

# *d- and f-Block Elements*

## *(Some Important Problem of NCERT)*

**Q. 1** Write down the electronic configuration of:

(a)  $\text{Cr}^{3+}$       (b)  $\text{Cu}^+$       (c)  $\text{Co}^{2+}$       (d)  $\text{Mn}^{2+}$

(e)  $\text{Pm}^{3+}$       (f)  $\text{Ce}^{+4}$       (g)  $\text{Lu}^{2+}$       (h)  $\text{Th}^{4+}$

**Ans.** (a)  ${}_{24}\text{Cr}^{3+}$ ;  $[\text{Ar}] 3d^3$       or       $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$   
 (b)  ${}_{29}\text{Cu}^+$ ;  $[\text{Ar}] 3d^{10}$       or       $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$   
 (c)  ${}_{27}\text{Co}^{2+}$ ;  $[\text{Ar}] 3d^7$       or       $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$   
 (d)  ${}_{25}\text{Mn}^{2+}$ ;  $[\text{Ar}] 3d^5$       or       $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$   
 (e)  ${}_{61}\text{Pm}^{3+}$ ;  $[\text{Xe}] 4f^4$       or       $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 4f^4$   
 (f)  ${}_{58}\text{Ce}^{+4}$ ;  $[\text{Xe}]$       or       $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6$   
 (g)  ${}_{71}\text{Lu}^{2+}$ ;  $[\text{Xe}] 4f^{14} 5d^1$       or       $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 4f^{14} 5d^1$   
 (h)  ${}_{90}\text{Th}^{4+}$ ;  $[\text{Rn}]$       or       $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^6 4d^{10} 4f^{14} 5s^2 5p^6 5d^{10} 6s^2 6p^6$

**Q. 2** Why are  $\text{Mn}^{2+}$  compounds more stable than  $\text{Fe}^{2+}$  towards oxidation to their + 3 state?

**Ans.** The electron configuration of  $\text{Mn}^{2+}$  in  $[\text{Ar}] 3d^5$  and in it 3d – orbitals are half – filled (each d – orbital has one electron) which is a stable configuration as compared to that of  $\text{Fe}^{2+}$  i.e.  $[\text{Ar}] 3d^6$ . Due to this  $\text{Fe}^{2+}$  has a tendency to lose an electron to form  $\text{Fe}^{3+}$  having a more stable configuration  $[\text{Ar}] 3d^5$  (stable due to half filled orbitals).

**Q. 3** Explain briefly how +2 state becomes more and more stable in the first half of the first row transition elements with increasing atomic number?

**Ans.** The first row of transition elements include elements from Sc ( $z = 21$ ) to Zn ( $Z = 30$ ). In its first half i.e. from Sc ( $z = 21$ ) to Mn ( $z = 25$ ), the stability of + 2 oxidation increases from Sc to Mn because of increase in effective nuclear charge.

**Q. 4** To what extent do the electronic configurations decide the stability of oxidation states in the first series of the transition elements? Illustrate your answer with example.

**Ans.** To a large extent, the electronic configurations decide the stability of oxidation state in the first series of transition elements.

Elements with larger number of oxidation states are found in or near the middle of the series e.g. Mn ( $Z = 25$ ) exhibits all the states from + 2 to + 7. The elements with lesser number of oxidation states are present at the extreme ends stems and they have a few electrons to lose or share e.g. Sc ( $3d^14s^2$ ), Ti ( $3d^2s^2$ ) or too many electrons hence fewer orbitals are available e.g. Cu ( $3d^{10}4s^1$ ) Zn ( $3d^{10}4s^2$ ) etc.

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

**Ans.**  $3d^5$  would be most stable because in this state the 3d – orbitals are half – filled (each d – orbitals has one electron)

Ground state configuration	Element	Stable oxidation state
$3d^34s^2$	V	+5, $V^{+5}$ more stable than $V^{3+}$
$3d^54s^1$	Cr	+3, $Cr^{3+} > Cr^{2+}$
$3d^54s^2$	Mn	+2, $Mn^{2+} > Mn^{3+}$
$3d^84s^2$	Ni	+2, $Ni^{+2}$

**Q. 6** Name the oxometal anions of the first series of the transition metals in which the metal exhibits the oxidation state equal to its group number.

**Ans.**  $MnO_4^-$  , permanganate.

In it the oxidation state of Mn is +7 which is equal to group number of Mn (i.e. group, 7) or  $CrO_4^{2-}$  , In it the oxidation state of Cr is + 6 which is equal to group number of Cr (i.e. group 6).

