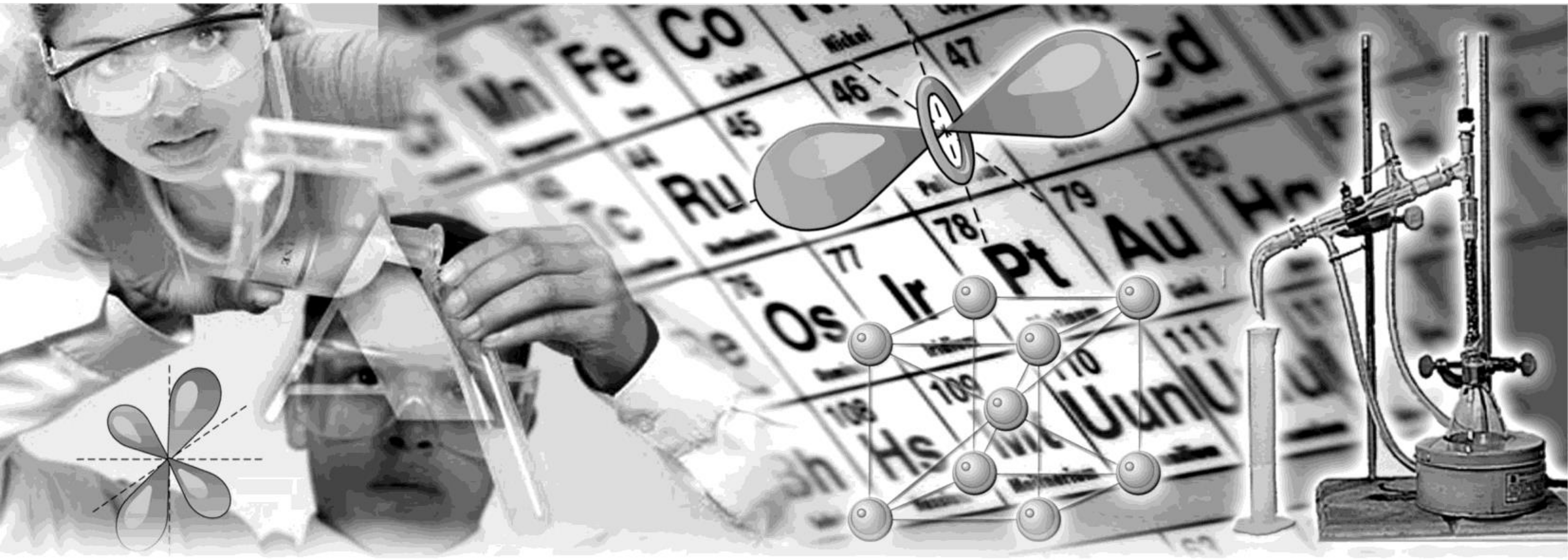


Chapter

19

d and *f*-Block Elements

d-Block elements

A transition element may be defined as an element whose atom in the ground state or ion in common oxidation state has ***incomplete sub-shell, has electron*** **1 *to* 9**. It is called transition element due to fact that it is lying between most electropositive (*s*-block) and most electronegative (*p*-block) elements and represent a transition from them. The ***general electronic configuration*** of these element is $(n-1)^{1\text{ to }10}\ ns^{0\text{ to }2}$.

The definition of transition metal excludes Zn, Cd and Hg because they have complete *d*- orbital. Their common oxidation state is $Zn^{++}, Cd^{++}, Hg^{++}$. They also do not show the characteristics of transition element. Element of group 3 (*Sc*, *Y*, *La* and *Ac*) and group 12 (Zn, Cd, Hg) are called **non typical transition element**.

Table : 19.1 First transition or 3*d* series :

Element	Symbol	At. No.	Electronic configuration
Scandium	*Sc*	21 3*d*-orbitals are filled up	$[Ar]\ 3d^1 4s^2$
Titanium	*Ti*	22	$[Ar]\ 3d^2 4s^2$
Vanadium	*V*	23	$[Ar]\ 3d^3 4s^2$
Chromium	*Cr**	24	$[Ar]\ 3d^5 4s^1$
Manganese	*Mn*	25	$[Ar]\ 3d^5 4s^2$
Iron	*Fe*	26	$[Ar]\ 3d^6 4s^2$
Cobalt	*Co*	27	$[Ar]\ 3d^7 4s^2$
Nickel	*Ni*	28	$[Ar]\ 3d^8 4s^2$
Copper	*Cu**	29	$[Ar]\ 3d^{10} 4s^1$
Zinc	*Zn*	30	$[Ar]\ 3d^{10} 4s^2$

Table : 19.2 Second transition or 4*d*-series :

Element	Symbol	At. No.	Electronic configuration
Yttrium	*Y*	39 4*d*-orbitals are filled up	$[Kr]\ 4d^1 5s^2$
Zirconium	*Zr*	40	$[Kr]\ 4d^2 5s^2$
Niobium	*Nb**	41	$[Kr]\ 4d^4 5s^1$
Molybdenum	*Mo**	42	$[Kr]\ 4d^5 5s^1$
Technetium	*Tc*	43	$[Kr]\ 4d^5 5s^2$
Ruthenium	*Ru**	44	$[Kr]\ 4d^7 5s^1$
Rhodium	*Rh**	45	$[Kr]\ 4d^8 5s^1$
Palladium	*Pd**	46	$[Kr]\ 4d^{10} 5s^0$
Silver	*Ag**	47	$[Kr]\ 4d^{10} 5s^1$
Cadmium	*Cd*	48	$[Kr]\ 4d^{10} 5s^2$

Table : 19.3 Third transition or 5*d*-series :

Element	Symbol	At. No.	Electronic configuration
Lanthanum	*La*	57 5*d*-orbitals are filled	$[Xe]\ 5d^1 6s^2$
Hafnium	*Hf*	72	$[Xe]\ 4f^{14} 5d^2 6s^2$
Tantalum	*Ta*	73	$[Xe]\ 4f^{14} 5d^3 6s^2$

Tungsten	*W*	74	$[Xe]\ 4f^{14}5d^{4}6s^{2}$
Rhenium	*Re*	75	$[Xe]\ 4f^{14}5d^{5}6s^{2}$
Osmium	*Os*	76	$[Xe]\ 4f^{14}5d^{6}6s^{2}$
Iridium	*Ir*	77	$[Xe]\ 4f^{14}5d^{7}6s^{2}$
Platinum	Pt^{*}	78	$[Xe]\ 4f^{14}5d^{10}6s^{0}$
Gold	Au^{*}	79	$[Xe]\ 4f^{14}5d^{10}6s^{1}$
Mercury	*Hg*	80	$[Xe]\ 4f^{14}5d^{10}6s^{2}$

Table : 19.4 Fourth transition or 6*d*-series :

Element	Symbol	At. No.		Electronic configuration
Actinium	*Ac*	89	6*d*-orbitals are filled up ↓	$[Rn]\ 6d^{1}7s^{2}$
Rutherfordium	*Rf*	104		$[Rn]\ 5f^{14}6d^{2}7s^{2}$
Hahnium	*Ha*	105		$[Rn]\ 5f^{14}6d^{3}7s^{2}$
Seaborgium	*Sg*	106		$[Rn]\ 5f^{14}6d^{4}7s^{2}$
Bohrium	*Bh*	107		$[Rn]\ 5f^{14}6d^{5}7s^{2}$
Hassium	*Hs*	108		$[Rn]\ 5f^{14}6d^{6}7s^{2}$
Meitnerium	*Mt*	109		$[Rn]\ 5f^{14}6d^{7}7s^{2}$
Ununnilium	*Uun*	110		$[Rn]\ 5f^{14}6d^{8}7s^{2}$
Unununium	*Uuu*	111		$[Rn]\ 5f^{14}6d^{9}7s^{2}$
Unubium	*Uub*	112		$[Rn]\ 5f^{14}6d^{10}7s^{2}$

Elements marked with asterisk have anomalous configurations. These are attributed to factors like nuclear-electron and electron-electron forces and stability of half filled and full filled orbital.

All transition elements are *d* block elements but all *d* block elements are not transition elements.

Physico-Chemical Properties of d-Block Elements

(1) **Atomic radii :** The atomic, radii of 3*d*-series of elements are compared with those of the neighbouring *s* and *p*-block elements.

K	*Ca*	*Sc*	*Ti*	*V*	*Cr*	*Mn*
227	197	144	132	122	117	117
Fe	*Co*	*Ni*	*Cu*	*Zn*	*Ga*	*Ge*
117	116	115	117	125	135	122*

* in pm units

The atomic radii of transition elements show the following characteristics,

(i) The atomic radii and atomic volumes of *d*-block elements in any series decrease with increase in the atomic number. The decrease however, is not regular. The atomic radii tend to reach minimum near at the middle of the series, and increase slightly towards the end of the series.

Explanation **:** When we go in any transition series from left, to right, the nuclear charge increases gradually by one unit at each elements. The added electrons enter the same penultimate shell, (inner *d*-shell). These added electrons shield the outermost electrons from the attraction of the nuclear charge. The increased nuclear charge tends to reduce the atomic radii, while the added electrons tend to increase the atomic radii. At the beginning of the series, due to smaller number of electrons in the *d*-orbitals, the effect of increased nuclear charge predominates, and the atomic radii decrease. Later in the series, when the number of *d*-electrons increases, the increased shielding effect and the increased repulsion between the electrons tend to increase the atomic radii. Somewhere in the middle of the series, therefore the atomic radii tend to have a minimum value as observed.

(ii) The atomic radii increase while going down in each group. However, in the third transition series from hafnium (*Hf*) and onwards, the elements have atomic radii nearly equal to those of the second transition elements.

Explanation **:** The atomic radii increase while going down the group. This is due to the introduction of an additional shell at each new element down the group. Nearly equal radii of second and third transition series elements is due to a special effect called ***lanthanide* contraction**.

(2) **Ionic radii :** For ions having identical charges, the ionic radii decrease slowly with the increase in the atomic number across a given series of the transition elements.

Elements (m):	Ionic radius,$(M^{2+})/pm$:	$Pm{:}(M^{3+})/pm$:
Sc	–	81
Ti	90	76
V	88	74
Cr	84	69
Mn	80	66
Fe	76	64
Co	74	63
Ni	72	–
Cu	69	–
Zn	74	–

Explanation **:** The gradual decrease in the values of ionic radius across the series of transition elements is due to the increase in the **effective nuclear charge**.

(3) **Ionisation energies :** The ionisation energies of the elements of first transition series are given below:

Elements	I_1	I_2	I_3
Sc	632	1245	2450
Ti	659	1320	2721
V	650	1376	2873
Cr	652	1635	2994
Mn	716	1513	3258
Fe	762	1563	2963
Co	758	1647	3237
Ni	736	1756	3400
Cu	744	1961	3560
Zn	906	1736	3838

* in $kJ\ mol^{-1}$

The following generalizations can be obtained from the ionisation energy values given above.

(i) The ionisation energies of these elements are high and in the most cases lie between those of *s*- and *p*-block elements. This indicates that the transition elements are less electropositive than *s*-block elements.

Explanation **:** Transition metals have smaller atomic radii and higher nuclear charge as compared to the alkali metals. Both these factors tend to increase the ionisation energy, as observed.

(ii) The ionisation energy in any transition series increases in the nuclear with atomic number; the increase however is not smooth and as sharp as seen in the case of *s* and *p*-block elements.

Explanation **:** The ionisation energy increases due to the increase in the nuclear charge with atomic number at the beginning of the series. Gradually, the shielding effect of the added electrons also increases. This **shielding effect** tends to decrease the attraction due to the nuclear charge. These two opposing factors lead to a rather gradual increase in the ionisation energies in any transition series.

(iii) The first ionisation energies of 5*d*-series of elements are much higher than those of the 3*d* and 4*d* series elements.

Explanation **:** In the 5*d*-series of transitions elements, after lanthanum (*La*), the added electrons go to the next inner 4*f* orbitals. The 4*f* electrons have poor shielding effect. As a result, the outermost electrons experience greater nuclear attraction. This leads to higher ionisation energies for the 5*d*- series of transition elements.

(4) **Metallic character :** All the transition elements are metals. These are hard, and good conductor of heat and electricity. All these metals are malleable, ductile and form alloys with other metals. These elements occur in three types *e.g.*, face- centered cubic (*fcc*), hexagonal close-packed (*hcp*) and body-centered cubic (*bcc*), structures.

The transition elements shows both covalent as well as metallic bonding amongst their atoms.

Explanation **:** The ionisation energies of the transition elements are not very high. The outermost shell in their atoms have many vacant, **partially filled orbitals**. These characteristics make these elements metallic in character. The hardness of these metals, suggests the presence of covalent bonding in these metals. The presence of unfilled *d*-orbitals favour covalent bonding. Metallic bonding in these metals is indicated by the conducting nature of these metals. Therefore, it appears that there exists covalent and metallic bonding in transition elements.

(5) **Melting and boiling points :** The melting and boiling points of transition elements except *Cd* and *Hg*, are very high as compared to the s-block and *p*-block elements. The melting and boiling points **first increase**, pass through maxima and then **steadily decrease** across any transition series. The maximum occurs around middle of the series.

Explanation **:** Atoms of the transition elements are closely packed and held together by strong metallic bonds which have appreciable covalent character. This leads to high melting and boiling points of the transition elements.

The strength of the metallic bonds depends upon the number of unpaired electrons in the outermost shell of the atom. Thus, greater is the number of unpaired electrons stronger is the metallic bonding. In any transition element series, the number of unpaired electrons first increases from 1 to 5 and then decreases back to the zero .The maximum five unpaired electrons occur at *Cr* (3*d* series). As a result, the melting and boiling points first increase and then decrease showing maxima around the middle of the series.

The low melting points of ***Zn*, *Cd*, and *Hg*** may be due to the absence of **unpaired *d*-electrons** in their atoms.

(6) **Enthalpies of atomization :** Transition metals exhibit high enthalpies of atomization.

Explanation **:** This is because the atoms in these elements are closely packed and held together by strong metallic bonds. The metallic bond is formed as a result of the interaction of electrons in the outermost shell. Greater the number of valence electrons, stronger is the metallic bond.

(7) **Oxidation states :** Most of the transition elements exhibit several oxidation states *i.e.*, they show variable valency in their compounds. Some common oxidation states of the first transition series elements are given below in table,

Outer Ele. Confi. and O. S. for 3d- elements

Elements	Outer electronic configuration	Oxidation states
Sc	$3d^1\ 4s^2$	+ 2, + 3
Ti	$3d^2\ 4s^2$	+ 2, + 3, + 4
V	$3d^3\ 4s^2$	+ 2,+ 3,+ 4,+ 5
Cr	$3d^5\ 4s^1$	+ 1, + 2, + 3, + 4, + 5, + 6
Mn	$3d^5 4s^2$	+ 2, + 3, + 4, + 5, + 6, + 7
Fe	$3d^6 4s^2$	+ 2, + 3, + 4, + 5, + 6
Co	$3d^7 4s^2$	+ 2, + 3, + 4
Ni	$3d^8 4s^2$	+ 2, + 3, + 4
Cu	$3d^{10} 4s^1$	+ 1,+ 2
Zn	$3d^{10} 4s^2$	+ 2

Explanation **:** The outermost electronic configuration of the transition elements is $(n - 1)d^{1-10}ns^2$. Since, the energy levels of $(n\text{-}1)d$ and ns-orbitals are quite close to each other, hence both the ns and $(n\text{-}1)$ d-electrons are available for bonding purposes. Therefore, the number of oxidation states show by these elements depends upon the number of d-electrons it has. For example, *Sc* having a configuration $3d^14s^2$ may show an oxidation state of + 2 (only s-electrons are lost) and + 3 (when d-electron is also lost). The highest oxidation state which an elements of this group might show is given by the total number of ns and $(n\ \text{-}1)$ d-electrons.

The relative stability of the different oxidation states depends upon the factors such as, electronic configuration, nature of bonding, stoichiometry, lattice energies and solvation energies. The highest oxidation states are found in fluorides and oxides because fluorine and oxygen are the most electronegative elements. The highest oxidation state shown by any transition metal is eight. The oxidation state of eight is shown by ***Ru* and *Os***.

An examination of the common oxidation states reveals the following conclusions.

(i) The variable oxidation states shown by the transition elements are due to the participation of **outer *ns* and inner (*n*–1)*d*-electrons** in bonding.

(ii) Except scandium, the most common oxidation state shown by the elements of first transition series is +2. This oxidation state arises from the loss of two 4*s* electrons. This means that after scandium, *d*-orbitals become more stable than the *s*-orbital.

(iii) The highest oxidation states are observed in fluorides and oxides. The highest oxidation state shown by any transition elements (by *Ru* and *Os*) is 8.

(iv) The transition elements in the + 2 and + 3 oxidation states mostly form ionic bonds. In compounds of the higher oxidation states (compound formed with fluorine or oxygen), the bonds are essentially covalent. For example, in permanganate ion MnO_4^-, all bonds formed between manganese and oxygen are covalent.

(v) Within a group, the maximum oxidation state increases with atomic number. For example, iron shown the common oxidation state of + 2 and + 3, but ruthenium and osmium in the same group form compounds in the + 4, + 6 and + 8 oxidation states.

(vi) Transition metals also form compounds in low oxidation states such as +1 and 0. For example, nickle in, nickel tetracarbonyl, $Ni(CO)_4$ has **zero oxidation state**. Similarly *Fe* in $(Fe(CO)_5$ has **zero oxidation state**.

The bonding in the compounds of transition metals in low oxidation states is not always very simple.

(vii) ***Ionisation energies and the stability of oxidation states*** :The values of the ionisation energies can be used in estimating the relative stability of various transition metal compounds (or ions). For example, Ni^{2+} compounds are found to be thermodynamically more stable than Pt^{2+}, whereas Pt^{4+} compounds are more stable than Ni^{4+} compounds. The relative stabilities of Ni^{2+} relative to Pt^{2+} and that of Pt^{4+} relative to Ni^{4+} can be explained as follows,

The first four ionisation energies of Ni and Pt

Metal	(IE_1+IE_2) $kJmol^{-1}$,	(IE_3+IE_4) $kJmol^{-1}$,	Etotal, $kJ\ mol^{-1}$ $(= IE_1 + IE_2 + IE_3 + IE_4)$
Ni	2490	8800	11290
Pt	2660	6700	9360

Thus, the ionisation of *Ni* to Ni^{2+} requires lesser energy (2490 $kJ\ mol^{-1}$) as compared to the energy required for the production of Pt^{2+} (2660 $kjmol^{-1}$). Therefore, Ni^{2+} compounds are thermodynamically more stable than Pt^{2+} compounds.

On the other hand, formation of Pt^{4+} requires lesser energy (9360 $kJ\ mol^{-1}$) as compared to that required for the formation of Ni^{4+}(11290 $kJ\ mol^{-1}$). Therefore, Pt^{4+} compounds are more stable than Ni^{4+} compounds.

This is supported by the fact that $[PtCl_6]^{2-}$ complex ion is known, while the corresponding ion for nickel is not known. However, other factors which affect the stability of a compound are,

(a) Enthalpy of sublimation of the metal.

(b) Lattice and the solvation energies of the compound or ion.

(viii) Transition elements like *Sc*, *Y*, *La* and *Ac* do not show variable valency.

(8) **Electrode potentials** (E^o) **:** Standard electrode potentials of some half–cells involving 3*d*-series of transition elements and their ions in aqueous solution are given in table,

Standard electrode potentials for 3*d*-elements

Elements	Ion	Electrode reaction	*E*°/ volt
Sc	Sc^{3+}	$Sc^{3+} + 3e^- \rightarrow Sc$	– 2.10
Ti	Ti^{2+}	$Ti^{2+} + 2e^- \rightarrow Ti$	– 1.60
V	V^{2+}	$V^{2+} + 2e^- \rightarrow V$	– 1.20
Cr	Cr^{3+}	$Cr^{3+} + 3e^- \rightarrow Cr$	– 0.71
Mn	Mn^{2+}	$Mn^{2+} + 2e^- \rightarrow Mn$	– 1.18
Fe	Fe^{2+}	$Fe^{2+} + 2e^- \rightarrow Fe$	– 0.44
Co	Co^{2+}	$Co^{2+} + 2e^- \rightarrow Co$	– 0.28
Ni	Ni^{2+}	$Ni^{2+} + 2e^- \rightarrow Ni$	– 0.24
Cu	Cu^{2+}	$Cu^{2+} + 2e^- \rightarrow Cu$	+ 0.34
Zn	Zn^{2+}	$Zn^{2+} + 2e^- \rightarrow Zn$	– 0.76

The negative values of *E*° for the first series of transition elements (except for Cu^{2+}/Cu) indicate that,

(i) These metals should liberate hydrogen from dilute acids i.e., the reactions,

$M + 2H^+ \rightarrow M^{2+} + H_2\ (g)$; $2M + 6H^+ \rightarrow 2M^{3+} + 3H_2(g)$

are favourable in the forward direction. In actual practice however, most of these metals react with dilute acids very slowly. Some of these metals get coated with a **thin protective layer** of oxide. Such an oxide layer prevents the metal to react further.

(ii) These metals should act as good reducing agents. There is no regular trend in the *E*° values. This is due to irregular variation in the ionisation and sublimation energies across the series.

Relative stabilities of transition metal ions in different oxidation states in aqueous medium can be predicted from the electrode potential data. To illustrate this, let us consider the following,

$M(s) \rightarrow M(g)$; $\Delta H_1 =$ Enthalpy of sublimation, ΔH_{sub}

$M(g) \rightarrow M^+(g) + e^-$; $\Delta H_2 = \text{Ionisation energy}, IE$

$M^+(g) \rightarrow M^+(aq)$; $\Delta H_3 = \text{Enthalpy of hydration}, \Delta H_{hyd}$

Adding these equations one gets,

$M(s) \rightarrow M^+(aq) + e^-$

$$\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3 = \Delta H_{sub} + IE + \Delta H_{hyd}$$

The ΔH represents the enthalpy change required to bring the solid metal *M* to the monovalent ion in aqueous medium, M^+(aq).

The reaction, $M(s) \rightarrow M^+(aq) + e^-$, will be favourable only if ΔH is negative. More negative is the value is of ΔH, more favourable will be the formation of that cation from the metal. Thus, the oxidation state for which ΔH value is more negative will be stable in the solution.

Electrode potential for a M^{n+}/M half-cell is a measure of the tendency for the reaction, $M^{n+}(aq) + ne^- \rightarrow M\ (s)$

Thus, this reduction reaction will take place if the electrode potential for M^{n+}/M half- cell is positive. The reverse reaction, $M(s) \rightarrow M^{n+}(aq) + ne^-$

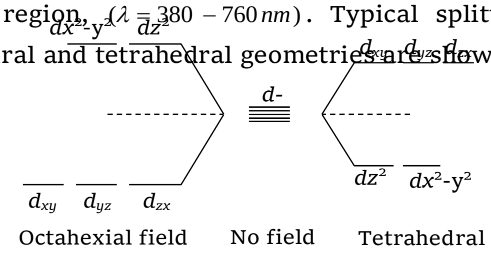
Involving the formation of M^{n+}(aq) will occur if the electrode potential is negative, *i.e.*, the tendency for the formation of M^{n+}(aq) from the metal *M* will be more if the corresponding *E*° value is more negative. In other words, *the oxidation state for which E° value is more negative (or less positive) will be more stable in the solution.*

When an elements exists in more than one oxidation states, the standard electrode potential (*E*°) values can be used in the predicting the relative stabilities of different oxidation states in aqueous solutions. The following rule is found useful.

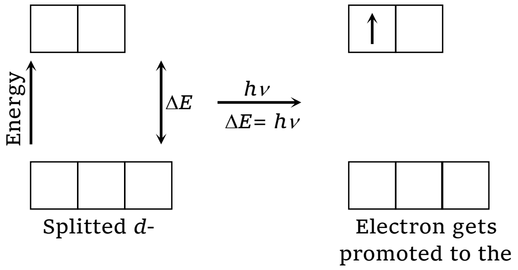
The oxidation state of a cation for which $\Delta H = (\Delta H_{sub} + IE + \Delta H_{hyd})$ *or E° is more negative (for less positive) will be more stable.*

(9) **Formation of coloured ions :** Most of the compound of the transition elements are coloured in the solid state and /or in the solution phase. The compounds of transition metals are coloured due to the presence of unpaired electrons in their *d*-orbitals.

Explanation **:** In an isolated atom or ion of a transition elements, all the five *d*-orbitals are of the same energy (they are said to be regenerate). Under the influence of the combining anion (*s*), or electron-rich molecules, the five *d*-orbitals split into two (or sometimes more than two) levels of different energies. The difference between the two energy levels depends upon the nature of the combining ions, but corresponds to the energy associated with the radiations in the visible region, $(\lambda = 380 - 760\,nm)$. Typical splitting for octahedral and tetrahedral geometries are shown in fig.



The splitting of *d*-orbital energy levels in (a) an octahedral, (b) a tetrahedral, geometry. This spllitting is termed as the crystal field splitting.



Promotion of *d*-electron to a higher level

The transition metals in elements form or in the ionic form have one or more unpaired electrons. When visible light falls on the sample, the electrons from the lower energy level get promoted to a higher energy level due to the absorption of light of a characteristic wavelength (or colour). This wavelength (or colour) of the absorbed light depends upon the energy difference of the two levels. Rest of the light gets transmitted. The transmitted light has a colour complementary to the absorbed colour. Therefore, the compound or the solution appears to be of the complementary colour. For example, $Cu(H_2O)_6^{2+}$ ions absorb red radiation, and appear **blue-green** (blue-green is complementary colour to red). Hydrated Co^{2+} ions absorb radiation in the blue-green region, and therefore, appear red in sunlight. Relationship between the colour of the absorbed radiation and that of the transmitted light is given in table

Relationship between the colours of the absorbed and transmitted light: the complementary colours.

Colour of the		**Colour of the**	
Absorbed light	**Transmitted light**	**Absorbed light**	**Transmitted light**
IR	White	Blue-green	Red
Red	Blue-green	Blue	Orange
Orange	Blue	Indigo	Yellow
Yellow	Indigo	Violet	Yellow-green
Yellow-green	Violet	UV	White
Green	Purple		

However, if radiations of all the wavelengths (or colours) except one are absorbed, then the colour of the substance will be the colour of the transmitted radiation. For example, if a substance absorbs all colours except green, then it would appear green to the eyes.

The transition metal ions which have completely filled *d*-orbitals are colourless, as there are no vacant *d*-orbitals to permit promotion of the electrons. Therefore, Zn^{2+} ($3d^{10}$), Cd^2 + ($4d^{10}$) and Hg^{2+}($5d^{10}$) Sc^{3+}, Ti^{4+}, Cu^+ ions and *Zn*, *Cd*, *Hg* are colourless and diamagnetic. The transition metal ions which have completely empty *d*-orbitals are also colourless, Thus, Sc^{3+} and Ti^{4+} ions are colourless, unless a coloured anion is present in the compound.

Colours and the outer- electronic configurations of the some important ions of the first transition series elements are given bellow,

Ion	**Outer configuration**	**Number of unpaired electrons**	**Colour of the ion**
Sc^{3+}	$3d^0$	0	Colourless
Ti^{3+}	$3d^1$	1	Purple
Ti^{4+}	$3d^0$	0	Colourless
V^{3+}	$3d^2$	2	Green
Cr^{3+}	$3d^3$	3	Violet
Mn^{2+}	$3d^5$	5	Light pink
Mn^{3+}	$3d^4$	4	Violet
Fe^{2+} Fe^{3+}	$3d^6$ $3d^5$	4 5	Green Yellow
Co^{3+}	$3d^7$	3	Pink
Ni^{2+}	$3d^8$	2	Green
Cu^{2+}	$3d^9$	1	Blue
Cu^+	$3d^{10}$	0	Colourless
Zn^{2+}	$3d^{10}$	0	Colourless

(10) **Magnetic properties :** Most of the transition elements and their compounds show **paramagnetism**. The paramagnetism first increases in any transition element series, and then decreases. The maximum paramagnetism is seen around the middle of the series. The paramagnetism is described in **Bohr Magneton** (BM) units. The paramagnetic moments of some common ions of first transition series are given below in Table

Explanation **:** A substance which is attracted by magnetic filed is called paramagnetic substance. The substances which are repelled by magnetic filed are, called **diamagnetic substances**. Paramagnetism is due to the presence of unpaired electrons in atoms, ions or molecules.

The magnetic moment of any transition element or its compound/ion is given by (assuming no contribution from the orbital magnetic moment).

$$\mu_s = \sqrt{4S(S+1)} \qquad BM = \sqrt{n(n+2)} \quad BM$$

where, S is the total spin $(n \times s)$: n is the number of unpaired electrons and s is equal to ½ (representing the spin of an unpaired electron).

From the equation given above, the magnetic moment (μ_s) increases with an increase in the number of unpaired electrons.

Magnetic moments of some ions of the 3d-series elements

Ion	Outer configuration	No. of unpaired electrons	Magnetic moment (BM)	
			Calculated	observed
Sc^{3+}	$3d^0$	0	0	0
Ti^{3+}	$3d^1$	1	1.73	1.75
Ti^{2+}	$3d^2$	2	2.84	2.86
V^{2+}	$3d^3$	3	3.87	3.86
Cr^{2+}	$3d^4$	4	4.90	4.80
Mn^{2+}	$3d^5$	5	5.92	5.95
Fe^{2+}	$3d^6$	4	4.90	5.0-5.5
Co^{2+}	$3d^7$	3	3.87	4.4-5.2
Ni^{2+}	$3d^8$	2	2.84	2.9-3.4
Cu^{2+}	$3d^9$	1	1.73	1.4-2.2
Zn^{2+}	$3d^{10}$	0	0	0

In d-obitals belonging to a particular energy level, there can be at the maximum five unpaired electrons in d^5 cases. Therefore, paramagnetism in any transition series first increases, reaches a maximum value for d^5 cases and then decreases thereafter.

(11) **Formation of complex ions :** Transition metals and their ions show strong tendency for complex formation. The cations of transition elements (d-block elements) form complex ions with certain molecules containing one or more lone-pairs of electrons, viz., CO, NO, NH_3 etc., or with anions such as, F^-, Cl^-, CN^- etc. A few typical complex ions are,

$$[Fe(CN)_6]^{4-}, [Cu(NH_3)_4]^{2+}, [Y(H_2O)_6]^{2+},$$

$$[Ni(CO)_4], [Co(NH_3)_6]^{3+} [FeF_6]^{3-}$$

***Explanation* :** This complex formation tendency is due to,

(i) Small size and high nuclear charge of the transition metal cations.

(ii) The availability to vacant inner d-orbitals of suitable energy.

(12) **Formation of interstitial compounds :** Transition elements form a few interstitial compounds with elements having small atomic radii, such as hydrogen, boron, carbon and nitrogen. The small atoms of these elements get entrapped in between the void spaces (called interstices) of the metal lattice. Some characteristics of the interstitial compound are,

(i) These are non-stoichiometric compounds and cannot be given definite formulae.

(ii) These compounds show essentially the same chemical properties as the parent metals, but differ in physical properties such as density and hardness. Steel and cast iron are hard due to the formation of interstitial compound with carbon. Some non-stoichimetric compounds are, $VSe_{0.98}$ (Vanadium selenide), $Fe_{0.94}O$ and titanium nitride.

***Explanation* :** Interstital compounds are hared and dense. This is because, the smaller atoms of lighter elements occupy the interstices in the lattice, leading to a more closely packed structure. Due to greater electronic interactions, the strength of the metallic bonds also increases.

(13) **Catalytic properties :** Most of the transition metals and their compounds particularly oxides have good catalytic properties. Platinum, iron, vanadium pentoxide, nickel, etc., are important catalysts. Platinum is a general catalyst. Nickel powder is a good catalyst for hydrogenation of unsaturated organic compound such as, hydrogenation of oils some typical industrial catalysts are,

(i) Vanadium pentoxide (V_2O_5) is used in the Contact process for the manufacture of sulphuric acid,

(ii) Finely divided iron is used in the Haber's process for the synthesis of ammonia.

***Explanation* :** Most transition elements act as good catalyst because of,

(i) The presence of vacant d-orbitals.

(ii) The tendency to exhibit variable oxidation states.

(iii) The tendency to form reaction intermediates with reactants.

(iv) The presence of defects in their crystal lattices.

(14) **Alloy formation :** Transition metals form alloys among themselves. The alloys of transition metals are hard and high metals are high melting as compared to the host metal. Various steels are alloys of iron with metals such as chromium, vanadium, molybdenum, tungsten, manganese etc.

***Explanation* :** The atomic radii of the transition elements in any series are not much different from each other. As a result, they can very easily replace each other in the lattice and form solid solutions over an appreciable composition range. Such solid solutions are called alloys.

(15) **Chemical reactivity :** The *d*-block elements (transition elements) have lesser tendency to react, *i.e.*, these are less reactive as compared to *s*-block elements.

Explanation : Low reactivity of transition elements is due to,

(i) Their high ionisation energies.

(ii) Low heats of hydration of their ions.

(iii) Their high heats of sublimation.

Chromium containing compounds

Potassium dichromate, ($K_2Cr_2O_7$)

Potassium dichromate is one of the most important compound of chromium, and also among dichromates. In this compound *Cr* is in the hexavalent (+6) state.

Preparation : It can be prepared by any of the following methods,

(i) ***From potassium chromate* :** Potassium dichromate can be obtained by adding a calculated amount of sulphuric acid to a saturated solution of potassium chromate.

$$\underset{\substack{\text{potassium chromate}\\(yellow)}}{2K_2CrO_4} + H_2SO_4 \rightarrow \underset{\substack{\text{potassium dichromate}\\(orange)}}{K_2Cr_2O_7} + K_2SO_4 + H_2O$$

$K_2Cr_2O_7$ Crystals can be obtained by concentrating the solution and crystallisation.

(ii) ***Manufacture from chromite ore* :** $K_2Cr_2O_7$ is generally manufactured from chromite ore ($FeCr_2O_4$). The process involves the following steps.

(a) *Preparation of sodium chromate* : Finely powdered chromite ore is mixed with soda ash and quicklime. The mixture is then roasted in a reverberatory furnace in the presence of air. Yellow mass due to the formation of sodium chromate is obtained.

$$4FeCr_2O_4 + O_2 \rightarrow 2Fe_2O_3 + 4Cr_2O_3$$

$$4Cr_2O_3 + 8Na_2CO_3 + 6O_2 \rightarrow 8Na_2CrO_4 + 8CO_2(g)$$

$$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 2Fe_2O_3 + 8CO_2(g) + \underset{\text{sodium chromate}}{8Na_2CrO_4}$$

The yellow mass is extracted with water, and filtered. The filtrate contains sodium chromate.

The reaction may also be carried out by using *NaOH* instead of Na_2CO_3. The reaction in that case is,

$$4FeCr_2O_4 + 16NaOH + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8H_2O$$

(b) *Conversion of chromate into dichromate* : Sodium chromate solution obtained in step (a) is treated with concentrated sulphuric acid when it is converted into sodium dichromate.

$$\underset{\text{sodium chromate}}{2Na_2CrO_4} + H_2SO_4 \rightarrow \underset{\text{sodium dichromate}}{Na_2Cr_2O_7} + Na_2SO_4 + H_2O$$

On concentration, the less soluble sodium sulphate, $Na_2SO_4.10H_2O$ crystallizes out. This is filtered hot and allowed to cool when sodium dichromate, $Na_2Cr_2O_7.2H_2O$, separates out on standing.

(c) *Concentration of sodium dichromate to potassium dichromate* : Hot concentrated solution of sodium dichromate is treated with a calculated amount of potassium chloride. When potassium dichromate being less soluble crystallizes out on cooling.

$$\underset{\text{sod.dichromate}}{Na_2Cr_2O_7} + 2KCl \rightarrow \underset{\text{pot.dichromate}}{K_2Cr_2O_7} + 2NaCl$$

Physical properties

(i) Potassium dichromate forms orange-red coloured crystals.

(ii) It melts at 699 *K*.

(iii) It is very stable in air (near room temperature) and is generally, used as a primary standard in the volumetric analysis.

(iv) It is soluble in water though the solubility is limited.

Chemical properties

(i) ***Action of heat*** : Potassium dichromate when heated strongly. Decomposes to give oxygen.

$$4K_2Cr_2O_7(s) \xrightarrow{\Delta} 4K_2CrO_4(s) + 2Cr_2O_3(s) + 3O_2$$

(ii) ***Action of acids***

(a) In cold, with concentrated H_2SO_4, red crystals of chromium trioxide separate out.

$$K_2Cr_2O_7(aq) + conc.H_2SO_4 \rightarrow KHSO_4(aq) + 2CrO_3(s) + H_2O$$

On heating a dichromate-sulphuric acid mixture, oxygen gas is given out.

$$2K_2Cr_2O_7 + 8H_2SO_4 \rightarrow 2K_2SO_4 + 2Cr_2(SO_4)_3 + 8H_2O + 3O_2$$

(b) With *HCl*, on heating chromic chloride is formed and Cl_2 is liberated.

$$K_2Cr_2O_{7(aq)} + 14HCl(aq) \rightarrow 2CrCl_{3(aq)} + 2KCl(aq) + 7H_2O + 3Cl_2(g)$$

(iii) ***Action of alkalies*** : With alkalies, it gives chromates. For example, with *KOH*,

$$\underset{\text{orange}}{K_2Cr_2O_4} + 2KOH \rightarrow \underset{\text{yellow}}{2K_2CrO_4} + H_2O$$

On acidifying, the colour again changes to orange-red owing to the formation of dichromate.

$$2K_2CrO_4 + H_2SO_4 \rightarrow K_2Cr_2O_7 + K_2SO_4 + H_2O$$

Actually, in dichromate solution, the $Cr_2O_7^{2-}$ ions are in equilibrium with CrO_4^{2-} ions.

$$Cr_2O_7^{2-} + H_2O \rightleftharpoons 2CrO_4^{2-} + 2H^+$$

(iv) ***Oxidising nature*** **:** In neutral or in acidic solution, potassium dichromate acts as an excellent oxidising agent, and $Cr_2O_7^{2-}$ gets reduced to Cr^{3+}. The standard electrode potential for the reaction,

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{+3} + 7H_2O$ is $+1.31V$.

This indicates that dichromate ion is a fairly strong oxidising agent, especially in strongly acidic solutions. That is why potassium dichromate is widely used as an oxidising agent, for quantitative estimation of the reducing agents such as, Fe^{2+}. It oxidises,

(a) *Ferrous salts to ferric salts*

$$K_2CrO_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$

$$2FeSO_4 + H_2SO_4 + [O] \rightarrow Fe_2[SO_4]_3 + H_2O \times 3$$

$$K_2Cr_2O_7 + 6FeSO_4 + 7H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + 7H_2O$$

Ionic equation

$$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$$

(b) *Sulphites to sulphates and arsenites to arsenates.*

$$K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$

$$Na_2SO_3 + [O] \rightarrow Na_2SO_4] \times 3$$

$$K_2Cr_2O_7 + 4H_2SO_4 + 3Na_2SO_3 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 3Na_2SO_4 + 4H_2O$$

Ionic equation

$$Cr_2O_7^{2-} + 8H^+ + 3SO_3^{2-} \rightarrow 2Cr^{3+} + 3SO_4^{2-} + 4H_2O$$

Similarly, arsenites are oxidised to arsenates.

$$Cr_2O_7^{2-} + 8H^+ + 3AsO_3^{3-} \rightarrow 2Cr^{3+} + 3AsO_4^{3-} + 4H_2O$$

(c) *Hydrogen halides to halogens.*

$$K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$

$$2HX + O \rightarrow H_2O + X_2] \times 3$$

$$K_2Cr_2O_7 + 4H_2SO_4 + 6HX \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3X_2$$

where, X may be Cl, Br, I.

Ionic equation :

$$Cr_2O_7^{2-} + 8H^+ + 6HX \rightarrow 2Cr^{3+} + 3X_2 + 7H_2O$$

(d) *Iodides to iodine*

$$K_2Cr_2O_7 + H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$

$$2KI + H_2O + [O] \rightarrow 2KOH + I_2] \times 3$$

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O] \times 3$$

$$K_2Cr_2O_7 + 7H_2SO_4 + 6KI \rightarrow 4K_2SO_4 + Cr_2(SO_4)_3 + 3I_2 + 7H_2O$$

Ionic equation :

$$Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow 2Cr^{3+} + 7H_2O + 3I_2$$

Thus, when KI is added to an acidified solution of $K_2Cr_2O_7$ iodine gets liberated.

