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**Questions & Answers on Coordination Chemistry**

**1. Define transition elements.**

**Ans.** Transition element is defined as the one which has incompletely filled *d* orbitals in its ground state or in any one of its oxidation states.

**2. What is the position of the d block elements in the periodic table?**

**Ans.** The d block elements are in the middle of s and p blocks, comprising the groups 3 to 12. They are the four rows of elements in the periods 4th (3d series), 5th (4d series), 6th (5d series) and 7th (6d series).

**3. Zinc, cadmium and mercury of group 12 are not regarded as transition metals, Why ?**

**Ans.** Zinc, cadmium and mercury of group 12 have full *d*<sup>10</sup> configuration ( *d* orbitals are completely filled ) in their ground state as well as in their common oxidation states and hence, are not regarded as transition metals

**4. Why d- block elements are named as ‘transition elements ‘?**

**Ans.** The *d*-block elements occupies the middle of the periodic table and their properties are transitional between *s*- and *p*- block elements.

**5. Write the general electronic configuration of d block elements.**

**Ans.** [ Noble gas] (n-1)*d*<sup>1-10</sup>*ns*<sup>1-2</sup>

**6. Write the general outer electronic configuration of d- block elements. .**

**Ans.** The general outer electronic configuration of d- block elements is (n-1)*d*<sup>1-10</sup> *ns*<sup>1-2</sup>

**7. Write the general electronic configuration of f- block elements.**

**Ans.** The general electronic configuration of f- block elements (Lanthanoids) is  
[Xe] 4*f*<sup>1-14</sup> 5*d*<sup>0-1</sup> 6*s*<sup>2</sup>

**8. Name a member of the lanthanoid series which is well known to exhibit +4 oxidation state.**

**Ans.** Cerium

**9. The outer electronic configuration of Cr is  $3d^5 4s^1$  instead of  $3d^4 4s^2$ , why?**

**Ans.** Half filled ( $3d^5$ ) orbitals are relatively more stable, hence one electron of 4s orbital jumps to 3d orbital.

**10. The outer electronic configuration of Cu is  $3d^{10} 4s^1$  instead of  $3d^9 4s^2$ , why?**

**Ans.** Completely filled ( $3d^{10}$ ) orbitals are relatively more stable, hence one electron of 4s orbital jumps to 3d orbital.

**11. Account for high melting point and boiling points of transition metals.**

**Ans.** The melting and boiling points of transition metals are high because of the involvement of greater number of electrons from  $(n-1)d$  orbitals in addition to the  $ns$  electrons in the inter atomic metallic bonding.

**12. What is the trend in melting points of transition metals in a series?**

**Ans.** The melting points of the transition metals in a series rise to a maximum at the middle of the series (i.e. Cr or Mo or W - element with  $d^5$  configuration) and fall regularly as the atomic number increases.

**13. Why do transition metals have higher enthalpies of atomization?**

**Ans.** Involvement of a large number of unpaired electrons of  $d$  orbitals favour stronger inter atomic interactions resulting in stronger bonds between the atoms of a metal and higher enthalpies of atomization.

**14. Name one 3d series elements, that do not show variable oxidation states.**

**Ans.** Sc (+3)

**15. Transition metals exhibit variable oxidation states in its compounds, why?**

**Ans.** Transition metals exhibit variable oxidation states in its compounds due to the availability of both  $ns$  &  $(n-1)d$  electrons for bond formation.

**16. Name 3d series metal which shows highest oxidation state.**

**Ans.** The highest oxidation state shown by 3d series transition metals is +7 by Mn

**17. Name a metal in the 3d series of transition metals which exhibit +1 oxidation state most frequently.**

**Ans.** copper

**18. What is the trend in oxidation state of transition metals ?**

**Ans.** The oxidation state increases with increase in atomic number & reaches a maximum in the middle and then decreases.

**19. 3d series transition metals exhibit +2 as the most common oxidation state (except Sc) why?**

**Ans.** The +2 oxidation state, which commonly occurs for nearly all the transition metals is due to the loss of their outer 4s electrons

**20. Why transition metals and their compounds shows paramagnetic behavior ?**

**Ans.** The transition metal ions are generally containing one or more unpaired electrons in them & hence their compounds are generally paramagnetic.

