PRACTICE SHEET

Inorganic Chemistry Exceptions — JEE Main

The anomalies that break periodic trends, with the reason behind each one.

5 sections · 25 questions · about 35 min

SECTION 1 — Alkali metals and the lithium anomaly

1. Which alkali metal forms a nitride (M_3N) upon burning in nitrogen gas?

- A Lithium (Li)
- B Potassium (K)
- C Rubidium (Rb)
- D Sodium (Na)

2. When sodium burns in excess oxygen, the primary product is:

- A A mixture of all three oxides
- B Superoxide NaO_2
- C Peroxide Na_2O_2
- D Normal oxide Na_2O only

3. How does the solubility of LiF compare to that of NaF?

- A LiF is much more soluble than NaF
- B Solubility depends on temperature only
- C Both have identical solubility
- D LiF is less soluble than NaF

4. LiCl differs from NaCl, KCl, and other alkali chlorides primarily in that:

- A It forms a complex with water molecules
- B It is covalent and soluble in organic solvents like ethanol and pyridine
- C It is ionic and insoluble in polar solvents
- D It decomposes above room temperature

5. Lithium shows a diagonal relationship with which element?

- A Magnesium (Mg)
- B Calcium (Ca)
- C Aluminum (Al)
- D Beryllium (Be)

SECTION 2 — Diagonal relationships, Group 13 and back bonding

6. Beryllium and aluminum share amphoteric hydroxides, $Be(OH)_2$ and $Al(OH)_3$. This is an exception because:

- A All Group 2 elements form amphoteric hydroxides
- B Be and Al show a diagonal relationship; other Group 2 and Group 13 members form basic or acidic hydroxides respectively
- C All Group 13 elements form amphoteric hydroxides
- D Amphoteric hydroxides are the normal trend in both groups

7. The first ionization enthalpy of gallium is unexpectedly higher than that of aluminum because:

- A Gallium is more electronegative than aluminum
- B The 4p orbital is more tightly bound than the 3p orbital
- C The filled $3d^{10}$ electrons in Ga provide poor shielding of the $4p^1$ valence electron
- D Gallium has a lower atomic radius

8. Boron's melting point is anomalously high compared to other Group 13 elements. This is because boron is:

- A A metallic conductor with delocalized electrons
- B Highly reactive with atmospheric oxygen
- C The lightest element in the group
- D A covalent network solid with an icosahedral structure

9. BF_3 is a weaker Lewis acid than BCl_3, even though fluorine is more electronegative than chlorine. The reason is:

- A BCl_3 is ionic while BF_3 is covalent
- B Fluorine is larger than chlorine, so BF_3 is sterically crowded
- C Fluorine's 2p lone pairs overlap efficiently with boron's empty 2p orbital, so BF_3 is less electron deficient
- D Boron is in a different oxidation state in the two compounds

10. BCl_3 hydrolyses instantly in water, while CCl_4 does not react at all. The reason is:

- A The B–Cl bond is much weaker than the C–Cl bond
- B Boron is more electronegative than carbon
- C CCl_4 is ionic and water cannot polarise it
- D Boron has a vacant orbital that a water lone pair can attack; carbon has a complete octet and no accessible d orbitals

SECTION 3 — Groups 14 to 16: the octet, covalency and hydrogen bonding

11. Nitrogen gas (N_2) is inert under ordinary conditions, while white phosphorus (P_4) is reactive. The primary reason is:

- A P_4 has a higher electron affinity
- B N_2 contains a very strong triple bond; P_4 contains weaker single bonds arranged in a strained structure
- C Nitrogen is less abundant than phosphorus
- D N_2 has lower electronegativity

12. Nitrogen cannot form NCl_5, but phosphorus readily forms PCl_5. The reason is:

- A Nitrogen's valence shell (n=2) lacks accessible d-orbitals for expansion beyond an octet
- B Nitrogen atoms are smaller and cannot accommodate five large chlorine atoms
- C Nitrogen is more electronegative than phosphorus
- D PCl_5 is more stable because phosphorus is more oxidizing