(e) *It oxidises H_2S to S.*

$$K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$

$$H_2S + [O] \rightarrow H_2O + S] \times 3$$

$$K_2Cr_2O_7 + 4H_2SO_4 + 3H_2S \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3S$$

Ionic equation

$$Cr_2O_7^{2-} + 8H^+ + 3H_2S \rightarrow 2Cr^{3+} + 3S + 7H_2O$$

(v) ***Formation of insoluble chromates*** : With soluble salts of lead, barium etc., potassium dichromate gives insoluble chromates. Lead chromate is an important yellow pigment.

$$2Pb(NO_3)_2 + K_2Cr_2O_7 + H_2O \rightarrow 2PbCrO_4 + 2KNO_3 + 2HNO_3$$

(vi) ***Chromyl chloride test*** **:** When potassium dichromate is heated with conc. H_2SO_4 in the presence of a soluble chloride salt, the orange-red vapours of chromyl chloride (CrO_2Cl_2) are formed.

$$K_2Cr_2O_7 + 4NaCl + 6H_2SO_4 \xrightarrow{heat} 2KHSO_4 + 4NaHSO_4 + \underset{\substack{\text{chromyl chloride} \\ \text{(orange-red vapours)}}}{2CrO_2Cl_2}$$

Chromyl chloride vapours when passed through water give yellow-coloured solution containing chromic acid.

$$CrO_2Cl_2 + 2H_2O \rightarrow 2HCl + \underset{\text{Chromic acid.(yellow solution)}}{H_2CrO_4}$$

Chromyl chloride test can be used for the detection of chloride ion is any mixture.

Uses : Potassium dichromate is used as,

(i) An oxidising agent

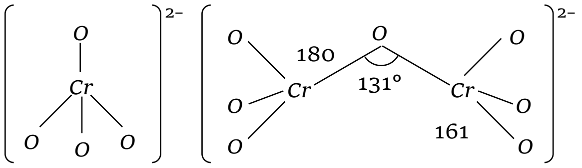
(ii) In chrome tanning

(iii) The raw meterial for preparing large number of chromium compounds

(iv) Primary standard in the volumetric analysis.

Structures of Chromate and Dichromate Ions

Chromates and dichromates are the salts of chromic acid (H_2CrO_4). In solution, these ions exist in equilibrium with each other. Chromate ion has four oxygen atoms arranged tetrahedrally around Cr atom. (see Fig). Dichromate ion involves a Cr–O–Cr bond as shown in Fig.



Chromate ion Dichromate

The structure of chromate (CrO^{2-}_4) and dichromate

Manganese containing compound

Potassium Permanganate, ($KMnO_4$)

Potassium permanganate is a salt of an unstable acid $HMnO_4$ (permanganic acid). The *Mn* is an +7 state in this compound.

Preparation : Potassium permanganate is obtained from pyrolusite as follows.

***Conversion of pyrolusite to potassium manganate* :** When manganese dioxide is fused with potassium hydroxide in the presence of air or an oxidising agent such as potassium nitrate or chlorate, potassium manganate is formed, possibly via potassium manganite.

$$MnO_2 + 2KOH \xrightarrow{fused} \underset{\text{potassium manganite}}{K_2MnO_3} + 4H_2O] \times 2$$

$$2K_2MnO_3 + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$$

$$\underset{\text{pyrolusite}}{2MnO_2} + 4KOH + O_2 \xrightarrow{fused} \underset{\substack{\text{potassium manganate}\\ [\text{dark - green mass}]}}{2K_2MnO_4} + 2H_2O$$

Oxidation of potassium manganate to potassium permanganate : The potassium manganate so obtained is oxidised to potassium permanganate by either of the following methods.

***By chemical method* :** The fused dark-green mass is extracted with a small quantity of water. The filtrate is warmed and treated with a current of ozone, chlorine or carbon dioxide. Potassium manganate gets oxidised to potassium permanganate and the hydrated manganese dioxide precipitates out. The reactions taking place are,

When CO_2 is passed

$$\underset{\text{potassium manganate}}{3K_2MnO_4} + 2H_2O \rightarrow \underset{\text{potassium permanganate}}{2KMnO_4} + MnO_2 \downarrow + 4KOH$$

$$2CO_2 + 4KOH \rightarrow 2K_2CO_3 + 2H_2O$$

When chlorine or ozone is passed

$$2K_2MnO_4 + Cl_2 \rightarrow 2KMnO_4 + 2KCl$$

$$2K_2MnO_4 + O_3 + H_2O \rightarrow 2KMnO_4 + 2KOH + O_2(g)$$

The purple solution so obtained is concentrated and dark purple, needle-like crystals having metallic lustre are obtained.

***Electrolytic method* :** Presently, potassium manganate (K_2MnO_4) is oxidised electrolytically. The electrode reactions are,

At anode: $\underset{\text{green}}{2MnO_4^{2-}} \rightarrow \underset{\text{purple}}{2MnO_4^-} + 2e^-$

At cathode: $2H^+ + 2e^- \rightarrow H_2(g)$

The purple solution containing $KMnO_4$ is evaporated under controlled condition to get crystalline sample of potassium permanganate.

Physical properties

$KMnO_4$ crystallizes as dark purple crystals with greenish luster (m.p. 523 *K*).

It is soluble in water to an extent of 6.5*g per* 100*g* at room temperature. The aqueous solution of $KMnO_4$ has a purple colour.

Chemical properties : Some important chemical reactions of $KMnO_4$ are given below,

***Action of heat* :** $KMnO_4$ is stable at room temperature, but decomposes to give oxygen at higher temperatures.

$$2KMnO_4(s) \xrightarrow{heat} K_2MnO_4(s) + MnO_2 + O_2(g)$$

***Oxidising actions* :** $KMnO_4$ is a powerful agent in neutral, acidic and alkaline media. The nature of reaction is different in each medium. The oxidising character of $KMnO_4$ (to be more specific, of MnO_4^-) is indicated by high positive reduction potentials for the following reactions.

Acidic medium

$$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O \quad E^o = 1.51\,V$$

Alkaline medium

$$MnO_4^- + 2H_2O + 3e^- \rightleftharpoons MnO_2 + 4OH^- \quad E^o = 1.23\,V$$

In strongly alkaline solutions and with excess of MnO_4^-, the reaction is $MnO_4^- + e^- \rightleftharpoons MnO_4^{2-} \quad E^o = 0.56\,V$

There are a large number of oxidation-reduction reactions involved in the chemistry of manganese compounds. Some typical reactions are,

In the presence of excess of reducing agent in acidic solutions permanganate ion gets reduced to manganous ion, e.g., $5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$

An excess of reducing agent in alkaline solution reduces permanganate ion only to manganese dioxide e.g.,

$$3NO_2^- + MnO_4^- + 2OH^- \rightarrow 3NO_3^- + MnO_2 + H_2O$$

In faintly acidic and neutral solutions, manganous ion is oxidised to manganese oxidised to manganese dioxide by permanganate.

$$2MnO_4^- + 3Mn^{+2} + 2H_2O \rightarrow 5MnO_2 + 4H^+$$

In strongly basic solutions, permangante oxidises manganese dioxide to manganate ion.

$$MnO_2 + 2MnO_4^- + 4OH^- \rightarrow 3MnO_4^{2-} + 2H_2O$$

In acidic medium, $KMnO_4$ oxidises,

Ferrous salts to ferric salts

$$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$

$$\underline{2FeSO_4 + H_2SO_4 + [O] \rightarrow Fe_2(SO_4)_3 + H_2O] \times 5}$$

$$\underline{2KMnO_4 + 8H_2SO_4 + 10FeSO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O}$$

Ionic equation

$$2MnO_4^- + 16H^+ + 10Fe^{2+} \rightarrow 2Mn^{2+} + 10Fe^{3+} + 8H_2O$$

The reaction forms the basis of volumetric estimation of Fe^{2+} in any solution by $KMnO_4$.

Oxalic acid to carbon dioxide

$$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$

$$\underline{(COOH)_2 + [O] \rightarrow 2CO_2 + H_2O] \times 5}$$

$$\underline{2KMnO_4 + 3H_2SO_4 + 5(COOH)_2 \rightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O}$$

Ionic equation

$$2MnO_4^- + 6H^+ + 5(COOH)_2 \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

Sulphites to sulphates

$$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$

$$\underline{Na_2SO_3 + [O] \rightarrow Na_2SO_4] \times 5}$$

$$\underline{2KMnO_4 + 3H_2SO_4 + 5Na_2SO_3 \rightarrow K_2SO_4 + 2MnSO_4 + 5Na_2SO_4 + 3H_2O}$$

Ionic equation

$$2MnO_4^- + 6H^+ + 5SO_3^{2-} \rightarrow 2Mn^{2+} + 5SO_4^{2-} + 3H_2O$$

Iodides to iodine in acidic medium

$$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$

$$2KI + H_2O + [O] \rightarrow I_2 + 2KOH \times 5$$

$$\underline{2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O\ ] \times 5}$$

$$\underline{2KMnO_4 + 8H_2SO_4 + 10KI \rightarrow 6K_2SO_4 + 2MnSO_4 + 5I_2 + 8H_2O}$$

Ionic equation

$$2MnO_4^- + 16H^+ + 10I^- \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$$

Hydrogen peroxide to oxygen

$$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$

$$\underline{H_2O_2 + [O] \rightarrow H_2O + O_2 \uparrow \times 5}$$

$$\underline{2KMnO_4 + 3H_2SO_4 + 5H_2O_2 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5O_2}$$

Manganous sulphate (*$MnSO_4$*) to manganese dioxide (*MnO_2*)

$$2KMnO_4 + H_2O \rightarrow 2KOH + 2MnO_2 + 3[O]$$

$$MnSO_4 + H_2O + [O] \rightarrow MnO_2 + H_2SO_4 \times 3$$

$$\underline{2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O}$$

$$\underline{2KMnO_4 + 3MnSO_4 + 2H_2O \rightarrow 5MnO_2 + K_2SO_4 + 2H_2SO_4}$$

Ionic equation

$$2MnO_4^- + 3Mn^{2+} + 2H_2O \rightarrow 5MnO_2 + 4H^+$$

Ammonia to nitrogen

$$2KMnO_4 + H_2O \rightarrow 2MnO_2 + 2KOH + 3[O]$$

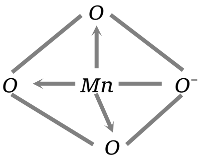
$$\underline{2NH_3 + 3[O] \rightarrow N_2(g) + 3H_2O}$$

$$\underline{2KMnO_4 + 2NH_3 \rightarrow 2MnO_2 + 2KOH + 2H_2O + N_2(g)}$$

Uses : $KMnO_4$ is used,

(i) As an oxidising agent. (ii) As a disinfectant against disease-causing germs. (iii) For sterilizing wells of drinking water. (iv) In volumetric estimation of ferrous salts, oxalic acid etc. (v) Dilute alkaline $KMnO_4$ solution known as **Baeyer's reagent**.

Structure of Permanganate Ion (MnO_4^-) : Mn in MnO_4^- is in +7 oxidation state. Mn^{7+} exhibits sp^3 hybridisation in this ion. The structure of MnO_4^- is, shown in fig.



Strucutre of MnO_4^- ion

Iron and its Compounds

(1) **Ores of iron :** Haematite Fe_2O_3, Magnetite (Fe_3O_4), Limonite ($Fe_2O_3.3H_2O$), Iron pyrites (FeS_2), Copper pyrities ($CuFeS_2$) etc.

(2) **Extraction :** Cast iron is extracted from its oxides by reduction with carbon and carbon monoxide in a blast furnace to give pig iron.

Roasting : Ferrous oxide convert into ferric oxide.

$$Fe_2O_3.3H_2O \rightarrow Fe_2O_3 + 3H_2O\,;\ 2FeCO_3 \rightarrow 2FeO + 2CO_2$$

$$4FeO + O_2 \rightarrow 2Fe_2O_3$$

Smelting : Reduction of roasted ore of ferric oxide carried out in a blast furnace.

(i) The reduction of ferric oxide is done by carbon and carbon monoxide (between 1473*k to* 1873*k*)

$2C+O_2 \rightarrow 2CO$

(ii) $Fe_2O_3+3CO \xrightleftharpoons{673\,K} 2Fe+3CO_2$. It is a reversible and exothermic reaction. Hence according to *Le-chatelier* principle more iron will be produced in the furnace at lower temp. $\underset{\text{(it is not reversible)}}{Fe_2O_3+CO \rightarrow 2FeO+CO_2}$

(iii) $FeO+C \xrightarrow[\text{endothermic reaction}]{1073\,K} Fe+CO$

The gases leaving at the top of the furnace contain up to 28% CO and are burnt in **cowper's stove** to pre-heat the air for blast

Varieties of iron : The three commercial varieties of iron differ in their carbon contents. These are;

(1) **Cast iron or Pig-iron :** It is most impure form of iron and contains highest proportion of carbon (2.5–4%).

(2) **Wrought iron or Malleable iron :** It is the purest form of iron and contains minimum amount of carbon (0.12–0.25%).

(3) **Steel :** It is the most important form of iron and finds extensive applications. Its carbons content (Impurity) is mid-way between cast iron and wrought iron. *It contains 0.2–1.5% carbon. Steels containing 0.2–0.5% of carbon are known as mild steels, while those containing 0.5–1.5% carbon are known as hard steels.*

Steel is generally manufactured from cast iron by three processes, *viz*, (i) Bessemer Process which involves the use of a large pear-shaped furnace (vessel) called Bessemer converter, (ii) L.D. process and (iii) open hearth process, Spiegeleisen (an alloy of *Fe*, *Mn* and *C*) is added during manufacture of steel.

Heat treatment of steels **:** Heat treatment of steel may be defined as the process of carefully heating the steel to high temperature followed by cooling to the room temperature under controlled conditions. Heat treatment of steel is done for the following two purposes,

(i) To develop certain special properties like hardness, strength, ductility etc. without changing the chemical composition.

(ii) To remove some undesirable properties or gases like entrapped gases, internal stresses and strains. The various methods of heat treatment are,

(a) *Annealing :* It is a process of heating steel to redness followed by slow cooling.

(b) *Quenching or hardening :* It is a process of heating steel to redness followed by sudden cooling by plunging the red hot steel into water or oil.

(c) *Tempering :* It is a process of heating the hardened or quenched steel to a temperature much below redness (473–623*K*) followed by slow cooling.

(d) *Case-hardening :* It is a process of giving a thin coating of hardened steel to wrought iron or to a strong and flexible mild steel by heating it in contact with charcoal followed by quenching in oil.

(e) *Nitriding :* It is a process of heating steels at about $700\,^oC$ in an atmosphere of ammonia. This process imparts a hard coating of iron nitride on the surface of steel.

Properties of steel **:** The properties of steel depend upon its carbon contents. With the increase in carbon content, the hardness of steel increases while its ductility decreases.

(i) Low carbon or soft steels contain carbon upto 0.25%.

(ii) Medium carbon steels or mild steels contain 0.25–0.5% carbon.

(iii) High carbon or hard steels contains 0.1 – 1.5 percent carbon.

(iv) Alloy steels or special steels are alloys of steel with Ni, Cr, Co, W, Mn, V etc., For example

(a) Stainless steel (*Fe* = 73%, *Cr* = 18%, *Ni* = 8% + *C*) is resistant to corrosion and is used for making ornamental pieces, cutlery etc.

(b) Invar (*Fe* = 64%, *Ni* = 36%) has small coefficient of expansion and is used for making metre scales, pendulum rods and watches.

(c) Manganese steel (*Fe* = 86%, *Mn* 13% + carbon) is very hard and resistant to wear and hence is used for making rock drills, safes etc.

(d) Tungsten steel (*Fe* = 94%, *W* = 5% + carbon) is quite hard and is used for making high speed cutting tools.

(e) Permalloy (*Fe* = 21%, *Ni* = 78% + carbon) is strongly magnetised by electric current but loses magnetism when current is cut off. It is used for making electromagnets, ocean cables etc.

Properties of iron

(1) Dry or moist air has no action on pure iron but impure iron when exposed to moist air is covered with a layer of rust $Fe_2O_3+Fe(OH)_3$. However, finely divided pure iron burns in air or oxygen forming Fe_3O_4 (magnetic oxide of iron).

$3Fe+2O_2 \rightarrow Fe_3O_4$

(2) Iron decomposes steam at red heat

$3Fe+\underset{\text{Steam}}{4H_2O} \xrightarrow{\text{Red heat}} Fe_3O_4+4H_2$

(3) **Action of acids** : Iron reacts with dil. HCl and dil. H_2SO_4 liberating hydrogen. with hot conc. H_2SO_4, it gives SO_2, with dil. HNO_3, it gives NH_4NO_3 and moderately conc. HNO_3 reacts with iron forming NO_2.

Cold conc. HNO_3 makes iron passive due to the deposit of a thin layer of iron oxide (Fe_3O_4) on the surface.

Hot conc. HNO_3 reacts with iron liberating NO.

$$Fe + 4HNO_3(\text{hot conc.}) \rightarrow Fe(NO_3)_3 + NO + 2H_2O$$

(4) Iron does not react with alkalies.

(5) It displaces less electropositive metals (*e.g.*, *Cu*, *Ag* etc.) from their salts

$$CuSO_4 + Fe \rightarrow FeSO_4 + Cu$$

(6) Finely divided iron combines with *CO* forming penta carbonyl

$$Fe + 5CO \rightarrow Fe(CO)_5$$

(7) Iron does not form amalgam with *Hg*.

(8) Iron is the most abundant and most widely used transition metal.

Compounds of iron

(1) **Oxides of Iron :** Iron forms three oxides FeO, Fe_2O_3 (Haematite), Fe_3O_4 (magnetite also called magnetic oxide or load stone).

(i) ***Ferrous oxide,*** FeO : It is a black powder, basic in nature and reacts with dilute acids to give ferrous salts.

$FeO + H_2SO_4 \rightarrow FeSO_4 + H_2O$ **;** It is used in glass industry to impart green colour to glass.

(ii) ***Ferric oxide*** Fe_2O_3 : It is a reddish brown powder, not affected by air or water; amphoteric in nature and reacts both with acids and alkalis giving salts. It can be reduced to iron by heating with *C* or *CO*.

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO \ ; \quad Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

It is used as red pigment to impart red colour to external walls and as a polishing powder by jewellers.

(iii) ***Ferrosoferricoxide*** $Fe_3O_4(FeO.Fe_2O_3)$: It is more stable than FeO and Fe_2O_3, magnetic in nature and dissolves in acids giving a mixture of iron (II) and iron (III) salts.

$$Fe_3O_4 + 4H_2SO_4\,(\text{dil}) \rightarrow FeSO_4 + Fe_2(SO_4)_3 + 4H_2O$$

(2) **Ferrous sulphide** FeS : It is prepared by heating iron filing with sulphur. With dilute H_2SO_4, it gives H_2S. $FeS + H_2SO_4\,(\text{dil}) \rightarrow FeSO_4 + H_2S \uparrow$

(3) **Ferric chloride** $FeCl_3$: (i) ***preparation*** : It is prepared by treating $Fe(OH)_3$ with HCl

$$Fe(OH)_3 + 3HCl \rightarrow FeCl_3 + 3H_2O$$

The solution on evaporation give yellow crystals of $FeCl_3.6H_2O$

(ii) ***Properties :*** (a) Anhydrous $FeCl_3$ forms reddish-black deliquescent crystals.

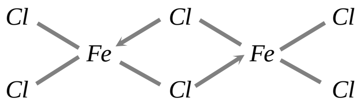
(b) $FeCl_3$ is hygroscopic and dissolves in H_2O giving brown acidic solution due to formation of HCl

$$FeCl_3 + 3H_2O \rightarrow \underset{\text{(Brown)}}{Fe(OH)_3} + 3HCl$$

(c) Due to oxidising nature Fe^{3+} ions $FeCl_3$ is used in etching metals such as copper

$$2Fe^{3+} + Cu \rightarrow 2Fe^{2+} + Cu^{2+}(aq)$$

(d) In vapour state $FeCl_3$ exists as a dimer, Fe_2Cl_6



(e) $FeCl_3$ is used as stypic to stop bleeding from a cut.

(4) **Ferrous sulphate,** $FeSO_4, 7H_2O$ (Green vitriol) : It is prepared as follow ,

$$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$$

(i) One pressure to moist air crystals become brownish due to oxidation by air.

$$4FeSO_4 + 2H_2O + O_2 \rightarrow 4Fe(OH)SO_4$$

(ii) On heating, crystals become anhydrous and on strong heating it decomposes to Fe_2O_3, SO_2 and SO_3.

$$FeSO_4.7H_2O \xrightarrow{\text{heat}} FeSO_4 + 7H_2O$$

$$2FeSO_4 \xrightarrow[\text{heating}]{Strong} Fe_2O_3 + SO_2 + SO_3$$

(iii) It can reduce acidic solution of $KMnO_4$ and $K_2Cr_2O_7$

(iv) It is generally used in double salt with ammonium sulphate.

$$(NH_4)_2SO_4 + FeSO_4 + 6H_2O \rightarrow \underset{\text{Mohr's salt}}{FeSO_4.(NH_4)_2\,SO_4.6H_2O}$$

Mohr’s salt is resistant to atmospheric oxidation.

(v) It is used in the ring test for nitrate ions where it gives brown coloured ring of compound $FeSO_4.NO$.

$$FeSO_4 + NO \rightarrow FeSO_4.NO$$

(vi) $FeSO_4$ is used in manufacture of blue black ink.

(vii) $FeSO_4 + H_2O_2$ is known as a name of **Fenton’s reagent.**

(5) **Mohr's salt** $FeSO_4.(NH_4)_2\,SO_4.6H_2O$: It is a double salt and is prepared by crystallising a solution containing equivalent amounts of $FeSO_4.7H_2O$ and $(NH_4)_2SO_4$. It may be noted that Mohr’s salt contains only Fe^{2+} ions without any trace of Fe^{3+} ions. In contrast $FeSO_4.7H_2O$ always contains some Fe^{3+} ions due to aerial oxidation of Fe^{2+} ions. Mohr salt is, therefore, used as a primary standard in volumetric analysis since a standard solution of Fe^{2+} ions can be obtained directly by weighing a known amount of the Mohr salt.

It acts as a reducing agent and as such reduces acidified $KMnO_4$ and $K_2Cr_2O_7$ solutions.

$$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

$$Cr_2O_7^{2-} + \underset{\text{(From mohrs salt)}}{6Fe^{2+}} + 14H^+ \rightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O$$

Copper and its Compounds

(1) **Ores :** Copper pyrites (chalcopyrite) $CuFeS_2$, Cuprite (ruby copper) Cu_2O, Copper glance (Cu_2S), Malachite $[Cu(OH)_2.CuCO_3]$, Azurite $[Cu(OH)_2.2CuCO_3]$

(2) **Extraction :** Most of the copper (about 75%) is extracted from its sulphide ore, copper pyrites.

Concentration of ore : Froth floatation process.

Roasting : Main reaction :

$$2CuFeS_2 + O_2 \rightarrow Cu_2S + 2FeS + SO_2.$$

Side reaction : $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$

$$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2.$$

Smelting : $FeO + SiO_2 \rightarrow FeSiO_3\text{(slag)}$

$$Cu_2O + FeS \rightarrow FeO + Cu_2S$$

The mixture of copper and iron sulphides melt together to form '**matte**' $(Cu_2S + FeS)$ and the slag floats on its surface.

Conversion of matte into Blister copper (Bessemerisation) **:** Silica is added to matte and a hot blast of air is passed $FeO + SiO_2 \rightarrow FeSiO_3\text{(slag)}$. Slag is removed. By this time most of iron sulphide is removed. $Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$

Blister copper : Which contain about 98% pure copper and 2% impurities (*Ag*, *Au*, *Ni*, *Zn* etc.)

Properties of copper : It has reddish brown colour. It is highly malleable and ductile. It has high electrical conductivity and high thermal conductivity. Copper is second most useful metal (first being iron). It undergoes displacement reactions with lesser reactive metals e.g. with *Ag*. It can displace *Ag* from $AgNO_3$. The finally divided *Ag* so obtained is black in colour.

Copper shows oxidation states of +1 and +2. Whereas copper (I) salts are colourless, copper (II) salts are blue in colour. *Cu* (I) salts are less stable and hence are easily oxidised to *Cu* (II) salts $(2Cu^+ \rightarrow Cu^{2+} + Cu)$. This reaction is called **disproportionation.**

(1) In presence of atmospheric CO_2 and moisture, copper gets covered with a green layer of basic copper carbonate (green layer) which protects the rest of the metal from further acton.

$$Cu + O_2 + CO_2 + H_2O \rightarrow \underset{\text{(green layer)}}{Cu(OH)_2CuCO_3}$$

(2) In presence of oxygen or air, copper when heated to redness (below 1370*K*) first forms red cuprous oxide which changes to black cupric oxide on further heating. If the temperature is too high, cupric oxide changes back to cuprous oxide

$$4Cu + O_2 \xrightarrow{\text{Below 1370 K}} \underset{\text{(Red)}}{2Cu_2O} \xrightarrow[\text{Above 1370 } K]{O_2} \underset{\text{(Black)}}{4CuO}$$

$$CuO + Cu \xrightarrow{\text{High temp.}} Cu_2O$$

(3) Action of acids. Non oxidising dil. acids such as HCl, H_2SO_4 have no action on copper. However, copper dissolves in these acids in presence of air.

$$Cu + 2HCl + \frac{1}{2}O_2\text{(air)} \rightarrow CuCl_2 + H_2O$$

With dil. HNO_3, *Cu* liberates *NO* (nitric oxide)

$$3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$

With conc. HNO_3, copper gives NO_2

$$Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

With hot conc. H_2SO_4, copper gives SO_2

$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$$

Compounds of Copper

(1) **Halides of copper :** Copper (II) chloride, $CuCl_2$ is prepared by passing chlorine over heated copper. Concentrated aqueous solution of $CuCl_2$ is dark brown but changes first to green and then to blue on dilution.

On heating, it disproportionates to copper (I) chloride and chlorine

$$2CuCl_2 \xrightarrow{\text{Heat}} 2CuCl + Cl_2$$

It is used as a catalyst in the **Daecon's process** for the manufacture of chlorine.

Copper (I) chloride, *CuCl* is a white solid insoluble in water. It is obtained by boiling a solution of $CuCl_2$ with excess of copper turnings and conc. *HCl*.

$$CuCl_2 + Cu \xrightarrow{\text{HCl}} 2CuCl$$

It dissolves in conc. *HCl* due to the formation of complex $H[CuCl_2]$

$$CuCl + HCl \rightarrow H[CuCl_2]$$

It is used as a catalyst alongwith NH_4Cl in the preparation of synthetic rubber.

(2) **Cuprous oxide** Cu_2O **:** It is a reddish brown powder insoluble in water but soluble in ammonia solution, where it forms diammine copper (I) ion. $Cu^+ + 2NH_3 \rightarrow [Cu(NH_3)_2]^+$ **.** It is used to impart red colour to glass in glass industry.

(3) **Cupric oxide** *CuO* **:** It is dark black, hygroscopic powder which is reduced to *Cu* by hydrogen, *CO* etc. It is used to impart light blue colour to glass. It is prepared by heating copper nitrate.

$$2Cu(NO_3)_2 \xrightarrow{\Delta} 2CuO + 4NO_2 + O_2$$

(4) **Copper sulphate** $CuSO_4.5H_2O$ (Blue vitriol) **:** It is prepared by action of dil H_2SO_4 on copper scrap in presence of air. $2Cu + 2H_2SO_4 + \underset{\text{(air)}}{O_2} \rightarrow CuSO_4 + 2H_2O$

(i) On heating this blue salt becomes white due to loss of water of crystallization.

$$\underset{\text{Blue}}{CuSO_4.5H_2O} \xrightarrow{503\,K} \underset{\text{White}}{CuSO_4} + 5H_2O$$

At about 1000 K, $CuSO_4$ decomposes to give CuO and SO_3.

$$CuSO_4 \xrightarrow{1000\,K} CuO + SO_3$$

(ii) It gives a deep blue solution of tetrammine copper (II) sulphate with NH_4OH.

$$Cu_2SO_4 + 4NH_4OH, \rightarrow \underset{\text{Blue colour}}{[Cu(NH_3)_4]SO_4} + 4H_2O$$

(iii) With KCN it first gives yellow precipitate of $CuCN$ which decomposes of give $Cu_2(CN)_2$. $Cu_2(CN)_2$ dissolves in excess of KCN to give $K_3[Cu(CN)_4]$

$$2CuSO_4 + 4KCN \rightarrow Cu_2(CN)_2 + 2K_2SO_4 + (CN)_2$$

(iv) With KI it gives white ppt. of Cu_2I_2

$$4KI + 2CuSO_4 \rightarrow 2K_2SO_4 + \underset{\text{White ppt.}}{Cu_2I_2} + I_2$$

(v) With $K_4[Fe(CN)_6], CuSO_4$ gives a reddish brown ppt. of $Cu_2[Fe(CN)_6]$

$$2CuSO_4 + K_4[Fe(CN)_6] \rightarrow \underset{\text{Reddish brown ppt.}}{Cu_2[Fe(CN)_6]} + 2K_2SO_4$$

Uses *:* For electroplating and electrorefining of copper. As a mordant in dyeing. For making Bordeaux mixture (11 parts lime as milk of lime + 16 parts copper sulphate in 1,000 parts of water). It is an excellent fungicide. For making green pigments containing copper carbonate and other compounds of copper. Like Verdigris which is $Cu(CH_3COO)_2Cu(OH)_2$ *i.e.* basic copper acetate and is used as a green pigment in paints. As a fungicide in starch paste for book binding work.

(5) **Cupric sulphide** CuS : It is prepared as follows : $Cu(NO_3)_2 + H_2S \rightarrow \underset{\text{Black ppt.}}{CuS} + 2HNO_3$.

(6) **Basic copper carbonates :** Because of lower solubility of the hydroxide, the normal carbonate does not exist. Two basic copper carbonates occur in nature viz **malachite** $CuCO_3.Cu(OH)_2$ which has a fine green colour, and **azurite,** $2CuCO_3, Cu(OH)_2$ which is deep blue in colour.

Malachite is prepared by heating a mixture of $CuSO_4$ solution and limestone in a sealed tube at 423 – 443 K

$$2CuSO_4 + 2CaCO_3 + H_2O \xrightarrow{423\text{-}443K} \underset{\text{Malachite}}{CuCO_3Cu(OH)_2}$$
$$+2CaSO_4 + CO_2$$

At lower temperature *azurite* is formed

$$3CuSO_4 + 3CaCO_3 + H_2O \xrightarrow{<423\,K} \underset{\text{Azurite}}{2CuCO_3.Cu\ (OH)_2}$$
$$+3CaSO_4 + CO_2$$

On heating, both decompose to give black cupric oxide, water and CO_2.

They are used as green and blue painter's pigments under the name '**malachite green**' and **azurite blue**'.

Silver and its Compounds

(1) **Ores :** Argentite (silver glance) Ag_2S, Horn silver ($AgCl$), Ruby silver (Pyrargyrite) $3Ag_2S.Sb_2S_3$.

(2) **Extraction :** *Cyanide process or Mac Arthus-Forrest cyanide process* **:** This method depends on the fact that silver, its sulphide or chloride, forms soluble complex with alkali cyanides in the silver. This implies that silver compounds will dissolve in solution of alkali cyanides in the presence of blast of air.

$$4Ag + 8NaCN + 2H_2O + \underset{\text{air}}{O_2} \rightleftharpoons 4Na[Ag(CN)_2] + 4NaOH$$

or $4Ag + 8CN^- + 2H_2O + O_2 \rightleftharpoons 4[Ag(CN)_2]^- + 4OH^-$

$$Ag_2S + 4NaCN \rightleftharpoons 2Na[Ag(CN)_2] + Na_2S$$

$$AgCl + 2NaCN \rightleftharpoons Na[Ag(CN)_2] + NaCl.$$

The reaction with the sulphide is reversible and accumulation of Na_2S must be prevented. A free excess of air is continuously passed through the solution which oxidizes Na_2S into sulphate and thiosulphate.

$$2Na_2 + 2O_2 + H_2O \rightarrow Na_2S_2O_3 + 2NaOH$$

$$Na_2S_2O_3 + 2NaOH + 2O_2 \rightarrow 2Na_2SO_4 + H_2O$$

$$2Na[Ag(CN)_2] + 4NaOH + Zn \rightarrow Na_2ZnO_2 +$$
$$4NaCN + 2H_2O + 2Ag$$

(3) **Extraction of Ag from argentiferrous lead (*$PbS + Ag_2S$*)– Parke's Process :** It is based upon the following facts (i) Molten *Zn* and *Pb* are immiscible, zinc forms the upper layer (ii) *Ag* is more soluble in molten *Zn* (iii) *Zn-Ag* alloy solidifies earlier than molten *Pb* (IV) *Zn* being volatile can be separated from *Ag* by distillation. *Ag* is purified by cupellation.

Properties of Silver: Silver is a white lustrous metal, best conductor of heat and electricity. Being soft, it is alloyed. The silver alloy used for making jewellery contain 80% *Ag* and 20% *Cu*. The composition of a silver alloy is expressed as its purity i.e. the amount of *Ag* present in 1000 parts of the alloy *Ag* does not react with dilute *HCl* or dil. H_2SO_4 and aqua regia but reacts with dil. HNO_3 and conc. HNO_3

forming NO and NO_2 respectively. Chlorine also reacts with Ag to form $AgCl$.

$$2Ag + Cl_2 \to 2AgCl$$

Hot conc. H_2SO_4 reacts with Ag forming SO_2 like Cu

Compounds of Silver:

(1) **Silver oxide** (Ag_2O)**:** It is unstable and decomposes into Ag and O_2 on slow heating.

$$2Ag_2O \to 4Ag + O_2$$

(2) **Silver halides (*AgF, AgCl, AgBr and AgI*) :** Only *AgF* is soluble in H_2O. $AgCl$ is insoluble in H_2O but dissolves in NH_4OH , $Na_2S_2O_3$ and KCN solutions. *AgBr* is partly soluble whereas AgI is completely insoluble in NH_4OH . Except AgF , all the remaining three silver halides are photosensitive.

$$AgCl + 2NH_4OH \to \underset{\text{Diamine silver (I)chloride}}{[Ag(NH_3)_2]Cl} + 2H_2O$$

$$AgCl + 2KCN \to \underset{\text{Pot. Dicyanoargentate (I)}}{K[Ag(CN)_2]} + KCl$$

$$AgCl + 2Na_2S_2O_3 \to \underset{\text{Sod. Dithiosulphato argentate (I)}}{Na_3[Ag(S_2O_3)_2]} + NaCl$$

(3) **Silver nitrate (*AgNO₃*) :** Silver nitrate (*AgNO₃*) is called lunar caustic silver nitrate on *heating above* its m.p. (485 *K*) decomposes to silver nitrite but on heating to red heat gives silver.

$$2\ AgNO_3 \xrightarrow{\text{Above 485 K}} 2\ AgNO_2 + O_2$$

$$2\ AgNO_3 \xrightarrow{\text{Red heat}} 2\ Ag + 2NO_2 + O_2$$

When treated with *alkali*, $AgNO_3$ forms *silver* oxide which in case of NH_4OH dissolves to form complex ion.

$$2AgNO_3 + 2NaOH \to Ag_2O + 2NaNO_3 + H_2O$$

$$2AgNO_3 + 2NH_4OH \to Ag_2O + 2NH_4NO_3 + H_2O$$

$$Ag_2O + 4NH_4OH \to \underset{\text{Diamine silver hydroxide}}{2[Ag(NH_3)_2]OH} + 3H_2O$$

$AgNO_3$ reacts with iodine in two ways

$6AgNO_3$ (excess) + $3I_2 + 3H_2O \to AgIO_3 + 5AgI + 6HNO_3$

$5AgNO_3 + 3I_2$ (excess)

$+ 3H_2O \to HIO_3 + 5AgI + 5HNO_3$

In contact with organic matter (skin, cloth, paper etc.) $AgNO_3$ is reduced to metallic silver (black)

$2AgNO_3 + H_2O \to 2Ag + 2HNO_3 + [O] \to$ oxidises organic matter

$AgNO_3$ gives different coloured ppt. with different anions like $Cl^-, Br^-, I^-, S^{2-}, S_2O_3^{2-}, CrO_4^{2-}, PO_4^{3-}$ etc.

$AgNO_3$ is used in the preparation of ink and hair dyes.

Photography : The photographic plate is coated with a colloidal gelatinised solution of $AgBr$. During exposure, *AgBr* is reduced to metallic silver.

$$2AgBr \to 2Ag + Br_2$$

The exposed film is developed. The developer used is an alkaline solution of hydroquinone or quinol which reduces some of the exposed *AgBr* to black silver.

$$\underset{\text{Quinol}}{C_6H_4(OH)_2} + 2AgBr \to 2Ag + \underset{\text{Quinone}}{C_6H_4O_2} + 2HBr$$

The film is finally fixed by dipping in a solution of sodium thiosulphate or hypo which removes unchanged *AgBr* as complex ion.

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

After taking a print of the photograph it is finally toned by dipping in a dilute solution of gold chloride to impart a beautiful golden colour or it is dipped in potassium chloro platinate K_2PtCl_6 solution to get a shining grey tinge.

$$AuCl_3 + 3Ag \to 3AgCl + Au$$

Gold and its Compounds

(1) **Occurrence of gold :** Gold is mainly found in native state either as vein gold, placer gold or alluvial gold. It is also present to a small extent in the combined state as sulphide, telluride and arsenosulphide. It is considered to be the king of metal.

Some important ores of gold are:

(i) Calaverite, *AuTe₂* (ii) Sylvanite, *AuAgTe₂* and

(iii) Bismuth aurite, $BiAu_2$

(2) **Extraction of gold :** (i) ***Mac-Arthur-Forest Cyanide process*** : The powdered gold ore, after concentration by *Froth-floatation process*, is roasted to remove easily oxidisable impurities of tellurium, arsenic and sulphur. The roasted ore is then treated with a dilute solution of *KCN* in presence of atmospheric oxygen when gold dissolves due to the formation of an aurocyanide complex.

$$4Au + 8KCN + 2H_2O + O_2 \to \underset{\text{Solution}}{4K[Au(CN)_2]} + 4KOH$$

The metal is then extracted by adding zinc dust.

$$2K[Au(CN)_2] + Zn \to K_2[Zn(CN)_4] + \underset{\text{ppt.}}{2Au\downarrow}$$

(ii) ***Plattner's chlorine process*** **:** The roasted ore is moistened with water and placed in wooden vats with false perforated bottoms. It is saturated with current of chlorine, gold chloride thus formed is leached with water and the solution is treated with a reducing agent such as $FeSO_4$ or H_2S to precipitate gold.

$$AuCl_3 + 3FeSO_4 \to Au\downarrow + FeCl_3 + Fe_2(SO_4)_3$$

$$2\,AuCl_3 + 3H_2S \to 6HCl + 3S + 2Au\downarrow$$

The impure gold thus obtained contains impurities of *Ag* and *Cu*. The removal of *Ag* and *Cu* from gold is called parting. This is done by heating impure gold with conc. H_2SO_4 (or HNO_3) when *Ag* and *Cu* dissolve leaving behind *Au*.

$$Cu + 2H_2SO_4 \to CuSO_4 + SO_2 + 2H_2O$$

$$2Ag + 2H_2SO_4 \to Ag_2SO_4 + SO_2 + 2H_2O$$

Properties of Gold: Gold is a yellow, soft and heavy metal. Gold and *Ag* are called noble metals since they are not attacked by atmospheric oxygen. However, *Ag* gets tarnished when exposed to air containing traces of H_2S . Gold is malleable, ductile and a good conductor of heat and electricity.

Pure gold is soft. It is alloyed with *Ag* or *Cu* for making jewellery. Purity of gold is expressed in terms of carats. Pure gold is 24 carats. Gold '14 carats' means that it is an alloy of gold which contains 14 parts by weight of pure gold and 10 parts of copper per 24 parts by weight of the alloy. Thus the percentage of gold in '14 carats" of gold is = $\frac{100}{24} \times 14 = 58.3\%$.

Most of the jewellery is made from 22 carat gold (91.66% pure gold). Gold is quite inert. It does not react with oxygen, water and acids but dissolves in aqua regia

$$3HCl + HNO_3 \to NOCl + 2\,H_2O + 2Cl] \times 3$$

$$Au + 3\;Cl \to AuCl_3] \times 2$$

$$2\,Au + 9\,HCl + 3\,HNO_3 \to \underset{\text{Auric chloride}}{2\,AuCl_3} + 6\,H_2O + \underset{\text{Nitrosyl chloride}}{3NOCl}$$

Oxidation states of gold: The principal oxidation states of gold are + 1 and + 3 though + 1 state is more stable than + 3.

Compounds of gold

(1) **Auric chloride, $AuCl_3$:** It is prepared by passing dry Cl_2 over finely divided gold powder at 573 *K*

$$2\,Au + 3Cl_2 \xrightarrow{573\;K} 2\,AuCl_3$$

It is a red coloured crystalline solid soluble in water and decomposes on heating to give gold (I) chloride and Cl_2

$$AuCl_3 \xrightarrow{\text{Heat}} AuCl + Cl_2$$

It dissolves in conc. *HCl* forming chloroauric acid

$$AuCl_3 + HCl \to H[AuCl_4]$$

Chloroauric acid is used in photography for toning silver prints and as an antidote for snake poisoning.

(2) **Aurous sulphide, Au_2S :** It is prepared when H_2S is passed through an acidified solution of potassium aurocyanide, $K[Au(CN)_2]$

$$2K[Au(CN)_2] + H_2S \to Au_2S + 2KCN + 2HCN$$

It is a dark brown solid, not attached by dilute mineral acids and hence is probably the most stable gold compound.

Zinc and its Compounds

(1) **Occurrence of zinc:** Zinc does not occur in the native form since it is a reactive metal. The chief ores of zinc are (i) Zinc blende (ZnS) (ii) Calamine or zinc spar ($ZnCO_3$) and (iii) Zincite (ZnO)

(2) **Extraction of zinc :** Zinc blende, after concentration by Froth floatation process, is roasted in air to convert it into *ZnO*. In case of calamine, ore is calcined to get *ZnO*. The oxide thus obtained is mixed with crushed coke and heated at 1673 *K* in fire clay retorts (Belgian Process) when *ZnO* gets reduced to metallic zinc. Being volatile at this temperature, the metal distils over and is condensed leaving behind *Cd, Pb* and *Fe* as impurities. The crude metal is called spelter. The metal may be refined either by electrolysis or by fractional distillation.

Properties of *Zn* : Zinc is more reactive than mercury. It is a good conductor of heat and electricity. Zinc readily combines with oxygen to form *ZnO*. Pure zinc does not react with non-oxidising acids (*HCl* or H_2SO_4) but the impure metal reacts forming Zn^{2+} ions and evolving H_2 gas.

$$Zn + 2HCl \to ZnCl_2 + H_2\uparrow$$

Hot and conc. H_2SO_4 attacks zinc liberating SO_2 gas

$$Zn + 2\,H_2SO_4 \to ZnSO_4 + SO_2 + 2H_2O$$

Zinc also reacts with both dilute (hot and cold) HNO_3 and conc. HNO_3 liberating nitrous oxide (N_2O), ammonium nitrate (NH_4NO_3) and nitrogen dioxide (NO_2) respectively.

$$4Zn + 10HNO_3 \text{ (warm, dilute)} \to 4\,Zn(NO_3)_2 + N_2O + 5\,H_2O$$

$$4Zn + 10HNO_3 \text{ (coldvery dilute)} \to 4Zn(NO_3)_2 + NH_4NO_3 + 3H_2O$$

$$Zn + 4HNO_3 \text{ (hot and conc.)} \to Zn(NO_3)_2 + 2NO_2 + 2H_2O$$

Zinc dissolves in hot concentrated *NaOH* forming the soluble sod. Zincate

$$Zn + 2NaOH + 2H_2O \to Na_2[Zn(OH)_4] + H_2$$

or $Zn + 2NaOH \to Na_2ZnO_2 + H_2$

(3) **Special varieties of zinc.** (i) ***Zinc dust* :** It is prepared by melting zinc and then atomising it with a blast of air.

(ii) ***Granulated zinc* :** It is prepared by pouring molten zinc into cold water.

Both these varieties of zinc are used as reducing agents in laboratory.

Compounds of zinc

(1) **Zinc oxide (Zinc white or Chinese white), *ZnO* :** It is obtained by burning zinc in air or by heating zinc carbonate or zinc nitrate.

$$2Zn + O_2 \xrightarrow{\text{Heat}} 2ZnO$$

$$ZnCO_3 \xrightarrow{\text{Heat}} ZnO + CO_2$$

$$2Zn(NO_3)_2 \xrightarrow{\text{Heat}} 2ZnO + 4NO_2 + O_2$$

It is a white powder but becomes yellow on heating and again white on cooling.

It is insoluble in water and is very light and hence commonly known as **philosopher's wool**.

It is amphoteric in nature.

$$\underset{\text{(Basic)}}{ZnO} + 2HCl \rightarrow ZnCl_2 + H_2O$$

$$\underset{\text{(Acidic)}}{ZnO} + 2NaOH \rightarrow \underset{\text{Sod.zincate}}{Na_2ZnO_2} + H_2O$$

or $ZnO + 2NaOH + H_2O \rightarrow \underset{\text{Sod. tetrahydroxozincate (II)}}{Na_2[Zn(OH)_4]}$

It is reduced both by carbon and H_2 and is used as a white paint

$$ZnO + C \rightarrow Zn + CO \text{ ; } ZnO + H_2 \rightarrow Zn + H_2O$$

(2) **Zinc chloride, *ZnCl₂* :** It is obtained when *Zn* metal, *ZnO* or $ZnCO_3$ is treated with dil. *HCl*. It crystallizes as $ZnCl_2.2H_2O$ and becomes anhydrous on heating. $ZnCl_2$ is highly deliquescent and is highly soluble in H_2O and also readily dissolves in organic solvents like acetone, alcohol, ether etc. its aqueous solution is acidic due to hydrolysis.

$$ZnCl_2 + H_2O \rightarrow Zn(OH)Cl + HCl$$

Anhydrous $ZnCl_2$ is used as a Lewis acid catalyst in organic reactions. Mixed with moist zinc oxide, it is used for filling teeth and its solution is used for preserving timber. Anhydrous $ZnCl_2$ used as a Lucas reagent with conc. *HCl*.

(3) **Zinc sulphide, *ZnS* :** It is a white solid. It is soluble in dil. *HCl* and thus does not get precipitated by H_2S in the acidic medium.

$$ZnS + 2HCl \rightarrow ZnCl_2 + H_2S \text{ .}$$

It is a constituent of lithopone $(ZnS + BaSO_4)$

(4) **Zinc sulphate, *ZnSO₄.7H₂O* :** It is commonly known as white vitriol and is obtained by the action of dil. H_2SO_4 on zinc metal, *ZnO* or $ZnCO_3$. On heating, it first loses six molecules of water of crystallization at 373 *K*. At 723 *K*, it becomes anhydrous and on further heating, it decomposes.

$$ZnSO_4.7H_2O \xrightarrow{373\,K} ZnSO_4.H_2O \xrightarrow{723\,K}$$

$$2ZnSO_4 \xrightarrow{1073\,K} 2ZnO + 2SO_2 + O_2$$

It is used to prepare lithopone $(BaSO_4 + ZnS)$, a white paint and also in galvanising iron.

$$ZnSO_4 + BaS \rightarrow ZnS + BaSO_4$$

It is also used as an eye lotion.

Mercury and its compounds

(1) **Occurrence and extraction of mercury : Cinnabar (*HgS*)** is the only important ore of *Hg*. It is concentrated by froth floatation method and mercury is extracted from this ore by heating it in air at 773-873 *K* (auto reduction).

$$HgS + O_2 \xrightarrow{273-873\,K} Hg + SO_2$$

The mercury vapours thus obtained are condensed to give liquid metal. *Hg* thus obtained contains impurities of *Zn*, *Sn* and *Pb*. These are removed by treating the impure metal with dil HNO_3, mercurous nitrate, $Hg_2(NO_3)_2$ thus formed react with metals present as impurities forming their nitrates which pass into solution leaving behind pure mercury. However, it is best purified by distillation under reduced pressure.

$$6Hg + 8HNO_3(dil.) \xrightarrow{\text{warm}} 3Hg_2(NO_3)_2 + 4H_2O + 2NO$$

$$Zn + Hg_2(NO_3)_2 \rightarrow Zn(NO_3)_2 + 2Hg$$

Similar reaction is given by *Pb* and *Sn*.

Properties of mercury : Mercury is less reactive than *Zn*. It is a liquid at room temperature and has low thermal and electrical conductivity. Mercury forms dimeric mercury (I) ions, Hg_2^{+2} in which the two atoms are bonded by a covalent bond. It is slowly oxidised to *HgO* at about its boiling point. *Hg* does not react with dil. *HCl* or dil. H_2SO_4 but reacts with hot concentrated H_2SO_4 to form $HgSO_4$, it reacts with both warm dil. and conc. HNO_3 evolving *NO* and NO_2 respectively.

$$Hg + 2H_2SO_4(\text{hot, conc.}) \rightarrow HgSO_4 + SO_2 + 2H_2O$$

$$Hg + 4HNO_3(\text{conc.}) \rightarrow Hg(NO_3)_2 + 2NO_2 + 2H_2O$$

Hg does not react with steam or water hence can't form any hydroxide.

Compounds of mercury

(1) **Mercuric oxide, *HgO* :** It is obtained as a red solid by heating mercury in air or oxygen for a long time at 673 *K*

$$2Hg + O_2 \xrightarrow{673\,K} 2HgO(\text{red})$$

or by heating mercuric nitrate alone or in the presence of Hg

$$2Hg(NO_3)_2 \xrightarrow{\text{Heat}} \underset{\text{red}}{2HgO} + 4NO_2 + O_2$$

When $NaOH$ is added to a solution of $HgCl_2$, yellow precipitate of HgO are obtained.

$$Hg_2Cl_2 + 2NaOH \longrightarrow \underset{\text{(yellow)}}{HgO\downarrow} + H_2O + 2NaCl$$

Red and yellow forms of HgO differ only in their particle size. On heating to 673 K, yellow form changes to red form.

$$\underset{\text{yellow}}{HgO} \xrightarrow{673\,K} \underset{\text{red}}{HgO}$$

It is used in oil paints or as a mild antiseptic in ointments.

(2) **Mercuric chloride, $HgCl_2$:** It is obtained by treating Hg with Cl_2 or by heating a mixture of $NaCl$ and $HgSO_4$ in presence of small amount of MnO_2 (which oxidises any Hg(I) salts formed during the reaction).

$$HgSO_4 + 2NaCl \xrightarrow[MnO_2]{\text{Heat}} HgCl_2 + Na_2SO_4$$

It is a white crystalline solid and is commonly known as **corrosive sublimate**. It is a covalent compound since it dissolves in organic solvents like ethanol and ether.

It is extremely poisonous and causes death. Its best antidote is white of an egg.

When treated with stannous chloride, it is first reduced to white ppt. of mercurous chloride and then to mercury (black).

$$2HgCl_2 + SnCl_2 \rightarrow \underset{\text{white ppt.}}{Hg_2Cl_2} + SnCl_4$$

$$Hg_2Cl_2 + SnCl_2 \rightarrow \underset{\text{grey}}{2Hg} + SnCl_4$$

With ammonia it gives a white ppt. known as infusible white ppt.

$$HgCl_2 + 2NH_3 \rightarrow Hg(NH_2)Cl + NH_4Cl$$

A dilute solution of $HgCl_2$ is used as an antiseptic.

(3) **Mercuric iodide, HgI_2 :** It is obtained when a required amount of KI solution is added to a solution of $HgCl_2$.

$$HgCl_2 + 2KI \rightarrow \underset{\text{(red)}}{HgI_2} + 2KCl$$

Below 400 K, HgI_2 is red but above 400 K, it turns yellow

$$\underset{\text{(red)}}{HgI_2} \underset{\text{below } 400}{\overset{\text{above } 400}{\rightleftharpoons}} \underset{\text{(yellow)}}{HgI_2}$$

HgI_2 readily dissolves in excess of KI solution to form the $(HgI_4)^{2-}$ complex ion.

$$\underset{\text{Red ppt.}}{HgI_2} + 2KI \rightarrow \underset{\text{soluble colourless solution}}{K_2HgI_4}$$

An alkaline solution of $K_2[HgI_4]$ is called Nessler's reagent and is used to test NH_4^+ ions.

It gives a brown ppt. of $NH_2-Hg-O-Hg-I$ (Iodide of Millon's base) with NH_4^+ ions.

$$2K_2[HgI_4] + NH_3 + 3KOH \rightarrow NH_2.HgO.HgI + 7KI + 2H_2O$$

It is used in ointments for treating skin infections.

(4) **Mercurous chloride, Hg_2Cl_2 :** It is obtained as under :

(a) $Hg_2(NO_3)_2 + 2NaCl \rightarrow \underset{\text{white ppt.}}{Hg_2Cl_2} + 2NaNO_3$

(b) $HgCl_2 + Hg \xrightarrow{\text{Heat in an iron retort}} Hg_2Cl_2$ (condenses on cooling)

It is purified by sublimation.

Mercurous chloride is also called calomel. It is a white powder insoluble in H_2O. On heating, it decomposes to give $HgCl_2$ and Hg.

$$Hg_2Cl_2 \xrightarrow{\text{Heat}} HgCl_2 + Hg$$

It dissolves in chlorine water forming mercuric chloride.

$$Hg_2Cl_2 + Cl_2 \rightarrow 2HgCl_2$$

With ammonia, it turns black due to the formation of a mixture of finely divided black Hg and mercuric amino chloride.

$$Hg_2Cl_2 + 2NH_3 \rightarrow \underbrace{Hg + NH_2HgCl}_{\text{(black)}} + NH_4Cl$$

It is used to prepare standard calomel electrode and as a purgative in medicine.

(5) **Mercuric sulphide, HgS :** The solubility product of HgS is lower than that of ZnS and hence it gets precipitated as black solid when H_2S is passed through an acidic solution of any mercury (II) salt.

$$HgCl_2 + H_2S \rightarrow HgS + 2HCl$$

It is insoluble in water and *HCl* but dissolves in aqua regia (1 part conc. $HNO_3 + 3$ parts conc. *HCl*)

$$\underset{\text{Aqua regia}}{3HCl + HNO_3} \rightarrow \underset{\text{Nitrosyl chloride}}{NOCl} + 2H_2O + \underset{\text{Nascent chlorine}}{2[Cl]}$$

$$HgS + 2|Cl| \rightarrow \underset{\text{(Soluble)}}{HgCl_2} + S\downarrow$$

On sublimation, its colour changes to red and hence it is used as a red pigment.

(6) **Mercuric sulphate, *HgSO*$_4$:** It is obtained when *HgS* is treated with conc. H_2SO_4.

$$Hg + 2H_2SO_4 \rightarrow HgSO_4 + SO_2 + 2H_2O$$

It is a white solid which decomposes on heating to give mercurous sulphate.

$$3HgSO_4 \xrightarrow[675\,K]{\Delta} Hg_2SO_4 + Hg + 2SO_2 + 2O_2$$

It is used as a catalyst in the hydration of alkynes to give aldehydes or ketones. It is also used as a cosmetic under the name **Vermillon** and in ayurvedic medicine as **makardhwaj**.

(7) **Amalgams :** Mercury forms alloys commonly known as amalgams, with all metals except iron and platinum. Hence it is transported in iron containers.

(8) **Alloy of transition metal :** See in table discuss earlier in metallurgy.

Lanthanides and Actinides

Lanthanides and actinides are collectively called *f*-block elements because last electron in them enters into *f*-orbitals of the antepenultimate (*i.e.*, inner to penultimate) shell partly but incompletely filled in their elementary or ionic states. The name inner transition, elements is also given to them because they constitute transition series with in transition series (*d*-block elements) and the last electron enters into antepenultimate shell (*n*-2)*f*. In addition to incomplete *d*-subshell, their *f*-subshell is also incomplete. Thus, these elements have three incomplete outer shells i.e., (*n*–2), (*n*–1) and *n* shells and the general electronic configuration of *f*-block elements is $(n-2)\, f^{1-14}\, (n-1)d^{0-10} ns^2$.

(1) **Lanthanides :** The elements with atomic numbers 58 to 71 *i.e.* cerium to lutetium (which come immediately after lanthanum Z = 57) are called lanthanides or ***lanthanones or rare earths***. These elements involve the filling of 4 *f*-orbitals. Their general electronic configuration is, $[Xe]4f^{1-14}5d^{0-10}6s^2$. Promethium (*Pm*), atomic number 61 is the only synthetic (man made) radioactive lanthanide.

Properties of lanthanides

(i) These are highly dense metals and possess high melting points.

(ii) They form alloys easily with other metals especially iron. e.g. ***misch metal*** consists of a rare earth element (94–95%), iron (upto 5%) and traces of *S*, *C*, *Ca* and *Al*, pyrophoric alloys contain *Ce* (40–5%), *La* + neodymium (44%), *Fe* (4–5%), *Al* (0–5%) and the rest is *Ca*, *Si* and *C*. It is used in the preparation of ignition devices e.g., trace bullets and shells and flints for lighters and cigarette.

(iii) ***Oxidation state*** : Most stable oxidation state of lanthanides is +3. Oxidation states + 2 and + 4 also exist but they revert to +3 e.g. $Sm^{2+}, Eu^{2+}, Yb^{2+}$ lose electron to become +3 and hence are good reducing agents, where as Ce^{4+}, Pr^{4+}, Tb^{4+} in aqueous solution gain electron to become + 3 and hence are good oxidizing agents. There is a large gap in energy of 4 *f* and 5 *d* subshells and thus the number of oxidation states is limited.

(iv) ***Colour*** : Most of the trivalent lanthanide ions are coloured both in the solid state and in aqueous solution. This is due to the partly filled *f*-orbitals which permit *f*–*f* transition. The elements with *xf* electrons have a similar colour to those of (14 – *x*) electrons.

(v) ***Magnetic properties*** : All lanthanide ions with the exception of Lu^{3+}, Yb^{3+} and Ce^{4+} are paramagnetic because they contain unpaired electrons in the 4 *f* orbitals. These elements differ from the transition elements in that their magnetic moments do not obey the simple "**spin only**" formula $\mu_{eff} = \sqrt{n(n+2)}$ B.M. where *n* is equal to the number of unpaired electrons. In transition elements, the orbital contribution of the electron towards magnetic moment is usually quenched by interaction with electric fields of the environment but in case of lanthanides the 4*f*-orbitals lie too deep in the atom for such quenching to occur. Therefore, magnetic moments of lanthanides are calculated by taking into consideration spin as well as orbital contributions and a more complex formula

$$\mu_{eff} = \sqrt{4S(S+1) + L(L+1)} \text{ B.M.}$$

which involves the orbital quantum number *L* and spin quantum number *S*.

(vi) ***Complex formation*** : Although the lanthanide ions have a high charge (+3) yet the size of their ions is very large yielding small charge to size ratio *i.e.*, low charge density. As a consequence, they have poor tendency to form complexes. They form complexes mainly with strong chelating agents such as EDTA, β-diketones, oxine etc. *No* complexes with π-bonding ligands are known.

(vii) ***Lanthanide contraction*** : The regular decrease in the size of lanthanide ions from La^{3+} to Lu^{3+} is known as lanthanide contraction. It is due to greater effect of the increased nuclear charge than that of the screening effect.

Consequences of lanthanide contraction

(a) It results in slight variation in their chemical properties which helps in their separation by ion exchange

(b) Each element beyond lanthanum has same atomic radius as that of the element lying above it in the group (e.g. *Zr* 145 *pm*, *Hf* 144 *pm*); *Nb* 134 *pm*, *Ta* 134 *pm* ; *Mo* 129 *pm*, *W* 130 *pm*).

(c) The covalent character of hydroxides of lanthanides increases as the size decreases from La^{3+} to Lu^{3+}. However basic strength decreases. Thus $La(OH)_3$ is most basic whereas $Lu(OH)_3$ is least basic. Similarly, the basicity of oxides also decreases in the order from La^{3+} to Lu^{3+}.

(d) Tendency to form stable complexes from La^{3+} to Lu^{3+} increases as the size decreases in that order.

(e) There is a slight increase in electronegativity of the trivalent ions from *La* to *Lu*.

(f) Since the radius of Yb^{3+} ion (86 pm) is comparable to the heavier lanthanides *Tb*, *Dy*, *Ho* and *Er*, therefore they occur together in natural minerals.

(2) **Actinides :** The elements with atomic numbers 90 to 103 i.e. thorium to lawrencium (which come immediately after actinium, *Z* = 89) are called actinides or actinones. These elements involve the **filling of 5 *f*-orbitals**. Their general electronic configuration is, $[Rn]5f^{1-14}6d^{0-1}7s^2$.

They include three naturally occuring elements thorium, protactinium and uranium and eleven transuranium elements or transuranics which are produced artificially by nuclear reactions. They are synthetic or man made elements. All actinides are radioactive.

Properties of actinides

(i) ***Oxidation state*** : The dominant oxidation state of actinides is +3 which shows increasing stability for the heavier elements. *Np* shows +7 oxidation state but this is oxidising and is reduced to the most stable state +5. *Pu* also shows states upto +7 and *Am* upto +6 but the most stable state drops to *Pu* (+4) and *Am* (+3). *Bk* in +4 state is strongly oxidising but is more stable than *Cm* and *Am* in 4 state due to f^7 configuration. Similarly, *No* is markedly stable in +2 state due to its f^{14} configuration. When the oxidation number increases to + 6, the actinide ions are no longer simple. The high charge density causes the formation of oxygenated ions e.g., UO_2^{2+}, NpO_2^{2+} etc. The exhibition of large number of oxidation states of actinides is due to the fact that there is a very small energy gap between 5*f*, 6*d* and 7*s* subshells and thus all their electrons can take part in bond formation.

(ii) ***Actinide contraction*** : There is a regular decrease in ionic radii with increase in atomic number from *Th* to *Lr*. This is called actinide contraction analogous to the lanthanide contraction. It is caused due to imperfect shielding of one 5*f* electron by another in the same shell. This results in increase in the effective nuclear charge which causes contraction in size of the electron cloud.

(iii) ***Colour of the ions*** **:** Ions of actinides are generally coloured which is due to $f-f$ transitions. It depends upon the number of electrons in 5 *f* orbitals.

(iv) ***Magnetic properties*** **:** Like lanthanides, actinide elements are strongly paramagnetic. The magnetic moments are lesser than the theoretically predicted values. This is due to the fact that 5*f* electrons of actinides are less effectively shielded which results in quenching of orbital contribution.

(v) ***Complex formation*** **:** Actinides have a greater tendency to form complexes because of higher nuclear charge and smaller size of their atoms. They form complexes even with π-bonding ligands such as alkyl phosphines, thioethers etc, besides EDTA, β-diketones, oxine etc. The degree of complex formation decreases in the order.

$$M^{4+} > MO_2^{2+} > M^{3+} > MO_2^{+}$$

Where *M* is element of actinide series. There is a high concentration of charge on the metal atom in MO_2^{2+} which imparts to it relatively high tendency towards complex formation.

Tips & Tricks

✍ Iron pyrites is also known as Fool's gold ($CuFeS_2$).

✍ *Ni* can be extracted by or ford process.

✍ Chromium oxide is also known as chrome green.

✍ Cr_2O_3/C_5H_5N or solution of chromic oxide in pyridine is known as Collin's reagent.

- $Cr_2O_3.2H_2O$ is also known as Guignet's green.
- Zn, Cd and Hg are not expected to form covalent bond amongst themselves, hence they have relatively lower melting point.
- The +2 oxidation state become more stable while the +3 state become less stable from left to right in the periodic table.
- For the first four element of a transition series higher oxidation states are more stable than lower oxidation state. For next five-element lower oxidation state are more stable than higher oxidation state.
- Many transition metal compound are isomorphous *e.g.* $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$ because of almost equal ionic sizes of these metals.
- Lightest transition metal is Sc and heaviest and densest transition element is osmium.
- Mercurous ion exist as dimer Hg_2^{2+} and not as Hg^+ and this explains its diamagnetic nature.
- Pt, Pd and Ir are inert metal.
- $TiCl_4$ and TiO_2 are used in smoke screens.
- Mo is used in X-ray tube, Ta in analytic weight and instrument used in surgery of veins.
- Fe^{2+} is green and Fe^{3+} is yellow.
- Fe^{3+} is powerful oxidizing agent than Fe^{2+} ion.
- Iron carbide or cementite is Fe_3C.
- Kipp's base is $FeS + H_2SO_4$.
- Copper dissolves in an aqueous solution of $FeCl_3$.
- $CuSO_4$ reacts only with KI does not react with KCl, KBr or KF.
- $CuCl_2$ and $CuBr_2$ are covalent and exist as polymer while CuF_2 is an ionic solid.
- All silver halide except AgF are insoluble in water.
- Ag, Au and Cu are known as coinage metals.
- Fulminating gold is $Au(NH_2) = NH$ or N_2H_3.
- Purple of cassius is a colloidal solution of gold.
- Mercuric salts are more stable than mercurous salts.
- All the elements of *f*-block are in group 3 of the periodic table.
- Schweitzer reagent is $[Cu(NH_3)_4]SO_4$.
- Etard reagent is CrO_2Cl_2.
- Barfoed's reagent is $Cu(CH_3COO)_2 + CH_3COOH$.
- Milon's reagent is the solution of mercuric and mercurous nitrate.
- Zeigler natta catalyst is $TiCl_4 + (C_2H_5)_3Al$.
- Lindlar's catalyst is $Pd/BaSO_4$.
- Wilkinson's catalyst is $[Ph_3P]_3RhCl$.
- Adam catalyst is Pt/PtO.
- Brown's catalyst is Nickel boride (P-2 catalyst).

Ordinary Thinking

Objective Questions

General Characteristics

1. The number of unpaired electrons in Cr^+ will be
(a) 3 (b) 4
(c) 5 (d) 6

2. The highest oxidation state of Cr will be
(a) 2 (b) 3
(c) 4 (d) 6

3. Which statement is true about the transitional elements **[MP PMT 1995]**
(a) They are highly reactive
(b) They show variable oxidation states
(c) They have low M.P.
(d) They are highly electropositive

4. The transitional metal which form green compound in +3 oxidation state and yellow orange compound in +6 oxidation state is
(a) Fe (b) Ni
(c) Cr (d) Co

5. Highest (+7) oxidation state is shown by **[MP PMT 1990, 2001; RPMT 1999; AIIMS 1999; JIPMER 2001; CBSE PMT 1994, 2002; MP PET 1989, 2003]**
(a) Co (b) Cr
(c) V (d) Mn

6. Transitional elements are
(a) All metals
(b) Few metals and few non-metals
(c) All solids
(d) All highly reactive

7. Which of the following has highest ionic radii **[MP PMT 1990]**
(a) Cr^{+3} (b) Mn^{+3}
(c) Fe^{+3} (d) Co^{+3}

8. In a reaction the ferrous (Fe^{++}) iron is oxidised to ferric (Fe^{+++}) ion. The equivalent weight of the ion in the above reaction is equal to **[CPMT 1985]**
(a) Half of the atomic weight
(b) 1/5 of the atomic weight
(c) The atomic weight
(d) Twice the atomic weight

9. Which of the following element has maximum density
(a) Hg (b) Au
(c) Os (d) Pb

10. Which is heaviest among the following**[CPMT 1986]**
(a) Iron (b) Copper
(c) Gold (d) Silver

11. Transitional elements exhibit variable valencies because they release electrons from the following orbits **[MP PET/PMT 1988; MP PET 1989;UPSEAT 2001]**
(a) *ns* orbit (b) *ns* and *np* orbits
(c) (*n* – 1)*d* and *ns* orbits(d) (*n* – 1)*d* orbit

12. The tendency towards complex formation is maximum in
(a) *s* - block elements (b) *p* - block elements
(c) *d* - block elements (d) *f* - block elements

13. Which forms coloured salts **[CPMT 1984; MP PET 1995]**
(a) Metals (b) Non-metals
(c) *p* - block elements (d) Transitional elements

14. Which element belongs to *d* – block **[CPMT 1984]**
(a) Na (b) Ca
(c) Cu (d) Ar

15. Variable valency is shown by**[MP PMT 1986; AMU 1999]**
(a) Na (b) Cu
(c) Mg (d) Al

16. The element with a atomic number 26 is**[CPMT 1972]**
(a) A non-metal (b) Krypton
(c) Iron (d) Manganese

17. One of the following metals forms a volatile carbonyl compound and this property is taken advantage of for its extraction. This metal is**[NCERT 1984]**
(a) Iron (b) Nickel
(c) Cobalt (d) Tungston

18. The coinage metals are
(a) Iron, Cobalt, Nickel (b) Copper and Zinc
(c) Copper, Silver and Gold (d)Gold and Platinum

19. Which of the following structure is that of a coinage metal **[CPMT 1973, 86]**
(a) 2, 8, 1 (b) 2, 8, 18, 1
(c) 2, 8, 8 (d) 2, 18, 8, 3

20. An elements in+3 oxidation state has the electronic configuration $(Ar)3d^3$. Its atomic number is **[JIPMER 2002]**
(a) 24 (b) 23
(c) 22 (d) 21

21. The catalytic activity of the transition metals and their compounds is ascribed to their**[Kerala (Engg.) 2002]**
(a) Chemical reactivity
(b) Magnetic behaviour
(c) Unfilled *d*-orbitals
(d) Ability to adopt multiple oxidation states and their complexing ability

22. What is the general electronic configuration for 2nd row transition series **[Orrisa JEE 2002]**

(a) $[Ne]3d^{1-10}, 4s^2$ (b) $[Ar]3d^{1-10}, 4s^{1-2}$

(c) $[Kr]4d^{1-10}, 5s^{1-2}$ (d) $[Xe]5d^{1-10}, 5s^{1-2}$

23. Transitional elements are named transition elements because their characters are

(a) In between s and p - block elements

(b) Like that of p and d - block elements

(c) They are members of $I - A$ group

(d) They are like inactive elements

24. Those elements whose two outermost orbitals are incompletely filled with electrons are

(a) p - block elements

(b) s - block elements

(c) Transitional elements

(d) Both s and p - block elements

25. Which ion has maximum magnetic moment **[AIIMS 1983; MP PMT 1990]**

(a) V^{+3} (b) Mn^{+3}

(c) Fe^{+3} (d) Cu^{+2}

26. Which of the following transition metal is present in misch metal

(a) La (b) Sc

(c) Ni (d) Cr

27. Which of the following statements is not true in regard to transition elements **[EAMCET 1988, 89]**

(a) They readily form complex compounds

(b) They show variable valency

(c) All their ions are colourless

(d) Their ions contain partially filled d -electron levels

28. Which of the following represents the electronic configuration of a transition element **[EAMCET 1987]**

(a) $1s^2, 2s^2p^6 .... ns^2p^3$

(b) $1s^2, 2s^2p^6 .... ns^2p^6d^3, (n+1)s^2$

(c) $1s^2, 2s^2p^6 .... ns^2p^6d^{10}, (n+1)s^2p^1$

(d) $1s^2, 2s^2p^6 .... ns^2p^6$

29. The general electronic configuration of transition elements is **[CPMT 1984, 90, 2002; CBSE PMT 1991, 96; AIIMS 2001; Pb. CET 2000; MP PMT 2003]**

(a) $(n-1)d^{1-5}$ (b) $(n-1)d^{1-10}ns^1$

(c) $(n-1)d^{1-10}ns^{1-2}$ (d) $ns^2(n-1)d^{10}$

30. Transition elements are coloured **[MP PMT 1986; Pb. CET 1989; RPET 1999]**

(a) Due to small size

(b) Due to metallic nature

(c) Due to unpaired d - electrons

(d) All of these

31. Which of the following has the maximum number of unpaired d-electrons **[BIT 1992; CBSE PMT 1999]**

(a) Zn (b) Fe^{2+}

(c) Ni^{3+} (d) Cu^{+}

32. Which is not amphoteric **[CPMT 1991]**

(a) Al^{3+} (b) Cr^{3+}

(c) Fe^{3+} (d) Zn^{2+}

33. Which does not form amalgam **[AFMC 1988; MP PET 2001]**

(a) Fe (b) Co

(c) Ag (d) Zn

34. Transition metals are often paramagnetic owing to **[Bihar CEE 1992]**

(a) Their high M.P. and B.P.

(b) The presence of vacant orbitals

(c) The presence of one or more unpaired electrons in the system

(d) Their being less electropositive than the elements of groups I-A and II-A

35. Elements which generally exhibit multiple oxidation states and whose ions are usually coloured are **[NCERT 1973; MP PMT 2000]**

(a) Metalloids (b) Transition elements

(c) Non-metals (d) Gases

36. Which of the following transition metal cation has maximum unpaired electrons **[MP PET/PMT 1988; MP PMT 1991; RPMT 1997]**

(a) Mn^{+2} (b) Fe^{+2}

(c) Co^{2+} (d) Ni^{2+}

37. Maximum number of oxidation states of transition metal is derived from the following configuration **[MP PET/PMT 1988]**

(a) ns electron (b) $(n-1)d$ electron

(c) $(n+1)d$ electron (d) $ns + (n-1)d$ electron

38. Which of the following statement is correct **[MP PET/PMT 1988; MP PMT 1991]**

(a) Iron belongs to 3rd transition series of the periodic table

(b) Iron belongs to f-block of the periodic table

(c) Iron belongs to second transition series of the periodic table

(d) Iron belongs to group VIII of the periodic table

39. Zinc does not show variable valency like d-block elements because **[MP PET 1989; MP PMT 1992; CPMT 1984]**

(a) It is a soft metal

(b) d-orbital is complete

(c) It is low melting

(d) Two electrons are present in the outermost orbit

40. Which of the following is a transitional element **[MP PMT 1989; DPMT 1982]**

(a) Al (b) As

(c) Ni (d) Rb

41. Which is not true for transition elements

(a) They are all metals

(b) They show variable valency

(c) They form coloured ions

(d) They do not form co-ordinate compounds

42. The main reason for not using a mercury electrolytic cell in $NaOH$ manufacture is that **[CPMT 1988]**

(a) Hg is toxic

(b) Hg is a liquid

(c) Hg has a high vapour pressure

(d) Hg is a good conductor of electricity

43. Lanthanum is grouped with *f*-block elements because **[AMU 2000]**

(a) It has partially filled f-orbitals

(b) It is just before *Ce* in the periodic table

(c) It has both partially filled *f* and *d*-orbitals

(d) The properties of Lanthanum are very similar to the elements of 4*f* block

44. The element having electronic configuration belongs to $ns^2(n-1)d^{1-10}(n-2)f^{1-14}$ **[UPSEAT 2001]**

(a) *s*-block (b) *p*-block

(c) *d*-block (d) *f*-block

45. Variable valency is shown by **[UPSEAT 2001]**

(a) Typical elements (b) Normal elements

(c) Transition elements (d) None of these

46. Which ion is not coloured **[DPMT 2001]**

(a) Cr^{3+} (b) Co^{2+}

(c) Cr^{2+} (d) Cu^{+}

47. The number of unpaired electrons in ferrous ion is **[JIPMER (Med.) 2001]**

(a) 5 (b) 4

(c) 3 (d) 2

48. Fe, Co and Ni have valuable catalytic properties in process involving

(a) Organic compound (b) Oxidation

(c) Hydrogenation (d) Compounds of hydrogen

49. Which of the following statement is not correct **[NCERT 1983]**

(a) Metals contribute their valency electrons to the common sea of electrons

(b) Metals have high co-ordination number

(c) Metals tend to adopt closely packed structures

(d) Metals have high lattice energy

50. Zinc, cadmium and mercury show the properties of

(a) Typical elements (b) Normal elements

(c) Transitional elements (d) Rare elements

51. Iron is

(a) A normal element (b) A typical element

(c) A transitional element (d) An inert element

52. Platinum, palladium, iridium etc., are called noble metals because **[NCERT 1975; CPMT 1976]**

(a) Alfred Noble discovered them

(b) They are inert towards many common reagents

(c) They are shining lustrous and pleasing to look at

(d) They are found in active state

53. Which of the following statement is not true about *Mohr's* salt **[CPMT 1988]**

(a) It decolourises $KMnO_4$

(b) It is a primary standard

(c) It is a double salt

(d) Oxidation state of iron is +3 in this salt

54. Which one of the following statement is true for transition elements **[AIIMS 1983; AFMC 1987; JIPMER 1997]**

(a) They exhibit diamagnetism

(b) They exhibit inert pair effect

(c) They do not form alloys

(d) They show variable oxidation states

55. The valence shell electronic configuration of Cr^{2+} ion is **[Orissa JEE 2005]**

(a) $4s^0 3d^4$ (b) $4s^2 3d^2$

(c) $4s^2 3d^0$ (d) $3p^6 4s^2$

56. The hardness of Cr is due to ...... and metallic lusture is due to ....

(a) Covalent bond, metallic bond

(b) Covalent bond, hydrogen bond

(c) Metallic bond, covalent bond

(d) Metallic bond, hydrogen bond

57. In the first transition series, the highest B.P. and M.P. is of

(a) Cr (b) V

(c) Ni (d) Fe

58. In the following transition elements, the lowest M.P. and B.P. is exhibited by

(a) Cr (b) Hg

(c) Cu (d) Au

59. In the following members of transition elements, the lowest ionization energy is of

(a) Ti (b) Sc

(c) V (d) Mn

60. Which of the following has second ionisation potential less than expected

(a) Cr (b) Zn

(c) V (d) Mo

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

[CBSE PMT 1996]

(a) 25 (b) 26

(c) 22 (d) 19

62. The transition element have a characteristic electronic configuration which can be represented as

[MP PMT/PET 1988; MP PMT 1989]

(a) $(n-2)s^2p^6d^{1-10}(n-1)s^2p^6ns^2$

(b) $(n-2)s^2p^6d^{1-10}(n-1)s^1p^6d^1$ or d^1ns^1

(c) $(n-1)s^1p^6d^{10}ns^2p^6nd^{1-10}$

(d) $(n-1)s^2p^6d^{1-10}ns^1$ or ns^2

63. Number of unpaired electrons in $Fe^{+++}(Z=26)$ is

[MP PMT 1995; RPET 2003]

(a) 4 (b) 5

(c) 6 (d) 3

64. Of the ions Zn^{2+}, Ni^{2+} and Cr^{3+} [atomic number of $Zn=30$, $Ni=28$, $Cr=24$] **[MP PET 1996]**

(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

65. Common oxidation state of scandium, a transition element is/are [atomic number of Sc = 21]**[MP PET 1996]**

(a) + 4 (b) + 1

(c) + 2 and + 3 (d) + 4 and +1

66. Which of the following is not correct about transition metals

[MP PET 1996]

(a) Their melting and boiling points are high

(b) Their compounds are generally coloured

(c) They can form ionic or covalent compounds

(d) They do not exhibit variable valency

67. From +6 to +1 oxidation state is shown by the element of....... group

(a) V-B (b) VI-B

(c) VII-B (d) VIII

68. The electronic configuration of cobalt is

(a) $1s^2, 2s^2 2p^6 . 3s^2 3p^6 3d^1, 4s^2$

(b) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^7, 4s^2$

(c) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^3, 4s^2$

(d) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5, 4s^2$

69. Out of all the known elements the number of transitional elements is

(a) 80 (b) 61

(c) 43 (d) 38

70. **Cigarette** or **gas lighter** is made up of

(a) Misch metal (b) Alkali metal

(c) Noble metal (d) None

71. **Bullet-proof steel** alloy is prepared by using

(a) Sc (b) Ni

(c) Zr (d) Zn

72. In making **gun-berrel**, the steel used is

(a) $Fe-Mn$ (b) $Fe-Cr$

(c) $Fe-W$ (d) $Ni-Mo$

73. Neobium and tantalum metals are used in making surgical instruments because they are

(a) Non-corrosive (b) Hard

(c) Soft (d) All

74. To support tungstun filament in electric bulb, the steel used is

(a) Cr (b) Ni

(c) Mn (d) Mo

75. The elements belonging to the first transition series have atomic number from

(a) 19 to 37 (b) 22 to 32

(c) 24 to 30 (d) 21 to 30

76. Which of the following elements does not belong to the first transition series **[BHU 2000; MP PMT 1995]**

(a) Fe (b) V

(c) Ag (d) Cu

77. Fe^{2+} shows **[RPET 2000]**

(a) Ferromagnetism (b) Paramagnetism

(c) Diamagnetism (d) None of these

78. Zinc and mercury do not show variable valency like d-block elements because**[RPMT 2000; MP PMT 2000]**

(a) They are soft

(b) Their d- shells are complete

(c) They have only two electrons in the outermost subshell

(d) Their d-shells are incomplete

79. Cuprous ion is colourless while cupric ion is coloured because **[KCET 2000]**

(a) Both have half filled p and d-orbitals

(b) Cuprous ion has incomplete d-orbital and cupric ion has a complete d-orbital

(c) Both have unpaired electrons in the d-orbitals

(d) Cuprous ion has a complete *d*-orbital and cupric ion has an incomplete *d*-orbital

