

NCERT Solutions For Class 12 Chemistry Chapter 8 The d and f block elements

Question 8.1 Silver atom has completely filled d-orbitals ($4d^{10}$) in its ground state. How can you say that it is a transition element?

Answer :

Silver atom (atomic no. = 47) has completely filled d-orbital in its ground state ($4d^{10}$). However, in +2 oxidation state, the electron of d-orbitals get removed. As a result, the d-orbital become incomplete (d^9). Hence it is a transition element.

Question 8.2 In the series $Sc(z = 21)$ to $Zn(z = 30)$, the enthalpy of atomisation of zinc is the lowest, i.e., 126 kJ mol^{-1} . Why?

Answer :

The enthalpy of atomisation of zinc is lowest due to the absence of an unpaired electron, which is responsible for metallic bonding in the elements. Therefore, the inter-atomic bonding is weak in zinc (Zn). Hence it has a low enthalpy of atomisation.

Question 8.3 Which of the 3d series of the transition metals exhibits the largest number of oxidation states and why?

Answer :

In 3d series of transition metals Manganese shows largest number of oxidation states because it has highest number of unpaired electrons in its d -orbitals. So, that by removing its all electrons we get different oxidation states.

Example- $MnO_2(+4)$, $MnO_4^-(+7)$, $MnO(+2)$ etc.

Question 8.4 The $E^\ominus(M^{2+}/M)$ value for copper is positive (+0.34V). What is possible reason for this? (Hint: consider its high $\Delta_a H^\ominus$ and low $\Delta_{hyd} H^\ominus$)

Answer :

The $E^\ominus(M^{2+}/M)$ value for metal depends on-

- Sublimation energy
- Ionisation energy
- Hydration energy

Copper has a high value of atomisation enthalpy and low hydration energy. Thus, as a result, the overall effect is $E^\ominus(M^{2+}/M)$ for copper is positive.

Question 8.5 How would you account for the irregular variation of ionisation enthalpies (first and second) in the first series of the transition elements?

Answer :

The irregular variation in ionisation enthalpies is due to the extra stability of the configuration like d^0 , d^5 , d^{10} because these states are extremely stable and have high ionisation enthalpies.

In the case of chromium (Cr) has low 1st IE because after losing one electron it attains stable configuration (d^5). But in the case of Zinc (Zn), the first IE is very high, because we remove an electron from a stable configuration ($3d^{10}, 4s^2$).

The second IE is much higher than the 1st IE. This is because it becomes difficult to remove an electron when we already did that and it already has a stable configuration (such as d^0 , d^5 , d^{10}). For example elements such as Cr^+ and Cu^+ the second IE is

extremely high because they already in a stable state. And we know that removal of an electron from a stable state requires a lot of energy.

Question 8.6 Why is the highest oxidation state of a metal exhibited in its oxide or fluoride only?

Answer :

Oxygen and fluorine are strong oxidising agents and both of their oxides and fluorides are highly electronegative in nature and also small in size. Because of these properties, they can oxidise the metal to its highest oxidation states.

Question 8.7 Which is a stronger reducing agent Cr^{+2} or Fe^{+2} and why ?

Answer :

Cr^{+2} is a better reducing agent as compared to Fe^{+2} , as this can be explained on the basis of standard electrode potential of Cr^{+2} (-0.41) and Fe^{+2} (+0.77).

It can also be explained on the basis of their electronic configuration achieved.

Cr^{+2} obtained d^3 configuration whereas Fe^{+2} gets d^5 configuration upon reduction. It is known that d^3 is more stable than d^5 . So Cr^{+2} is a better reducing agent as compared to Fe^{+2} .

Question 8.8 Calculate the 'spin only' magnetic moment of M^{2+} (aq) ion ($Z = 27$).

Answer :

Atomic number (Z) = 27

So the electronic configuration cobalt (Co) is $3d^7, 4s^2$

M^{2+} (aq) ion means, it loses its two electrons and become d^7 configuration. And it has 3

unpaired electrons

So, $\mu = \sqrt{n(n+2)}$, where n = no. of unpaired electron

by putting the value of n= 3

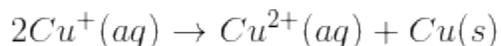
we get, $\mu = \sqrt{15}$

$\approx 4 \text{ BM}$

Question 8.9 Explain why Cu^+ ion is not stable in aqueous solutions?

Answer :

Cu^+ ion is unstable in aq. solution and disproportionate to give Cu^{2+} and Cu



The hydration energy release during the formation of Cu^{2+} compensates the energy required to remove an electron from d^{10} -configuration.

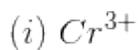
Question 8.10 Actinoid contraction is greater from element to element than lanthanoid contraction. Why?

Answer :

Actinoid contraction is greater from element to element than lanthanoid contraction. The reason behind it is the poor shielding effect of 5 f (in actinoids) orbitals than 4 f orbitals (in lanthanoids). As a result, the effective nuclear charge experienced by valence electrons is more in actinoids than lanthanoids elements.

