

The d- and f-Block Elements — NEET Chemistry PYQ (2005-2021)

Class 12 Chemistry · 40 real NEET & AIPMT questions, year-tagged · answers checked by RankUp

NEET 2021

1. Zr (Z = 40) and Hf (Z = 72) have similar atomic and ionic radii because of :

- (A) belonging to same group
- (B) diagonal relationship
- (C) lanthanoid contraction
- (D) having similar chemical properties

NEET 2021

2. The incorrect statement among the following is :

- (A) Actinoid contraction is greater for element to element than Lanthanoid contraction.
- (B) Most of the trivalent Lanthanoid ions are colorless in the solid state.
- (C) Lanthanoids are good conductors of heat and electricity.
- (D) Actinoids are highly reactive metals, especially when finely divided.

NEET 2020 · Q103

3. The calculated spin only magnetic moment of Cr^{2+} ion is :

- (A) 3.87 BM
- (B) 4.90 BM
- (C) 5.92 BM
- (D) 2.84 BM

NEET 2020 · Q126

4. Identify the incorrect statement.

- (A) Cr^{2+} (d^4) is a stronger reducing agent than Fe^{2+} (d^6) in water.
- (B) The transition metals and their compounds are known for their catalytic activity due to their ability to adopt multiple oxidation states and to form complexes.
- (C) Interstitial compounds are those that are formed when small atoms like H, C or N are trapped inside the crystal lattices of metals.
- (D) The oxidation states of chromium in CrO_4^{2-} and $\text{Cr}_2\text{O}_7^{2-}$ are not the same.

NEET 2019 · Q80

5. The manganate and permanganate ions are tetrahedral, due to:

- (A) The π -bonding involves overlap of p-orbitals of oxygen with d-orbitals of manganese
- (B) There is no π -bonding
- (C) The π -bonding involves overlap of p-orbitals of oxygen with p-orbitals of manganese
- (D) The π -bonding involves overlap of d-orbitals of oxygen with d-orbitals of manganese

NEET 2018 · Q69

6. Match the metal ions given in Column I with the spin magnetic moments of the ions given in Column II and assign the correct code: Column I: a. Co^{3+} b. Cr^{3+} c. Fe^{3+} d. Ni^{2+} ; Column II: i. $\sqrt{8}$ B.M. ii. $\sqrt{35}$ B.M. iii. $\sqrt{3}$ B.M. iv. $\sqrt{24}$ B.M. v. $\sqrt{15}$ B.M.

- (A) a-iv, b-i, c-ii, d-iii
- (B) a-i, b-ii, c-iii, d-iv
- (C) a-iv, b-v, c-ii, d-i
- (D) a-iii, b-v, c-i, d-ii

NEET 2018 · Q70

7. Which one of the following ions exhibits d-d transition and paramagnetism as well?

- (A) MnO_4^-
- (B) $\text{Cr}_2\text{O}_7^{2-}$
- (C) CrO_4^{2-}
- (D) MnO_4^{2-}

NEET 2017 · Q1

8. HgCl_2 and I_2 both when dissolved in water containing I^- ions the pair of species formed is:

- (A) HgI_2 , I_3^-
- (B) HgI_2 , I^-
- (C) HgI_4^{2-} , I_3^-
- (D) Hg_2I_2 , I^-

NEET 2017 · Q35

9. The reason for greater range of oxidation states in actinoids is attributed to:

- (A) the radioactive nature of actinoids
- (B) actinoid contraction
- (C) 5f, 6d and 7s levels having comparable energies
- (D) 4f and 5d levels being close in energies

NEET 2017 (Gujarati paper) · Q21

10. Which of the following lanthanoids shows +4 oxidation state to acquire noble gas configuration? (At. nos.: La = 57, Ce = 58, Eu = 63 and Yb = 70)

- (A) Ce
- (B) Yb
- (C) La
- (D) Eu

NEET 2016 Phase 1 · Q59

11. Which one of the following statements is correct when SO_2 is passed through acidified $\text{K}_2\text{Cr}_2\text{O}_7$ solution?

- (A) The solution turns blue.
- (B) The solution is decolourized.
- (C) SO_2 is reduced.
- (D) Green $\text{Cr}_2(\text{SO}_4)_3$ is formed.

