# Chapter 8

# The *d* and *f*-Block Elements

## Solutions

### SECTION - A

**Objective Type Questions**

**(The *d*-Block elements)**

1. Coinage metals are

   (1) Normal metals (2) Transition metals (3) Active metals (4) Highly electropositive

**Sol.** Answer (2)

Generally, we consider Cu, Ag, Au as coinage metals and they come under transition metals.

2. Pyrolusite is used to prepare potassium permanganate $MnO_2 \xrightarrow{X} MnO_4^{-2} \xrightarrow{Y} MnO_4^-$

   X and Y are

   (1) Fuse with KOH/air, electrolytic reduction (2) Fuse with KOH/air, electrolytic oxidation

   (3) Fuse with con. $HNO_3$/air, electrolytic reduction (4) All are correct

**Sol.** Answer (2)

$$MnO_2 \xrightarrow{KOH\ /\ Air} MnO_4^{2-} \xrightarrow[Oxidation]{Electrolytic} MnO_4^-$$

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

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

**Sol.** Answer (3)

Among the given, Mn exhibit highest oxidation state, *i.e.* +7.

4. A purple coloured solution is made alkaline with KOH and is treated with KI forming potassium iodate. The same solution is acidified with $H_2SO_4$ and again it is treated with KI. However this time instead of potassium iodate, iodine gas is released. The purple coloured solution is of

   (1) $K_2Cr_2O_7$ (2) $K_2Cr_2O_4$ (3) $KMnO_4$ (4) $K_2MnO_4$

**Sol.** Answer (3)

$$2KMnO_4 + H_2O + I^- \xrightarrow{Alkaline} 2MnO_2 + 2OH^- + KIO_3$$

$$KMnO_4 + H_2SO_4 + KI \longrightarrow Mn^{2+} + 8H_2O + 5I_2$$

$\Rightarrow$ $KMnO_4$ is the required solution.

5. Acidified solution of chromic acid on treatment with $H_2O_2$ gives blue colour which is due to

(1) $CrO_3 + H_2O + O_2$ (2) $Cr_2O_3 + H_2O + O_2$

(3) $CrO_5 + H_2O$ (4) $H_2Cr_2O_7 + H_2O + CO_2$

**Sol.** Answer (3)

$$K_2Cr_2O_7 + H_2SO_4 + 4H_2O_2 \longrightarrow \underset{\text{Blue}}{2CrO_5} + 5H_2O + K_2SO_4$$

6. $FeSO_4$ on heating gives

(1) $SO_2$ and $SO_3$ (2) $SO_2$ only (3) $SO_3$ only (4) $SO_2$ and $O_2$

**Sol.** Answer (1)

$$FeSO_4 \xrightarrow{\Delta} Fe_3O_4 + 2SO_3 + SO_2$$

7. What are the species X and Y in the following?

$$X + H_2O \longrightarrow H_2Cr_2O_7 \xrightarrow{OH^-} Y$$

(1) $CrO_4^{-2}$, $Cr_2O_7^{-2}$ (2) $CrO_3$, $Cr_2O_3$ (3) $H_2CrO_4$, $H_2Cr_2O_7$ (4) $CrO_3$, $CrO_4^{-2}$

**Sol.** Answer (4)

$$\underset{(X)}{CrO_3} + H_2O \longrightarrow H_2Cr_2O_7 \xrightarrow{OH^-} \underset{(Y)}{CrO_4^-}$$

8. The correct statement

(1) Green vitriol and blue vitriol are isomorphus

(2) $KMnO_4$ and $K_2Cr_2O_7$ are coloured due to d-d transitions

(3) $Cu_2Cl_2$ and $Ag_2S$ are coloured

(4) Upon strong heating paramagnetic gases are evolved by $NaNO_3$ and $AgNO_3$

**Sol.** Answer (4)

Fact.

9. Which oxide of manganese is acidic in nature?

(1) MnO (2) $Mn_2O_7$

(3) $Mn_2O_3$ (4) $MnO_2$

**Sol.** Answer (2)

$Mn_2O_7$ is acidic in nature (fact).

10. The blue colour produced on adding $H_2O_2$ to acidified $K_2Cr_2O_7$ is due to the formation of

(1) $CrO_5$ (2) $Cr_2O_3$ (3) $CrO_4^{2-}$ (4) $CrO_3$

**Sol.** Answer (1)

$$K_2Cr_2O_7 + H_2SO_4 + 4H_2O_2 \longrightarrow \underset{\text{Blue}}{2CrO_5} + K_2SO_4 + 5H_2O$$

11. $4K_2Cr_2O_7 \longrightarrow 4K_2CrO_4 + 3O_2 + X$, in this reaction X is

(1) $CrO_3$ (2) $Cr_2O_7$ (3) $Cr_2O_3$ (4) $CrO_5$

**Sol.** Answer (3)

$4K_2Cr_2O_7 \longrightarrow 4K_2CrO_4 + 3O_2 + 2Cr_2O_3$

12. Which of the following is not coloured?

(1) $Mn^{2+}$ (2) $Cr^{3+}$ (3) $Zn^{2+}$ (4) $Cu^{2+}$

**Sol.** Answer (3)

$Zn^{2+}$ does not show any colour because no any transition is possible there due to $3d^{10}$ configuration.

13. Ammonium dichromate is used in fireworks.The green coloured powder blown in the air is

(1) $CrO_3$ (2) $Cr_2O_3$ (3) Cr (4) $CrO(O)_2$

**Sol.** Answer (2)

$$(NH_4)_2Cr_2O_7 \longrightarrow \underset{\text{Green}}{Cr_2O_3} + N_2 + 4H_2O$$

14. Which of the following statement is correct for 3*d*-transition element?

(1) All the metals except Sc forms 'MO' oxide (2) All the metals except Zn forms 'MO' oxide

(3) All the metals except Zn and Sc form 'MO' oxide (4) All the metals except Mn forms 'MO' oxide

**Sol.** Answer (1)

Fact.

15. Which of the following belongs to group '8'?

(1) Ni, Pd, Pt (2) F, Cl, Br (3) Fe, Ru, Os (4) Xe, Ar, Kr

**Sol.** Answer (3)

Fe, Ru, Os belong to group 8 due to their electronic configuration.

16. Which one of the following pairs of ions have same electronic configuration?

(1) $Cr^{3+}$ $Fe^{3+}$ (2) $Mn^{2+}$, $Fe^{3+}$ (3) $Fe^{3+}$ $Co^{3+}$ (4) $Sc^{3+}$, $Cr^{3+}$

**Sol.** Answer (2)

$Mn^{2+}$ : $3d^5$

$Fe^{3+}$ : $3d^5$

17. The equivalent weight of $MnSO_4$ is equal to its molecular weight when it is converted to

(1) $Mn_2O_3$ (2) $MnO_2$ (3) $MnO_4^-$ (4) $MnO_4^{2-}$

**Sol.** Answer (1)

$$2\overset{2+}{Mn}SO_4 \longrightarrow \overset{3+}{Mn_2}O_3$$

n-factor = 1

$\therefore$ Molecular weight = Equivalent weight.

18. Gun metal contains

(1) Cu, Sn, Zn (2) Cu, Ni

(3) Cu, Ni, Fe (4) Cu, Sn, P

**Sol.** Answer (1)

Gun metal contains (Cu, Sn, Zn) casting alloy.

The main alloying constituent is beside copper, tin with 1.5 to 11%, Zn 1 – 9%

**Note :** *Cu, Ni, Fe are monel metal, not gun metal.*

19. The colour of $K_2Cr_2O_7$ and $Fe^{2+}$ ions are respectively due to

(1) *d-d* transition and charge transfer spectra (2) Charge transfer spectra and *d-d* transition

(3) Crystal defects and charge transfer spectra (4) Charge transfer spectra and crystal defects

**Sol.** Answer (2)

$K_2Cr_2O_7 \Rightarrow$ Colour due to charge transfer.

$Fe^{2+}$ ions $\Rightarrow$ Colour due to *d-d* transition.

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

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

**Sol.** Answer (4)

Highest oxidation state of Fe is +6 and $Fe^{6+} \Rightarrow 3d^2$.

21. $CrO_3$ is coloured due to

(1) Crystal defect (2) Unpaired electrons

(3) Charge transfer spectra (4) Low I.E.

**Sol.** Answer (3)

In $CrO_3$ colour is due to charge transfer (fact).

22. Which of the following occur when $AgNO_3$ becomes, red hot?

(1) $2AgNO_3 \longrightarrow 2Ag + 2NO_2 + O_2$ (2) $AgNO_3 \longrightarrow Ag + NO + O_2$

(3) $2AgNO_3 \longrightarrow AgNO_2 + O_2$ (4) $2AgNO_3 \longrightarrow 2Ag + N_2 + 3O_2$

**Sol.** Answer (1)

If $AgNO_3$ is red hot, it gets decomposed as

$2AgNO_3 \longrightarrow 2Ag + 2NO_2 + O_2$

23. Which one alloy does not contain copper?

(1) Bronze (2) Brass

(3) German silver (4) Mischmetal

**Sol.** Answer (4)

Misch metal : 50% Ce, 25% La, small amount of Nd and Pr blended with FeO.

24. The metal which can form cation having metal - metal bond

(1) Mercury (2) Copper (3) Osmium (4) Iron

**Sol.** Answer (1)

Hg forms $Hg_2^{2+}$

25. Value of magnetic moment of a divalent metal ion is 5.92 BM. Total number of electron in its atom would be

(1) 24 (2) 25 (3) 26 (4) 27

**Sol.** Answer (2)

In divalent state, *i.e.* $M^{2+}$

Given that $\mu$ = 5.92 BM

$\Rightarrow$ Number of unpaired electrons = 5

$\Rightarrow$ $3d^5$ configuration

$\therefore$ Among the given options it should be 25.

26. In black and white photography, the developed film is fixed by washing with

(1) AgBr solution (2) Hypo solution (3) $Na_2S_4O_6$ solution (4) $FeC_2O_4$ solution

**Sol.** Answer (2)

In black and white photography hypo solution is used.

27. Gold dissolves in aqua regia to give

(1) $H[AuCl_4]$ (2) $AuNO_3$ (3) $H_2[AuCl_6]$ (4) $Au(NO_3)_3$

**Sol.** Answer (1)

$Au + \text{Aqua regia} \longrightarrow H\left[AuCl_4\right]$.

**(The *f*-Block elements)**

28. Ce(Z = 58) and Yb(Z = 70) exhibits stable +4 and +2 oxidation states respectively. This is because

(1) $Ce^{4+}$ and $Yb^{2+}$ acquire $f^7$ configuration (2) $Ce^{4+}$ and $Yb^{2+}$ acquire $f^0$ configuration

(3) $Ce^{4+}$ and $Yb^{2+}$ acquire $f^0$ and $f^{14}$ configuration (4) $Ce^{4+}$ and $Yb^{2+}$ acquire $f^7$ and $f^{14}$ configuration

**Sol.** Answer (3)

Fact.

29. Transuranic elements begin with

(1) Np (2) Cm (3) Pu (4) U

**Sol.** Answer (1)

Transuranic elements are the elements, having atomic number greater than 92.

Atomic number of Np = 93

$\Rightarrow$ Transuranic elements begin with Np.

## SECTION - B

**Previous Years Questions**

1. The manganate and permanganate ions are tetrahedral, due to : **[NEET-2019]**

   (1) The $\pi$-bonding involves overlap of p-orbitals of oxygen with d-orbitals of manganese

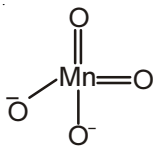
   (2) There is no $\pi$-bonding

   (3) The $\pi$-bonding involves overlap of p-orbitals of oxygen with p-orbitals of manganese

   (4) The $\pi$-bonding involves overlap of d-orbitals of oxygen with d-orbitals of manganese

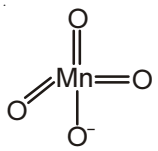
**Sol.** Answer (1)

- Manganate ($MnO_4^{2-}$) :



$\Rightarrow$ $\pi$-bonds are of $d\pi$–$p\pi$ type

- Permanganate ($MnO_4^-$) :



$\Rightarrow$ $\pi$-bonds are of $d\pi$–$p\pi$ type

2. Which one of the following ions exhibits d-d transition and paramagnetism as well? **[NEET-2018]**

   (1) $CrO_4^{2-}$ (2) $Cr_2O_7^{2-}$ (3) $MnO_4^{2-}$ (4) $MnO_4^-$

**Sol.** Answer (3)

$CrO_4^{2-} \Rightarrow Cr^{6+}$ = [Ar]

Unpaired electron (n) = 0; Diamagnetic

$Cr_2O_7^{2-} \Rightarrow Cr^{6+}$ = [Ar]

Unpaired electron (n) = 0; Diamagnetic

$MnO_4^{2-} = Mn^{6+} = [Ar]\ 3d^1$

Unpaired electron (n) = 1; Paramagnetic

$MnO_4^- = Mn^{7+}$ = [Ar]

Unpaired electron (n) = 0; Diamagnetic

3. The reason for greater range of oxidation states in actinoids is attributed to **[NEET-2017]**

   (1) The radioactive nature of actinoids

   (2) Actinoid contraction

   (3) 5*f*, 6*d* and 7*s* levels having comparable energies

   (4) 4*f* and 5*d* levels being close in energies

**Sol.** Answer (3)

It is a fact.

4. Which one of the following statements related to lanthanons is **incorrect**? **[NEET(Phase-2)-2016]**

(1) Europium shows +2 oxidation state

(2) The basicity decreases as the ionic radius decreases from Pr to Lu

(3) All the lanthanons are much more reactive than aluminium

(4) Ce(+4) solutions are widely used as oxidizing agent in volumetric analysis

**Sol.** Answer (3)

Fact.

5. Jahn-Teller effect is not observed in high spin complexes of **[NEET(Phase-2)-2016]**

(1) $d^7$ (2) $d^8$ (3) $d^4$ (4) $d^9$

**Sol.** Answer (2)

Fact.

6. Which one of the following statements is corrected when $SO_2$ is passed through acidified $K_2Cr_2O_7$ solution? [**NEET-2016]**

(1) Green $Cr_2(SO_4)$, is formed (2) The solution turns blue

(3) The solution is decolourized (4) $SO_2$ is reduced

**Sol.** Answer (1)

Fact

7. The electronic configurations of Eu (Atomic no. 63), Gd (Atomic No. 64) and Tb (Atomic No. 65) are **[NEET-2016]**

(1) $[Xe]4f^7 6s^2$, $[Xe]4f^7 5d^1 6s^2$ and $[Xe]4f^9 6s^2$ (2) $[Xe]4f^7 6s^2$, $[Xe]4f^8 6s^2$ and $[Xe]4f^8 5d^1 6s^2$

(3) $[Xe]4f^6 5d^1 6s^2$, $[Xe]4f^7 5f^1$ and $[Xe]4f^9 6s^2$ (4) $[Xe]4f^6 5d^1 6s^2$, $[Xe]4f^7 5d^1 6s^2$ and $[Xe]4f^8 5d^1 6s^2$

**Sol.** Answer (1)

Fact

8. Gadolinium belongs to 4*f* series. Its atomic number is 64. Which of the following is the correct electronic configuration of gadolinium? **[Re-AIPMT-2015]**

(1) $[Xe]4f^7 5d^1 6s^2$ (2) $[Xe]4f^6 5d^2 6s^2$ (3) $[Xe]4f^8 6d^2$ (4) $[Xe]4f^9 5s^1$

**Sol.** Answer (1)

Fact.

9. Because of lanthanoid contraction, which of the following pairs of elements have nearly same atomic radii? (Numbers in the parenthesis are atomic numbers) **[AIPMT-2015]**

(1) Zr (40) and Ta (73) (2) Ti (22) and Zr (40)

(3) Zr (40) and Nb (41) (4) Zr (40) and Hf (72)

**Sol.** Answer (4)

Zr and Hf have same size.

10. 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

**Sol.** Answer (3)

Both Fe and Sn are in lower oxidation state. Therefore redox is not possible.

11. The reaction of aqueous $KMnO_4$ with $H_2O_2$ in acidic conditions gives **[AIPMT-2014]**

(1) $Mn^{4+}$ and $O_2$ (2) $Mn^{2+}$ and $O_2$ (3) $Mn^{2+}$ and $O_3$ (4) $Mn^{4+}$ and $MnO_2$

**Sol.** Answer (2)

$$2KMnO_4 + 3H_2SO_4 + 5H_2O_2 \longrightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5O_2$$

12. Magnetic moment 2.83 BM is given by which of the following ions ? (At. nos. Ti=22, Cr=24, Mn=25, Ni=28) **[AIPMT-2014]**

(1) $Ti^{3+}$ (2) $Ni^{2+}$ (3) $Cr^{3+}$ (4) $Mn^{2+}$

**Sol.** Answer (2)

$$\sqrt{n(n+2)} = 2.83$$

$$n^2 + 2n = (2.83)^2$$

$\therefore$ n = 2

$Ni^{2+} = 3d^8$

*i.e.*, 2 unpaired electrons

13. Reason of lanthanoid contraction is **[AIPMT-2014]**

(1) Negligible screening effect of 'f' orbitals (2) Increasing nuclear charge

(3) Decreasing nuclear charge (4) Decreasing screening effect

**Sol.** Answer (1)

*f*-orbitals have poor shielding effect.

14. Which of the following lanthanoid ions is diamagnetic? (At nos. Ce=58, Sm=62, Eu=63, Yb=70) **[NEET-2013]**

(1) $Sm^{2+}$ (2) $Eu^{2+}$ (3) $Yb^{2+}$ (4) $Ce^{2+}$

**Sol.** Answer (3)

15. Which of the following statements about the interstitial compounds is incorrect ? **[NEET-2013]**

(1) They are chemically reactive

(2) They are much harder than the pure metal

(3) They have higher melting points than the pure metal

(4) They retain metallic conductivity

**Sol.** Answer (1)

16. Which of the statements is not true ? **[AIPMT (Prelims)-2012]**

(1) $K_2Cr_2O_7$ solution in acidic medium is orange

(2) $K_2Cr_2O_7$ solution becomes yellow on increasing the pH beyond 7

(3) On passing $H_2S$ through acidified $K_2Cr_2O_7$ solution, a milky colour is observed

(4) $Na_2Cr_2O_7$ is preferred over $K_2Cr_2O_7$ in volumetric analysis

**Sol.** Answer (4)

$Na_2Cr_2O_7$ is not preferred over $K_2Cr_2O_7$ in volumetric analysis. $K_2Cr_2O_7$ is used as primary standard in volumetric analysis.

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

**[AIPMT (Mains)-2012]**

(1) Ti < V < Cr < Mn : increasing number of oxidation states

(2) $Ti^{3+} < V^{3+} < Cr^{3+} < Mn^{3+}$ : increasing magnetic moment

(3) Ti < V < Cr < Mn : increasing melting points

(4) Ti < V < Mn < Cr : increasing 2nd ionization enthalpy

**Sol.** Answer (3)

The incorrect order of increasing melting point is

Ti < V < Cr < Mn

Melting point increases from $T_1$ to chromium but decreases in case of Mn. Mn has melting point even lower than that of Ti.

18. Which of the following exhibits only +3 oxidation state ? **[AIPMT (Mains)-2012]**

(1) U (2) Th (3) Ac (4) Pa

**Sol.** Answer (3)

19. Four successive members of the first series of the transition metals are listed below. For which one of them the standard potential ($E^\circ_{M^{2+}/M}$) value has a positive sign ? **[AIPMT (Mains)-2012]**

(1) Co (Z = 27) (2) Ni (Z = 28) (3) Cu (Z = 29) (4) Fe (Z = 26)

**Sol.** Answer (3)

20. Acidified $K_2Cr_2O_7$ solution turns green when $Na_2SO_3$ is added to it. This is due to the formation of

**[AIPMT (Prelims)-2011]**

(1) $CrSO_4$ (2) $Cr_2(SO_4)_3$ (3) $CrO_4^{2-}$ (4) $Cr_2(SO_3)_3$

**Sol.** Answer (2)

21. For the four successive transition elements (Cr, Mn, Fe and Co), the stability of +2 oxidation state will be there in which of the following order? **[AIPMT (Prelims)-2011]**

(At nos. Cr = 24, Mn = 25, Fe = 26, Co = 27)

(1) Cr > Mn > Co > Fe (2) Mn > Fe > Cr > Co

(3) Fe > Mn > Co > Cr (4) Co > Mn > Fe > Cr

**Sol.** Answer (2)

More the number of unpaired electrons more will be the stability.

Hence, the correct order is, Mn > Fe > Cr > Co.

22. Which of the following ions will exhibit colour in aqueous solutions ? **[AIPMT (Prelims)-2010]**

(1) $La^{3+}$ (Z = 57) (2) $Ti^{3+}$ (Z = 22)

(3) $Lu^{3+}$ (Z = 71) (4) $Sc^{3+}$ (Z = 21)

**Sol.** Answer (2)

23. Which one of the following ions has electronic configuration [Ar] $3d^6$ ? **[AIPMT (Prelims)-2010]**

(1) $Ni^{3+}$ (2) $Mn^{3+}$

(3) $Fe^{3+}$ (4) $Co^{3+}$

**Sol.** Answer (4)

24. Which of the following pairs has the same size ? **[AIPMT (Prelims)-2010]**

(1) $Fe^{2+}$, $Ni^{2+}$ (2) $Zr^{4+}$, $Ti^{4+}$

(3) $Zr^{4+}$, $Hf^{4+}$ (4) $Zn^{2+}$, $Hf^{4+}$

**Sol.** Answer (3)

25. Which of the following oxidation states is the most common among the lanthanoids ? **[AIPMT (Mains)-2010]**

(1) 4 (2) 2 (3) 5 (4) 3

**Sol.** Answer (4)

Lanthanides show 3+ oxidation state generally.

26. The correct order of decreasing second ionisation enthalpy of Ti(22), V(23), Cr(24) and Mn(25) is **[AIPMT (Prelims)-2008]**

(1) Ti > V > Cr > Mn (2) Cr > Mn > V > Ti

(3) V > Mn > Cr > Ti (4) Mn > Cr > Ti > V

**Sol.** Answer (2)

Cr > Mn > V > Ti

This is the order of the decreasing second ionization enthalpy of above elements. After loosing an electron Cr gains stable $3d^5$ configuration which describes it high 2nd ionization enthalpy. Mn also loses an electron and form stable half filled $Mn^+(3d^5 4s^1)$. Vanadium due to smaller size posses higher 2nd ionization enthalpy that Ti.

27. Number of moles of $MnO_4^-$ required to oxidize one mole of ferrous oxalate completely in acidic medium will be **[AIPMT (Prelims)-2008]**

(1) 0.2 moles (2) 0.6 moles

(3) 0.4 moles (4) 7.5 moles

**Sol.** Answer (2)

28. Identify the incorrect statement among the following **[AIPMT (Prelims)-2007]**

(1) Shielding power of 4f electrons is quite weak

(2) There is a decrease in the radii of the atoms or ions as one proceeds from La to Lu

(3) Lanthanoid contraction is the accumulation of successive shrinkages

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

**Sol.** Answer (4)

29. Which one of the following ions is the most stable in aqueous solution? (Atomic number. Ti = 22, V = 23, Cr = 24, Mn = 25) **[AIPMT (Prelims)-2007]**

(1) $Mn^{2+}$ (2) $Cr^{3+}$

(3) $V^{3+}$ (4) $Ti^{3+}$

**Sol.** Answer (2)

$Cr^{3+} \Rightarrow d^3$ configuration

*i.e.* $t_{2g}$ orbitals is half filled $\Rightarrow$ Stable aqueous compound.

30. More number of oxidation states are exhibited by the actinoids than by the lanthanoids. The main reason for this is **[AIPMT (Prelims)-2006]**

(1) More energy difference between 5f and 6d orbitals than that between 4f and 5d orbitals

(2) Lesser energy difference between 5f and 6d orbitals than that between 4f and 5d orbitals

(3) Greater metallic character of the lanthanoids than that of the corresponding actinoids

(4) More active nature of the actinoids

**Sol.** Answer (2)

31. Copper sulphate dissolves in excess of KCN to give **[AIPMT (Prelims)-2006]**

(1) CuCN (2) $[Cu(CN)_4]^{3-}$

(3) $[Cu(CN)_4]^{2-}$ (4) $Cu(CN)_2$

**Sol.** Answer (2)

$$CuSO_4 + \underset{(\text{excess})}{KCN} \longrightarrow K_3[Cu(CN)_4]$$

32. 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) **[AIPMT (Prelims)-2006]**

(1) $Ni^{2+}$, $Ti^{3+}$ (2) $Sc^{3+}$, $Ti^{3+}$

(3) $Sc^{3+}$, $Co^{2+}$ (4) $Ni^{2+}$, $Cu^{+}$

**Sol.** Answer (1)

$Ti^{3+}$ ($3d^1$) and $Ni^{2+}$ ($3d^8$) have unpaired electrons.

$\therefore$ Both $Ti^{3+}$ and $Ni^{2+}$ ions are coloured in aqueous solution.

33. The number of moles of $KMnO_4$ reduced one mole of KI in alkaline medium is **[AIPMT (Prelims)-2005]**

(1) One fifth (2) Five (3) One (4) Two

**Sol.** Answer (4)

In alkaline medium

$$2MnO_4^- + H_2O + I^- \longrightarrow 2MnO_2 + 2OH^- + IO_3^-$$

$\Rightarrow$ 2 moles of $KMnO_4$ are reduced by 1 mole of KI.

34. The aqueous solution containing which one of the following ions will be colourless? (Atomic no. Sc = 21, Fe = 26, Ti = 22, Mn = 25) **[AIPMT (Prelims)-2005]**

(1) $Sc^{3+}$ (2) $Fe^{2+}$ (3) $Ti^{3+}$ (4) $Mn^{2+}$

**Sol.** Answer (1)

$Sc^{3+}$ has $3d^0$ configuration with no unpaired electron. Therefore $Sc^{3+}$ is colourless in its aqueous solution.

35. Four successive members of the first row transition elements are listed below with their atomic numbers. Which one of them expected to have the highest third ionization enthalpy? **[AIPMT (Prelims)-2005]**

(1) Vanadium (Z = 23) (2) Chromium (Z = 24) (3) Iron (Z = 26) (4) Manganese (Z = 25)

**Sol.** Answer (4)

36. The main reason for larger number of oxidation states exhibited by the actinides than the corresponding lanthanides, is **[AIPMT (Prelims)-2005]**

(1) Lesser energy difference between 5f and 6d orbitals than between 4f and 5d orbitals

(2) Larger atomic size of actinides than the lanthanides

(3) More energy difference between 5f and 6d orbitals than between 4f and 5d orbitals

(4) Greater reactive nature of the actinides than the lanthanides

**Sol.** Answer (1)

Because of the lesser energy difference between 5*f* and 6*d* orbitals as compared to that of 4*f* and 5*d* orbitals, achnoids exhibits more number of oxidation states.

37. The catalytic activity of transition metals and their compounds is ascribed mainly to

(1) Their magnetic behaviour (2) Their unfilled *d*-orbitals

(3) Their ability to adopt variable oxidation states (4) Their chemical reactivity

**Sol.** Answer (3)

The ability to adopt variable oxidation state is the main reason which explains the catalytic activity of transition metals.

38. Which one of the following elements shows maximum number of different oxidation states in its compounds?

(1) Gd (2) La (3) Eu (4) Am

**Sol.** Answer (4)

Americium (Am) being an actinide exhibits more number of oxidation states than lanthanides. It exhibits +3, +4, +6, and +5 oxidation states.

39. Without losing its concentration $ZnCl_2$ solution cannot be kept in contact with

(1) Pb (2) Al (3) Au (4) Ag

**Sol.** Answer (2)

Aluminium (Al) is more reactive than Zn and it can displace Zn from its salt solution.

40. Which ion is colourless?

(1) $Cr^{4+}$ (2) $Sc^{3+}$

(3) $Ti^{3+}$ (4) $V^{3+}$

**Sol.** Answer (2)

$Sc^{3+}$ does not have any unpaired electron, hence it is colourless.

$Sc^{3+} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6$

41. General electronic configuration of lanthanides is

(1) $(n-2)\, f^{1-14}\, (n-1)\, d^{0-1}\, ns^2$ (2) $(n-2)\, f^{10-14}\, (n-1)\, d^{0-1}\, ns^2$

(3) $(n-2)\, f^{0-14}\, (n-1)\, d^{10}\, ns^2$ (4) $(n-2)\, d^{0-1}\, (n-1)\, f^{1-14}\, ns^2$

**Sol.** Answer (1)

The general electronic configuration of lanthanides is $(n-2)\, f^{1-14}\, (n-1)\, d^{0-1}\, ns^2$

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

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

**Sol.** Answer (3)

Manganese show maximum number of oxidation states from +2 to +7.

43. In the silver plating of copper, $K[Ag(CN)_2]$ is used instead of $AgNO_3$. The reason is

(1) A thin layer of Ag is formed on Cu

(2) More voltage is required

(3) $Ag^+$ ions are completely removed from solution

(4) Less availability of $Ag^+$ ions, as Cu can not displace Ag from $[Ag(CN)_2]^-$ ion

**Sol.** Answer (4)

Fact.

44. $CuSO_4$ when reacts with KCN forms CuCN, which is insoluble in water. It is soluble in excess of KCN, due to formation of the following complex

(1) $K_2[Cu(CN)_4]$ (2) $K_3[Cu(CN)_4]$ (3) $CuCN_2$ (4) $Cu[K\ Cu(CN)_4]$

**Sol.** Answer (2)

$$CuSO_4 + 2KCN \longrightarrow CuCN + K_2SO_4$$

$$CuCN + 3KCN \longrightarrow K_3\left[Cu(CN)_4\right]$$

45. Which of the following is expected to be coloured in solutions?

(1) $Cu^{+}$ (2) $Cu^{2+}$

(3) $Ti^{4+}$ (4) $Sc^{3+}$

**Sol.** Answer (2)

$Cu^{2+} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^9$

$Cu^{2+}$ contains unpaired electron in d-subsheel and hence $Cu^{2+}$ is coloured in solution.

46. The basic character of the transition metal monoxides follows the order (Atomic nos. Ti = 22, V = 23, Cr = 24, Fe = 26)

(1) VO > CrO > TiO > FeO (2) CrO > VO > FeO > TiO

(3) TiO > FeO > VO > CrO (4) TiO > VO > CrO > FeO

**Sol.** Answer (4)

TiO > VO > CrO > FeO

47. The correct order of ionic radii of $Y^{3+}$, $La^{3+}$, $Eu^{3+}$ and $Lu^{3+}$ is (Atomic nos. Y = 39, La = 57, Eu = 63, Lu = 71)

(1) $Y^{3+} < La^{3+} < Eu^{3+} < Lu^{3+}$ (2) $Lu^{3+} < Y^{3+} < Eu^{3+} < La^{3+}$

(3) $Lu^{3+} < Eu^{3+} < La^{3+} < Y^{3+}$ (4) $La^{3+} < Eu^{3+} < Lu^{3+} < Y^{3+}$

**Sol.** Answer (2)

The correct order of ionic radii of $Y^{3+}$, $La^{3+}$, $Eu^{3+}$ and $Lu^{3+}$ is

$Y^{3+} < Lu^{3+} < Eu^{3+} < La^{3+}$

Due to lanthanide contraction, the size of 3+ ion decreases continuously from La to Iu, but $Lu^{+3}$ ion has ionic size greater than that of $Y^{+3}$ which is a d block element.

48. Among the following series of transition metal ions, the one where all metal ions have $3d^2$ electronic configuration is [At. Nos. Ti = 22, V = 23, Cr = 24, Mn = 25]

(1) $Ti^{3+}$, $V^{2+}$, $Cr^{3+}$, $Mn^{4+}$ (2) $Ti^{+}$, $V^{4+}$, $Cr^{6+}$, $Mn^{7+}$

(3) $Ti^{4+}$, $V^{3+}$, $Cr^{2+}$, $Mn^{3+}$ (4) $Ti^{2+}$, $V^{3+}$, $Cr^{4+}$, $Mn^{5+}$

**Sol.** Answer (4)

$Ti = 3d^2, 4s^2$; $V = 3d^3, 4s^2$; $Cr^{4+} = 3d^5, 4s^1$; $Mn = 3d^5, 4s^2$

$\therefore$ $Ti^{+2}$, $V^{+3}$, $Cr^{+4}$ and $Mn^{+5}$ have $3d^2$ configuration.

49. Lanthanides are

(1) 14 elements in the sixth period (atomic number 90 to 103) that are filling 4*f* sublevel

(2) 14 elements in the seventh period (atomic number = 90 to 103) that are filling 5*f* sublevel

(3) 14 elements in the sixth period (atomic number = 58 to 71) that are filling the 4*f* sublevel

(4) 14 elements in the seventh period (atomic number = 50 to 71) that are filling 4*f* sublevel

**Sol.** Answer (3)

Lanthanides are member of $6^{th}$ period and starts from atomic number 58 to 71. They are 14 element in which filling of electrons takes place in 4*f* sublevel.

50. Which of the following statement is not correct?

(1) $La(OH)_2$ is less basic than $Lu(OH)_3$

(2) In lanthanide series ionic radius of $Lu^{+3}$ ion decreases

(3) La is actually an element of transition series rather lanthanides

(4) Atomic radius of Zr and Hf are same because of lanthanide contraction

**Sol.** Answer (1)

As we go right in a period, the basic character decreases.

51. 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) $3d^5 4s^2$

**Sol.** Answer (4)

$3d^5 4s^2$ will show highest numbers of oxidation states.

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

(1) +4 (2) +8

(3) +6 (4) +10

**Sol.** Answer (2)

OS shows 8+ oxidation state (maximum).

## SECTION - C

### Assertion - Reason Type Questions

1. A : FeO is basic in character.

R : Oxides of Transition metals are basic when metal is in lower oxidation state.

**Sol.** Answer (1)

Both are correct and correct explanation (fact).

2. A : Ti (IV) complexes are white.

R : Ti (IV) has no electrons in *d* subshell.

**Sol.** Answer (1)

$Ti^{4+} \Rightarrow 3d^0 \Rightarrow$ no *d-d* transition $\Rightarrow$ no colour.

3. A : $Ce^{4+}$ is a good oxidizing agent.

R : $Sm^{2+}$ is a good reducing agent.

**Sol.** Answer (2)

Both the statements are true.

But, reason is not the correct explanation for oxidizing character of $Ce^{4+}$.

4. A : Equivalent mass of $K_2Cr_2O_7$ when it acts as an oxidizing agent in acidic medium is M/6.

R : During reduction, oxidation number of chromium changes from +6 to +3.

**Sol.** Answer (1)

In acidic medium, n-factor of $K_2Cr_2O_7$ is 6

$\therefore$ Equivalent mass = $\frac{M}{6}$

5. A : All Cr–O bond length in $K_2Cr_2O_7$ are equal.

R : Both the Cr are present in $dsp^2$ hybrid state.

