SOLVED EXAMPLES

Ex. 1 Amongst $[TiF_6]^{2-}$, $[CoF_6]^{3-}$, Cu_2Cl_2 and $[NiCl_4]^{2-}$ [Atomic number ; Ti = 22, Co = 27, Cu = 29, Ni = 28] the colourless species are :

(A) $[TiF_6]^{2-}$ and $[Cu_2Cl_2]$ **(B)** Cu_2Cl_2 and $[NiCl_4]^{2-}$ **(C)** $[TiF_6]^{2-}$ and $[CoF_6]^{3-}$ **(D)** $[CoF_6]^{3-}$ and $[NiCl_4]^{2-}$

Ans. (A)

Sol. In $[TiF_6]^{2-}$ the titanium is in +4 oxidation state having the electronic configuration $[Ar]^{18} 3d^0 4s^0$. Similarly in Cu_2Cl_2 the copper is in +1 oxidation state having the electronic configuration $[Ar]^{18}\ 3d^{10}\ 4s^0$. As they do not have any unpaired electrons for d-d transition, they are therefore colourless.

In $[NiCl_4]^{2-}$ the nickel is in +2 oxidation state and electronic configuration is $[Ar]^{18}\ 3d^8\ 4s^0$. As it has two unpaired electrons, so the complex is coloured.

In $[CoF_6]^{3-}$, the cobalt is in +3 oxidation state having electron configuration $[Ar]\ 3d^6\ 4s^0$. As it has four unpaired electrons, so the complex is coloured.

Ex. 2 On the basis of trends in the properties of the 3d-series elements, suggests possible M^{2+} aqua ions for use as reducing agents, and write a balanced chemical equation for the reaction of one of these ions with O_2 in acidic solution.

Sol. Because oxidation state +2 is most stable for the later elements of 3d-series elements, strong reducing agents include ions of the metals on the left of the series: such ions include V^{2+} (aq) and Cr^{2+} (aq) The Fe^{2+} (aq) ion is only weakly reducing. The Co^{2+} (aq), Ni^{2+} (aq), and Cu^{2+} (aq) ions are not oxidized in water.

$$Fe^{3+} \xrightarrow{+0.77} Fe^{2+} \xrightarrow{-0.44} Fe$$

The chemical equation for the oxidation is then

$$4\ Fe^{2+}(aq) + O_2(g) + 4H^+(aq) \longrightarrow 4Fe^{3+}(aq) + 2H_2O\ (\bullet).$$

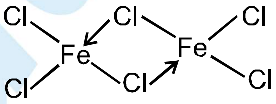
Ex. 3 Match the reactions given in column-I with the characteristic(s) of the reaction products given in column-II.

	Column-I		Column-II
(A)	$TiCl_4 \xrightarrow{Zn}$	**(p)**	One of the products is bright orange coloured but diamagnetic.
(B)	$FeCl_3 \xrightarrow{573K}$	**(q)**	One of the products is green coloured and paramagnetic.
(C)	$KMnO_4 \xrightarrow{750K}$	**(r)**	One of the products is violet and paramagnetic.
(D)	$K_2Cr_2O_7 + H_2SO_4$ (cold & conc.)	**(s)**	One of the products exists as dimer.

Ans. [A – r] ; [B – s ; [C – q] ; [D – p].

Sol. **(A)** $TiCl_4 \xrightarrow{Zn} TiCl_3$, violet (one unpaired electron so d-d transition is possible).

(B) $2FeCl_3 \xrightarrow{573K}$



gas dimer.

(C) $2KMnO_4 \xrightarrow{750K} K_2MnO_4$ green (one unpaired electron so d-d transition is possible) + $MnO_2 + O_2$.

(D) $K_2Cr_2O_7 + 2H_2SO_4 \longrightarrow 2CrO_3$ bright orange (diamagnetic) + $2KHSO_4 + H_2O$.

Ex. 4 Among the following statements choose the true or false statement(s).

(a) $K_2Cr_2O_7$ on heating with charcoal gives metallic potassium and Cr_2O_3.

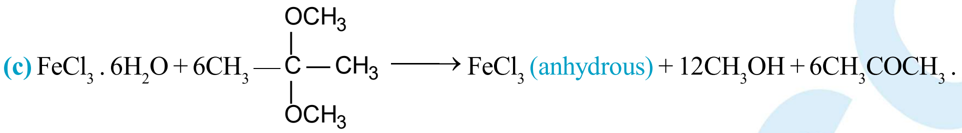
(b) On heating in current of H_2 the crystalline $KMnO_4$ is converted into KOH and Mn_3O_4.

(c) Hydrated ferric chloride on treatment with 2, 2–dimethoxypropane gives anhydrous ferric chloride.

Ans. **(a)** False **(b)** False **(c)** True

Sol. (a) $K_2Cr_2O_7 + 2C\,(\text{charcoal}) \xrightarrow{\Delta} Cr_2O_3 + K_2CO_3 + CO\uparrow$.

(b) $2KMnO_4 + 5H_2 \xrightarrow{\Delta} 2\,KOH + 2MnO + 4H_2O$.



$$\textbf{(c)}\ FeCl_3\,.\,6H_2O + 6CH_3-\underset{\underset{OCH_3}{|}}{\overset{\overset{OCH_3}{|}}{C}}-CH_3 \longrightarrow FeCl_3\,(\text{anhydrous}) + 12CH_3OH + 6CH_3COCH_3\,.$$

Ex. 5 A compound (A) is used in paints instead of salts of lead. Compound (A) is obtained when a white compound (B) is strongly heated. Compound (B) is insoluble in water but dissolves in sodium hydroxide forming a solution of compound (C). The compound (A) on heating with coke gives a metal (D) and a gas (E) which burns with blue flame. (B) also dissolves in ammonium sulphate solution mixed with ammonium hydroxide. Solution of compound (A) in dilute HCl gives a bluish white / white precipitate (F) with excess of $K_4[Fe(CN)_6]$. Identify **(A)** to (F) and explain the reactions.

Ans. **(A)** ZnO, **(B)** $Zn(OH)_2$, **(C)** Na_2ZnO_2 , **(D)** Zn, **(E)** CO, **(F)** $K_2Zn_3\,[Fe(CN)_6]_2$

Sol. $Zn(OH)_2\ \textbf{(B)} \xrightarrow{\Delta} ZnO\ \textbf{(A)} + H_2O$.

$Zn(OH)_2\ \textbf{(B)}\downarrow + 2OH^- \longrightarrow [Zn(OH)_4]^{2-}\ \textbf{(C)}$ (soluble complex).

$ZnO\ \textbf{(A)} + C \xrightarrow{\Delta} Zn\ \textbf{(D)} + CO\ (E)$.

$Zn(OH)_2\ \textbf{(B)} + 4NH_3 \longrightarrow [Zn(NH_3)_4]^{2+}$ (soluble complex) $+ 2OH^-$.

$ZnO + 2HCl \longrightarrow ZnCl_2 + H_2O$.

$3ZnCl_2 + 2K_4[Fe(CN)_6] \longrightarrow K_2Zn_3[Fe(CN)_6]_2\downarrow$ (bluish white/white) **(F)** $+ 6KCl$.

Ex. 6 An unknown inorganic compound (X) gave the following reactions:

(i) The compound (X) on heating gave a residue, oxygen and oxide of nitrogen.

(ii) An aqueous solution of compound (X) on addition to tap water gave a turbidity which did not dissolve in HNO_3.

(iii) The turbidity dissolves in NH_4OH.

Identify the compound (X) and give equations for the reactions (i), (ii) & (iii).

Ans. $X = AgNO_3$

Sol. $2AgNO_3\ (X) \xrightarrow{\Delta} 2\,Ag + 2NO_2 + O_2$.

$AgNO_3\,(aq.) + Cl^- \longrightarrow AgCl\downarrow\,(\text{white}) + NO_3^-$.

$AgCl + 2NH_3 \longrightarrow [Ag(NH_3)_2]^+$ (soluble complex).

Ex. 7 Which of the following is true for the species having $3d^4$ configuration ?

(A) Cr^{2+} is reducing in nature.
(B) Mn^{3+} is oxidising in nature.
(C) Both **(A)** and **(B)**
(D) None of these

Sol. Cr^{2+} is reducing as its configuration changes from d^4 to d^3, the latter having a half-filled t^3_{2g} energy level of 3d orbitals in octahedral crystal field spliting. On the other hand, the change from Mn^{3+} to Mn^{2+} results in the half-filled (d^5) configuration which has extra stability.

Therefore, **(C)** option is correct.

Ex. 8 Which of the following increasing order of oxidising power is correct for the following species ?

VO_2^+, MnO_4^-, $Cr_2O_7^{2-}$

(A) $VO_2^+ < Cr_2O_7^{2-} < MnO_4^-$
(B) $VO_2^+ < MnO_4^- < Cr_2O_7^{2-}$
(C) $Cr_2O_7^{2-} < VO_2^+ < MnO_4^-$
(D) $Cr_2O_7^{2-} < MnO_4^- < VO_2^+$

Sol. This is attributed to the increasing stability of the lower species to which they are reduced.

MnO_4^- is reduced to Mn^{2+} which has stable half filled valence shell electron configuration [$3d^5$].

$Cr_2O_7^{2-}$ is reduced to Cr^{3+} which has half filled t^3_{2g} energy level of 3d orbitals in octahedral crystal field spliting

VO_2^+ is reduced to V^{3+} which has electronic configuration $[Ar]^{18}\ 3d^2\ 4s^0$.

So the order of increasing stability of the reduced species is $Mn^{2+} > Cr^{3+} > V^{3+}$ and, therefore, the increasing order of oxidising power is $VO_2^+ < Cr_2O_7^{2-} < MnO_4^-$.

Therefore, **(A)** option is correct.

Ex. 9. Which of the following statement(s) is/are correct ?

(A) Transition metals and many of their compounds show paramagnetic behaviour.

(B) The enthalpies of atomisation of the transition metals are high

(C) The transition metals generally form coloured compounds

(D) Transition metals and their many compounds act as good catalyst.

Sol. **(A)** As metal ions generally contain one or more unpaired electrons in them & hence their complexes are generally paramagnetic

(B) Because of having larger number of unpaired electrons in their atoms, they have stronger inter atomic interaction and hence stronger bonding between the atoms.

(C) According to CFT, in presence of ligands the colour of the compound is due to the d-d transition of the electrons.

(D) This activity is ascribed to their ability to adopt multiple oxidation state and to form complexes.

Therefore, (A,B,C,D) options are correct.

Ex. 10 **Statement-1 :** The number of unpaired electrons in the following gaseous ions :
Mn^{3+}, Cr^{3+}, V^{3+} and Ti^{3+} are 4, 3, 2 and 1 respectively.

Statement-2 : Cr^{3+} is most stable in aqueous solution among these ions.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

Sol. **(B)** $Mn^{3+} = [Ar]^{18}\ 3d^4$, $Cr^{+3} = [Ar]^{18}\ 3d^3$, $V^{3+} = [Ar]^{18}\ 3d^2$, $Ti^{3+} = [Ar]^{18}\ 3d^1$

Cr^{3+} is most stable in aqueous solution because it has half filled t^3_{2g} energy level of 3d orbitals in octahedral crystal field spliting and according to crystal field theory (CFT) it has highest value of CFSE i.e. $1.2\ \Delta_O$.

Ex. 11 **S1 :** Interstitial compounds have high melting points, higher than those of pure metals.

S2 : Permanganate titrations in presence of hydrochloric acid are unsatisfactory.

S3 : $KMnO_4$ does not act as an oxidising agent in strong alkaline medium.

S4 : $KMnO_4$ on heating in a current of H_2 gives MnO.

(A) T T F T **(B)** T F F T **(C)** T F T T **(D)** F F T F

Sol. **S1 :** Due to strong interatomic forces.

S2 : Some of the hydrochloric acid is oxidised to chlorine and thus we get less volume of $KMnO_4$ than the actual one.

S3 : $MnO_4^- + e^- \xrightarrow{OH^-} MnO_4^{2-}$

S4 : $2KMnO_4 + 5H_2 \longrightarrow 2KOH + 2MnO + H_2O$.

Therefore, **(A)** option is correct.

Ex. 12 Match the reactions in **Column I** with nature of the reactions/type of the products in **Column II**.

Column I	Column II
(A) $AgNO_3(aq) + I_2\,(excess) + H_2O \longrightarrow$	**(p)** Disproportionation
(B) $K_2MnO_4(aq) + CO_2(g) \longrightarrow$	**(q)** Comproportionation
(C) $Na_2Cr_2O_7 + C \xrightarrow{\Delta}$	**(r)** Redox
(D) $CuCl_2(aq) + Cu(s) \longrightarrow$	**(s)** One of the products is insoluble in water

Ans. (A → p, r, s) ; (B → p, r, s) ; (C → r, s) : (D → q, r, s)

Sol. **(A)** $5AgNO_3(aq) + 3\overset{0}{I_2}\,(excess) + 3H_2O \longrightarrow \overset{+V}{HIO_3} + 5Ag\overset{-1}{I} + 5HNO_3$

So it is redox and disproportionation reaction. AgI insoluble in water.

(B) $3K_2\overset{+VI}{Mn}O_4\,(aq) + 2CO_2(g) \longrightarrow 2K\overset{+VII}{Mn}O_4 + \overset{+IV}{Mn}O_2 + 2K_2CO_3$

So it is redox and disproportionation reaction. MnO_2 insoluble in water.

(C) $2\overset{0}{C} + Na_2\overset{+VI}{Cr_2}O_7 \xrightarrow{\Delta} \overset{+III}{Cr_2}O_3 + Na_2\overset{+IV}{C}O_3 + \overset{+II}{C}O\uparrow$

So it is redox reaction. Cr_2O_3 (green pigment) is insoluble in water.

(D) $\overset{+II}{Cu}Cl_2\,(aq) + \overset{0}{Cu}\,(s) \longrightarrow \overset{+I}{Cu_2}Cl_2\,(s)$

So it is redox and comproportionation reaction. Cu_2Cl_2 is insoluble in water.

Ex. 13 When CO_2 is passed into aqueous :

(A) Na_2CrO_4 solution, its yellow colour changes to orange.

(B) K_2MnO_4 solution, it disproportionates to $KMnO_4$ and MnO_2

(C) $Na_2Cr_2O_7$ solution, its orange colour changes to green

(D) $KMnO_4$ solution, its pink colour changes to green.

Sol. **(A)** $Na_2CrO_4 \xrightarrow{H^+} Na_2Cr_2O_7$ (orange colour)

(B) $MnO_4^{2-} \xrightarrow{H^+} MnO_4^- + MnO_2$, in neutral or acidic medium

(C) False - In acidic medium no colour change takes place.

(D) $MnO_4^- + e^- \xrightarrow{OH^-} MnO_4^{2-}$; in strong alkaline medium pink colour of $KMnO_4$ changes to green.

Therefore, (A,B) options are correct.

Ex. 14 Which of the following statement(s) is (are) not correct with reference to ferrous and ferric ions

(A) Fe^{3+} gives brown colour with potassium ferricyanide

(B) Fe^{2+} gives blue precipitate with potassium ferricyanide

(C) Fe^{3+} gives red colour with potassium sulphocyanide

(D) Fe^{2+} gives brown colour with potassium sulphocyanide

Sol. Fe^{3+} produces red colouration with KSCN but Fe^{2+} does not give brown colour with KSCN.

