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The d- and f-Block Elements — CBSE Class 12 Chemistry Chapter Test

FREE CHAPTER TEST · CLASS XII · CHEMISTRY (043) · PATTERN OF THE CBSE SAMPLE QUESTION PAPER 2026-27

TIME ALLOWED	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
1½ hours	37	17 (A 8 · B 3 · C 3 · D 1 · E 2)	

GENERAL INSTRUCTIONS

Read the following instructions very carefully and strictly follow them:

1. This question paper contains 17 questions. All questions are compulsory.
2. This question paper is divided into five sections: A, B, C, D and E.
3. Section A (Q1–8) contains 6 multiple choice questions and 2 assertion-reason based questions of 1 mark each.
4. Section B (Q9–11) contains short answer questions of 2 marks each.
5. Section C (Q12–14) contains short answer questions of 3 marks each.
6. Section D (Q15) contains case-based questions of 4 marks each, with sub-parts of 1, 1 and 2 marks.
7. Section E (Q16–17) contains long answer questions of 5 marks each.
8. There is no overall choice. However, an internal choice has been provided in 1 question in Section B, 1 question in Section C, 1 question in Section D, 2 questions in Section E. Attempt only one of the alternatives in such questions.
9. Use of log tables and calculators is not allowed.
10. This chapter test follows the section structure, question types and marks per question of the CBSE Class XII Chemistry (043) Sample Question Paper 2026-27, at about half the length of the 70-mark board paper: 37 marks in 1½ hours.
11. The answer key and the marking scheme are at the end of this booklet. Attempt the paper in 1½ hours before you look at them.

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Chapter: The d- and f-Block Elements · **Topics:** Electronic configurations and general properties · Oxidation states and E° values · Magnetic properties and colour · Potassium dichromate and potassium permanganate · Lanthanoids and lanthanoid contraction · Actinoids

SECTION A

This section comprises 8 questions of 1 mark each: 6 multiple choice questions (MCQs) and 2 assertion-reason based questions.

1. The spin-only magnetic moment of Mn^{2+} (Z of Mn = 25) is about 1

(A) 5.92 BM (B) 4.90 BM

(C) 3.87 BM (D) 1.73 BM

2. Which of the following ions is colourless in aqueous solution? 1

(A) Ti^{3+} (B) V^{3+}

(C) Sc^{3+} (D) Cr^{3+}

3. The general electronic configuration of the lanthanoids is 1

(A) [Xe] $4f^{14}\ 5d^{10}\ 6s^2$ (B) [Xe] $4f^{1–14}\ 5d^{0–1}\ 6s^2$

(C) [Rn] $5f^{1–14}\ 6d^{0–1}\ 7s^2$ (D) [Xe] $4f^{0}\ 5d^{1–10}\ 6s^2$

4. The most common oxidation state of the lanthanoids is 1

(A) +2 (B) +4

(C) +5 (D) +3

5. When acidified $KMnO_4$ acts as an oxidising agent, the number of electrons gained by each MnO_4^- ion is 1

(A) 3 (B) 1

(C) 5 (D) 4

6. The only oxidation state shown by scandium in its compounds is 1

(A) +3 (B) +2

(C) +4 (D) +1

7. **Assertion (A) :** The transition metals form many coloured compounds. 1
Reason (R) : Iron is the most abundant transition metal in the Earth's crust.

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, and R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

8. **Assertion (A) :** Zinc, cadmium and mercury are regarded as typical transition elements. 1
Reason (R) : Zinc, cadmium and mercury have completely filled d orbitals in their ground state and in their common oxidation states.

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, and R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

SECTION B

This section comprises 3 short answer questions of 2 marks each.

9. Find the spin-only magnetic moments of Fe^{2+} (Z = 26) and Cu^{2+} (Z = 29). 2

10. (a) Give two reasons why transition metals and their compounds are good catalysts. 2

OR

(b) Why is Ce^{4+} a good oxidising agent, while Eu^{2+} and Yb^{2+} are good reducing agents?

11. Write balanced ionic equations for the reaction of (i) acidified potassium permanganate with iron(II) ions, and (ii) acidified potassium dichromate with iodide ions. 2

SECTION C

This section comprises 3 short answer questions of 3 marks each.

12. (a) Explain the following: 3

(i) E° for the Mn^{3+}/Mn^{2+} couple is much more positive than for Cr^{3+}/Cr^{2+} or Fe^{3+}/Fe^{2+}.

(ii) Cu^{+} is unstable in aqueous solution.

(iii) The transition metals have high enthalpies of atomisation.

OR

(b) Explain the following:

(i) Zinc(II) salts are white, but copper(II) salts are coloured.

(ii) Transition metals readily form alloys.

(iii) The highest oxidation state of a transition metal is usually shown in its oxide or fluoride.

13. (i) Write the equations for the preparation of potassium permanganate from pyrolusite (MnO_2): fusion with KOH in air, and the disproportionation of the manganate ion in acid solution. 3

(ii) Write the balanced ionic equation for the oxidation of oxalate ions by acidified permanganate.