80. Transition metals are related to which block **[MP PMT 2003; CPMT 1991]**

(a) *s*-block (b) *p*-block

(c) *d*-block (d) None of these

81. The number of unpaired electrons in cobalt atom is (atomic number of Co = 27) **[MP PMT 2003]**

(a) 2 (b) 3

(c) 4 (d) 1

82. Zn is related to which group **[MP PMT 2003]**

(a) IIB (b) IIA

(c) IA (d) IB

83. Which of the following element does not show variable valency **[MP PMT 2003]**

(a) Ni (b) Zn

(c) Cu (d) Mn

84. Which of the following is diamagnetic transitional metal ion

(a) Ni^{+2} (b) Zn^{+2}

(c) Co^{+2} (d) Cu^{+2}

85. Which of the following is not an actinide **[DPMT 2005]**

(a) Curium (b) Californium

(c) Uranium (d) Terbium

86. The ability to form complex compounds by the transitional metal ion is due to

(a) Small size (b) Vacant '*d*' orbitals

(c) High nuclear charge (d) All of these

87. Which of the following will give green hydrated ion

(a) Fe^{+2} (b) Ni^{+2}

(c) (a) and (b) both (d) V^{+3}

88. Magnetic moment is expressed in

(a) Faraday (b) Calorie

(c) Bohr Magneton (d) Debye

89. If the colours of salts of transition elements are due to the presence of unpaired electrons in the transition metal ions, which of the following ions will be colourless in aqueous solution

(a) Ti^{3+} (b) Ti^{4+}

(c) Fe^{2+} (d) Fe^{3+}

(The at. no. of Ti and Fe are 22 and 26 respectively)

90. In the periodic table first transition series is placed in

(a) Third period (b) Fourth period

(c) Fifth period (d) None of these

91. The element having general electronic configuration $3d^4 4s^1$ is **[BHU 1978; CPMT 1987]**

(a) Noble gas (b) Non-metal

(c) Metalloid (d) Transition metal

92. Which of the following general configuration of outermost shell represents chromium element [Cr's atomic number = 24] **[CBSE PMT 1991; MP PMT 1992, 2001; RPET/PMT 1999]**

(a) d^5s^1 (b) d^6s^0

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

93. Which element gives maximum balanced oxide **[MP PMT 1990]**

(a) V (b) Cr

(c) Mn (d) Fe

94. In first transition series, the melting point of Mn is low because **[MP PMT/PET 1988]**

(a) Due to d^{10} configuration, metallic bonds are strong

(b) Due to d^7 configuration, metallic bonds are weak

(c) Due to d^5 configuration, metallic bonds are weak

(d) None of these

95. Which of the following ions has the least magnetic moment **[MP PMT 1993]**

(a) Cu^{+2} (b) Ni^{+2}

(c) Co^{+3} (d) Fe^{+2}

96. Among the following outermost configurations of transition metals, which shows the highest oxidation state **[MP PMT 1993; MP PET 1995, 2001]**

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

(c) $3d^5 4s^2$ (d) $3d^6 4s^2$

97. Which of the following is not true for transition metals **[MP PET 1993]**

(a) They are malleable and ductile

(b) They have high boiling and melting points

(c) They crystallize with body centred cubic and hexagonal close-packed structures only

(d) They show variable oxidation states although not always

98. The most malleable of all the metals is

(a) Silver (b) Sodium

(c) Gold (d) Platinum

99. Paramagnetism is exhibited by molecules **[NCERT 1981; Manipal MEE 1995]**

(a) Not attracted in a magnetic field

(b) Containing only paired electrons

(c) Carrying a positive charge

(d) Carrying unpaired electrons

100. The higher number of unpaired electrons are in

[DCE 2001]

(a) Fe
(b) Fe^{+}
(c) Fe^{+2}
(d) Fe^{+3}

101. Which one of the following statements concerning lanthanides elements is false

(a) Lanthanides are separated from one another by ion exchange methods
(b) The ionic radii of trivalent lanthanides steadily increase with increase in atomic number
(c) All lanthanides are highly dense metals
(d) Most typical oxidation of lanthanides is $+3$

102. Complex ion is shown by **[CPMT 2001]**

(a) Ag
(b) Au
(c) Cu
(d) All of these

103. Which of the following transition metal is used as a catalyst

[CPMT 2001]

(a) Nickel
(b) Cobalt
(c) Gold
(d) Both (a) and (b)

104. For which of the following transition metal ion is shown highest magnetic moment having outer electronic configuration **[MP PET 2003]**

(a) $3d^1$
(b) $3d^8$
(c) $3d^5$
(d) $3d^7$

105. The number of unpaired electrons is maximum in (Atomic no. : Ti = 22; V= 23; Cr = 24; Fe = 26)**[MP PET 2003]**

(a) Cr
(b) Fe
(c) V
(d) Sc

106. Europium is **[DPMT 2005]**

(a) s-block element
(b) p-block element
(c) d-block element
(d) f-block element

107. Which of the following elements is alloyed with copper to form brass **[MP PET 2003; MP PMT 2004]**

(a) Lead
(b) Silver
(c) Zinc
(d) Antimony

108. In which of the following metallic bond is strongest

[MP PET 2003]

(a) Fe
(b) Sc
(c) V
(d) Cr

109. Which of the following is a colourless ion**[EAMCET 1992]**

(a) Cu^{+2}
(b) Fe^{+3}
(c) Ti^{+3}
(d) Zn^{+2}

110. The substance used in cancer therapy is**[DPMT 2002]**

(a) Rn
(b) Ni
(c) Fe
(d) Co

111. In solution of $AgNO_{3,}$ if Cu is a solution become blue due to

[MH CET 2002]

(a) Oxidation of Ag
(b) Oxidation of Cu
(c) Reduction of Ag
(d) Reduction of Cu

112. Lanthanide for which + II and + III oxidation states are common is **[AIIMS 2003]**

(a) La **[AMU 2001]**
(b) Nd
(c) Ce
(d) Eu

113. The number of unpaired electrons in Zn^{++} is

(a) 2
(b) 3
(c) 4
(d) 0

114. The first transition element is

(a) Chromium
(b) Scandium
(c) Nickel
(d) Copper

115. The electronic configuration (outermost) of Mn^{+2} ion (atomic no. of $Mn = 25$) in its ground state is

[MP PET 1993; MP PMT 1994; AFMC 2002]

(a) $3d^5 4s^0$
(b) $3d^4 4s^1$
(c) $3d^3 4s^2$
(d) $3d^2 4s^2 4p^2$

116. The highest magnetic moment is shown by the transition metal ion with the outer electronic configuration

[MP PET 1993; MP PMT 1995; RPMT 1999]

(a) $3d^2$
(b) $3d^5$
(c) $3d^7$
(d) $3d^9$

117. Which has valency two

(a) Al
(b) Rb
(c) Cu
(d) Ge

118. All the following statements about the transitional elements are true except that**[Kerala (Med.) 2**

(a) All of the transitional elements are predominantly metallic
(b) In aqueous solution many of their simple ions are coloured
(c) Most of the transitional elements show pronounced catalytic activity
(d) Most of the transitional elements show only one valence state

119. Which of the following transition metals can have highest oxidation state **[RPET 2003]**

(a) Cr
(b) Co
(c) Ni
(d) Cu

120. Which of the following melts in boiling water**[MNR 1984]**

(a) Gun metal
(b) Wood's metal
(c) Monel metal
(d) Bell metal
(e) None of these

121. On the basis of position in the electrochemical series, the metal which does not displace hydrogen from water and acid is

(a) Hg
(b) Al
(c) Pb
(d) Ba

122. The tendency of 3*d*-metal ions to form stable complexes is due to their **[MP PMT 1997]**

(a) Variable oxidation state

(b) Strong electronegative nature

(c) High charge/size ratio and vacant *d*-orbitals

(d) Very low ionization energies

123. The 3*d*-metal ions are paramagnetic in nature because **[MP PMT 1997]**

(a) They are reducing agents

(b) They form coloured salts

(c) They have one or more paired *s*-electrons

(d) They have one or more unpaired *d*-electrons

124. Lanthanide contraction occurs because **[AMU 2000; BHU 2003]**

(a) *f*-orbital electrons are easily lost

(b) *f*-orbital an incompletely filled

(c) *f*-orbital electron an poor shielders of nuclear charge

(d) *f*-orbital do not come out on the surface of atom and are buried inside

125. Which is most reactive metal **[BHU 1979]**

(a) Fe (b) Pt

(c) Ni (d) Co

126. Least reactive metal is

(a) Fe (b) Os

(c) Ni (d) Pt

127. Which occludes hydrogen

(a) Os (b) Pt

(c) Ni (d) All of these

128. Which has the maximum ferromagnetic character

(a) Fe (b) Co

(c) Ni (d) Pt

129. Which forms interstitial compounds **[BHU 1982; MP PMT 1983]**

(a) Fe (b) Co

(c) Ni (d) All of these

130. Which occurs in nature in free state

(a) Fe (b) Co

(c) Ni (d) Pt

131. $3d^{10}4s^0$ electronic configuration exhibits

(a) Zn^{++} (b) Cu^{++}

(c) Cd^{++} (d) Hg^{++}

132. $3d^0 4s^0$ electronic configuration exhibits

(a) Pd^{+2} (b) Sc^{+2}

(c) Ti^{+4} (d) Zn^{+2}

133. Rare-earth elements are exhibited by

(a) At. No. 58 to 71 (b) At. No. 21 to 30

(c) At. No. 39 to 71 (d) At. No. 81 to 91

134. All those elements belong to *f* - block whose atomic numbers are

(a) 58 to 71 (b) 90 to 103

(c) Both (a) and (b) (d) None

135. The correct order of density is

(a) $Cu > Ni > Zn > Sc$

(b) $Ni > Cu > Zn > Sc$

(c) $Zn > Cu > Ni > Sc$

(d) $Sc > Zn > Ni > Cu$

136. The property exhibited by only transitional elements

(a) To form paramagnetic compounds

(b) To form coloured compounds

(c) To form complex compounds

(d) To show inert tendency

137. Which of the following will have standard oxidation potential less than SHE

(a) Zn (b) Cu

(c) Fe (d) Ni

138. Hydrated Cu^{+2} ion will be

(a) Green (b) Violet

(c) Blue (d) Colourless

139. The placement of Zn, Cd and Hg along with 'd' block elements is not proper because

(a) Their 'd' orbitals are completely filled

(b) Their 'd' orbitals are empty

(c) They do not form complex compounds

(d) They do not form coloured compounds

140. Which of the following is the weakest reducing agent

(a) Zn (b) Cu

(c) H_2 (d) Li

141. The decrease in atomic volume from Cr to Cu is very negligible because

(a) Increase in nuclear change

(b) Screening effect

(c) Unpaired electrons of Cr

(d) None

142. The heaviest atom amongst the following is **[Kurukshetra CEE 1998]**

(a) Uranium (b) Radium

(c) Lead (d) Mercury

143. Thallium shows different oxidation states because **[Kurukshetra CEE 1998]**

(a) It is a transition metal

(b) Of inert-pair effect

(c) Of its high reactivity

(d) Of its amphoteric character

144. The test of ozone O_3 can be done by **[AFMC 1997]**

(a) Ag
(b) Hg
(c) Au
(d) Cu

145. Which of the following set of elements does not belong to transitional elements set **[EAMCET 1998]**

(a) Fe, Co, Ni
(b) Cu, Ag, Au
(c) Ti, Zr, Hf
(d) Ga, In, Tl

146. The transition metals mostly are **[MP PMT 2000; Kerala (Med.) 2002]**

(a) Diamagnetic
(b) Paramagnetic
(c) Neither diamagnetic nor paramagnetic
(d) Both diamagnetic and paramagnetic

147. The correct statement in respect of *d*-block elements **[MP PMT 2000, 02]**

(a) They are all metals
(b) They show variable valency
(c) They form coloured ions and complex salts
(d) All above statements are correct

148. Which one of the following is an example of non-typical transition elements

(a) *Li, K, Na*
(b) *Be, Al, Pb*
(c) *Zn, Cd, Hg*
(d) *Ba, Ca, Sr*

149. Which one is wrong in the following statements **[Kurukshetra CET 2002]**

(a) Gold is considered to be the king of metals
(b) Gold is soluble in mercury
(c) Copper is added to gold to make it hard
(d) None of these

150. The number of unpaired electrons in Cr^{3+} ion is **[Kurukshetra CET 2002]**

(a) 3
(b) 5
(c) 4
(d) 1

151. The metal ion which does not form coloured compound is **[Kurukshetra CET 2002]**

(a) Chromium
(b) Manganese
(c) Zinc
(d) Iron

152. Super alloys are usually **[Kurukshetra CET 2002]**

(a) Iron based
(b) Nickel based
(c) Cobalt based
(d) Based on all of these

153. The transitional metal which shows oxidation state from +2 to +7 belong to group

(a) VII B
(b) VI B
(c) II B
(d) III B

154. Which of the following may be colourless **[RPMT 1997; RPET/PMT 1999]**

(a) Cr^{+3}
(b) Cu^{+}
(c) Fe^{+3}
(d) Cu^{2+}

155. Which of the following ions is paramagnetic

(a) Cu^{+}
(b) Zn^{+2}
(c) Ti^{+3}
(d) Ti^{+4}

156. Which of the following metals absorbs hydrogen

(a) K
(b) Al
(c) Zn
(d) Pd

157. Which of the following ions is coloured **[BHU 1997]**

(a) Cu^{+}
(b) Cu^{2+}
(c) Ti^{4+}
(d) V^{5+}

158. The metal present in B_{12} is **[BHU 1997]**

(a) Magnesium
(b) Iron
(c) Cobalt
(d) Manganese

159. Which metal does not give the following reaction M + water or steam $\rightarrow$ oxide + $H\downarrow$ **[Pb. PMT 2001]**

(a) Mercury
(b) Iron
(c) Sodium
(d) Magnesium

160. Ionisation potential values of *d*-block elements as compared to ionization potential value of *f*-block elements are **[MP PMT 2002]**

(a) Higher
(b) Equal
(c) lower
(d) All of these

161. Which one of the following properties is not of transition elements **[MP PET 1999; CPMT 2002]**

(a) Colour
(b) Paramagnetism
(c) Fixed valency
(d) None of the above

162. In which of the following, tendency towards formation of coloured ions is maximum **[MP PET 1999]**

(a) *s*-block elements
(b) *d*-block elements
(c) *p*-block elements
(d) *f*-block elements

163. The electronic configuration $1s^2,2s^2p^6,3s^2p^6d^6$ corresponds to **[MP PET 1994]**

(a) Mn^{2+}
(b) Fe^{2+}
(c) Co
(d) Ge

164. Which of the following statements is not correct about the electronic configuration of gaseous chromium atom **[MP PET 1994]**

(a) It has 5 electrons in $3d$ and one electron in $4s$ orbitals
(b) The principal quantum numbers of its valence electrons are 3 and 4
(c) It has 6 electrons in $3d$ orbital
(d) Its valance electrons have quantum number 'l' 0 and 2

165. Zn and Hg belong to the same group, they differ in many of their properties. The property that is shared by both is

[Pb. PMT 1998]

(a) They form oxide readily

(b) They react with steam readily

(c) They react with hot concentrated sulphuric acid

(d) They react with hot sodium hydroxide

166. Which of the following ionic species will impart colour to an aqueous solution **[CBSE PMT 1998; BHU 2001]**

(a) Ti^{4+} (b) Cu^{+}

(c) Zn^{2+} (d) Cr^{3+}

167. The number of electrons in the outermost shell of the 3d-transition elements generally remains

[MP PMT 1997]

(a) $(n-1)d^n$ (b) nd^n

(c) ns^2 (d) $(n-1)s^2$

168. The 3*d*-elements show variable oxidation states. What is the maximum oxidation state shown by the element Mn

[MP PMT 1997; JIPMER 2002]

(a) + 4 (b) + 5

(c) + 6 (d) + 7

169. Which of the following ions gives coloured solution

[MP PET 1995]

(a) Cu^{+} (b) Zn^{++}

(c) Ag^{+} (d) Fe^{++}

170. Which metal represents more than one oxidation state

[CPMT 1990]

(a) Al (b) Na

(c) Mg (d) Fe

171. A reduction in atomic size with increase in atomic number is a characteristic of elements of **[AIEEE 2003]**

(a) High atomic masses (b) *d*-block

(c) f –block (d) Radioactive series

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

[CBSE PMT 2003]

(a) Variable oxidation states

(b) High enthalpy of atomization

(c) Paramagnetic behaviour

(d) Colour of hydrated ions

173. The number of oxidation states of manganese is

(a) 4 (b) 6

(c) 3 (d) 8

174. Which of the following transitional metal has lowest density

(a) Sc (b) Ti

(c) V (d) Cr

175. Which of the following transitional metal has lowest boiling point (B.P.)

(a) Zn (b) Sc

(c) Ti (d) V

176. Which of the following electronic configuration is that of a transitional element **[NCERT 1983; CPMT 1989, 97; MP PET/PMT 1997; AIIMS 2000; MP PMT 2002]**

(a) $1s^2, 2s^2p^6, 3s^2p^6d^{10}, 4s^2p^6$

(b) $1s^2, 2s^2p^6, 3s^2p^6d^{10}, 4s^2p^1$

(c) $1s^2, 2s^2p^6, 3s^2p^6d^2, 4s^2$

(d) $1s^2, 2s^2p^6, 3s^2p^6, 4s^2$

177. Fe has been placed in the eighth group, the number of electrons in the outermost orbit is

(a) 1 (b) 2

(c) 3 (d) 4

178. Due to covalent bonding, the transitional metals are

(a) Lustrous (b) Conductor

(c) Hard and brittle (d) Ductile

179. The magnetic moment of a metal ion of first transition series is 2.83 BM. Therefore it will have unpaired electrons

(a) 6 (b) 4

(c) 3 (d) 2

180. Which of the following pair of ions may exhibit same colour

(a) Cr^{+++} and Fe^{++}

(b) Ti^{+++} and V^{++}

(c) Fe^{+++} and Mn^{++}

(d) Cu^{+} and Ni^{++}

181. The number of incomplete orbitals in inner transition element is **[Pb. PMT 2001]**

(a) 2 (b) 3

(c) 4 (d) 1

182. Most common oxidation states of Cs (cesium) are

[AIEEE 2002]

(a) + 2, + 3 (b) + 2, + 4

(c) + 3, + 4 (d) + 3, + 5

183. The $3d$ elements show variable oxidation states because the energies of the following sets of orbitals are almost similar

(a) $ns, (n-1)d$ (b) ns, nd

(c) $(n-1)s, nd$ (d) $np, (n-1)d$

184. Which of the following $3d$ bivalent metal ions has the smallest number of unpaired d electrons

(a) $3d^6$ (b) $3d^7$

(c) $3d^8$ (d) $3d^9$

185. The $3d$ metal ions form coloured compounds because the energy corresponding to the following lies in the visible range of electromagnetic spectrum

(a) Free energy change of complex formation by $3d$ metal ions

(b) $d-d$ transitions of $3d$ electrons

(c) Heat of hydration of $3d$ metal ions

(d) Ionisation energy of $3d$ metal ions

186. The oxidation number of iron in potassium ferrocyanide is

(a) +2 (b) +3

(c) +4 (d) Zero

187. In transition elements, the orbitals partially filled by electrons are **[DPMT 1984; MP PMT 1999]**

(a) s - orbitals (b) p - orbitals

(c) d - orbitals (d) f - orbitals

188. Number of unpaired electrons in Mn^{2+} is

[CPMT 1997; Pb. PET/PMT 1999]

(a) 3 (b) 5

(c) 4 (d) 1

189. Mercury is the only metal which is liquid at $0^o C$. This is due to its **[CBSE PMT 1995]**

(a) Very high ionisation energy and weak metallic bond

(b) Low ionisation potential

(c) High atomic weight

(d) High vapour pressure

190. Essential constituent of an amalgam is

[DPMT 1982; CPMT 1973, 77, 78, 89]

(a) Iron (b) An alkali metal

(c) Silver (d) Mercury

191. Mercury is transported in metal containers made of

[DPMT 1982; CPMT 1973]

(a) Silver (b) Lead

(c) Iron (d) Aluminium

192. The electroplating of chromium is undertaken because

[MP PMT 1994]

(a) Electrolysis of chromium is easier

(b) Chromium can form alloys with other metals

(c) Chromium gives protective and decorative coating to the base metal

(d) Of the high reactivity of metallic chromium

193. An element having the electronic configuration $[Ar]3d^2 4s^2$ belongs to **[MP PMT 1993]**

(a) s - block elements (b) p - block elements

(c) d - block elements (d) f - block elements

194. Which one of the following is not a transition metal

[MP PMT 1999]

(a) Chromium (b) Titanium

(c) Lead (d) Tungsten

195. The atomic number of an element is 22. The highest oxidation state exhibited by it in its compounds is

[MP PMT 1996]

(a) 1 (b) 2

(c) 3 (d) 4

196. d-block elements form

(a) Ionic compounds

(b) Covalent compounds

(c) Ionic and covalent compounds

(d) Only complex compounds

197. The transition metals have a less tendency to form ions due to **[Bihar CEE 1995]**

(a) High ionisation energy

(b) Low heat of hydration of ion

(c) High heat of sublimation

(d) All of these

198. The electronic configuration of Ag atom is **[CPMT 1984]**

(a) $[Kr]3d^{10} 4s^1$ (b) $[Xe]4f^{14} d^{10} 6s^1$

(c) $[Kr]4d^{10} 5s^1$ (d) $[Kr]4d^9 5s^2$

199. Most powerful oxidizing property of manganese is shown by which of the following oxidation state **[MP PET 2**

(a) $Mn(+7)$ (b) $Mn(+2)$

(c) $Mn(+4)$ (d) $Mn(+5)$

200. Which one of the following ions is colourless

[MP PET 1999; RPET/PMT 1999]

(a) Cu^+ (b) Co^{2+}

(c) Ni^{2+} (d) Fe^{3+}

201. The atomic radii of the elements are almost same of which series

(a) $Fe-Co-Ni$ (b) $Na-K-Rb$

(c) $F-Cl-Br$ (d) $Li-Be-B$

202. In human body if necessary, the plate, screw or wire used for surgery are made up of

(a) Ni (b) Au

(c) Pt (d) Ta

203. Manganese is related to which block of periodic table

[MP PMT 2003]

(a) s-block (b) p-block

(c) d-block (d) f -block

204. A hard and resistant metal (alloy) generally used in tip of nib of fountain pen is **[BHU 1982]**

(a) $Os.Ir$ (b) $Pt.Cr$
(c) $V.Fe$ (d) $Fe.Cr$

205. Chloride of which of the following elements will be coloured **[MP PMT 1999]**

(a) Silver (b) Mercury
(c) Zinc (d) Cobalt

206. Which of the following ions has the highest magnetic moment **[JIPMER 1997; AIEEE 2002]**

(a) Ti^{3+} (b) Sc^{3+}
(c) Mn^{2+} (d) Zn^{2+}

207. Cerium $(Z = 58)$ is an important member of the lanthanoids. Which of the following statements about cerium is incorrect **[AIEEE 2004]**

(a) The +4 oxidation state of cerium is not known in solutions
(b) The +3 oxidation state of cerium is more stable than the +4 oxidation state
(c) The common oxidation states of cerium are +3 and +4
(d) Cerium (IV) acts as an oxidizing agent

208. Of the following outer electronic configurations of atoms, the highest oxidation state is achieved by which one of them **[AIEEE 2004]**

(a) $(n-1)d^3ns^2$ (b) $(n-1)d^5ns^1$
(c) $(n-1)d^8ns^2$ (d) $(n-1)d^5ns^2$

209. Among the following series of transition metal ions, the one where all metals ions have $3d^2$ electronic configuration is **[CBSE PMT 2004]**

(a) $Ti^{4+}, V^{3+}, Cr^{2+}, Mn^{3+}$ (b) $Ti^{2+}, V^{3+}, Cr^{4+}, Mn^{5+}$
(c) $Ti^{3+}, V^{2+}, Cr^{3+}, Mn^{4+}$ (d) $Ti^{+}, V^{4+}, Cr^{6+}, Mn^{7+}$

210. Lanthanoids are **[CBSE PMT 2004]**

(a) 14 elements in the sixth period (atomic no. = 58 to 71) that are filling 4f sublevel
(b) 14 elements in the seventh period (atomic no. = 58 to 71) that are filling 4f sublevel
(c) 14 elements in the sixth period (atomic no. = 90 to 103) that are filling 4f sublevel
(d) 14 elements in the seventh period (atomic no. = 90 to 103) that are filling 4f sublevel

211. Which of the following metals make the most efficient catalyst **[BHU 1995]**

(a) Transition (b) Alkali
(c) Alkaline earth (d) Coloured metals

212. Lanthanides and actinides resemble in **[AFMC 2004]**

(a) Electronic configuration (b) Oxidation state
(c) Ionization energy (d) Formation of complexes

213. The lanthanide contraction relates to **[Kerala PMT 2004]**

(a) Atomic radii
(b) Atomic as well as M^{3+} radii
(c) Valence electrons
(d) Oxidation states
(e) Ionisation energy

214. Which of the following species is expected to show the highest magnetic moment? (At. Nos.: Cr=24, Mn = 25, Co = 27, Ni = 28, Cu = 29) **[Kerala PMT 20**

(a) Cr^{2+} (b) Mn^{2+}
(c) Cu^{2+} (d) Co^{2+}
(e) Ni^{2+}

215. Which one belongs to 3d-transition series **[MP PMT 2004]**

(a) Copper (b) Gold
(c) Cobalt (d) Silver

216. Which one of the following organisation's iron and steel plant was built to use charcoal as a source of power, to start with, but later switched over to hydroelectricity **[AIIMS 2004]**

(a) The Tata Iron and Steel Company
(b) The Indian Iron and Steel Company
(c) Mysore Iron and Steel Limited
(d) Hindustan Steel Limited

217. Which of the following is the correct sequence of atomic weights of given elements **[Pb. CET 2002]**

(a) $Fe > Co > Ni$ (b) $Ni > Co > Fe$
(c) $Co > Ni > Fe$ (d) $Fe > Ni > Co$

218. Which of the following element has maximum first ionisation potential **[Pb. CET 2002]**

(a) V (b) Ti
(c) Cr (d) Mn

219. A metal M having electronic configuration

M - $1s^2 2s^2 2p^6 3s^2 3p^6 3p^6 3d^{10} 4s^1$ **[DCE 2002]**

(a) s-block element (b) d-block element
(c) p-block element (d) None of these

220. Identify the transition element **[MH CET 2003]**

(a) $1s^2, 2s^2 2p^6, 3s^2, 3p^6, 4s^2$
(b) $1s^2, 2s^2 2p^6, 3s^2, 3p^6 3d^2, 4s^2$
(c) $1s^2, 2s^2 2p^6, 3s^2, 3p^6 3d^{10}, 4s^2 4p^2$
(d) $1s^2, 2s^2 2p^6, 3s^2, 3p^6 3d^{10}, 4s^2 4p^1$

221. What is the name of element with atomic number 105 **[CPMT 2004]**

(a) Kurchatovium (b) Dubnium

(c) Nobelium (d) Holmium

222. Electrons in a paramagnetic compound are **[UPSEAT 2004]**

(a) Shared (b) Unpaired

(c) Donated (d) Paired

223. Which of the following pairs involves isoelectronic ions **[UPSEAT 2004]**

(a) Mn^{3+} and Fe^{2+} (b) Mn^{2+} and Fe^{3+}

(c) Cr^{3+} and Mn^{2+} (d) Fe^{2+} and Co^{2+}

224. Which of the following is paramagnetic **[Pb. CET 2000]**

(a) Ni^{++} (b) Cu^{+}

(c) Zn^{++} (d) Sc^{+++}

225. The electronic configuration of chromium is **[BHU 2005; Pb. CET 2000]**

(a) $[Ne]3s^2 3p^6 3d^4, 4s^2$ (b) $[Ne]3s^2 3p^6 3d^5, 4s^1$

(c) $[Ne]3s^2 3p^6 3d^6, 4s^1$ (d) $[Ne]3s^2 3p^5 3d^5, 4s^2$

226. Electronic configuration of $Cu(Z = 29)$ is **[Pb. CET 2001]**

(a) $[Ar]3d^9 4s^2$ (b) $[Ar]3d^{10} 4s^1$

(c) $[Ar]3d^5 4s^2$ (d) $[Ar]3d^6 4s^2$

227. *Ce*-58 is a member of **[Pb. CET 2002]**

(a) *s*-block (b) *p*-block

(c) *d*-block (d) *f*-block

228. How many unpaired electrons are there in Ni^{2+} **[MP PET 2004]**

(a) 2 (b) 4

(c) 5 (d) 0

229. The main reason for larger number of oxidation states exhibited by the actinoids than the corresponding lanthanoids is **[CBSE PMT 2005]**

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

(b) Larger atomic size of actinoids than the lanthanoids

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

(d) Greater reactive nature of the actinoids than the lanthanoids

230. Four successive members of the first row transition elements are listed below with their atomic numbers. Which one of them is expected to have the highest third ionization enthalpy **[CBSE PMT 2005]**

(a) Vanadium (*Z* = 23) (b) Chromium (*Z* = 24)

(c) Iron (*Z* = 26) (d) Manganese (*Z* = 25)

231. The aqueous solution containing which one of the following ions will be colourless **[CBSE PMT 2000, 05]**

(a) Sc^{3+} (b) Fe^{2+}

(c) Ti^{3+} (d) Mn^{2+}

(Atomic number *Sc* = 21, *Fe* = 26, *Ti* = 22, *Mn* = 25)

232. Which of the following trivalent ion has the largest atomic radii in the lanthanide series **[BHU 2002]**

(a) *La* (b) *Ce*

(c) *Pm* (d) *Lu*

233. Which of the following does not have valence electron in 3*d*-subshell **[AIIMS 2002]**

(a) *Fe* (III) (b) *Mn* (II)

(c) *Cr* (I) (d) *P* (0)

234. Among the following pairs of ions, the lower oxidation state in aqueous solution is more stable than the other in **[AIIMS 2005]**

(a) Tl^{+}, Tl^{3+} (b) Cu^{+}, Cu^{2+}

(c) Cr^{2+}, Cr^{3+} (d) V^{2+}, VO^{2+}

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

(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 *Zn* have the same oxidation sate

236. Which of the following factors may be regarded as the main cause of lanthanide contraction **[AIEEE 2005]**

(a) Poor shielding of one of 4*f* electron by another in the subshell

(b) Effective shielding of one of 4*f* electrons by another in the subshell

(c) Poorer shielding of 5*d* electrons by 4*f* electrons

(d) Greater shielding of 5*d* electron by 4*f* electrons

237. Which of the following have maximum number of unpaired electrons **[BHU 2005]**

(a) Fe^{3+} (b) Fe^{2+}

(c) Co^{2+} (d) Co^{3+}

238. Transition metals show paramagnetism **[BHU 2005]**

(a) Due to characteristic configuration

(b) High lattice energy

(c) Due to variable oxidation states

(d) Due to unpaired electrons

239. Which of the following pairs of elements cannot form an alloy **[KCET 2005]**

(a) *Zn*, *Cu* (b) *Fe*, *Hg*

(c) *Fe*, *C* (d) *Hg*, *Na*

240. Which belongs to the actinides series **[J & K 2005]**

(a) *Ce* (b) *Cf*

(c) *Ca* (d) *Cs*

241. Effective magnetic droment of Sc^{+3} ion is **[Kerala CET 200**

(a) 1.73 (b) 0

(c) 5.92 (d) 2.83

(e) 3.87

Compounds of Transitional elements

1. Potassium permanganate acts as an oxidant in neutral, alkaline as well as acidic media. The final products obtained from it in the three conditions are, respectively **[MP PMT 1997]**

(a) MnO_2, MnO_2, Mn^{2+} (b) $MnO_4^{2-}, Mn^{3+}, Mn^{2+}$

(c) $MnO_2, MnO_4^{2-}, Mn^{3+}$ (d) MnO, MnO_4, Mn^{2+}

2. In acidic medium one mole of MnO_4^- accepts how many moles of electrons in a redox process ? **[MP PET/PMT 1998]**

(a) 1 (b) 3

(c) 5 (d) 6

3. In acidic medium potassium dichromate acts as an oxidant according to the equation, $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$. What is the equivalent weight of $K_2Cr_2O_7$? (mol. Wt. = M) **[MP PET/PMT 1998]**

(a) M (b) $M/2$

(c) $M/3$ (d) $M/6$

4. The correct formula of permanganic acid is **[MP PET 1999]**

(a) $HMnO_4$ (b) $HMnO_5$

(c) H_2MnO_4 (d) H_2MnO_3

5. Acidified potassium dichromate is treated with hydrogen sulphide. In the reaction, the oxidation number of chromium **[MP PET 1996]**

(a) Increases from + 3 to + 6

(b) Decreases from +6 to +3

(c) Remains unchanged

(d) Decreases from +6 to +2

6. When $KMnO_4$ reacts with acidified $FeSO_4$ **[MP PET 1996]**

(a) Only $FeSO_4$ is oxidised

(b) Only $KMnO_4$ is oxidised

(c) $FeSO_4$ is oxidised $KMnO_4$ and is reduced

(d) None of these

7. When calomel reacts with NH_4OH, we get **[CBSE PMT 1996]**

(a) $HgNH_2Cl$ (b) $NH_2-Hg-Hg-Cl$

(c) Hg_2O (d) HgO

8. $AgCl$ dissolves in a solution of NH_3 but not in water because **[MP PMT 1984, 86]**

(a) NH_3 is a better solvent than H_2O

(b) Ag^+ forms a complex ion with NH_3

(c) NH_3 is a stronger base than H_2O

(d) The dipole moment of water is higher than NH_3

9. In solid $CuSO_4.5H_2O$ copper is co-ordinated to **[MP PET 1985, 86]**

(a) Five water molecules (b) Four water molecules

(c) One sulphate anion (d) One water molecule

10. A white powder soluble in NH_4OH but insoluble in water is **[AFMC 1987]**

(a) $BaSO_4$ (b) $CuSO_4$

(c) $PbSO_4$ (d) $AgCl$

11. **Verdigris** is **[BHU 1987]**

(a) Basic copper acetate (b) Basic lead acetate

(c) Basic lead (d) None of these

12. Number of moles of $K_2Cr_2O_7$ reduced by one mole of Sn^{2+} ions is **[KCET 1996]**

(a) 1/3 (b) 3

(c) 1.6 (d) 6

13. Which one of the following is reduced by hydrogen peroxide in acid medium **[EAMCET 1997]**

(a) Potassium permanganate

(b) Potassium iodide

(c) Ferrous sulphate

(d) Potassium ferrocyanide

14. Which oxide of manganese is amphoteric **[AFMC 1995]**

(a) MnO_2 (b) Mn_2O_3

(c) Mn_2O_7 (d) MnO

15. Which one of the following oxides is ionic **[IIT-JEE 1995]**

(a) MnO (b) Mn_2O_7

(c) CrO_3 (d) P_2O_5

16. Correct formula of **calomel** is **[CPMT 1994; AFMC 1998]**

(a) Hg_2Cl_2 (b) $HgCl_2$

(c) $HgCl_2.H_2O$ (d) $HgSO_4$

17. One of the important use of ferrous sulphate is in the

(a) Manufacture of blue black ink

(b) Manufacture of chalks

(c) Preparation of hydrogen sulphide

(d) Preparation of anhydrous ferric chloride

18. Copper sulphate is not used

(a) In electrotyping

(b) In dyeing and calicoprinting

(c) In detecting water

(d) As fertilizer

19. **Blue vitriol** is **[AFMC 1992]**

(a) $CuSO_4$ (b) $CuSO_4.5H_2O$

(c) Cu_2SO_4 (d) $CuSO_4.H_2O$

20. A solution of copper sulphate may be kept safely in the container made up of

(a) Fe (b) Ag

(c) Zn (d) Al

21. Silver nitrate produces a black stain on skin due to

(a) Being a strong reducing agent
(b) Its corrosive action
(c) Formation of complex compound
(d) Its reduction to metallic silver

22. When hypo solution is added to cupric sulphate solution, the blue colour of the latter is discharged, due to formation of
(a) CuS_2O_3 (b) $Na_2S_4O_6$
(c) $NaCuS_2O_3$ (d) Cu_2O

23. Metal oxides which decomposes on heating is **[MNR 1984; UPSEAT 1999]**
(a) ZnO (b) Al_2O_3
(c) CuO (d) Na_2O
(e) HgO

24. Anhydrous sample of ferric chloride is prepared by heating
(a) $Fe + HCl$ (b) $Fe + Cl_2$
(c) $FeCl_2 + Cl_2$ (d) Hydrated ferric chloride

25. Light green crystals of ferrous sulphate lose water molecule and turn brown on exposure to air. This is due to its oxidation to
(a) Fe_2O_3 (b) $Fe_2O_3.H_2O$
(c) $Fe(OH)SO_4$ (d) $Fe_2O_3 + FeO$

26. In alkaline condition $KMnO_4$, reacts as follows :
$2KMnO_4 + 2KOH \rightarrow 2K_2MnO_4 + H_2O + O$
Therefore its equivalent weight will be **[NCERT 1974; CPMT 1977; DCE 2002]**
(a) 31.5 (b) 52.7
(c) 72.0 (d) 158.0

27. Equivalent weight of $KMnO_4$ acting as an oxidant in acidic medium is equal to **[CPMT 1990; MP PMT 1999]**
(a) Molecular weight of $KMnO_4$
(b) $\frac{1}{2} \times$ Molecular weight of $KMnO_4$
(c) $\frac{1}{3} \times$ Molecular weight of $KMnO_4$
(d) $\frac{1}{5} \times$ Molecular weight of $KMnO_4$

28. In which of the following ionic radii of chromium would be smallest **[MP PET 1994]**
(a) K_2CrO_4 (b) CrO_2
(c) $CrCl_3$ (d) CrF_2

29. $CoO.Al_2O_3$ is called
(a) Cobalt aluminate (b) Thenard's blue
(c) Both (a) and (b) (d) None of these

30. $ZnO.CoO$ is called
(a) Cobalt zincate (b) Rinman's green
(c) Both (a) and (b) (d) None of these

31. $FeSO_4.(NH_4)_2SO_4.6H_2O$ is called **[Bihar CEE 1995]**
(a) Mohr's salt (b) Green salt
(c) Alum (d) Glauber's salt

32. Molybdenum compounds are used in
(a) Dye industry (b) For colouring leather
(c) For colouring rubber (d) All of these

33. When copper turnings and concentrated HCl is heated with copper sulphate the compound formed is **[CPMT 1984]**
(a) Cupric chloride (b) Cuprous chloride
(c) Copper sulphate (d) SO_2

34. The compound of copper which turns green on keeping in air is **[CPMT 1984]**
(a) Copper sulphate (b) Copper nitrate
(c) Cupric chloride (d) Cuprous chloride

35. Cu_2Cl_2 with HCl in presence of oxidising agents gives **[CPMT 1984]**
(a) $CuCl_2$ (b) H_2CuCl_2
(c) Hydrogen gas (d) Chlorine gas

36. $K_2Cr_2O_7$ on heating with aqueous $NaOH$ gives **[CBSE PMT 1997]**
(a) CrO_4^{2-} (b) $Cr(OH)_3$
(c) $Cr_2O_7^{2-}$ (d) $Cr(OH)_2$

37. $KMnO_4$ reacts with oxalic acid according to the equation :
$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$
Here 20 *ml* of 0.1 M $KMnO_4$ is equivalent to **[CBSE PMT 1996]**
(a) $20 ml$ of 0.5 M $C_2H_2O_4$
(b) $50 ml$ of 0.1 M $C_2H_2O_4$
(c) $50 ml$ of 0.5 M $C_2H_2O_4$
(d) $20 ml$ of 0.1 M $C_2H_2O_4$

38. The equivalent weight of potassium permanganate for acid solution is **[MP PET 1999]**
(a) 158 (b) 31.6
(c) 52.16 (d) 79

39. Which statement is not correct **[MP PET 1999]**
(a) Potassium permanganate is a powerful oxidising substance
(b) Potassium permanganate is a weaker oxidising substance than potassium dichromate
(c) Potassium permanganate is a stronger oxidising substance than potassium dichromate
(d) Potassium dichromate oxidises a secondary alcohol into a ketone

40. The formula of corrosive sublimate is **[CPMT 1997]**
(a) $HgCl_2$ (b) Hg_2Cl_2
(c) Hg_2O (d) Hg

41. Which is mild oxidising agent **[AFMC 1971]**
(a) Ag_2O (b) $KMnO_4$

(c) $K_2Cr_2O_7$ (d) Cl_2

42. The equivalent weight of $K_2Cr_2O_7$ in acidic medium

(a) 294 (b) 298

(c) 49 (d) 50

43. The transitional element of III-B group is isomorphic with $Al_2(SO_4)_3$. Therefore the compound will be

(a) Purple (b) Blue

(c) White (d) Uncertain

44. A copper salt is isomorphic with $ZnSO_4$, the salt will be

(a) Paramagnetic (b) Diamagnetic

(c) Ferromagnetic (d) None

45. V_2O_5 is useful as catalyst in

(a) Manufacture of H_2SO_4

(b) Manufacture of HNO_3

(c) Manufacture of Na_2CO_3

(d) It is not a catalyst

46. $KMnO_4$ in basic medium is reduced to **[Orissa JEE 2005]**

(a) K_2MnO_4 (b) MnO_2

(c) $Mn(OH)_2$ (d) Mn^{2+}

47. When $KMnO_4$ is reduced with oxalic acid in acidic solution, the oxidation number of Mn changes from

[CPMT 1989]