Therefore, **(D)** option is correct.

Ex. 15 **Statement-1 :** Ammonical silver nitrate converts glucose to gluconic acid and metallic silver is precipitated.

Statement-2 : Glucose acts as a weak reducing agent.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

Sol. **(A)** $Ag_2O + C_6H_{12}O_6 \rightarrow 2Ag + C_6H_{12}O_7$.

Ex. 16 What is the composition of mischmetal alloy and what are it's uses ?

Ans. Mischmetal consists of lanthanoid metal (~95%) and iron (~5%) and traces of S,C,Ca and Al. Mischmetal is used in Mg based alloy to produce bullets, shell and lighter flint.

Exercise # 1 [Single Correct Choice Type Questions]

1. The atomic volumes of the transition elements are low compared with elements in neighboring group 1 and 2 because
(A) the nuclear charge is poorly screened and so attracts all the electrons more strongly.
(B) the extra electrons added occupy inner orbitals.
(C) **(A)** and **(B)** both.
(D) none.

2. The transition elements have a general electronic configuration :
(A) $ns^2\ np^6\ nd^{1-10}$
(B) $(n-1)\ d^{1-10}\ ns^{0-2}\ np^{0-6}$
(C) $(n-1)\ d^{1-10}\ ns^{1-2}$
(D) none.

3. The wrong statement regarding transition metals among the following is :
(A) 4s electrons penetrate towards the nucleus more than 3d electrons
(B) atomic radii of transition metals increase rapidly with increase in atomic number because of poor shielding of nuclear attraction by $(n-1)$d electrons
(C) second and third transition series elements have nearly the same size
(D) their densities are higher and densities of the 5d series elements are higher than those of 4d series elements.

4. Which of the following statements is correct ?
(A) The lesser number of oxidation states in 3d-series in the beginning of the series is due to the presence of too few electrons to loose or share
(B) The lesser number of oxidation states in 3d-series towards the end of the series is due to the presence of too many electrons and thus fewer empty orbitals to share electrons with the ligands
(C) **(A)** and **(B)** both
(D) None is correct

5. First IE of 5d series elements are higher than those of 3d and 4d series elements. This is due to :
(A) bigger size of atoms of 5d-series elements than 3d-series elements.
(B) greater effective nuclear charge is experienced by valence electrons because of the weak shielding of the nucleus by 4*f*-electrons in 5d series.
(C) **(A)** and **(B)** both.
(D) None of these.

6. Maximum oxidation sate is shown by :
(A) Os **(B)** Mn **(C)** Cr **(D)** Co

7. Ionisation energies of Ni and Pt in kJ mol^{-1} are given below.

	$\underbrace{(IE)_1 + (IE)_2}$	$\underbrace{(IE)_3 + (IE)_4}$
Ni	2.49	8.80
Pt	2.60	6.70

So, (select the correct statement)
(A) nickel (II) compounds tend to be thermodynamically more stable than platinum (II)
(B) platinum (IV) compounds tend to be more stable than nickel (IV)
(C) **(A)** & **(B)** both
(D) none is correct

8. Which of the following statement is false ?
(A) Of the d^4 species, manganese (III) is strongly reducing while Cr^{2+} is strongly oxidising.
(B) Cobalt(II) is stable in aqueous solution but in the presence of complexing reagents it is easily oxidised.
(C) The d^1 configuration is very unstable in ions.
(D) None of these

9. Magnetic moment of Cr^{+2} (Z = 24), Mn^{+2} (Z = 25) and Fe^{2+} (Z = 26) are x,y,z. They are in order :
(A) $x < y < z$ **(B)** $x > y > z$ **(C)** $z < x = y$ **(D)** $x = z < y$

10. The magnetic moment of $_{25}Mn$ in ionic state is $\sqrt{15}$ B.M, then Mn is in :
(A) +2 state **(B)** +3 state **(C)** +4 state **(D)** +5 state

11. Which of the following group of ions is paramagnetic in nature :
(A) Cu^{+}, Zn^{2+}, Sc^{3+} **(B)** $Mn^{2+}, Fe^{3+}, Ni^{2+}$ **(C)** $Cr^{2+}, Mn^{3+}, Sc^{3+}$ **(D)** $Cu^{2+}, Ni^{2+}, Ti^{4+}$

12. Which of the following has the maximum number of unpaired d-electron?
(A) Zn^{2+} **(B)** Fe^{2+} **(C)** Ni^{2+} **(D)** Cu^{2+}

13. The highest magnetic moment is shown by the transition metal ion with the outermost electronic configuration is :
(A) $3d^5$ **(B)** $3d^2$ **(C)** $3d^7$ **(D)** $3d^9$

14. A metal ion from the first transition series has a magnetic moment (calculated) of 3.87 B.M. How many unpaired electrons are expected to be present in the ion?
(A) 1 **(B)** 2 **(C)** 3 **(D)** 4

15. The colour of transition metal ions is attributed to :
(A) exceptionally small size of cations **(B)** absorption of ultraviolet rays
(C) incomplete (n – 1) d - subshell **(D)** absorption of infrared radiations

16. Which one of the ionic species will impart colour to an aqueous solution ?
(A) Ti^{4+} **(B)** Cu^{+} **(C)** Zn^{2+} **(D)** Cr^{3+}

17. MnO_4^- is of intense pink colour, though Mn is in (+7) oxidation state. It is due to :
(A) oxygen gives colour to it
(B) charge transfer when Mn gives its electron to oxygen
(C) charge transfer when oxygen gives its electron to Mn making it Mn(+VI) hence coloured
(D) none is correct

18. $CuSO_4.5H_2O$ is blue in colour because
(A) It contains water of crystallization.
(B) SO_4^{2-} ions absorb red light.
(C) Cu^{2+} ions absorb red light.
(D) Cu^{2+} ions absorb all colours except red from the white light.

19. The yellow colour of chromates changes to orange on acidification due to formation of :
(A) Cr^{3+} **(B)** Cr_2O_3 **(C)** $Cr_2O_7^{2-}$ **(D)** CrO_4^-

20. Cementite is :
(A) interstitial compound of iron and carbon **(B)** an alloy of Fe and Cr
(C) a compound resembling cement **(D)** an ore of iron

21. The catalytic activity of the transition metals and their compounds is ascribed to :
(A) their chemical reactivity.
(B) their magnetic behaviour.
(C) their filled d-orbitals.
(D) their ability to adopt multiple oxidation state and their complexing ability.

22. Which forms interstitial compounds?
(A) Fe **(B)** Co **(C)** Ni **(D)** All

23. A compound is yellow when hot and white when cold. The compound is :
(A) Al_2O_3 **(B)** PbO **(C)** CaO **(D)** ZnO

24. On heating $ZnCl_2.2H_2O$, the compound obtained is :
(A) $ZnCl_2$ **(B)** $Zn(OH)Cl$ **(C)** $Zn(OH)_2$ **(D)** Zn

25. When copper is placed in the atmosphere for sufficient time, a green crust is formed on its surface. The composition of the green crust is :
(A) $Cu(OH)_2$ **(B)** CuO **(C)** $CuCO_3$ **(D)** $CuCO_3.Cu(OH)_2$

26. $KMnO_4$ is the oxo salt of :
(A) MnO_2 **(B)** Mn_2O_7 **(C)** MnO_3 **(D)** Mn_2O_3

27. When $K_4[Fe(CN)_6]$ is added to $FeCl_3$, the complex compound formed is :
(A) $Fe_3[Fe(CN)_6]_4$ **(B)** $Fe_4[Fe(CN)_6]_3$ **(C)** $K_2Fe[Fe(CN)_6]$ **(D)** $K_2Fe_3[Fe(CN)_6]_2$

28. $FeCl_3.6H_2O$ is actually :
(A) $[Fe(H_2O)_6]Cl_3$ **(B)** $[Fe(H_2O)_5Cl]Cl_2.H_2O$
(C) $[Fe(H_2O)_4Cl_2]Cl.2H_2O$ **(D)** $[Fe(H_2O)_3Cl_3].3H_2O$

29. The solubility of silver bromide in hypo solution (excess) is due to the formation of :
(A) Ag_2SO_3 **(B)** $Ag_2S_2O_3$ **(C)** $[Ag(S_2O_3)]^-$ **(D)** $[Ag(S_2O_3)_2]^{3-}$

30 In dilute alkaline solution, MnO_4^- changes to :
(A) MnO_4^{2-} **(B)** MnO_2 **(C)** Mn_2O_3 **(D)** MnO

31. Cl_2 gas is obtained by various reactions but not by :
(A) $KMnO_4(s) + \text{conc HCl} \xrightarrow{\Delta}$ **(B)** $KCl(s) + K_2Cr_2O_7(s) + \text{conc } H_2SO_4 \xrightarrow{\Delta}$
(C) $MnO_2(s) + \text{conc HCl} \xrightarrow{\Delta}$ **(D)** $KCl(s) + F_2(\lambda) \longrightarrow$

32. $FeCl_3$ dissolves in :
(A) water **(B)** ether **(C)** ammonia **(D)** **(A)** and **(B)** both

33. Which of the following compounds is used as the starting material for the preparation of potassium dichromate?
(A) $K_2SO_4.Cr_2(SO_4)_3.24H_2O$ (chrome alum) **(B)** $PbCrO_4$ (chrome yellow)
(C) $FeCr_2O_4$ (chromite) **(D)** $PbCrO_4.PbO$ (chrome red)

34. CrO_3 dissolves in aqueous NaOH to give :
(A) CrO_4^{2-} **(B)** $Cr(OH)_3$ **(C)** $Cr_2O_7^{2-}$ **(D)** $Cr(OH)_2$

35. $CuSO_4$ solution + lime is called :
(A) Lucas reagent **(B)** Fenton's reagent
(C) Fehling solution A **(D)** Bordeaux mixture

36. The developer used in photography is an alkaline solution of :
(A) hydroquinone **(B)** glycerol **(C)** phenol **(D)** picric acid

37. When acidified solution of $K_2Cr_2O_7$ is shaken with aqueous solution of $FeSO_4$, then :
(A) $Cr_2O_7^{2-}$ ion is reduced to Cr^{3+} ions **(B)** $Cr_2O_7^{2-}$ ion is converted to CrO_4^{2-} ions
(C) $Cr_2O_7^{2-}$ ion is reduced to Cr **(D)** $Cr_2O_7^{2-}$ ion is converted to CrO_3

38. The final products obtained for the following reaction is :

$$KMnO_4 \text{ (excess)} + H_2SO_4 \text{ (concentrated and cold)} \longrightarrow$$

(A) Mn_2O_7 **(B)** MnO **(C)** Mn_3O_4 **(D)** MnO_3^+

39. When $AgNO_3$ (aq) reacts with excess of iodine, we get :
(A) $AgIO_3$ **(B)** HIO_3 **(C)** AgO **(D)** HI

40. $ZnO + CoO \xrightarrow{\Delta} X$; Product 'X' colour is :

(A) Green **(B)** Blue **(C)** Pink **(D)** Bluish green

41. The compound that gets oxidised even on exposure to atmosphere is :

(A) $Co_2(SO_4)_3$ **(B)** $NiSO_4$ **(C)** $KMnO_4$ **(D)** $FeSO_4$

42. The f-block of the periodic table contains those elements in which :

(A) only 4f orbitals are progressively filled in 6th period.

(B) only 5f orbitals are progressively filled in 7th period.

(C) 4f and 5f orbitals are progressively filled in 6th and 7th periods respectively.

(D) none

43. Among the lanthanoides the one obtained by synthetic method is :

(A) Lu **(B)** Pm **(C)** Pr **(D)** Gd

44. The most common lanthanoide is :

(A) lanthanum **(B)** cerium **(C)** samarium **(D)** plutonium

45. The lanthonoide contraction is reponsible for the fact that

(A) Zr and Y have about the same radius **(B)** Zr and Nb have similar oxidation state

(C) Zr and Hf have about the same radius **(D)** Zr and Ce have the same oxidation state

46. Lanthanoid and actinides resemble in :

(A) electronic configuration **(B)** oxidation state

(C) ionization energy **(D)** formation of complexes

47. The separation of lanthanoids by ion exchange method is based on

(A) sizes of the ions **(B)** oxidation state of the ions

(C) the solubility of their nitrates **(D)** basicity of hydroxides of lanthanides

48. Across the lanthanide series, the basicity of the lanthanoide hydroxides :

(A) increases **(B)** decreases

(C) first increases and then decreases **(D)** does not change

49. The +3 ion of which one of the following has half filled 4f subshell ?

(A) La **(B)** Lu **(C)** Gd **(D)** Ac

50. Actinides :

(A) are all synthetic elements **(B)** includes element 104

(C) have only short lived isotopes **(D)** have variable valency

51. Atoms of the transition elements are smaller than those of the s-block elements, because :

(A) there is increase in the nuclear charge along the period.

(B) orbital electrons are added to the penultimate d–subshell rather than to the outer shell of the atom.

(C) the shielding effect of d-electrons is small.

(D) All of these

52. Which of the following factor may be regarded as the main cause of Lanthanide contraction ?

(A) Poor shielding of 4 f-electrons in compare to other electrons in the sub-shell.

(B) Effective shielding of one of the 4 f-electrons by another in the sub-shell.

(C) Poorer shielding of 5 d electron by 4 f- electrons.

(D) Greater shielding of 5 d electron by 4 f- electron.

53. Which of the following transition metal ions has the lowest density ?

(A) Copper **(B)** Nickel **(C)** Scandium **(D)** Zinc

54. The correct ground state electronic configuration of chromium atom (Z = 24) is :

(A) [Ar] $4d^5\,4s^1$ **(B)** [Ar] $3d^4\,4s^2$ **(C)** [Ar]$3d^6\,4s^0$ **(D)** [Ar] $3d^5\,4s^1$

55. Transition metals :

(A) exhibit only diamagnetism **(B)** undergo inert pair effect

(C) do not form alloys **(D)** show variable oxidation states

56. The radii (metallic) of Fe,Co and Ni are nearly same.
This is due to :

(A) lanthanide contraction

(B) the fact that successive addition of d–electrons screen the outer electrons (4s) from the inward pull of the nucleus.

(C) increase in radii due to increase in 'n' is compensated by decrease in radii due to increase in effective nuclear charge (Z).

(D) atomic radii do not remain constant but decrease in a normal gradation.

57. Of the ions Zn^{2+} , Ni^{2+} and Cr^{3+} (atomic number Zn = 30, Ni = 28, Cr = 24) :

(A) only Zn^{2+} is colourless and Ni^{2+} and Cr^{3+} are coloured.

(B) all three are colourless.

(C) all three are coloured.

(D) only Ni^{2+} is coloured and Zn^{2+} and Cr^{3+} are colourless.

58. Among the following pairs of ions, the lower oxidation state in aqueous solution is more stable than the other, in:

(A) Zn^{2+} , Zn^{3+} **(B)** Cu^{+} , Cu^{2+} **(C)** Cr^{2+} , Cr^{3+} **(D)** V^{2+}, VO^{2+}

59. VO_2 is an amphoteric oxide and in acidic medium it forms :

(A) VO^{2+} **(B)** VO^{+}_{2} **(C)** V^{3+} **(D)** VO_2^{2+}

60. $E^{\ominus}$ values for the couples Cr^{3+}/Cr^{2+} and Mn^{3+}/Mn^{2+} are – 0.41 and + 1.51 volts respectively. Considering these values select the correct option from the following statements.