NEET 2016 Phase 1 · Q60

12. The electronic configurations of Eu (Atomic No. 63), Gd (Atomic No. 64) and Tb (Atomic No. 65) are:

- (A) $[\text{Xe}]4f^76s^2$, $[\text{Xe}]4f^86s^2$ and $[\text{Xe}]4f^85d^16s^2$
- (B) $[\text{Xe}]4f^65d^16s^2$, $[\text{Xe}]4f^75d^16s^2$ and $[\text{Xe}]4f^96s^2$
- (C) $[\text{Xe}]4f^65d^16s^2$, $[\text{Xe}]4f^75d^16s^2$ and $[\text{Xe}]4f^85d^16s^2$
- (D) $[\text{Xe}]4f^76s^2$, $[\text{Xe}]4f^75d^16s^2$ and $[\text{Xe}]4f^96s^2$

AIPMT 2015

13. Magnetic moment 2.84 B.M. is given by : (At. Nos., Ni = 28, Ti = 22, Cr = 24, Co = 27)

- (A) Co^{2+}
- (B) Ni^{2+}
- (C) Ti^{3+}
- (D) Cr^{2+}

AIPMT 2015

14. Because of lanthanoid contraction, which of the following pairs of elements have nearly same atomic radii ? (Numbers in the parenthesis are atomic numbers).

- (A) Zr (40) and Ta (73)
- (B) Ti (22) and Zr (40)
- (C) Zr (40) and Nb (41)
- (D) Zr (40) and Hf (72)

AIPMT 2014

15. The reaction of aqueous KMnO_4 with H_2O_2 in acidic conditions gives:

- (A) Mn^{2+} and O_2
- (B) Mn^{2+} and O_3
- (C) Mn^{4+} and MnO_2
- (D) Mn^{4+} and O_2

AIPMT 2014

16. In acidic medium, H_2O_2 changes $\text{Cr}_2\text{O}_7^{2-}$ to CrO_5 which has two (-O-O-) bonds.

Oxidation state of Cr in CrO_5 is:

- (A) +3
- (B) +6
- (C) -10
- (D) +5

AIPMT 2014

17. Magnetic moment 2.83 BM is given by which of the following ions? (At. nos. Ti = 22, Cr = 24, Mn = 25, Ni = 28)

- (A) Ni^{2+}
- (B) Cr^{3+}
- (C) Mn^{2+}
- (D) Ti^{3+}

AIPMT 2014

18. Reason of lanthanoid contraction is:

- (A) Increasing nuclear charge
- (B) Decreasing nuclear charge
- (C) Decreasing screening effect
- (D) Negligible screening effect of 'f' orbitals

NEET 2013

19. Which of the following does not give oxygen on heating ?

- (A) KClO_3
- (B) $\text{Zn}(\text{ClO}_3)_2$
- (C) $\text{K}_2\text{Cr}_2\text{O}_7$
- (D) $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$

NEET 2013

20. Which of the following lanthanoid ions is diamagnetic ? (At. No. Ce = 58, Sm = 62, Eu = 63, Yb = 70)

- (A) Ce^{2+}
- (B) Sm^{2+}
- (C) Eu^{2+}
- (D) Yb^{2+}

NEET 2013

21. KMnO_4 can be prepared from K_2MnO_4 as per the reaction: $3\text{MnO}_4^{2-} + 2\text{H}_2\text{O} \rightleftharpoons 2\text{MnO}_4^- + \text{MnO}_2 + 4\text{OH}^-$. The reaction can go to completion by removing OH^- ions by adding

- (A) HCl
- (B) KOH
- (C) CO_2
- (D) SO_2

NEET 2013

22. Which of the following statements about the interstitial compounds is incorrect?

- (A) They retain metallic conductivity
- (B) They are chemically reactive
- (C) They are much harder than the pure metal
- (D) They have higher melting points than the pure metal

AIPMT 2012 Mains

23. Which one of the following does not correctly represent the correct order of the property indicated against it?

- (A) $\text{Ti} < \text{V} < \text{Cr} < \text{Mn}$: increasing number of oxidation states
- (B) $\text{Ti}^{3+} < \text{V}^{3+} < \text{Cr}^{3+} < \text{Mn}^{3+}$: increasing magnetic moment
- (C) $\text{Ti} < \text{V} < \text{Cr} < \text{Mn}$: increasing melting points
- (D) $\text{Ti} < \text{V} < \text{Mn} < \text{Cr}$: increasing 2nd ionization enthalpy

AIPMT 2012 Mains

24. Four successive members of the first series of the transition metals are listed below. For which one of them the standard potential $E^\circ(\text{M}^{2+}/\text{M})$ value has a positive sign?