(a) 7 to 4 (b) 6 to 4

(c) 7 to 2 (d) 4 to 2

48. Nesseler's reagent is

[MP PET 1991; MP PMT 1993; AFMC 2001]

(a) K_2HgI_4 (b) $K_2HgI_4 + KOH$

(c) $K_2HgI_2 + KOH$ (d) $K_2HgI_4 + Hg$

49. When ammonium dichromate is heated, the gas formed is

[MP PMT 1993; IIT-JEE 1999]

(a) N_2 (b) O_2

(c) H_2 (d) NH_3

50. Acidified potassium dichromate on reacting with a sulphite is reduced to

(a) CrO_2Cl_2 (b) CrO_4^{2-}

(c) Cr^{3+} (d) Cr^{2+}

51. The product of oxidation of I^- ion by MnO_4^- in alkaline medium is

(a) I_2 (b) IO_3^-

(c) IO_4^- (d) I_3^-

52. Identify the statement which is not correct regarding copper sulphate

(a) It reacts with KI to give iodine

(b) It reacts with KCl to give Cu_2Cl_2

(c) It reacts with $NaOH$ and glucose to give Cu_2O

(d) It give CuO on strong heating in air

53. Acidified potassium permanganate solution is decolourised by **[MNR 1984]**

(a) Bleaching powder (b) White vitriol

(c) Mohr's salt (d) Microcosmic salt

(e) Laughing gas

54. Which of the following oxides is white but becomes yellow on heating **[MP PET 1995]**

(a) AgO (b) Ag_2O

(c) FeO (d) ZnO

55. Amalgams are

(a) Highly coloured alloys

(b) Always solid

(c) Alloys which contain mercury as one of the contents

(d) Alloys which have great resistance to abrasion

56. In photography sodium thiosulphate is used as

[DPMT 2005]

(a) Complexing agent (b) Oxidising agent

(c) Reducing agent (d) None of these

57. The substance that sublimes on heating

[EAMCET 1978, 82; MP PMT 1999]

(a) Magnesium chloride (b) Silver chloride

(c) Mercurous chloride (d) Sodium chloride

58. $K_3[Fe(CN)_6]$ is called

(a) Potassium ferricyanide

(b) Red prussiate of potash

(c) Potassium hexacyanoferrate (III)

(d) All of these

59. Which of the following will show increase in weight when kept in magnetic field

(a) TiO_2 (b) $Fe_2(SO_4)_3$

(c) $KMnO_4$ (d) $ScCl_3$

60. 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 **[CBSE PMT 1995]**

(a) CoF_6^{3-} and $NiCl_4^{2-}$ (b) TiF_6^{2-} and CoF_6^{3-}

(c) Cu_2Cl_2 and $NiCl_4^{2-}$ (d) TiF_6^{2-} and Cu_2Cl_2

61. Which of the following imparts green colour to the glass

[CPMT 1993]

(a) Cu_2O (b) CdS

(c) MnO_2 (d) Cr_2O_3

62. On the heating copper nitrate strongly, ... is finally obtained **[CPMT 1971, 74, 78]**

(a) Copper (b) Copper oxide

(c) Copper nitrate (d) Copper nitride

[UPSEAT 2000, 01]

63. On adding KI to a solution of copper sulphate

[CPMT 1973; NCERT 1977; MP PMT 1989]

(a) Cupric oxide is precipitated

(b) Metallic copper is precipitated

(c) Cuprous iodide is precipitated with liberation of iodine

(d) No change occurs

64. Which of the following statements is correct about equivalent weight of $KMnO_4$ **[MP PET 1994]**

(a) It is one third of its molecular weight in alkaline medium

(b) It is one fifth of its molecular weight in alkaline medium

(c) It is equal to its molecular weight in acidic medium

(d) It is one third of its molecular weight in acidic medium

65. The reaction of $K_2Cr_2O_7$ with $NaCl$ and conc. H_2SO_4 gives **[MP PET 1994]**

(a) $CrCl_3$
(b) $CrOCl_2$
(c) CrO_2Cl_2
(d) Cr_2O_3

66. Silver nitrate is supplied in coloured bottles because it is **[CPMT 1985]**

(a) Oxidised in air
(b) Decomposes in sunlight
(c) Explosive in sunlight
(d) Reactive towards air in sunlight

67. A nitrate when mixed with common salt gives a white precipitate which is soluble in dilute NH_4OH. It is the nitrate of **[CPMT 1985]**

(a) Copper
(b) Mercury
(c) Silver
(d) Gold

68. Which one of the following is **lunar caustic** **[CPMT 1984]**

(a) $AgNO_3$
(b) Cu_2Cl_2
(c) $CuCl_2$
(d) Hg_2Cl_2

69. Invar, an alloy of *Fe* and *Ni* is used in watches and meter scale, its characteristic property is **[Kerala (Engg.) 2002]**

(a) Small coefficient of expansion
(b) Resistance to corrosion
(c) Hardness and elasticity
(d) Magnetic nature

70. The extraction of nickel involves

(a) The formation of $Ni(CO)_4$

(b) The decomposition of $Ni(CO)_4$

(c) The formation and thermal decomposition of $Ni(CO)_4$

(d) The formation and catalytic decomposition of $Ni(CO)_4$

71. On adding excess of NH_3 solution to $CuSO_4$ solution, the dark blue colour is due to **[CPMT 1990; AIIMS 1982; MP PMT 1989, 92; BHU 1996; JIPMER 1997]**

(a) $[Cu(NH_3)_4]^{++}$
(b) $[Cu(NH_3)_2]^{++}$
(c) $[Cu(NH_3)]^{+}$
(d) None of the above

72. If M is the molecular weight of $KMnO_4$, its equivalent weight will be when it is converted into K_2MnO_4 **[MP PET 1993]**

(a) M
(b) $M/3$
(c) $M/5$
(d) $M/7$

73. While writing the formula of ferrous oxide it is written as (FeO), because it is

(a) Non-stoichiometric
(b) Non-existant
(c) Paramagnetic
(d) Ferromagnetic

74. Which of the following exhibit maximum oxidation state of vanadium

(a) $VOCl_3$
(b) VCl_4
(c) VCl_3
(d) VCl_2

75. **Prussian blue** is due to the formation of **[BHU 1980; CBSE PMT 1990; KCET 1992; MP PET 1995]**

(a) $Fe_4[Fe(CN)_6]_3$
(b) $Fe_2[Fe(CN)_6]$
(c) $Fe_3[Fe(CN)_6]$
(d) $Fe[Fe(CN)_6]_3$

76. The Nesseler's reagent contains **[CPMT 1976, 88; NCERT 1987; MP PMT 1985; BHU 1996]**

(a) Hg_2^{++}
(b) Hg^{++}
(c) HgI_2^{--}
(d) HgI_4^{--}

77. Formula of ferric sulphate is **[AFMC 2003]**

(a) $FeSO_4$
(b) $Fe(SO_4)_2$
(c) Fe_2SO_4
(d) $Fe_2(SO_4)_3$

78. When $CuSO_4$ is hydrated, then it becomes **[AFMC 2003]**

(a) Acidic
(b) basic
(c) Neutral
(d) Amphoteric

79. Silvering of mirror is done by **[AFMC 2003]**

(a) $AgNO_3$
(b) Ag_2O_3
(c) Fe_2O_3
(d) Al_2O_3

80. The colour of $K_2Cr_2O_7$ changes from red orange to lemon yellow on treatment with aqueous KOH because of **[MP PMT 1994]**

(a) The reduction of Cr^{VI} to Cr^{III}
(b) The formation of chromium hydroxide
(c) The conversion of dichromate to chromate
(d) The oxidation of potassium hydroxide to potassium peroxide

81. On heating pyrollusite with KOH in presence of air we get

(a) $KMnO_4$
(b) K_2MnO_4
(c) $Mn(OH)_2$
(d) Mn_3O_4

82. $Cu(CN)_4^{2-}$ is colourless as it absorbs light in

(a) Visible region
(b) Ultraviolet region
(c) Infrared region
(d) All above are wrong

83. Acidified solution of chromic acid on treatment with hydrogen peroxide yields **[MP PET 1999; AFMC 2000]**

(a) $CrO_3 + H_2O + O_2$ (b) $Cr_2O_3 + H_2O + O_2$

(c) $CrO_5 + H_2O$ (d) $H_2Cr_2O_7 + H_2O + O_2$

84. Which of the following metals corrodes readily in moist air

[CPMT 1972, 82; CBSE PMT 1989]

(a) Gold (b) Silver

(c) Nickel (d) Iron

85. Which one of the following compounds is not coloured

[AIIMS 1997]

(a) Na_2CuCl_4 (b) Na_2CdCl_4

(c) $K_4Fe(CN)_6$ (d) $K_3Fe(CN)_6$

86. Acidified $KMnO_4$ is decolourzed by **[AMU 1999]**

(a) Br_2 (b) O_3

(c) HCl (d) HBr

87. Which of the following compound expected to be colourless

(a) ScO (b) V_2O_3

(c) $CuCN$ (d) $Cr_2(SO_4)_3$

88. Crystals of which pair are isomorphous **[CPMT 1990]**

(a) $ZnSO_4$, $SnSO_4$ (b) $MgSO_4$, $CaSO_4$

(c) $ZnSO_4$, $MgSO_4$ (d) $PbSO_4$, $NiSO_4$

89. On heating $Mn(OH)_2$ with PbO_2 and conc. HNO_3 pink colour is obtained due to the formation of **[MP PET 1995]**

(a) $KMnO_4$ (b) $HMnO_4$

(c) $Pb(MnO_4)_2$ (d) $PbMnO_4$

90. Which of the following is used as white pigment

(a) TiO_2 (b) V_2O_5

(c) CuO (d) HgO

91. Which metal oxide is used to make blue glass

(a) Fe_2O_3 (b) CoO

(c) Cu_2O (d) NiO

92. The chemical formula for certain pyrophosphate is $Ca_2P_2O_7$, the formula of its ferric pyrophosphate will be

(a) $Fe_2(P_2O_7)_3$ (b) $Fe_4(P_4O_{14})$

(c) $Fe_4(P_2O_7)_3$ (d) Fe_3PO_4

93. Which of the following compounds does not dissolve in ammonium hydroxide solution

(a) AgF (b) $AgBr$

(c) $AgCl$ (d) AgI

94. Which of the following is non-stoichiometric

(a) Fe_3O_4 (b) Fe_2O_3

(c) FeO (d) All the above

95. Ferrosilicon is used in steel industry as **[Kerala (Med.) 2003]**

(a) A flux (b) Scavenger of hydrogen

(c) A reducing agent (d) A cutting tool

(e) Alloying agent

96. In the reaction,

$$2KMnO_4 + 16HCl \rightarrow 5Cl_2 + 2MnCl_2 + 2KCl + 8H_2O$$

the reduction product is **[Kerala (Med.) 2003]**

(a) Cl_2 (b) $MnCl_2$

(c) H_2O (d) KCl

97. Which one of the following statements is correct

[AIEEE 2003]

(a) Manganese salts give violet borax bead test in the reducing flame

(b) From a mixed precipitate of $AgCl$ and AgI ammonia solution dissolves only $AgCl$

(c) Ferric ions give a deep green precipitate on adding potassium ferrocyanide solution

(d) On boiling a solution having K^+, Ca^{2+} and HCO_3^- ions we get a precipitate of $K_2Ca(CO_3)_2$

98. Collin's reagent is **[RPMT 2002]**

(a) MNO_2 / HCl (b) MNO_4 / C_5H_5N

(c) $K_2Cr_2O_7 / H_2SO_4$ (d) $Cr_2O_3 / 2C_5H_5N$

99. Which compound has coloured aqueous solution

[RPMT 2002]

(a) $Zn(NO_3)_2$ (b) $LiNO_3$

(c) $Co(NO_3)_2$ (d) $Ba(NO_3)_2$

100. Zinc oxide when treated with $NaOH$ solution gives

(a) $Zn(OH)_2$ (b) $ZnCl_2$

(c) Na_2ZnO_2 (d) $Zn(OH)_3$

101. Which of the following compounds volatilises on heating

[BHU 1998]

(a) $MgCl_2$ (b) $HgCl_2$

(c) $CaCl_2$ (d) $FeCl_3$

102. Which of the following statement is not true

(a) Colourless compounds of transition elements are paramagnetic

(b) Coloured compounds of transition elements are paramagnetic

(c) Colourless compounds of transition elements are diamagnetic

(d) Transition elements form the complex compounds

103. Calamine is a mineral, which is **[MP PMT 2003]**

(a) $ZnCO_3$ (b) ZnS

(c) $ZnSO_4$ (d) ZnO

104. Super conductors are derived from compounds of

[Kerala (Engg.) 2002]

(a) *p*-block elements (b) Lanthanides

(c) Actinides (d) Transition elements

105. Manganese achieves its highest oxidation state in its compound **[MP PET 1993, 2001; MP PMT 2004]**

(a) MnO_3 (b) Mn_3O_4
(c) $KMnO_4$ (d) K_2MnO_4

106. Which can be reduced to the metal by heating it in a stream of hydrogen **[DPMT 2000]**
(a) Copper (II) oxide (b) Magnesium oxide
(c) Aluminium oxide (d) Calcium oxide

107. Which of the following is coloured
(a) $ScCl_3$ (b) TiO_2
(c) $MnSO_4$ (d) $ZnSO_4$

108. **Chrome green** is
(a) Chromium sulphate (b) Chromium chloride
(c) Chromium nitrate (d) Chromium oxide

109. The colour of $(NH_4)_2SO_4Fe(SO_4)_3.24H_2O$ is **[BHU 1982; CPMT 1989]**
(a) White (b) Green
(c) Violet (d) Blue

110. Correct formula of potassium ferricyanide is **[DPMT 1982, 83; CPMT 1974; AFMC 2005]**
(a) $K_4Fe(CN)_6$ (b) $K_3Fe(CN)_6$
(c) $K_3[Fe(CN)_3]$ (d) $K_3[Fe(CN)_4]$

111. The form of iron having the highest carbon content is **[DPMT 2005]**
(a) Cast iron (b) Wrought iron
(c) Strain steel (d) Mild steel

112. Aqueous solution of ferric chloride is **[MP PMT 1999]**
(a) Acidic (b) Basic
(c) Neutral (d) Amphoteric

113. In the reduction of dichromate by $Fe(II)$ the number of electrons involved per chromium atom is **[Pb. PMT 2001]**
(a) 2 (b) 3
(c) 4 (d) 1

114. A group of acidic oxide is **[MP PET 2003]**
(a) CrO_3, Mn_2O_7 (b) ZnO, Al_2O_3
(c) CaO, ZnO (d) Na_2O, Al_2O_3

115. Silver nitrate is mainly used **[CPMT 1988, 93]**
(a) In photography (b) In model formation
(c) As reducing agent (d) As dehydrating agent

116. The correct order of magnetic moments (spin only values in B.M.) among is **[AIEEE 2004]**
(a) $[Fe(CN)_6]^{4-} > [MnCl_4]^{2-} > [CoCl_4]^{2-}$
(b) $[MnCl_4]^{2-} > [Fe(CN)_6]^{4-} > [CoCl_4]^{2-}$
(c) $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [Fe(CN)_6]^{4-}$
(d) $[Fe(CN)_6]^{4-} > [CoCl_4]^{2-} > [MnCl_4]^{2-}$
(Atomic nos. $Mn = 25, Fe = 26, Co = 27$)

117. Hybridization of $[Ni(CO)_4]$ is **[Pb. CET 2000]**
(a) sp^3 (b) d^2sp^3
(c) sp^3d (d) sp^2

118. What is the oxidation number of iron in the compound $[Fe(H_2O)_5(NO)]SO_4$ **[Pb. CET 2001]**
(a) +2 (b) +3
(c) ±1 (d) ±4

119. Which of the following metal gives hydrogen gas, when heated with hot concentrated alkali **[Pb. CET 2002]**
(a) Cu (b) Ag
(c) Zn (d) Ni

120. When ferric oxide reacts with $NaOH$, the product formed is **[Pb. CET 2002]**
(a) NaF (b) $FeCl_3$
(c) $Fe(OH)_3$ (d) $NaFeO_2$

121. The compound insoluble in water is **[AIIMS 2004]**
(a) Mercurous nitrate (b) Mercuric nitrate
(c) Mercurous chloride (d) Mercurous perchlorate

122. Which is an amphoteric oxide **[JEE Orissa 2004, 05]**
(a) ZnO (b) CaO
(c) BaO (d) SrO

123. What is the magnetic moment of $[FeF_6]^{3-}$ **[JEE Orissa 2004]**
(a) 5.92 (b) 5.49
(c) 2.32 (d) 4

124. How H_2S is liberated in laboratory **[JEE Orissa 2004]**
(a) $FeSO_4 + H_2SO_4$
(b) $FeS + dil.\ H_2SO_4$
(c) $FeS + \text{conc. } H_2SO_4$
(d) Elementary H_2 + elementary S

125. The spin magnetic moment of cobalt in the compound $Hg[Co(SCN)_4]$ is **[IIT JEE Screening 2004]**
(a) $\sqrt{3}$ (b) $\sqrt{8}$
(c) $\sqrt{15}$ (d) $\sqrt{24}$

126. In which of these processes platinum is used as a catalyst **[DCE 2004]**
(a) Oxidation of ammonia to form HNO_3
(b) Hardening of oils
(c) Production of synthetic rubber
(d) Synthesis of methanol

127. Iron is dropped in dil. HNO_3, it gives **[DCE 2004]**
(a) Ferric nitrate
(b) Ferric nitrate and NO_2
(c) Ferrous nitrate and ammonium nitrate
(d) Ferrous nitrate and nitric oxide

128. CrO_3 dissolves in aqueous $NaOH$ to give **[J & K 2005]**
(a) CrO_4^{2-} (b) $Cr(OH)_3^-$

(c) $Cr_2O_7^{2-}$ (d) $Cr(OH)_2$

129. KI and $CuSO_4$ solution when mixed, give **[CPMT 2004; UPSEAT 2004]**

(a) $CuI_2 + K_2SO_4$ (b) $Cu_2I_2 + K_2SO_4$

(c) $K_2SO_4 + Cu_2I_2 + I_2$ (d) $K_2SO_4 + CuI_2 + I_2$

130. When Cu reacts with $AgNO_3$ solution, the reaction takes place is **[CPMT 2004]**

(a) Oxidation of Cu (b) Reduction of Cu

(c) Oxidation of Ag (d) Reduction of NO_3^-

131. By annealing, steel **[BHU 2004]**

(a) Becomes soft

(b) Becomes liquid

(c) Becomes hard and brittle

(d) Is covered with a thin film of Fe_3O_4

132. Which of the following is more soluble in ammonia **[MH CET 2003]**

(a) $AgCl$ (b) $AgBr$

(c) AgI (d) None of these

133. Potassium permagnate works as oxidising agent both in acidic and basic medium. In both state product obtained by $KMnO_4$ is respestively **[Kerala CET 2005]**

(a) MnO_2^- and Mn^{3+} (b) Mn^{3+} and Mn^{2+}

(c) Mn^{2+} and Mn^{3+} (d) MnO_2 and Mn^{2+}

(e) Mn^{2+} and MnO_2

134. Which of the followign is the green coloured powder produced when ammonium dichromate is used in fire works **[J & K 2005]**

(a) Cr (b) CrO_3

(c) Cr_2O_3 (d) $CrO(O_2)$

135. Which compound does not dissolve in hot dilute HNO_3 **[DCE 2002; NCERT 1977]**

(a) HgS (b) CuS

(c) PbS (d) CdS

136. The least stable oxide at room temperature is **[DCE 2002]**

(a) ZnO (b) CuO

(c) Sb_2O_3 (d) Ag_2O

137. Which of the following pari of elements cannot form an alloy **[KCET 2005]**

(a) $Zn - Cu$ (b) $Fe - Hg$

(c) Fe, C (d) Na, Hg

138. Which of the following shows dimerisation **[DCE 2002]**

(a) $HgCl_2$ (b) B_2H_6

(c) $TiCl_4$ (d) SO_2

139. Which of the following is also known as "Fools gold" **[DCE 2003]**

(a) Wurtzite (b) Iron pyrites

(c) Chalcosite (d) Silver glance

140. Which one of the following is highest melting halide **[DCE 2003]**

(a) $AgCl$ (b) $AgBr$

(c) AgF (d) AgI

141. $4K_2Cr_2O_7 \xrightarrow{\text{heat}} 4K_2CrO_4 + 3O_2 + X$. In the above reaction X is **[DCE 2004]**

(a) CrO_3 (b) Cr_2O_7

(c) Cr_2O_3 (d) CrO_5

142. Monds process is used for **[AFMC 2004]**

(a) Ni (b) Al

(c) Fe (d) Cu

143. Stainless steel is an alloy of **[AFMC 2004]**

(a) Copper (b) Nickel and chromium

(c) Manganese (d) Zinc

144. Percentage of silver in German silver is **[AFMC 2004; CPMT 1985; CBSE PMT 2000; MP PMT 2001]**

(a) 0% (b) 1%

(c) 5% (d) None of these

145. Which process of purification is represented by the following scheme $\underset{\text{impure}}{Ti} + 2I_2 \xrightarrow{250^oC} TiI_4 \xrightarrow{1400^oC} \underset{\text{pure}}{Ti} + I_2$ **[Kerala PMT 2004]**

(a) Cupellation (b) Poling

(c) Electrolytic refining (d) Zone refining

(e) Van-Arkel process

146. Which of the following sulphides when heated strongly in air gives the corresponding metal **[Kerala PMT**

(a) Cu_2S (b) CuS

(c) Fe_2S_3 (d) FeS

(e) HgS

147. Guignet's green is known as **[Kerala PMT 2004]**

(a) $Cr_2O_3 . 2H_2O$ (b) $FeO_3 .2H_2O$

(c) Cu_2O_3 (d) $FeCO_3 .Cr_2O_3$

(e) $FeO . Cr_2O_3$

148. Vanadium (III) oxide is a strong **[Kerala PMT 2004]**

(a) Drying agent (b) Oxidising agent

(c) Reducing agent (d) Wetting agent

(e) Precipitating agent

149. Stainless steel does not rust because **[KCET 2004]**

(a) Chromium and nickel combine with iron

(b) Chromium forms an oxide layer and protects iron from rusting

(c) Nickel present in it, does not rust

(d) Iron forms a hard chemical compound with chromium present in it.

150. The main product obtained when a solution of sodium carbonate reacts with mercuric chloride is **[KCET 2004]**

(a) $Hg(OH)_2$ (b) $HgCO_3 .HgO$

(c) $HgCO_3$ (d) $HgCO_3.Hg(OH)_2$

151. Which of the following has diamagnetic character **[Pb. CET 2003]**

(a) $[NiCl_4]^{2-}$ (b) $[CoF_6]^{3-}$

(c) $[Fe(H_2O)_6]^{2+}$ (d) $[Ni(CN)_4]^{2-}$

152. The solubility of silver bromide in hypo solution due to the formation of **[Pb. CET 2003; CPMT 1987]**

(a) $[Ag(S_2O_3)]^{-3}$ (b) Ag_2SO_3

(c) $[Ag(S_2O_3)]^{-}$ (d) $Ag_2S_2O_3$

153. Brass is an alloy of **[DPMT 1982, 83; CPMT 1972, 80, 89; MLNR 1985; AFMC 1990; Pb. CET 2004; EAMCET 1993; MP PMT 1996; KCET 2000]**

(a) Zn and Sn (b) Zn and Cu

(c) Cu, Zn and Sn (d) Cu and Sn

154. Iodine is formed when KI reacts with a solution of **[Pb. CET 2004]**

(a) $CuSO_4$ (b) $(NH_4)_2SO_4$

(c) $ZnSO_4$ (d) $FeSO_4$

155. Rust is **[Pb. CET 2004]**

(a) $FeO+Fe(OH)_2$ (b) Fe_2O_3

(c) $Fe_2O_3+Fe(OH)_2$ (d) Fe_2O_3 and $Fe(OH)_3$

156. $[Sc(H_2O)_6]^{3+}$ ion is **[Pb. CET 2004]**

(a) Colourless and diamagnetic

(b) Coloured and octahedral

(c) Colourless and paramagnetic

(d) Coloured and paramagnetic

157. Which of the following is called white vitriol **[MP PET 1990; Bihar MEE 1995; BVP 2004]**

(a) $ZnCl_2$ (b) $MgSO_4.7H_2O$

(c) $ZnSO_4.7H_2O$ (d) $Al_2(SO_4)_3$

158. $FeSO_4.7H_2O$ shows isomorphism with **[BVP 2004]**

(a) $ZnSO_4.7H_2O$ (b) $MnSO_4.4H_2O$

(c) $CaSO_4.5H_2O$ (d) $CaCl_2.2H_2O$

159. Which pair of compound is expected to show similar colour in aqueous medium **[IIT Screening 2005]**

(a) $FeCl_2$ and $CuCl_2$ (b) $VOCl_2$ and $CuCl_2$

(c) $VOCl_2$ and $FeCl_2$ (d) $FeCl_2$ and $MnCl_2$

160. Which of the following dissolves in hot conc. $NaOH$ solution **[CPMT 2004]**

(a) Fe (b) Zn

(c) Sn (d) Ag

161. Which of the following sulphides is yellow in colour **[CPMT 1983, 88, 2004; NCERT 1976]**

(a) CuS (b) CdS

(c) ZnS (d) CoS

162. Which of the following is not oxidized by O_3 **[IIT Screening 2005]**

(a) KI (b) $FeSO_4$

(c) $KMnO_4$ (d) K_2MnO_4

163. The number of moles of $KMnO_4$ reduced by one mole of KI in alkaline medium is **[CBSE PMT 2005]**

(a) One fifth (b) Five

(c) One (d) Two

164. Excess of KI reacts with $CuSO_4$ solution and then $Na_2S_2O_3$ solution is added to it. Which of the statements is **incorrect** for this reaction **[AIEEE 2004]**

(a) $Na_2S_2O_3$ is oxidised (b) CuI_2 is formed

(c) Cu_2I_2 is formed (d) Evolved I_2 is reduced

165. The only cations present in a slightly acidic solution are Fe^{3+}, Zn^{2+} and Cu^{2+}. The reagent that when added in excess to this solution would identify and separate Fe^{3+} in one step is **[IIT 1997]**

(a) $2M\ HCl$ (b) $6M\ NH_3$

(c) $6M\ NaOH$ (d) H_2S gas

166. Which element is alloyed with copper to form bronze **[CPMT 1972, 80, 93; CPMT 1980, 82]**

(a) Fe (b) Mn

(c) Sn (d) Zn

167. Emery consists of **[AFMC 1999]**

(a) Impure corundum (b) Impure carborundum

(c) Impure graphite (d) Purest form of iron

168. The metal commonly present in brass and german silver is **[EAMCET 1988]**

(a) Mg (b) Zn

(c) C (d) Al

169. In the equation

$$4M+8CN^-+2H_2O+O_2 \longrightarrow 4[M(CN_2)]^- +4OH^-$$

The metal M is **[MP PET 2000]**

(a) Copper (b) Iron

(c) Gold (d) Zinc

170. The term platforming is **[Kerala (Med.) 2002]**

(a) Platinum painting

(b) Flat sheet of platinum

(c) Platinum manufacturing

(d) Platinum used as a catalyst

171. Purple of cassium is **[BHU 2002]**

(a) Gold solution (b) Silver solution

(c) Copper solution (d) Platinum solution

172. Match the items under **List 1** with the compounds/elements from the **List 2**. Select the correct answer from the sets (a), (b), (c) and (d).

List 1	**List 2**
(i) Explosive	(A) NaN_3
(ii) Artificial gem	(B) Fe_3O_4
(iii)	Self reduction (C)

(iv) Magnetic material (D) Al_2O_3

(E) $Pb(N_3)_2$

(F) Fe_2O_3

(G) Cu

(H) SiC

(a) (i) A, (ii) D, (iii) G, (iv) B
(b) (i) A, (ii) D, (iii) G, (iv) F
(c) (i) E, (ii) D, (iii) G, (iv) B
(d) (i) E, (ii) H, (iii) C, (iv) F

173. Blood haemoglobin contains the metal
(a) Al (b) Mg
(c) Cu (d) Fe

174. Percentage of carbon in steel is
(a) 2.5 – 4.5% (b) 0.25 – 0.5%
(c) 0.2 – 1.5% (d) 3 – 3.5%

175. Steel is manufactured from
(a) Wrought iron (b) Cast iron
(c) (a) and (b) both (d) Haematite

176. Modern method for the manufacture of steel is
(a) Bessemer process
(b) Seimen-Martin's open hearth process
(c) Duplex method
(d) L.D. process

177. **Spiegeleisen** is an alloy of
(a) Fe, C and Mn (b) Fe, Mg and C
(c) Fe, Co and Cr (d) Fe, Cu and Ni

178. Stainless steel is an alloy steel of the following metals
[MP PET 1990; Pb. PET 1999; KCET 2000]
(a) Fe Only (b) Cr and Ni
(c) W and Cr (d) Ni and Be

179. In the manufacture of steel, the Bessemer converter is containing lining of
(a) SiO_2 (b) CaO
(c) CaO and MgO (d) Fe_2O_3

180. Which of the following alloys contain only Cu and Zn
[DCE 1999]
(a) Bronze (b) Brass
(c) Gun metal (d) Bell metal

181. Steel becomes soft and pliable by **[MP PET 1989]**
(a) Annealing (b) Nitriding
(c) Tempering (d) Case hardening

182. Most stable oxidation state of iron is
[AFMC 1976; CPMT 1988]
(a) $+2$ (b) $+3$
(c) -2 (d) -3

183. Nickel steel contain % of Ni **[MP PMT/PET 1988]**
(a) $1-5\%$ (b) $3-5\%$
(c) $6-5\%$ (d) $8-5\%$

184. Permanent magnet is made from
[MP PET/PMT 1988; CBSE 1989]
(a) Cast iron (b) Steel
(c) Wrought Iron (d) All of these

185. In nitriding process of steel
[MP PET/PMT 1988; CBSE 1989]
(a) Steel is heated in an atmosphere of ammonia
(b) Steel is made red hot and then cooled
(c) Steel is made red hot and then plunged into oil for cooling
(d) None of these

186. Iron on reacting with carbon give
(a) FeC (b) Fe_2C
(c) Fe_3C (d) FeC_2

187. Iron loses magnetic property at **[KCET 2002]**
(a) Melting point (b) 1000K
(c) Curie point (d) Boiling point

188. Heat treatment alters the properties of steel due to
[KCET 2002]
(a) Chemical reaction on heating
(b) Partial rusting
(c) Change in the residual energy
(d) Change in the lattice structure due to differential rate of cooling

189. Pure conc. HNO_3 makes iron passive as the surface is covered with protective layer of
[Orrisa JEE 2002; EAMCET 1993]
(a) Fe_2O_3 (b) FeO
(c) Fe_3O_4 (d) $Fe(NO_3)_3$

190. Red hot iron absorbs SO_2 giving the product
[Orrisa JEE 2002]
(a) $FeS+O_2$ (b) Fe_2O_3+FeS
(c) $FeO+FeS$ (d) $FeO+S$

191. If steel is heated to a temperature well below red heat and is then cooled slowly, the process is called
[Kerala (Med.) 2002]
(a) Tempering (b) Hardening
(c) Softening (d) Annealing

192. In smelting of iron, which of the following reactions takes place in Blast furnace at 400^oC-600^oC **[MP PET 2002]**
(a) $CaO+SiO_2 \rightarrow CaSiO_3$
(b) $2FeS+3O_2 \rightarrow 2Fe+SO_2$
(c) $FeO+SiO_2 \rightarrow FeSiO_3$
(d) $Fe_2O_3+3CO \rightarrow 2Fe+3CO_2$

193. Soil containing both Al and Fe is called **[DPMT 2002]**
(a) Laterite (b) Bauxite
(c) Pedalfers (d) Clay

194. German silver is an alloy of **[EAMCET 1979; CPMT 1986, 93; MP PET/PMT 1998; UPSEAT 1999; CBSE PMT 2000; KCET 2000; MP PMT 2001]**
(a) Copper, zinc and nickel (b) Copper and silver
(c) Copper, zinc and tin (d) Copper, zinc and silver

195. Iron is rendered passive by the action of

[IIT 1982; MP PET 1985; MP PMT 1987; DPMT 1984; KCET 1993]

(a) Conc. H_2SO_4 (b) Conc. H_3PO_4
(c) Conc. HCl (d) Conc. HNO_3

196. Iron sheets are galvanized by depositing a coating of **or** In galvanisation, iron surface is coated with **[MP PET 1985, 86, 87, 89, 92, 96; NCERT 1980; Bihar CEE 1995]**

(a) Zinc (b) Tin
(c) Chromium (d) Nickel

197. Chemical formula of rust is **[BHU 1986; MP PET 1990]**

(a) FeO (b) Fe_3O_4
(c) $Fe_2O_3.xH_2O$ (d) $FeO.xH_2O$

198. Heating steel to bright redness and then cooling suddenly by plunging it into oil or water, makes it **[MP PET 1990]**

(a) Hard and pliable (b) Soft and pliable
(c) Soft and brittle (d) Hard and brittle

199. Which of the following is found in body **[CPMT 1975]**

(a) Pb (b) Fe
(c) Cd (d) Al

200. Which of the following pairs of elements might form an alloy **[NCERT 1981]**

(a) Zinc and lead (b) Iron and mercury
(c) Iron and carbon (d) Mercury and platinum

201. Ferrous sulphate on strong heating gives

(a) SO_2 (b) $Fe_2(SO_4)_3$
(c) $FeO + SO_3$ (d) $Fe_2O_3 + SO_2 + SO_3$

202. Green vitriol is **[DPMT 1985; BHU 1997; RPET 1999; JIPMER 2002]**

(a) $CuSO_4.5H_2O$ (b) $FeSO_4.7H_2O$
(c) $CaSO_4.2H_2O$ (d) $ZnSO_4.7H_2O$

203. When conc. sulphuric acid is added slowly to a solution of ferrous sulphate containing nitrate ion, a brown colour ring is formed. The composition of the ring is **[CPMT 1989]**

(a) $[Fe(H_2O)_5NO]SO_4$ (b) $FeSO_4.NO_2$
(c) $Fe[(H_2O)_5](NO_3)_2$ (d) None of these

204. F_2 is the formed by reacting K_2MnF_6 with **[AIIMS 2005]**

(a) SbF_5 (b) MnF_3
(c) $KSbF_6$ (d) MnF_4

205. Railway wagon axles are made by heating rods of iron embedded in charcoal powder. The process is known as **[CPMT 1972; DCE 2000; KCET 2003; UPSEAT 2001]**

(a) Case hardening (b) Sheradizing
(c) Annealing (d) Tempering

206. The alloy of steel that is used in making automobile parts and utensils **[EAMCET 1979; MP PMT 1993]**

(a) Stainless steel (b) Nickel steel
(c) Tungstun steel (d) Chromium steel

207. Which of the following has lowest percentage of carbon **[DPMT 1984; CPMT 1989, 91, 94; KCET 2000]**

(a) Cast iron (b) Wrought iron
(c) Steel (d) All have same percentage

208. Galvanisation is the **[CPMT 1980, 86, 91, 99; MP PET/PMT 1988; Pb. PET 1999]**

(a) Deposition of Zn on Fe
(b) Deposition of Al on Fe
(c) Deposition of Sn on Fe
(d) Deposition of Cu on Fe

209. Tempered steel is

(a) Soft and pliable
(b) Hard and brittle
(c) Neither so hard nor so brittle
(d) Very soft

210. Best quality of steel is manufactured by **[BHU 1996]**

(a) Siemen –Martin's open hearth process
(b) Electrical process
(c) Bessemer process
(d) Blast furnace

211. The presence of Si in steel gives it

(a) Fibrous structure (b) Silicate type structure
(c) Sheet type structure (d) None of these

212. The presence of Mn in steel produces

(a) Elasticity
(b) Increases tensile strength
(c) Both (a) and (b)
(d) None of these

213. Presence of Cr in steel makes it

(a) Resistant to chemical action
(b) Useful for making cutlery
(c) Increases chemical action
(d) (a) and (b) both

214. The addition of metals like Cr, Mn, W and Ni to ordinary steel makes it

(a) More useful
(b) Alters the properties of ordinary steel
(c) Both (a) and (b)
(d) None of these

215. Stainless steel is non-corrosive. This character is more prominent in

(a) Mn steel (b) Ordinary steel
(c) Ti steel (d) All of these

216. When little vanadium is mixed with steel, it becomes

(a) More hard (b) More tensility
(c) Both (a) and (b) (d) No effect

217. To obtain steel entirely free from sulphur and phosphorus, the process used is

(a) Electrothermal process (b) Bessemer process
(c) Open-hearth process (d) Duplex process

218. Stainless steel contains .... Cr
(a) 14% (b) 5%
(c) 50% (d) 2.5%

219. The chief constituents of steel made in India are **[MP PMT/PET 1988]**
(a) Mn and Cr (b) Al and Zn
(c) V and Co (d) Ni and Mg

220. Which of the following is used to prepare medical instruments
(a) Cast iron (b) Wrought iron
(c) Steel (d) Alloy of Cu and Fe

221. A clock spring is heated to redness and then plunged into cold water. This treatment will cause it to become **[NCERT 1979]**
(a) Soft and ductile (b) More springy than before
(c) Strongly magnetic (d) Hard and brittle

222. Mark the steel in which carbon % is highest
(a) Mild steel (b) Hard steel
(c) Alloy steel (d) None of these

223. Mark the variety of iron which has highest melting point
(a) Pig iron (b) Cast iron
(c) Wrought iron (d) Steel

224. Bessemer converter is used in the manufacture of **[CPMT 1991]**
(a) Pig iron (b) Steel
(c) Wrought iron (d) Cast iron

225. Steel contains **[MP PMT 1989; KCET 2000]**
(a) $Fe+C+Mn$ (b) $Fe+C+Al$
(c) $Fe+Mn$ (d) $Fe+Mn+Cr$

226. Steel differs from pig iron and wrought iron in that it contains **[KCET 1991]**
(a) No carbon at all
(b) Less carbon than either
(c) More carbon than either
(d) An amount of carbon intermediate between two

227. Finely divided iron combines with CO to give **[MNR 1994]**
(a) $Fe(CO)_5$ (b) $Fe_2(CO)_9$
(c) $Fe_3(CO)_{12}$ (d) $Fe(CO)_6$

228. Mohr's salt is **[KCET 1993;DCE 1999; AIIMS 2000]**
(a) $FeSO_4.7H_2O$
(b) $Fe(NH_4)SO_4.6H_2O$
(c) $(NH_4)_2SO_4.FeSO_4.6H_2O$
(d) $[Fe(NH_4)_2](SO_4)_2.6H_2O$

229. Mohr's salt is **[MNR 1986]**
(a) Normal salt (b) Acid salt
(c) Basic salt (d) Double salt

230. An example of double salt is **[CPMT 1986; CBSE PMT 1989; Roorkee 1990]**
(a) Bleaching powder (b) $K_4[Fe(CN)_6]$
(c) Hypo (d) Potash alum

231. The passivity of iron in concentrated nitric acid is due to **[MP PMT 1994]**
(a) Ferric nitrate coating on the metal
(b) Ammonium nitrate coating on the metal
(c) A thin oxide layer coating on the metal
(d) A hydride coating on the metal

232. The action of steam on heated iron is represented as **[MP PMT 1994]**
(a) $3Fe+4H_2O \to Fe_3O_4+4H_2$
(b) $2Fe+3H_2O \to Fe_2O_3+3H_2$
(c) $Fe+H_2O \to FeO+H_2$
(d) $2Fe+H_2O+O_2 \to Fe_2O_3+H_2$

233. Which metal is used to make alloy steel for armour plates, safes and helmets **[KCET 2003]**
(a) Al (b) Mn
(c) Cr (d) Pb

234. Rusting on iron needs **[MP PMT 1995]**
(a) Dry air
(b) Air and water
(c) Distilled water and carbon dioxide
(d) Oxygen and carbon dioxide

235. Iron when treated with concentrated nitric acid **[MP PET 1996]**
(a) Readily reacts (b) Slowly reacts
(c) Becomes passive (d) Gives ferrous nitrate

236. An alloy which does not contain copper is **[DPMT 1984]**
(a) Solder (b) Bronze
(c) Brass (d) Bell metal

237. Which one of the following statements shows the correct percentage of carbon in steel, pig iron and wrought iron
(a) Steel containing less than 0.15% carbon; wrought iron 0.15 to 2.0% carbon; and pig iron over 2% carbon
(b) Pig iron less than 0.15% carbon; wrought iron 0.15 to 2.0% carbon; and steel over 2% carbon
(c) Wrought iron less than 0.15% carbon; steel 0.15 to 2.0% carbon; and pig iron over 2% carbon
(d) Wrought iron less than 0.15% carbon; pig iron 0.15 to 2.0% carbon; and steel over 2.0% carbon

238. In the Bessemer and open–hearth process for the manufacture of steel, which one of the following is used for the removal of carbon in part or whole

	Bessemer	**Open– hearth**
(a)	Ferric oxide	Air
(b)	Air	Ferric oxide

(c) Oxygen Scrap iron

(d) Air Scrap iron

239. About the basic open hearth process, which statement is wrong

(a) Limestone is added to the charge

(b) Phosphorus impurity cannot be removed by this process

(c) Carbon content of the steel can be uniformly controlled over a series of batches

(d) Iron scrap can be utilized

240. Which of the following statements is wrong

(a) Heating to a high temperature and then cooling suddenly, *e.g.* by dipping in water, makes steel hard and brittle

(b) Steel can be softened by heating it to a high temperature for a prolonged time and then cooling slowly. This is called quenching.