**21. Name an of alloys of transition metals with non transition metals.**

**Ans.** Brass ( Cu & Zn) or Bronze ( Cu & Sn)

**22. What is the action of neutral or faintly alkaline permanganate solution on iodide ?**

**Ans.** Alkaline permanganate solution oxidize iodide to iodate.

**23. What happens when potassium permanganate is heated to 513 K ?**

**Ans.** Potassium permanganate decomposes at 513K to potassium manganate, manganese dioxide and oxygen.

**24. What is the principal oxidation state exhibited by the lanthanoids?**

**Ans.** The principal oxidation state of lanthanoids is +3.

**25. Write the spin-only formula used to calculate the magnetic moment of metal ions.**

**Ans.** The magnetic moment is determined by using the spin only formula, where n is the number of unpaired electrons and  $\mu$  is the magnetic moment in units of Bohr magneton (BM).

**26. Why is Sc<sup>3+</sup> (or Zn<sup>2+</sup>) diamagnetic?**

**Ans.** Sc<sup>3+</sup>(Z=21) 3d<sup>0</sup> no unpaired electron, n=0,  $\mu=0$ .  
(or Zn<sup>2+</sup>(Z=30) 3d<sup>10</sup> no unpaired electron, n=0,  $\mu=0$ )

**27. What is the most common oxidation state of lanthanoids and actinoids?**

**Ans.** The most common oxidation state of lanthanoids and actinoids is +3.

**28. What is Actinoid contraction?**

**Ans.** There is a gradual decrease in the size of atoms or M<sup>3+</sup> ions across the series. This is known as the actinoid contraction.

**29. Actinoid contraction is more than lanthanoid contraction. Give reason.**

**Ans.** The actinoid contraction is, more than lanthanoid contraction due to poor shielding by 5f electrons from nuclear charge.

**30. Actinoids show larger number of oxidation states than lanthanoids. Why?**

**Ans.** In actinoids 5f, 6d and 7s levels are of comparable energies, hence electrons

from these orbitals are available to lose or share.

**31. Give one use of Mischmetall .**

**Ans.** Mischmetall is used in Mg-based alloy to produce bullets, shell and lighter flint.

**32. Why transition metals forms alloys readily?**

**Ans.** Transition metals readily form alloys with other transition metals because of their similar radii

**33. Give one use of transition metal alloy.**

**Ans.** Ferrous alloys containing chromium, vanadium, tungsten, molybdenum and manganese are used for the production of a variety of steels.

**34. Name two characteristic properties exhibited by d – block elements due to their partly filled d orbitals.**

**Ans.** The characteristic properties exhibited by d – block elements due to their partly filled d orbitals are variable; (i) Oxidation states  
(ii) Formation of coloured ions.

**35. Name two typical metallic properties displayed by transition elements.**

**Ans.** High tensile strength, ductility malleability, high thermal and electrical conductivity and metallic luster etc.

**36. What are interstitial compounds? Give example.**

**Ans.** Interstitial compounds are those which are formed when small atoms like H, C or N are trapped inside the crystal lattices of transition metals.

Example; TiC, Mn<sub>4</sub>N, Fe<sub>3</sub>H, VH<sub>0.56</sub> and TiH<sub>1.7</sub>, etc.

**37. Give any two physical characteristics of interstitial compounds.**

**Ans.** Two physical characteristics of interstitial compounds are: (i) They have high melting points, higher than those of pure metals. (ii) They are very hard and they retain metallic conductivity.

**38. Calculate the ‘spin only’ magnetic moment of M<sup>2+</sup> (aq) ion (Z = 27).**

**Ans.** M (z= 27, 3d<sup>7</sup> 4s<sup>2</sup>), M<sup>+2</sup> (3d<sup>7</sup> 4s<sup>0</sup>) hence it has 3 unpaired electrons n= 3

$$\mu = \sqrt{n(n+2)} = \sqrt{3(3+2)} = 3.87 \text{ BM}$$

**39. The second ionisation enthalpy is high for Cr and Cu , why?**

**Ans:** The second ionisation enthalpy is unusually high values for Cr and Cu because when M<sup>+</sup> ion ionize to M<sup>+2</sup> ion , the d<sup>5</sup> and d<sup>10</sup> configurations of the M<sup>+</sup> ions (i.e Cr<sup>+</sup> or Cu<sup>+</sup>) are disrupted, with considerable loss of exchange energy .