**Sol.** Answer (4)

In $K_2Cr_2O_7$, some Cr–O bonds have double bond and some are single bond, so bond lengths are different and Cr is $sp^3$ hybridized.

6. A : $FeCl_3$ reacts with KCNS to give blood red colour.

R : $FeCl_3$ reacts with KCNS to form potassium ferro-ferricyanide.

**Sol.** Answer (3)

$$\underset{\text{(Yellow)}}{FeCl_3} + KCNS \longrightarrow \underset{\substack{\text{(Blood red}\\ \text{ferric thiocyanate)}}}{Fe(CNS)_3} + 3KCl$$

7. A : $La(OH)_3$ is less basic than $Lu(OH)_3$.

R : Basic character of hydroxides of lanthanides increase on moving from $La^{+3}$ to $Lu^{+3}$.

**Sol.** Answer (4)

As we go right in a period the basic nature of hydroxides decreases.

8. A : $KMnO_4$ is purple in colour due to charge transfer.

R : In $MnO_4^-$, Mn is in + 7 oxidation state and thus has no electron present in *d* orbitals.

**Sol.** Answer (1)

$KMnO_4$ is purple.

In $Mn^{7+}$ no any *d* electron, so *d-d* transition is not possible. Hence charge transfer.

9. A : $CuSO_4.5H_2O$ on heating to 250°C losses all the five $H_2O$ molecules and becomes anhydrous.

R : All the five $H_2O$ molecules are co-ordinated to the central $Cu^{+2}$ ion.

**Sol.** Answer (3)

$$CuSO_4 \cdot 5H_2O \xrightarrow[250°C]{\Delta} \underset{\text{(anhydrous)}}{CuSO_4} + 5H_2O$$

All the $5H_2O$ molecules are not bonded to the central atom.

10. A : $Cr_2O_7^{-2}$ is orange in colour.

R : It is due to the presence of unpaired electrons in d-subshell of Cr.

**Sol.** Answer (3)

$Cr_2O_7^{-2} \Rightarrow$ orange colour $\Rightarrow$ true

Here Cr is in 6+ $\Rightarrow 3d^0\ 4s^0 \Rightarrow$ no any unpaired electron in *d*-subshell.

11. A : Mn shows exceptional M.P. in 3*d* series.

R : Its outer configuration is $4s^2\ 3d^5$.

**Sol.** Answer (1)

Mn shows exceptional MP. Due to its very stable configuration i.e. $3d^5\ 4s^2$.

12. A : I.E. of 5*d* elements > 4d elements in general.

R : It is due to lanthanide contraction.

**Sol.** Answer (1)

I.E. 5*d* elements > I.E. 4*d* elements due to lanthanide contraction.

13. A : There is very less gap between the value of radii of 4*d* and 5*d* elements.

R : Size of 5*d* is more than 4*d* subshell.

**Sol.** Answer (2)

The gap between radii of 4*d* and 5*d* elements is very less due to lanthanide contraction and size of 5*d* is greater than size of 4*d* $\Rightarrow$ True.

14. A : $Mn_2O_7$ is acidic in nature.

R : Mn has +7 oxidation state.

**Sol.** Answer (1)

$Mn_2O_7$ acidic in nature $\Rightarrow$ True. In 7+ state Mn has high tendency to accept electron.

15. A : $NiCl_2$ is more stable than $PtCl_2$.

R : $K_2PtCl_6$ is more stable than $K_2NiCl_6$.

**Sol.** Answer (2)

$NiCl_2$ is more stable than $PtCl_2 \Rightarrow$ True

$K_2PtCl_6$ is more stable than $K_2NiCl_6 \Rightarrow$ True

Reason is CFSE.

16. A : $Cr_2O_7^{2-}$ becomes equilibrium with $CrO_4^{2-}$ at PH > 5.

R : $Cr_2O_7^{2-}$ is tetrahedral having Cr – O – Cr angle 109º28′.

**Sol.** Answer (4)

$$CrO_4^{2-} \underset{}{\overset{P^H = 4}{\rightleftharpoons}} Cr_2O_7^{2-}$$

In $K_2 Cr_2O_7$ the Cr–O–Cr angle is 126°.

17. A : In $CrO_5$ oxidation state of Cr is +10.

R : $Cr_2O_7^{2-}$ (aq) is yellow in colour.

**Sol.** Answer (4)

In $CrO_5$, oxidation state of Cr is 6+.

$Cr_2O_7^{2-}$ (aq) is orange in colour.

18. A : $Cu^{2+}$ is the only ion ($M^{2+}$) which has positive $E^{\circ}_{red}$ ($M^{2+}/M$) in 3*d* series.

R : Cu has lower hydration enthalpy as comparision to its I.E. and $\Delta H_{atm}$.

**Sol.** Answer (1)

Both the statements are correct with proper explanation.

19. A : Hg is a liquid transition metal.

R : It has strong metallic bonding.

**Sol.** Answer (4)

Hg is not a transition metal and there is no any strong metallic bonding that is why it is liquid.

20. A : Lanthanides have +3 as most common oxidation state.

R : Electrons of 4f in lanthanides rarely participate in bonding.

**Sol.** Answer (1)

Lanthanides, most commonly shows 3+ oxidation state because the 4f electrons do not participate in bonding.

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