**Q. 7** What is lanthanoid contraction? What are the consequences of lanthanoid contraction?

**Ans.** **Lanthanoid contraction.** On moving from lanthanum (La) to Lutetium (Lu), a gradual decrease in size of lanthanoids is observed with increase in atomic number. This is known as lanthanoid contraction.

#### Consequences

(i) The properties of 4d – and 5d – elements closely resemble because of lanthanoid contraction.

(ii) There is only a little variation in chemical properties among lanthanoids.

**Q. 8** What are the characteristics of the transition elements and why are they called transition elements? Which of the  $d$  – block elements may not be regarded as the transition elements?

**Ans. Characteristic of Transition Elements**

(i) They belong to  $d$  – block of the periodic table.

(ii) They show variable oxidation states.

(iii) They are coloured.

(iv) They are generally paramagnetic in nature.

(v) They have a tendency to form complexes.

They are called transition elements because their properties lie in between those of  $s$  – block elements (metals) and  $p$  – block elements (non – metals). They are more electropositive than  $s$  – block elements but less electropositive than  $p$  – block elements. The elements Zn, Cd and Hg are not regarded as transition elements because neither the atoms of these elements nor their ions ( $\text{Cd}^{2+}$ ,  $\text{Zn}^{2+}$  or  $\text{Hg}^{2+}$ ) have partially filled  $d$  – orbitals.

**Q. 9** In what way is the electronic configuration of the transition elements different from that of the non – transition elements?

**Ans.** In case of transition elements the incoming electron enters  $(n - 1)$   $d$  – orbitals whereas in case of non – transition elements (i.e.  $s$  – block and  $p$  – block elements) the incoming electron enters the  $ns$  – or  $np$  – orbitals.

In case of transition elements the last two shells are incomplete whereas in case of non – transition elements only the last shell is incomplete and is being progressively filled up.

**Q. 10** What are the different oxidation states exhibited by the lanthanoids?

**Ans.** Various oxidation states shown by lanthanoids are +2, +3 and +4. The +3 state is common to all the lanthanoids.

**Q. 11** Explain giving reason:

(a) Transition metals and many of their compounds show paramagnetic behavior.

(b) The enthalpies of atomization of the transition metals are high.

(c) The transition metals generally form coloured compounds.

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

**Ans.** (a) The paramagnetic behaviour is due to presence of unpaired electron in the atom or ion of transition metals.

(b) The high enthalpies of atomization of transition metals can be attributed to strong metallic bond and additional covalent bond because of the presence of unpaired d – electrons in such metals.

(c) The colour of transition metal compounds is due to d – d transition in them. The unpaired electron present in them undergo d – d transition by absorbing light from the u.v. region and thereby radiate complementary colour.

(d) The transition metals and their compounds act as good catalysts because they can show variable oxidation states.

**Q.12** What are interstitial compound? Why are such compounds well known for transition metals?

**Ans.** Crystal lattices of transition metals have interstitial voids in between the adjacent atoms, consequently, the small sized atoms like H, B, C, N etc. can be taken up by these voids to form so called interstitial compounds.

The chemical properties of interstitial compounds are quite similar to those of parent metal, however in physical properties such as hardness, rigidity and electrical conductance these compounds differ from parent metal.

There is a decrease in malleability and ductility but an increase in tenacity. e.g. steel and cast iron are harder than pure iron. It is due to formation of interstitials of iron with carbon in case of steel and cast iron.

**Q.13** How is the variability in oxidation states of transition metals different from that of the non – transition metals? Illustrate with examples.

**Ans.** In transition metals the oxidation states differ by 1 (e.g. Fe<sup>2+</sup> and Fe<sup>3+</sup>, Cr<sup>2+</sup> and Cr<sup>3+</sup> etc.) whereas in non – transition elements they differ by two (e.g. Tl<sup>+</sup> and Tl<sup>3+</sup>, Sn<sup>2+</sup> and Sn<sup>4+</sup> etc.).

The variable oxidation states of transition metals are due to availability of both (n – 1) d and ns orbitals which have nearly same energy where as the variable oxidation state in non – transition metals are due to the availability of ns<sup>2</sup>np<sup>1-6</sup> electrons for bond formation.

**Q.14** Describe the preparation of potassium dichromate from iron chromite ore. What is the effect of increasing ph on a solution of potassium dichromate?

**Ans.** It is prepared as under:

(i) **Preparation of sodium chromite.** The chromite ore is heated with molten alkali in presence of air in a reverbatory furnace



(ii) **Conversion of Sodium chromate into sodium dichromate.** Sodium chromate is extracted with water and acidified.