(c) Tempering of hardened steel is done by heating it to just below red heat at controlled temperature and duration

(d) Phosphorus impurity makes steel 'cold short'

241. Bell metal is an alloy of **[DPMT 1990, 96; CBSE PMT 1999; Kerala PMT 2002]**

(a) Cu, Zn and Sn (b) Cu, Zn and Ni

(c) Cu and Zn (d) Cu and Sn

242. Turnbull's blue is **[Bihar CEE 1995]**

(a) Ferricyanide (b) Ferrous ferricyanide

(c) Ferrous cyanide (d) Ferri-ferrocyanide

243. Addition of high proportions of manganese makes steel useful in making rails of rail-roads because manganese

[IIT 1998]

(a) Gives hardness to steel

(b) Helps the formation of oxides of iron

(c) Can remove oxygen and sulphur

(d) Can show highest oxidation state of $+7$

244. Copper displaces which of the metal from their salt solutions

[CPMT 1988]

(a) $AgNO_3$ (b) $ZnSO_4$

(c) $FeSO_4$ (d) All of these

245. Which of the following statement(s) is(are) correct with reference to the ferrous and ferric ions **[IIT 1998]**

(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 thiocyanate

(d) Fe^{2+} gives brown colour with ammonium thiocyanate

246. Which of the following element constitutes a major impurity in pig iron **[CBSE PMT 1998]**

(a) Silicon (b) Oxygen

(c) Sulphur (d) Graphite

247. Annealing is **[Pune CET 1998; AFMC 2002]**

(a) Heating steel in nitrogen and cooling

(b) Heating steel to bright redness and then cooling slowly

(c) Heating wrought iron with carbon to redness

(d) Heating steel to high temperature and cooling suddenly by plunging in water

248. In electroplating, the metal that is not used for plating is

[Pune CET 1998]

(a) Fe (b) Zn

(c) Ni (d) Au

249. Which one of the following is a wrong statement about cast iron **[KCET 1998]**

(a) It is also called pig iron

(b) It contains about 4.5% carbon

(c) It is corrosion resistant

(d) It contracts on cooling

250. Iron pipes lying under acidic soil are often attached to blocks of magnesium for protection from rusting. Magnesium offers protection to iron against corrosion because it

[KCET 1998]

(a) Is more readily converted into positive ions

(b) Is lighter than iron

(c) Forms a corrosion-resistant alloy with iron

(d) Prevents air from reaching the surface of iron

251. FeS_2 is **[RPET 1999]**

(a) Artificial silver (b) Fool's gold

(c) Mohr's salt (d) Cast iron

252. Stainless steel is an alloy of iron with **[DCE 1999]**

(a) 8% Cr, 50% Mn (b) 10% Ni, 2% Mn

(c) 2% Cr, 3% C (d) 12% Cr, 1% N

253. The chemical processes in the production of steel from haematite ore involve **[IIT-JEE (Screening) 2000]**

(a) Reduction

(b) Oxidation

(c) Reduction followed by oxidation

(d) Oxidation followed by reduction

254. The protection of steel by chrome plating is due to **[MP PMT 2001]**

(a) Cathodic protection

(b) Anodic protection

(c) Covering of steel surface

(d) Formation of alloy with iron

255. The most convenient method to protect bottom of ship made of iron is **[CBSE PMT 2001; Kerala (Engg.) 2002]**

(a) White tin platting

(b) Coating with red lead oxide
(c) Connecting with 'Pb' block
(d) Connecting with 'Mg' block

256. Carbon monoxide reacts with iron to form **[KCET (Med.) 2001]**
(a) $Fe(CO)_5$ (b) $FeCO_2$
(c) $FeO + C$ (d) $Fe_2O_3 + C$

257. Iron is extracted from magnetite by reduction with **[UPSEAT 2001]**
(a) H_2 (b) C
(c) Mg (d) Al

258. Malachite is a mineral of **[MP PMT 1990; MP PET 1992, 98, 2000; MP PMT 1998]**
(a) Zn (b) Fe
(c) Hg (d) Cu

259. The most important oxidation state of copper is **[MP PMT 1987]**
(a) + 1 (b) + 2
(c) + 3 (d) + 4

260. Hot and conc. nitric acid when reacts with copper, the gas obtained is
(a) N_2 (b) Nitrous oxide
(c) NO (d) NO_2

261. Which of the following property is not expected to be shown by copper **[MP PET/PMT 1988; NCERT 1975; MP PET 1989]**
(a) High thermal conductivity
(b) Low electrical conductivity
(c) Ductility
(d) Malleability

262. Which of the following metal gives more than one chloride
(a) Cu (b) Al
(c) Ag (d) Na

263. The metal which is the best conductor of electricity is **[CPMT 1996]**
(a) Iron (b) Copper
(c) Silver (d) Aluminium

264. Paris green is
(a) Double salt of copper carbonate and copper nitrate
(b) Double salt of copper acetate and copper arsinite
(c) Double salt of copper acetate and copper sulphate
(d) Double salt of copper and silver nitrate

265. Reaction between the following pairs will produce H_2 except **[CPMT 1973; CBSE PMT 1998]**
(a) $Na +$ ethyl alcohol (b) $Fe +$ steam
(c) $Fe + H_2SO_4$ $(aq.)$ (d) $Cu + HCl$ $(aq.)$

266. Which of the following is correct **[BHU 1995]**
(a) Gun metal : $Cu + Zn + Sn$
(b) Duralumin : $Al + Cu + Mg + Ag$
(c) German silver : $Cu + Zn + C$
(d) Solder : $Pb + Al$

267. Solder is an alloy of **[IIT 1995; MP PET 1995; AFMC 2005]**
(a) 70% lead, 30% tin (b) 30% lead, 70% tin
(c) 80% lead, 20% tin (d) 90% Cu, 10% tin

268. Zinc forms two important alloys, (i) Brass and (ii) German silver. Metals present in them mainly are
(a) In (i) zinc and tin; and in (ii) zinc, silver and nickel
(b) In (i) zinc and iron; and in (ii) zinc, nickel and cobalt
(c) In (i) zinc and copper; and in (ii) zinc, copper and nickel
(d) In (i) zinc and aluminium; and in (ii) zinc, nickel and aluminium

269. One of the constituent of german silver is **[IIT 1980; Kurukshetra CEE 1998; DCE 1999]**
(a) Ag (b) Cu
(c) Mg (d) Al

270. *Gun metal* is an alloy of **[MP PMT 1990; CPMT 1997]**
(a) Cu and Al (b) Cu, Sn and Zn
(c) Cu, Zn and Ni (d) Cu and Sn

271. Besides Zn and Cu, german silver contains the metal **[MP PET 1997]**
(a) Sn (b) Ag
(c) Ni (d) Mg

272. Which metal is present in brass, bronze and German silver **[CPMT 1997; AFMC 1998; AIIMS 1999; J & K 2005]**
(a) Zn (b) Mg
(c) Cu (d) Al

273. Which of the following is wrongly matched **[KCET (Med.) 1999]**
(a) German silver $Cu + Zn + Ni$
(b) Alnico $Fe + Al + Ni + CO$
(c) Monel metal $Cu + Zn + Sn$
(d) Duralumin $Al + Cu + Mg + Mn$

274. An extremely hot copper wire reacts with steam to give **[CPMT 1988]**
(a) CuO (b) Cu_2O
(c) Cu_2O_2 (d) CuO_2

275. From a solution of $CuSO_4$, the metal used to recover copper is **[MP PET 1992; CPMT 1990]**
(a) Sodium (b) Iron
(c) Silver (d) Hg

276. Copper sulphate is commercially made from copper scraps by **[CPMT 1973]**

(a) Dissolving in hot conc. H_2SO_4

(b) The action of dil. H_2SO_4 and air

(c) Heating with sodium sulphate

(d) Heating with sulphur

277. Cuprous ion is colourless, while cupric ion is coloured because **[EAMCET 1992; BHU 2002]**

(a) Both have unpaired electrons in d-orbital

(b) Cuprous ion has a completed d-orbital and cupric ion has an incomplete d-orbital

(c) Both have half-filled p and d-orbitals

(d) Cuprous ion has incomplete d-orbital and cupric ion has a completed d-orbital

278. A blue colouration is not obtained when **[CBSE PMT 1989]**

(a) Ammonium hydroxide dissolves in copper sulphate

(b) Copper sulphate solution reacts with $K_4[Fe(CN)_6]$

(c) Ferric chloride reacts with sodium ferrocyanide

(d) Anhydrous $CuSO_4$ is dissolved in water

279. Identify the statement which is not correct regarding $CuSO_4$ **[MNR 1992; Pb. PMT 1998]**

(a) It reacts with KI to give iodine

(b) It reacts with KCl to give Cu_2Cl_2

(c) It reacts with $NaOH$ and glucose to give Cu_2O

(d) It gives CuO on strong heating in air

280. Copper sulphate solution reacts with KCN to give **[MP PMT 1992; MNR 1994; IIT 1996; AIIMS 1999; CBSE PMT 2002]**

(a) $Cu(CN)_2$	(b) $CuCN$
(c) $K_2[Cu(CN)_4]$	(d) $K_3[Cu(CN)_4]$

281. If excess of NH_4OH is added to $CuSO_4$ solution, it forms blue coloured complex which is **[MP PMT 1971, 79; Bihar CEE 1995; RPET 1999; AFMC 2001]**

(a) $Cu(NH_3)_4SO_4$	(b) $Cu(NH_3)_2SO_4$
(c) $Cu(NH_4)_4SO_4$	(d) $Cu(NH_4)_2SO_4$

282. Which of the following metals displaces SO_2 gas from concentrated sulphuric acid

(a) Mg	(b) Zn
(c) Cu	(d) None of these

283. The method of zone refining of metals is based on the principle of **[CBSE PMT 2003]**

(a) Greater solubility of the impurity in the molten state than in the solid

(b) Greater mobility of the pure metal than that of the impurity

(c) Higher melting point of the impurity than that of the pure metal

(d) Greater noble character of the solid metal than that of the impurity

284. A metal when left exposed to the atmosphere for some time becomes coated with green basic carbonate. The metal in question is **[NDA 1999]**

(a) Copper	(b) Nickel
(c) Silver	(d) Zinc

285. When $CuSO_4$ solution is added to $K_4[Fe(CN)_6]$, the formula of the product formed is **[Bihar CEE 1995]**

(a) $Cu_2Fe(CN)_6$	(b) KCN
(c) $Cu(CN)_3$	(d) $Cu(CN)_2$

286. MnO_4^- on reduction in acidic medium forms **[MP PMT 1995]**

(a) MnO_2	(b) Mn^{++}
(c) MnO_4^{--}	(d) Mn

287. Which of the following metals will not react with a solution of $CuSO_4$ **[CPMT 1996]**

(a) Fe	(b) Zn
(c) Mg	(d) Hg

288. Which one of the following metals will not reduce H_2O **[EAMCET 1997]**

(a) Ca	(b) Fe
(c) Cu	(d) Li

289. The reaction, which forms nitric oxide, is **[KCET (Med.) 2001]**

(a) C and N_2O	(b) Cu and N_2O
(c) Na and NH_3	(d) Cu and HNO_3

290. A cuprous ore among the following is **[KCET 2002]**

(a) Cuprite	(b) Malachite
(c) Chalcopyrites	(d) Azurite

291. When metallic copper comes in contact with moisture, a green powdery/ pasty coating can be seen over it. This is chemically known as **[AFMC 2002]**

(a) Copper sulphide - Copper carbonate

(b) Copper carbonate - Copper sulphate

(c) Copper carbonate - Copper hydroxide

(d) Copper Sulphate - Copper sulphide

292. Orford process is used in extraction of

(a) Fe	(b) Co
(c) Pt	(d) Ni

293. Horn silver is

(a) $AgCl$	(b) Ag
(c) $AgBr$	(d) CH_3COOAg

294. Which of the following is used in photography **[CPMT 1980]**

(a) $AgCl$	(b) $AgBr$

(c) AgI (d) Ag_2O

295. Silver halides are used in photography because **[MP PMT 1989]**

(a) They are photosensitive

(b) Soluble in hypo

(c) Soluble in NH_4OH

(d) Soluble in acids

296. $AgCl$ when heated with Na_2CO_3 gives **[CPMT 1980; MP PET 1989; MP PMT 1982, 84]**

(a) Ag_2O (b) Ag

(c) Ag_2CO_3 (d) $NaAgCO_3$

297. $AgNO_3$ gives a red ppt. with **[NCERT 1972; BHU 1978; MP PMT 1995]**

(a) KI (b) $NaBr$

(c) $NaNO_3$ (d) K_2CrO_4

298. Silver nitrate is prepared by **[CPMT 1984]**

(a) The action of only conc. HNO_3 on silver

(b) Heating silver oxide with NO_2

(c) The action of hot dil. HNO_3 on silver

(d) Dissolve Ag in aqua–regia

299. $AgCl$ is soluble in **[EAMCET 1992]**

(a) Aqua–regia (b) H_2SO_4

(c) HCl (d) NH_3 (aq)

300. Which of the following is least soluble in water **[NCERT 1974, 78; MNR 1984, 89]**

(a) AgI (b) $AgCl$

(c) $AgBr$ (d) Ag_2S

301. Photographic films and plates have an essential ingredient of **[CPMT 1980; CBSE PMT 1989]**

(a) Silver nitrate (b) Silver bromide

(c) Sodium chloride (d) Oleic acid

302. Which of the following does not react with $AgCl$ **[AIIMS 1997]**

(a) $NaNO_3$ (b) Na_2CO_3

(c) $Na_2S_2O_3$ (d) NH_4OH

303. Which one of the following is known as lunar caustic when in fused state **[MP PMT 1999; JIPMER 2002]**

(a) Silver nitrate (b) Silver sulphate

(c) Silver chloride (d) Sodium sulphate

304. Which silver halide is used in medicine **[DPMT 1996]**

(a) $AgNO_3$ (b) $AgCl$

(c) $AgBr$ (d) AgF

305. When silver nitrate is heated to red hot, what is formed **[CPMT 1996; NCERT 1970]**

(a) Ag (b) Ag_2O

(c) Ag_2O_3 (d) AgO_2

306. For making Ag from $AgNO_3$, which of the following is used **[AFMC 1998]**

(a) PH_3 (b) AsH_3

(c) Na_2CO_3 (d) NH_3

307. Which one of the following reacts with concentrated sulphuric acid **[EAMCET 1998]**

(a) Au (b) Ag

(c) Pt (d) Pb

308. The nitrate of which metal left globule on heating strongly **[JIPMER 2001]**

(a) $Pb(NO_3)_2$ (b) $NaNO_3$

(c) $AgNO_3$ (d) $Cu(NO_3)_2$

309. During extraction of silver, which of the following is formed **[MP PET 2002]**

(a) $Na[Ag(CN)_2]$ (b) $Na_2[Ag(CN)_2]$

(c) $Na_4[Ag(CN)_2]$ (d) None of these

310. Colourless solutions of the following four salts are placed separately in four different test tubes and a strip of copper is dipped in each one of these. Which solution will turn Blue **[MP PET 2002]**

(a) KNO_3 (b) $AgNO_3$

(c) $Zn(NO_3)_2$ (d) $ZnSO_4$

311. Zinc when reacted with excess of $NaOH$ gives **[CPMT 1974, 78, 94; MP PMT 1999]**

(a) Zinc hydroxide (b) Zinc oxide

(c) Di sodium zincate (d) Sodium zincate

312. Pair of metals which dissolves in $NaOH$ solution

(a) Al, Cu (b) Zn, Hg

(c) Zn, Cu (d) Zn, Al

313. ***Lucas reagent*** is **[CPMT 1980; AIIMS 1980, 82; DPMT 1983; MP PET 1995; MP PMT 1997, 98]**

(a) Anhydrous $ZnCl_2 + conc. HCl$

(b) Hydrous $ZnCl_2 + dil. HCl$

(c) Conc. $HNO_3 +$ anhydrous $ZnCl_2$

(d) Conc. $HNO_3 +$ anhydrous $MgCl_2$

314. What is the effect of shaking dil. H_2SO_4 with small quantity of anhydrous $CuSO_4$ **[NCERT 1975; CPMT 1975, 88]**

(a) The white solid dissolves to form a colourless solution

(b) The white solid dissolves to form a green solution

(c) The white solid turns blue but does not dissolve

(d) The white solid dissolves to form a blue solution

315. Which metal is electro-deposited on iron surface to prevent rusting **[MP PET 1990]**

(a) Cu (b) Zn

(c) Mg (d) Pb

316. To prevent corrosion, iron pipes carrying drinking water are covered with zinc. The process involved is

[CPMT 1986; MP PMT 1993; MP PET 1999]

(a) Photoelectrolysis (b) Electroplating

(c) Galvanization (d) Cathodic protection

317. From aqueous solution of $ZnSO_4$, normal zinc carbonate may be precipitated by **[CPMT 1973]**

(a) Boiling with $CaCO_3$ (b) Adding Na_2CO_3

(c) Adding $NaHCO_3$ (d) Passing CO_2

318. Which one of the following dissolve in hot concentrated $NaOH$ solution **[IIT 1980]**

(a) Fe (b) Zn

(c) Cu (d) Ag

319. Which of the following metal forms an amphoteric oxide

[CPMT 1976]

(a) Ca (b) Fe

(c) Cu (d) Zn

320. Reaction of zinc with cold and very dilute nitric acid yields

[MP PET 1985, 92, 97; BHU 1995, 2000; NCERT 1974; MP PMT 1995]

(a) $Zn(NO_3)_2 + N_2O$ (b) $Zn(NO_3)_2 + NO$

(c) $Zn(NO_3)_2 + NH_4NO_3$ (d) $Zn(NO_3)_2 + NO_2$

321. The number of unpaired electrons in Zn^{2+} is

(a) 2 (b) 3

(c) 4 (d) 0

322. The trace metal present in insulin is **[KCET 1991]**

(a) Iron (b) Cobalt

(c) Zinc (d) Manganese

323. The chemical name of borax is **[CPMT 1994]**

(a) Sodium orthoborate

(b) Sodium metaborate

(c) Sodium tetraborate

(d) Sodium tetraborate decahydrate

324. Hydrogen is not obtained when zinc reacts with

[CPMT 1994]

(a) Cold water (b) Dilute H_2SO_4

(c) Dilute HCl (d) Hot 20% $NaOH$

325. The metal which gives hydrogen on treatment with acid as well as sodium hydroxide is **[MP PET 1996]**

(a) Iron (b) Zinc

(c) Copper (d) None of the above

326. To protect iron against corrosion, the most durable metal plating on it, is **[CBSE PMT 1994]**

(a) Nickel plating (b) Tin plating

(c) Copper plating (d) Zinc plating

327. The compound $ZnFe_2O_4$ is **[Kerala (Engg.) 2002]**

(a) A normal spinel compound

(b) Interstitial compound

(c) Covalent compound

(d) Co-ordination compound

328. ZnO when heated with BaO at $1100\,°C$ gives a compound. Identify the compound **[AFMC 2002]**

(a) $BaZnO_2$ (b) $BaO_2 + Zn$

(c) $BaCdO_2$ (d) $Ba + ZnO_2$

329. Zn gives hydrogen gas with H_2SO_4 and HCl but not with HNO_3 because **[CBSE PMT 2002]**

(a) NO_2 is reduced in preference to H_3O^+

(b) HNO_3 is weaker acid than H_2SO_4 and HCl

(c) Zn acts as oxidising agent when reacts with HNO_3

(d) In electrochemical series Zn is placed above the hydrogen

330. The metal used for making radiation shield is

[Kerala (Med.) 2002]

(a) Aluminium (b) Iron

(c) Zinc (d) Lead

331. Which of the following metal is obtained by leaching out process using a solution of $NaCN$ and then precipitating the metal by addition of zinc dust

[NCERT 1984; AIIMS 1983; CBSE PMT 1989]

(a) Copper (b) Silver

(c) Nickel (d) Iron

332. While extracting an element from its ore, the ore is ground and leached with dilute KCN solution to form the soluble product potassium argentocyanide. The element is

[CBSE PMT 1989]

(a) Lead (b) Chromium

(c) Manganese (d) Silver

333. In Mc Arthur Forest method, silver is extracted from the solution of $Na[Ag(CN)_2]$ by the use of: **[CPMT 2004**

(b) Fe (b) Mg

(c) Cu (d) Zn

334. Iron obtained from blast furnace is known as

[DPMT 1981; CPMT 1988; MP PET 2000]

(a) Wrought iron (b) Cast iron

(c) Pig iron (d) Steel

335. Extraction of silver from commercial lead is possible by

[BHU 1979]

(a) Mond's process (b) Park's process

(c) Haber's process
(d) Clark's process

336. Impurities of lead in silver are removed by **[AIIMS 1987]**

(a) Park process
(b) Solvey process
(c) Cyanide process
(d) Amalgamation process

337. Park's process is used in the extraction of **[BHU 1977; CBSE PMT 1992; MP PMT 1996; Kurukshetra CEE 1998]**

(a) Iron
(b) Zinc
(c) Silver
(d) Lead

338. From argentite (Ag_2S) ore the method used in obtaining metallic silver is **[MP PMT 1989]**

(a) Fused mixture of Ag_2S and KCl is electrolysed
(b) Ag_2S is reduced with CO
(c) Ag_2S is roasted to Ag_2O which is reduced with carbon
(d) Treating argentite with $NaCN$ solution followed by metal displacement with zinc

339. In the extraction of zinc which gas is burnt in the jackets surrounding the retorts

(a) Water gas
(b) Producer gas
(c) Oil gas
(d) Coal gas

340. MacArther process is used for **[BHU 1995]**

(a) Hg
(b) Fe
(c) Cl
(d) O_2

341. In the metallurgy of zinc, the zinc dust obtained from roasting and reduction of zinc sulphide contains some ZnO. How is this removed **[MP PET 1993; AFMC 2002]**

(a) Absorbance of ultraviolet light and re-emission of white light is employed
(b) Shock cooling by contact with a shower of molten lead is done
(c) X–ray method is used
(d) Smelting is employed

342. In the metallurgy of copper, metallic copper is finally formed in the furnace by the reactions

(a) $Cu_2S + O_2 \rightarrow 2Cu + SO_2$
(b) $2CuS + 3O_2 \rightarrow 2CuO + 2SO_2$
$2CuO + CuS \rightarrow 3Cu + SO_2$
(c) $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$
$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$
(d) $CuS + O_2 \rightarrow Cu + SO_2$

343. In the smelting of roasted copper pyrites ore, melting occurs so that the first reaction is

(a) All the sulphur preferentially combines with iron to form FeS and CuO is formed
(b) All the sulphur preferentially combines with copper to form CuS and FeO is formed
(c) All the sulphur preferentially combines with iron to form FeS and Cu_2O is formed
(d) All the sulphur preferentially combines with copper to form Cu_2S and FeO is formed

344. In the oxidation of Cu, the reaction which takes place in bessemer converter is **[CPMT 1999]**

(a) $2CuFeS_2 + O_2 \rightarrow Cu_2S + FeS + SO_2$
(b) $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$
(c) $2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$
(d) $2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$

345. Silica is added to roasted copper ore during smelting in order to remove **[KCET 1998]**

(a) Cuprous sulphide
(b) Cuprous oxide
(c) Ferrous oxide
(d) Ferrous sulphide

346. Parke’s process is used to extract **[MP PMT 2002]**

(a) Silver using $NaCN$
(b) Copper using $CuFeS_2$
(c) Silver from argentiferrous lead
(d) Silver by forming amalgam

347. Identify the reaction that doesn’t take place during the smelting process of copper extraction **[KCET 20**

(a) $2FeS + 3\,O_2 \rightarrow 2\,FeO + 2\,SO_2 \uparrow$
(b) $Cu_2O + FeS \rightarrow Cu_2S + FeO$
(c) $2Cu_2S + 3\,O_2 \rightarrow 2Cu_2O + 2SO_2 \uparrow$
(d) $FeO + SiO_2 \rightarrow FeSiO_3$

348. The extraction of which of the following metals involves bessemerisation **[DCE 2004]**

(a) Fe
(b) Ag
(c) Al
(d) Cu

349. Bessemer converter is used for **[AFMC 2004]**

(a) Steel
(b) Wrought iron
(c) Pig iron
(d) Cast iron

350. In the cyanide process for the extraction of silver, sodium cyanide is used to **[MP PMT 1994]**

(a) Convert silver into a soluble silver complex
(b) Reduce silver
(c) Precipitate silver
(d) Oxidise silver

351. Parke's process of desilverization of lead depends upon

(a) Partition coefficient of silver between molten zinc/molten lead having a high value
(b) Partition coefficient of silver between molten zinc/molten lead having a low value
(c) Crystallizing out of pure lead while the silver–lead eutectic which has a lower melting point is left behind in liquid form
(d) Chemical combination of zinc and silver which precipitates out easily

352. Which is impure form of iron

(a) Cast iron
(b) Wrought iron

(c) Steel iron (d) None

353. Blister copper is **[CPMT 1976, 85, 2002; DPMT 1982; MP PET 1995; Bihar CEE 1995]**

(a) Pure copper (b) Ore of copper
(c) Alloy of copper (d) 1% impure copper

354. In the extraction of copper when molten copper is cooled slowly, blister copper is obtained due to evolution of the following gas

(a) Water vapour (b) Sulphur dioxide
(c) Carbon dioxide (d) Carbon monoxide

355. In the electrolytic purification of copper some gold is found in the **[CPMT 1972; AFMC 1995; RPET 2003]**

(a) Cathode (b) Cathode mud
(c) Anode mud (d) Electrolyte

356. Purest form of iron is **[CPMT 1975, 80, 84, 87, 89; DPMT 1982, 83; MP PMT 1987, 90, 91; MP PET 1995; BHU 1999; MH CET 2003]**

(a) Cast iron (b) Wrought iron
(c) Hot steel (d) Stainless steel

357. ***Spelter*** is **[CPMT 1988]**

(a) Impure Cu (b) Impure Zn
(c) ZnO (d) CuO

358. A copper coin is completely covered with a gold film and is placed in dilute HNO_3. This will result in formation of **[CPMT 1981]**

(a) Gold nitrate (b) Copper nitrate
(c) None of these (d) Purple of cassins

359. When zinc is added to $CuSO_4$ copper gets ppt. due to **[CPMT 1979]**

(a) Reduction of copper ions
(b) Oxidation of copper ions
(c) Hydrolysis of copper sulphate
(d) Complex formation

360. Addition of iron filings to $CuSO_4$ solution caused precipitation of Cu owing to the **[CPMT 1990]**

(a) Reduction of Cu^{++}
(b) Oxidation of Cu^{++}
(c) Reduction of Fe
(d) Reduction of Fe^{+++}

361. Oxygen gas can be prepared from solid $KMnO_4$ by **[DPMT 2001]**

(a) Strongly heating the solid
(b) Treating the solid with H_2 gas
(c) Dissolving the solid in dil. H_2SO_4
(d) Dissolving the solid in dil. HCl

Critical Thinking

Objective Questions

1. Transition metal with low oxidation number will act as **[DCE 2001]**

(a) A base
(b) An acid
(c) An oxidising agent
(d) None of these

2. Which of the following pair will have effective magnetic moment equal

(a) Cr^{+3} and Mn^{+2} (b) Cr^{+2} and Fe^{+2}
(c) V^{+2} and Sc^{+3} (d) Ti^{+2} and V^{+2}

3. Which is least soluble in water **[MNR 1984, 89]**

(a) $AgCl$ (b) $AgBr$
(c) AgI (d) Ag_2S
(e) AgF

4. Which one of the following has the maximum number of unpaired electrons **[UPSEAT 2001]**

(a) Mg^{2+} (b) Ti^{3+}
(c) V^{3+} (d) Fe^{2+}

5. Which of the following ions form most stable complex compound **[MP PMT 1995]**

(a) Cu^{++} (b) Ni^{++}
(c) Fe^{++} (d) Mn^{++}

6. Mn^{++} can be converted into Mn^{7+} by reacting with **[UPSEAT 2003]**

(a) SO_2 (b) Cl_2
(c) PbO_2 (d) $SnCl_2$

7. General configuration of outermost and penultimate shell is $(n-1)s^2(n-1)p^6(n-1)d^x ns^2$. If n = 4 and x = 5 then no. of proton in the nucleus will be **[MP PET 2003]**

(a) > 25 (b) < 24
(c) 25 (d) 30

8. Which transition metal reduces steam to evolve hydrogen **[MP PMT 2003; DCE 2002]**

(a) Mg (b) Fe
(c) Sc (d) Pt

9. Chloride of which of the following element is coloured **[MP PMT 1990]**

(a) Ag (b) Hg
(c) Zn (d) Co

10. Arrange $Ce^{+3}, La^{+3}, Pm^{+3}$ and Yb^{+3} in increasing order of their ionic radii **[AIEEE 2002]**

(a) $Yb^{+3} < Pm^{+3} < Ce^{+3} < La^{+3}$

(b) $Ce^{+3} < Yb^{+3} < Pm^{+3} < La^{+3}$

(c) $Yb^{+3} < Pm^{+3} < La^{+3} < Ce^{+3}$

(d) $Pm^{+3} < La^{+3} < Ce^{+3} < Yb^{+3}$

11. $KMnO_4$ reacts with ferrous sulphate according to the equation $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$ Here $10ml$ of $0.1M$ $KMnO_4$ is equivalent to **[CPMT 1999]**

(a) $20ml$ of $0.1M$ $FeSO_4$

(b) $30ml$ of $0.1M$ $FeSO_4$

(c) $40ml$ of $0.1M$ $FeSO_4$

(d) $50ml$ of $0.1M$ $FeSO_4$

12. Which of the following is/are soluble in ethanol **[Roorkee Qualifying 1998]**

(a) HgF_2 (b) $HgCl_2$

(c) $HgBr_2$ (d) HgI_2

13. Out of all the known elements, the percentage of transitional elements is approximately

(a) 30% (b) 50%

(c) 60% (d) 75%

14. Atomic number of *Cr* and *Fe* are 24 and 26 respectively. Which of the following is paramagnetic with the spin of electron **[CBSE PMT 2002]**

(a) $[Cr(NH_3)_6]^{+3}$ (b) $[Fe(CO)_5]$

(c) $[Fe(CN)_6]^{-4}$ (d) $[Cr(CO)_6]$

15. Which of the following is not an element **[DCE 2001]**

(a) Graphite (b) Diamond

(c) 22-carat gold (d) Rhombic sulphur

16. Which of the following is more paramagnetic **[DCE 2001]**

(a) Fe^{+2} (b) Fe^{+3}

(c) Cr^{+3} (d) Mn^{+3}

17. The number of *d*-electrons in Fe^{2+} (at no. of $Fe = 26$) is not equal to that of the **[MNR 1994]**

(a) *p* - electrons in *Ne* (at. no. = 10)

(b) *s* - electrons in Mg (at. no. = 12)

(c) *d* - electrons in Fe

(d) *p* - electrons in Cl^- (at. no. of $Cl = 17$)

18. The basic character of the transition metal monoxides follows the order **[CBSE PMT 2003]**

(a) $TiO > VO > CrO > FeO$

(b) $VO > CrO > TiO > FeO$

(c) $CrO > VO > FeO > TiO$

(d) $TiO > FeO > VO > CrO$

(Atomic no. *Ti* = 22, *V* = 23, *Cr* = 24, *Fe* = 26)

19. Amongest 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) $FeSO_4.5H_2O$

20. In nitroprusside ion, the iron and NO exist as Fe^{II} and NO^+ rather than Fe^{III} and NO. These forms can be differentiated by **[IIT-JEE 1998]**

(a) Estimating the concentration of iron

(b) Measuring the concentration of CN^-

(c) Measuring the solid state magnetic moment

(d) Thermally decomposing the compound

21. Among the following, the compound that is both paramagnetic and coloured is **[IIT-JEE 1997]**

(a) $K_2Cr_2O_7$ (b) $(NH_4)_2(TiCl_6)$

(c) $VOSO_4$ (d) $K_3[Cu(CN_4)]$

22. The number of moles of $KMnO_4$ that will be needed to react completely with one mole of ferrous oxalate $Fe(C_2O_4)$ in acidic solution is **[IIT-JEE 1997**

(a) 3/5 (b) 2/5

(c) 4/5 (d) 1

23. In following reaction

$$yMnO_4^- + xH^+ + C_2O_4^- \rightarrow yMn^{++} + 2CO_2 + \frac{x}{2}H_2O,$$

x and *y* are **[CPMT 1997]**

(a) 2 and 16 (b) 16 and 2

(c) 8 and 16 (d) 5 and 2

24. Which of the following weighs less when weighed in magnetic field

(a) VCl_3 (b) $ScCl_3$

(c) $TiCl_3$ (d) $FeCl_3$

25. An elements is in M^{3+} form. Its electronic configuration is $[Ar]3d^1$ the ion is **[JIPMER 2002]**

(a) Ti^{3+} (b) Ti^{4+}

(c) Ca^{2+} (d) Sc^+

26. The atomic number of vanadium (*V*), chromium (*Cr*), manganese (*Mn*) and iron (*Fe*) are respectively 23, 24, 25 and 26 which one of these may be expected to have the highest second ionization enthalpy **[AIEEE 2003]**

(a) *V* (b) *Cr*

(c) *Mn* (d) *Fe*

Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false.

(e) If assertion is false but reason is true.

1. Assertion : Cuprous ion (Cu^+) has unpaired electrons while cupric ion (Cu^{++}) does not

Reason : Cuprous ion (Cu^+) is colourless where as cupric ion (Cu^{++}) is blue in the aqueous solution **[AIIMS 2002]**

2. Assertion : Zn^{2+} is diamagnetic

Reason : The electrons are lost from 4 s orbital to form Zn^{2+} **[IIT-JEE 1998]**

3. Assertion : Transition metals show variable valence.

Reason : Due to a large energy difference between the ns^2 and $(n-1)d$ electrons.

[AIIMS 1996]

4. Assertion : The aqueous solution of $FeCl_3$ is basic in nature.

Reason : $FeCl_3$ hydrolyses in water.**[AIIMS 1998]**

5. Assertion : $AgCl$ dissolves in NH_4OH solution.

Reason : Due to formation of a complex.

[AIIMS 1998]

6. Assertion : Pure iron is not used for making tools and machines.

Reason : Pure iron is hard. **[AIIMS 1998]**

7. Assertion : Solution of Na_2CrO_4 in water is intensely coloured.

Reason : Oxidation state of Cr in Na_2CrO_4 is +VI.

[AIIMS 2003]

8. Assertion : Copper metal gets readily corroded in an acidic aqueous solution.

Reason : Free energy change for this process is positive. **[AIIMS 2004]**

9. Assertion : The free gaseous Cr atom has six unpaired electrons.

Reason : Half filled 's' orbital has greater stability.

[AIIMS 2004]

10. Assertion : Fe^{2+} is paramagnetic.

Reason : Fe^{2+} contains four unpaired electrons.

11. Assertion : Transition metals are good catalysts.

Reason : V_2O_5 or Pt is used in the preparation of H_2SO_4 by contact process.

12. Assertion : Rusting of an iron is an example of corrosion.

Reason : Rusting of iron is decreased by acids and electrolytes.

13. Assertion : $AgBr$ is used in photography.

Reason : $AgBr$ undergoes photochemical reaction.

14. Assertion : Tungsten filament is used in electric bulbs.

Reason : Tungsten is a metal of high melting point.

15. Assertion : $Na_2Cr_2O_7$ is not a primary standard in volumetric analysis.

Reason : $Na_2Cr_2O_7$ Is hygroscopic.

16. Assertion : Promethium is a man made element.

Reason : It is radioactive and has been prepared by artificial means.

17. Assertion : Magnetic moment values of actinides are lesser than the theoretically predicted values.

Reason : Actinide elements are strongly paramagnetic.

18. Assertion : The degree of complex formation in actinides decreases in the order $M^{4+} > MO_2^{2+} > M^{3+} > MO_2^{+}$.

Reason : Actinides form complexes with π -bonding ligands such as alkyl phosphines and thioethers.

19. Assertion : In transition elements ns orbital is filled up first and $(n-1)d$ afterwards, during ionization ns electrons are lost prior to $(n-1)d$ electrons.

Reason : The effective nuclear charge felt buy $(n-1)d$ electrons is higher as compared to that by ns electrons.