(A) Cr^{2+} acts as a reducing agent and Mn^{3+} acts as an oxidising agent in their aqueous solutions.

(B) Cr^{2+} (aq.) is more stable than Cr^{3+} (aq.).

(C) Mn^{3+} (aq.) is more stable than Mn^{2+} (aq).

(D) None of these.

61. Which one of the following shows highest magnetic moment ?

(A) V^{3+} **(B)** Cr^{3+} **(C)** Fe^{3+} **(D)** Co^{3+}

62. Amongst the following the lowest degree of paramagnetism per mole of the compound at 298 K will be shown by:

(A) $MnSO_4.4H_2O$ **(B)** $CuSO_4.5H_2O$ **(C)** $FeSO_4.6H_2O$ **(D)** $NiSO_4.6H_2O$

63. Match the compounds of column X with oxidation state of column Y.

	Column X	**Column Y**
I	$[Cr(H_2O)_6]Cl_3$	5
II	CrO_5	4
III	K_3CrO_8	6
IV	$(NH_3)_3CrO_4$	3

	I	II	III	IV
(A)	3	6	5	4
(B)	3	4	5	6
(C)	4	5	6	3
(D)	6	5	4	3

64. Which of the following transition element shows the highest oxidation state :

(A) Mn **(B)** Fe **(C)** V **(D)** Cr

65. Standard reduction electrode potential of Zn^{2+} / Zn is – 0.76 V. This means :

(A) ZnO is reduced to Zn by H_2

(B) Zn can't liberates H_2 with concentrated acids

(C) Zn is generally the anode in an electrochemical cell

(D) Zn is generally the cathode in an electrochemical cell

66. Which one of the transition metal ions is coloured in aqueous solution ?

(A) Cu^+ **(B)** Zn^{2+} **(C)** Sc^{3+} **(D)** V^{4+}

67. Compound that is both paramagnetic and coloured is :

(A) $K_2Cr_2O_7$ **(B)** $(NH_4)_2[TiCl_6]$ **(C)** $VOSO_4$ **(D)** $K_3[Cu(CN)_4]$

68. Which of the following compounds is expected to be coloured ?

(A) Ag_2SO_4 **(B)** CuF_2 **(C)** MgF_2 **(D)** CuCl

69. German silver is an alloy of copper and :

(A) Zn + Ni **(B)** Al + Ag **(C)** Zn + Ag **(D)** Sn + Zn

70. Ferric sulphate on heating gives :

(A) SO_2 and SO_3 **(B)** SO_2 only **(C)** SO_3 only **(D)** S

71. Anhydrous ferric chloride is prepared by :

(A) dissolving ferric hydroxide in dilute HCl.

(B) dissolving ferric hydroxide in concentrated HCl.

(C) by passing dry Cl_2 gas over heated scrap iron .

(D) by dissolving iron (III) oxide in concentrated HCl.

72. Most transition metals :

I : form sets of compounds which display different oxidation states of the metal.
II : form coloured ions in solution.
III : burn vigorously in oxygen.
IV : form complex compound.
of these :

(A) I, II, III are correct **(B)** II, III, IV are correct **(C)** I, II are correct **(D)** all are correct.

73. The aqueous solution of the following salts will be coloured in the case of :

(A) $Zn(NO_3)_2$ **(B)** $LiNO_3$ **(C)** $Co(NO_3)_2$ **(D)** Potash alum

74. Which one of the following characteristics of the transition metals is associated with their catalytic activity ?

(A) Colour of hydrated ions.

(B) Variable oxidation states.

(C) High enthalpy of atomization.

(D) Paramagnetic behaviour.

75. At 300ºC, $FeCl_3$:

(A) decomposes into $FeCl_2$ and Cl_2 **(B)** decomposes into Fe and Cl_2

(C) sublimes to give liquid $FeCl_3$ **(D)** sublimes to give gaseous dimer $(FeCl_3)_2$

76. Iron is rendered passive by treatment with concentrated :

(A) HCl **(B)** H_2SO_4 **(C)** H_3PO_4 **(D)** HNO_3

77. Lucas reagent is :

(A) Anhydrous $ZnCl_2$ + HCl (conc.) **(B)** $MnO_2 + H_2O$

(C) H_2SO_4 + HCl **(D)** NO + H_2O

78. Sodium thiosulphate is used in photography because of its :
(A) oxidising behaviour **(B)** reducing behaviour
(C) complexing behaviour **(D)** photochemical behaviour

79. MnO_4^{2-} (1 mole) in neutral aqueous medium disproportionates to :
(A) 2/3 mole of MnO_4^- and 1/3 mole of MnO_2 **(B)** 1/3 mole of MnO_4^- and 2/3 mole of MnO_2
(C) 1/3 mole of Mn_2O_7 and 1/3 mole of MnO_2 **(D)** 2/3 mole of Mn_2O_7 and 1/3 mole of MnO_2

80. When H_2O_2 is added to an acidified solution of $K_2Cr_2O_7$:
(A) solution turns green due to formation of Cr_2O_3
(B) solution turns yellow due to formation of K_2CrO_4
(C) a blue coloured compound $CrO(O_2)_2$ is formed
(D) solution gives green ppt of $Cr(OH)_3$

81. Which one of the following dissolves in hot concentrated NaOH ?
(A) Fe **(B)** Zn **(C)** Cu **(D)** Ag

82. The compound used for gravimetric estimation of Cu(II) is :
(A) $Cu_2(SCN)_2$ **(B)** Cu_2O **(C)** Cu_2I_2 **(D)** Cu_2CO_3

83. In the reaction, $2CuCl_2 + 2H_2O + SO_2 \rightarrow A + H_2SO_4 + 2HCl$; A is
(A) Cu_2Cl_2 **(B)** Cu **(C)** $CuSO_4$ **(D)** CuS

84. The number of moles of $KMnO_4$ that will be needed to react with one mole of sulphite ion in acidic medium is
(A) 2/5 **(B)**3/5 **(C)** 4/5 **(D)** 1

85. Ammonium dichromate is used in some fire works. The green coloured powder blown in the air is
(A) CrO_3 **(B)** Cr_2O_3 **(C)** Cr **(D)** $CrO(O_2)$

86. Super conductors are derived from compounds of :
(A) p-block elements **(B)** lanthanoides **(C)** actinoides **(D)** transition elements

87. The number of moles of $KMnO_4$ that will be needed to react completely with one mole of ferrous oxalate in acidic solution is :
(A) 3/5 **(B)** 2/5 **(C)** 4/5 **(D)** 1

88. Which of the following is the most suitable description of transition elements ?
(A) Low melting points **(B)** No catalytic activity.
(C) Show variable oxidation states. **(D)** Exhibit inert pair effect.

89. The tendency of the transition elements to form coloured compound is attributed to :
(A) transition of electrons from one atoms to the other.
(B) transition of electrons from s-orbitals of the outer shells to p-orbitals.
(C) d-d-transition of electron in last but one shell.
(D) none of the reason is correct.

90. The ions from among the following which are colourless are :
(i) Ti^{4+} , (ii) Cu^{+1} , (iii) Co^{3+} , (iv) Fe^{2+} .
(A) (i) and (ii) only **(B)** (i), (ii) and (iii) **(C)** (iii) and (iv) **(D)** (ii) and (iii).

91. Which of the following does not belong to 3d series of transition elements ?
(A) Titanium **(B)** Iron **(C)** Palladium **(D)** Vanadium.

92. For the process $Cu(g) \rightarrow Cu^+(g) + e^-$, the electron is to be removed from
(A) 3d sub-shell **(B)** 4s sub-shell **(C)** 3p sub-shell **(D)** any of the above.

93. In general, the melting and boiling points of transition metals :
(A) increase gradually across the period from left to right.
(B) decrease gradually across the period from left to right.
(C) first increase till the middle of the period and then decrease towards the end.
(D) first decrease regularly till the middle of the period and then increase towards the end.

94. The transition elements are more metallic than the representative elements because they have :
(A) the electrons in d-orbitals **(B)** electron pairs in d-orbitals
(C) greater availability of d-orbitals for bonding **(D)** empty metallic orbitals

95. Which oxide of manganese is most acidic in nature ?
(A) MnO **(B)** Mn_2O_7 **(C)** Mn_2O_3 **(D)** MnO_2 .

96. Which of the following transition metal ions has least magnetic moment ?
(A) Co^{3+} **(B)** Fe^{3+} **(C)** Cr^{2+} **(D)** V^{3+}

97. Within each transition series, the oxidation states :
(A) regularly decrease from left to right. **(B)** first increase upto middle of the series then decrease.
(C) first decrease upto middle and then increase. **(D)** none of these.

98. The maximum oxidation state shown by V(Z = 23), Cr(Z = 24), Co(Z = 27), Sc(Z = 21) are respectively :
(A) + 5 , + 6 , + 3 , + 3 **(B)** + 3 , + 4 , + 5, + 2 **(C)** + 5, + 3 , + 2 , + 1 **(D)** + 4 in each case.

99. The stability of particular oxidation state of a metal in aqueous solution is determined by :
(A) enthalpy of sublimation of the metal **(B)** ionisation energy
(C) enthalpy of hydration of the metal ion **(D)** all of these.

100. Which of the following shall have the highest value of magnetic moment ?
(A) Zn(II) ion **(B)** Mn(IV) ion **(C)** Fe(II) ion **(D)** Ti(III) ion.

101. The highest oxidation state is exhibited by the transition metals with configuration :
(A) $(n-1)\,d^3ns^2$ **(B)** $(n-1)\,d^5ns^1$ **(C)** $(n-1)\,d^5ns^2$ **(D)** $(n-1)\,d^8ns^2$.

102. In general, the transition elements exhibit their highest oxidation states in their compounds with elements like :
(A) C **(B)** S **(C)** S and P **(D)** F and O.

103. Transition elements are frequently used as catalyst because :
(A) of variable oxidation state **(B)** of high ionic charge
(C) large surface area of reactants **(D)** of their specific nature.

104. The first ionisation energies of the elements of the first transition series :
(A) increase as the atomic number increase.
(B) decrease as the atomic number increase.
(C) do not show any change as the addition of electrons takes place in the inner (n – 1) d–orbitals.
(D) increase from Ti to Mn and then decrease from Mn to Cu.

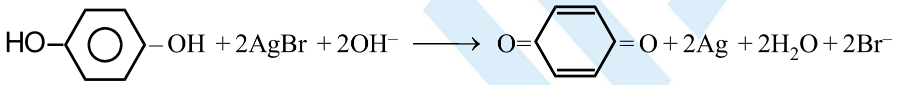
Exercise # 2 Part # I [Multiple Correct Choice Type Questions]

1. The colour of the transition metal ions is/are due to :
(A) d-d transition of electrons in presence of ligands
(B) charge transfer from ligand to metal ion.
(C) change in the geometry
(D) polarisation of anion by cation

2. Which of the following statement(s) is/are not correct ?
(A) The blue colour of aqueous $CuCl_2$ is due to $[Cu(H_2O)_4]^{2+}$
(B) The yellow colour of aqueous $CuCl_2$ is due to $[CuCl_4]^{2-}$
(C) The green colour of aqueous $CuCl_2$ is due to the presence of both $[Cu(H_2O)_4]^{2+}$ and $[CuCl_4]^{2-}$
(D) The blue colour of aqueous $CuCl_2$ is due to $[CuCl_4]^{2-}$

3. Select correct statement (s).
(A) MnO_4^- is intense pink colour due to d-d transition of electron.
(B) Cu(I) is diamagnetic while Cu(II) is paramagnetic.
(C) CrO_3 is amphoteric oxide.
(D) $[Ti(H_2O)_6]^{3+}$ and $[Sc(H_2O)_6]^{3+}$ both are coloured in aqueous solution.

4 In photography, quinol is used as developer according to following reaction.



Which of the following describe(s) the role of quinol in this reaction ?
(A) It acts as an acid.
(B) It acts as a weak base.
(C) It acts as an oxidising agent.
(D) It acts as a reducing agent.

5. Which of the following statement (s) is/are correct ?
(A) $S_2O_8^{2-}$ oxidise Ag^+ in presence of pyridine and give red colour compound.
(B) MnO_4^{2-} disproportionates to yield MnO_4^- and MnO_2 in presence of H^+ ions.
(C) In $Cr_2O_7^{2-}$ each Cr is linked to four oxygen atoms.
(D) Ti^{3+} is purple while Ti^{4+} is colourless.

6. Following reaction(s) is/are involved in the iodometric estimation.
(A) $Cr_2O_7^{2-} + H^+ + I^- \longrightarrow 2Cr^{3+} + I_2 ; I_2 + S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + I^-$
(B) $MnO_4^- + H^+ + I^- \longrightarrow Mn^{2+} + I_2 ; I_2 + S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + I^-$
(C) $MnO_4^- + OH^- + I^- \longrightarrow MnO_2 + I_2 ; I_2 + S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + I^-$
(D) $Cr_2O_7^{2-} + OH^- + I^- \longrightarrow 2\,Cr^{3+} + I_2 ; I_2 + S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + I^-$

7. Correct statements about transition metals are that they :
(A) form complex
(B) show variable oxidation states
(C) show magnetic properties
(D) do not form coloured compounds

8. Transition elements have greater tendency to form complexes because they have :
(A) vacant d–orbitals
(B) small size
(C) higher nuclear charge
(D) variable oxidation states

9. Which of the following statements are correct when a mixture of NaCl and $K_2Cr_2O_7$ is gently warmed with conc. H_2SO_4 ?
(A) Deep red vapours are liberated
(B) Deep red vapours dissolve in NaOH (aq.)forming a yellow solution.
(C) Greenish yellow gas is liberated
(D) Deep red vapours dissolve in water forming yellow solution

10. Which of the following chemical reaction(s) is/are involved in developing of photographic plate ?

(A) $C_6H_4(OH)_2 + 2AgBr \longrightarrow 2Ag + C_6H_4O_2 + 2HBr$

(B) $AgBr + 2Na_2S_2O_3 \longrightarrow Na_3[Ag(S_2O_3)_2] + NaBr$

(C) $2AgNO_3 + Na_2S_2O_3 \longrightarrow Ag_2S_2O_3 + 2NaNO_3$

(D) $AgNO_3 + KCN \longrightarrow AgCN + KNO_3$

11. Pyrolusite is MnO_2 used to prepare $KMnO_4$. Steps are :

$$MnO_2 \xrightarrow{I} MnO_4^{2-} \xrightarrow{II} MnO_4^-$$

Steps I and II are respectively :

(A) fuse with KOH / air, electrolytic oxidation

(B) fuse with KOH / KNO_3, electrolytic oxidation

(C) fuse with concentrated HNO_3 / air, electrolytic reduction

(D) dissolve in H_2O, oxidation

12. Which are correct statements ?

(A) In less acidic solution $K_2Cr_2O_7$ and H_2O_2 gives violet coloured diamagnetic $[CrO(O_2)(OH)]^-$ ion.

(B) In alkaline H_2O_2, K_2CrO_8 (with tetraperoxo species $[Cr(O_2)_4]^{3-}$) is formed with $K_2Cr_2O_7$.

(C) In ammonical solution of H_2O_2, $(NH_3)_3CrO_4$ is formed with $K_2Cr_2O_7$.

(D) CrO_4^{2-} changes to $Cr_2O_7^{2-}$ by oxidation.

13. Which of the following reaction(s) is/are incorrect for silver nitrate ?

(A) $6\,AgNO_3 + 3I_2\,(excess) + 3\,H_2O \longrightarrow AgIO_3 + 5\,AgI + 6HNO_3$

(B) $AgNO_3\,(excess) + 2\,KCN \longrightarrow K[Ag(CN)_2] + KNO_3$

(C) $2AgNO_3 + 4Na_2S_2O_3(excess) \longrightarrow 2Na_3[Ag(S_2O_3)_2] + 2NaNO_3$

(D) $PH_3 + 6AgNO_3 + 3H_2O \longrightarrow 6Ag + 6HNO_3 + H_3PO_3$

14. Which of the following reaction(s) is/are used for the preparation of anhydrous $FeCl_3$?

(A) $FeCl_3 6H_2O + 6SOCl_2 \longrightarrow FeCl_3 + 12HCl + 6SO_2$

(B) $Fe(OH)_3\downarrow + 3HCl \longrightarrow FeCl_3 + 3H_2O$

(C) $2Fe + 4HCl\,(aq.) + Cl_2 \longrightarrow 2FeCl_3 + 2H_2$

(D) $2Fe + 3Cl_2(dry) \longrightarrow 2FeCl_3$

15. Which of the following is/are false ?

(A) $Na_2Cr_2O_7$ is used as a primary standard in volumetric analysis.

(B) Potassium permanganate in excess on treatment with conc. H_2SO_4 forms manganese heptoxide

(C) Phosphine, arsine and stibine all precipitates silver from silver nitrate

(D) From kipp's apparatus waste ferric sulphate and ferrous sulphate mixture is obtained when air or oxygen is passed for longer time.

16. When CO_2 is passed into aqueous :

(A) Na_2CrO_4 solution, its yellow colour changes to orange.

(B) K_2MnO_4 solution, it disproportionates to $KMnO_4$ and MnO_2

(C) $Na_2Cr_2O_7$ solution, its orange colour changes to green

(D) $KMnO_4$ solution, its pink colour changes to green.

17. Which of the following statement(s) is/are correct ?

(A) Transition metals and many of their compounds show paramagnetic behaviour.

(B) The enthalpies of atomisation of the transition metals are high.

(C) The transition metals generally form coloured compounds.

(D) Transition metals and their many compounds act as good catalyst.

18. Potassium manganate (K_2MnO_4) is formed when :
(A) potassium permanganate reacts with formaldehyde in acidic medium.
(B) manganese dioxide is fused with potassium hydroxide in air.
(C) manganese hydroxide reacts with K_2O_2 in alkaline medium.
(D) potassium permanganate is heated at 750K.

19. Select the incorrect statement(s) :
(A) In K_2MnO_4 and CrO_2Cl_2, the central transition metals/ions have same oxidation state.
(B) Both sodium and potassium dichromate can be used as primary standard in volumetric estimations.
(C) Potassium dichromate on strong heating evolves oxygen gas and forms green powder.
(D) Potassium permanganate on heating with solid KOH evolves oxygen gas and forms a black powder.

20. Select the correct statement(s) with respect to oxides and oxoanions of transition metals.
(A) Among oxides of chromium, CrO is basic, Cr_2O_3 is amphoteric and CrO_3 is acidic.
(B) No higher oxides of iron above Fe_2O_3 are found.
(C) Ti,V, Cr and Mn form oxides MO and their correct increasing order of acidic character is MnO<CrO<VO<TiO.
(D) Vandium(V) oxide does not react with acids but reacts with alkalies only.

21. In which of the following compound(s), the colour is due to the charge transfer spectra ?
(A) $KMnO_4$ **(B)** CrO_3 **(C)** $CuCl_2$ **(D)** Cu_2O.

22. Which of the following oxide(s) of transition metals is/are amphoteric in nature.
(A) Cr_2O_3 **(B)** V_2O_5 **(C)** Mn_2O_7 **(D)** ZnO.

23. The hydrated cupric chloride is strongly heated. Which of the following statement(s) is (are) correct for this?
(A) It is reduced to Cu_2Cl_2.
(B) Cupric oxide is formed along with Cu_2Cl_2 .
(C) Cl_2 is liberated only but it is not liberated along with HCl.
(D) Cl_2 and HCl both are liberated.

24. Cuprous chloride can be prepared :
(A) by passing SO_2 through the solution containing $CuSO_4$ and NaCl.
(B) by heating excess of copper with concentrated HCl in presence of a little $KCIO_3$.
(C) by boiling copper sulphate solution with excess of copper turnings in presence of hydrochloric acid.
(D) by dissolving cupric oxide or copper carbonate in concentrated HCI.

State Weather the Questions .... is True or False :

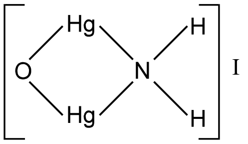
25. **S1 :** Acidic dichromate solutions on treatment with H_2O_2 gives deep blue $CrO(O_2)_2$.
S2 : A deep red liquid, CrO_2Cl_2 is formed by the reaction of chromium(III) oxide with HCl in presence of conc.H_2SO_4.
S3 : $(NH_4)_2Cr_2O_7$ on heating yields green chromium(III) oxide and nitrogen gas.
S4 : $K_2Cr_2O_7$ on heating with charcoal produces K_2CO_3 .
and arrange in the order of true/false.
(A) T T T T **(B)** T F T T **(C)** T F T F **(D)** F F T T

26. **S1 :** Mn^{II} ions in solution is oxidised to MnO_4^- by PbO_2 or $NaBiO_3$.
S2 : MnO_4^{2-} ions in neutral, acid or slightly basic solutions readily disproportionates.
S3 : $KMnO_4$ gives MnO on heating in current of hydrogen.
and arrange in the order of true/ false.
(A) T T T **(B)** T F T **(C)** T F F **(D)** F T F.

27. **S1 :** Interstitial compounds have high melting points, higher than those of pure metals.
S2 : Permanganate titrations in presence of hydrochloric acid are unsatisfactory.
S3 : $KMnO_4$ does not act as an oxidising agent in strong alkaline medium.
S4 : $KMnO_4$ on heating in a current of H_2 gives MnO.
(A) T T F T **(B)** T F F T **(C)** T F T T **(D)** F F T F

28. **S1 :** Mn^{2+} compounds are more stable than Fe^{2+} towards oxidation to their +3 state.
S2 : Titanium and copper both in the first series of transition metals exhibits +1 oxidation state most frequently.
S3 : Cu^+ ion is stable in aqueous solutions.
S4 : The E^{θ} value for the Mn^{3+}/Mn^{2+} couple is much more positive than that for Cr^{3+}/Cr^{2+} or Fe^{3+}/Fe^{2+}.
(A) T T F T **(B)** T F F T **(C)** T F T T **(D)** F F T F

29. **S1 :** Covalent and ionic radii of Nb and Ta are almost the same.
S2 : Ionisation energies of transition elements decrease with increase in atomic number in a given group.
S3 : Iodide of Millon's base is believed to have the structure.



S4 : Yellow colour of CrO_4^{2-} is due to d-d transition.
(A) T T F T **(B)** T F F T **(C)** T F T F **(D)** F F T F

30. If a non metal is added to the interstitial sites of a metal, then the metal becomes :
(A) softer **(B)** less tensile **(C)** less malleable **(D)** more ductile.

31. The reaction $MnO_4^- + e^- \rightleftharpoons MnO_4^{2-}$ takes place in :
(A) a basic medium (strong) **(B)** acidic medium
(C) neutral medium **(D)** both acidic and basic medium.

32. Reaction of $KMnO_4$ in neutral or very weakly alkaline solution can be represented as :
(A) $MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$. **(B)** $2MnO_4^- + 2OH^- \rightarrow 2MnO_4^{2-} + 1/2O_2 + H_2O$.
(C) $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$. **(D)** $MnO_4^- + e^- \rightarrow MnO_4^{2-}$.

33. On heating $KMnO_4$, one among the following is not formed :
(A) K_2MnO_4 **(B)** O_2 **(C)** MnO_2 **(D)** MnO.

34. Among the following series of transition metal ions, the one where all metal ions have $3d^2$ electronic configuration is
(A) $Ti^{3+}, V^{2+}, Cr^{3+}, Mn^{4+}$ **(B)** $Ti^+, V^{4+}, Cr^{6+}, Mn^{7+}$
(C) $Ti^{2+}, V^{3+}, Cr^{2+}, Mn^{3+}$ **(D)** $Ti^{2+}, V^{3+}, Cr^{4+}, Mn^{5+}$.

35. The pair of the compounds in which both the metals are in the highest possible oxidation state is,
(A) $[Fe(CN)_6]^{3-}, [Co(CN)_6]^{3-}$ **(B)** CrO_2Cl_2, MnO_4^-.
(C) TiO_2, MnO_2 **(D)** $[Co(CN)_6]^{3-}, Mn_2O_7$.

36. Which of the following can be used for the conversion of potassium manganate to potassium permanganate?
(A) O_3 **(B)** Cl_2 **(C)** CO_2 **(D)** All.

37. One of the products formed due to the reaction between $KMnO_4$ and HCl is :
(A) red liquid, CrO_2Cl_2 **(B)** black powder, MnO_2
(C) greenish yellow gas, Cl_2 **(D)** colourless liquid, $HClO_4$.

38. Which one of the following compounds does not decolourise an acidified aqueous solution of $KMnO_4$?
(A) Sulphur dioxide **(B)** Ferric chloride **(C)** Hydrogen peroxide **(D)** Ferrous sulphate.

39. Which of the following is used in the preparation of chlorine ?
(A) Only MnO_2. **(B)** Only $KMnO_4$.
(C) Both MnO_2 and $KMnO_4$. **(D)** None.

40. The yellow colour solution of Na_2CrO_4 changes to orange red on passing CO_2 gas due to the formation of :
(A) CrO_5 **(B)** CrO_3 **(C)** $Na_2Cr_2O_7$ **(D)** Na_3CrO_8.

41. Reaction of potassium chromate and $CuSO_4$ in aqueous solution produces :
(A) $CuCrO_4$ only **(B)** $Cu_5[CrO_4]_2$ only
(C) $CuCr_2O_7$ only **(D)** both $CuCrO_4$ and $Cu_2Cr_2O_7$.

42. $FeCr_2O_4 + Na_2CO_3 + O_2 \xrightarrow{\text{Fusion}} [X] \xrightarrow[H_2O]{H^+} [Y] \xrightarrow[H_2O_2]{H^+} [Z]$

Which of the following statement is true for the compounds [X], [Y] and [Z] ?
(A) In all three compounds, the chromium is in + 6 oxidation state.
(B) [Z] is a deep blue–violet coloured compound which decomposes rapidly in aqueous solution into Cr^{3+} and dioxygen.
(C) Saturated solution of [Y] gives bright orange compound, chromic anhydride, with cold and concentrated H_2SO_4.
(D) All of these.

43. $KMnO_4$ in excess on treatment with concentrated H_2SO_4 forms a compound (X) which decomposes explosively on heating forming (Y) . The (X) and (Y) are respectively :
(A) Mn_2O_7 , MnO_2 **(B)** Mn_2O_7 , Mn_2O_3
(C) $MnSO_4$, Mn_2O_3 **(D)** Mn_2O_3 , MnO_2

44. Potassium dichromate in alkaline solution, with 30% H_2O_2 produces :
(A) K_3CrO_8 **(B)** $CrO(O_2)_2$ **(C)** CrO_3 **(D)** K_2CrO_4 .

45. Which of the following statement is wrong ?
(A) An acidified solution of $K_2Cr_2O_7$ liberates iodine from iodides.
(B) In acidic solution dichromate ions are converted to chromate ions.
(C) Ammonium dichromate on heating undergo exothermic decomposition to give Cr_2O_3 .
(D) Potassium dichromate is used as a titrant for Fe^{2+}.

46. Oxygen is absorbed by molten Ag, which is evolved on cooling and the silver particles are scattered ; the phenomenon is known as :
(A) silvering of mirror. **(B)** spitting of silver. **(C)** frosting of silver. **(D)** hairing of silver.

47. The image on an exposed and developed photographic film is due to :
(A) AgBr **(B)** $[Ag(C_2O_3)_2]^{3+}$ **(C)** Ag **(D)** Ag_2O.

48. Which of the following does not react with AgCl ?
(A) $Na_2S_2O_3$ **(B)** NH_4OH **(C)** $NaNO_3$ **(D)** Na_3AsO_3 .

49. Addition of iron fillings to $CuSO_4$ solution caused precipitation of Cu owing to the :
(A) reduction of Cu^{2+} **(B)** oxidation of Cu^{2+} **(C)** reduction of Fe **(D)** None of these

50. Identify the incorrect statement.

(A) $CuSO_4$ reacts with KCl in aqueous solution to give Cu_2Cl_2 .
(B) $CuSO_4$ reacts with KI in aqueous solution to give Cu_2I_2 .
(C) $CuSO_4$ reacts with NaOH and glucose in aqueous medium to give Cu_2O.
(D) $CuSO_4$ on strong heating gives CuO.

51. Solution of CuCl in NH_4OH absorbs :

(A) CO_2
(B) SO_2
(C) H_2SO_4
(D) CO.

52. Which of the following reactions represents "developing" in photography ?

(A) $AgNO_3 + NaBr \rightarrow AgBr + NaNO_3$.
(B) $AgBr + 2Na_2S_2O_3 \rightarrow Na_3[Ag(S_2O_3)_2] + NaBr$.
(C) $AgBr + hv \rightarrow AgBr$.
(D) $C_6H_4(OH)_2 + 2AgBr \rightarrow C_6H_4O_2 + 2HBr + 2Ag$.
(E) $AgBr + 2NH_3 \rightarrow [Ag(NH_3)_2]Br$.

53. Transition metal with low oxidation state will act as :

(A) a base
(B) an acid
(C) both **(A)** and **(B)**
(D) none of these.

54. Boiling $CuCl_2$ with Cu in concentrated HCl gives :

(A) CuCl
(B) $CuCl_2$
(C) $CuCl_3$
(D) Cu_2Cl.

55. $CuFeS_2 + O_2$ (excess) $\xrightarrow{\Delta} X(s) + Y(s)$

Note : Correspondings sulphates of copper and iron are formed respectively.

Which is correct choice for (X) and (Y) ?

(A) (X) liberates iodine from soluble iodides like KI
(B) (Y) on heating liberates SO_3 only
(C) (X) forms bluish white precipitate with sodium hydroxide which redissolves in excess of sodium hydroxide.
(D) (Y) on reaction with potassium ferricyanide gives brown precipitate.

56. An extremely hot copper wire reacts with steam to produce :

(A) Cu_2O
(B) CuO_2
(C) Cu_2O_2
(D) CuO.

57. A compound of iron exists as a dimer in vapour state. It is hygroscopic in nature and dissolves in water giving brown acidic solution. The compound is :

(A) Fe_3O_4
(B) $FeSO_4$
(C) $FeCl_3$
(D) $FeCl_2$.

58. Which of the following statements is not correct ?

(A) $La(OH)_3$ is less basic than $Lu(OH)_3$
(B) In lanthanide series ionic radius of Ln^{3+} ions decreases
(C) La is actually an element of transition series rather than lanthanide series
(D) Atomic radii of Zr and Hf are same because of lanthanide contraction

59. Transuranic elements begin with

(A) Np
(B) Cm
(C) Pu
(D) U

60. Lanthanide contraction is observed in :

(A) Gd
(B) At
(C) Xe
(D) Ac

61. The names transition and inner transition metals are used to indicate the elements of :

(A) d-block elements only
(B) f-block elements only
(C) p- and d-blocks elements respectively
(D) d- and f-blocks elements respectively

62. The correct statement(s) from among the following is/are :
(i) all the d and f-block elements are metals
(ii) all the d and f-block elements form coloured ions
(iii) all the d- and f-block elements form paramagnetic ions
(A) (i) only **(B)** (i) and (ii) **(C)** (ii) and (iii) **(D)** All

63. The actinides showing +7 oxidation state are :
(A) U, Np **(B)** Pu, Am **(C)** Np, Pu **(D)** Am, Cm

64. Which of the following is not an actinoide ?
(A) Curium **(B)** Californium **(C)** uranium **(D)** terbium

65. Lanthanide contraction is due to increase in :
(A) shielding by 4f electrons **(B)** atomic number
(C) effective nuclear charge **(D)** size of 4f orbitals

66. The melting point of Zn is lower as compared to those of the other elements of 3d series because :
(A) the d-orbitals are completely filled. **(B)** the d-orbitals are partially filled.
(C) d-electrons do not participate in metallic bonding. **(D)** size of Zn atom is smaller

67. The less stable oxidation states of Cr are :
(A) Cr^{2+} **(B)** Cr^{3+} **(C)** Cr^{4+} **(D)** Cr^{6+}

68. Which of the following statements are correct ?
(A) Transition elements exhibit higher enthalpies of atomization as they have stronger interatomic interaction
(B) IE_2 of ${}_{23}V < {}_{24}Cr > {}_{25}Mn$ and ${}_{28}Ni < {}_{29}Cu > {}_{30}Zn$
(C) Ni(II) compounds are more stable than Pt(II) where as Pt(IV) compounds are more stable than nickel (IV).
(D) The elements which gives the greatest number of oxidation states does not occur in or near the middle of the series.

69. Which of the following ions give(s) colourled aqueous solution?
(A) Ni^{2+} **(B)** Fe^{2+} **(C)** Cu^{2+} **(D)** Cu^{+}

70. Which of the following statement is/are correct ?
(A) Transition metals and their many compounds act as good catalyst.
(B) The enthalpies of atomistation of the transition metals are high.
(C) The transition metals generally form interstitial compounds with small atoms like C, B, H etc.
(D) All transition metal compounds are not paramagnetic.

71. Select correct statement (s).
(A) PH_3 reduces $AgNO_3$ to metallic Ag.
(B) Organic tissues turn $AgNO_3$ black by reducing it to Ag.
(C) AgCN is soluble in KCN.
(D) Zr and Ta have almost similar size due to lanthanide contraction.

Part # II [Assertion & Reason Type Questions]

Each question has 5 choices (A), (B), (C), (D) and (E) out of which only one is correct.

(A) Statement-1 is true, Statement-2 is true and Statement-2 is correct explanation for Statement-1
(B) Statement-1 is true, Statement-2 is true and Statement-2 is not correct explanation for Statement-1
(C) Statement-1 is true, Statement-2 is false
(D) Statement-1 is false, Statement-2 is true
(E) Both Statements are false

1. **Statement-1 :** Mn atom loses ns electrons first during ionisation as compared to (n – 1) d-electrons.
Statement-2 : The effective nuclear charge experienced by (n – 1) d electrons is greater than that by ns electron.

2. **Statement-1 :** $CuSO_4.5H_2O$ on heating to 250°C loses all the five H_2O molecules and becomes anhydrous.
Statement-2 : All the five H_2O molecules are co-ordinated to the central Cu^{2+} ion.

3. **Statement-1 :** Silver chloride dissolves in excess ammonia.
Statement-2 : AgCl forms a soluble complex, $[Ag(NH_3)_2]$ Cl with ammonia.

4. **Statement-1 :** The order of atomic radii of Cu, Ag and Au is $Cu < Ag \approx Au$.
Statement-2 : The atomic radii of 4d series elements are larger than those of 3d series elements but generally the radii of 4d and 5d series elements are almost identical.

5. **Statement-1 :** 4d & 5d series elements have nearly same atomic radius.
Statement-2 : Lanthanoide contraction.

6. **Statement-1 :** Tungsten has very high melting point
Statement-2 : Tungsten is a covalent compound

7. **Statement-1 :** CrO_3 is an acid anhydride.
Statement-2 : CrO_3 is obtained as bright orange crystals by the reaction of $K_2Cr_2O_7$ with cold concentrated H_2SO_4.

8. **Statement-1 :** Solid potassium dichromate gives greenish yellow vapours with concentrated H_2SO_4 and solid ammonium chloride.
Statement-2 : The reaction of ammonium chloride with solid $K_2Cr_2O_7$ and concentrated H_2SO_4 produces chromyl chloride.

9. **Statement-1 :** Permanganate titrations is not carried out in presence of hydrochloric acid.
Statement-2 : Hydrochloric acid is oxidised to chlorine.

10. **Statement-1 :** Copper metal is turned green when exposed to atmospheric CO_2 and moisture.
Statement-2 : Copper gets covered with a green layer of basic copper carbonate.

11. **Statement-1 :** Ammoniacal silver nitrate converts glucose to gluconic acid and metallic silver is precipitated.
Statement-2 : Glucose acts as a weak reducing agent.

12. **Statement-1 :** 4d & 5d series elements have nearly same atomic radius.
Statement-2 : Lanthanoide contraction.

13. **Statement-1 :** The free gaseous chromium atom has six unpaired electrons.
Statement-2 : Half filled orbital has greater stability than fully filled.

14. **Statement-1 :** K_2CrO_4 has yellow colour due to charge transfer.
Statement-2 : CrO_4^{2-} ion is tetrahedral in shape.

15. **Statement-1 :** The green manganate is paramagnetic but the purple permanganate is diamagnetic in nature.

Statement-2 : MnO_4^{2-} contains one unpaired electron while in MnO_4^- all electrons are paired.

16. **Statement-1 :** The highest manganese fluoride is MnF_4 and the highest oxide is Mn_2O_7 .

Statement-2 : In Mn_2O_7, each Mn is tetrahedrally surrounded by O′s including Mn–O–Mn bridge.

17. **Statement-1 :** The lowest oxide of a transition metal (say, chromium, atomic number 24) is basic where as the highest oxide is usually acidic.

Statement-2 : Cr_2O_3 is amphoteric in nature.

18. **Statement-1 :** In acid solution permanganate is reduced to Mn^{2+} by an excess of reducing agent.

Statement-2 : MnO_4^- redused in Mn^{2+} in acidic medium and the product in the presence of an excess of permanganate is MnO_2 .

19. **Statement-1 :** The number of unpaired electrons in the following gaseous ions ;

Mn^{3+}, Cr^{3+}, V^{3+} and Ti^{3+} are 4, 3, 2 and 1 respectively.

Statement-2 : Cr^{3+} is most stable in aqueous solution amongst these ions .

20. **Statement-1 :** The value of enthalpy of atomisation is maximum at about the middle of each series.

Statement-2 : There is one unpaired electron per d-orbital and this results in stronger interatomic interaction.

21. **Statement-1 :** The spin only magnetic moment of Sc^{3+} is 1.73 B.M.

Statement-2 : The spin only magnetic moment of an ion is equal to $\sqrt{n(n+2)}$; where n is the number of unpaired electrons in the ion.

22. **Statement-1 :** Hydrochloric acid is not used to acidify a $KMnO_4$ solution in volumetric analysis of Fe^{2+} and $C_2O_4^{2-}$ because.

Statement-2 : Part of the oxygen produced from $KMnO_4$ and HCl is used up in oxidising HCl to Cl_2 .

23. **Statement-1 :** Potassium dichromates gives deep red vapours with concentrated H_2SO_4 and sodium chloride.

Statement-2 : The reaction of sodium chloride with solid $K_2Cr_2O_7$ and concentrated H_2SO_4 produces chromyl chloride.

24. **Statement-1 :** Solution of Na_2CrO_4 in water is intensely coloured.

Statement-2 : Oxidation state of Cr in Na_2CrO_4 is (+VI).

25. **Statement-1 :** Silver nitrate is reduced to silver by the hydrides of 15th group elements (except NH_3) because

Statement-2 : They act as strong reducing agents.

26. **Statement-1 :** $Ag_2S + 4\,KCN \xrightleftharpoons{O_2} 2K\,[Ag(CN)_2] + K_2S$

Statement-2 : The reaction is carried out in presence of air or O_2 so that K_2S is oxidised to K_2SO_4 thereby shifting the equilibrium in forward direction.

27. **Statement-1 :** Reaction of thionyl chloride with hydrated ferric chloride yields anhydrous ferric chloride.

Statement-2 : Water of crystallisation present with ferric chloride reacts with thionyl chloride to liberate HCl and SO_2 gases.

28. **Statement-1 :** Hydroquinone is used as a developer for developing black and white photographic film.

Statement-2 : Hydroquinone reduces silver bromide to black silver particles and an inverted image of the object is produced on a celluloid film.

Exercise # 3 Part # I [Matrix Match Type Questions]

1. Match the reactions listed in Column (I) with the characteristic(s) of the products/type of reactions listed in Column (II).

Column - I	Column - II
(A) $MnO_4^{2-} + CO_2 \longrightarrow$	(p) Two pungent smelling gases are liberated.
(B) $CrO_4^{2-} + H^+ \longrightarrow$	(q) Show disproportionation reaction.
(C) $FeSO_4 \xrightarrow{\Delta}$	(r) Dimeric bridged tetrahedral metal ion.
(D) $CuCI_2\,2H_2O \xrightarrow{\Delta}$	(s) One of the products has central metal in its highest stable oxidation state.

2. Match the salts/mixtures listed in Column (I) with their respective name listed in Column (II).

Column - I	Column - II
(A) $ZnS + BaSO_4$ mixture	(p) Lunar caustic
(B) $FeSO_4\,(NH_4)_2SO_4 . 6H_2O$	(q) Schwitzer`s regent.
(C) $AgNO_3$	(r) Lithopone
(D) $[Cu(NH_3)_4]SO_4$	(s) Mohr's salt

3. Match the pairs of complexes/compounds listed in Column (I) with the characteristic(s) of the reaction products listed in Column (II).

Column - I	Column - II
(A) Cu(I) and Zn (II) complexes	(p) Pair of compounds having similar colour and some magnetic moment but equal.
(B) $KMnO_4$ and $K_2Cr_2O_7$	(q) Pair of compounds which are diamagnetic but coloured.
(C) Cu_2O and HgI_2	(r) Pair of compounds having metals in the highest stable oxidation states.
(D) $VOCI_2$ and $CuCI_2$	(s) Pair of compounds which show diamagnetism and are colourless.

4.

Column-I (Metals)	Column-II (Ores)
(A) Zn	(p) Cyanide process
(B) Cu	(q) hydrometallurgical process
(C) Ag	(r) roasting
(D) Pt	(s) brass.

5.

Column-I (Alloys)	Column-II (Constituents)
(A) $TiCl_4$	(p) Adams catalyst in reduction
(B) $PdCl_2$	(q) In preparation of $(CH_3)_2\,SiCl_2$
(C) Pt/PtO	(r) Used as the Natta catalyst in polythene production
(D) Cu	(s) Wake process for converting C_2H_4 to CH_3CHO

6. Match the reactions in Column I with the types of products / the use of products in Column II.

Column - I	Column - II
(A)  $+ AgBr(s) \rightarrow$	(p) Turnbull's blue pigment
(B) $BaCl_2 + K_2Cr_2O_7 + H_2SO_4 \rightarrow$	(q) Schwitzer's reagent
(C) $FeSO_4 + K_3[Fe(CN)_6] \rightarrow$	(r) Rinmann's green pigment
(D) $Cu(OH)_2 + NH_4OH + (NH_4)_2SO_4 \rightarrow$	(s) Chromyl chloride test
(E) $ZnO + Co(NO_3)_2 \xrightarrow{\Delta}$	(t) Photography

7. Match the reactions in Column I with nature of the reactions/type of the products in Column II.

Column I	Column II
(A) $FeSO_4 \xrightarrow{\Delta}$	**(p)** One of the products is coloured due to charge transfer
(B) $Mn^{2+} + S_2O_8^{2-} + H_2O \longrightarrow$	**(q)** One of the products is in + VI oxidation state
(C) $Na_2Cr_2O_7$ + H_2SO_4(conc.) $\longrightarrow$ (saturated solution)	**(r)** Redox reaction
(D) $N_2H_4 + CuSO_4 \longrightarrow$	**(s)** One of the products is acidic oxide

8. Match the properties given in Column I with the transition elements given in Column II.

Column I (Property)	Column II (Transition elements)
(A) Highest oxidation state.	**(p)** Cr.
(B) Highest density.	**(q)** Os.
(C) Element with maximum unpaired electrons.	**(r)** Tc.
(D) Radioactive transition element.	**(s)** Ru.

9. Match the transition element ions given in Column I with the characteristic(s) of products given in Column II.

Column I	Column II
(A) Cu^{2+} .	**(p)** Form amphoteric oxide.
(B) Zn^{2+} .	**(q)** Diamagnetic and colourless compounds.
(C) Cr^{3+}.	**(r)**) Coloured hydrated transition metal ion.
(D) Ni^{2+}.	**(s)** Paramagnetic.

Part # II [Comprehension Type Questions]

Comprehension # 1

(i) A powdered substance (A) on treatment with fusion mixture gives a green coloured compound (B).
(ii) The solution of (B) in boiling water on acidification with dilute H_2SO_4 gives a pink coloured compound (C) and brown colour compound (D).
(iii) The aqueous solution of (A) on treatment with NaOH and Br_2–water gives the compound (D).
(iv) A solution of (D) in concentrated HNO_3 on treatment with lead peroxide at boiling temperature produced a compound (E) which was of the same colour at that of (C).
(v) A solution of (A) on treatment with a solution of barium chloride gave a white precipitate of compound (F) which was insoluble in concentrated HNO_3 and concentrated HCl.

1. Which of the following is true for compound (C) ?
(A) It oxidises ammonia to nitrogen dioxide in neutral medium.
(B) It's pink colour is due to d-d transition.
(C) It can be oxidised by ozone.
(D) It is obtained by alkaline fusion of pyrolusite followed by electrolytic oxidation.

2. The oxidation state of central metal ions of (A), (B) and (C) compounds are respectively :
(A) +II , + VI and + VII **(B)** +II , + VI and + VI
(C) +II , + VII and + VII **(D)** +VI , + VII and + VII

3. Consider the following statements ;
(I) anions of both (B) and (C) are diamagnetic and have tetrahedral geometry.
(II) anions of both (B) and (C) are paramagnetic and have tetrahedral geometry.
(III) anion of (B) is paramagnetic and that of (C) is diamagnetic but both have tetrahedral geometry.
(IV) green coloured compound (B) in a neutral or acidic medium disproportionates to give (C) and (D).
of these select the correct one from the codes given :
(A) I and III only **(B)** II and III only **(C)** II and IV only **(D)** III and IV only

Comprehension # 2

Paramagnetism is a property due to the presence of unpaired electrons. In case of transition metals, as they contain unpaired electrons in the (n – 1) d orbitals, most of the transition metal ions and their compounds are paramagnetic. Paramagnetism increases with increases in number of unpaired electrons. Magnetic moment is calculated from 'Spin only formula' viz.

$$\mu = \sqrt{n(n+2)}\ \text{B.M}\quad n = \text{number of unpaired electrons}$$

Similarly the colour of the compounds of transition metals may be attributed to the presence of incomplete (n–1)d sub-shell. When an electron from a lower energy of d-orbital is excited to a higher energy d-orbital, the energy of excitation corresponds to the frequency of light absorbed. This frequency generally lies in the visible region. The colour observed corresponds to complementary colour of the light absorbed. The frequency of the light absorbed is determined by the nature of the ligand.

1. Which of the following pair of compounds is expected to exhibit same colour in aqueous solution.

(A) $FeCl_2$, $CuCl_2$ **(B)** $VOCl_2$, $CuCl_2$ **(C)** $VOCl_2$, $FeCl_2$ **(D)** $FeCl_2$, $MnCl_2$

2. Titanium shows magnetic moment of 1.73 BM in its compound. What is the oxidation state of titanium in the compound ?

(A) +2 **(B)** +1 **(C)** +3 **(D)** +4

3. The colourless species is :

(A) VCl_3 **(B)** $VOSO_4$ **(C)** Na_3VO_4 **(D)** $[V(H_2O)_5SO_4]2H_2O$

4. Identify the incorrect statement.

(A) Mn^{2+} has the highest paramagnetism amongst the bivalent cations of the Ist transition series.
(B) The coloured ions or compounds of transition elements are due to d-d transition and charge transfer spectrum.
(C) In 3 d series the paramagnetic character first increase to maximum & then starts decreasing.
(D) None of these

Comprehension # 3

Transition metals usually form coloured complexes and d – d transitions ($t_{2g} \rightleftharpoons e_g$) are responsible for colour as the energy difference between t_{2g} and e_g lies in visible region. But all the coloured ions are not due to d–d transition but charge transfer bands also play important roles. Charge transfer bands may be of two types.
(i) ligand to metal (CTLM) (ii) metal to ligand (CTML).
Charge transfer transition always produces intense colour as compared to d-d transition.

1. Select the incorrect statement :

(A) d-block metal ions are usually coloured.
(B) Colour of the most of d-block metal ions is generally due to d-d transition.
(C) All the complexes of Cu^+ are colourless on account of diamagnetic nature i.e. d^{10} configuration.
(D) CrO_3 is bright orange due to CTLM.

2. MnO_4^- is dark purple coloured although Mn is in (+ VII) oxidation state with $3d^0$ configuration :

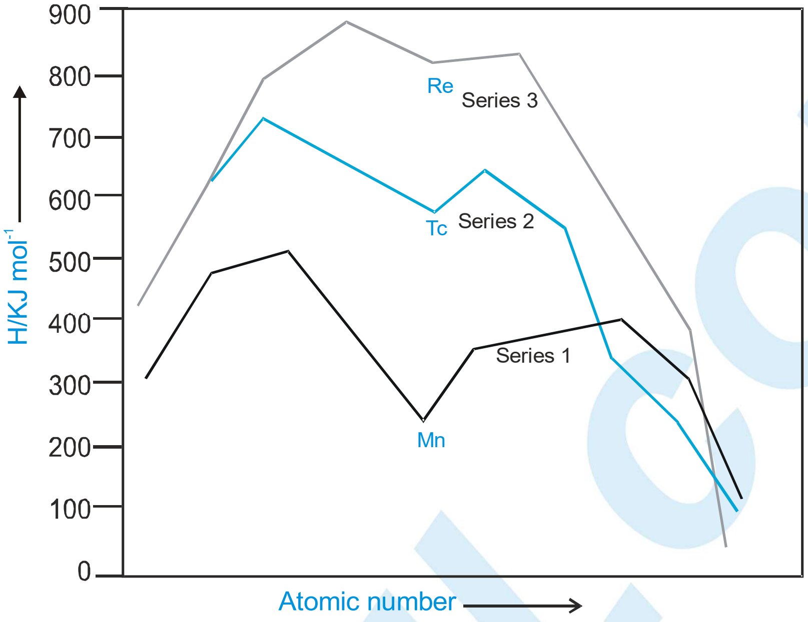
(A) due to d-d transition. **(B)** due to CTML spectra.
(C) due to CTLM spectra **(D)** none of these.

3. Select the correct statement.

(A) In CTML, no net reduction-oxidation takes place because of the short life time of excited state.
(B) Cu_2O is a red coloured salt.
(C) Vermilon (HgS) is a red coloured compound.
(D) All of these.

Comprehension # 4

Read the following graph and gives the answer for the following questions.



Trends in enthalpies of atomisation of transition elements

1. The dip in the boiling point of manganese in 3d series is due to :

(A) less delocalisation of valence electrons owing to extra stable half filled configuration.

(B) smaller size of atom.

(C) less electronegativity of atom.

(D) all of these

2. Consider the following statements :

(I) The transition elements (except the 12th group elements) are very much hard and have low volatility.

(II) Generally in a given series the melting points of the transition elements rises to a maximum and then fall as the atomic number increases.

(III) Transition metals have high thermal and electrical conductivity and metallic luster.

Select the correct from the codes given.

(A) I and III only **(B)** II and III only **(C)** All of these **(D)** None of these

Comprehension # 5

Pyrolusite ore on oxidation with $KClO_3/KNO_3$ in basic medium produces dark green coloured compound (A), which on electrolysis produces a purple coloured compound (B). The purple coloured compound can be crystallised to deep purple rhombic prisms. It shows different reactions in different mediums.

Excess of compound (B) on heating with concentrated H_2SO_4 gives an explosive oil (C), which on heating decomposes to gives another compound (D) along with oxygen.

1. The nature of compound **(C)** is :

(A) basic **(B)** acidic **(C)** neutral **(D)** amphoteric

2. On passing CO_2 in the solution of (A), a purple coloured solution along with brown precipitate is observed. Select the correct statement.

(A) This is a disproportionation reaction where oxidation number changes from +6 to +7 , +4.

(B) This is a comproportionation reaction where oxidation number changes from +3 to +2.

(C) both **(A)** and **(B)**

(D) none

3. Identify **(D)** .

(A) Mn_2O_7 **(B)** MnO_2 **(C)** $MnSO_4$ **(D)** Mn_2O_3

4. When **(D)** reacts with PbO_2/HNO_3 it produces a purple/pink coloured compound (E). Identify (E).

(A) $NaMnO_4$ **(B)** $Mn(OH)_2$ **(C)** $HMnO_4$ **(D)** Na_2MnO_4

5. Red coloured oxide (M) whose cation has pseudo inert electronic configuration reacts with compound (B) in acidic medium gives another oxide (N) which is black in colour. When sulphate of its metal is reacted with $K_4[Fe(CN)_6]$ it produces brown precipitate. Select the correct statement.

(A) The brown precipitate formed is $Cu_2[Fe(CN)_6]$

(B) The red coloured oxide is Cu_2O

(C) The black coloured oxide is CuO

(D) All of these

Comprehension # 6

Photography is based on the nature of silver halides. Except AgF, the silver halides are photosensitive. These undergo decomposition in light and turn black due to formation of free silver.

$$2AgBr \xrightarrow{\text{Light}} 2Ag + Br_2$$

The photographic plates or films are prepared in a dark and dust free room by applying a light sensitive mixture called emulsion which is prepared by adding 20 per cent aqueous solution of silver nitrate to ammonium bromide solution containing gelatin.

When such a film is exposed, the emulsion gets affected. Since different parts of the body reflect light of varied intensity, the film or plate is affected proportionately. An actual but inverted image of the object is thus formed on the film or plate which is not visible to the eye. It is, therefore, called the latent image.

When this exposed film or plate is dipped in a developer which contains a reducing agent, the parts affected most during exposure are reduced to maximum. The image becomes visible. It is called a negative. The remaining sensitive emulsion on the negative is removed by dissolving it in hypo solution (fixer). Finally, a positive of the negative already prepared is made on silver bromide paper.

1. The compound formed on the unexposed photographic film or plate is :

(A) silver nitrate. **(B)** ammonium bromide.

(C) diamminesilver bromide. **(D)** silver bromide.

2. The exposed part of the film or plate after developing contains :

(A) silver metal **(B)** silver oxide **(C)** silver bromide **(D)** silver nitrate.

3. The solution of the developer consists :

(A) alkaline solution of pyrogallol **(B)** alkaline solution of quinol

(C) either **(A)** or **(B)** **(D)** neither **(A)** nor **(B)**.

4. Silver halides are used in photography because these compounds :

(A) are insoluble in water

(B) are affected by light

(C) are soluble in ammonia solution

(D) easily stick on the surface of photographic plate or film

5. Silver bromide dissolves in hypo solution forming :

(A) $Ag_2S_2O_3$ **(B)** Ag_2S **(C)** $Na_3[Ag(S_2O_3)_2]$ **(D)** $NaAgS_2O_3$

Exercise # 4 [Subjective Type Questions]

1. Why are Mn^{2+} compounds more stable than Fe^{2+} towards oxidation to their +3 state?

2. How is the variability in oxidation states of transition metals different from that of the non transition metals? Illustrate with examples.

3. Which metal in the first series of transition metals exhibits +1 oxidation state most frequently and why?

4. Between Na^+ and Ag^+, which is stronger Lewis acid and why?

5. Why the highest oxidation state of a metal is exhibited in its oxide or fluoride only?

6. What may be the stable oxidation state of the transition element with the following d electron configurations in the ground state of their atoms: $3d^3$, $3d^5$, $3d^8$ and $3d^4$?

7. The E^θ (M^{2+}/M) value for copper is positive (+0.34V). What is possibly the Statement-2 for this?

8. Why is the E^θ value for the Mn^{3+}/Mn^{2+} couple much more positive than that for Cr^{3+}/Cr^{2+} or Fe^{3+}/Fe^{2+}? Explain.

9. Which is a stronger reducing agent Cr^{2+} or Fe^{2+} and why?

10. Copper dissolves in dilute nitric acid but not in dilute HCl. Why?

11. Blue colour of $CuSO_4$ solution is discharged slowly when an iron rod is dipped into it. Why?

12. Copper (I) salts are not known in aqueous solutions.

13. Explain why Cu^+ ion is not stable in aqueous solutions?

14. The aqueous solution of $FeCl_3$ is acidic. Why?

15. Ferric iodide is very unstable but ferric chloride is not.

16. Calculate the number of unpaired electrons in the following gaseous ions: Mn^{3+}, Cr^{3+}, V^{3+} and Ti^{3+}. Which one of these is the most stable in aqueous solution?

17. Mercurous ion is written as Hg_2^{2+} whereas cuprous ion is written as Cu^+. Explain.

18. Copper sulphate dissolves in NH_4OH solution but $FeSO_4$ does not.

19. A hydrated metallic salt (A), light green in colour, on careful heating gives a white anhydrous residue (B), (B) is soluble in water and its aqueous solution gives a dark blue precipitate (C) with potassium hexacyanidoferrate(III). (B) on strong heating gives a brown residue (D) and a mixture of two gases (E) and (F). The gaseous mixture when passed through acidified potassium dichromate, produces green colour solution and when passed through lead acetate solution gave a white precipitate. Out of two gases (E) can act as both reducing as well as oxidising agent.
(a) Identify (A), (B), (C), (D), (E) and (F) and give the reactions involved.
(b) Explain why salt (A) becomes white on heating.

20. A white substance (A) reacts with dilute H_2SO_4 to produce a colourless suffocating gas (B) and a colourless solution (C). The reaction of gas (B) with potassium iodate and starch solution produces a blue colour solution. Aqueous solution of (A) gives a white precipitate with $BaCl_2$ solution which is soluble in dilute HCl. Addition of aqueous NH_3 or NaOH to (C) produces first a precipitate which dissolves in excess of the respective reagent to produce a clear solution. Similarly addition of excess of potassium ferrocyanide to (C) produces a precipitate (D) which also dissolves in aqueous NaOH giving a clear solution. Identify (A), (B), (C) and (D). Write the equations of the reactions involved.

21. Write the balanced chemical equation for the following reaction :-
Nitrogen is obtained in the reaction of aqueous ammonia with potassium permanganate

22. An aqueous solution of inorganic compound **(X)** gives following reactions.
(i) With an aqueous solution of barium chloride a precipitate insoluble in dilute HCl is obtained.
(ii) Addition of excess of KI gives a brown precipitate which turns white on addition of excess of hyposolution.
(iii) With an aqueous solution of $K_4[Fe(CN)_6]$, a brown coloured precipitate is obtained.
Identify (X) and give equations for the reaction for **(i), (ii)** and **(iii)** observations.

23. H_2S gas is passed through an acidic solution of $K_2Cr_2O_7$. The solution turns milky, why?

24. What happens when **(i)** a small amount of $KMnO_4$ is added to concentrated H_2SO_4 **(ii)** an excess amount of $KMnO_4$ is added to concentrated H_2SO_4 solution.

25. Complete and / balance the following equation :
$Ag_2S + CuCl_2 + Hg$ ....+.................+ S + 2Ag

26. Which out of the two, $La(OH)_3$ and $Lu(OH)_3$, is more basic and why ?

27. One among the lanthanoides, Ce(III), can be easily oxidized to Ce(IV) (At. No. of Ce = 58). Explain why ?

28. Transition metals forms a large number of interstitial compounds. Explain.

29. Explain the large difference in melting point of Cr(1920ºC) and Zn(420ºC).

30. Although Cu^+ does not exist in solution state, but $CuCl_{(s)}$ is formed in presence of Cl^- ions in aqueous solution of $Cu_{(s)}$ and Cu^{2+}.

31. Atomic radius in a transition series does not vary much while that of s and p-block does. Why ?

32. The paramagnetic character in 3d transition series increases upto Cr and then decreases. Explain.

33. The ionisation energies of first five members of 3d-series increase with increase in atomic number and then become constant or irregular for next five members. Explain.

34. Pyrolusite on heating with KOH in the presence of air gives a dark green compound (A). The solution of (A) on treatment with H_2SO_4 gives a purple coloured compound (B), which gives following reactions :
(i) KI on reaction with alkaline solution of (B) changes into a compound (C).
(ii) The colour of the compound (B) disappears on treatment with the acidic solution of $FeSO_4$.
(iii) With concentrated H_2SO_4 compound (B) gives (D) which can decompose to yield (E) and oxygen on heating.
Identify (A) to (E) and write balanced chemical equations for the formation of (A) and (B) and for the steps **(i)** to **(iii)**.

35. A black compound (A) in solid state is fused with KOH and $KClO_3$. The aqueous extract of fused mass is green colour solution (B). On passing CO_2 gas through it pink colour of (C) is noticed along with some black insoluble mass of (A). The pink coloured solution is decolourised by Fe^{2+} in acidic medium. What are (A) (B) and (C).

36. **(i)** An ore (A) on roasting with sodium carbonate and lime in the presence of air gives two compounds, (B) and (C).
(ii) The solution of (B) in conc. HCl on treatment with potassium ferrocyanide gives a blue colour or precipitate of compound (D).
(iii) The aqueous solution of (C) on treatment with conc. H_2SO_4 gives a yellow coloured compound (E).
(iv) Compound (E) when treated with KCl gives an orange-red compound (F) which is used as an oxidising agent.
(v) The solution of (F) on treatment with oxalic acid and then with an excess of potassium oxalate gives blue/violet crystals of compound (G).
Identify (A) to (G) and give balanced chemical equations for reactions at steps (i) to (v).