On cooling  $\text{Na}_2\text{SO}_4$  separates out as  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$  and  $\text{Na}_2\text{Cr}_2\text{O}_7$  remains in solution.

(iii) **Conversion of  $\text{Na}_2\text{Cr}_2\text{O}_7$  into  $\text{K}_2\text{Cr}_2\text{O}_7$ .** The solution containing  $\text{Na}_2\text{Cr}_2\text{O}_7$  is treated with KCl

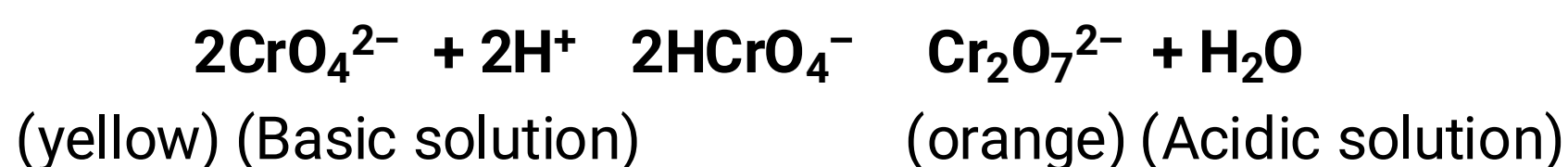


Sodium chloride being less soluble separates out.

### Effect of pH

The chromate ion,  $\text{CrO}_4^{2-}$  and dichromate ion  $\text{Cr}_2\text{O}_7^{2-}$  exist in equilibrium and interconvertible by alternating pH of the solution.

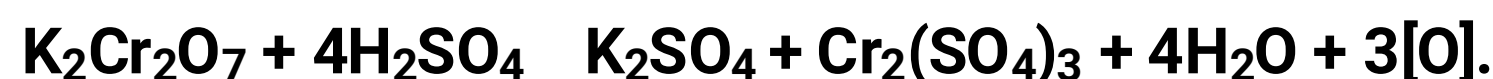
In alkaline solution (*increasing the pH*), the dichromate ions get converted to chromate ions whereas in acidic solution (decreasing the pH), the chromate ions changes to dichromate ions



**Q.15** Describe the oxidizing action of potassium dichromate and write the ionic equations for its reaction with:

(a) Iodide      (b) Iron (II) solution      (c)  $\text{H}_2\text{S}$

**Ans.** Potassium dichromate acts as a strong oxidizing agent in acidic medium.

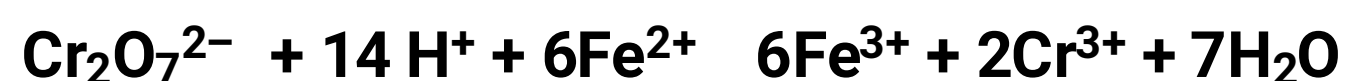


The reactions are

(i)  $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$  ] 3



(ii)  $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$  ] 6



(iii)  $\text{H}_2\text{S} \rightarrow 2\text{H}^+ + \text{S} + 2\text{e}^-$  ] 3



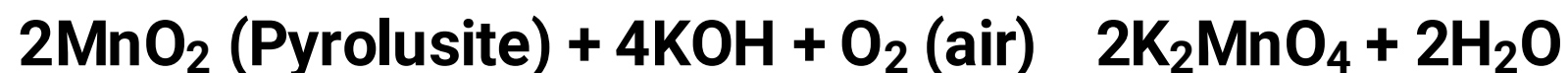
**Q.16** Describe the preparation of potassium permanganate. How does the acidified permanganate solution reaction with

a) iron (II) ions      b)  $\text{SO}_2$       c) oxalic acid?

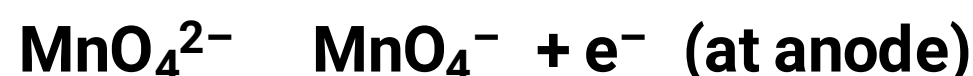
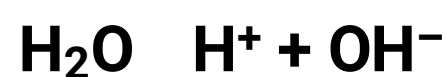
Write the ionic equations for the reactions.