- (A) Co ($Z = 27$)
- (B) Ni ($Z = 28$)
- (C) Cu ($Z = 29$)
- (D) Fe ($Z = 26$)

AIPMT 2012 Mains

25. Which of the following exhibits only +3 oxidation state?

- (A) U
- (B) Th
- (C) Ac
- (D) Pa

AIPMT 2012 Prelims

26. Which of the statements is not true?

- (A) $\text{K}_2\text{Cr}_2\text{O}_7$ solution becomes yellow on increasing the pH beyond 7
- (B) On passing H_2S through acidified $\text{K}_2\text{Cr}_2\text{O}_7$ solution, a milky colour is observed
- (C) $\text{Na}_2\text{Cr}_2\text{O}_7$ is preferred over $\text{K}_2\text{Cr}_2\text{O}_7$ in volumetric analysis
- (D) $\text{K}_2\text{Cr}_2\text{O}_7$ solution in acidic medium is orange

AIPMT 2011 Prelims

27. Acidified $\text{K}_2\text{Cr}_2\text{O}_7$ solution turns green when Na_2SO_3 is added to it. This is due to the formation of

- (A) CrSO_4
- (B) $\text{Cr}_2(\text{SO}_4)_3$
- (C) CrO_4^{2-}
- (D) $\text{Cr}_2(\text{SO}_3)_3$

AIPMT 2010 Mains · Q114

28. Which of the following oxidation states is the most common among the lanthanoids?

- (A) 4
- (B) 2
- (C) 5
- (D) 3

29. Which of the following pairs has the same size?

- (A) Zn^{2+} , Hf^{4+}
- (B) Fe^{2+} , Ni^{2+}
- (C) Zr^{4+} , Ti^{4+}
- (D) Zr^{4+} , Hf^{4+}

30. Which one of the following ions has electronic configuration $[\text{Ar}]3d^6$? (At. nos. Mn = 25, Fe = 26, Co = 27, Ni = 28)

- (A) Co^{3+}
- (B) Ni^{3+}
- (C) Mn^{3+}
- (D) Fe^{3+}

31. Which of the following ions will exhibit colour in aqueous solutions?

- (A) Sc^{3+} ($Z = 21$)
- (B) La^{3+} ($Z = 57$)
- (C) Ti^{3+} ($Z = 22$)
- (D) Lu^{3+} ($Z = 71$)

32. Which one of the elements with the following outer orbital configurations may exhibit the largest number of oxidation states?

- (A) $3d^5 4s^1$
- (B) $3d^5 4s^2$
- (C) $3d^2 4s^2$
- (D) $3d^3 4s^2$

33. The correct order of decreasing second ionisation enthalpy of Ti (22), V (23), Cr (24) and Mn (25) is

- (A) $\text{Ti} > \text{V} > \text{Cr} > \text{Mn}$
- (B) $\text{Cr} > \text{Mn} > \text{V} > \text{Ti}$
- (C) $\text{V} > \text{Mn} > \text{Cr} > \text{Ti}$
- (D) $\text{Mn} > \text{Cr} > \text{Ti} > \text{V}$

34. Which one of the following ions is the most stable in aqueous solution? (At. No. Ti = 22, V = 23, Cr = 24, Mn = 25)

- (A) V^{3+}
- (B) Ti^{3+}
- (C) Mn^{3+}
- (D) Cr^{3+}

35. Identify the incorrect statement among the following:

- (A) Lanthanoid contraction is the accumulation of successive shrinkages.
- (B) As a result of lanthanoid contraction, the properties of 4d series of the transition elements have no similarities with the 5d series of elements.
- (C) Shielding power of 4f electrons is quite weak.
- (D) There is a decrease in the radii of the atoms or ions as one proceeds from La to Lu.

