASSIGNMENT —