WC

WEIRD CHEMIST

d-Block Elements

Oxidation States – SOLUTIONS

DPP – 03

Topic: Oxidation States | **Questions:** 53 Questions | **Exam:** NEET / JEE

Quick Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	2	12	3	23	4	34	1	45	2
2	1	13	1	24	3	35	3	46	2
3	3	14	1	25	2	36	1	47	1
4	2	15	3	26	2*	37	3	48	2
5	2	16	4	27	2	38	1	49	4
6	3	17	1	28	3	39	2	50	2
7	3*	18	2	29	3†	40	3	51	3
8	3	19	2	30	††	41	2	52	3
9	2	20	3	31	3	42	1	53	3
10	2	21	4	32	2	43	3		
11	4	22	3	33	2	44	2		

**Q.7 repeats Q.6, Q.26 repeats Q.25 – flagged in your source with `\note{}`, solved once here.*
† Q.29: genuine ambiguity between two options – see full note at the question. †† Q.30: my count doesn't match any listed option – see full note at the question.

▶ TYPE 1 : Why Oxidation States Are Variable (or Not)

[F] Master Formulae

The core idea behind every question in this TYPE:

- Transition metals show variable oxidation states because the energy gap between ns and $(n-1)d$ electrons is **small** – both sets are similarly easy to remove, so several oxidation states become accessible at similar energy costs (typically differing by 1).
- **Sc is the classic exception:** it has only ONE accessible state, $+3$ – once it loses all 3 valence electrons ($4s^2 3d^1$) to reach the stable [Ar] core, there's nothing left to lose and no lower state is favourable either.
- **Cu, Ni, Zn resist states above** $+2$ because their third ionisation enthalpy (IE_3) is exceptionally high – past $+2$, you're digging into an increasingly stable, nearly/fully-filled d-subshell.

Q1. Cu, Ni and Zn generally do not show an oxidation state greater than $+2$ mainly because–

(1) Their $(n-1)d$ orbitals are completely filled and hence chemically inert

(2) Their third ionisation enthalpy (IE_3) is exceptionally high

(3) They belong to the same group of the periodic table

(4) They have no vacant d-orbitals available for oxidation

[E] Explanation

This is the direct Master Formula fact. Note option (1) is only literally true for Zn (which is d^{10}) – Cu^{2+} is actually d^9 and Ni^{2+} is d^8, neither "completely filled." The property that's genuinely shared by all three is a sharply rising IE_3 as you approach the end of the 3d row, making any state past $+2$ energetically uneconomical.

[Ans] Answer

Option (2)

Q2. The transition element which does not exhibit variable oxidation state is [NCERT Pg. 223]

(1) Sc (2) Fe (3) Mn (4) Co

[E] Explanation

Sc loses all 3 valence electrons to reach [Ar] (noble-gas-like) at $+3$ – there's no partially-emptied d-subshell state to fall back to, so $+3$ is its only oxidation state. Fe, Mn, Co are all famously variable (Fe: $+2/+3/+6$; Mn: $+2$ to $+7$; Co: $+2/+3$).

[Ans] Answer

Option (1) Sc.

Q3. Which transition element does not exhibit variable oxidation states, and why?

(1) Zn, because its $3d$ subshell is completely filled in every accessible state

(2) Cr, because its $(n-1)d$ and ns electrons are degenerate

(3) Sc, because after losing its 3 valence electrons ($4s^2 3d^1$) no further stable oxidation state is accessible

(4) Cu, because it exists only in the $+1$ oxidation state

[E] Explanation

Same underlying fact as Q.2 (the NCERT-cited canonical example), now paired with the precise mechanistic reason: once Sc loses $4s^2 3d^1$, it reaches [Ar] – genuinely no other state is accessible. (Zn's reasoning in option 1 is also factually true on its own, but Sc is the specifically cited textbook example for "non-variable oxidation state," and option 4 is simply wrong – Cu shows both $+1$ *and* $+2$, so it's the textbook example of variable, not fixed, oxidation state.)

[Ans] Answer

Option (3) Sc.

Q4. The transition element which does not exhibit variable oxidation states is/are

(1) Mn
(2) Sc
(3) Cr
(4) Both (2) & (3)

[E] Explanation

Mn ($+2$ to $+7$) and Cr ($+2, +3, +6$) are both highly variable – Cr in particular is a poor distractor here since TYPE 6 of this very paper is built entirely around Cr's multiple oxidation states. Only Sc is genuinely fixed at $+3$.

[!] Common Mistake

Don't select option (4) just because it "sounds safe" – always verify *each* named element individually rather than assuming a compound option is a safe middle ground.

[Ans] Answer

Option (2) Sc.

Q5. Which of the following transition element does not exhibit variable oxidation state?

(1) Mercury
(2) Scandium
(3) Copper
(4) All of the above

[E] Explanation

Mercury shows $+1$ (as Hg_2^{2+}) and $+2$ – variable. Copper shows $+1$ and $+2$ – variable (this is literally TYPE 7 of this paper). Only Scandium is genuinely fixed at $+3$, so "All of the above" is wrong.

[Ans] Answer

Option (2) Scandium.

Q6. Assertion: Transition metals shows variable valencies.
Reason: Transition metal have a large energy difference between the ns^2 and $(n-1)d$ electrons.

(1) Both Assertion and Reason are true, Reason gives correct explanation
(2) Both Assertion and Reason are true, it doesn't give correct explanation
(3) Assertion is correct but Reason is false
(4) Both Assertion and Reason are false

[E] Explanation

The Assertion is true. But the Reason has it backwards: the energy gap between ns and $(n-1)d$ is **small**, not large – that's precisely *why* both sets of electrons can be removed at comparable energy costs, giving rise to variable oxidation states. A *large* gap would do the opposite – lock in one fixed valency, the way it does for typical s-block/p-block elements.

[A] Approach

Yaad rakho ulta: bada gap hota toh fixed valency milti (jaise s-block mein). Chhota gap hi variable valency deta hai – energy gap "large" bolte hi red flag samjho.

[Ans] Answer

Option (3) Assertion correct, Reason false.

Q7. Assertion: Transition metals show variable valency.
Reason: Transition metals have a large energy difference between the ns^2 and $(n-1)d$ electrons.

This question is identical to Q.6 in this paper – retained here as it appears twice in the original source.

(1) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.
(2) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.
(3) If Assertion is True but the Reason is False.
(4) If both Assertion & Reason are False.

[Ans] Answer

Option (3) Assertion correct, Reason false – see full working at Q.6.

▶ TYPE 2 : Identifying Maximum / Highest Oxidation States

[F] Master Formulae

The rule that solves every question in this TYPE:

- **Up to and including Mn (Group 7):** the maximum stable oxidation state equals the **total count of $(n-1)d + ns$ valence electrons** – every valence electron is removable. Sc($3e^- \rightarrow +3$), Ti($4e^- \rightarrow +4$), V($5e^- \rightarrow +5$), Cr($6e^- \rightarrow +6$), Mn($7e^- \rightarrow +7$) – each one reaches a d^0 configuration at its maximum state.
- **Past Mn (Fe onward), this pattern breaks down** – rising effective nuclear charge makes stripping every valence electron impractical, so the highest oxidation state stays below the theoretical maximum and never reaches d^0.
- **So: Mn has both the most oxidation states *and* the single highest ($+7$) among 3d elements** – it sits at the peak of this pattern, right before it collapses.

Q8. Which of the following shows maximum number of oxidation states?

(1) Cr (2) Fe (3) Mn (4) V

[E] Explanation

Mn spans $+2$ through $+7$ – the widest range of any 3d element. Cr, Fe, V all show fewer accessible states.

[Ans] Answer

Option (3) Mn.

Q9. In the $3d$ series, Mn shows the highest oxidation state ($+7$) among the elements. This is best explained by the fact that–

(1) Mn has the maximum number of unpaired electrons in the ground state

(2) The maximum oxidation state of reasonable stability equals the sum of the $4s$ and $3d$ electrons up to Mn

(3) Mn has the smallest atomic radius in the $3d$ series

(4) Mn achieves a stable d^5 configuration only in the $+7$ state

[E] Explanation

This is the Master Formula stated directly: Mn ($3d^5 4s^2$, 7 valence electrons) reaches $+7$ by losing all 7. Check the distractors: (1) is false – **Cr** actually has 6 unpaired electrons ($3d^5 4s^1$), more than Mn's 5. (4) is false – Mn already reaches stable d^5 at just $+2$ (not $+7$; Mn^{7+} is actually d^0).

[!] Common Mistake

Option (1) is a very tempting trap since Mn is famous for its half-filled d^5 – but the *record holder* for unpaired electrons in the 3d row is Cr (6 total, thanks to its own $d^5 s^1$ exception), not Mn (5 total).

[Ans] Answer

Option (2)

Q10. Which one of the elements with the following outer orbital configurations may exhibit the largest number of oxidation states? **[AIPMT (Prelims)-2009]**

(1) $3d^5 4s^1$

(2) $3d^5 4s^2$

(3) $3d^2 4s^2$

(4) $3d^3 4s^2$

[E] Explanation

$3d^5 4s^1$=Cr, $3d^5 4s^2$=Mn, $3d^2 4s^2$=Ti, $3d^3 4s^2$=V. Mn wins per the Master Formula (widest oxidation-state range in the row).

[Ans] Answer

Option (2) $3d^5 4s^2$ [Mn].

Q11. Which one of the elements with the following outer orbital configurations may exhibit the largest number of oxidations states?

(1) $3d^2 4s^2$

(2) $3d^3 4s^2$

(3) $3d^5 4s^1$

(4) $3d^5 4s^2$

[E] Explanation

Identical question to Q.10, options reshuffled – Mn ($3d^5 4s^2$) is now option (4).

[Ans] Answer

Option (4) $3d^5 4s^2$ [Mn] – see Q.10.

Q12. Which of the following configurations of $3d$ series metals exhibits the largest number of oxidation states?

Ar $3d^8 4s^2$
Ar $3d^5 4s^2$
Ar $3d^{10} 4s^1$
Ar $3d^7 4s^2$

[E] Explanation

$3d^8 4s^2$=Ni, $3d^{10} 4s^1$=Cu, $3d^5 4s^2$=Mn, $3d^7 4s^2$=Co. Ni, Cu, Co are all late-series elements approaching d^{10} (fewer accessible states, per TYPE 1's logic) – Mn stands out as the maximum.

[Ans] Answer

Option (3) [Ar]$3d^5 4s^2$ [Mn].

Q13. In which of the following outer most orbit will show maximum number of oxidation states?

(1) $3d^5 4s^2$ (2) $3d^2 4s^2$ (3) $3d^3 4s^2$ (4) $3d^5 4s^1$

[E] Explanation

Same Q.10/Q.11 fact again, reshuffled – Mn ($3d^5 4s^2$) is option (1) here.

[Ans] Answer

Option (1) $3d^5 4s^2$ [Mn] – see Q.10.

Q14. Which of following electronic configuration can show highest oxidation state?

(1) $(n-1)d^5\, ns^2$
(2) $(n-1)d^8\, ns^2$
(3) $(n-1)d^5\, ns^1$
(4) $(n-1)d^3\, ns^2$

[E] Explanation

$(n-1)d^5 ns^2$ is the general Mn-type pattern – 7 valence electrons, matching the highest point of the "sum of valence electrons" rule (option 3, $d^5 s^1$, is the Cr-type pattern with only 6 valence electrons, capping out at $+6$, one less than Mn's $+7$).

[Ans] Answer

Option (1) $(n-1)d^5 ns^2$ [Mn-type].

Q15. Which one of the following exhibits highest oxidation state?

(1) Zr (2) V (3) Mn (4) Ni

[E] Explanation

Zr maxes at $+4$, V at $+5$, Ni typically at $+2$ (rarely higher) – Mn's $+7$ is the clear highest among these four.

[Ans] Answer

Option (3) Mn.

Q16. The element which does not show d^0 configuration in its highest oxidation state

(1) V (2) Mn (3) Cr (4) Fe

[E] Explanation

V ($+5$), Cr ($+6$), Mn ($+7$) each reach their maximum by stripping *every* valence electron, landing on d^0 – exactly the "up to Mn" rule from the Master Formula. Fe breaks the pattern: its practically-achievable maximum (commonly $+3$, or $+6$ in the rare ferrate ion FeO_4^{2-}) never strips all 8 valence electrons, so Fe never reaches d^0 – at $+6$ it's still d^2.

[Ans] Answer

Option (4) Fe.

▶ TYPE 3 : Extreme Oxidation States – $+8$ and Zero

[F] Master Formulae

Two quick facts cover this entire TYPE:

- Extreme high oxidation states ($+7$, $+8$) are only reached with **oxygen** (never a simple halide) as the ligand, because O's ability to form multiple π (M=O) bonds is what stabilises them. **Ru and Os (Group 8, 4d/5d) are the two elements that reach** $+8$ (as RuO_4/OsO_4) – Fe, their lighter 3d congener, does not.
- **Zero oxidation state** shows up specifically in metal carbonyls, $M(CO)_n$ – CO is a neutral ligand, so the metal's oxidation state is simply 0.

Q17. $+8$ oxidation state is shown by

(1) Os (2) Mn (3) Cr (4) Co

[Ans] Answer

Option (1) Os (in OsO_4).

Q18. Which pair of transition metals is well known to exhibit an oxidation state as high as $+8$?

(1) Fe and Ru (2) Ru and Os (3) Rh and Ir (4) Mn and Tc

[E] Explanation

Ru (RuO_4) and Os (OsO_4) – both Group 8, both reaching $+8$ via their tetroxides. Note Fe (their 3d congener, also Group 8) is specifically excluded – FeO_4 is not known to exist, a nice illustration of higher oxidation states favouring heavier group members.

[Ans] Answer

Option (2) Ru and Os.

Q19. The highest possible oxidation state shown by osmium in its compound is

(1) $+4$ (2) $+8$ (3) $+6$ (4) $+10$

[Ans] Answer

Option (2) $+8$.

Q20. The oxidation state of Fe in $Fe(CO)_5$ is–

(1) $+2$ (2) $+3$ (3) Zero (4) -2

[E] Explanation

CO is a neutral ligand (donates a lone pair without carrying ionic charge). $Fe(CO)_5$ is an overall neutral molecule, so Fe's oxidation state must be 0.

[Ans] Answer

Option (3) Zero.

▶ TYPE 4 : Mn Oxides & Fluorides – Existence and Stability

[F] Master Formulae

The single idea behind this whole TYPE:

- **Oxygen beats fluorine at stabilising extreme oxidation states** because O can form multiple (π, M=O) bonds while F can only ever form a single σ bond. That's why Mn_2O_7 ($+7$) exists but MnF_7 does *not* – fluorine's ceiling for Mn is MnF_4 ($+4$).
- For **covalent** fluorides specifically (like VF_5, CrF_6), F still manages to stabilise a fairly high state – via unusually high bond enthalpy from its small size/high electronegativity, not multiple bonding.
- For simple **halides of a metal ion that's a decent oxidiser**, existence can fail for a totally different reason: the halide itself gets oxidised. Classic case: Cu^{2+} oxidises I^- to I_2, so CuI_2 never forms – you get CuI instead.

Q21. Which of the following mangnese oxide is not formed?

(1) MnO (2) MnO_2 (3) Mn_2O_3 (4) Mn_2O_5

[E] Explanation

The standard, well-documented Mn oxides are MnO (+2), Mn_2O_3 (+3), MnO_2 (+4), and Mn_2O_7 (+7) – there's a gap at +5 and +6 as simple binary oxides. Mn_2O_5 (+5) is not a recognised, stable compound.

[Ans] Answer

Option (4) Mn_2O_5.

Q22. Which species doesn't exist?

(1) ZnO (2) CrO (3) ScO (4) V_2O_5

[E] Explanation

Sc's *only* accessible oxidation state is +3 (TYPE 1) – so ScO, which would require Sc^{2+}, cannot exist. Sc's oxide is always Sc_2O_3. ZnO (Zn^{2+}) and V_2O_5 (V^{5+}) are both extremely common; CrO (Cr^{2+}) is a real, if less common, compound.

[Ans] Answer

Option (3) ScO.

Q23. Which compound is non existing?

(1) MnO_3F (2) Mn_2O_7 (3) CrO_3 (4) MnF_7

[E] Explanation

MnO_3F (permanganyl fluoride, a real if exotic Mn(VII) mixed oxo-fluoride), Mn_2O_7, and CrO_3 are all genuine, documented compounds. MnF_7 is the one that fails – fluorine simply cannot push Mn past +4 (Master Formula above).

[Ans] Answer

Option (4) MnF_7.

Q24. The ability of fluorine to stabilize the highest oxidation states in CrF_6, VF_5 is due to–

(1) Oxidising property of higher oxidation states
(2) Higher lattice energy
(3) High bond enthalpy due to covalent character
(4) Ability to form multiple bonds.

[E] Explanation

CrF_6 and VF_5 are specifically **covalent** fluorides – for this category, NCERT attributes fluorine's stabilising power to unusually high bond enthalpy arising from covalent character (small F, high electronegativity, strong single σ bond), *not* to multiple-bond formation (that's oxygen's mechanism, and precisely why fluorine still can't reach MnF_7). "Higher lattice energy" is the separate explanation used for *ionic* high-oxidation-state fluorides like CoF_3 – a different category from the covalent compounds named here.

[Ans] Answer

Option (3) High bond enthalpy due to covalent character.

Q25. Highest stable Mn fluoride is MnF_4 where as highest Mn oxide is Mn_2O_7 due to–

(1) O atom is smaller the F.

(2) Oxygen has ability to form multiple bonds

(3) Mn^{7+} does not exist

(4) F can not-stabilise higher oxidation states.

[E] Explanation

Direct statement of the Master Formula. Quick check on the distractors: (1) is factually backwards – F is actually the *smaller* atom, not O. (3) directly contradicts the question's own premise (Mn_2O_7, i.e. Mn^{7+}, is stated to exist). (4) is too absolute – F *can* stabilise fairly high states (Q.24's VF_5/CrF_6), just not as extreme as O can for Mn specifically. The precise, correct mechanism is oxygen's multiple-bonding ability.

[Ans] Answer

Option (2) Oxygen has ability to form multiple bonds.

Q26. Highest stable Mn fluoride is MnF_4 where as highest Mn oxide is Mn_2O_7 due to–

This question is identical to Q.25 in this paper – retained here as it appears twice in the original source.

(1) O atom is smaller than F.

(2) Oxygen has ability to form multiple bonds

(3) Mn^{7+} does not exist

(4) F can not-stabilise higher oxidation states.

[Ans] Answer

Option (2) Oxygen has ability to form multiple bonds – see full working at Q.25.

Q27. Which statement is correct.

(i) Highest Mn fluoride is MnF_7

(ii) Highest Mn fluoride is MnF_4

(iii) Highest Mn oxide is Mn_2O_7

(iv) Mn_2O_7 is a covalent green oil

(1) i, iii (2) ii, iii, iv (3) i, iv (4) i, ii

[E] Explanation

(i) is false (MnF_7 doesn't exist, Q.23). (ii), (iii) are both established true facts from this TYPE. (iv) is also a genuine, well-known physical description of Mn_2O_7 – it's a covalent, dark green, oily liquid at room temperature (much like CrO_2Cl_2, chromyl chloride). So (ii), (iii), (iv) are all correct.

[Ans] Answer

Option (2) ii, iii, iv.

Q28. Which statement is incorrect.

(i) Ferrates (VI) $[FeO_4]^{2-}$ are formed in alkaline medium but readily decompose to Fe_2O_3 and O_2
(ii) Oxidation state of V in VO_2^+ is $+5$
(iii) Oxidation state of V in VO_2^+ is $+4$
(iv) Oxidation state of Ti in TiO^{2+} is $+4$

(1) i (2) ii (3) iii (4) iv

[E] Explanation

Compute oxidation states directly: VO_2^+ – charge $+1$, two O at -2 each (-4 total), so $V + (-4) = +1 \Rightarrow V = +5$. Statement (ii) is correct; statement (iii), claiming $+4$ for the *same* ion, directly contradicts this – it's the incorrect one. (TiO^{2+}: $Ti + (-2) = +2 \Rightarrow Ti = +4$, matches (iv), correct. Ferrate(VI) really is formed in alkaline medium and does decompose this way – (i) is correct.)

[Ans] Answer

Option (3) iii.

Q29. Which statement is incorrect.

(1) Cu^{+2} oxidises I^- to I_2
(2) MnO_3F exist
(3) MnF_7 exist
(4) The high energy to transform Cu(s) to Cu^{2+}(aq) is not balanced by its hydration enthalpy.

[E] Explanation

(1) is a well-known, correct fact (also the reason CuI_2 doesn't exist – TYPE 7). (2) is correct (Q.23). (3) is **false** – established repeatedly in this TYPE, MnF_7 does not exist.

[!] Common Mistake

Flagging honestly: option (4)'s wording is also questionable by standard NCERT reasoning – the textbook explanation for why $Cu^2{\equiv}(aq)$ is stable is that the high ionisation energy *is* more than compensated (balanced) by Cu^{2+}'s strongly negative hydration enthalpy, which is the opposite of what option (4) states. That would make (4) *also* a false statement, and I can't fully resolve which

single option your source intends as "the" answer from the wording alone. I'm going with (3) since it's the most unambiguous, cross-referenceable false statement (directly contradicted three times earlier in this very TYPE) – please double check option (4) against your official key.

[Ans] Answer

Option (3) MnF_7 exist (this is definitely false). *Possible second candidate: option (4) – see note above.*

Q30. Number of species which exist.

(i) MnF_7
(ii) MnF_4
(iii) MnO_3F
(iv) $NiCl_3$
(v) CoF_3
(vi) VCl_5
(vii) CuF_2
(viii) CoI_2

(1) 2 (2) 3 (3) 4 (4) 6

[E] Explanation

Going through each individually:

- (i) MnF_7 – does **not** exist (established throughout this TYPE).
- (ii) MnF_4 – **exists** (the established ceiling for Mn fluorides).
- (iii) MnO_3F – **exists** (Q.23/Q.29, permanganyl fluoride).
- (iv) $NiCl_3$ – does **not** exist; Ni(III) is not stabilised by a simple, easily-oxidised halide like chloride the way it can be by F or O.
- (v) CoF_3 – **exists** (a genuine, documented fluorinating agent; fluoride, unlike chloride, *can* stabilise Co(III)).
- (vi) VCl_5 – treated as **not existing** at this level (the standard teaching point: V(V) is stabilised by F, not Cl; the highest well-known vanadium chloride is VCl_4). A genuinely "elusive" form was reportedly isolated in advanced research in 2012 under special conditions, but that's well outside NEET/JEE scope.
- (vii) CuF_2 – **exists** (common, well known).
- (viii) CoI_2 – **exists** (Co^{2+} isn't a strong enough oxidiser to attack I^-, unlike Cu^{2+}, so this is perfectly stable).

By this analysis, **5** species exist (ii, iii, v, vii, viii) – which doesn't match any of the four given options (2, 3, 4, 6).

[!] Common Mistake

Flagging transparently: I've checked each of these individually (including a literature check on the more obscure ones, $NiCl_3$ and VCl_5) and consistently get 5, which isn't offered as an option. This could mean either your source's answer key uses a different convention for one of the more obscure species than I have here, or there's a typo in the option list. If your official key says (3) "4", the most likely candidate to flip is CoF_3 or MnO_3F being treated as "doesn't count" at whatever level this question bank was written for – worth cross-checking rather than me guessing further.

[Ans] Answer

My count: 5 (not listed). Closest listed options are (3) 4 or (4) 6 – please verify against your official key.

▶ TYPE 5 : Oxidising Power and Redox Behaviour

[F] Master Formulae

Two directions, two different rules – don't mix them up:

- **Across a period**, oxidising power of the analogous high-oxidation-state oxoanion **increases**: $VO_2^+ < Cr_2O_7^{2-} < MnO_4^-$. Reason: the *reduced* product becomes progressively more stable/-favourable as you move right, making reduction (i.e. acting as oxidiser) more thermodynamically attractive.
- **Down a group**, oxidising power of the *same* oxidation state **decreases**: $CrO_3 > MoO_3 > WO_3$. Reason: the high oxidation state itself becomes progressively *more stable* for heavier congeners – Mo(VI)/W(VI) are comfortable being what they are, so they resist being reduced.

Q31. What is oxidation no. of Cr in $K_2Cr_2O_7$

(1) $+2$ (2) $+4$ (3) $+6$ (4) $+7$

[E] Explanation

$2(+1) + 2\text{Cr} + 7(-2) = 0 \Rightarrow 2\text{Cr} = 12 \Rightarrow \text{Cr} = +6.$

[Ans] Answer

Option (3) $+6$.

Q32. The increasing order of oxidising power $VO_2^+ < Cr_2O_7^{2-} < MnO_4^-$ can best be explained by–

(1) Increasing atomic radius of the central metal atom down the series

(2) Increasing stability of the reduced (lower oxidation state) species formed

(3) Increasing number of oxygen atoms bonded to the central metal

(4) Decreasing electronegativity of the central metal atom

[E] Explanation

Direct statement of the "across a period" Master Formula rule: as V→Cr→Mn, the product each is reduced *to* becomes progressively more stable/favourable, making the forward (oxidising) reaction more thermodynamically downhill.

[Ans] Answer

Option (2)

Q33. Which among the following order of oxidising power is correct?

(1) $CrO_4^- < MoO_4^- < WO_4^-$

(2) $VO_2^+ < Cr_2O_7^{2-} < MnO_4^-$

(3) $CrO_3 < MnO_2 < Fe_2O_3$

(4) $Pb^{4+} < Sn^{4+} < C^{4+}$

[E] Explanation

(1) has the "down a group" direction backwards – oxidising power should *decrease* Cr→Mo→W, not increase. (2) is the correct period-wise order (Master Formula). (3) is backwards – CrO_3 (Cr, VI) is actually a far stronger oxidiser than Fe_2O_3 (Fe, III is barely oxidising at all). (4) is backwards too – inert-pair effect makes Pb^{4+} the *strongest* oxidiser in Group 14 (most eager to drop back to +2), not the weakest.

[Ans] Answer

Option (2)

Q34. Which among the following order of oxidising character is correct?

(1) $CrO_3 > MoO_3$

(2) $K_2Cr_2O_7 > KMnO_4$

(3) $Fe(CO)_5 > Mn(CO)_5$

(4) $V_2O_3 > V_2O_5$

[E] Explanation

(1) matches the "down a group" rule directly – correct. (2) is backwards (MnO_4^- is the stronger oxidiser, Q.32). (3) compares an odd pairing – "$Mn(CO)_5$" isn't even a normal stable species (Mn carbonyl dimerises to $Mn_2(CO)_{10}$ to satisfy the 18-electron rule), so this isn't a meaningful oxidising-power comparison. (4) is backwards – the *higher*-oxidation-state oxide (V_2O_5) is the more oxidising one, not V_2O_3.

[Ans] Answer

Option (1) $CrO_3 > MoO_3$.

Q35. The pair of compounds that can exist together is **[AIPMT-2014]**

(1) $FeCl_3$, $SnCl_2$
(2) $HgCl_2$, $SnCl_2$
(3) $FeCl_2$, $SnCl_2$
(4) $FeCl_3$, KI

[E] Explanation

Check for redox incompatibility in each pair: Fe^{3+} oxidises Sn^{2+} (pair 1 reacts); Hg^{2+} oxidises Sn^{2+} (pair 2 reacts); Fe^{3+} oxidises I^- (pair 4 reacts, same logic as Cu^{2+}/I^-). Only $FeCl_2$ + $SnCl_2$ has *no* oxidiser paired against the reducer – both are already in their lower/reduced states, so nothing reacts.

[A] Approach

Har pair mein pehle check karo: kya ek partner doosre ko oxidise/reduce kar sakta hai? Agar dono already "reduced side" pe hain (Fe^{2+} aur Sn^{2+}), koi redox drive nahi hoga – peacefully coexist karenge.

[Ans] Answer

Option (3) $FeCl_2$, $SnCl_2$.

Q36. The tetrahedral $[MO_4]^{n-}$ ions known for.

(1) V(+5), Cr(+6), Mn(+5), Mn(+6), Mn(+7)
(2) V(+2), Cr(+3), Mn(+2)
(3) Sc(+3), Ni(+3), Zn(+3)
(4) None of these

[E] Explanation

Tetrahedral MO_4^{n-} oxoanions (VO_4^{3-}, CrO_4^{2-}, MnO_4^{3-}, MnO_4^{2-}, MnO_4^{-}) are all genuine, well-documented species – and they're all *high*-oxidation-state, close-to-d^0 ions. Low oxidation states like V(+2), Cr(+3), or Sc/Ni/Zn(+3) simply don't form this tetrahedral oxoanion family.

[Ans] Answer

Option (1)

Q37. Assertion: $KMnO_4$ is strong oxidising agent than $K_2Cr_2O_7$.
Reason: Cr has +7 oxidation state and Mn has +6 oxidation state.

(1) Both Assertion and Reason are true, Reason gives correct explanation
(2) Both Assertion and Reason are true, it doesn't give correct explanation
(3) Assertion is correct but Reason is false
(4) Both Assertion and Reason are false

[E] Explanation

The Assertion is true. But the Reason has the oxidation states **swapped**: Cr in dichromate is actually +6 (not +7), and Mn in permanganate is actually +7 (not +6) – the exact reverse of what's stated. Reason is false.

[Ans] Answer

Option (3) Assertion correct, Reason false.

Q38. Assertion: Cr(VI) in the form of dichromate in acidic medium is a strong oxidising agent where as MoO_3 & WO_3 are not.
Reason: Mo(VI) & W(VI) are found to be more stable then Cr(VI).

(1) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.

(2) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

(3) If Assertion is True but the Reason is False.

(4) If both Assertion & Reason are False.

[E] Explanation

Both true and directly linked – this is the exact "down a group" Master Formula: Mo(VI)/W(VI) being more stable is *why* they resist reduction (poor oxidisers), while the comparatively less stable Cr(VI) readily gets reduced to Cr(III) (strong oxidiser).

[Ans] Answer

Option (1)

▶ TYPE 6 : Stability and Reactivity of Cr^{2+}/Cr^{3+}

[F] Master Formulae

One picture solves this whole TYPE: in an octahedral field, Cr^{3+} (d^3) sits at $t_{2g}^3 e_g^0$ – all three lower orbitals singly occupied, none in the higher e_g set. This is an exceptionally stable arrangement (no Jahn-Teller distortion, maximum crystal-field stabilisation for this electron count). Cr^{2+} ($d^4 = t_{2g}^3 e_g^1$) is one electron away from that stability – so it readily **gives up** that extra electron to become Cr^{3+}, which is exactly what makes Cr^{2+} a reducing agent.

Q39. The stable oxidation state of Cr is.

(1) Cr^{2+} (2) Cr^{3+} (3) Cr^{4+} (4) Cr^{+5}

[Ans] Answer

Option (2) Cr^{3+}.

Q40. Which of the following is most stable

(1) Cr^{+4} (2) Cr^{+2} (3) Cr^{+3} (4) Cr^{+5}

[Ans] Answer

Option (3) Cr^{+3}.

Q41. Which of the following ions from most stable complex compound in aqueous solution.

(1) Cr^{+2} (2) Cr^{+3} (3) Cr^{+4} (4) Cr^{+5}

[E] Explanation

Cr^{3+} forms famously kinetically-inert, stable complexes in water (e.g. $[Cr(H_2O)_6]^{3+}$, $[Cr(NH_3)_6]^{3+}$) – a hallmark of Cr(III) coordination chemistry.

[Ans] Answer

Option (2) Cr^{+3}.

Q42. Cr^{2+} is reducing in nature because–

(1) In Cr^{2+}, configuration changes from d^4 to d^3 to achieve half filled t_{2g}.

(2) Cr^{2+} gain an electron to achieve d^5 configuration

(3) Cr^{2+} give an electron to achieve d^5 configuration

(4) In Cr^{2+} configuration changes from d^4 to d^3 to achieve half filled d-subshell.

[E] Explanation

Cr^{2+} (d^4) *gives up* an electron to become Cr^{3+} (d^3) – correct direction and correct destination in option (1). Option (4) gets the destination right ($d^4 \rightarrow d^3$) but mislabels it: d^3 is *half-filled* t_{2g} (3 of the 6 t_{2g} slots), not "half-filled d-subshell" (which would mean d^5, out of 10 possible d-electrons). Options (2) and (3) are simply wrong on the resulting configuration – gaining or giving one electron from d^4 never lands on d^5.

[!] Common Mistake

Don't confuse "half-filled t_{2g}" (d^3, in an octahedral field) with "half-filled d-subshell" (d^5, the atomic-orbital sense) – they describe different electron counts and options (1) vs (4) are testing exactly this distinction.

[Ans] Answer

Option (1)

Q43. Half filled t_{2g} orbitals are responsible for :–

(1) The stability of Cr^{2+} (aq.)

(2) The oxidising nature of Cr^{2+} (aq.)

(3) The reducing nature of Cr^{2+} (aq.)

(4) All of these

[E] Explanation

Half-filled t_{2g} (d^3) is what Cr^{2+} (d^4) is *driven toward* by losing an electron – this driving force is precisely the reducing behaviour of Cr^{2+}(aq), not its own stability (Cr^{2+} itself is the *less* stable, e_g^1-carrying species that wants to change).

[Ans] Answer

Option (3) The reducing nature of Cr^{2+}(aq.).

▶ TYPE 7 : Cu^{+}/Cu^{2+} – Stability, Disproportionation and Halides

[F] Master Formulae

Cu^{+} (d^{10}) disproportionates in water: $2Cu^{+}(aq) \rightarrow Cu^{2+}(aq) + Cu(s)$, because Cu^{2+}'s far more negative hydration enthalpy more than compensates for the extra ionisation energy needed to reach it. Separately, Cu^{2+} is a mild oxidiser – strong enough to oxidise I^{-} (but not other halides), which is exactly why CuI_2 never forms.

Q44. Cu^{+} ion is not stable in aqueous solution, due to–

(1) d^{10} configuration
(2) Disproportionation
(3) Less charge
(4) Pseudo inert gas configuration

[E] Explanation

Options (1) and (4) both describe features that are normally associated with *stability*, not instability – so they can't directly explain why Cu^{+} disappears in water. The actual, direct process responsible is disproportionation: Cu^{+} converts itself into Cu^{2+} and Cu metal, driven by Cu^{2+}'s much stronger hydration enthalpy.

[Ans] Answer

Option (2) Disproportionation.

Q45. All Cu (II) halide are known, except it's iodide?

(1) Iodide is a larger ion
(2) Cu^{2+} oxidises I^{-} to I_2
(3) Hydration enthalpy of $Cu^{2+}_{(aq)}$ is highly negative
(4) Cu^{2+} is very small ion

[E] Explanation

Cu^{2+} is just oxidising enough to convert I^{-} to I_2, getting reduced to Cu^{+} in the process – so instead of CuI_2, you get CuI (copper(I) iodide) plus iodine. Cu^{2+} isn't strong enough to do this to Cl^{-}, Br^{-}, or F^{-}, which is why those three halides are all perfectly stable.

[Ans] Answer

Option (2) Cu^{2+} oxidises I^{-} to I_2.

▶ TYPE 8 : Matching, Mismatches and Element Identification

[F] Master Formulae

This TYPE is a pure recall-and-cross-check section – it draws on facts already built up across TYPE 1–7 (Sc's fixed $+3$, Mn/Cr's highest states, Ru/Os's $+8$, Cr's stable $+3$, etc.) rather than introducing new mechanisms. The one new idea: standard reduction potentials (E°) for $M^{3}{\equiv}/M^{2+}$ couples tell you which M^{2+} ions are strong reducing agents (very negative E°, e.g. Ti, V, Cr) versus which M^{3+} ions are strong oxidising agents (very positive E°, e.g. Mn, Co).

Q46. Most common oxidation states are matched below with the elements. Which one is mismatched?

(1) Iron $(+2, +3)$

(2) Chromium $(+1, +2)$

(3) Manganese $(+2, +7)$

(4) Titanium $(+3, +4)$

[E] Explanation

Chromium's genuinely common oxidation states are $+2$, $+3$, and $+6$ – $+1$ is essentially never cited as a common Cr state. Iron, Manganese, and Titanium's listed pairs are all standard and correct.

[Ans] Answer

Option (2) Chromium $(+1, +2)$ – mismatched.

Q47. A transition element x has a configuration [Ar] $3d^4$ in its $+3$ oxidation state. Its atomic number is.

(1) 25 (2) 26 (3) 22 (4) 19

[E] Explanation

Work backwards: if $X^{3+} = 3d^4$, the neutral atom is $3d^5 4s^2$ (add back 2 electrons to $4s$, then 1 to $3d$). $3d^5 4s^2$ is Mn, $Z = 25$. Check: $Mn^{2+} = 3d^5$ (remove $4s^2$), $Mn^{3+} = 3d^4$ (remove one more from $3d$) – matches exactly.

[Ans] Answer

Option (1) 25.

Q48. Match the column

Metal	Highest oxidation state
A. Sc	i. $+8$
B. Mn	ii. $+6$
C. Cr	iii. $+7$
D. Ru	iv. $+3$

(1) A–iii; B–iv; C–ii; D–i

(2) A–iv; B–iii; C–ii; D–i

(3) A–iv; B–iii; C–i; D–ii

(4) A–iv; B–ii; C–iii; D–i

[E] Explanation

Pure recall from earlier TYPEs: Sc's only state is $+3$ (iv); Mn's highest is $+7$ (iii); Cr's highest is $+6$ (ii); Ru reaches $+8$ (i, TYPE 3). So A–iv, B–iii, C–ii, D–i.

[Ans] Answer

Option (2) A–iv; B–iii; C–ii; D–i.

Q49. Which among the following statements is incorrect

(1) In d-block elements oxidation state differ by unity.

(2) In p-block metals oxidation state differ by two units.

(3) In a group of p-block lower oxidation states are favoured by the heavier members.

(4) In a group of d-block higher oxidation states are favoured by the lighter member.

[E] Explanation

(1), (2), (3) are all standard, correct rules (the last being the classic inert-pair effect: heavier p-block metals like Pb favour $+2$ over $+4$). (4) has the direction backwards: in the d-block, going **down** a group, **higher** oxidation states become **more** stable – it's the *heavier* member (Mo, W) that favours the higher state, not the lighter one (Cr). This is the exact opposite of the p-block trend, and precisely the fact tested in TYPE 5 (Q.32/Q.38).

[!] Common Mistake

This question is really testing whether you know that d-block and p-block trends run in *opposite* directions down a group – p-block favours lower oxidation states in heavier members, d-block favours higher. Mixing the two up is the exact trap here.

[Ans] Answer

Option (4)

Q50. How many statements are incorrect?

(a) Mn^{+3} and Co^{+3} are strongest oxidising agent

(b) Ti^{+2}, V^{2+} and Cr^{2+} are strongest reducing agent

(c) CrO_3 is acidic in nature

(d) $E^{\circ}_{M^{3+}/M^{2+}} = -$Ve for Fe

(1) 2 (2) 1 (3) 4 (4) None

[E] Explanation

Check each: (a) True – Mn^{3+} and Co^{3+} are indeed the standout strong oxidising M^{3+} ions in the 3d row (their M^{2+} products, d^5 and the common Co(II) state respectively, are comparatively favourable). (b) True – Ti^{2+}, V^{2+}, Cr^{2+} are all well known as strong reducing agents, each keen to reach a more stable M^{3+} state. (c) True – CrO_3 is a classic acidic oxide (dissolves to give chromic acid), consistent with high-oxidation-state metal oxides trending acidic. (d) **False** – $E^{\circ}(Fe^{3} \equiv /Fe^{2+}) = +0.77$ V, a well-known *positive* value (one of the higher ones in the row, precisely because Fe^{2+}, d^6, has no special drive to further oxidise). So only **one** statement, (d), is incorrect.

[Ans] Answer

Option (2) 1 (only statement (d) is incorrect).

▶ TYPE 9 : Periodic Trends – Lanthanide Contraction and Group Position

[F] Master Formulae

Lanthanide contraction (poor shielding by the filled $4f$ subshell, sitting between the 4d and 5d rows) is why 4d/5d congeners in the same group end up almost identical in size – and size, in turn, drives most of their shared chemistry.

Q51. Although Zirconium belongs to $4d$ transition series and Hafnium to $5d$ transition series even then they show similar physical and chemical properties because _____ :–

(1) Both belong to d-block

(2) Both have same number of electrons

(3) Both have similar atomic radius

(4) Both belong to the same group of the periodic table

[E] Explanation

Being in the same group (option 4) is true of *any* group pair, yet most such pairs (e.g. Ti vs Zr) still show a normal, noticeable size/property jump between periods. Zr and Hf are unusually close in behaviour specifically because lanthanide contraction leaves them with nearly **identical atomic radius** – that's the direct, proximate cause of their near-twin chemistry, not simply "same group" on its own.

[Ans] Answer

Option (3) Both have similar atomic radius.

Q52. The lanthanide contraction is responsible for the fact that :

(1) Zr & Y have about the same radius

(2) Zr and Nb have similar oxidation state

(3) Zr and Hf have almost the same radius

(4) Zr and Zn have the same oxidation state

[Ans] Answer

Option (3) Zr and Hf have almost the same radius.

Q53. The position of Cu, Ag and Au in the periodic table is in between :

(1) Alkali and alkaline earth metals

(2) Alkali metals and halogens

(3) VIII group and zinc metals

(4) Alkaline earth metals' and halogens

[E] Explanation

Cu, Ag, Au (Group 11, the coinage metals) sit directly between the old "Group VIII" triads (Fe/-Co/Ni, Ru/Rh/Pd, Os/Ir/Pt – Group 8–10) and the zinc-group metals (Zn/Cd/Hg – Group 12) in the periodic table.

[Ans] Answer

Option (3) VIII group and zinc metals.

Oxidation states in the d-block all trace back to one idea:
how many electrons can be pulled out before you hit a configuration too stable to disturb.

– Your Weird Chemist