36. More number of oxidation states are exhibited by the actinoids than by the lanthanoids. The main reason for this is :

- (A) more energy difference between 5f and 6d orbitals than that between 4f and 5d orbitals
- (B) lesser energy difference between 5f and 6d orbitals than that between 4f and 5d orbitals
- (C) greater metallic character of the lanthanoids than that of the corresponding actinoids
- (D) more active nature of the actinoids

37. In which of the following pairs are both the ions coloured in aqueous solution ? (At. no. : Sc = 21, Ti = 22, Ni = 28, Cu = 29, Co = 27)

- (A) Ni^{2+} , Ti^{3+}
- (B) Sc^{3+} , Ti^{3+}
- (C) Sc^{3+} , Co^{2+}
- (D) Ni^{2+} , Cu^{+}

38. The aqueous solution containing which one of the following ions will be colourless ? (Atomic no. : Sc = 21, Fe = 26, Ti = 22, Mn = 25)

- (A) Sc^{3+}
- (B) Fe^{2+}
- (C) Ti^{3+}
- (D) Mn^{2+}

39. Four successive members of the first row transition elements are listed below with their atomic numbers. Which one of them is expected to have the highest third ionization enthalpy ?

- (A) Vanadium (Z = 23)
- (B) Chromium (Z = 24)
- (C) Iron (Z = 26)
- (D) Manganese (Z = 25)

40. The main reason for larger number of oxidation states exhibited by the actinides than the corresponding lanthanides, is :

- (A) lesser energy difference between 5f and 6d orbitals than between 4f and 5d orbitals
- (B) larger atomic size of actinides than the lanthanides
- (C) more energy difference between 5f and 6d orbitals than between 4f and 5d orbitals
- (D) greater reactive nature of the actinides than the lanthanides

Answer key and explanations

1. Answer: (C) lanthanoid contraction

Between Zr (4d) and Hf (5d) the fourteen 4f elements are filled; poor shielding by 4f electrons causes the lanthanoid contraction, cancelling the expected size increase. Being in the same group alone would predict Hf to be larger.

2. Answer: (B) Most of the trivalent Lanthanoid ions are colorless in the solid state.

Most trivalent lanthanoid ions are coloured in the solid state and in solution because of f-f transitions (La^{3+} and Lu^{3+} are exceptions), so calling them colourless is the incorrect statement. Actinoid contraction from element to element is indeed greater, because 5f electrons shield poorly.

3. Answer: (B) 4.90 BM

Cr^{2+} is $3d^4$ with 4 unpaired electrons, so $\mu = \sqrt{n(n+2)} = \sqrt{24} \approx 4.90$ BM. The value 3.87 BM corresponds to 3 unpaired electrons (Cr^{3+}) and 5.92 BM to 5 unpaired electrons.

4. Answer: (D) The oxidation states of chromium in CrO_4^{2-} and $\text{Cr}_2\text{O}_7^{2-}$ are not the same.

In CrO_4^{2-} , $x - 8 = -2$ gives +6, and in $\text{Cr}_2\text{O}_7^{2-}$, $2x - 14 = -2$ gives +6, so chromium has the same oxidation state in both; the statement saying they differ is incorrect. Cr^{2+} does reduce more strongly than Fe^{2+} ($\text{Cr}^{2+} \rightarrow \text{Cr}^{3+}$ reaches stable t_{2g}^3), and the statements on catalysis and interstitial compounds are true.

5. Answer: (A) The π -bonding involves overlap of p-orbitals of oxygen with d-orbitals of manganese

In MnO_4^{2-} and MnO_4^- the Mn is tetrahedrally σ -bonded to four O atoms, and π -bonding arises from overlap of filled oxygen p-orbitals with manganese d-orbitals (NCERT). Oxygen has no d-orbitals in its valence shell, so d-d overlap is impossible.

6. Answer: (C) a-iv, b-v, c-ii, d-i

$\mu = \sqrt{n(n+2)}$: Co^{3+} ($3d^6$, 4 unpaired) $\sqrt{24}$; Cr^{3+} ($3d^3$, 3 unpaired) $\sqrt{15}$; Fe^{3+} ($3d^5$, 5 unpaired) $\sqrt{35}$; Ni^{2+} ($3d^8$, 2 unpaired) $\sqrt{8}$. Matching Ni^{2+} with $\sqrt{3}$ would assume only one unpaired electron.

