

JEE Main: inorganic chemistry exceptions

Original revision sheet. Author-checked; not yet reviewed by a subject teacher. Confirm in your textbook.

Periodic trends (easy)

Which has the higher first ionisation enthalpy?

Answer: Beryllium. Beryllium ($2s^2$) has a filled $2s$ subshell. Boron loses a $2p$ electron, which is higher in energy and shielded by the $2s$ electrons, so it comes off more easily.

Periodic trends (easy)

Which has the higher first ionisation enthalpy?

Answer: Nitrogen. Nitrogen has a half-filled $2p^3$ configuration, which is extra stable. Oxygen has a paired electron in a $2p$ orbital; the repulsion makes it easier to remove, so O is lower than N.

Periodic trends (medium)

Which element has the most negative electron gain enthalpy?

Answer: Chlorine. Fluorine is very small, so the added electron is strongly repelled by the electrons already in the compact $2p$ subshell. Chlorine's larger $3p$ subshell has less repulsion, so Cl releases more energy.

Periodic trends (medium)

Among O, S, Se and Te, which has the most negative first electron gain enthalpy?

Answer: S. As with F and Cl, oxygen's small $2p$ subshell repels the incoming electron, so sulphur is more negative than oxygen. Se and Te are less negative than S.

Periodic trends (hard)

Gallium has a smaller atomic radius than aluminium, even though it lies below it. Why?

Answer: The $3d$ electrons shield the nuclear charge poorly. Between Al and Ga the ten $3d$ electrons are added. d electrons shield poorly, so the effective nuclear charge on Ga's outer electrons is higher and the atom is not larger than Al.

s-block (medium)

Which alkali metal has the most negative standard electrode potential (M^+/M)?

Answer: Li. Li has the highest ionisation enthalpy of the group but its very small Li^+ ion has by far the highest hydration enthalpy. The hydration term wins, so Li is the strongest reducing agent in water.

s-block (easy)

On burning in excess air, which alkali metal forms mainly the normal oxide?

Answer: Lithium. Li^+ is small and polarises larger peroxide and superoxide ions, so they are unstable. Lithium gives Li_2O (with a little Li_2O_2); sodium gives mainly Na_2O_2 ; K, Rb and Cs give superoxides.

s-block (medium)

Which alkali metal carbonate decomposes to the oxide and CO_2 on moderate heating?

Answer: Li_2CO_3 . The small Li^+ ion polarises the carbonate ion strongly and Li_2O has a high lattice enthalpy, so Li_2CO_3 decomposes. The other alkali metal carbonates are stable to much higher temperatures.

s-block (medium)

Which halide of an alkaline earth metal is predominantly covalent?

Answer: $BeCl_2$. Be^{2+} is very small with a high charge density. By Fajans' rules it strongly polarises Cl^- , so $BeCl_2$ is covalent (a polymeric chain in the solid). The others are ionic.

s-block (easy)

Which of these hydroxides is amphoteric?

Answer: $Be(OH)_2$. $Be(OH)_2$ dissolves in both acids and strong bases, giving beryllate ions. The hydroxides of Mg, Ca and Ba are basic, and basic strength increases down the group.

p-block (hard)

Which order of Lewis acid strength is correct for the boron trihalides?

Answer: $BBr_3 > BCl_3 > BF_3$. Electronegativity alone would predict BF_3 as the strongest. But in BF_3 the filled $2p$ orbital of F overlaps well with the empty $2p$ orbital of B (back-bonding), reducing electron deficiency. This overlap weakens down the group, so BBr_3 is the strongest acid.

p-block (medium)

Which group 13 element is most stable in the +1 oxidation state?

Answer: Tl. The inert pair effect: the heavier the element, the less the ns^2 electrons take part in bonding. Thallium is more stable as Tl^+ than as Tl^{3+} .

p-block (medium)

Which statement about group 14 oxidation states is correct?