**Ans.**  $\text{KMnO}_4$  is prepared from *Pyrolusite* as follows.

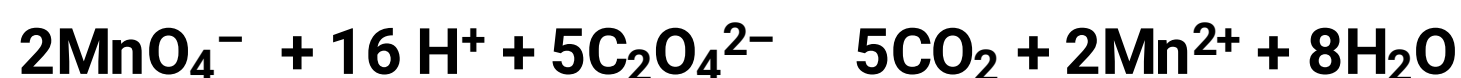
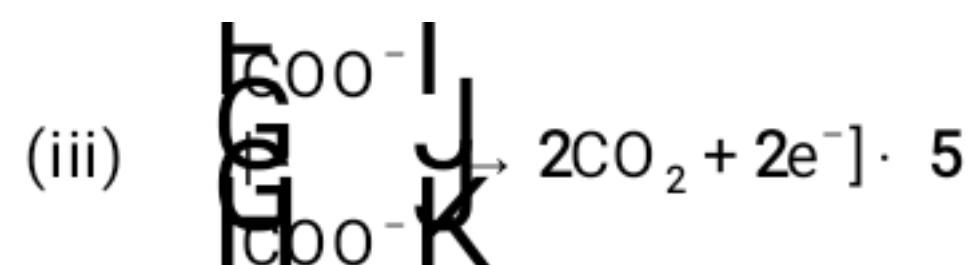
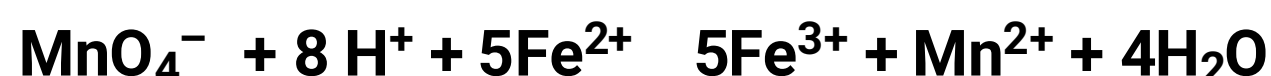
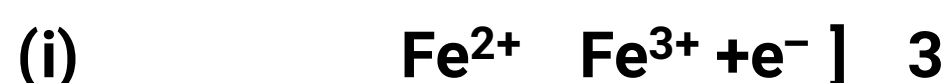
Pyrolusite is fused with potassium hydroxide and the molten liquid is stirred in presence of air when the following reactions occurs and  $K_2MnO_4$  (potassium manganate) is formed:



$K_2MnO_4$  is then electrolysed electrochemically. The  $MnO_4^{2-}$  ions get oxidized to  $MnO_4^-$  ions at anode and hydrogen gas is evolved at cathode



**Reactions of Acidified  $KMnO_4$  (It is a oxidizing agent)**



**Q. 17** For  $M^{2+} / M$  and  $M^{3+} / M^{2+}$  system the  $E^\ominus$  values for some metals are as follows:



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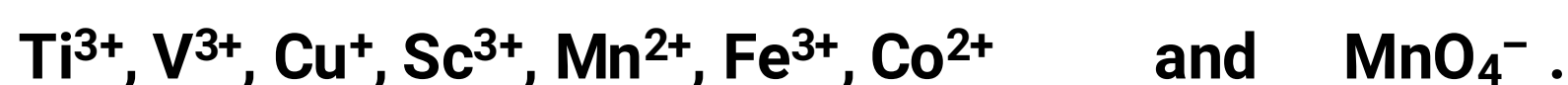
(a) The stability of  $Fe^{3+}$  in acid solution as compared to that of  $Cr^{3+}$  or  $Mn^{3+}$

(b) The ease with which iron can be oxidized as compared to the similar process for either chromium or manganese metal.

**Ans.** (a) In acidic medium the stability of  $Fe^{3+}$  is more than the stability of  $Mn^{3+}$  but less than that of  $Cr^{3+}$ .

(b) Iron can be easily oxidized as compared to Cr and Mn.

**Q.18** Predict which of the following will be coloured in aqueous solution?



Give reason for each.

**Ans.** The coloured ions are  $\text{Ti}^{3+}$ ,  $\text{V}^{3+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Co}^{2+}$  and  $\text{MnO}_4^-$ . Their colour is due to presence of unpaired electrons in them. The unpaired electrons in them can undergo d – d transitions by absorbing light from visible region and the complementary colour is radiated.

**Q. 19** Compare the stability of + 2 oxidation state for the elements of the first transition series.

**Ans.** The stability of +2 oxidation state increases from Sc ( $z = 21$ ) to Mn ( $z = 25$ ) which is attributed to the increase in effective nuclear charge. After that in case of Iron,  $\text{Fe}^{2+}$  is less stable than  $\text{Fe}^{3+}$  as also  $\text{Mn}^{2+}$ ;  $\text{Co}^{2+}$  is less stable than  $\text{Co}^{3+}$  but  $\text{Ni}^{2+}$  is more stable than  $\text{Ni}^{3+}$  and  $\text{Cu}^{2+}$  is more stable than  $\text{Cu}^+$ ,  $\text{Zn}^{2+}$  is most stable because of its stable electronic configuration. Thus we have  $\text{Cu}^{2+} > \text{Ni}^{2+} > \text{Co}^{2+} > \text{Fe}^{2+} > \text{Mn}^{2+} > \text{V}^{2+} > \text{Ti}^{2+} > \text{Sc}^{2+}$ .