NCERT Solutions for Class 12 Chemistry Chapter 8 The d and f block elements- Exercise Questions

Question 8.1(i) Write down the electronic configuration of:

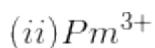


Answer :

Chromium has atomic number 24. So, nearest noble gas element is Argon (Ar)

So electronic configuration of (i) $Cr^{3+} = [Ar]^{18}3d^34s^0$

Question 8.1(ii) Write down the electronic configuration of:

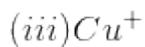


Answer :

Atomic number of promethium is 61 and the nearest noble gas is xenon(Xe)

So, atomic configuration of $Pm^{3+} = [Xe]^{54}4f^4$

Question 8.1(iii) Write down the electronic configuration of:

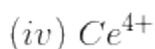


Answer :

Atomic number of copper is 29 and previous noble element is Argon (Ar)

the electronic configuration of $Cu^+ = [Ar]^{18}3d^{10}$

Question 8.1(iv) Write down the electronic configuration of:



Answer :

The atomic number of cerium (Ce) is 58 and the previous noble element is Xenon (Xe)

The electronic configuration of $Ce^{4+} = [Xe]^{54}4f^0$

Question 8.1(v) Write down the electronic configuration of:

(v) Co^{2+}

Answer :

The atomic number of cobalt (Co) is 27 and the previous noble element is Argon (Ar)

Thus electronic configuration of $Co^{2+} = [Ar]^{18}3d^74s^0$

Question 8.1(vi) Write down the electronic configuration of:

(vi) Lu^{2+}

Answer :

The atomic number of lutetium is 71 and the previous noble element is Xe (xenon)

the electronic configuration of $Lu^{2+} = [Xe]^{54}4f^{14}5d^16s^0$

Question 8.1(vii) Write down the electronic configuration of:

(vii) Mn^{2+}

Answer :

The atomic number of Manganese is 25 and the previous noble element is Ar (argon)

So, the electronic configuration of $Mn^{2+} = [Ar]^{18}3d^54s^0$

Question 8.1(viii) Write down the electronic configuration of:

(viii) Th^{4+}

Answer :

The atomic number of thorium (Th) is 90 and the previous noble gas element is Xenon (Xe)

So, the electronic configuration of $Th^{4+} = [Rn]^{86}5f^0$

Question 8.2 Why are Mn^{2+} compounds more stable than Fe^{2+} towards oxidation to their +3 state?

Answer :

$Mn^{2+} = 1s^2, 2s^2p^6, 3s^2p^6d^5$ (Half filled d – orbital)

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

In +2 oxidation state of manganese has more stability than +2 oxidation state of iron, it is because half filled and fully filled d-orbitals are more stable and Mn^{2+} has half filled electron stability Manganese (Mn^{2+}) has d^5 configuration so it wants to remain in this configuration. On the other hand, Fe^{2+} has d^6 configuration and after losing one electron it becomes d^5 configuration and attains its stability. That's why Mn^{2+} compounds more stable than Fe^{2+} towards oxidation to their +3 state.

Question 8.3 Explain briefly how +2 state becomes more and more stable in the first half of the first row transition elements with increasing atomic number?

Answer :

According to our observation, except scandium, all other elements of the first row shows +2 oxidation state. On moving from Sc to Mn the atomic number increases from 21 to 25 and also the increasing number of electrons in 3d orbitals from $d^1 - d^5$. when metals lose two electrons from its 4s orbital then they achieve +2 oxidation state. Since the number of d electrons in (+2) state increases from $Ti(+2) - Mn(+2)$, the stability of the +2 oxidation state increases as d-orbitals is becoming more and more half filled.

Mn(+2) has d^5 configuration, which is half filled (it makes it highly stable)

Question 8.4 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 examples.

Answer :

Elements of the first half of the transition series exhibit many oxidation states. manganese shows the maximum number of oxidation states (+2 to +7). The stability of +2 oxidation states increases with the increase in atomic number (as more number of electrons are filled in d-orbital). However, the *Sc* does not exhibit +2 oxidation states, its EC is $3d^1 4s^2$. It loses all three electrons to attain stable d^0 -configuration (noble gas configuration). $Ti(IV)$ and $V(+5)$ are stable for the same reason. In the case of manganese, (+2) oxidation state is very stable because of half-filled d-electron(d^5 - configuration).

Question 8.5 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 $3d^4$?

Answer :

$3d^3$

Vanadium (atomic number- 23)

E.C = $[Ar]^{18}3d^34s^2$,

So the stable oxidation states are (+2, +3, +4, +5)

$3d^5$

Manganese (atomic number = 25)

E.C = $[Ar]^{18}3d^54s^2$,

So the stable oxidation state are (+2, +4, +6, +7)

$3d^5$

chromium (atomic number = 24)

E.C = $[Ar]^{18}3d^54s^1$,

So the stable oxidation state are (+3, +4, +6)

$3d^4$

No elements has d^4 electronic configuration in their ground state.

Question 8.6 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.

Answer :

Following oxometal anions of the first series that exhibits the oxidation state equal to its group number-

1. Vanadate (VO_3^-)

Group number of vanadium (V) is 5 and here the oxidation state is also +5

2. Chromate ion (CrO_4^{2-})

Group number of chromium is (VIB) and the oxidation state is +6

3. Permanganate ion (MnO_4^-)

Group number of (Mn) is VIIB and here the oxidation number is also +7

Question 8.7 What is lanthanoid contraction? What are the consequences of lanthanoid contraction?

Answer :

On moving along the lanthanoid series, the atomic number is gradually increased by one. It means the no. of electrons and protons of the atom is also increases by one. And because of it the effective nuclear charge increases (electrons are adding in the same shell, and the nuclear attraction overcomes the interelectronic repulsion due to adding of a proton). Also, with the increase in atomic number, the number of electrons in orbital also increases. Due to the poor shielding effect of the electrons, the effective nuclear

charge experienced by an outer electron is increased, and also the attraction of the nucleus for the outermost electron is increased. As a result, there is a gradual decrease in the atomic size as an increase in atomic number. This is known as **lanthanoid contraction**.