Answer: Pb(II) is more stable than Pb(IV). Inert pair effect again: for lead the +2 state is more stable, so Pb(IV) compounds such as PbO₂ are oxidising agents. For tin, +4 is more stable than +2, so Sn(II) is a reducing agent.

p-block (easy)

Which of these compounds does not exist?

Answer: NF₅. Nitrogen has no d orbitals in its second shell, so it cannot expand its octet to form five bonds. P, As and Sb can.

p-block (medium)

What is the basicity of phosphorous acid, H₃PO₃?

Answer: 2. H₃PO₃ has one P-H bond and two O-H groups. Only hydrogens in O-H groups are acidic, so it is dibasic. (H₃PO₂ is monobasic; H₃PO₄ is tribasic.)

p-block (easy)

Which halogen shows no positive oxidation state in its compounds?

Answer: Fluorine. Fluorine is the most electronegative element and has no d orbitals, so it shows only -1 (and 0 in F₂). The others show positive states in oxides, oxoacids and interhalogens.

d-block (easy)

What is the ground-state electron configuration of chromium?

Answer: [Ar] 3d⁵ 4s¹. A half-filled d subshell with a half-filled s subshell (3d⁵ 4s¹) is more stable than 3d⁴ 4s², because of exchange energy and the small 3d-4s gap. Copper likewise is 3d¹⁰ 4s¹.

d-block (medium)

Which of these is not counted as a transition element by the IUPAC definition?

Answer: Zn. IUPAC counts an element as transition if its atom or a common ion has an incomplete d subshell. Zn (3d¹⁰ 4s²) and Zn²⁺ (3d¹⁰) are both full. Cu²⁺ is 3d⁹, so Cu still counts.

d-block (medium)

Which 3d metal has a positive standard electrode potential for M²⁺/M?

Answer: Cu. Copper is +0.34 V: the enthalpy of atomisation is high and the hydration enthalpy of Cu²⁺ is not large enough to compensate. So Cu does not liberate hydrogen from dilute acids.

d-block (medium)

Zr and Hf have almost the same atomic radii. The cause is:

Answer: Lanthanide contraction. The 4f electrons filled across the lanthanides shield poorly, so the 5d series (Hf) is smaller than expected and ends up close in size to the 4d series (Zr).

Coordination (hard)

Which complex is square planar and diamagnetic?

Answer: [Ni(CN)₄]²⁻. CN⁻ is a strong-field ligand, so in Ni²⁺ (d⁸) the electrons pair up, leaving one empty d orbital used in dsp² hybridisation: square planar and diamagnetic. [NiCl₄]²⁻ is tetrahedral and paramagnetic. [Ni(CO)₄] is tetrahedral (Ni(0), d¹⁰) and diamagnetic. [Zn(NH₃)₄]²⁺ is tetrahedral.

Bonding and oxides (easy)

Which of these oxides of nitrogen is neutral?

Answer: N₂O. N₂O (and NO) are neutral oxides: they do not react with water to give acids or with bases to give salts. N₂O₃, N₂O₅ and NO₂ are acidic.

Bonding and oxides (medium)

Molecular orbital theory correctly predicts that O₂ is:

Answer: Paramagnetic with bond order 2. O₂ has 12 valence electrons; the last two occupy the degenerate pi* orbitals singly, giving two unpaired electrons (paramagnetic). Bond order = (8 - 4)/2 = 2. A simple Lewis structure wrongly suggests all electrons are paired.

Bonding and oxides (easy)

Which is the weakest acid in water?

Answer: HF. HF is the weakest because the H-F bond is very strong and F⁻ is strongly hydrogen-bonded. Acid strength rises down the group: HF < HCl < HBr < HI, which is the reverse of what electronegativity alone suggests.

Bonding and oxides (hard)

Which halogen molecule has the highest bond dissociation enthalpy?

Answer: Cl₂. The order is Cl₂ > Br₂ > F₂ > I₂. F₂ is unusually weak because the lone pairs on two very small F atoms repel strongly across the short F-F bond.