14. Give three differences between the lanthanoids and the actinoids. 3

SECTION D

This section comprises 1 case-based question of 4 marks, with sub-parts of 1, 1 and 2 marks.

15. Potassium chromate solution is yellow. When dilute acid is added it turns orange, and when alkali is then added it turns yellow again. The two ions, CrO_4^{2-} and $Cr_2O_7^{2-}$, are in equilibrium, and which one is present depends on the pH. Acidified dichromate is used in the laboratory as an oxidising agent, turning green as it reacts.

(I) Which ion is present in the orange solution? [1]

(II) What is the oxidation state of chromium in the chromate ion and in the dichromate ion? [1]

(III) Write the balanced equations for the change of chromate into dichromate in acid, and of dichromate into chromate in alkali. [2]

OR

(III) Write the balanced ionic equation for the oxidation of hydrogen sulphide by acidified dichromate. Which ion gives the green colour? [2]

SECTION E

This section comprises 2 long answer questions of 5 marks each.

16. (a) (i) Why do the transition elements show variable oxidation states? Why does manganese show the largest number of oxidation states in the first series? 5

(ii) Why are most transition metal ions coloured and paramagnetic?

(iii) Find the spin-only magnetic moments of V^{3+} (Z = 23) and Co^{2+} (Z = 27).

OR

(b) (i) Write the equations for the preparation of potassium dichromate from chromite ore ($FeCr_2O_4$).

(ii) Describe the structures of the chromate and dichromate ions.

(iii) Give one use of potassium dichromate.

17. (a) (i) What is the lanthanoid contraction? What causes it? State two of its consequences. 5

(ii) Why do the actinoids show a larger number of oxidation states than the lanthanoids? Why is the actinoid contraction greater than the lanthanoid contraction?

OR

(b) (i) What are interstitial compounds? Give two of their characteristic properties.

(ii) How do the melting points of the 3d metals vary across the series, and why?

(iii) Why is E° for the Cu^{2+}/Cu couple positive (+0.34 V), unlike the other 3d metals?

END OF THE QUESTION PAPER

ANSWER KEY — SECTION A

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
(A)	(C)	(B)	(D)	(C)	(A)	(B)	(D)

MARKING SCHEME AND WORKED SOLUTIONS

Marks for each step are shown in brackets, as in the CBSE marking scheme. Any correct alternative method earns full marks.

Q1. Answer (A). Mn^{2+} is $3d^5$ with 5 unpaired electrons: $\mu = \sqrt{(5 \times 7)} = \sqrt{35} \approx 5.92$ BM.

Q2. Answer (C). Sc^{3+} is $3d^0$: there is no d electron for a d–d transition.

Q3. Answer (B). In the lanthanoids the 4f orbitals are being filled; [Rn] $5f^{1–14}$ $6d^{0–1}$ $7s^2$ is the configuration of the actinoids.

Q4. Answer (D). All lanthanoids show +3; +2 and +4 occur only for a few (e.g. Eu^{2+}, Ce^{4+}).

Q5. Answer (C). $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$: Mn goes from +7 to +2.

Q6. Answer (A). Scandium ($3d^14s^2$) loses all three outer electrons to give Sc^{3+} with the stable configuration of argon.

Q7. Answer (B). Both are true, but the colour comes from d–d transitions of partly filled d orbitals, not from the abundance of iron. Answer B.

Q8. Answer (D). Because their d orbitals are full (d^{10}), they are not regarded as transition elements: A is false, R is true. Answer D.

Q9. (2 marks) Answer: 4.90 BM; 1.73 BM.
Fe^{2+}: $3d^6$, 4 unpaired electrons: $\mu = \sqrt{(4 \times 6)} = \sqrt{24} \approx 4.90$ BM. [1]
Cu^{2+}: $3d^9$, 1 unpaired electron: $\mu = \sqrt{(1 \times 3)} \approx 1.73$ BM. [1]

Q10. (2 marks) Answer: (a) variable oxidation states; adsorption on surfaces; (b) +3 is the most stable lanthanoid state.
(a) They can show several oxidation states, so they can form unstable intermediates and change oxidation state easily (e.g. Fe^{3+}/Fe^{2+} in the $S_2O_8^{2-} + I^-$ reaction). [1] Their surfaces provide sites (using d electrons) where reactant molecules are adsorbed and weakened, bringing them together (e.g. Ni in hydrogenation, Fe in the Haber process). [1]
OR (b) Ce^{4+} readily changes to the common, more stable +3 state (E° for Ce^{4+}/Ce^{3+} is about +1.74 V), so it is a strong oxidising agent. [1] Eu^{2+} ($4f^7$) and Yb^{2+} ($4f^{14}$) are readily oxidised to the common +3 state, so they are good reducing agents. [1]

Q11. (2 marks) Answer: balanced equations.
(i) $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$. [1]
(ii) $Cr_2O_7^{2-} + 6I^- + 14H^+ \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O$. [1]

