UNIT – 4 TRNSITION AND INNER TRANSITION ELEMENTS

I. CHOOSE THE CORRECT ANSWER

1. Sc(Z=21) is a transition element but Zinc (z=30) is not because
    a) both Sc^{3+} and Zn^{2+} ions are colourless and form white compounds.
    b) in case of Sc, 3d orbital are partially filled but in Zn these are completely filled
    c) last electron as assumed to be added to 4s level in case of zinc
    d) both Sc and Zn do not exhibit variable oxidation states
2. Which of the following d block element has half filled penultimate d sub shell as well as half filled valence sub shell?
    a) Cr b) Pd c) Pt d) none of these
3. Among the transition metals of 3d series, the one that has highest negative (M^{2+}/M) standard electrode potential is
    a) Ti b) Cu c) Mn d) Zn
4. Which one of the following ions has the same number of unpaired electrons as present in V^{3+}?
    a) Ti^{3+} b) Fe^{3+} c) Ni^{2+} d) Cr^{3+}
5. The magnetic moment of Mn^{2+} ion is
    a) 5.92BM b) 2.80BM c) 8.95BM d) 3.90BM
6. Which of the following compounds is colourless?
    a) Fe^{3+} b) Ti^{4+} c) Co^{2+} d) Ni^{2+}
7. The catalytic behaviour of transition metals and their compounds is ascribed mainly due to
    a) their magnetic behaviour b) their unfilled d orbitals
    c) their ability to adopt variable oxidation states d) their chemical reactivity
8. The correct order of increasing oxidizing power in the series
    a) $VO_2^+ < Cr_2O_7^{2-} < MnO_4^-$ b) $Cr_2O_7^{2-} < VO_2^+ < MnO_4^-$
    c) $Cr_2O_7^{2-} < MnO_4^- < VO_2^+$ d) $MnO_4^- < Cr_2O_7^{2-} < VO_2^+$
9. The alloy of copper that contain Zinc is
    a) Monel metal b) Bronze c) bell metal d) brass
10. Which of the following does not give oxygen on heating?
    a) $K_2Cr_2O_7$ b) $(NH_4)_2Cr_2O_7$ c) $KClO_3$ d) $Zn(ClO_3)_2$
11. In acid medium, potassium permanganate oxidizes oxalic acid to
    a) oxalate b) Carbon dioxide c) acetate d) acetic acid
12. Which of the following statements is not true?
    a) on passing H_2S, through acidified $K_2Cr_2O_7$ solution, a milky colour is observed.
    b) $Na_2Cr_2O_7$ is preferred over $K_2Cr_2O_7$ in volumetric analysis
    c) $K_2Cr_2O_7$ solution in acidic medium is orange in colour
    d) $K_2Cr_2O_7$ solution becomes yellow on increasing the PH beyond 7
13. Permanganate ion changes to ________ in acidic medium
    a) MnO_4^{2-} b) Mn^{2+} c) Mn^{3+} d) MnO_2
14. A white crystalline salt (A) react with dilute HCl to liberate a suffocating gas (B) and also forms a yellow precipitate . The gas (B) turns potassium dichromate acidified with dil H2SO4 to a green coloured solution(C). A,B and C are respectively
    a) Na_2SO_3 , SO_2 , $Cr_2(SO_4)_3$ b) $Na_2S_2O_3$, SO_2 , $Cr_2(SO_4)_3$
    c) Na_2S , SO_2 , $Cr_2(SO_4)_3$ d) Na_2SO_4 , SO_2 , $Cr_2(SO_4)_3$
15. MnO_4^- react with Br^- in alkaline PH to give
    a) BrO_3^-, MnO_2 b) Br_2, $MnO4^{2-}$ c) Br_2, MnO_2 d) BrO^-, MnO_4^{2-}
16. How many moles of I2 are liberated when 1 mole of potassium dichromate react with potassium iodide?
    a) 1 b) 2 c) 3 d) 4