**40. Why first ionisation enthalpy of Cr is lower than that of Zn ?**

**Ans:** IE1 of Cr is lower, because removal of an electron from Cr does not change the d ( $3d^5 4s^1$  to  $3d^5 4s^0$ ) configuration. Cr ( $z=24, 3d^5 4s^1$ )  $\square$  Cr<sup>+</sup> ( $3d^5 4s^0$ ) ----- IE1  
 IE1 value for Zn is higher, because removal of electron from 4s level needs more energy. Zn ( $z=30, 3d^{10} 4s^2$ ), Zn<sup>+</sup> ( $3d^{10} 4s^1$ ) ----- IE1  
 IE1 (Zn) > IE1 (Cr)

**41. Give two characteristics of transition metal alloys.**

**Ans:** The alloys are hard and have high melting points.

**42. What is the action of heat on potassium permanganate? Give equation.**

**Ans.** It decomposes at 513K to potassium manganate, manganese dioxide and oxygen.  
 $2\text{KMnO}_4 \rightarrow \text{K}_2\text{MnO}_4 + \text{MnO}_2 + \text{O}_2$

**43. What is the action of neutral or faintly alkaline permanganate solution on iodide? Give equation.**

**Ans.** Alkaline permanganate solution oxidize iodide to iodate.  
 $\text{I}^- + 2\text{MnO}_4^- + \text{H}_2\text{O} \rightarrow \text{IO}_3^- + 2\text{MnO}_2 + 2\text{OH}^-$

**44. Explain the oxidising action of acidified potassium dichromate on (iron(II) salts) Fe<sup>+2</sup> ions and write the ionic equations for the reaction.**

**Ans.** Acidified potassium dichromate oxidises iron(II) salts to iron(III).  
 $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{Fe}^{2+} \rightarrow 2\text{Cr}^{3+} + 6\text{Fe}^{3+} + 7\text{H}_2\text{O}$

**45. The transition metals generally form coloured compounds, why?**

**Ans.** The compounds of transition elements shows colour due to presence of unpaired electron & ability to undergo d-d transition.  
 When an electron from a lower energy d orbital is excited to a higher energy d orbital, the energy of excitation corresponds to the frequency of light absorbed. This frequency generally lies in the visible region.

**46. Give reason “ transition metals and their many compounds acts as good catalysts”.**

**Ans.** Transition metals and their many compounds acts as good catalysts, it is due to (i) partially filled (n-1) d orbital (ii) variable oxidation state and provide a suitable surface for the reaction to take place.

**47. Explain giving reason “transition metals form a large number of complex compounds”.**

**Ans.** Transition metals form a large number of complex compounds due to (i) Small size & high charge density of the ions of transition metals. (ii) presence of vacant d orbitals of suitable for bond formation.

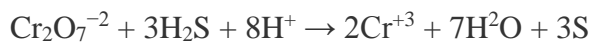
**48. What is the effect of increasing pH on a solution of potassium dichromate?**

**Ans.** On increasing the pH of the solution Potassium dichromate (orange) becomes potassium chromate (yellow)  $\text{Cr}_2\text{O}_7^{2-} + 2\text{OH}^- \rightarrow 2\text{CrO}_4^{2-} + \text{H}_2\text{O}$

**49. What happens when H<sub>2</sub>S is passed into potassium dichromate in acidic medium?**

**Give the equation.**

**Ans.** H<sub>2</sub>S gets oxidized to sulphur



**50. What is 'disproportionation' of an oxidation state ? Give one example of disproportionation reaction in aqueous solution.**

**Ans.** A particular oxidation state, which is relatively less stable compared to other oxidation states, undergoes disproportionation.

Manganese (VI) which is relatively less stable changes over to manganese (VII) and manganese (IV) in acid solution.



**51. What is lanthanoid contraction? Write any one consequence of lanthanoid contraction.**

**Ans.** Steady decrease in the size of lanthanides with increase in atomic number is known as lanthanoid contraction. Due to lanthanoid contraction radii of members of 3rd transition series are very much similar to corresponding members of 2nd series.

**52. Write any two consequences of lanthanoid contraction.**

**Ans.** Two consequences of lanthanoid contractions are (i) The radii of the members of the third transition series to be very similar to those of the corresponding members of the second series. Ex. The almost identical radii of Zr (160 pm) and Hf (159 pm) & Nb (146pm) & Ta (146pm) (ii) Difficulty in separation of lanthanoids due to similarity in chemical properties.

**53. Name the two series of f-block.**

**Ans.** The f-block consists of the two series, lanthanoids (the fourteen elements following lanthanum) and actinoids (the fourteen elements following actinium).

**54. The chemistry of actinoids is more complicated than lanthanoids. Why?**

**Ans.** The actinoids are radioactive elements having half lives varying. Some members can be prepared only in nanogram quantities. These facts render their study more difficult.

**55. Write two comparisons of variability in oxidation states of transition metals and non transition elements (p-block elements) ?**

**Ans.** 1. In transition elements, variable oxidation state differ from each other by unity, whereas in case of non transition elements, oxidation state differ by units of two. (For example Fe exhibits o.s of +2 and +3. Similarly copper exhibits two o.s of +1 and +2. On the other hand, Sn, Pb exhibit o.s of +2 and +4.)

2. In transition elements, higher o.s are more favoured in elements of higher atomic mass, whereas in p-block elements lower o.s are favoured by heavier members (due to inert pair

effect, For example Mo(VI) and W(VI) are more stable than Cr(VI). On the other hand Pb(II) is more stable than Sn(II)

**56. What happens when**

**(a) A lanthanoid reacts with dilute acids ?**

**(b) A lanthanoid reacts with water?**

**Ans.**(a) When lanthanoid reacts with dilute acids , it liberates hydrogen gas.

(b)When lanthanoid reacts with water , it forms lanthanoid hydroxide and liberate hydrogen gas.

**57. What is the gas liberated when**

**i) crystals of potassium permanganate is heated to 513K ?**

**ii) acidified potassium permanganate is treated with oxalate ion at 333K?**

**Ans.** i) When crystals of potassium permanganate is heated to 513K Oxygen (O<sub>2</sub>) gas is liberated .

ii) Acidified potassium permanganate when treated with oxalate ion at 333K liberates Carbon dioxide (CO<sub>2</sub>) gas.

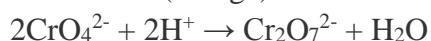
**58. What is the composition of mischmetall? Give its one use.**

**Ans.** The composition of mischmetall is lanthanoid metal (~ 95%) and iron (~ 5%) and traces of S, C, Ca and Al.

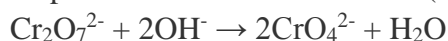
Mischmetall is used in Mg-based alloy to produce bullets, shell and lighter flint

**59. Show the interconversion of chromate and dichromate**

**Ans.** The chromates and dichromates are interconvertible in aqueous solution depending upon pH of the solution. At pH less than 7: Chromate (yellow) on adding acid becomes dichromate (orange)



At pH more than 7: Dichromate (orange) on adding base becomes Chromate (yellow)



**60.How does the neutral or faintly alkaline potassium permanganate solution react with (a) Iodide (b) thiosulphite? Write the ionic equations for the reactions**

**Ans.** In neutral or faintly alkaline solutions:

(a) The oxidation of iodide to iodate:  $2\text{MnO}_4^- + \text{H}_2\text{O} + \text{I}^- \longrightarrow 2\text{MnO}_2 + 2\text{OH}^- + \text{IO}_3^-$

(b) Thiosulphate is oxidised almost quantitatively to sulphate:



**61.Name the metal of the 1<sup>st</sup> row transition series that**

**Ans.** i) has highest value for magnetic moment

ii) has zero spin only magnetic moment in its +2 oxidation state.

iii) exhibit maximum number of oxidation states.