Q12. (3 marks) Answer: (a) d^5 stability; disproportionation and hydration; unpaired electrons; (b) d^{10} against d^9; similar radii; small electronegative O and F.
(a) (i) Mn^{2+} has the stable half-filled $3d^5$ configuration, so Mn^{3+} ($3d^4$) is very readily reduced to it. [1]
(ii) Cu^+ disproportionates: $2Cu^+ \rightarrow Cu^{2+} + Cu$, because the much larger hydration enthalpy of the small, highly charged Cu^{2+} more than makes up for the second ionisation enthalpy. [1]
(iii) They have many unpaired electrons (in d and s orbitals) that take part in strong metallic bonding. [1]
OR (b) (i) Zn^{2+} ($3d^{10}$) has a full d subshell, so no d–d transition is possible; Cu^{2+} ($3d^9$) has a vacancy, absorbs visible light as an electron jumps between d orbitals, and so is coloured. [1]
(ii) Their atomic radii are very similar, so atoms of one metal can easily take the place of the other in the lattice. [1]
(iii) Oxygen and fluorine are very small and very electronegative; oxygen can also form multiple bonds to the metal, which stabilises the highest oxidation states. [1]

Q13. (3 marks) Answer: balanced equations.
(i) $2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$. [1] $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$. [1]
(ii) $2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$. [1]

Q14. (3 marks) Answer: any three differences.
Any three [3]: the actinoids show a wider range of oxidation states (+3 to +7) than the lanthanoids (mainly +3); all actinoids are radioactive, only promethium among the lanthanoids is; the actinoid contraction is larger than the lanthanoid contraction (5f electrons shield even more poorly); the actinoids form complexes and oxocations (such as UO_2^{2+}) more readily.

Q15. (4 marks) Answer: (I) $Cr_2O_7^{2-}$; (II) +6; (III) equations; Cr^{3+} is green.
(I) Dichromate, $Cr_2O_7^{2-}$. [1]
(II) +6 in both (the change is not a redox reaction). [1]
(III) $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$ [1]; $Cr_2O_7^{2-} + 2OH^- \rightarrow 2CrO_4^{2-} + H_2O$. [1]
OR (III) $Cr_2O_7^{2-} + 3H_2S + 8H^+ \rightarrow 2Cr^{3+} + 3S + 7H_2O$. [1] The green colour is due to Cr^{3+}. [1]

Q16. (5 marks) Answer: (a) similar energies of (n−1)d and ns; d–d transitions; 2.83 BM; 3.87 BM; (b) chromite → chromate → dichromate.
(a) (i) The (n−1)d and ns electrons have similar energies, so different numbers of them can be lost or shared. [1] Mn ($3d^5 4s^2$) has the most electrons that can take part, so it shows oxidation states from +2 to +7. [1]
(ii) Partly filled d orbitals: electrons absorb visible light and jump between d orbitals split in energy (d–d transitions), and the complementary colour is seen; unpaired d electrons make them paramagnetic. [1]
(iii) V^{3+}: $3d^2$, 2 unpaired: $\mu = \sqrt{8} \approx 2.83$ BM. [1] Co^{2+}: $3d^7$, 3 unpaired: $\mu = \sqrt{15} \approx 3.87$ BM. [1]
OR (b) (i) $4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$ (fusion in air). [1] $2Na_2CrO_4 + 2H^+ \rightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$ (acidify). [1] $Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$ (less soluble $K_2Cr_2O_7$ crystallises). [1]
(ii) Chromate is tetrahedral; dichromate is two tetrahedra sharing one corner oxygen (Cr–O–Cr bridge). [1]
(iii) Any one: volumetric analysis (estimation of Fe^{2+}), oxidising agent in organic chemistry, leather tanning. [1]

Q17. (5 marks) Answer: (a) poor shielding by 4f electrons; Zr and Hf; 5f, 6d, 7s close in energy; (b) interstitial compounds; positive E° of Cu.
(a) (i) The steady decrease in atomic and ionic (M^{3+}) radii from La to Lu. [1] Cause: each added electron enters a 4f orbital, and 4f electrons shield one another very poorly from the nuclear charge, which increases by one at each step. [1] Consequences (any two): Zr/Hf and Nb/Ta have nearly the same radii and properties; the basic strength of $Ln(OH)_3$ decreases from La to Lu; the lanthanoids are hard to separate. [1]
(ii) In the actinoids the 5f, 6d and 7s levels have comparable energies, so more electrons can take part in bonding. [1] 5f electrons shield even more poorly than 4f electrons, so the contraction from element to element is greater. [1]
OR (b) (i) Small atoms such as H, C or N trapped in the holes of the metal lattice (e.g. TiC, Mn_4N, Fe_3H). [1] They have high melting points, are very hard, keep metallic conductivity and are chemically inert. [1]
(ii) Melting points rise to a maximum near the middle of the series (about d^5) and then fall, because the number of unpaired electrons available for metallic bonding first increases and then decreases. [1]
(iii) E° = +0.34 V: copper's high enthalpy of atomisation and the sum of its first two ionisation enthalpies need more energy than is returned by the hydration of Cu^{2+}, so $Cu(s) \rightarrow Cu^{2+}(aq)$ is unfavourable; copper does not liberate H_2 from acids. [2]

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