Consequences of Lanthanoid contraction-

- Similarities in the properties of second and third transition series
- Separation of lanthanoid can be possible due to LC.
- Due to LC, there is variation in basic strength of hydroxide of lanthanoid. (basic strength decrease from $La(OH)_3 - Lu(OH)_3$).

Question 8.8 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?

Answer :

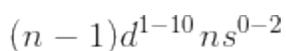
Transition elements are those which have partially filled d or f orbitals. These elements lie in the $d - block$ and show transition properties between s block and p-block. Thus these are called transition elements.

Zn, Hg, Cd are not considered as transition elements due to the fully filled d-orbitals.

Question 8.9 In what way is the electronic configuration of the transition elements different from that of the non transition elements?

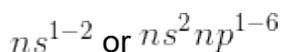
Answer :

Transition elements have partially filled d -orbitals. Thus general electronic configuration of transition elements is



Non-transition elements either have fully filled **d- orbital** or do not have d- orbitals.

Therefore general electronic configuration is



Question 8.10 What are the different oxidation states exhibited by the lanthanoids?

Answer :

In lanthanoid +3 oxidation states are more common. $Ln(III)$ compounds are most predominant. However, +2 and +4 oxidation also formed by them in the solution or solid compounds.

Question 8.11(i) Explain giving reasons:

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

Answer :

Paramagnetism is arising due to the presence of unpaired electron. And we know that transition metals have unpaired electrons in their d -orbitals. That's why they show paramagnetic behaviour.

Question 8.11(ii) Explain giving reasons:

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

Answer :

Transition metals have high effective nuclear charge and also high outer most electrons. Thus they form a very strong metallic bond and due to these, transition elements have a very high enthalpy of atomisation.

Question 8.11(iii) Explain giving reasons:

(iii) The transition metals generally form coloured compounds.

Answer :

Most of the complex of transition elements are coloured. This is due to the absorption of radiation from visible light region to excite the electrons from its one position to another position in d-orbitals. In the presence of ligands, d-orbitals split into two sets of different orbital energies. Here transition of electron takes place and emit radiation which falls on the visible light region.

Question 8.11(iv) Explain giving reasons:

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

Answer :

The catalytic activity of transition metals is because of two reasons-

1. They provide a suitable surface for the reaction to occur.
2. Ability to show variable oxidation states and form complexes, transition metals are also able to form intermediate compounds and thus they give the new path, which has lower activation energy for the reaction.

Question 8.12 What are interstitial compounds? Why are such compounds well known for transition metals?

Answer :

Transition metals contain lots of interstitial sites. These elements trap the other elements which are small in size such as Carbon, Hydrogen and Nitrogen in their interstitial site of the crystal lattice as a result forms interstitial compounds.

Question 8.13 How is the variability in oxidation states of transition metals different from that of the non-transition metals? Illustrate with examples.

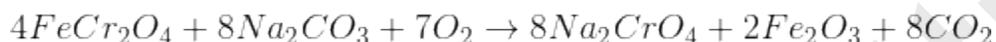
Answer :

In transition metals, the variation of oxidation states is from +1 to the highest oxidation number, by removing all its valence electrons. Also in transition metals, the oxidation number is differed by one unit like ($Fe^{3+} - Fe^{2+}$; $Cu^+ - Cu^{2+}$). But in non-transition elements, the oxidation states are differed by two (+2 and +4 or +3 and +5 etc.)

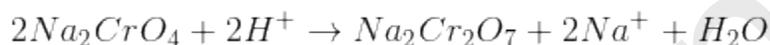
Question 8.14 Describe the preparation of potassium dichromate from iron chromite ore. What is the effect of increasing pH on a solution of potassium dichromate?

Answer :

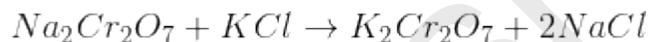
potassium dichromate is obtained from the fusion of chromite ore ($FeCr_2O_4$) with sodium and potassium carbonate in the free supply of air.



Sodium chromate is filtered and acidified with sulphuric acid (H_2SO_4) to form sodium dichromate, ($Na_2Cr_2O_7 \cdot 2H_2O$) can be crystallised

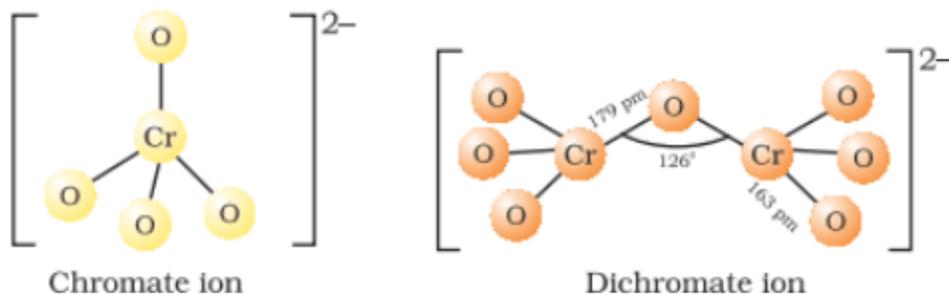


Sodium dichromate is more soluble than potassium dichromate. So, treat the solution of dichromate with the potassium chloride (KCl)



The chromate and dichromate are interconvertible in aqueous solution at pH 4

Structures of chromate and dichromate ion



Question 8.15(i) Describe the oxidising action of potassium dichromate and write the ionic equations for its reaction with:

(i) iodide

Answer :

Potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) act as a strong oxidising agent in acidic medium. It takes the electron to get reduced.