Ans. i) Chromium ii) Zinc iii) Manganese

**62. Transition metals form a large number of complex compounds. Give reason.**

**Ans.** Transition metals form complex compounds due to,

- i) small sizes of metal cations
- ii) their ionic charges and
- iii) availability of d orbitals for bond formation.

**63. Explain the trend in atomic size of 3d series of transition elements with reason.**

**Ans.** With increase in atomic number in 3d series - atomic size decreases (Sc to Cr), then remain almost constant (Cr to Cu) and increase slightly at the end (Cu to Zn).

Reason: In the beginning of the series the screening (or shielding effect) effect of a d electron is not that effective, hence the net electrostatic attraction between the nuclear charge and the outermost electron increases, hence atomic size radius decreases.

In the middle of the series, increase in nuclear charge and increase in screening effect balance each other. So atomic radii become almost constant.

Increase in atomic radii towards the end is due to the electro – electron repulsions causes the expansion of electron cloud.

**64. Explain trend in Ionisation Enthalpies of 3d series of transition elements.**

**Ans.** Ionisation enthalpy increase along each series of the transition elements from left to right. However many small variations, IE of Chromium is lower because removal of an electron from Chromium does not change in the d (3d<sup>5</sup> 4s<sup>1</sup> to 3d<sup>5</sup> 4s<sup>0</sup>) configuration. I.E value for Zn (3d<sup>10</sup> 4s<sup>2</sup>) is higher because an electron is removed from 4s level which needs more energy.

**65. How is potassium dichromate prepared from iron chromite ore?**

**Ans.** Potassium dichromate is manufactured from chromite ore (FeCr<sub>2</sub>O<sub>4</sub>).

(i) Chromite ore is fused (FeCr<sub>2</sub>O<sub>4</sub>) with sodium or potassium carbonate in free access of air to get sodium chromate.  $4\text{FeCr}_2\text{O}_4 + 8\text{Na}_2\text{CO}_3 + 7\text{O}_2 \rightarrow 8\text{Na}_2\text{CrO}_4 + 2\text{Fe}_2\text{O}_3 + 8\text{CO}_2$

(ii) The yellow solution of sodium chromate is filtered and acidified with sulphuric acid to give a solution from which orange sodium dichromate, Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> · 2H<sub>2</sub>O can be crystallised.

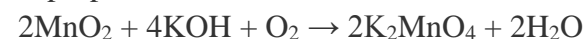


Potassium dichromate prepared by treating the solution of sodium dichromate with potassium chloride.  $\text{Na}_2\text{Cr}_2\text{O}_7 + 2\text{KCl} \rightarrow \text{K}_2\text{Cr}_2\text{O}_7 + 2\text{NaCl}$

Orange crystals of potassium dichromate crystallise out.

**66. Describe the preparation of potassium permanganate from manganous dioxide.**

**Ans.** Potassium permanganate is prepared by fusion of MnO<sub>2</sub> with an alkali metal hydroxide and an oxidising agent like KNO<sub>3</sub>. This produces the dark green K<sub>2</sub>MnO<sub>4</sub> which disproportionates in a neutral or acidic solution to give permanganate.

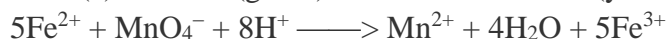




**67. How does the acidified permanganate solution react with (a) iron(II) ions (b) oxalic acid and (c) hydrogen sulphide? Write the ionic equations for the reactions**

**In acid solutions:**

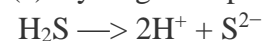
**Ans.** (a)  $\text{Fe}^{2+}$  ion (green) is converted to  $\text{Fe}^{3+}$  (yellow):



(b) Oxalate ion or oxalic acid is oxidised at 333 K:



(c) Hydrogen sulphide is oxidised, sulphur being precipitated:

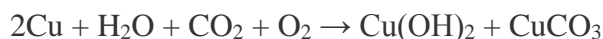


**1. Copper becomes green when exposed to moist air for a long period. This is due to:-**

- (1) the formation of a layer of cupric oxide on the surface of copper.
- (2) the formation of basic copper sulphate layer on the surface of the metal
- (3) the formation of a layer of cupric hydroxide on the surface of copper.
- (4) the formation of a layer of basic carbonate of copper on the surface of copper.

**Solution:**

copper becomes green when exposed to moist air for a long period of time because of the formation of a layer of basic carbonate of copper on the surface of copper.



Hence option (4) is the answer.

**2. Which one of the following exhibits the largest number of oxidation states?**

- (1) Mn(25)
- (2) V(23)
- (3) Cr (24)
- (4) Ti (22)

**Solution:**

Manganese can show 6 oxidation states from +2 to +7. It has 5 unpaired electrons in 3d orbitals and 2 electrons in the 4s orbitals.

Hence option (1) is the answer.

**3. The type of isomerism present in nitro- pentamine chromium (III) chloride is**

- (1) optical
- (2) linkage
- (3) ionization

(4) polymerisation

**Solution:**

The nitro group can attach to metal through nitrogen as (-NO<sub>2</sub>) or through oxygen as nitrito (-ONO). So isomerism in nitro-pentamine chromium (III) chloride is linkage isomerism.

Hence option (2) is the answer.

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

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

**Solution:**

Ferrous oxide is more basic in nature than ferric oxide. Ferrous compounds are less volatile since the ferrous compounds are more ionic. Ferrous compounds are relatively more ionic than the corresponding ferric compounds. Ferric compounds are less volatile than the corresponding ferrous compounds. So the statement (1) is incorrect.

Hence option (1) is the answer.

**5. Potassium dichromate when heated with concentrated sulphuric acid and a soluble chloride, gives brown-red vapours of:**

- (1) CrO<sub>3</sub>
- (2) Cr<sub>2</sub>O<sub>3</sub>
- (3) CrCl<sub>3</sub>
- (4) CrO<sub>2</sub>Cl<sub>2</sub>

**Solution:**



Potassium dichromate when heated with concentrated sulphuric acid and a soluble chloride, gives brown-red vapours of CrO<sub>2</sub>Cl<sub>2</sub>

Hence option (4) is the answer.

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

- (1) the 5f orbitals extend further from the nucleus than the 4f orbitals
- (2) the 5f orbitals are more buried than the 4f orbitals
- (3) there is a similarity between 4f and 5f orbitals in their angular part of the wave function
- (4) the actinoids are more reactive than the lanthanoids.

**Solution:**

Since the distance between the nucleus and 5f orbitals is more than the distance between the nucleus and 4f orbitals, the hold of the nucleus on valence electron decreases in actinides. So actinoids exhibit more number of oxidation states in general.

Hence option (1) is the answer.

**7. Which of the following is not formed when H<sub>2</sub>S reacts with acidic K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> solution?**

- (1) K<sub>2</sub>SO<sub>4</sub>
- (2) Cr<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>
- (3) S
- (4) CrSO<sub>4</sub>

**Solution:**

When H<sub>2</sub>S reacts with acidic K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> solution



Hence option (4) is the answer.

**8. The lanthanide contraction is responsible for the fact that**

- (1) Zr and Y have about the same radius
- (2) Zr and Nb have a similar oxidation state
- (3) Zr and Hf have about the same radius
- (4) Zr and Zn have the same oxidation state.

**Solution:**

The pairs of elements such as Zr-Hf, Mo-W, Nb-Ta, etc possess almost the same properties.

Due to lanthanide contraction, in each vertical column of transition elements, the elements of second and third transition series resemble each other more closely than the elements of first and second transition series on account of lanthanide contraction.

Hence option (3) is the answer.

**9. Which of the following statements is false?**

- (1) has a Cr – O – Cr bond
- (2) is tetrahedral in shape
- (3) Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> is a primary standard in volumetry
- (4) Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> is less soluble than K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>

**Solution:**

Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> is a secondary standard in volumetry. Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> is more soluble than K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>

Hence option (3) and (4) is the answer.

**10. In context with the transition elements, which of the following statements is incorrect?**

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

**Solution:**

In highest oxidation states, transition metals form anionic complexes. So statement (4) is incorrect.

Hence option (4) is the answer.

**11. The element that usually does not show variable oxidation states is**

- (a) V
- (b) Ti
- (c) Cu
- (d) Sc

**Solution:**

Sc usually does not show variable oxidation states.