**Q. 20** Name chief ore of iron. How is the pig iron converted into steel? Describe any one method of steel making in detail.

**Ans.** Chief ore of iron is *haematite*

Any one of the following processes can be used to convert pig iron into steel.

(i) Bessemer process

(ii) Open – hearth process

(iii) The oxygen top blowing process

(iv) The electric arc process

(v) The high frequency induction process.

**Open – hearth Process**

In this process, a mixture of molten pig iron, scrap steel and lime stone is heated on a shallow hearth furnace by producer gas. The furnace is adapted for different types of pig iron feed by using *acidic* or *basic* lining. The impurities get oxidized by iron oxide and form slag with the lining. e.g.



(impurity) (iron oxide)

Oxides of P and Si + lining (CaO + MgO) Phosphate and silicate (slag).

Towards the end (after 10 hours), an alloy of Mn, Fe and C (Spiegleisen) is added along with alloying metal.

**Q.21** Name the chief ore of copper and zinc. Describe the principle of extraction of these metals from the respective ore.

**Ans. Chief ores**

Copper – Copper pyrites (CuFeS<sub>2</sub>)

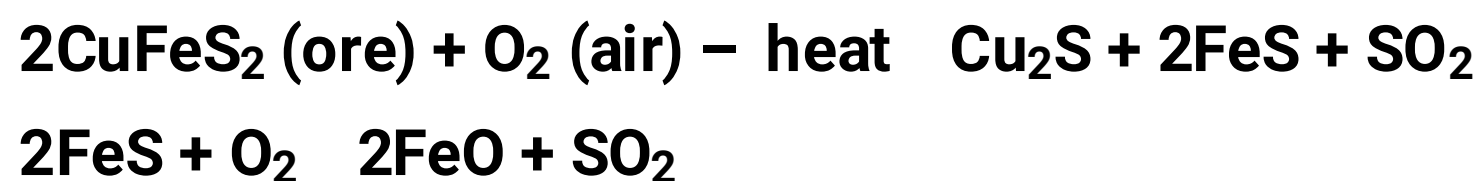
Zinc – Zinc blende (ZnS)

*Principle of extraction of copper from copper pyrites*

The extraction involves the following steps:

**(i) Concentration.** It is concentrated by *froth floatation process*.

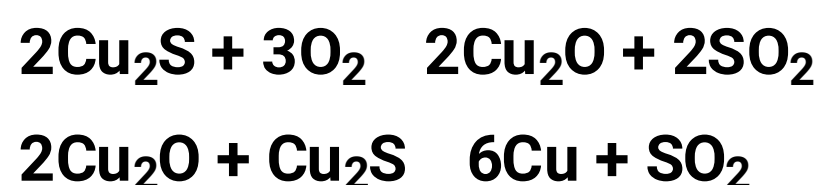
**(ii) Roasting.** The concentrated ore is roasted in a current of air in a reverberatory furnace, below the fusion point, to remove arsenic and sulphur as their volatile oxides.



**(iii)** The temperature is then allowed to rise above the fusion point and silica (SiO<sub>2</sub>) is added as *flux*. Iron (II) oxide (FeO) reacts with silica to form iron silicate (FeSiO<sub>3</sub>) which is removed as slag.



**(iv) Bessemerisation.** The **matte** consists of Cu<sub>2</sub>S and FeS. The matte is charged into silicalined converter through which hot compressed air is passed. The remaining sulphide is converted into FeO which reacts with silica to form slag. Copper (I) sulphide is reduced to copper by Cu<sub>2</sub>O.



The copper thus obtained is known as **blister copper**.

**(v) Electrolytic Refining.** Impure copper is made the anode, pure copper is taken as cathode and acidified CuSO<sub>4</sub> solution is taken as electrolyte. When electrolyzed pure copper gets deposited at cathode and impure copper from anode goes in solution.



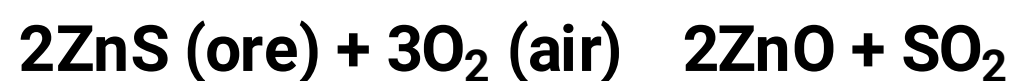
**Extraction of zinc from zinc blende (ZnS)**



It involves the following steps:

(i) **Concentration.** The ore is concentrated by *froth* floatation process.

(ii) **Roasting.** It is heated in presence of air when ZnS changes to ZnO and SO<sub>2</sub> goes out



(iii) **Bessemerization.** During this remaining ZnS converts ZnO to Zn.