($\text{K}_2\text{Cr}_2\text{O}_7$) oxidises iodide to iodine

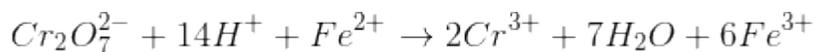
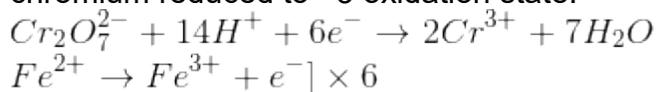
In first reaction oxidation state of chromium reduced from +6 to +3

Question 8.15(ii) Describe the oxidising action of potassium dichromate and write the ionic equations for its reaction with:

(ii) iron(II) solution

Answer :

Potassium dichromate react with (Fe^{2+}) ion to produce solution of (Fe^{3+}) ion and chromium reduced to +3 oxidation state.



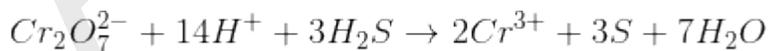
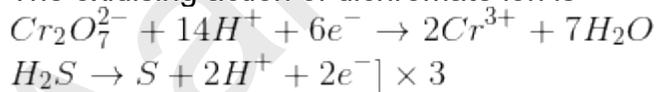
Question 8.15(iii) Describe the oxidising action of potassium dichromate and write the ionic equations for its reaction with:

(iii) H_2S

Answer :

Potassium dichromate oxidise H_2S (hydrogen sulphide) to sulphur (zero oxidation state)

The oxidising action of dichromate ion is -



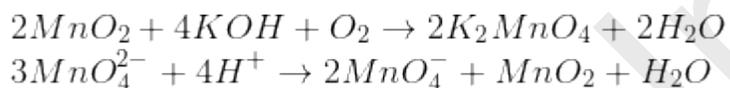
Question 8.16(i) Describe the preparation of potassium permanganate. How does the acidified permanganate solution react with

(i) iron

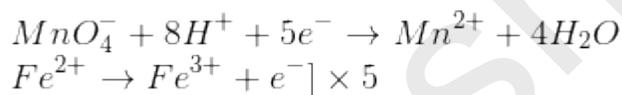
Write the ionic equations for the reactions .

Answer :

Potassium permanganate can be prepared from the fusion of pyrolusite ore (MnO_2) with an alkali metal hydroxide and an oxidising agent (like KNO_3). This gives dark green K_2MnO_4 . It disproportionates in acidic or neutral medium to give permanganate.



(i) Acidified permanganate ion reacts with iron-



Question 8.16(ii) Describe the preparation of potassium permanganate. How does the acidified permanganate solution react with

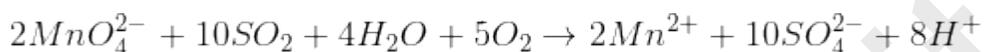
(ii) SO_2

Write the ionic equations for the reaction.

Answer :

Reaction of acidified permanganate solution with sulphur dioxide (SO_2). It oxidises the SO_2 to sulphuric acid (H_2SO_4)

Here are the reactions-



Question 8.16(iii) Describe the preparation of potassium permanganate. How does the acidified permanganate solution react with

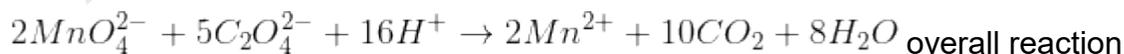
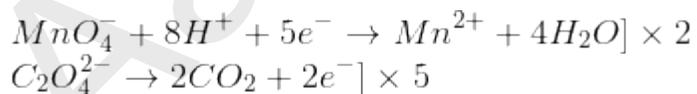
(iii) oxalic acid

Write the ionic equations for the reactions.

Answer :

When acidified permanganate solution react with oxalic acid ($H_2C_2O_4$) it converts oxalic acid into carbon dioxide (CO_2)

Here are the reactions-



Question 8.17(i) For M^{2+}/M and M^{3+}/M^{2+} systems the E^\ominus values for some metals are as follows:

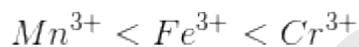
Use this data to comment upon:

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

Answer :

The E^\ominus value of Fe^{3+}/Fe^{2+} is higher than that of Cr^{3+}/Cr^{2+} but less than that of Mn^{3+}/Mn^{2+} . So, the reduction of ferric ion (Fe^{3+}) to ferrous ion (Fe^{2+}) is easier than Mn^{3+}/Mn^{2+} but as not easy as Cr^{3+}/Cr^{2+} . Hence ferric ion is more stable than manganese ion (Mn^{3+}), but less stable than chromium ion (Cr^{3+}).

Order of relative stabilities of different ions is-



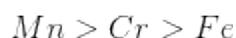
Question 8.17(ii) For M^{2+}/M and M^{3+}/M^{2+} systems the E^\ominus values for some metals are as follows:

Use this data to comment upon:

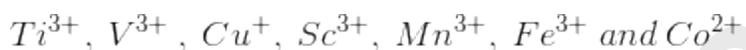
(ii) the ease with which iron can be oxidised as compared to a similar process for either chromium or manganese metal.

Answer :

From the values of E° , the order of oxidation of the given metal to the divalent cation is-



Question 8.18(i) Predict which of the following, will be coloured in aqueous solution?