7. Answer: (D) MnO_4^{2-}

In MnO_4^{2-} manganese is +6 ($3d^1$): one unpaired electron makes it paramagnetic and allows d-d transitions. MnO_4^- (Mn^{+7}), $\text{Cr}_2\text{O}_7^{2-}$ and CrO_4^{2-} (Cr^{+6}) are d^0 and diamagnetic; their colour is due to charge transfer.

8. Answer: (C) HgI_4^{2-} , I_3^-

In excess iodide, HgCl_2 first gives HgI_2 , which dissolves in more I^- as the complex HgI_4^{2-} (as in Nessler's reagent), while I_2 combines with I^- to form the triiodide ion I_3^- . HgI_2 cannot remain as such because excess I^- is present.

9. Answer: (C) 5f, 6d and 7s levels having comparable energies

In actinoids the 5f, 6d and 7s orbitals are close in energy, so varying numbers of electrons from all three can be used in bonding, giving many oxidation states. 4f and 5d levels belong to the lanthanoids, and radioactivity or contraction does not create extra oxidation states.

10. Answer: (A) Ce

Ce is $[\text{Xe}]4f^15d^16s^2$; losing four electrons gives Ce^{4+} with the noble gas configuration $[\text{Xe}]$. Eu and Yb show +2 to reach stable $4f^7$ and $4f^{14}$, and La shows only +3, which already gives $[\text{Xe}]$.

11. Answer: (D) Green $\text{Cr}_2(\text{SO}_4)_3$ is formed.

SO_2 acts as a reducing agent: it is oxidised to sulphate while orange dichromate (Cr^{+6}) is reduced to Cr^{3+} , giving green $\text{Cr}_2(\text{SO}_4)_3$. The solution turns green rather than colourless, and SO_2 is oxidised, not reduced.

12. Answer: (D) $[\text{Xe}]4f^76s^2$, $[\text{Xe}]4f^75d^16s^2$ and $[\text{Xe}]4f^96s^2$

Eu (63) has a half-filled $4f^7$ shell: $[\text{Xe}]4f^76s^2$. In Gd (64) the extra electron goes to 5d to keep the stable $4f^7$: $[\text{Xe}]4f^75d^16s^2$. Tb (65) has $[\text{Xe}]4f^96s^2$. Writing Gd as $4f^96s^2$ ignores the extra stability of the half-filled f subshell.

13. Answer: (B) Ni^{2+}

$\mu = \sqrt{n(n+2)} = 2.84$ BM gives $n = 2$. Ni^{2+} ($3d^8$) has 2 unpaired electrons, whereas Ti^{3+} ($3d^1$) has 1, Co^{2+} ($3d^7$) has 3 and Cr^{2+} ($3d^4$) has 4.

14. Answer: (D) Zr (40) and Hf (72)

The 14 lanthanoids between La and Hf cause a contraction that cancels the expected size increase from the 4d to the 5d series. So Zr (160 pm) and Hf (159 pm) have almost the same radius. Ti and Zr differ normally because no f-block intervenes.

15. Answer: (A) Mn^{2+} and O_2

In acid, MnO_4^- is reduced to Mn^{2+} while H_2O_2 is oxidised to O_2 : $2\text{MnO}_4^- + 5\text{H}_2\text{O}_2 + 6\text{H}^+ \rightarrow 2\text{Mn}^{2+} + 5\text{O}_2 + 8\text{H}_2\text{O}$. Ozone is never formed, and $\text{Mn}^{4+}/\text{MnO}_2$ forms only in neutral or weakly basic medium.

16. Answer: (B) +6

CrO_5 has one oxide oxygen (-2) and two peroxide O-O groups (four O at -1). $x - 2 - 4 = 0$ gives $x = +6$; treating all five O as -2 would give the impossible $+10$.

17. Answer: (A) Ni^{2+}

$\mu = \sqrt{n(n+2)} = 2.83$ BM gives $n = 2$ unpaired electrons. Ni^{2+} ($3d^8$) has 2, while Cr^{3+} ($3d^3$) has 3, Mn^{2+} ($3d^5$) has 5 and Ti^{3+} ($3d^1$) has 1.