Hence option (4) is the answer.

**12. The pair that has similar atomic radii is**

- (1) Mn and Re
- (2) Ti and Hf
- (3) Sc and Ni
- (4) Mo and W

**Solution:**

Because of lanthanoid contraction, the atomic radii of the elements of the second and third transition series are nearly the same. Hence option (4) is the answer.

**13. In the context of the lanthanoids, which of the following statement is not correct?**

- (1) There is a gradual decrease in the radii of the members with increasing atomic number in the series.
- (2) All the members exhibit a +3 oxidation state.
- (3) Because of similar properties, the separation of lanthanoids is not easy.

(4) Availability of 4f electrons results in the formation of compounds in +4 state for all the members of the series.

**Solution:**

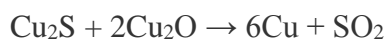
Availability of 4f electrons does not result in the formation of compounds in +4 state for all the members of the series. Statement (4) is wrong.

Hence option (4) is the answer.

**14. Heating mixture of Cu<sub>2</sub>O and Cu<sub>2</sub>S will give**

- (a) Cu + SO<sub>2</sub>
- (b) Cu + SO<sub>3</sub>
- (c) CuO + CuS
- (d) Cu<sub>2</sub>SO<sub>3</sub>

**Solution:**



Hence option (1) is the answer.

**15. Knowing that the chemistry of lanthanoids (Ln) is dominated by its +3 oxidation state, which of the following statements is incorrect?**

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

**Solution:**

Ln<sup>3+</sup> compounds are usually coloured in the solid-state as well as in an aqueous solution. Colour appears because of the presence of unpaired f-electrons which undergo f-f transition.

Hence option (3) is the answer.

**16. The atomic numbers 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 ionisation enthalpy?**

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

**Solution:**

The second ionisation potential values of Cu and Cr are sufficiently higher than those of neighbouring elements. This is due to the electronic configuration of  $\text{Cu}^+$  which is  $3d^{10}$  and of  $\text{Cr}^+$  which is  $3d^5$ .

Hence option (2) is the answer.

**Q1. What do you mean by d-d transition?**

**Sol.** In the transition metal particles, the electrons can be advanced from one energy level to another energy level in a similar d-subshell. This process is called d-d-transition. By this property just transition elements indicates color.

**Q2. What are transition elements and why are they called so?**

**Sol.** The elements which have mostly filled d-orbitals either in ground state or in at least one of their oxidation state are called d-block elements or transition elements. They are called so on the grounds that their properties are intermediate between s-block elements and p-block elements. They are more electropositive than p-block elements however less electropositive than s-block elements. They are all metals.

**Q3. What is meant by transition elements?**

**Sol.** Transition elements imply their properties are intermediate between s-block elements and p-block elements. They are more electropositive than p-block elements however less electropositive than s-block elements. They are all metals.

**Q4. How reactive are transition elements?**

**Sol.** The transition metals are put in the middle point of the periodic table, between groups 2 and 3. They are for the most part hard and thick, and less reactive than the alkali metals. Iron, copper, silver and gold are vital transition metals.

**Q5. What are the advantages of CuO over other transition metal oxides in the field of photocatalysis?**

**Sol.** The photocatalytic effect of CuO nanoparticles presents limitations in terms to their quick recombination of photogenerated electron-hole pair.

**Q6. Please suggest the procedure for synthesis of transition metal complexes of hydroxycinnamic acids?**

**Sol.** For the synthesis of complexes of transition metals with substituted hydroxycinnamic acids, to be specific, p-coumaric acid and ferulic acid.

**Q7. Why is  $\text{VO}_2$  a thermochromic material? Are there any other transition metal oxide which show same property?**

**Sol.** it exist lots of other transition metal oxide exhibiting thermochromism. In case of  $\text{VO}_2$ , it is a metal-insulator transition, which is widely studied.

You have similar mechanisms in cobaltite and nickelate perovskite ( $\text{RENiO}_3$  and  $\text{RECoO}_3$ ; with RE= La, Pr, Nd and Sm).

Dr. A. K. Ghosh