Answer :

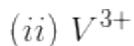
Ions which have incomplete d-orbital, they are able to do $d-d$ transition, which is responsible for colour. And those which has vacant d-orbitals or complete d -orbitals are colourless

$Ti^{3+} = [Ar]3d^1$	Purple
$V^{3+} = [Ar]3d^1$	green
$Sc^{3+} = [Ar]3d^0$	colourless
$Mn^{2+} = [Ar]^{18}d^54s^0$	pink

$Fe^{3+} = [Ar]^{18}3d^54s^0$	yellow
$Co^{2+} = [Ar]^{18}d^74s^0$	blue pink
$Cu^+ = [Ar]^{18}3d^{10}4s^0$	colourless

From the table, we notice that Sc^{3+} and Cu^+ have $3d^0$ and $3d^{10}$ configuration, so their aqueous solutions are colourless. All others are coloured in aqueous medium.

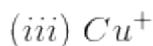
Question **8.18(ii)** Predict for the following, will be coloured in aqueous solution? Give reason.



Answer:

Yes, V^{3+} (vanadium) ions has coloured aqueous solution because vanadium has two electron in its d -orbitals, as a result d-d transition will occur and which is responsible for colour of the solution.

Question **8.18(iii)** Predict for the following, will be coloured in aqueous solution? Give reason.



Answer :

No, Cu^+ aqueous solution has no color because it has fully filled d-orbitals. So, that d-d transition will not happen, which is responsible for colour.

electronic configuration of $Cu^+ = [Ar]^{18}3d^{10}4s^0$

Question 8.18(iv) Predict for the following, will be coloured in aqueous solution? Give reason.

(iv) Sc^{3+}

Answer :

No, aqueous solution of Sc^{3+} ion will have no colour because it has empty d-orbitals.

Thus the d-d transition will not happen (due absence of electron), which is responsible for colour.

The electronic configuration of $Sc^{3+} = [Ar]^{18}3d^04s^0$

Question 8.18(v) Predict for the following, will be coloured in aqueous solution? Give reason.

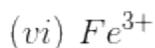
(v) Mn^{2+}

Answer :

Yes, the aqueous solution of Mn^{2+} (manganese ion) will be coloured due to half filled electron in its d-orbitals (d^5) and because of that d-d transition will occur, which is responsible for colour.

the electronic configuration of $Mn^{2+} = [Ar]^{18}d^54s^0$

Question 8.18(vi) Predict for the following, will be coloured in aqueous solution? Give reason.

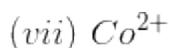


Answer :

Yes, the aqueous solution of Fe^{3+} (ferric ion) will be coloured due to half filled electron in it d -orbitals(d^5) and because of that d-d transition will occurs , which is responsible for colour

electronic configuration of $Fe^{3+} = [Ar]^{18}3d^54s^0$

Question 8.18(vii) Predict for the following, will be coloured in aqueous solution? Give reason.



Answer :

Yes, the aqueous solution of Co^{2+} (ferric ion) will be coloured due to presence of electron in it d -orbitals(d^7) and because of that d-d transition will occurs , which is responsible for colour

electronic configuration of $Co^{2+} = [Ar]^{18}d^74s^0$

Question 8.19 Compare the stability of +2 oxidation state for the elements of the first transition series.

Answer :

According to our observation, except scandium, all other elements of the first row shows +2 oxidation state. On moving from *Sc* to *Mn* the number of oxidation states increases but from *Mn* to *Zn* number of oxidation states decreases due to a decrease in unpaired electrons. The stability of +2 oxidation state increase on moving from *Sc* to *Zn* due to increase in difficulty level of removal of the third electron from d -orbital.

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
+3	+2	+2	+2	+2	+2	+2	+2	+1	+2
	+3	+3	+3	+3	+3	+3	+3	+2	
	+4	+4	+4	+4	+4	+4	+4		
		+5	+5	+5					
			+6	+6	+6				
				+7					

Question 8.20(i) Compare the chemistry of actinoids with that of the lanthanoids with special reference to:

(i) electronic configuration

Answer :

The general electronic configuration of actinoids series is $[Rn]^{86}5f^{1-14}6d^{0-1}7s^2$ and that for lanthanoids are $[Xe]^{54}4f^{1-14}5d^{0-1}6s^2$. 5 *f* orbitals do not deeply participate in bonding to a large extent.

Question 8.20(ii) Compare the chemistry of actinoids with that of the lanthanoids with special reference to:

(ii) atomic and ionic sizes

Answer :

Similar to lanthanoids, actinoids also shows actinoid contraction. But the contraction is greater in actinoids because of poor shielding effects of 5*f* orbitals

Question 8.20(iii) Compare the chemistry of actinoids with that of the lanthanoids with special reference to:

(iii) oxidation state

Answer :

The principle oxidation state of lanthanoids are +3, but sometimes it also shows +2 and +4 oxidation states. This is due to the extra stability of fully- filled and half filled orbitals. Actinoids have a greater range of oxidation states due to comparable energies of and it also has principle oxidation state is +3 but have more compounds in +3 oxidation states than lanthanoids.

Question 8.20(iv) Compare the chemistry of actinoids with that of the lanthanoids with special reference to:

(iv) chemical reactivity.

Answer :

In lanthanoid series, an earlier member of the series is more reactive, and that is comparable to . with an increase in atomic number, lanthanoids starts behaving similar to aluminium.

Actinoids are highly reactive metals, especially when they are finally divided. When we add them into the water, they give a mixture of oxide and hydride. Actinoids combine with most of the non-metals at moderate temperature. Alkalies have no action on these actinoids metals

Question 8.21(i) How would you account for the following:

(i) Of the d^4 species, Cr^{2+} is strongly reducing while manganese(III) is strongly oxidising.