18. Answer: (D) Negligible screening effect of 'f' orbitals

4f orbitals are diffuse and shield the outer electrons poorly, so as nuclear charge rises across the series the effective nuclear charge increases and radii shrink. Increasing nuclear charge alone would not explain it; the poor f-shielding is the cause.

19. Answer: (D) $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$

$(\text{NH}_4)_2\text{Cr}_2\text{O}_7 \rightarrow \text{N}_2 + \text{Cr}_2\text{O}_3 + 4\text{H}_2\text{O}$ on heating, releasing nitrogen, not oxygen. KClO_3 and $\text{Zn}(\text{ClO}_3)_2$ release O_2 , and $\text{K}_2\text{Cr}_2\text{O}_7$ on strong heating gives K_2CrO_4 , Cr_2O_3 and O_2 .

20. Answer: (D) Yb^{2+}

Yb ($Z = 70$) is $[\text{Xe}]4f^{14}6s^2$, so Yb^{2+} is $4f^{14}$ with every electron paired: diamagnetic. Ce^{2+} ($4f^2$), Sm^{2+} ($4f^6$) and Eu^{2+} ($4f^7$) all have unpaired f electrons.

21. Answer: (C) CO_2

CO_2 is weakly acidic and neutralises OH^- (forming carbonate) without reacting with the permanganate, pushing the equilibrium to the right. HCl and SO_2 are reducing agents that would be oxidised by MnO_4^- , and KOH would add OH^- and push the reaction backwards.

22. Answer: (B) They are chemically reactive

Interstitial compounds (small atoms like H, C, N trapped in metal lattices) keep metallic conductivity, are very hard and have high melting points, but they are chemically inert. So calling them chemically reactive is incorrect.

23. Answer: (C) $\text{Ti} < \text{V} < \text{Cr} < \text{Mn}$: increasing melting points

Manganese has a much lower melting point (about 1246°C) than chromium (about 1907°C) because its stable $3d^54s^2$ configuration weakens metallic bonding, so $\text{Ti} < \text{V} < \text{Cr} < \text{Mn}$ for melting point is wrong. The other orders are right: Cr has the highest 2nd ionisation enthalpy (removing an electron from stable $3d^5$), and unpaired electrons rise from d^1 to d^4 across Ti^{3+} to Mn^{3+} .

24. Answer: (C) Cu ($Z = 29$)

Copper is the only one of these with a positive $E^\circ(\text{M}^{2+}/\text{M})$, about $+0.34\text{ V}$, because its high atomisation enthalpy and low hydration enthalpy are not compensated. Fe, Co and Ni all have negative values.

25. Answer: (C) Ac

Actinium ($5f^0$) shows only the +3 oxidation state. Thorium is mainly +4, protactinium up to +5 and uranium shows +3 to +6.

26. Answer: (C) $\text{Na}_2\text{Cr}_2\text{O}_7$ is preferred over $\text{K}_2\text{Cr}_2\text{O}_7$ in volumetric analysis

$\text{Na}_2\text{Cr}_2\text{O}_7$ is hygroscopic, so $\text{K}_2\text{Cr}_2\text{O}_7$, which is not, is preferred as a primary standard in volumetric analysis; the statement favouring sodium dichromate is false. The others are true: raising pH converts orange $\text{Cr}_2\text{O}_7^{2-}$ to yellow CrO_4^{2-} , and H_2S is oxidised to colloidal sulphur, giving a milky appearance.

27. Answer: (B) $\text{Cr}_2(\text{SO}_4)_3$

Sulphite reduces dichromate in acid: $\text{Cr}_2\text{O}_7^{2-} + 3\text{SO}_3^{2-} + 8\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 3\text{SO}_4^{2-} + 4\text{H}_2\text{O}$. The green colour is due to Cr^{3+} , i.e. $\text{Cr}_2(\text{SO}_4)_3$. Chromate is yellow and Cr would not be reduced to +2.

28. Answer: (D) 3

All lanthanoids show the +3 oxidation state, which is the characteristic and most common one. +2 (Eu, Yb) and +4 (Ce) occur only for a few elements with stable f^0 , f^7 or f^{14} configurations.