13. Oxygen has a maximum covalency of 4 (e.g., no OF_6 exists), while sulfur readily forms SF_6. The reason is:

- A SF_6 is unstable and decomposes slowly
- B Fluorine cannot bond to oxygen
- C Sulfur's larger size and accessible 3d orbitals allow it to expand its octet beyond 4 bonds
- D Oxygen is more electronegative than sulfur

14. CO_2 is a gas at room temperature, while SiO_2 is a solid melting above 1700 °C. The reason is:

- A Silicon is more electronegative than carbon
- B Carbon forms pπ–pπ double bonds to oxygen, giving discrete O=C=O molecules; silicon does not, so SiO_2 is a covalent network
- C CO_2 molecules are held together by hydrogen bonds
- D SiO_2 is ionic while CO_2 is covalent

15. Water boils at 100 °C while H_2S boils at −60 °C, breaking the trend down Group 16. The reason is:

- A Oxygen has a larger atomic radius than sulfur
- B Water has the higher molar mass
- C H_2S is ionic in the liquid state
- D Hydrogen bonding between water molecules

SECTION 4 — Halogens, noble gases and the inert pair effect

16. Which halogen has the highest electron affinity?

- A Chlorine (Cl)
- B Fluorine (F)
- C Iodine (I)
- D Bromine (Br)

17. Hydrofluoric acid (HF) is classified as a weak acid, despite fluorine being the most electronegative element. The primary reason is:

- A HF decomposes rapidly in water
- B HF is a weak acid because the H-F bond is extremely strong and H-bonding reduces dissociation
- C Fluorine has lower electronegativity than chlorine
- D Fluorine does not form stable anions

18. The inert pair effect describes the increasing stability of lower oxidation states down Groups 13–16. Which statement correctly illustrates this?

- A Tl(III) is more stable than Tl(I)
- B Pb(IV) is more stable than Pb(II)
- C Tl(I) is more stable than Tl(III)
- D Gallium preferentially forms Ga(III) over Ga(I)

19. Fluorine is the strongest oxidising agent among the halogens in aqueous solution, although chlorine has the higher electron affinity. The main reasons are:

- A The low F–F bond dissociation enthalpy and the very high hydration enthalpy of F^-
- B Fluorine's high electron affinity together with its large atomic size
- C The vacant d orbitals of fluorine
- D The exceptional strength of the F–F bond

20. Xenon forms compounds such as XeF_4, while helium and neon form none. The reason is:

- A Helium and neon are heavier than xenon
- B Xenon's octet is incomplete
- C Xenon has unpaired electrons in its ground state
- D Xenon's ionisation enthalpy is far lower, so its outer electrons can be shared with highly electronegative atoms

SECTION 5 — The d-block and the lanthanide contraction

21. Chromium's ground-state configuration is $[Ar]3d^5 4s^1$, not the expected $[Ar]3d^4 4s^2$. The reason is:

- A Chromium loses an electron to the argon core
- B The 3d and 4s orbitals are degenerate in chromium
- C A half-filled 3d subshell together with a half-filled 4s gives extra exchange energy
- D The 4s orbital is always higher in energy than 3d in neutral atoms

22. Which two elements of the first transition series have anomalous ground-state configurations?

- A Chromium and copper
- B Scandium and zinc
- C Manganese and iron
- D Vanadium and nickel

23. Zinc, cadmium and mercury are not regarded as typical transition elements because:

- A They belong to the p-block
- B Their d subshell is completely filled in the atom and in their common ions
- C They never form coloured compounds under any conditions
- D They are liquids or low-melting metals

24. Zirconium and hafnium have almost the same atomic radius, although hafnium sits one period below. This is a consequence of:

- A The diagonal relationship
- B Hafnium's higher oxidation state
- C The inert pair effect
- D The lanthanide contraction

25. Mn^{2+} is unusually stable compared with the M^{2+} ions on either side of it. The reason is:

- A It has a half-filled $3d^5$ configuration
- B It is the smallest ion in the series
- C It has no d electrons at all
- D It has a completely filled $3d^{10}$ configuration