(iv) **Electrorefining.** The impure zinc is made anode and pure zinc made cathode. An acidified solution of ZnSO<sub>4</sub> is used as electrolyte when pure zinc gets deposited at cathode and impure zinc from anode gets dissolved.



**Q. 22** Describe the chemistry of the three stages of photography, i.e., exposure, developing and fixing.

**Ans. Exposure.** The film is loaded in a camera and the light from the object is allowed to fall on the film by opening the shutter of the camera for a moment. The image of the object is formed on the film. In this AgBr changes to Ag particles.

**Developing.** It is the process in which exposed photographic film is treated with a reducing agent (generally an alkaline of hydroquinone). This agent is called **developer** (AgBr is reduced to Ag). The rate of reduction depends upon intensity of illumination through the exposure period. Thus parts of film which were most illuminated become darkest.

**Fixing.** Removal of unreduced AgBr from the surface of developed film is called *fixing*. For this the developed film is dipped in a solution of sodium thiosulphate (Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>, *hypo*) in a dark room. AgBr forms a soluble complex



**Q. 23** Compare the chemistry of actinoids with that of the lanthanids with special reference to:

- (a) electronic configuration                      (b) oxidation state  
(c) atomic and ionic sizes and                      (d) chemical reactivity

**Ans. (a) Electronic configuration.** In case of lanthanoids the 4 *f* – orbitals are progressively filled whereas in case of actinoids 5 *f* – orbitals are filled up.

**(b) Oxidation states.** The most common oxidation state shown by lanthanoids is + 3 though some of them also show + 2 and + 4 states. The oxidation states shown by

actinoids are + 3, + 4, + 5, + 6 and + 7.

**(c) Atomic and ionic sizes.** The size is larger in case of actinoids than that of lanthanoids.

**(d) Chemical reactivity.** Actinoids are more reactive than lanthanoids because of their larger size and low I. E.

**Q. 24** How would you account for the following:

**(a)** Of the  $d^4$  species,  $\text{Cr}^{2+}$  is strongly reducing while manganese (III) is strongly oxidizing.

**(b)** Cobalt (III) is stable in aqueous solution but in the presence of complexing reagents it is easily oxidized.

**(c)** The  $d^1$  configuration is very unstable in ions.

**Ans.** **(a)**  $\text{Cr}^{2+}$  is strongly reducing because it changes to  $\text{Cr}^{3+}$  which is more stable but  $\text{Mn}^{3+}$  is strongly oxidizing because it changes to  $\text{Mn}^{2+}$  which is more stable.

**(b)**  $\text{Co}^{2+}$  gets oxidized to  $\text{Co}^{3+}$  in presence of a complexing agent because  $\text{Co}^{3+}$  is more stable than  $\text{Co}^{2+}$ .

**(c)** In ions  $d^1$  configuration is quite unstable because after losing one electron it will become stable. All elements in  $d^1$  configuration are either *reducing agents* or they undergo *disproportionation*.

**Q.25** What is meant by 'disproportionation'? Give two examples of disproportionation reaction in aqueous solution.

**Ans.** **Disproportionation.** It means that the same substance is oxidised as well as reduced. e.g.

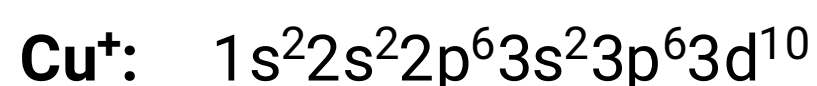
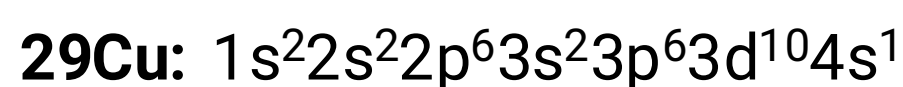
**Examples**



**Q. 26** Which metal in the first series of transition metals exhibits + 1 oxidation state most frequently and why?

**Ans.** **Copper.**

**Reason.** With formation of  $\text{Cu}^+$  from Cu, a stable electronic configuration is attained.



(completely filled d – orbitals)

**Q. 27** Calculate the number of unpaired electrons in following gaseous ions:  $\text{Mn}^{3+}$ ,  $\text{Cr}^{3+}$ ,  $\text{V}^{3+}$  and  $\text{Ti}^{3+}$ . Which one of these is the most stable in aqueous solution?