29. Answer: (D) Zr^{4+} , Hf^{4+}

Because of the lanthanoid contraction, Hf (5d) is almost the same size as Zr (4d), so Zr^{4+} and Hf^{4+} have nearly identical radii. Ti^{4+} is a 3d ion and clearly smaller than Zr^{4+} .

30. Answer: (A) Co^{3+}

Co ($Z = 27$) is $[\text{Ar}]3d^74s^2$; removing 3 electrons gives $\text{Co}^{3+} = [\text{Ar}]3d^6$. Fe^{3+} is $3d^5$, Mn^{3+} is $3d^4$ and Ni^{3+} is $3d^7$.

31. Answer: (C) Ti^{3+} ($Z = 22$)

Ti^{3+} is $3d^1$ with one unpaired electron, so a d-d transition gives colour (violet). Sc^{3+} ($3d^0$), La^{3+} ($4f^0$) and Lu^{3+} ($4f^{14}$) have no unpaired d/f electrons and are colourless.

32. Answer: (B) $3d^54s^2$

$3d^54s^2$ (manganese) has seven electrons that can take part in bonding and shows oxidation states from +2 up to +7, the widest range here. $3d^54s^1$ (Cr) goes up to +6, and the others to +4 and +5.

33. Answer: (B) $\text{Cr} > \text{Mn} > \text{V} > \text{Ti}$

The second electron is removed from M^+ . Cr^+ is $3d^5$, a stable half-filled shell, so removing a 3d electron costs the most. Mn^+ ($3d^54s^1$) loses its 4s electron more easily, and V^+ and Ti^+ follow in order of nuclear charge. Observed values ($\approx 1590, 1510, 1410, 1310\text{ kJ mol}^{-1}$) give $\text{Cr} > \text{Mn} > \text{V} > \text{Ti}$. $\text{Mn} > \text{Cr}$ would hold for the third, not the second, ionisation enthalpy.

34. Answer: (D) Cr^{3+}

Cr^{3+} ($3d^3$) has a half-filled t_{2g} set and a very high hydration energy, making it the most stable in water. Ti^{3+} and V^{3+} are oxidised easily, and Mn^{3+} (d^4) disproportionates.

35. Answer: (B) As a result of lanthanoid contraction, the properties of 4d series of the transition elements have no similarities with the 5d series of elements.

Because of lanthanoid contraction, 4d and 5d elements of the same group have nearly identical radii (e.g. Zr and Hf) and very similar properties. Saying they have no similarities is therefore the incorrect statement; the others are true.

36. Answer: (B) lesser energy difference between 5f and 6d orbitals than that between 4f and 5d orbitals

In actinoids the 5f, 6d and 7s orbitals are very close in energy, closer than 4f, 5d and 6s in lanthanoids, and 5f electrons are less tightly held. So more electrons can take part in bonding, giving many more oxidation states. A larger 5f-6d gap would have the opposite effect.

37. Answer: (A) Ni^{2+} , Ti^{3+}

Colour needs partly filled d orbitals for d-d transitions. Ni^{2+} ($3d^8$) and Ti^{3+} ($3d^1$) are both coloured. Sc^{3+} is $3d^0$ and Cu^+ is $3d^{10}$, so each pair containing one of them has a colourless ion.

38. Answer: (A) Sc^{3+}

Sc^{3+} is $3d^0$, so no d-d transition is possible and its solution is colourless. Ti^{3+} ($3d^1$), Mn^{2+} ($3d^5$) and Fe^{2+} ($3d^6$) have unpaired d electrons and are coloured.

39. Answer: (D) Manganese (Z = 25)

The third electron of Mn is removed from Mn^{2+} ($3d^5$), a stable half-filled configuration, so Mn has the highest third ionisation enthalpy. For Fe, removal from $3d^6$ gives the stable $3d^5$, so it is easier.

40. Answer: (A) lesser energy difference between 5f and 6d orbitals than between 4f and 5d orbitals

In actinides the 5f, 6d and 7s levels are closer in energy than 4f, 5d and 6s in lanthanides, so more electrons can take part in bonding, giving more oxidation states. A larger energy gap would do the opposite.

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