Answer :

Cr^{2+} is strongly reducing in nature. It has d^4 configuration. By losing one electron it gets oxidised to Cr^{3+} (electronic configuration d^3) which can be written as t_{2g}^3 and it is a more stable configuration. On the other hand Mn^{3+} has also d^4 configuration by accepting one

electron it gets reduced and act as strongly oxidising agent (electronic configuration d^5). Thus it is extra stable due to half-filled with d-orbital.

Question 8.21(ii) How would you account for the following:

(ii) Cobalt(II) is stable in aqueous solution but in the presence of complexing reagents it is easily oxidised.

Answer :

Cobalt (II) is more stable in aq. solution but in presence of strong field ligand complexing agents, it gets oxidised to Cobalt (III). Though the third ionisation energy of Co is high but the CFSE (**crystal field stabilisation energy**) is very high in presence of strong field ligand which overcomes the ionisation energy.

Question 8.21(iii) How would you account for the following:

(iii) The d^1 configuration is very unstable in ions.

Answer :

The d^1 configuration is very unstable in ions because after losing one more electron it attains stable d^0 configuration.

Question 8.22 What is meant by 'disproportionation'? Give two examples of disproportionation reaction in aqueous solution.

Answer :

In a chemical reaction a substance gets oxidised as well as reduced simultaneously is called disproportionation reaction. For examples-

- $3CrO_4^{3-}(V) + 8H^+ \rightarrow 2CrO_4^{2-}(VI) + Cr^{3+}(III) + 4H_2O$
- $3MnO_4^{2-}(VI) + 4H^+ \rightarrow 2MnO_4^-(VII) + MnO_2(IV) + 2H_2O$

Question 8.23 Which metal in the first series of transition metals exhibits +1 oxidation state most frequently and why?

Answer :

In the first transition series, Cu (copper) exhibits +1 oxidation states most frequently. This is because Cu^+ has stable electronic configuration of $[Ar]3d^{10}$. The fully filled d-orbital makes it highly stable.

Question 8.24(i) Calculate the number of unpaired electrons in the following gaseous ions:

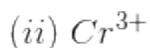
(i) Mn^{3+}

Answer :

The number of unpaired electrons in Mn^{3+} is 4
 $Mn^{3+}(Z = 25) = [Ar] 3d^4$

after losing 3 electrons, Mn has 4 electrons left.

Question 8.24(ii) Calculate the number of unpaired electrons in the following gaseous ions:



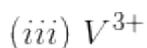
Answer :

Electronic configuration of chromium is $Cr = 3d^5 4s^1$. The number of unpaired electron in Cr^{3+} is 3



after losing 3 electron, Cr has 3 electron left d-orbital

Question 8.24(iii) Calculate the number of unpaired electrons in the following gaseous ions:



Answer :

Electronic configuration of $V = 3d^3 4s^2$. The number of unpaired electron in V^{3+} is 2



after losing 3 electron, V has 2 electron left d-orbital

Question 8.24(iv) Calculate the number of unpaired electrons in the following gaseous ions:

(iv) Ti^{3+}

Answer :

Electronic configuration of $Ti = 3d^2 4s^2$. The number of unpaired electron in Ti^{3+} is 1
 $Ti^{3+} (Z = 22) = [Ar] 3d^1$

after losing 3 electron, Ti has 1 electron left d-orbital

Question 8.24 Which one of these is the most stable in aqueous solution?

- (i) Mn^{3+}
- (ii) Cr^{3+}
- (iii) V^{3+}
- (iv) Ti^{3+}

Answer :

Cr^{3+} is the most stable in the aqueous solution because it attains the t_{2g}^3 configuration, which is stable d -configuration.

Electronic configuration of $Cr^{3+} = [Ar] 3d^3 4s^0$

Question 8.25(i) Give examples and suggest reasons for the following feature of the transition metal chemistry:

(i) The lowest oxide of transition metal is basic, the highest is amphoteric/acidic.

Answer :

The lowest oxidation states of transition metals are basic because some of their valence electrons are not participating in bonding. Thus they have free electrons, which they can donate and act as a base. In the higher oxide of transition metals, valence electron of their participate in bonding, so they are unavailable. But they can accept electrons and behave as an acid. For example MnO (+2)- behave as a base and Mn_2O_7 (+7) behave as an acid.

Question 8.25(ii) Give examples and suggest reasons for the following feature of the transition metal chemistry:

(ii) A transition metal exhibits highest oxidation state in oxides and fluorides .

Answer :

Oxygen and fluorine are a strong oxidizing agent because of their small in size and high electronegativity. So, they help transition metals to exhibit the highest oxidation states. Examples of oxides and fluorides of transition metals are OsF_6 (+6) and V_2O_5 (+5)

Question 8.25(iii) Give examples and suggest reasons for the following feature of the transition metal chemistry:

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

Answer :

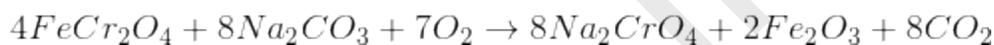
Oxygen is a strong oxidizing agent because of its small size and high electronegativity. Thus oxo-anions of metals show the highest oxidation state. For example- $KMnO_4$, here manganese shows +4 oxidation state.

Question 8.26(i) Indicate the steps in the preparation of:

(i) $K_2Cr_2O_7$ from chromite ore .

Answer :

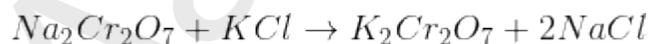
(i) Potassium dichromate is obtained from the fusion of **chromite ore** ($FeCr_2O_4$) with sodium and potassium carbonate in the free supply of air.