17. The number of moles of acidified KMnO4 required to oxidize 1 mole of ferrous oxalate(FeC_2O_4) is
    a) 5 b) 3 c) 0.6 d) 1.5
18. When a brown compound of Mn (A) ids treated with HCl , it gives a gas (B) . The gas (B) taken in excess reacts with NH3 to give an explosive compound (C). The compound A, B and C are
    a) MnO_2 , Cl_2 , NCl_3 b) MnO, Cl_2 , NH_4Cl
    c) Mn_3O_4 , Cl_2, NCl_3 d) MnO_3, Cl_2 , NCl_2
19. Which one of the following statements related to lanthanons is incorrect?
    a) Europium shows +2 oxidation state.
    b) The basicity decreases as the ionic radius decreases from Pr to Lu.
    c) All the lanthanons are much more reactive than aluminium.
    d) Ce^{4+} solutions are widely used as oxidising agents in volumetric analysis.
20. Which of the following lanthanoid ions is diamagnetic?
    a) Eu^{2+} b) Yb^{2+} c) Ce^{2+} d) Sm^{2+}
21. Which of the following oxidation states is most common among the lanthanoids?
    a) 4 b) 2 c) 5 d) 3
22. **Assertion :** Ce^{4+} is used as an oxidizing agent in volumetric analysis.
    Reason: Ce^{4+} has the tendency of attaining +3 oxidation state.
    a) Both assertion and reason are true and reason is the correct explanation of assertion.
    b) Both assertion and reason are true but reason is not the correct explanation of assertion.
    c) Assertion is true but reason is false.
    d) Both assertion and reason are false.
23. The most common oxidation state of actinoids is
    a) +2 b) +3 c) +4 d) +6
24. The actinoid elements which show the highest oxidation state of +7 are
    a) Np, Pu ,Am b) U, Fm, Th c) U, Th, Md d) Es, No, Lr
25. Which one of the following is not correct?
    a) $La(OH)_2$ is less basic than $Lu(OH)_3$
    b) In lanthanoid series ionic radius of Ln^{3+} ions decreases
    c) La is actually an element of transition metal series rather than lanthanide series
    d) Atomic radii of Zr and Hf are same because of lanthanide contraction.

ANSWER

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
b	***a***	***a***	***c***	***a***	***b***	***c***	***a***	***d***	***b***
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
b	***b***	***b***	***a***	***a***	***c***	***c***	***a***	***c***	***b***
21	**22**	**23**	**24**	**25**					
d	***a***	***c***	***a***	***a***					

Answer the following questions:

1. What are transition metals? Give four examples.

Transition metal as an element whose atom has an incomplete d sub shell or which can give rise to cations with an incomplete d sub shell. Example : Iron, Cobalt, Nickel, Copper.

2. Explain the oxidation states of 3d series elements.

The energy difference between the ns and the (n-1)d orbitals is very less. So they show variable oxidation state.

At the beginning +3 is stable. Ex. Sc^{+3}

At the end +2 is stable. Ex. Zn^{+2}

Copper shows +1 and +2.

Scandium show only +3.

Manganese shows +2 to +7 oxidation state.

Iron show +2 and +3 oxidation states.

Mn^{+2} is more stable than $Mn^{+3.}$ Because Mn^{+2} is having half filled stable d^5 configuration.

3. What are inner transition elements?

The elements in which the extra electron enters (n-2)f orbitals are called f-block elements. These elements are also called as inner transition elements because they form a transition series within the transition elements.

In the inner transition elements there are two series of elements.

1) Lanthanoids (Previously called lanthanides) 2) Actinoids (Previously called actinides)

4. Justify the position of lanthanides and actinides in the periodic table.

The actual position of Lanthanoids in the periodic table is at group number 3 and period number 6.However, in the sixth period after lanthanum, the electrons are preferentially filled in inner 4f sub shell and these fourteen elements following lanthanum show similar chemical properties. Therefore these elements are grouped together and placed at the bottom of the periodic table. This position can be justified as follows.

1. Lanthanoids have general electronic configuration [Xe] $4f^{2-14}5d^{0-1}6s^2$
2. The common oxidation state of lanthanoides is +3
3. All these elements have similar physical and chemical properties.

Similarly the fourteen elements following actinium resemble in their physical and chemical properties. If we place these elements after Lanthanum in the periodic table below 4d series, the properties of the elements belongs to a group would be different and it would affect the proper structure of the periodic table. Hence a separate position is provided to the inner transition elements**.**

5. What are actinides? Give three examples.

The fourteen elements following actinium ,i.e., from thorium (Th) to lawrentium (Lr) are called actinoids. Plutonium(Pu), Neptunium(Np), Uranium(U).

6. Why Gd^{3+} is colourless?

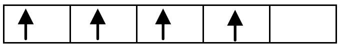
Electronic configuration of Gd is [Xe]$4f^75d^16s^2$

Electronic configuration of Gd^{3+} is [Xe] $4f^75d^06s^0$

In Gd^{3+}, no electrons are there in outer 5d orbitals.d-d transition is not possible. So Gd^{3+} is colourless.

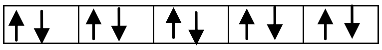
7. Explain why compounds of Cu^{2+} are coloured but those of Zn^{2+} are colourless.

Cu^{2+} : $3d^4$:



4 unpaired electrons , so coloured.

Zn^{2+} : $3d^{10}$:



No unpaired electrons, so colourless.