20. Assertion : Extraction of iron metal from iron oxide ore is carried out by heating with coke.

Reason : The reaction $Fe_2O_3(s) \rightarrow Fe(s) + \frac{3}{2}O_2(g)$ is a spontaneous process. **[AIIMS 2005]**

Answers

General Characteristics

1	c	2	d	3	b	4	c	5	d
6	a	7	a	8	c	9	c	10	c
11	c	12	c	13	d	14	c	15	b
16	c	17	b	18	c	19	b	20	a
21	d	22	c	23	a	24	c	25	c
26	a	27	c	28	b	29	c	30	c
31	b	32	c	33	a	34	c	35	b
36	a	37	d	38	d	39	b	40	c
41	d	42	d	43	d	44	d	45	c
46	d	47	b	48	c	49	a	50	c
51	c	52	b	53	d	54	d	55	a
56	a	57	a	58	b	59	b	60	b
61	a	62	d	63	b	64	a	65	c
66	d	67	b	68	b	69	b	70	a
71	c	72	d	73	a	74	d	75	d
76	c	77	b	78	b	79	d	80	c
81	b	82	a	83	b	84	b	85	d
86	d	87	c	88	c	89	b	90	b
91	d	92	a	93	c	94	c	95	a
96	c	97	c	98	c	99	d	100	d
101	b	102	d	103	d	104	c	105	a
106	d	107	c	108	d	109	d	110	d
111	b	112	a	113	d	114	b	115	a
116	b	117	c	118	d	119	c	120	b
121	a	122	c	123	d	124	d	125	a
126	d	127	d	128	a	129	d	130	d
131	a	132	c	133	a	134	c	135	b
136	c	137	b	138	c	139	a	140	b
141	b	142	a	143	b	144	b	145	d
146	b	147	d	148	c	149	d	150	a
151	c	152	d	153	a	154	b	155	c
156	d	157	b	158	c	159	a	160	a
161	c	162	b	163	b	164	c	165	a
166	d	167	c	168	d	169	d	170	d
171	c	172	a	173	b	174	a	175	a
176	c	177	b	178	c	179	d	180	a
181	b	182	c	183	a	184	d	185	b
186	a	187	c	188	b	189	a	190	d
191	c	192	c	193	c	194	c	195	d
196	c	197	d	198	c	199	a	200	a
201	a	202	d	203	c	204	b	205	d
206	c	207	a	208	d	209	b	210	a
211	a	212	b	213	b	214	b	215	c
216	a	217	c	218	d	219	b	220	b
221	b	222	b	223	b	224	a	225	b
226	b	227	d	228	a	229	a	230	d
231	a	232	a	233	d	234	a	235	c
236	a	237	a	238	d	239	b	240	b
241	b								

Compounds of Transitional elements

1	a	2	c	3	d	4	a	5	b
6	c	7	a	8	b	9	b	10	d
11	a	12	a	13	a	14	a	15	a
16	a	17	a	18	d	19	b	20	b
21	d	22	c	23	e	24	b	25	c
26	d	27	d	28	a	29	c	30	c
31	a	32	d	33	b	34	d	35	a
36	a	37	b	38	b	39	b	40	a
41	a	42	c	43	c	44	a	45	a
46	b	47	c	48	b	49	a	50	c
51	b	52	b	53	c	54	d	55	c
56	a	57	c	58	d	59	b	60	d
61	d	62	b	63	c	64	a	65	c
66	b	67	c	68	a	69	a	70	c
71	a	72	a	73	a	74	a	75	a
76	d	77	d	78	d	79	a	80	c

81	b	82	d	83	c	84	d	85	b
86	a	87	c	88	c	89	b	90	a
91	b	92	c	93	d	94	c	95	e
96	b	97	b	98	d	99	c	100	c
101	b	102	a	103	a	104	d	105	c
106	a	107	c	108	d	109	b	110	b
111	a	112	a	113	b	114	a	115	a
116	c	117	a	118	a	119	c	120	c
121	c	122	a	123	a	124	b	125	c
126	a	127	c	128	a	129	c	130	a
131	a	132	a	133	d	134	c	135	a
136	d	137	b	138	a	139	b	140	c
141	c	142	a	143	b	144	d	145	e
146	e	147	a	148	c	149	b	150	b
151	d	152	a	153	b	154	a	155	c
156	a	157	c	158	a	159	b	160	b
161	b	162	c	163	d	164	b	165	d
166	c	167	a	168	b	169	c	170	d
171	a	172	c	173	d	174	c	175	c
176	d	177	a	178	b	179	c	180	b
181	a	182	b	183	b	184	b	185	a
186	c	187	c	188	d	189	c	190	c
191	a	192	d	193	c	194	a	195	d
196	a	197	c	198	d	199	b	200	c
201	d	202	b	203	a	204	a	205	a
206	a	207	b	208	a	209	c	210	a
211	a	212	c	213	a	214	c	215	c
216	c	217	a	218	a	219	a	220	c
221	d	222	b	223	c	224	b	225	a
226	d	227	a	228	c	229	d	230	d
231	c	232	a	233	b	234	b	235	c
236	a	237	c	238	d	239	a	240	d
241	d	242	b	243	ab	244	a	245	bc
246	d	247	b	248	a	249	d	250	a
251	b	252	a	253	d	254	a	255	a
256	d	257	b	258	d	259	b	260	d
261	b	262	a	263	c	264	b	265	d
266	a	267	b	268	c	269	b	270	b
271	c	272	c	273	c	274	b	275	b
276	b	277	b	278	b	279	b	280	d
281	a	282	c	283	a	284	a	285	a
286	b	287	d	288	c	289	d	290	a
291	c	292	d	293	a	294	b	295	a
296	b	297	d	298	c	299	d	300	d
301	b	302	a	303	a	304	a	305	a
306	a	307	b	308	c	309	a	310	b
311	d	312	d	313	a	314	d	315	b
316	c	317	c	318	b	319	d	320	c
321	d	322	c	323	d	324	a	325	b
326	d	327	a	328	a	329	b	330	d
331	b	332	d	333	d	334	c	335	b
336	a	337	c	338	d	339	b	340	a
341	d	342	c	343	a	344	c	345	c
346	c	347	c	348	d	349	c	350	a
351	a	352	a	353	d	354	b	355	c
356	b	357	b	358	c	359	a	360	a
361	a								

Critical Thinking Questions

1	c	2	b	3	d	4	d	5	a
6	c	7	b	8	b	9	d	10	a
11	d	12	abc	13	c	14	a	15	c
16	b	17	d	18	a	19	b	20	c
21	c	22	a	23	b	24	b	25	a
26	b								

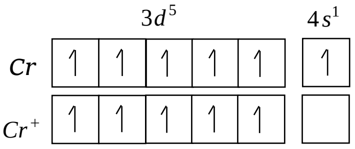
Assertion & Reason

1	e	2	b	3	c	4	e	5	a
6	c	7	a	8	d	9	c	10	a
11	b	12	c	13	b	14	a	15	a
16	a	17	b	18	b	19	a	20	d

Answers and Solutions

General characteristics

1. (c)



2. (d) There are 6 electrons in its ultimate and penultimate shell.

3. (b) They show variable oxidation state due to participation of ns and $(n-1)d$ electrons.

4. (c) $(Cr^{+6} K_2Cr_2O_7$ – yellow $Cr^{+3} Cr_2(SO_4)_3$ – green)

7. (a) Ionic radii $\propto \frac{1}{\text{Atomic No.}}$ Ionic radius decreases from left to right in a period.

8. (c) The atomic weight;

$$\text{Equivalent weight} = \frac{\text{Atomic weight}}{\text{No. of } e^- \text{ lost or gained}}$$

$$Fe^{2+} \rightarrow Fe^{3+} + e^-$$

$\therefore$ Equivalent weight = Atomic weight

10. (c) Gold; $([Xe]5d^{10}6s^1)$.

11. (c) $(n-1)d$ and *ns* orbits.

12. (c) *d*-block elements; because

(i) Small atomic size

(ii) High nuclear charge

(iii) Presence of vacant *d*-orbitals

13. (d) Transitional elements form coloured salts due to the presence of unpaired electrons in *d*-orbital.

14. (c) *Cu*; because last electron enters *d*-orbital $(3d^{10}4s^1)$.

15. (b) *Cu* due to the presence of vacant *d*-orbital.

17. (b) Nickel; $Ni + 4CO \rightarrow [Ni(CO)_4]$ (volatile)

18. (c) Copper, silver and gold; all the three were used for making coins.

19. (b) 2, 8, 18, 1 = *Cu*

23. (a) In between *s* and *p*-block elements.

25. (c) Fe^{+3}

S. No.	Outer configu-ration	No. of unpaired e^-	Colour of ion	Magnetic moment
V^{+3}	$3d^2$	2	Green	2.76
Mn^{+3}	$3d^4$	4	Violet	1.9
Fe^{+3}	$3d^5$	5	Yellow	5.96
Cu^{+2}	$3d^9$	1	Blue	1.9

26. (a) Misch metal is an alloy of rare earth metals with composition :

Rare earth metals – 94.95%

Iron (Fe) – 5%

$S, C, Ca, Al .....$ – Traces

27. (c) "All their ions are colourless" this sentence is false because they are 90% coloured and only few are colourless.

28. (b) $1s^2, 2s^2p^6 .... ns^2p^6d^3, (n+1)s^2$ as last electron enters *d*-subshell.

30. (c) Due to unpaired *d*-electrons.

31. (b) $Fe^{+2} - 3d^6 4s^0 - 4$ unpaired e^-.

32. (c) All the oxides of $Fe(FeO, Fe_2O_3$ and $Fe_3O_4)$ are basic in nature.

34. (c) The presence of one or more unpaired electrons in the system.

35. (b) They show multiple oxidation state due to availability of vacant *d*-orbitals.

They are coloured due to *d*-*d* transition.

36. (a) $Mn^{2+} - 5$ unpaired electrons.

38. (d) Iron belongs to group VIII B of the periodic table.

39. (b) *d*-orbital is complete; $Zn - 3d^{10}4s^2$

41. (d) Transition elements form co-ordinate compounds because of

(i) High nuclear charge

(ii) Small size

(iii) Vacant *d*-orbital

42. (d) *Hg* is a good conductor of electricity.

45. (c) Transition metals show variable valency.

46. (d) Cu^+ do not have any unpaired electron.

47. (b) Fe^{2+} ion have 4 unpaired electrons

$$Fe^{2+} = 26 - 2 = 24 = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$$

48. (c) Hydrogenation – because they have tendency to occlude hydrogen on free surface.

49. (a) Metals contribute their valency electrons to the common sea of electrons.

52. (b) They are inert towards many common reagents.

53. (d) Oxidation state of iron in mohr's salt $FeSO_4(NH_4)_2SO_4.6H_2O$ is + 2.

54. (d) They show variable oxidation states due to participation of $(n-1)$ *d*-orbitals electrons with *ns* orbital electrons.

55. (a) Electronic configuration of chromium

$$Cr \rightarrow [Ar]3d^5 4s^1$$

$$Cr^{2+} \rightarrow [Ar]3d^4 4s^0 .$$

56. (a) Covalent bond is constituted by electrons of *d*-orbitals and lusture is due to free electrons of *s*-orbital in metallic bond.

57. (a) *Cr* has highest M.P. and B.P. due to maximum no. of unpaired electrons.

58. (b) *Hg* as there is no unpaired electron so M.P. and B.P are low. *Hg* is therefore liquid at room temperature with 234*K*.

60. (b) *Zn* due to increased shielding effect the attraction of electrons towards nucleus decreases.

61. (a) Number of electrons in excited state

$$X^{+3} = 18 + 4 = 22$$

Number of electrons in ground state

$$X = 22 + 3 = 25 .$$

62. (d) $(n-1)s^2p^6d^{1-10}ns^1$ or ns^2

64. (a) Ni^{2+} and Cr^{2+} are coloured. But Zn^{2+} is colourless because of absence of unpaired e^-.

66. (d) They show variable valency due to presence of vacant *d*-orbitals.

67. (b) Maximum oxidation state = 6

Maximum no. of e^- in last shell = 6

$\therefore$ Group is VI-B.

76. (c) Ag belongs to second (4*d*) transition series remaining all are in first transition series.

77. (b) Fe^{+2} ion have 4 unpaired electron so it is paramagnetic.

78. (b) $_{30}Zn$ and $_{80}Hg$ have their *d* orbitals completely filled so they do not show any variable valency.

80. (c) *d*-block elements are known as transition elements. These show variable valency due to their incomplete *d*-subshell.

81. (b) Electronic configuration of $_{27}Co$ -

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$,

hence unpaired e^- = 3

82. (a) $_{30}Zn$ has been placed in II B group of *d*-block in the long form of periodic table.

83. (b) The electronic configuration of Zn is $(Ar)3d^{10}4s^2$. Hence due to complete *d*-subshell, it does not show variable valency.

84. (b) $Zn^{+2} - 3d^{10}$

no unpaired electrons. Hence, diamagnetic in nature.

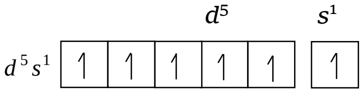
85. (d) Terbium is lanthanide as it belongs to $4f-$series having configuration $[Xe]4s^9 6s^2$. However the remaining members belong to $5f-$series (actinides).

87. (c) Fe^{+2} and Ni^{+2} both.

89. (b) $Ti^{+4} \rightarrow 3d^0 4s^0$ $\therefore$ no unpaired e^-.

91. (d) Transition metal as its last electron enters *d*-orbital.

92. (a)



This configuration is more stable because of symmetrical distribution of e^- and exchange energy.

93. (c) Among the transition metals Mn forms maximum no. of oxides.

$\underset{\text{basic}}{MnO}$ $\underset{\text{amphoteric}}{Mn_3O_4}$ $\underset{\text{amphoteric}}{Mn_2O_3}$ $\underset{\text{amphoteric}}{MnO_2}$ $\underset{\text{acidic}}{Mn_2O_7}$

94. (c) Due to d^5 configuration, metallic bonds are weak. d^5 orbital is half filled as a result $3d$ electrons are more tightly held by the nucleus and this reduces the de-localization of electrons resulting in weaker metallic bonding.

95. (a) Cu^{+2}

S.No	Ion	Electronic configuration	No. of unpaired electrons
(i)	Cu^{+2}	d^9	1
(ii)	Ni^{+2}	d^8	2
(iii)	Co^{+2}	d^7	3
(iv)	Fe^{+2}	d^6	4

$\mu = \sqrt{n(n+2)}$ (magnetic moment)

$\mu \propto \sqrt{n}$

Cu^{+2} there is only 1 unpaired electron so its magnetic moment is least.

96. (c) In the first transition series $Mn(3d^5 4s^2)$ shows the maximum oxidation state of + 7.

97. (c) They crystallize with body centered cubic and hexagonal close packed structure.

99. (d) Carrying unpaired electrons.

102. (d) All are transition elements and form complex ion.

103. (d) Ni and Co are used as catalyst.

104. (c) Magnetic moment depend upon the no. of unpaired electrons.

105. (a) Cr has 6 unpaired electrons.

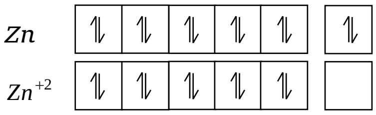
106. (d) Europium is a $f-$block elements as it follows the general electronic configuration of the $f-$block elements $(4f^{1-14}5d^{0,1}6s^2)$

$Eu = [Xe]4f^7 6s^2$

107. (c) 70% Cu and 30% Zn are mixed to form brass which is used in making utensils, artificial jewelry.

108. (d) Strength of metallic bond depends upon number of unpaired electrons. As number of unpaired electrons increases, the bond strength increases. So Cr, Mo, W show stronger bonding due to maximum number of unpaired electron.

109. (d) Zn^{+2} as there are no unpaired electrons.



110. (d) Cobalt is used in cancer therapy.

111. (b) Cu is oxidised which turns the solution blue.

113. (d) $Zn^{+2} - 3d^{10}4s^0$ so there are no unpaired electrons.

114. (b) $Sc - 21 \rightarrow 3d^1 4s^2$

116. (b) $3d^5$ as this configuration corresponds to maximum number of unpaired electrons.

121. (a) Hg because it lies below H_2 in electrochemical series and thus cannot reduce it.

122. (c) High charge/size – ratio and vacant *d*-orbitals.

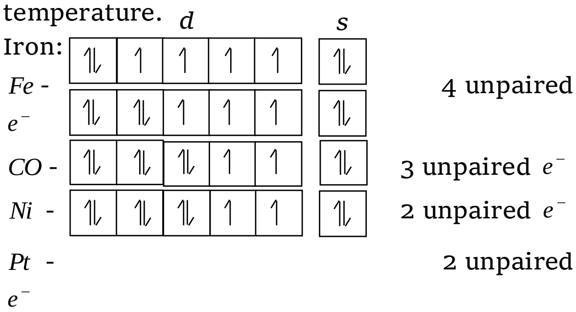
123. (d) They have one or more unpaired d - electron.

125. (a) Fe because it easily gets oxidised in moist air.

$Fe \xrightarrow[H_2O/H^+]{\text{air}} \underset{\text{Rust}}{Fe_2O_3.x\,H_2O}$

126. (d) *Pt,* because it is a noble metal and does not react with air, water or acid at room temperature.

128. (a) Iron:



Therefore, Fe is most ferromagnetic as it has maximum number of unpaired electrons.

129. (d) The transition metals form a large number of interstitial compounds in which small atoms like hydrogen, carbon, boron and nitrogen occupy interstitial sites in their lattices.

130. (d) Because Pt is a noble metal.

131. (a) $Zn - 3d^{10}4s^2$

$Zn^{++} - 3d^{10}4s^0$

132. (c) $Ti \rightarrow 3d^2 4s^2$

$Ti^{+4} \rightarrow 3d^0 4s^0$

133. (a) $\underbrace{\text{Atomic no. 58 to 71}}_{\text{Lanthanide s}}$ are rare earth metals.

134. (c). 58 to 71 and 90 to 103 (Lanthanides & actinides).

136. (c) To form complex compounds.

137. (b) *Cu* as it comes after *H* in electrochemical series.

139. (a) Their *d*-orbitals are completely filled.

140. (b) *Cu* as it comes after *H* in electrochemical series. It has positive standard reduction potential thus does not provide electrons for reduction.

144. (b) $6Hg + O_3 \rightarrow \underset{\text{Mercurous oxide}}{3Hg_2O}$

During this reaction, mercury loses its miniscus and starts sticking glass.

145. (d) Ga, In, Tl ; they belong to *p*-block.

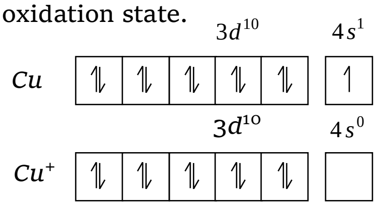
148. (c) *Zn, Cd* and *Hg* are non typical transition elements because they have complete *d*-orbitals.

150. (a) In Cr^{3+} number of unpaired $e^- = 3$. A electronic configuration of $Cr^{3+} = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$.

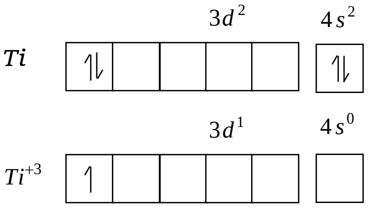
151. (c) Zinc does not have any unpaired electron pair so it forms only colourless compound.

153. (a) VII B groups as the metal must contain 7 electrons in ultimate shell in order to show + 7 oxidation state.

154. (b)



155. (c) Ti^{+3} is paramagnetic due to the presence of an unpaired electron.



156. (d) At 350*K* and 1 *atm* pressure 1 unit volume of *Pd* absorbs 900 unit volume of H_2.

157. (b) $Cu^{2+} \rightarrow 3d^9 4s^0$

1 unpaired e^-.

159. (a) Mercury does not give H_2 on reacting with water because its ionisation energy is so much high.

160. (a) Removal of electron is easier in f -block elements due to more shielding.

161. (c) Transition metal show variable valency due to presence of vacant *d*-orbitals.

163. (b) $Fe^{2+} - 1s^2 2s^2 p^6 3s^2 p^6 d^6$.

164. (c) It has 6 electrons in $3d$ orbital.

165. (a) They form oxide readily.

166. (d) Cr^{+3} due to presence of unpaired electrons.

169. (d) Fe^{++} due to presence of 4 unpaired electrons.

170. (d) *Fe* because it belongs to transition series.

171. (c) Lanthanide contraction takes place.

172. (a) Variable oxidation states give free valencies.

173. (b) $Mn = +2, +3, +4, +5, +6, +7$

175. (a) *Zn* due to no unpaired electron in *d*-orbital.

176. (c) $1s^2, 2s^2 p^6, 3s^2 p^6 d^2, 4s^2$.

179. (d) $\mu = \sqrt{n(n+2)}$ (μ = magnetic moment)

(n = no. of unpaired electron).

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

$n(n+2) = 8$

$n^2 + 2n - 8 = 0$

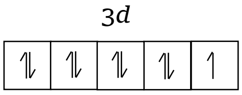
$n = 2$.

180. (a) $Cr^{+++} \rightarrow$ green

$Fe^{+++} \rightarrow$ Pale-green

181. (b) Inner transition elements means f-block element, they have three incomplete outer orbitals.

184. (d)



1 unpaired e^- only.

185. (b) $d-d$ transition of 3d electrons.

186. (a) $\underset{+1}{K_4}[\underset{x}{Fe}(\underset{-1}{CN})_6]$

$4+x-6=0$

$x=6-4$

$x=+2$.

188. (b) $Mn^{2+}-3d^5 \rightarrow$ unpaired e^-.

189. (a) Very high ionisation energy and weak metallic bond.

191. (c) Iron because mercury does not form amalgam with iron.

192. (c) Chromium gives protective and decorative coating to the base metal.

193. (c) d-block elements as last electron enters in d-orbital.

195. (d) Highest oxidation state → $\underset{2}{\text{no. of } s\text{-}e^-} \underset{+}{+} \underset{2}{\text{no. of } d\text{-}e^-} \underset{=4}{}$

196. (c) Ionic and covalent compounds.

198. (c) $[Kr]4d^{10}5s^1$ (atomic no. = 47)

199. (a) Magnese is stronger oxidising agent in + 7 oxidising state. *e.g.* $KMnO_4$

200. (a) $Cu^+-3d^{10}4s^0$; no unpaired e^-.

201. (a) $Fe-CO-Ni$. With the increase in the d-electrons, screening effect increases, this counter balances the increased nuclear charge due to increase in atomic number. As a result atomic radii remain practically same after chromium.

202. (d) Ta because it is non-corrosive.

205. (d) Cobalt due to presence of unpaired e^-.

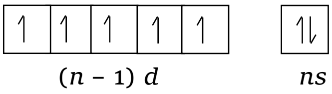
206. (c) $Ti^{3+} \rightarrow 3d^1 4s^0$; $Sc^{3+} \rightarrow 3d^0$

$Mn^{2+} \rightarrow 3d^5 4s^0$; $Zn^{2+} \rightarrow 3d^{10}4s^0$

In Mn^{2+} number of unpaired d $e^-=5$. So it has maximum magnetic moment according to the formula. $\mu=\sqrt{n(n+2)}$

207. (a) + 4 oxidation state of cerium is also known in solution.

208. (d)



$(n-1)\,d^5ns^2$ can achieve the maximum oxidation state of + 7.

209. (b) $Ti_{22}=3d^2 4s^2$; $Ti^{2+}=3d^2$

$V_{23}=3d^3 4s^2$; $V^{2+}=3d^2$

$Cr_{24}=3d^4 4s^2$; $Cr^{4+}=3d^2$

$Mn_{25}=3d^5 4s^2$; $Mn^{5+}=3d^2$

210. (a) As sixth period can accommodate only 18 element in the table, 14 member of HF series (atomic number 58 ot 71) are separately accommodated in a horizontal row below the periodic table. These are called as lanthanides.

212. (b) The oxidation state in both (lanthanide and actinide) is +3. The property of actinide are very similar to those of lanthanide when both are in +3 state.

213. (b) The lanthanide contraction relates to atomic as well as M^{3+} radii in which the regular decrease in the size of lanthanoid ion from La^{3+} to Lu^{3+} are found.

214. (b) Highest magnetic moment depends upon number of unpaired electron since

$Cr^{2+}=3d^4 4s^0$, $Mn^{2+}=3d^5 4s^0$

$Cu^{2+}=3d^9 4s^0$, $Co^{2+}=3d^7 4s^0$, $Ni^{2+}=3d^6 4s^0$

So Mn^{2+} contain maximum number of unpaired electron *i.e.* 5.

215. (c) Cobalt 27 belong to 3d transition series having in complete 3d orbitals *i.e.*, $3d^7$.

216. (a) It is the Tata iron and steel company.

217. (c) The atomic weight of Co, Ni and Fe are 58.90, 58.60, 55.85 respectively. Therefore $Co>Ni>Fe$ is the correct sequence of atomic weight.

218. (d) The first ionization energies of Ti, V, Cr and Mn are 656, 650, 652 and 717 $kJ/mole$ respectively. I.E. increase in a period from $L \rightarrow R$ hence, manganese has maximum first ionisation potential.

219. (b) Metal M belongs to d-block. Its electronic configuration can be arranged as, $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$.

220. (b) We know that transition element are those element which have partially filled d-subshell in their elementary form. Therefore, the general electronic configuration of d-block element is $(n-1)\,d^{1-10}ns^{1-2}$.

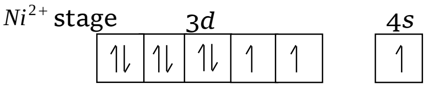
221. (b) The element with atomic no. 105 is dubnium. In IUPAC nomenclature, it is known as un-nil pentin.

222. (b) The compound which have the unpaired electron show the paramagnetic property.

223. (b) Among the given choice Mn^{2+} and Fe^{3+} involve isoelectronic ions.

224. (a) Elements or ions containing unpaired electrons are paramagnetic.

$_{28}Ni=[Ar]\,3d^8\,4s_2$; $Ni^{2+}=[Ar]\,3d^8\,4s^0$



Because Ni^{2+} have 2 unpaired electrons in 3*d* subshell therefore it is paramagnetic.

225. (b) $Cr(Z=24)$ has electronic configuration

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$ ($\because$ half filled *d* orbital is more stable than incompletely filled *d* orbital)

226. (b) The expected electronic configuration of *Cu* (29) is $[Ar]\,3d^9 4s^2$ but actually it is found to be $[Ar]\,3d^{10} 4s^1$. This is because fully filled *d* orbitals are more stable than incompletely filled *d*-orbitals. So there is a migration of one e^-, from 4*s* orbital to 3*d* orbital to give a more stable configuration.

227. (d) $Ce-58$ have configuration $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}$,

$4s^2 4p^6 4d^{10} 4f^2, 5s^2 5p^6 5d^0, 6s^2$

Since, its last electron enter in *f*- sub-shell, therefore it is a member of *f*-block.

228. (a) $Ni \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

$Ni^{2+} \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$

$3d^8 = 10-2=2$ unpaired electron.

230. (d) $_{25}Mn=3d^5 4s^2$

After losing two electron electronic configuration will be like this ($_{25}Mn^{++}3d$) and this is most stable configuration due to half filled orbitals hence third ionization enthalpy will be highest in this case.

231. (a) $_{21}Sc \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$

$Sc^{+3} \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6$

Due to presence of paired electron it will be colourless.

232. (a) Lanthanum is the first element of Lanthanide series so size decreases with increase in atomic number so *La* has the largest atomic radii.

234. (a) Tl^+ ions are more stable than Tl^{3+} and thus, Tl^{3+} ions change to Tl^+ ions thereby acting as oxidising agents.

Tl^{3+} compounds + 2*e* → Tl^+ compounds

(less stable oxidising (more stable oxidising

237. (a) Fe^{3+} → $[Ar]$ $3d^6$ $4s^0$, number of unpaired electrons = 5

Fe^{2+} → $[Ar]$ $3d^6$ $4s^0$, number of unpaired electrons = 4

Co^{2+} → $[Ar]$ $3d^7$ $4s^0$, number of unpaired electrons = 3

Co^{3+} → $[Ar]$ $3d^6$ $4s^0$, number of unpaired electrons = 4

238. (d) Paramagnetic character is actually due to presence of unpaired electrons.

239. (b) Mercury has the property of dissolving nearly all metals, forming liquid or solid solutions called amalgams. It amalgamates well with gold, silver and tin, but does not dissolve iron or platinum. Presence of these may result in sickening or flouring of the mercury.

240. (b) *Ce* -lanthanide, *Cs* -alkali metal, *Cf* -actinide, *Ca* -alkaline earth metal.

241. (b) Where $n=$ number of unpaired electron

For $Sc^{3+}=3d^0, n=0$, $\therefore$ $\mu=0$

Compounds of Transitional elements

1. (a) MnO_2, MnO_2, Mn^{2+}

In neutral medium :

$$2KMnO_4+3MnSO_4+2H_2O \rightarrow K_2SO_4+2H_2SO_4+5MnO_2$$

In alkaline medium :

$$2KMnO_4+H_2O \rightarrow 2MnO_2+2KOH+3O$$

In acidic medium :

$$2KMnO_4+3H_2SO_4 \rightarrow K_2SO_4+2\overset{+2}{Mn}SO_4+5H_2O+5O$$

2. (c) Oxidation state of *Mn* changes from +7 to +2 in acidic medium *i.e.* one mole of it accepts 5 mole of electrons.

3. (d) Since it accept $6e^-$ its

Equivalent weight = $\frac{M}{6}$.

5. (b) Decreases from + 6 to + 3.

$$K_2Cr_2O_7+4H_2SO_4 \rightarrow K_2SO_4+Cr_2(SO_4)_3+4H_2O+3O$$

$$[H_2S+[O] \rightarrow S+H_2O] \times 3$$

$$K_2\overset{+6}{Cr_2}O_7+4H_2SO_4+3H_2S \rightarrow K_2SO_4+\overset{+3}{Cr}(SO_4)_3+7H_2O+3S$$

6. (c) $FeSO_4$ is oxidised and $KMnO_4$ is reduced.

$$2KMnO_4 + 3H_2SO_4 \to K_2SO_4 + 2MnSO_4$$
$$[2FeSO_4 + H_2SO_4 \to Fe_2(SO_4)_3 + 2H] \times 5$$
$$\underline{[2H + [O] \to H_2O] \times 5}$$
$$2KMnO_4 + 8H_2SO_4 + 10FeSO_4 \to$$
$$K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$$

In this reaction oxidation state of Mn is changing from +7 to +2 while oxidation state of Fe is changing from +2 to +3.

7. (a) $\underset{\text{Calomal}}{Hg_2Cl_2} + 2NH_4OH \to NH_4Cl + 2H_2O + Hg + HgNH_2Cl$

8. (b) Ag^+ forms a complex ion with NH_3

$AgCl + 2NH_3 \to [Ag(NH_3)_2]Cl$

9. (b) Four water molecules.

$CuSO_4.5H_2O$ is a crystalline salt. Four H_2O molecules attach to copper forming a square planar symmetry and two oxygen atoms from SO_4^{2-} ion complete the distorted octahedron. The fifth water molecule is attached through hydrogen bonding between one of the co-ordinated water molecule and one of the sulphate ion.

10. (d) $AgCl$ is a covalent compound hence it is insoluble in water also it form complex with NH_4OH, thus is soluble in NH_4OH.

$AgCl + 2NH_4OH \to [Ag(NH_3)_2]Cl + H_2O$

11. (a) Basic copper acetate.

(Verdigris - $(CH_3COO)_2Cu.Cu(OH)_2$) is a blue green powder used in green pigment and in dyes. Also in manufacture of insectisides and fungicides.

13. (a) H_2O_2 reduces acidified $KMnO_4$ solution. As a result. The pink colour of $KMnO_4$ is changed.

14. (a) MnO_2 forms amphoteric oxide due to intermediate oxidation state.

15. (a) MnO is ionic due to lower oxidation state.

17. (a) Manufacture of blue black ink.

18. (d) As fertilizer because it is not required by plants.

20. (b) Since Ag is less reactive than Cu therefore it does not displace Cu from $CuSO_4$ while other metals are more reactive, they displace Cu from $CuSO_4$.

21. (d) Its reduction to metallic silver.

$2AgNO_3 \to \underset{\text{black stain}}{2Ag} + N_2 + 3O_2$

22. (c) $Na_2S_2O_3 + CuSO_4 \to NaCuS_2O_3$

23. (e) $2HgO \xrightarrow{\Delta} 2Hg + O_2$

24. (b) $2Fe + 3Cl_2 \to 2FeCl_3$

25. (c) $Fe(OH)SO_4$

$FeSO_4 \xrightarrow{H_2O} Fe(OH)SO_4$

27. (d) $\frac{1}{5} \times$ molecular weigth of $KMnO_4$

as transfer of $5e^-$ takes place when $KMnO_4$ acts as oxidant in acidic medium.

$2KMnO_4 + 3H_2SO_4 \to K_2SO_4 + 2MnSO_4 + 3H_2O + 5O$

28. (a) Oxidation number of Cr in options a, b, c and d are +6, + 4, + 3, + 3 respectively.

In given options (a) has high oxidation number therefore its radii will be low. Atomic radii decreases with increase in oxidation no.

33. (b) Cuprous chloride.

$Cu(s) + 2HCl + CuSO_4 \to \underset{\text{Cuprous chloride}}{2CuCl} + H_2SO_4$

34. (d) Cuprous chloride slowly oxidises to green basic cupric chloride.

$CuCl \xrightarrow{\text{air}} \underset{\text{green coloured}}{3CuO.CuCl_2.3H_2O}$

35. (a) $2CuCl + 2HCl + [O] \to 2CuCl_2 + H_2O$

38. (b) Equivalent weight of $KMnO_4$ in acidic medium is $M/5$

$\therefore$ Equivalent weight = $\frac{158}{5}$ = 31.6

39. (b) In acidic medium, $KMnO_4$ gives 5 oxygen while acidic $K_2Cr_2O_7$ gives 3 oxygen.

41. (a) Ag_2O is mild oxidising agent as greater the oxidation number of metal stronger oxidising agent.

42. (c)

$K_2Cr_2O_7 + 3H_2SO_4 \to K_2SO_4 + Cr_2(SO_4)_3 + 3(O) + 3H_2$

No. of electrons lossed = 12 – 6 = 6

$\therefore$ Equivalent weight = $\frac{M}{6} = \frac{294}{6} = 49.$

44. (a) $ZnSO_4 \to Zn^{++} + SO_4^{-2}$

$Zn^{++} \approx Cu^{++}$

$Cu^{+2} \to 3d^9 - 1\text{ unpaired } e^-$

$\therefore$ paramagnetic in nature.

46. (b) $KMnO_4$ is first reduced to manganate and then to insoluble manganese dioxide. Colour changes first from purple to green and finally becomes colourless.

$$2KMnO_7 + 2KOH \to 2K_2MnO_4 + H_2O + O$$
$$\underline{2K_2MnO_4 + 2H_2O \to 2MnO_2 + 4KOH + 2O}$$
$$2KMnO_2 + H_2O \xrightarrow{\text{alkaline}} 2MnO_2 + 2KOH + 3[O]$$

47. (c) $2KMnO_4 + 3H_2SO_4 + 5C_2H_2O_4 \to$

$2Mn^{2+} + 8H_2O + 10\,CO_2$

48. (b) $2KI + HgI_2 \rightarrow \underbrace{K_2HgI_4}_{\text{Nessler's reagent}} + KOH$

50. (c) $Cr_2O_7^{2-} + 8H^+ + 2SO_3^{2-} \rightarrow 2Cr^{+3} + 3SO_4^{2-} + 4H_2O$

51. (b) $KI + MnO_4^- \rightarrow K^+IO_3^- + Mn^{+2}$

52. (b) Among all the reactions given $CuSO_4$ does not react with KCl to give Cu_2Cl_2.

53. (c) Mohr's salt.

$$2KMnO_4 + 8H_2SO_4 + 10FeSO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$$

Mohr's salt decolourises $KMnO_4$ by reducing Mn^{+7} ions to Mn^{+2} ions.

55. (c) Amalgams are alloys which contain mercury as one of the contents.

56. (a) In order to make the image permanent, it is necessary to remove the unreduced silver bromide from the surface of the developed film. This operation is called fixing of image. Fixing is done by dipping the developed film or plate in sodium thiosulphate (hypo) solution. the hypo solution dissolves the unreduced silver bromide by forming a complex.

$$AgBr + 2Na_2S_2O_3 \rightarrow \underset{\substack{\text{Sodium argentothiosulphate} \\ \text{(soluble)}}}{Na_3[Ag(S_2O_3)_2]} + NaBr$$

Thus sodium thiosulphate acts as a complexing agent.

58. (d) All of these.

59. (b) $Fe^{+3} - 3d^5 - 5$ electrons unpaired.

Fe will be attracted in magnetic field so will show increase in weight.

60. (d) TiF_6^{2-} and Cu_2Cl_2 due to absence of unpaired electrons.

62. (b) Copper oxide; $2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$

63. (c) Cuprous iodide is precipitated with liberation of iodine.

$$2KI + CuSO_4 \rightarrow CuI_2 + K_2SO_4 + I_2$$

64. (a) It is one third of its molecular weight in alkaline medium because it gives 3 nascent oxygen in alkaline medium.

$$2KMnO_4 + H_2O \xrightarrow{+3e^-} 2KOH + 2MnO_2 + 3[O]$$

$\therefore$ Equivalent weight = $\frac{M}{3}$

65. (c) $NaCl + H_2SO_4 + K_2Cr_2O_7 \rightarrow \underset{\text{Chromyl chloride}}{CrO_2Cl_2} + K_2SO_4 + Na_2SO_4$

66. (b) Decomposes in sunlight.

$$2AgNO_3 \xrightarrow{\Delta} 2Ag + 2NO_2 + O_2$$

67. (c) Silver; $AgNO_3 + NaCl \rightarrow \underset{\text{White ppt.}}{AgCl} + NaNO_3$

70. (c) The formation and thermal decomposition of $Ni(CO)_4$.

71. (a) $CuSO_4 + 4NH_3 \rightarrow [Cu(NH_3)_4]^{++}SO_4^{--}$

72. (a) Equivalent $\text{wt.} = \frac{\text{molecular wt.}}{\text{total no. of } e^- \text{ gained or lost}} = \frac{M}{1} = M$

76. (d) $HgI_2 + 2KI \rightarrow K_2[HgI_4] \rightleftharpoons 2K^+ + [HgI_4]^{--}$

80. (c) The conversion of dichromate to chromate.

$$K_2Cr_2O_7 + 2KOH \rightarrow \underbrace{2K_2CrO_4}_{\text{yellow}} + H_2O$$

81. (b) $\underset{\text{pyrollusite}}{MnO_2} + KOH \rightarrow K_2MnO_4$

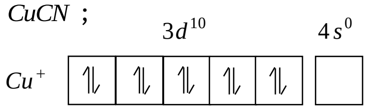
83. (c)

$$K_2Cr_2O_7 + H_2SO_4 + 4H_2O_2 \rightarrow K_2SO_4 + 2CrO_5 + 5H_2O$$

84. (d) Iron; $Fe + H_2O/H^+ \rightarrow Fe_2O_3.xH_2O$

85. (b) Na_2CdCl_4 - no unpaired electrons.

87. (c) $CuCN$;



as all the electrons are paired. It is expected to be colourless.

88. (c) $ZnSO_4, MgSO_4$ are isomorphous i.e. having same structure.

90. (a) TiO_2 because of $3d$ state *i.e.* no unpaired electrons.

91. (b) $CoO \rightarrow Co^{+2}$ is blue colour.

92. (c) $Ca_2P_2O_7 \rightarrow 2Ca^{++} + (P_2O_7)^{4-} Fe^{+3} + (P_2O_7)^{4-} \rightarrow Fe_4(P_2O_7)_3$

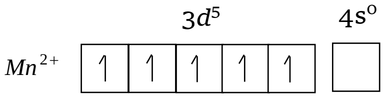
93. (d) *AgI* because of high covalent character along with strong Vander Waal's attraction and electrostatic attraction between silver and iodide ions.

100. (c) $ZnO + 2NaOH \rightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2} + H_2O$

101. (b) $HgCl_2$ compound is easily volatile. They are insoluble in water and soluble in acids.

102. (a) Colourless compounds are those which have no unpaired electrons and paramagnetic substance do have unpaired electrons. Therefore paramagnetic substance possess colour.

107. (c) $MnSO_4 \rightarrow Mn^{2+} + SO_4^{2-}$



due to presence of unpaired electrons it will form coloured salt.

111. (a) Cast iron : iron –93–95%

Carbon – 2.5 –5%, impurities about 2%.

112. (a) $FeCl_3$ is a salt of strong acid and weak base. It gives $Fe(OH)_3$ and HCl on hydrolysis. $Fe(OH)_3$ is a weak base and HCl is strong acid.

So the aqueous solution of $FeCl_3$ will be acidic in nature

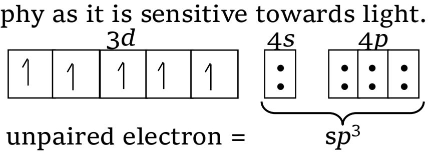
113. (b) $Cr_2^{6+} + 6e^- \to 2Cr^{3+}$; $Fe^{2+} \to Fe^{3+} + e^-$

114. (a) CrO_3 and Mn_2O_7 are acidic oxide since they react with water to form acid.

$$CrO_3 + H_2O \to \underset{\text{Chromic acid}}{H_2CrO_4} \ ; \ Mn_2O_7 + H_2O \to \underset{\text{Permagnic acid}}{2HMnO_4}$$

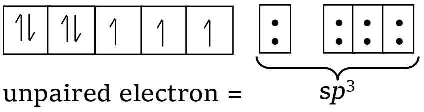
115. (a) In photography as it is sensitive towards light.

116. (c) $[MnCl_4]^{2-} \to$



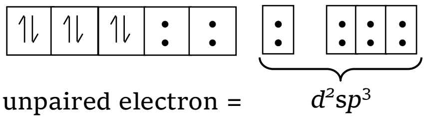
Number of unpaired electron =

$[CoCl_4]^{2-} \to$



Number of unpaired electron =

$[Fe(CN)_6]^{4-} \to$



Number of unpaired electron =

Magnetic moment $= \sqrt{n+2}$

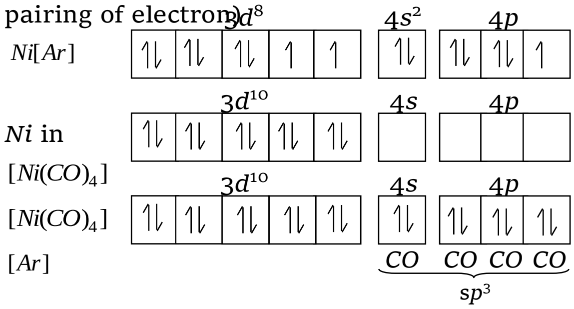
Where, n = number of unpaired electron *i.e.*, greater the number of unpaired electron greater will be the paramagnetic character.

117. (a) In the compound $[Ni(CO)_4]$

Oxidation number of $Ni = 0$

Co-ordination number of $Ni = 4$

(Co (carbonyl) is a strong ligand so it cause pairing of electron)



118. (a) Applying the oxidation number rule in $[Fe(H_2O)_5(NO)]SO_4$ ($\because$ H_2O and NO are neutral)

$$[x + (0) \times 5 + 0] + (-2) = 0$$

$$x + 0 + 0 - 2 = 0 \Rightarrow x = +2$$

Hence, oxidation number of Fe is +2.

119. (c) $Zn + \underset{\text{Conc.}}{NaOH} \to \underset{\text{Sodium zincate}}{Na_2ZnO_2} + \underset{\text{Hydrogen}}{H_2}$

Thus in this reaction hydrogen gas is produced when zinc is treated with concentrated *NaOH*.