(ii) Sodium chromate is filtered and acidified with sulphuric acid (H_2SO_4) to form sodium dichromate, ($Na_2Cr_2O_7 \cdot 2H_2O$) can be crystallised

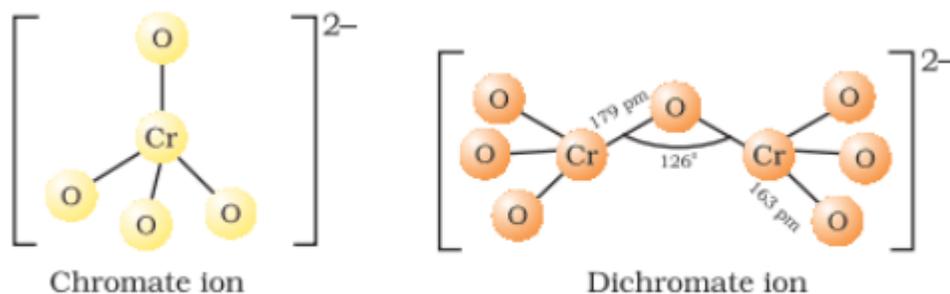


(iii) Sodium dichromate is more soluble than potassium dichromate. So, treat the solution of dichromate with the potassium chloride (KCl)



The chromate and dichromate are interconvertible in aqueous solution at pH 4

Structures of chromate and dichromate ion



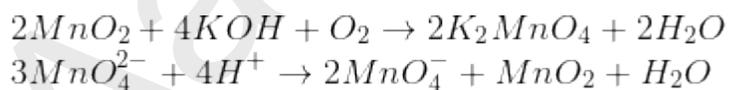
Question 8.26(ii) Indicate the steps in the preparation of:

(ii) KMnO_4 from pyrolusite ore.

Answer :

Potassium permanganate can be prepared from the fusion of pyrolusite ore (MnO_2) with an alkali metal hydroxide and an oxidising agent (like KNO_3).

This gives dark green K_2MnO_4 . It disproportionates in acidic or neutral medium to give permanganate.



Question 8.27 What are alloys? Name an important alloy which contains some of the lanthanoid metals. Mention its uses .

Answer :

It is a solid solution of two or more elements in a metallic matrix. Alloys possess different physical properties than component materials.

An important alloy of lanthanoid is mischmetal.

uses-

- mischmetal is used in cigarettes and gas lighters
- Used in flame-throwing tanks
- It is used in tracer bullets and shells

Question 8.28 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.

Answer :

Inner transition metals are those in which the last electrons are filled in f-orbitals. The elements in which 4f and 5f are filled are called f block elements. 59, 95 and 102 are the inner transition elements.

Question 8.29 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 .

Answer :

Lanthanoid primarily shows three oxidation states +2, +3, and +4 and out of these +3 is most common in lanthanoids. they show limited no. of oxidation states due to the large difference in energies of 4 *f* , 5 *d* and 6 *s* orbitals. But, actinoids shows large no. of oxidation state because they have comparable energy difference in 5 *f* ,6 *d* and 7 *s* orbitals. For example *U* and *Pu* exhibits +3, +4, +5 and +6 oxidation states.

Question 8.30 Which is the last element in the series of the actinoids? Write the electronic configuration of this element. Comment on the possible oxidation state of this element .

Answer :

The last element of the actinoid series is Lawrencium (*Lr*). Its atomic number is 103.

The electronic configuration of *Lr* is $[Rn]^{86}5f^{14}6d^17s^2$.

The possible oxidation state of lawrencium is +3 because after losing 3 electrons it becomes a stable molecule.

Question 8.31 Use Hund's rule to derive the electronic configuration of Ce^{3+} ion, and calculate its magnetic moment on the basis of 'spin-only' formula.

Answer :

Electronic configuration of $Ce = 1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^{10}5s^25p^64f^15d^16s^2$

Magnetic moment can be calculated as $\mu = \sqrt{n(n+2)}$, where n= no. of unpaired electrons

in Cerium $n = 2$

So, by putting the value of n we get $\mu = \sqrt{2(2+2)} = \sqrt{8} = 2.828 \text{ BM}$

Question 8.32 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 configurations of these elements.

Answer :

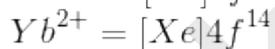
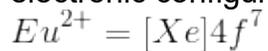
Members of the lanthanoids which exhibits $+4$ oxidation states

are- *Ce, Pr, Nd, Tb, Dy*

members who exhibit $+2$ oxidation states = *Nd, Sm, Eu, Tm, Yb*

After losing 4 electrons Ce^{4+} attains stable configuration $[Xe]$ and also the same thing happen to $Tb = [Xe]4f^7$

In the case of *Eu* and *Yb* , after losing two electrons they also get their stable electronic configuration.



Question 8.34 Write the electronic configurations of the elements with the atomic numbers 61, 91, 101, and 109.

Answer :

Atomic number = 61, Promethium

the electronic configuration is $[Xe]^{54}4f^55d^06s^2$

atomic number = 91, protactinium

the electronic configuration is $[Rn]^{86}5f^26d^17s^2$

Atomic number = 101, Mendelevium

the electronic configuration is $[Rn]^{86}5f^{13}6d^07s^2$

Atomic number = 109, Meitnerium

the electronic configuration is $[Rn]^{86}5f^{14}6d^77s^2$

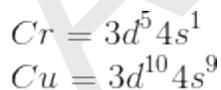
Question 8.35(i) Compare the general characteristics of the first series of the transition metals with those of the second and third series metals in the respective vertical columns. Give special emphasis on the following points:

(i) electronic configurations

Answer :

Electronic configurations-

In 1st, 2nd and 3rd transition metal series 3 *d* , 4 *d* and 5 *d* orbitals are used respectively. In first series copper and zinc show unusual electronic configuration.