**Ans,**  ${}_{25}\text{Mn}$ ;  $\text{Mn}^{3+} - [\text{Ar}] 3d^4$  i.e. It has **four** unpaired electrons.

${}_{24}\text{Cr}$ ;  $\text{Cr}^{3+} - [\text{Ar}] 3d^3$  i.e. It has **three** unpaired electrons.

${}_{23}\text{V}$ ;  $\text{V}^{3+} - [\text{Ar}] 3d^2$  i.e. It has **two** unpaired electrons.

${}_{22}\text{Ti}$ ;  $\text{Ti}^{3+} - [\text{Ar}] 3d^1$  i.e. It has **one** unpaired electrons.

of these  $\text{Cr}^{3+}$  is most stable in aqueous solution.

**Q. 28** Give example and suggest reason for the following features of the transition metal chemistry:

(a) The lowest oxide of transition metal is basic, the highest is acidic.

(b) A transition metal exhibits higher oxidation states in oxides and fluorides.

(c) The highest oxidation state is exhibited in oxoanions of a metal.

**Ans.** (a) In lowest oxidation state, ionic bonds are formed. Metals are electropositive and so they form basic oxides.

(b) Since both oxygen and fluorine are strong oxidizing agents so they can provide energy for excitation of electrons.

(c) In oxoanions, the highest oxidation state is exhibited because oxygen is a strong oxidizing agent.

**Q. 29** Indicate the steps in the preparation of:

(a)  $\text{K}_2\text{Cr}_2\text{O}_7$  from chromite ore

(b)  $\text{KMnO}_4$  from pyrolusite ore

(c) Copper sulphate from metallic copper

(d) Calomel from corrosive sublimate.

**Ans.** (a) Refer to Q. 14

(b) Refer to Q. 16.

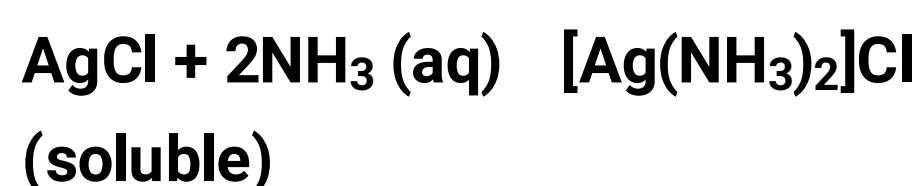
(c)  $\text{Cu} + 2\text{H}_2\text{SO}_4 \xrightarrow{\text{heat}} \text{CuSO}_4 + 2\text{H}_2\text{O} + \text{SO}_2$   
 (copper) (Conc.) (copper sulphate)

(d)  $\text{HgCl}_2 + \text{Hg} \xrightarrow{\text{heat}} \text{Hg}_2\text{Cl}_2$   
 Corrosive sublimate (Mercury) Calomel

**Q. 30** What happens when aqueous ammonia reacts with:

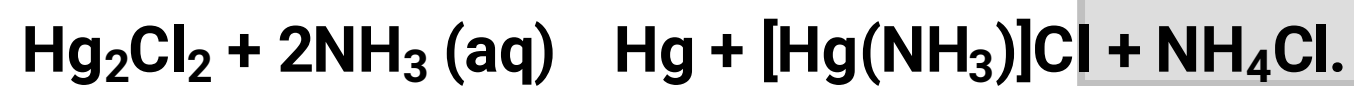
(a) silver chloride (b) mercury (I) chloride (c) mercury (II) chloride?

**Ans.** (a) A soluble complex is formed.



**Diammine silver (I) chloride.**

(b) *Disproportionation occurs*



(c) An infusible white precipitate is formed



white ppt.

**Q. 31** Describe the two uses of each of the following:

(a) Copper sulphate      (b) Silver nitrate      (c) Silver bromide.

**Ans.** (a) **Copper sulphate** is used

(i) in copper plating

(ii) as germicide and fungicide under the trade name *Bordeaux mixture* which is a mixture of  $\text{Cu}_2\text{O}$  and  $\text{Ca}(\text{OH})_2$ .

(iii) as a timber preservative.

(b) **AgNO<sub>3</sub>** is used

(i) in producing light sensitive films

(ii) as a medicine in nervous diseases

(iii) as a laboratory reagent.

(c) **AgBr** is used

(i) in printing out papers (P. O. P.)

(ii) in making X – rays films.

**Q. 32** What are alloys? Name an important alloy which contains some of the lanthanoid metals. Mention its uses.

**Ans.** **Alloys** are homogenous mixture of two or more metals or a metal and non – metal.

**Misch metal** is an alloy. It contains some of the lanthanoid metals (upto 45%), iron (5%) and traces of C, S, Ca and Al.