120. (c) $Fe_2O_3 + 6NaOH \to \underset{\substack{\text{Brown} \\ \text{(insoluble in } NaOH)}}{2Fe(OH)_3 \downarrow} + 3Na_2O$

121. (c) Mercurous chloride are insoluble in water while rest are soluble in water.

122. (a) *ZnO* is an amphoteric oxide,

$$ZnO + H_2SO_4 \to ZnSO_4 + H_2O$$

$$ZnO + 2NaOH \to Na_2ZnO_2 + H_2O$$

123. (a) Fe^{3+} ion has $[Ar]3d^5$ configuration hence number of unpaired electron is 5.

124. (b) $FeS + H_2SO_4 \to FeSO_4 + H_2S$

125. (c) In this complex CO^{2+} ion have 3 unpaired electron so spin only magnetic moment will be $\sqrt{3(3+2)}$ *i.e.*, $\sqrt{15}$ *B.M.*

126. (a) Platinum acts as catalyst in the oxidation of ammonia to form nitric oxide. This reaction is used in the Ostwald's method of nitric acid preparation

$$4NH_3 + 5O_2 \xrightarrow[750°C]{Pt} 4NO + 6H_2O$$

$$2NO + O_2 \to 2NO_2$$

$$4NO_2 + O_2 + 2H_2O \to 4HNO_3$$

127. (c) Iron is oxidised to ferrous nitrate and nitric acid is changed to ammonium nitrate

$$4Fe + 10HNO_3 \to 4Fe(NO_3)_2 + NH_4NO_3 + 3H_2O$$

128. (a) $CrO_3 + 2NaOH \to \underset{\text{Yellow solution}}{Na_2CrO_4} + H_2O$

129. (c) $2KI + CuSO_4 \to \underset{\text{Unstable}}{CuI_2} + K_2SO_4$

$$2CuI_2 \to Cu_2I_2 + I_2$$

Hence, solution contains Cu_2I_2, I_2 and K_2SO_4.

130. (a) *Cu* is placed above *Ag* in electrochemical series, hence it can replace *Ag* from its salts solution. Therefore the reaction occurs as follows,

$$\overset{0}{Cu} + AgNO_3 \xrightarrow{\text{Oxidation}} \overset{+1}{Cu}\,NO_3 + Ag$$

131. (a) When the quenched steel is heated to temperature below red hot and then allowed to cool slowly, it becomes soft. This process is known as annealing.

132. (a) We know that ammonia the order of solubility is $AgCl > AgBr > AgI$. Therefore, *AgCl* is more soluble in ammonia.

133. (d) In alkaline medium, $KMnO_4$ first reduced in manganate & then in insolusle manganese dioxide.

$$2MnO_4^- + H_2O \to 2MnO_2 + 2OH^- + 3[O]$$

In acidic medium, Manganous sulphate formed

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$.

134. (c) $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} 2K_2CrO_4 + Cr_2O_3 + \frac{3}{2}O_2$

135. (a) *HgS* is soluble in aqua-regia and it is insoluble in hot dil. HNO_3 .

136. (d) $Ag_2O \xrightarrow{\Delta} 2Ag + \frac{1}{2}O_2$

138. (a) $HgCl_2$ show dimerisation. It found in dimer form.

139. (b) Iron pyrites (FeS_2) is also called ‘fools gold’.

140. (c) According to Fajan, small anion is polarised to lesser extent than the larger anion. Hence *AgF* will be the most ionic and has high melting point.

141. (c) Potassium dichromate, on heating gives oxygen and chromic oxide (Cr_2O_3).

$4K_2Cr_2O_7 \xrightarrow{\Delta} 4K_2Cr_2O_4 + 3O_2 + 2Cr_2O_3$

142. (a) Nickel is purified by Mond’s process

$$\underset{\text{Impure}}{\text{Nickel}} + \underbrace{CO \xrightarrow{60-80°C} Ni(CO)_4 \xrightarrow{180°C} Ni + 4CO}_{\text{Gaseous comp.}}$$

143. (b) Stainless steel contains 11.5% *Cr* and 2.0% *Ni* with *Fe*.

144. (d) German silver is an alloy of copper not silver containing $Cu = 56.0\%$, $Zn = 24.0\%$ and $Ni = 20.0\%$.

145. (e) This scheme take place in Van Arekel process by this process ultrapure metal is prepared, the impure metal is first converted into a volatile stable compound generally iodide(leaving behind the impurities which is then decomposed at a higher temperature to give the pure metal. Metal like titanium, zirconium are purified by this method.

146. (e) *HgS* on strong heating gives *Hg*.

147. (a) $Cr_2O_3.2H_2O$ is known as cruignet green.

148. (c) Vanadium (III) oxide is a strong reducing agent vecause vanadium is electropositive metal and have high reduction potential. It has low heat of sublimation, low ionisation potential.

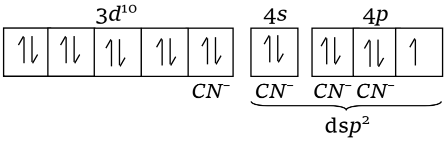
149. (b) Stainless steel does not rust because chromium forms an oxide layer and protect iron from rusting.

150. (b) $HgCl_2 + Na_2CO_3 \rightarrow HgCO_3 + 2NaCl$

$HgCO_3 \xrightarrow{\Delta} HgO + CO_2$

151. (d) *Ni* in presence of CN^-

$[Ni^{2+}$ in presence of $CN^- = [Ar]$



As $[Ni(CN)_4]^{2-}$ has no unpaired electron. It is diamagnetic.

152. (a) The solubility of silver bromide in hyposolution due to the formation of $[Ag(S_2O_3)_2]^{3-}$.

153. (b) Brass is an alloy of *Zn* and *Cu*.

154. (a) Iodine being a strong reducing agent reduce Cu^{2+} ions to Cu^+ ions and itself gets oxidised to iodine.

$$\underset{\text{Reduced}}{\overset{+2}{2CuSO_4}} + \underset{\text{Oxidised}}{\overset{-1}{4KI}} \rightarrow \overset{+1}{Cu_2}I_2 + \overset{0}{I_2} + 2K_2SO_4$$

155. (c) Rust is Fe_2O_3 and $Fe(OH)_3$

156. (a) ${}_{21}Sc = [Ar]\,3d^1 4s^2$

$Sc^{3+} = [Ar]\,3d^0 4s^0$ no unpaired electrons in *d* sub shell, so it is diamagnetic and colourless.

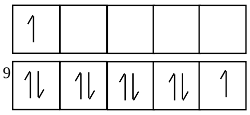
157. (c) Zinc sulphate $(ZnSO_4.7H_2O)$ is called white vitriol. It, when heated with barium sulphide, forms a white pigment lithopone.

158. (a) Isomorphic compound are those compounds which forms same type of crystals *i.e.,* have similar structure. $FeSO_4.7H_2O$ is isomorphous with $ZnSO_4.7H_2O$.

159. (b) Colour of transition metal ion salt is due to $d-d$ transition of unpaired electrons of *d*-orbital. Metal ion salt having similar number of similar number of unpaired electron in *d*-orbitals shows similar colour in aqueous medium

V^{4+} : $[Ar]\,3d^1$

Cu^{2+} : $[Ar]\,3d^9$



Number of unpaired electrons = 1

160. (b) *Zn* dissolve in Conc. *NaOH* due to the formation of Sodium Zincate.

$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$

161. (b) *CdS* -- Yellow

CuS -- Black

ZnS -- White

CoS -- Black

162. (c) $KMNO_4$ will not be oxidized further by ozone as maganese is already present in its highest possible oxidation state i.e. +7

163. (d) In alkaline medium

$2KMnO_4 + KI + H_2O \rightarrow 2MnO_2 + 2KOH + KIO_3$

164. (b) $2\overset{-1}{KI} + 2CuSO_4 \rightarrow \overset{O}{I_2} + Cu_2I_2 + 2K_2SO_4$

$\overset{O}{I_2} + 2Na_2\overset{+2}{S_2}O_3 \rightarrow Na_2\overset{+2.5}{S_4}O_6 + 2\overset{-1}{NaI}$

166. (c) Bronze contain $Cu = 75 - 90\%$, $Sn = 10 - 25\%$

168. (b) Brass $(Cu + Zn)$

German silver $(Cu + Zn + Ni)$

169. (c) $4Au + 8KCN + 2H_2O + O_2 \rightarrow \underset{\text{(Solube comple x)}}{4K[Au(CN)_2]} + 4KOH$

170. (d) Platforming is a process for manufacturing platinum.

171. (a) We know by reducing auric chloride by stannous chloride, the colloidal solution of gold is obtained. It is known as purple of cassium.

172. (c)

List 1	**List 2**
(i) Explosive	$Pb(N_3)_2$
(ii) Artficial gem	Al_2O_3
(iii) Self reduction	Cu
(iv) Magnetic material	Fe_3O_4

178. (b) $\underset{82\%}{Fe} + \underset{11\%}{Cr} + \underset{7\%}{Ni}$ = Stainless steel

179. (c) *CaO* and *MgO* are refractory materials. They have very high melting point.

180. (b) Brass contain $Cu = 60\%$ and $Zn = 40\%$ in its composition.

181. (a) Annealing is a process of heating steel to redness followed by slow cooling

182. (b)

$$_{26}Fe^{2+}\ \overset{3d^6}{\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}}\ \overset{4s^2}{\boxed{\uparrow\downarrow}}$$

$$Fe^{3+}\ \overset{3d^5}{\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}}$$

+ 3 state is most stable because of half filled *d* sub-shell

183. (b) $\underset{95-97\%}{Fe}$ and $\underset{3-5\%}{Ni}$.

185. (a) The process of producing a hard coating of iron nitride on steel is called nitriding.

187. (c) Iron loses magnetic property at curie point.

188. (d) Heat treatment alters the properties of steel due to change in the lattice structure due to differential rate of cooling.

189. (c) The passivity of iron is due to the formation of a thin insoluble and invisible iron film on surface which prevents its further reactions. The film is due to the formation of Fe_3O_4 .

190. (c) $2Fe + SO_2 \rightarrow FeO + FeS$

191. (a) The steel obtained by this process retains its hardness but is not brittle.

192. (d) In blast furnace at 400-600°*C* for the smelting of iron, following takes place:-

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

194. (a) $\underset{60\%}{Cu} + \underset{20\%}{Zn} + \underset{20\%}{Ni}$

195. (d) Iron is rendered passive by conc. HNO_3 and other oxidising agents like $K_2Cr_2O_7, KMnO_4$, Chloric acid, chromic acid, silver nitrate etc. A specimen of passive iron can be rendered active by scratching the film mechanically or chemically.

199. (b) *Fe* present in Haemoglobin

201. (d) $2FeSO_4 \rightarrow Fe_2O_3 + SO_2 + SO_3$

203. (a) $NO_3^- + H_2SO_4 \rightarrow HNO_3 + HSO_4^-$

$2HNO_3 \rightarrow H_2O + 2NO + 3[O]$

$FeSO_4 + NO + 5H_2O \rightarrow \underset{\text{Brown colour}}{[Fe(H_2O)_5 NO^+]SO_4}$

204. (a) $K_2MnF_6 + 2SbF_5 \rightarrow 2KSbF_6 + MnF_3 + \frac{1}{2}F_2$

In this reaction, the stronger Lewis acid SbF_5 displaces the weaker one, MnF_4 from its salt. MnF_4 is unstable and readily decomposes to give MnF_3 and fluorine.

205. (a) Case hardening : The process of hardening the surface of wrought iron by depositing a surface layer of steel on it is called case-hardening it is done by heating wrought iron in contact with potassium ferrocyanide.

Alternatively, case hardening can also be done by heating wrought iron with charcoal and then plunging it a suitable oil.

206. (a) Stainless steel is not corroded by air, moisture and small change in *pH*. Made up of $\underset{82\%}{Fe}, \underset{7\%}{N}$ and $\underset{11\%}{Cr}$.

207. (b)

Variety of irons	% of Carbon
Cast or Pig iron	2.5 – 4%
Wrought iron	0.12 – 0.25%
Steel	0.2 – 0.5%

208. (a)

209. (c) Tempering : If the quenched or hardened steel is reheated to a temperature between 503 to 573 *K* and then allowed to cool slowly, the process is called tempering.

226. (d) % of carbon in wrought iron is 0.2 – 0.5%, in steel 0.5 – 1.5% and in Pig iron 2.5 – 4%.

227. (a) $Fe + 5CO \rightarrow [Fe(CO)_5]$ Pentacarbonyl iron (O)

230. (d) Potash alum $K_2SO_4.Al_2(SO_4)_3.24H_2O$

231. (c) A thin layer of Fe_3O_4 is formed on the *Fe* metal

232. (a) $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

233. (b) *Mn* used to make alloy steel for armour plates, safes and helmets.

236. (a) Solder$(Pb + Sn)$, Bronze $(Cu + Sn)$, Brass $(Cu + Zn)$, Bell metal $(Cu + Sn)$.

241. (d) $\underset{80\%}{Cu} + \underset{20\%}{Sn} \rightarrow \text{Bell metal}$

242. (b) Turnbull's blue Ferrous ferri cyanide $Fe_3[Fe(CN)_6]_2$

244. (a) $Cu + 2AgNO_3 \rightarrow 2Ag + Cu(NO_3)_2$

$Cu + ZnSO_4 \rightarrow$ no reaction

$Cu + FeSO_4 \rightarrow$ no reaction

$$\left.\begin{aligned} E^0 Zn^{+2}/Zn &= -0.76\ V \\ E^0 Cu^{2+}/Cu &= +0.34\ V \\ E^0 Fe^{2+}/Fe &= -0.40\ V \\ E^0 Ag^{+}/Ag &= +0.80\ V \end{aligned}\right\}$$

As it is clear that reduction potential of copper is more than *Zn* and *Fe*. Hence it is unable to displace them from their salts.

245. (b,c) Ferrous salts react with potassium ferricyanide to give blue colouration due to the formation of Tumbull's blue in this reaction, first ferrous salt is oxidised to ferric salt by the ferricyanide ion which itself is reduced to ferrocyanide.

$$Fe^{+2} + \underset{\text{Ferricyanide}}{[Fe(CN)_6]^{3-}} \rightarrow Fe^{+3} + \underset{\text{Ferrocyanide}}{[Fe(CN)_6]^{4-}}$$

$$Fe^{+3} + [Fe(CN)_6]^{4-} \rightarrow \{Fe[Fe(CN)_6]\}^{-}$$

$$Fe^{+3} + [Fe(CN)_6]^{4-} + K^{+} \rightarrow \underset{\substack{\text{Pot. ferricferrocyanide} \\ \text{or Tumbull's blue}}}{K\{Fe[Fe(CN)_6]\}}$$

Ferric ions react with potassium thiocyanate to give blood red colouration due to the formation of ferric thiocyanate

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

250. (a) Electric protection : In this *Mg* acts as anode while iron pipe as cathode. *Mg* looses electrons prior to iron.

251. (b) Pyrite (FeS_2) known as fool's gold

252. (a) Stainless steel contains mainly Iron, Carbon, Nickel alongwith Chromium and Manganese.

253. (d) Firstly, carbon which is added along which crushed haematite ore is oxidised to CO (and CO_2) and second the produced CO acts as chief reducing agent for the reduction of haematite to steel.

255. (a) By white tin platting iron can be protect by water.

256. (d) $2Fe + 3CO \xrightarrow{\text{Heat}} \underset{\text{(cast iron)}}{Fe_2O_3} + 3C$

257. (b) Magnetite is reduced by carbon.

258. (d) Malachite $(Cu(OH)_2.CuCO_3)$ Basic copper carbonate

259. (b) + 2 is most important oxidation state

$Cu^{+1} + e^{-} \rightarrow Cu$; $E^0 = +0.52\ V$

$Cu^{+2} + 2e^{-} \rightarrow Cu$; $E^0 = +0.34\ V$

260. (d) $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

262. (a)

Metal	Chloride in + 1	+ 2 oxidation states
Cu	*CuCl*	Cu_2Cl_2
Ag	*AgCl*	–
Na	*NaCl*	–

265. (d) $Cu + HCl \rightarrow$ no reaction

Copper is less reactive than hydrogen. Therefore it is unable to displace hydrogen from acid.

$E^0_{Cu} = +0.34$ and $E^0_H = 0.00$

266. (a) Gun metal contains *Cu* (88%), *Zn* (2%), Sn(10%), *Pb* (0.5%)

267. (b) Solder – *Sn* 67% and *Pb* 33%.

268. (c) Brass contains $Cu = 80\%$, $Zn = 20\%$

German silver contains $Cu = 60\%$, $Zn = 20\%$, $Ni = 20\%$

269. (b) German silver contain $Cu = 60, Zn = 20,$ $Ni = 20\%$

270. (b) *Cu* = 88%, *Sn* = 10%, *Zn* = 2%, *Pb* = 0.5% → Gun Metal

274. (b) $4Cu + 2H_2O \rightarrow 2Cu_2O + 2H_2$

276. (b) $2Cu + 2H_2SO_4 + O_2 \rightarrow 2CuSO_4 + 2H_2O$

277. (b) Cuprous ion (Cu^{+}) $3d^{10}$ Completely filled *d* sub shell $3d^{10}$

↑↓	↑↓	↑↓	↑↓	↑↓

Cupric ion Cu^{+2} $3d^9$

↑↓	↑↓	↑↓	↑↓	↑

One unpaired electron

278. (b) $CuSO_4 + K_4[Fe(CN)_6] \rightarrow$ no reaction

$$4NH_4OH + CuSO_4 \rightarrow \underset{\text{Deep blue}}{[Cu(NH_3)_4]SO_4} + 4H_2O$$

$$\underset{\text{Anhydrous}}{CuSO_4} + 5H_2O \rightarrow \underset{\text{Blue}}{CuSO_4.5H_2O}$$

$$4FeCl_3 + 3Na_4[Fe(CN)_6] \rightarrow \underset{\substack{\text{Ferric ferrocyanide} \\ \text{(Prussian blue)}}}{Fe_4[Fe(CN)_6]} + 12NaCl$$

280. (d) $CuSO_4 + 2KCN \rightarrow Cu(CN)_2 + K_2SO_4$

$2Cu(CN)_2 \rightarrow Cu_2(CN)_2 + (CN)_2$

$Cu_2(CN)_2 + 6KCN \rightarrow 2K_3[Cu(CN)_4]$

281. (a) $CuSO_4 + 4NH_4OH \rightarrow \underset{\text{Blue}}{[Cu(NH_3)_4]SO_4} + 4H_2O$

282. (c) $Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$

284. (a) $2Cu + CO_2 + H_2O + O_2 \rightarrow \underset{\text{Basic copper carbonate}}{CuCO_3.Cu(OH)_2}$

285. (a) $2CuSO_4 + K_4(Fe(CN)_6] \rightarrow Cu_2[Fe(CN)_6] + 2K_2SO_4$

287. (d) $CuSO_4 + Hg \rightarrow$ No reaction

Hg is less reactive than *Cu* it comes below *Cu* in the reactivity series

288. (c) $Cu + H_2O \rightarrow$ No reaction

$E^0_{Li^+/Li} = -3.04\ V$ $\quad E^0_{H^+/H_2} = 0.00\ V$

$E^0_{Ca^+/Ca} = -2.87\ V$ $\quad E^0_{Cu^+/Cu} = +0.34\ V$

Cu comes below H in the electrochemical series. Hence, unable to displace hydrogen from water.

289. (d) $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

291. (c) $Cu + O_2 + CO_2 + H_2O \rightarrow Cu(OH)_2.CuCO_3$

292. (d) Orford process → During electrolytic refining of Ni from orford bottoms the Pt metal together with gold and silver collect as anode mud in concentrated form which is later processed to separate the metals.

294. (b) $AgBr$ is used in photography because it is light sensitive.

296. (b) $4AgCl + 2Na_2CO_3 \rightarrow 4Ag + 4NaCl + 2CO_2 + O_2$

297. (d) $2AgNO_3 + K_2CrO_4 \rightarrow \underset{\text{(Red)}}{Ag_2CrO_4} + 2KNO_3$

298. (c) $3Ag + \underset{\text{dilute}}{4HNO_3} \xrightarrow{\text{heat}} 3AgNO_3 + NO + 2H_2O$

299. (d) $AgCl + 2NH_3 \rightarrow [Ag(NH_3)_2]Cl$ (soluble complex)

301. (b) $AgBr$ is most sensitive to light and undergoes photochemical reduction

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

302. (a) $NaNO_3$ is purely ionic while $AgCl$ is covalent other compounds reacts with $AgCl$

$$2AgCl + Na_2CO_3 \rightarrow 2Ag + 2NaCl + CO_2 + \frac{1}{2}O_2$$

$$AgCl + 2Na_2CO_3 \rightarrow Na_2[Ag(S_2O_3)_2] + NaCl$$

$$AgCl + 2NH_4OH \rightarrow [Ag(NH_3)_2Cl] + 2H_2O$$

304. (a) A very dilute solution is used in causterisation of eyes and dental antiseptic

305. (a) $2AgNO_3 \rightarrow 2Ag + 2NO_2 + O_2$

306. (a) $2AgNO_3 \xrightarrow{PH_3} 2Ag + 2NO_2 + O_2$

307. (b) $2Ag + 2H_2SO_4 \rightarrow Ag_2SO_4 + SO_2 + 2H_2O$

308. (c) Ag salts on strong heating from Ag

309. (a) Silver metal is extracted from the argentite ore (Ag_2S) by the cyanide process, in which ore is treated with sodium cyanide sold. Dicyanoargentate(I) $[2Na\{Ag(CN)_2\}]$ is formed.

310. (b) When a strip of copper is dipped in the solution of silver nitrate, the solution becomes blue. Cu is placed above Ag in electrochemical series.

$$2AgNO_3 + Cu \rightarrow Cu(NO_3)_2 + 2Ag$$

311. (d) $ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

312. (d) $Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$

$$2Al + 2NaOH \rightarrow 2NaAlO_2$$

314. (d) The white solid dissolves to form a blue solution.

$$CuSO_4 + \text{dil.}H_2SO_4 \rightarrow \underset{\text{blue vitriol}}{CuSO_4.5H_2O}$$

317.

(c) $ZnSO_4 + 2NaHCO_3 \rightarrow ZnCO_3 + Na_2SO_4 + H_2O + CO_2$

318. (b) $Zn + 2NaOH \xrightarrow{\text{heat}} Na_2ZnO_2 + H_2$

319. (d) $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$

$$ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$$

320. (c) Very dil HNO_3 :→ Ammonium nitrate is formed

$$4Zn + 10HNO_3 \rightarrow 4Zn(NO_3)_2 + NH_4NO_3 + 3H_2O$$

321. (d) $Zn_{30} \rightarrow 3d^{10}$, $4S^2$

$$Zn^{+2} \rightarrow 3d^{10}$$

$$\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}$$

No unpaired electrons

323. (d) Sodium tetraborate decahydrate $(Na_2B_4O_7.10H_2O)$

324. (a) Zn does not react with cold water. However it reacts with hot water and yield H_2

$$Zn + H_2O \xrightarrow{\text{Boil}} ZnO + H_2$$

$$Zn + H_2SO_4\text{(dil)} \rightarrow ZnSO_4 + H_2$$

$$Zn + 2HCl\text{(dil)} \rightarrow ZnCl_2 + H_2$$

$$Zn + \underset{20\%}{2NaOH} \xrightarrow{\text{heat}} Na_2ZnO_2 + H_2$$

325. (b) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

$$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$$

327. (a) The compound $ZnFe_2O_4$ is a normal spinel compound.

328. (a) $ZnO + BaO \xrightarrow{1100^oC} BaZnO_2$

329. (b) $4Zn + 10HNO_3 \rightarrow 4Z(NO_3)_2 + NH_4NO_3 + 3H_2O$

330. (d) Lead is used for making radiation shield.

331. (b) $Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$

$$2Na[Ag(CN)_2] + Zn \rightarrow Na_2[Zn(CN)_4] + 2Ag$$

333. (d) In Mc Arthur Forest method, Silver is extarcted from solution of sodium argenticyanide by using Zn

$$2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(Cn)_4] + 2Ag\downarrow$$

338. (d) $Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$

$$2Na[Ag(CN)_2] + Zn \rightarrow Na_2[Zn(CN)_4] + 2Ag$$

342. (c) Self reduction

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$$

$$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$$

345. (c) $\underset{\text{Impurity}}{FeO} + \underset{\text{Flux}}{SiO_2} \rightarrow \underset{\text{Slag}}{FeSiO_3}$

346. (c) Parke's process is used to extract silver from argentiferrous lead.

347. (c) $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2 \uparrow$

348. (d) Copper metallurgy involves bessemerisation. In bessemerisation converter, the impurities of Ferric Oxide forms slag with Silica and Copper Oxide gets reduced to give blister copper.

$$FeO + SiO_2 \longrightarrow \underset{\text{Slag}}{FeSiO_3}$$

$$Cu_2S + Cu_2O \longrightarrow 6Cu \downarrow + SO_2 \uparrow$$

349. (c) Bessemer converter is used to purify Pig Iron by passing compressed air over pig iron in Bessemer converter to produce slag.

$$2Mn + O_2 \longrightarrow 2MnO \;;\; Si + O_2 \longrightarrow SiO_2$$

$$2C + O_2 \longrightarrow 2CO \;;\quad MnO + SiO_2 \longrightarrow \underset{\text{Slag}}{MnSiO_3}$$

353. (d) 1% Impure copper

358. (c) None of the above. Since, gold is a noble metal and common acids do not attack on it if used singly.

359. (a) Due to reduction of copper

$$Zn + CuSO_4 \rightarrow Cu + ZnSO_4$$

360. (a) Reduction of Cu^{++}.

$$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$$

Critical Thinking Questions

1. (c) Transition metal which have low oxidation number show the oxidising nature because of great tendency to lose the electron.

2. (b) Cr^{+2} and Fe^{+2}

$Cr^{+2} - 3d^4$ 4 unpaired electrons

$Fe^{+2} - 3d^6$ 4 unpaired electrons

3. (d) The solubility order is :

$$AgF > AgCl > AgBr > AgI > Ag_2S .$$

4. (d) No of unpaired electron in different ion are as under

$$Mg^{2+} \rightarrow 1s^2, 2s^2 2p^6, 3s^0 = 0$$

$$Ti^{3+} \rightarrow 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^1, 4s^0 = 1$$

$$V^{3+} \rightarrow 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^2, 4s^0 = 2$$

$$Fe^{2+} \rightarrow 1s^2, 2s^2 sp^6, 3s^2 3p^6 3d^6, 4s^0 = 4$$

5. (a) The magnitude of stability constants for some divalent metal ions of the first transition series with oxygen or nitrogen donar ligands increases in the order.

$$Mn^{2+} < Fe^{2+} < Co^{2+} < Ni^{2+} < Cu^{2+} < Zn^{2+}$$

6. (c) Strong oxidising agents such as PbO_2 or sodium bismulthate $(NaBiO_3)$ oxidise Mn^{2+} to MnO_4^- or Mn^{7+}.

7. (c) Given $n = 4$ $x = 5$

So $\underset{3s^2}{(4-1)s^2}\,\underset{3p^6}{(4-1)p^6}\,\underset{3d^5}{(4-1)d^5}\,\underset{4s^2}{4s^2}$

Total electron = 2 + 6 + 5 + 2 = 15

Electron in 1 + 2 orbit = 2 + 8 = 10

Total electron = 10 + 15 = 25

No. of electron = No. of proton

So total proton = 25

8. (b) Iron decomposes steam into hydrogen when it is passed over red hot iron

$$2Fe + 3H_2O \rightarrow Fe_2O_3 + 3H_2 \uparrow$$

9. (d) $CoCl_3 - Co^{+3} - 3d^6 4s^0$

4 unpaired electrons. So it will be coloured.

10. (a) Due to Lanthanoid contraction order will be $Yb^{+3} < Pm^{3+} < Ce^{+3} < La^{3+}$

11. (d) In this reaction

$$\underset{1}{MnO_4^-} + \underset{5}{5Fe^{2+}} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

5 time quantity of Fe^{2+} consumed.

So 5 time of $FeSO_4$ will be equivalent to 50 *ml*

12. (abc) Due to less capacity of hydrogen bonding of I_2 with water HgI_2 is less soluble in water.

13. (c) $\dfrac{\text{Transition element} + \text{Inner tran sition element}}{\text{Total element}} \times 100$

$$\frac{33+28}{105} \times 100 = 58.09 \approx 60\%$$

14. (a) All metal carbonyls are diamagnetic cyanide complexes are also diamagnetic.

15. (c) 22 carat gold is alloy of copper and gold.

16. (b) Fe^{3+} have highest no. of unpaired electron so it will be more paramagnetic.

17. (d) *p*-electrons in Cl^- (atomic no. of $Cl = 17$)

$$Cl^- \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6$$

$$Fe^{2+} \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$$

In Fe^{+2} total number of $de^- = 6$ which is not equal to pe^- in $Cl^- = 12$.

18. (a) Basic character of oxide decreases from left to right in a period of periodic table.

19. (b) $CuSO_4.5H_2O$ because it has only one unpaired electrons.

20. (c) The existence of Fe^{2+} and NO^+ in Ntroprusside ion $[Fe(CN)_5 NO]^{2-}$ can be established by measuring the magnetic moment of the solid compound which should correspond to $(Fe^{2+} = 3d^6)$ four unpaired electrons.

21. (c) $V^{+4} \rightarrow 3d^1 4s^0$

1 unpaired electrons. Hence, it is paramagnetic and coloured compound.

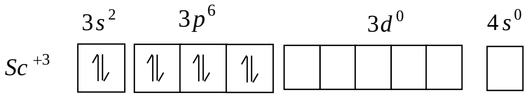
22. (a) $\underset{3M}{3MnO_4^-} + 5(\underset{5M}{Fe^{2+}} + C_2O_4^{2-}) + 24H^+ \rightarrow$

$$3Mn^2 + 5Fe^{3+} + 10CO_2 + 12H_2O$$

Thus 5M of FeC_2O_4 is oxidised by 3M of $KMnO_4$ then 1M of FeC_2O_4 is oxidised by 3/5 mole of $KMnO_4$.

23. (b) $2MnO_4^- + 16H^+ + C_2O_4^{--} \rightarrow 2Mn^{+2} + 2CO_2 + 8H_2O$

24. (b) $ScCl_3 \rightarrow Sc^{+3} + 3Cl^-$



No unpaired electron so will show diamagnetic character and will be repelled, so will weigh less.

25. (a) $(Ar)\, 3s^1 + 3 = Ti$, it means M^{3+} form Ti^{3+} ion.

26. (b) $V = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$

$Cr = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$

$Mn = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$

$Fe = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

In second ionization enthalpy Cr^+ has exact half filled d-sub shell.

Assertion and Reason

2. (b) Zn^{2+} is dimagnetic because it has no unpaired electrons

3. (c) The assertion is correct but the reason is false. Actually transition metal show variable valency due to very small difference between the ns^2 and $(n-1)d$ electrons, Therefore, assertion is correct but reason is false.

4. (e) The aqueous solution of $FeCl_3$ is acidic in nature because $FeCl_3$ hydrolyse in water to produce acid ion.

$FeCl_3 + 3H_2O \rightarrow Fe(OH)_3 + 3HCl$

Therefore, assertion is false but reason is true.

5. (a) $AgCl$ on adding to a solution of NH_4OH solution dissolves to form a complex diamine silver chloride.

$AgCl + 2NH_4OH \rightarrow Ag(NH_2)_2 Cl + 2H_2O$

Therefore, both assertion and reason are true and reason is a correct explanation of assertion.

6. (c) Pure iron is not used for making tools and machines as it is soft. Therefore, cannot be used for this purpose. Assertion is true but reason is false.

7. (a) A solution of Na_2CrO_4 in water is intensely coloured due to oxidation state of chromium in Na_2CrO_4 is +6. Here both assertion and reason are correct.

8. (d) Copper corrods at negligible rates in unpolluted air, water and deaerated non-oxidizing acids. Pure copper and the high copper alloys can be considered to exhibit similar resistance to most corrosive environments. They posses excellent resistance to atmospheric environments. Corrosion is a spontaneous process for which free energy change must be negative.

9. (c) ${}_{24}Cr \rightarrow [Ar]\, 3d^4\, 4s^2$

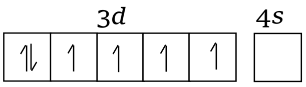
$Cr \rightarrow [Ar]\, 3d^5\, 4s^1$

Full-filled s-orbital has greater stability.

10. (a) Fe has atomic no. 26.

So its electronic configuration is $[Ar]\, 3d^6\, 4s^2$.

Fe^{2+} has electronic configuration $[Ar]\, 3d^6$.



It has four unpaired electrons and it is paramagnetic.

11. (b) Due to larger surface area and variable valencies to form intermediate absorbed complex easily, transition metals are used as good catalysts.

12. (c) Rusting involves reduction of absorbed oxygen to OH^- ions and oxidation of iron to Fe^{2+} ions. The two ions combine to yield $Fe(OH)_2$ which gets oxidized to give $Fe_2O_3.nH_2O$ (rust). The presence of acid helps dissolution of pure iron to ferrous ions while electrolytes increase the conductivity and assist the cell action.

13. (b) *AgBr* is the most sensitive silver halide to photo reduction. Hence it is used as the light sensitive material in photographic films. The unchanged *AgBr* is dissolved in hypo solution to cast an image on photographic plate.

$$2AgBr \xrightarrow{h\nu} 2Ag + Br_2$$

14. (a) Tungsten is a metal of high melting point and its filament gives brilliant light on passing electric current.

17. (b) The magnetic moments are lesser than the fact that 5*f* electrons of actinides are less effectively shielded which results in quenching of orbital contribution.

18. (b) The higher the charge on the metal ion, smaller is the ionic size and more is the complex forming decreases in the order $M^{4+} > MO_2^{2+} > M^{3+} > MO_2^{+}$. The higher tendency of complex formation of MO_2^{2+} of charge on metal atom *M* in MO_2^{2+}

20. (d) Extraction of iron metal from iron oxide ore is carried out by heating with coke and flux (calcium carbonate). Flux is a slag forming substance. It converts infusible impurities into fusible slag.

The reaction : $Fe_2O_{3\,(s)} \rightarrow Fe_{(s)} + 3/2\ O_{2\,(g)}$ is not a spontaneous process. Fe_2O_3 is converted to *FeO* at about 400°*C*. *FeO* is converted to *Fe* at about 800°*C* – 1000°*C*.

d and f-Block Elements

SET Self Evaluation Test -19

1. The equivalent weight of $MnSO_4$ is half of its molecular weight when it is converted to

(a) Mn_2O_3 (b) MnO_2

(c) MnO_4^- (d) MnO_4^{2-}

2. In which compound chromium has +6 oxidation state **[CPMT 2003]**

(a) $K_2Cr_2O_7$ (b) $CrCl_3$

(c) $Cr(SO_4)_3$ (d) None of these

3. Which of the following metal does not show variable valency **[RPET 2000]**

(a) Fe (b) Hg

(c) Zn (d) Cu

4. Which of the following metals will not react with solution of $CuSO_4$ **[CPMT 1974, 80; MH CET 2004]**

(a) Fe (b) Zn

(c) Mg (d) Ag

5. Which metal among following has strongest tendency to undergo oxidation **[CPMT 1989]**

(a) Zn (b) Cu

(c) Mg (d) Al

6. Which of the following has highest paramagnetic character

(a) Mn (II) (b) Fe (II)

(c) Co (II) (d) Ni (II)

7. Ammonia is a Lewis base. It forms complexes with cations. Which one of the following cations does not form complex with ammonia

(a) Ag^+ (b) Cu^{++}

(c) Cd^{++} (d) Pb^{++}

8. Which of the following is expected to form colourless complex **[AMU 2000]**

(a) Ni^{2+} (b) Cu^+

(c) Ti^{3+} (d) Fe^{3+}

9. Which of the following is ferromagnetic

(a) Cr (b) Mn

(c) W (d) Co

10. The most stable oxidation state of Mn is

(a) +2 (b) +4

(c) +5 (d) +7

11. The number of unpaired electrons in Mn^{+3} is

(a) 4 (b) 3

(c) 2 (d) Zero

12. The correct order of ionic radii of Y^{3-}, La^{3+}, Eu^{3+} and Lu^{3+} is **[CBSE PMT 2003]**

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

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

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

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

(Atomic No. Y = 39, La = 57, Eu = 63, Lu = 71)

13. One mole of potassium dichromate completely oxidises the following number of moles of ferrous sulphate in acidic medium **[MP PET 1997]**

(a) 1 (b) 3

(c) 5 (d) 6

14. The atomic radii from Cr to Cu is almost identical because of

(a) Increasing nuclear charge from Cr to Cu

(b) Repulsion among increased electrons

(c) Increased screening effect to nullify increased nuclear charge

(d) All the above

15. Oxidation number of Mn in K_2MnO_4 and in $KMnO_4$ are respectively **[MP PET 1991, 2001]**

(a) + 6 and + 7 (b) + 6 and + 6

(c) + 7 and + 7 (d) + 7 and + 6

16. When phosphine is passed through aqueous solution of copper sulphate, the product produced is

(a) $Cu(OH)_2$ (b) Cu_3P_2

(c) $[Cu(PH_3)_4]^{2+}$ (d) $[Cu(PH_3)_2]^{2+}$

17. Hydroxide soluble in ammonia is **[NCERT 1973, 77; MNR 1984; KCET 1992]**

(a) $Al(OH)_3$ (b) $Fe(OH)_3$

(c) $Cr(OH)_3$ (d) $Cu(OH)_2$

18. Which of the following pair of transitional elements exhibit highest and lowest density

(a) Os and Sc (b) Os and Pt

(c) Hg and Sc (d) Os and Ir

19. When an acidified solution of ferrous ammonium sulphate it treated with potassium permanganate solution, the ion which is oxidised is **[BHU 1979]**

(a) MnO_4 (b) NH_4^+

(c) Fe^{++} (d) SO_4^{2-}

Answers and Solutions

(SET -19)

1. (b) $MnSO_4 \xrightarrow{-2e^-} MnO_2$

Equivalent wt. $= \dfrac{\text{molecular wt.}}{\text{total no. of } e^- \text{ gained or lost}} = \dfrac{M}{2}$

2. (a) In $K_2Cr_2O_7$, Cr has + 6 oxidation state.

3. (c) Zn shows only + 2 valency.

4. (d) Because Ag comes below in the electromotive series also standard electrode potential of Cu and Ag are:

$Cu^{2+}(aq) + 2e^- \to Cu(s); [SEP - E^o_{298}(\text{volt}) = +0.18]$

$Ag^+(aq) + e^- \to Ag(s); [SEP - E^o_{298}(\text{volt}) = +0.80]$

5. (c) Mg ; because of its high hydration energy.

6. (a) $Mn^{+2} - 3d^5$

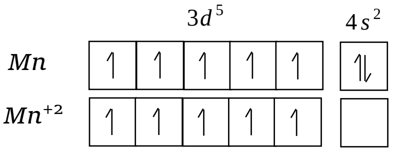
5 unpaired element in d-subshell so it has highest paramagnetic.

7. (d) Pb^{++} because it does not have vacant d-orbitals nor high nuclear charge and it does not belong to transition series.

8. (b) In Cu^{+1} (cuprous ion) d orbitals are completely filled so it will form colourless complex.

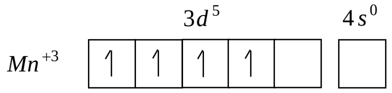
9. (d) The substances which are strongly attracted by magnetic field and show permanent magnetism even in absence of magnetic field are ferromagnetic *e.g.*. Co, Fe, Ni

10. (a)



As half filled orbitals are more stable than partial filled ones. Therefore, + 2 is most stable oxidation state.

11. (a)



12. (c) Lanthanide contraction results in small size of Lu^{3+}, so

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

13. (d) Oxidation number of chromium in potassium dichromate is +6 so it oxidise 6 moles of ferrous sulphate in acidic medium.

14. (c) Increased screening effect to nullify increased nuclear charge.

15. (a) O.N. of K_2MnO_4

$2 + x - 8 = 0$

$x = 6$

O.N. of $KMnO_4$

$1 + x - 8 = 0$

$x = 7$

16. (b) $3CuSO_4 + 2PH_3 \to Cu_3P_2 + 3H_2SO_4$

17. (d) Due to formation of complex

$Cu(OH)_2 + 4NH_3 \to [Cu(NH_3)_4](OH)_2$

18. (a) Os and Sc

$Os = 22.60\ gm/cm^3$

$Sc = 3.01 gm/cm^3$

19. (c) $Fe^{2+} \xrightarrow{\text{oxidises}} Fe^{3+}$

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