37. Compound (A) is a light green crystalline solid. It gives the following tests.

(i) Compound (A) is heated strongly. Gases (B) and (C) with pungent smell come out. A brown residue (D) is left behind.

(ii) It dissolves in dilute sulphuric acid. No gas is produced.

(iii) A drop of $KMnO_4$ is added to the above solution. The pink colour disappears.

(iv) The gas mixture (B and C) is passed into a dichromate solution. The solution turns green.

(v) The green solution from step **(iv)** gives a white precipitate (E) with a solution of barium nitrate.

(vi) Residue (D) from step **(i)** is heated on charcoal in a reducing flame. It gives a magnetic substance. Name the compounds (A), (B), (C), (D) and (E).

38. Cuprous chloride is insoluble in water and dilute HCl but dissolves in concentrated HCl.

39. **(i)** A blue coloured compound (A) on heating gives two products, (B) and (C).

(ii) A metal (D) is deposited on passing hydrogen through heated (B).

(iii) The solution of (B) in HCl on treatment with $K_4[Fe(CN)_6]$ gives a chocolate brown coloured precipitate of compound (E).

(iv) (C) turns lime water milky which disappears on continuous passage of (C) forming a compound (F).

Identify (A) to (F) and give chemical equations for the reactions at steps **(i)** to **(iv)**.

40. The $Cr_2O_7^{2-}$ ion is a powerful oxidant in acidic medium but is weak oxidant in basic medium.

41. Anhydrous $FeCl_3$ cannot be obtained by heating hydrated ferric chloride. Why ?

42. $FeCl_3$(aq.) gives CO_2 with $NaHCO_3$(aq.). Explain.

43. Why is $AgNO_3$ also called lunar caustic ?

44. Hydrated zinc chloride cannot be dehydrated on heating.

45. Compete the following by identifying (A) to (H)

(i) $CuSO_4.5H_2O \xrightarrow{100°C} \textbf{(A)} \xrightarrow{230°C} \textbf{(B)} \xrightarrow{800°C} \textbf{(C)} + \textbf{(D)}.$

(ii) $AgNO_3 \xrightarrow{\text{Red heat}} \textbf{(E)} + \textbf{(F)} + O_2$.

46. Why is $AgNO_3$ kept in brown coloured bottles ?

Exercise # 5

Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

1. Cerium (Z = 58) is an important member of the lanthanoide. Which of the following statement about cerium is incorrect? **[AIEEE 2004]**

(1) The common oxidation state of cerium are +3 and +4.

(2) The +3 oxidation state of cerium is more stable than +4 oxidation state.

(3) The +4 oxidation state of cerium is not known in solution.

(4) Cerium (IV) acts as an oxidizing agent.

2. The lanthanide contraction is responsible for the fact that **[AIEEE 2005]**

(1) Zr and Y have about the same radius **(2)** Zr and Nb have similar oxidation state

(3) Zr and Hf have about the same radius **(4)** Zr and Zn have same oxidation state.

3. Which of the following factors may be regarded as the main cause of lanthanide contraction ?

(1) Greater shielding of 5d electrons by 4f electrons **[AIEEE 2005]**

(2) Poorer shielding of 5d electron by 4f electrons

(3) Effective shielding of one of 4f electrons by another in the sub-shell

(4) Poor shielding of one of 4f electron by another in the sub-shell.

4. The "spin-only" magnetic moment [in units of Bohr magneton, (μ_B) of Ni^{2+} in aqueous solution would be (atomic number of Ni = 28) **[AIEEE 2006]**

(1) 2.84 **(2)** 4.90 **(3)** 0 **(4)** 1.73

5. Lanthanoid contraction is caused due to : **[AIEEE 2006]**

(1) the appreciable shielding on outer electrons by 4*f* electrons from the nuclear charge

(2) the appreciable shielding on outer electrons by 5*f* electrons from the nuclear charge

(3) the same effective nuclear charge from Ce to Lu

(4) the imperfect shielding on outer electrons by 4f electrons from the nuclear charge

6. Identify the incorrect statement among the following. **[AIEEE 2007]**

(1) The chemistry of various lanthanoids is very similar.

(2) 4f and 5f orbitals are equally shielded.

(3) d-block elements show irregular and erratic chemical properties among themselves.

(4) La and Lu have partially filled d orbitals and no other partially filled orbitals.

7. The actinoids exhibit more number of oxidation states in general than the lanthanoids. This is because

(1) The actinoids are more reactive than the lanthanoids. **[AIEEE 2007]**

(2) The 5f orbitals extend farther from the nucleus than the 4f orbitals.

(3) The 5f orbitals are more buried than the 4f orbitals

(4) There is a similarity between 4f and 5f orbitals in their angular part of the wave function

8. Larger number of oxidation states are exhibited by the actinoids than those by the lanthanoids, the main reason being. **[AIEEE 2008]**

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

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

(3) more reactive nature of the actinoids than the lanthanoids

(4) 4f orbitals more diffused than the 5f orbitals

9. In context with the transition elements, which of the following statements is incorrect ? **[AIEEE 2009]**

(1) In the highest oxidation states, the transition metal show basic character and form cationic complexes.
(2) In the highest oxidation states of the first five transition elements (Sc to Mn), all the 4s and 3d electrons are used for bonding.
(3) Once the d^5 configuration is exceeded, the tendency to involve all the 3d electrons in bonding decreases.
(4) In addition to the normal oxidation states, the zero oxidation state is also shown by these elements in complexes.

10. Knowing that the Chemistry of lanthanoids (Ln) is dominated by its +3 oxidation state, which of the following statement is incorrect ? **[AIEEE 2009]**

(1) The ionic sizes of Ln (III) decrease in general with increasing atomic number.
(2) Ln (III) compounds are generally colourless.
(3) Ln (III) hydroxides are mainly basic in character
(4) Because of the large size of the Ln (III) ions the bonding in its compounds is predominently ionic in character.

11. The correct order of $E^{\circ}_{M^{2+}/M}$ values with negative sign for the four successive elements Cr, Mn, Fe and Co is

[AIEEE 2010]

(1) Mn > Cr > Fe > Co **(2)** Cr > Fe > Mn > Co **(3)** Fe > Mn > Cr > Co **(4)** Cr > Mn > Fe > Co

12. In context of the lanthanoids, which of the following statement is not correct ? **[AIEEE 2011]**

(1) There is a gradual decrease in the radii of the members with increasing atomic number in the series.
(2) All the member exhibit +3 oxidation state.
(3) Because of similar properties the separation of lanthanoids is not easy.
(4) Availability of 4f electrons results in the formation of compounds in +4 state for all the members of the series.

13. The outer electron configuration of Lu (Atomic No : 71) is : **[AIEEE 2011]**

(1) $4f^3\,5d^5\,6s^2$ **(2)** $4f^8\,5d^0\,6s^2$ **(3)** $4f^4\,5d^4\,6s^2$ **(4)** $4f^{14}\,5d^1\,6s^2$

14. Iron exhibits +2 and + 3 oxidation states. Which of the following statements about iron is incorrect ?

(1) Ferrous oxide is more basic in nature than the ferric oxide. **[AIEEE 2012]**
(2) Ferrous compounds are relatively more ionic than the corresponding ferric compounds
(3) Ferrous compounds are less volatile than the corresponding ferric compounds
(4) Ferrous compounds are more easily hydrolysed than the corresponding ferric compounds.

15. Which of the following arrangements does not represent the correct order of the property stated against it ?

(1) $V^{2+} < Cr^{2+} < Mn^{2+} < Fe^{2+}$: paramagnetic behaviour **[JEE(Mains) 2013]**
(2) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$: ionic size
(3) $Co^{3+} < Fe^{3+} < Cr^{3+} < Sc^{3+}$: stability in aqueous solution
(4) Sc < Ti < Cr < Mn : number of oxidation states

16. Four successive members of the first row transition elements are listed below with atomic numbers. Which one of them is expected to have the highest $E^{0}_{M^{3+}/M^{2+}}$ value ? **[JEE(Mains) 2013]**

(1) Cr(Z = 24) **(2)** Mn(Z = 25) **(3)** Fe(Z = 26) **(4)** Co(Z = 27)

Part # II [Previous Year Questions][IIT-JEE ADVANCED]

1. The product of oxidation of I^- with MnO_4^- in alkaline medium is : **[JEE 2004]**

(A) IO_3^- **(B)** I_2 **(C)** IO^- **(D)** IO_4^-

2. The pair of compounds having metals in their highest oxidation state is : **[JEE 2004]**

(A) MnO_2, $FeCl_3$ **(B)** $[MnO_4]^-$, CrO_2Cl_2

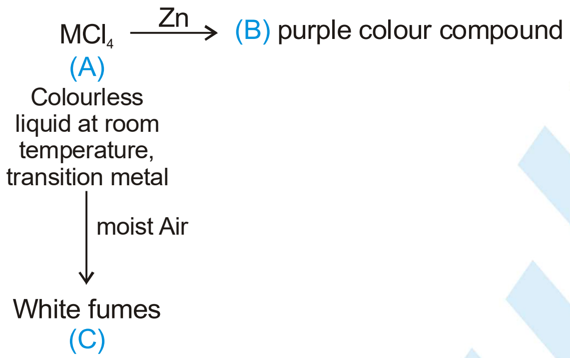
(C) $[Fe(CN)_6]^{2-}$, $[Co(CN)_6]^{3-}$ **(D)** $[NiCl_4]^{2-}$, $[Ni(CO)_4]$.

3. Which of the following pair of compounds is expected to exhibit same colour in aqueous solution ? **[JEE 2005]**

(A) $FeCl_3$, $CuCl_2$ **(B)** $VOCl_2$, $CuCl_2$ **(C)** $VOCl_2$, $FeCl_2$ **(D)** $FeCl_2$, $MnCl_2$

4. Give equations and describe the process for the developing of black and white photographic film. When sodium thiosulphate solution is treated with acidic solution turns milky white. Give the half reaction of the above described process. **[JEE 2005]**

5.



Identify **(A)**, **(B)** and **(C)**. Also explain colour difference between MCl_4 and **(B)**. **[JEE 2005]**

6. Match the reactions in Column I with nature of the reactions/type of the products in Column II. **[JEE 2007]**

	Column I		Column II
(A)	$O_2^- \rightarrow O_2 + O_2^{2-}$	**(p)**	Redox reaction
(B)	$CrO_4^{2-} + H^+ \rightarrow$	**(q)**	One of the products has trigonal planar structure
(C)	$MnO_4^- + NO_2^- + H^+ \rightarrow$	**(r)**	Dimeric bridged tetrahedral metal ion
(D)	$NO_3^- + H_2SO_4 + Fe^{2+} \rightarrow$	**(s)**	Disproportionation

7. Among the following, the coloured compound is : **[JEE 2008]**

(A) CuCl **(B)** $K_3[Cu(CN)_4]$ **(C)** CuF_2 **(D)** $[Cu(CH_3CN)_4]BF_4$

8. The oxidation number of Mn in the product of alkaline oxidative fusion of MnO_2 is. **[JEE 2009]**

9. Reduction of the metal centre in aqueous permanganate ion involves : **[JEE 2011]**

(A) 3 electrons in neutral medium **(B)** 5 electrons in neutral medium

(C) 3 electrons in alkaline medium **(D)** 5 electrons in acidic medium

10. The colour of light absorbed by an aqueous solution of $CuSO_4$ is : **[JEE 2012]**

(A) organge-red **(B)** blue-green **(C)** yellow **(D)** violet

11. Which of the following halides react(s) with $AgNO_3(aq)$ to give a precipitate that dissolves in $Na_2S_2O_3(aq)$?

(A) HCl **(B)** HF **(C)** HBr **(D)** HI **[JEE 2012]**

MOCK TEST

SECTION - I : STRAIGHT OBJECTIVE TYPE

1. In which compound does vanadium have an oxidation number of +4?
(A) $NH_4\ VO_2$ **(B)** $K_4[V(CN)_6]$ **(C)** VSO_4 **(D)** $VOSO_4$

2. In which of the following oxoanion the oxidation state of central atom is not same as that of its group number in the periodic table?
(A) MnO_4^- **(B)** $Cr_2O_7^{-2}$ **(C)** VO_4^{3-} **(D)** FeO_4^{2-}

3. Which of the following statements is incorrect?
(A) Transition elements exhibit higher enthalpies of atomization as they have stonger interatomic interaction.
(B) IE_2 of ${}_{23}V < {}_{24}Cr > {}_{25}Mn$ and ${}_{28}Ni < {}_{29}Cu > {}_{30}Zn$.
(C) Ni(II) compounds are more stable than Pt(II) where as Pt (IV) compounds are more stable than Ni(IV).
(D) The elements which give the greatest number of oxidation states do not occur in or near the middle of the series.

4. At 300°C, $FeCl_3$:
(A) Decomposes into $FeCl_2$ and Cl_2 **(B)** Decomposes into Fe and Cl_2
(C) Sublimes to give liquid $FeCl_3$ **(D)** Sublimes to give gaseous dimer $(FeCl_3)_2$

5. $FeCr_2O_4 + Na_2CO_3 + O_2 \xrightarrow{\text{Fusion}} [X] \xrightarrow[H_2O]{H^+} [Y] \xrightarrow[H_2O_2]{H^+} [Z]$

Which of the following statements are true for compounds [X], [Y] and [Z] ?
(A) In all three compounds, the chromium is in +6 oxidation state.
(B) [Z] is a deep-blue violet coloured compound which decomposes rapidly in aqueous solution into Cr^{+3} and dioxygen.
(C) Saturated solution of [Y] gives bright orange compound, chromic anhydride, with conc. H_2SO_4
(D) All of the above

6. $FeCl_3.6H_2O + C(CH_3)_2(CH_3O)_2 \rightarrow$ Products
Reaction product are :
(A) $FeCl_3$, CH_3OH and CH_3COCH_3 **(B)** $(CH_3O)_3Fe$, HCl and H_2O
(C) FeCl2, HCl and CH_3COCH_3 **(D)** $Fe(OH)_3$, $FeCl_3$ and CH_3COCH_3

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

7. Pyrolusite is MnO_2 used to prepare $KMnO_4$. Steps are, $MnO_2 \xrightarrow{I} MnO_4^{2-} \xrightarrow{II} MNO_4^-$.
Stesp I and II are respectively :
(A) fuse with KOH/ air and electrolytic oxidation
(B) fuse with KOH/KNO_3 and electrolytic oxidation
(C) fuse with conc. HNO_3/air and electrolytic reduction
(D) dissolve in H_2O and oxidation

8. Which of the following chemical reaction(s) is(are) involed in the developing of photographic plate?
(A) $C_6H_4(OH)_2 + 2AgBr \rightarrow 2Ag + C_6H_4O_2 + 2HBr$ **(B)** $AgBr + 2Na_2S_2O_3 \rightarrow Na_3[Ag(S_2O_3)_2] + NaBr$
(C) $AgBr + 2NH_3(aq) \rightarrow [Ag(NH_3)_2]Br$ **(D)** $2AgBr + Na_2S_2O_3 \rightarrow Ag_2S_2O_3 + 2NaBr$

9. The hydrated cupric chloride is strongly heated. Which of the following statement(s) is (are) correct for this :
(A) It is reduced to Cu_2Cl_2 **(B)** Cupric oxide is formed along wiht Cu_2Cl_2
(C) Only Cl_2 is liberated **(D)** Cl_2 and HCl both are liberated

10 Potassium manganate (K_2MnO_4) is formed. When :
(A) cuprous oxide reacts iwth alkaline $KMnO_4$ solution
(B) manganese dioxideis fused with K_2CO_3 in presence of KNO_3.
(C) formaldehyde reacts with potassium permanganate in presence of concentrated potassium hydroxide solution.
(D) potassium permanganate is heated with potassium hydroxide.