In the second transition series different electron configuration shown by following metals,

$Mo (42) = 4d^5 5s^1$, $Tc (43) = 4d^6 5s^1$, $Ru (44) = 4d^7 5s^1$, $Rh (45) = 4d^8 5s^1$, $Pd (46) = 4d^{10} 5s^0$, $Ag (47) = 4d^{10} 5s^1$

In 3rd series there are also some metals which show this types of behaviour such as;

$W (74) = 5d^4 6s^2$, $Pt (78) = 5d^9 6s^1$

Question 8.35(ii) Compare the general characteristics of the first series of the transition metals with those of the second and third series metals in the respective vertical columns. Give special emphasis on the following points:

(ii) oxidation states

Answer :

In each of the three transition series, the no. of oxidation state is minimum at the extremes and the highest at the middle of the row. In the first transition series, the +2 and +3 oxidation state are quite stable. Elements of first transition series metals form stable compounds of +2 and +3 oxidation state. But the stability of +2 and +3 oxidation state decreases in second and third series. Second and third transition series metals formed complexes in which their oxidation state is high (WCl_6, ReF_7) and in first transition series ($[Co(NH_3)_6]^{3+}$, $[Ti(H_2O)_6]^{3+}$) are stable complexes.

Question 8.35(iii) Compare the general characteristics of the first series of the transition metals with those of the second and third series metals in the respective vertical columns. Give special emphasis on the following points:

(iii) ionisation enthalpies

Answer :

In all of the three transition series, the 1st ionisation energy increases from the left side to right side. But, there are some exceptions like the first ionisation enthalpies of the third transition series are more significant than those of the first and second transition series. This is happening due to the weak shielding effect of 4 electrons in the third series. Some elements in the second series have higher first IE than elements of the same column in the first transition series. There are also elements in the 2nd transition series whose first IE are lower than those of the elements corresponding to the same vertical column in the 1st transition series.

Question 8.35(iv) Compare the general characteristics of the first series of the transition metals with those of the second and third series metals in the respective vertical columns. Give special emphasis on the following points:

(iv) atomic sizes.

Answer :

Generally, atomic sizes decrease from left to right across the period. In among the three transition series, the size of the second series element is bigger than that of the first transition element of the same vertical group. But the atomic size of the third transition

element is nearly the same as the element of the second transition series element. This is because of Lanthanoid contraction.

Question 8.36 Write down the number of 3d electrons in each of the following ions: Ti^{2+} , V^{2+} , Cr^{3+} , Mn^{2+} , Fe^{2+} , Fe^{3+} , Co^{2+} , Ni^{2+} and Cu^{2+} . Indicate how would you expect the five 3d orbitals to be occupied for these hydrated ions (octahedral).

Answer :

For Ti^{2+} d-orbital has two electron. So, filling of d-orbitals can be t_{2g}^2

In V^{2+} d-orbital has three electron. So, the filling of d-orbital can be t_{2g}^3

Similarly

Cr^{3+} (Ions)	d^3 (No. of d electrons)	t_{2g}^3 (Filling of d-orbitals)
Mn^{2+}	d^5	t_{2g}^3, e_g^2
Fe^{2+}	d^6	t_{2g}^4, e_g^2
Fe^{3+}	d^5	t_{2g}^3, e_g^2
Co^{2+}	d^7	t_{2g}^5, e_g^2

Ni^{2+}	d^8	t_{2g}^6, e_g^2
Cu^{2+}	d^9	t_{2g}^6, e_g^3

Question 8.37 Comment on the statement that elements of the first transition series possess many properties different from those of heavier transition elements.

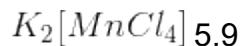
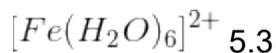
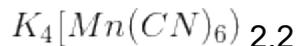
Answer :

Elements of the first transition series possess many properties different from those of heavier transition elements in the following ways-

1. The atomic size of the 1st transition series is smaller than those of 2nd and 3rd series elements. But due to lanthanoid contraction, atomic size of the 2nd series elements are nearly the same as 3rd series element of the corresponding same vertical group.
2. In 1st transition series +2 and +3 oxidation states are more common but in the 2nd and 3rd series higher oxidation states are more common.
3. The enthalpy of atomisation of first series elements is lower than 2nd and 3rd series elements.
4. The melting and boiling point of the 1st transition series is less than that of heavier metals. This is because of strong metallic bonding in heavier metals.

Question 8.38 What can be inferred from the magnetic moment values of the following complex species ?

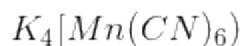
Example Magnetic Moment (BM)



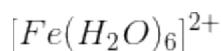
Answer :

Magnetic moment is given as - $\mu = \sqrt{n(n+2)}$

Putting the value on $n = 1, 2, 3, 4, 5$ (number of unpaired electrons in d-orbital) we get the value of μ are 1.732, 2.83, 3.87, 4.899, 5.92 respectively.



By comparing with our calculation we get the values n nearest to 1. It means, in above compound d-orbital has one unpaired electron ($Mn^{2+} = [d^5]$), which means CN is a strong field ligand that causes force pairing of the electron.



After comparing with our calculation the nearest value of $n = 4$. Here iron is in +2 oxidation state (d^6 configuration). So, we can say that H_2O is a weak field ligand, which does not cause any force pairing.



By observing we get the nearest value of n is 5. So, in this complex Manganese has d^5 configuration. So, we conclude that Cl ligand does not cause any force pairing and hence it is a weak ligand.