**Misch metal** is used in tracer bullets and flints for lighters.

**Q. 33** What are inner transition elements? Decide which of the following atomic numbers are the atomic numbers of the inner transition elements: 29, 59, 74, 95, 102, 104.

**Ans.** *Lanthanoids* and *actinoids* are known as inner transition elements.

Lanthanoids are 14 elements following Ln ( $z = 57$ ). They include atomic number 58 to 71.

Actinoids are 14 elements following Ac ( $z = 89$ ).

They include atomic number 90 to 103.

Of the given atomic number the inner transition elements are the elements with atomic numbers 59 (a lanthanoids) and 95, 102 (both actinoids).

**Q. 34** The chemistry of the actinoid elements is not so smooth as that of the lanthanoids. Justify this statement by giving some examples from the oxidation state of these elements.

**Ans.** All actinoids are radioactive and due to this their study is difficult. However, naturally occurring actinoids and the earlier members of the series have relatively long half-lives as compared to synthetic elements.

There is a greater range of oxidation states as compared to that of lanthanoids. Lanthanoids show oxidation states of +2 and +4 in addition to their common oxidation state of +3.

The actinoids show oxidation states of +3, +4, +5, +6 and +7.

**Q. 35** Which is the last element in the series of the actinoids? Write the electronic configuration of these elements. Comment on the possible oxidation state of this element.

**Ans.** The last member of actinoid series is Lr ( $z = 103$ ).



Its possible oxidation state is +3.

**Q. 36** Use Hund's rule to derive the electronic configuration of  $\text{Ce}^{3+}$  ion, and calculate its magnetic moment on the basis of 'spin-only' formula.

**Ans.**  $\text{Ce}^{3+}$ ;  $[\text{Xe}] 4f^1$  i.e. It has one unpaired electron

$$\begin{aligned} \therefore \mu &= \sqrt{4s(s+1)} \\ &= \sqrt{4 \cdot \frac{1}{2} \left( \frac{1}{2} + 1 \right)} \\ &= 3 \quad \text{or} \quad 1.732 \text{ B.} \end{aligned}$$

**Q. 37** Name the members of the lanthanoid series which exhibit +4 oxidation states and those which exhibit +2 oxidation states. Try to correlate this type of behaviour with the electronic configuration of these elements.

**Ans.** Actinoids showing +2 state and +4 state are

${}_{58}\text{Ce}$ ;  $[\text{Xe}] 4f^15d^16s^2$  – It shows +4 oxidation state

${}_{63}\text{Eu}$ ;  $[\text{Xe}] 4f^75d^06s^2$  – It shows +2 oxidation state

${}_{70}\text{Yb}$ ;  $[\text{Xe}] 4f^{14}5d^06s^2$  – It shows +2 oxidation state

After losing electrons they acquire stable configuration.

**Q. 38** Compare the chemistry of the actinoids with that of lanthanoids with reference to:  
(i) electronic configuration (ii) oxidation states, and (iii) chemical reactivity.

**Ans. (a) Electronic configuration.** In case of lanthanoids the 4  $f$  – orbitals are progressively filled whereas in case of actinoids 5  $f$  – orbitals are filled up.

**(b) Oxidation states.** The most common oxidation state shown by lanthanoids is + 3 though some of them also show + 2 and + 4 states. The oxidation states shown by actinoids are + 3, + 4, + 5, + 6 and + 7.

**(c) Chemical reactivity.** Actinoids are more reactive than lanthanoids because of their larger size and low I. E.

**Q. 39** What is lanthanoid contraction? What is its effect on the chemistry of the elements which follow the lanthanoids?

**Ans. Lanthanoid contraction.** On moving from lanthanum (La) to Lutetium (Lu), a gradual decrease in size of lanthanoids is observed with increase in atomic number. This is known as lanthanoid contraction.

#### Consequences

**(i)** The properties of 4d – and 5d – elements closely resemble because of lanthanoid contraction.

**(ii)** There is only a little variation in chemical properties among lanthanoids.

**Q. 40.** Write the electronic configurations of the elements with the atomic numbers 61, 91, 101 and 109.

**Ans.**  ${}_{61}\text{Pm}; [\text{Xe}] 6s^2 4f^5$

${}_{91}\text{Pa}; [\text{Rn}] 7s^2 5f^2 6d^1$

${}_{101}\text{Md}; [\text{Rn}] 7s^2 5f^{13}$

${}_{109}\text{Mt}; [\text{Rn}] 7s^2 5f^{14} 6d^7$ .