SECTION - III : ASSERTION AND REASON TYPE

11. **Statement -1** : The value of enthalpy of atomisation is generally maximum at about the middle of each series.
Statement - 2 : There is one unpaired electron per d-orbital and this results in stronger interatomic interaction.
(A) Statement - 1 is True, Statement-2 is True, Statemen-2 is a correct explanatio for Statement-1.
(B) Statement-2 is True, Statement-2 is True, Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

12. **Statement-1** : To a solution of potassium chromate if a strong acid is added it changes its colour from yellow to organce.
Statement - 2 : The colour change is due to hte oxidation of potassium chromate.
(A) Statemen-1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True, Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False.
(D) Statement-1 is False, Statement-2 is True

Consider the following statements and arrange in the order of true/false as given in the codes.

13. **S1** : Interstitial compounds have high melting points, higher than thoses of pure metals.
S2 : Permangnate titrations in presence of hydrochloric acid are unsatisfactory.
S3 : $KMnO_4$ does not act as an oxidising agent in strong alkaline medium.
S4 : $KMnO_4$ on heating in current of H_2 gives MnO.
(A) T T F T **(B)** T F F T **(C)** T F T T **(D)** F F T F

14. **S1** : Mn^{2+} compounds more stable than Fe^{2+} towards oxidation to their +3 state.
S2 : Titanium and copper both in the first series of transition metals exhibits +1 oxidation state most frequently.
S3 : Cu^{+} ion is stable in aqueous solutions.
S4 : The E° value for the Mn^{3+}/Mn^{2+} couple much more positive than that for Cr^{3+} / Cr^{2+} or Fe^{3+} / Fe^{2+}
(A) T T F T **(B)** T F F T **(C)** T F T T **(D)** F F T F

SECTION - IV : COMPREHENSION TYPE

Read the following comprehensions carefully and answer the questions.

Comprehension # 1

The (n–1) d shel of electrons in d-block elements is expanding and, therefore, they have many physical and chemical properties in common. They show variable oxidation state and all are metals. The transition elements i.e. d-block elements show an unparalled tendency to form coordination compounds with those groups whihc are able to donate an electron pair (i.e. lewis base).

15. Which oneis most acidic?
(A) Cr_2O_3 **(B)** V_2O_5 **(C)** Mn_2O_7 **(D)** Fe_2O_3

16. Which of the following statement is incorrect?

(A) Across a period from Sc toCu the densities increase with increasing atomic number

(B) The melting point of transition elements rise to a maximum from Sc to Cr and then decreases from Fe to Zn.

(C) Transition elements have high entahlpies of atomization and in 3d series increases regularly from Sc to Cu.

(D) On going down a group from 3d to 6d series the stability of higher oxidation state increases with increasing atomic number.

17. Which of the following products are obtained when Na_2CO_3 is added to a solution of copper sulphate?

(A) Basic coper carbonate [$CuCO_3Cu(OH)_2$], sodium sulphate and CO_2.

(B) Copper hydroxide, sodium sulphate and CO_2.

(C) Copper carbonate sodium sulphate and CO_2.

(D) Copper carbonate and sodium sulphate.

Comprehension # 2

Paramagnetism is a property due to the presence of unpaired electrons. In case of transition metals, as they contain unpaired electrons in the (n – 1) d orbitals, most of the transition metal ions and their compounds are paramagnetic. Paramagnetism increases with increases in number of unpaired electrons. Magtnetic moment is calculated from 'Spin only formula' viz.

$\mu = \sqrt{n(n+2)}$ B.M. = n = no. of unpaired electrons

Similarly the colour of the compounds of transitions metals may be attributed to the presence of incomplete (n –1) d subshell. When an electron froma lower energy of d-orbital is excited to a higher energy d-orbital, the energy of excitation corresponds to the frequency of light absorbed. This frequence generally lies in the visible region. The colour observed corresponds to complementary colour of the light absorbed. The frequency of the light absorbed is determined by the nature of the ligand.

18. Which of the following of compounds is expected to exhibit same colour in aqueous solution.

(A) $FeCl_2$, $CuCl_2$ **(B)** $VOCl_2$, $CuCl_2$ **(C)** $VOCl_2$, $FeCl_2$ **(D)** $FeCl_2$, $MnCl_2$

19. Titanium shows magnetic moment of 1.73 BM in its compound. What is the oxidation state of titanium in the compound?

(A) +2 **(B)** +1 **(C)** +3 **(D)** +4

20. Identify the incorrect statement.

(A) Mn^{2+} has the highest paramagnetism amongst the bivalent cations of the Ist transition series.

(B) The coloured ions or compounds of transition elements are due to d-d transition and charge transfer spectrum.

(C) In 3 d series the paramagnetic character first increase to maximum & then starts decreasing

(D) None of these

Comprehension # 3

(I) A powdered substanced (A) on treatment with fusion gives a green coloured compound (B).

(II) The solution of (B) in boiling water on acidification with dilute H_2SO_4 gives a pink coloured compound (C)

(III) The aqueous solution of (A) on treatment iwth NaOH and Br_2– water gives a compound (D).

(IV) A solution of (D) in conc. HNO_3 on treatment with lead peroxide at boiling temperature produced a compound (E) which was of the same colour at that of (C).

(V) A solution of (A) on treatment iwht a solution of barium chloride gave a white precipitate of compound (F) which was insoluble in conc. HNO_3 and conc. HCl.

21. Which of the following is true for compound (C).

(A) It oxidises ammonia to nitrogen dioxide in neutral medium

(B) It's pink colour is due to d-d transition.

(C) It can be oxidised by ozone.

(D) It is obtained by alkaline fusion of pyrolusite in presence of air followed by electrolytic oxidation.

22. The oxidation state of centre metal ions of (A), (B) and (C) compounds are respectively :

(A) + II, + VI and + VII **(B)** + II, + VI and + VI **(C)** + II, + VII and VII **(D)** + VI, + VII and + VII

23. Consider the following statements :

(I) Anions of both (B) and (C) are diamagnetic and have tetradedral geometry.

(II) Anions of both (B) and (C) are paramagnetic and have tetrahedral geometry.

(III) Anions of (B) and (C) are paramagnetic and have tetrahedral geometry.

(IV) Green coloured compound (B) in a neutral or acidic medium disproportionated to give (C) and (D).

Of these select the correct one from the codes given :

(A) I and III only **(B)** II and III only **(C)** II and IV only **(D)** III and IV only

SECTION - V : MATRIX - MATCH TYPE

24 Match the reactions in Column I with nature of the reactions/type of the products in Columns II.

Column I	Column II
(A) $MnO_4^{2-} + H^+ \rightarrow$	**(p)** One of the products of transition elementis paramagnetic
(B) $Cu^+(aq) \rightarrow$	**(q)** Disproportation reaction
(C) $Cr_2O_7^{2-}(s) + H^+(conc.) + Cl^-(s) \rightarrow$	**(r)** One of the products is liberated as coloured vapours.
(D) $Fe_2(SO_4)_3 + I^- \rightarrow$	**(s)** In one of the products central atom exhibits its highest oxidation state.

25 Match the reaction in Column I with type of the products/applications in Column II.

Column I	Column II
(A) $FeSO_4 \xrightarrow{\Delta}$	**(p)** One of the product is coloured due to charge transfer
(B) $Mn^{2+} + S_2O_8^{2-} + H_2O \rightarrow$	**(q)** One of the product is in + VI oxidation state
(C) $Na_2Cr_2O_7$(saturated salt) + H_2SO_4 (conc.) $\rightarrow$	**(r)** Redox reaction
(D) $N_2H_4 + CuSO_4 \rightarrow$	**(s)** One of the product is acidic oxide

26 Match the reaction in Column I with type of the products/applications in Column II.

Column I	Column II
(A)  (aq) + AgBr(s) $\rightarrow$	**(p)** Turnbull's blue pigment
(B) $BaCl_2$ (s) + $K_2Cr_2O_7$ (s) + H_2SO_4 (conc.) $\rightarrow$	**(q)** Schwitzer's reagent
(C) $FeSO_4$ (aq) + $K_3[Fe(CN)_6]$ (aq) $\rightarrow$	**(r)** Rinmann's green pigment
(D) $Cu(OH)_2$ (s) + NH_4OH (aq) + $(NH_4)_2SO_4$ (s) $\rightarrow$	**(s)** Chromyl chloride test
(E) ZnO (s) + $Co(NO_3)_2$ (s) $\xrightarrow{\Delta}$	**(t)** Photography

SECTION - VI : SUBJECTIVE TYPE

27. Write two compounds in which compound does vanadium have an oxidation number of +4?

28. How many elements are present in each transition series? Why this number can not be less or more?

29. Why do transition element exhibit higher enthalpies of atomisation ?

30. The second and third member in each group of transition elements have similar atomic radii. Explain why?

31. E° for Mn^{+3} / Mn^{+2} is more positive then for Fe^{+3} / Fe^{+2}. Account for this?

ANSWER KEY

EXERCISE - 1

1. C 2. C 3. B 4. C 5. B 6. A 7. C 8. A 9. D 10. C 11. B 12. B 13. A
14. C 15. C 16. D 17. C 18. C 19. C 20. A 21. D 22. D 23. D 24. B 25. D 26. B
27. B 28. C 29. D 30 B 31. B 32. D 33. C 34. A 35. D 36. A 37. A 38. A 39. B
40. A 41. D 42. C 43. B 44. B 45. C 46. A 47. A 48. B 49. C 50. D 51. D 52. A
53. C 54. D 55. D 56. B 57. A 58. A 59. A 60. A 61. C 62. B 63. A 64. A 65. C
66. D 67. C 68. B 69. A 70. C 71. C 72. C 73. C 74. B 75. D 76. D 77. A 78. C
79. A 80. C 81. B 82. A 83. A 84. A 85. B 86. A 87. A 88. C 89. C 90. A 91. C
92. B 93. C 94. C 95. B 96. D 97. B 98. A 99. D 100. C 101. C 102. D 103. A 104. A

EXERCISE - 2 : PART # I

1. A, B, D 2. D 3. B 4. A, D 5. A, B, C, D 6. A, B 7. A, B, C 8. A, B, C 9. A, B, D
10. A, B 11. A, B 12. A, B, C 13. A, B 14. A, D 15. A 16. A, B 17. A, B, C, D 18. B, C, D
19. B, D 20. A, B 21. A, B, D 22. A, B 23. A, B, D 24. A, B 25. B 26. A 27. A 28. B
29. C 30. C 31. A 32. A 33. D 34. D 35. B 36. D 37. C 38. B 39. C 40. C 41. D
42. D 43. A 44. A 45. B 46. B 47. C 48. C 49. A 50. A 51. D 52. D 53. B 54. A
55. A 56. D 57. C 58. A 59. A 60. A 61. D 62. A 63. C 64. D 65. C 66. A, C
67. A, C, D 68. A, B, C 69. A, B, C 70. A, B, C, D 71. A, B, C

PART # II

1. A 2. C 3. A 4. B 5. A 6. C 7. B 8. D 9. A 10. A 11. A 12. A 13. C
14. B 15. A 16. B 17. B 18. B 19. B 20. A 21. D 22. A 23. A 24. B 25. A 26. A
27. A 28. A

EXERCISE - 3 : PART # I

1. A → q, s; B → r, s ; C → p, s ; D → p, s 2. A → r, B → s ; C → p ; D → q
3. A → s ; B → q, r ; C → q, D → p 4. A → r, s ; B → r, s ; C → p, q ; D → p
5. A → r ; B → s ; C → p ; D → q 6. A → t ; B → s ; C → p ; D → q ; E → r
7. A → q, r, s ; B → p, q, r ; C → p, q, s ; D → q, r 8. A → q, s ; B → q ; C → p ; D → r.
9. A → r, s ; B → p, q ; C → p, r, s ; D → r, s.

PART # II

Comprehension # 1 : 1. D 2. A 3. B
Comprehension # 2 : 1. B 2. C 3. C 4. D
Comprehension # 3 : 1. C 2. C 3. D
Comprehension # 4 : 1. A 2. C
Comprehension # 5 : 1. B 2. A 3. B 4. C 5. D
Comprehension # 6 : 1. D 2. A 3. C 4. B 5. C

EXERCISE - 5 : PART # I

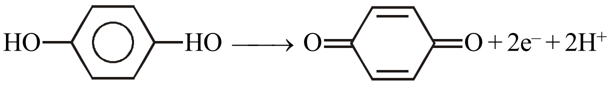
1. 3 **2.** 3 **3.** 4 **4.** 1 **5.** 4 **6.** 2 **7.** 2 **8.** 1 **9.** 1 **10.** 2 **11.** 1 **12.** 4 **13.** 4
14. 4 **15.** 1 **16.** 4

PART # II

1. A **2.** B **3.** B

4. Developer is usually a weak reducing agent like potassium ferrous oxalate, an alkaline solution of pyrogallol or an alkaline solution of quinol.

In the process of development of the photographic film, the exposed/activated AgBr grains are preferentially reduced by one of the reducing agent described above.



Hydroquinone Quinone

$AgBr + e^- \longrightarrow Ags + Br^-$

The photographic film is then fixed by washing with hypo solution to remove the unreduced AgBr grains from the film.

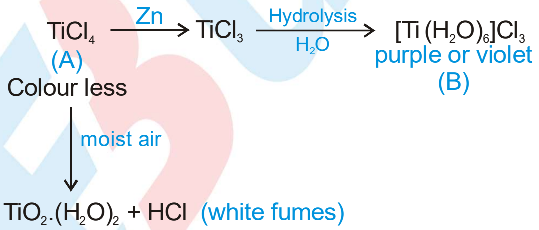
$AgBr + 2Na_2S_2O_3 \longrightarrow Na_3[Ag(S_2O_3)_2] + NaBr.$

$S_2O_3^{2-} + H_2O \longrightarrow 2SO_2 + 2H^+ + 4e^-.$

$S_2O_3^{2-} + 6H^+ \longrightarrow 2S\downarrow \text{(white milky)} + 3H_2O.$

5. (A) is $TiCl_4$ as it has no unpaired electron and is liguid at room temperature on account of covalent character because of high polarising power of Ti^{+4}. $TiCl_4$ being covalent gets hydrolysed forming $TiO_2(H_2O)_2$ and HCl (B) which fumes in air.

In $[Ti(H_2O)_6]Cl_3$ complex Ti(III) has one unpaired electron($3d^1$) which gives violet / purple colour due to d-d transition.



6. A → p, s; B → r ; C → p, q ; D → p. **7.** (C) **8.** 6 **9.** ACD **10.** A **11.** ACD

MOCK - TEST

1. D **2.** D **3.** D **4.** D **5.** D **6.** A **7.** A,B **8.** A,B **9.** A,B,D **10.** A,B,C,D **11.** A
12. C **13.** A **14.** B **15.** C **16.** C **17.** A **18.** B **19.** C **20.** D **21.** D **22.** A **23.** D
24. A → p, s ; B → r ; C → p, q ; D → p **25.** A → q, r, s ; B - p, q, r ; C - p, q, s 4 - q, r
26. A → t ; B → s ; C → p ; D → q ; E → r