8. Describe the preparation of potassium dichromate.

Extraction of Potassium dichromate from its ore:

1. Ore: Chromite - $FeO.Cr_2O_3$

2. Conversion of chrome iron ore to sodium chromate

$$4FeO.Cr_2O_3 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2\uparrow$$

3. Conversion of Na_2CrO_4 to $Na_2Cr_2O_7$

$$2Na_2CrO_4 + H_2SO_4 \rightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$$

4.Conversion of sodium dichromate into potassium dichromate

$$Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$$

9. What is lanthanide contraction and what are the effects of lanthanide contraction?

As we move across 4f series, the atomic and ionic radii of lanthanoids show gradual decrease with increase in atomic number. This decrease in ionic size is called lanthanoid contraction.

Consequences of lanthanoid contraction:

1) As we move from Ce^{3+} to Lu^{3+}, the basic character of Ln^{3+} ions decreases. Due to the decrease in the size of Ln^{3+} ions, the ionic character of Ln-OH bond decreases (covalent character increases) which results in the decrease in the basicity.

2) Because of this very small change in radii of lanthanoids, their chemical properties are quite similar.

3) The elements of the second and third transition series resemble each other more closely than the elements of the first and second transition series.

10. Complete the following:

a) $MnO_4^{2-} + H^+ \longrightarrow ?$

$3MnO_4^{2-} + 4H^+ \longrightarrow 2MnO_4^- + MnO_2 + 2H_2O$

b) $C_6H_5CH_3 \xrightarrow{\text{acidified-KMnO}_4} ?$

$C_6H_5CH_3 \xrightarrow{\text{acidified -KMnO}_4} C_6H_5COOH$

c) $MnO_4^- + Fe^{2+} \longrightarrow ?$

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

d) $KMnO_4 \xrightarrow{\text{Red hot}} ?$

$2KMnO_4 \xrightarrow{\text{Red hot}} K_2MnO_4 + MnO_2 + O_2$

e) $Cr_2O_7^{2-} + I^- + H^+ \longrightarrow ?$

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

f) $Na_2Cr_2O_7 + KCl \longrightarrow ?$

$Na_2Cr_2O_7 + 2KCl \longrightarrow K_2Cr_2O_7 + 2NaCl$

11. What are interstitial compounds?

An interstitial compound or alloy is a compound that is formed when small atoms like hydrogen, boron, carbon or nitrogen are trapped in the interstitial holes in a metal lattice. Ex : TiC, $ZrH_{1.92}$, Mn_4N.

12. Calculate the number of unpaired electrons in Ti^{3+}, Mn^{2+} and calculate the spin only magnetic moment.

Ion	Configuration	n	$\mu_s = \sqrt{n(n+2)}\ \mu_B$	μ_s (observed)
Ti^{3+}	d^1	1	1.73μ B	Paramagnetic
Mn^{2+}	d^5	5	5.91μ B	Paramagnetic

13. Write the electronic configuration of Ce^{4+} and Co^{2+}.

Electronic Configuration of Ce^{4+} (Z=58) = $[Xe]\ 4f^{0}5d^{0}6s^{0}$

Electronic configuration of Co^{2+} (Z=27) = $[Ar]3d^{7}4s^{0}$

14. Explain briefly how +2 states becomes more and more stable in the first half of the first row transition elements with increasing atomic number.

$E_0\ M^{2+}/M$ for 3d series upto Mn is highly negative. Therefore +2 states become more stable in the first half of the first row transition elements.

15. Which is more stable? Fe^{3+} or Fe^{2+} - explain.

Electronic Configuration.

Fe^{3+} : $[Ar]\ 3d^5$ Fe^{2+} : $[Ar]\ 3d^6$

Fe^{3+} ion has half filled d orbital which is more stable than partially filled d orbital of Fe^{2+}.

16. Explain the variation in $E_0\ M^{3+}/M^{2+}$ 3d series.

The standard electrode potential for the M^{3+}/M^{2+} half cell gives the relative stability between M^{3+} and M^{2+}. The negative values for titanium, vanadium and chromium indicate that the higher oxidation state is preferred. If we want to reduce such a stable Cr^{3+} ion, strong reducing agent which has high negative value for reduction potential like metallic zinc (E=-0.76V) is required.

The high reduction potential of Mn^{+3} / Mn^{2+} indicates Mn^{2+} is more stable than Mn^{3+}. For Fe^{3+} / Fe^{2+} the reduction potential is 0.77V, and this low value indicates that both Fe^{3+} and Fe^{2+} can exist under normal conditions.

17. Compare lanthanides and actinides.

S.No.	Lanthanoids	Actinoids
1	Orbital Differentiating electrons enters in 4f orbital	Orbital Differentiating electrons enters in 5f orbital.
2	Higher Binding energy of 4f orbitals are higher.	Lower Binding energy of 5f orbitals are lower.
3	They show less tendency to form complexes.	They show greater tendency to form complexes.
4	Most of the lanthanoids are colourless.	Most of the actinoids are coloured. Eg. U^{3+} (Red), U^{4+}(Green),UO_2^{2+} (Yellow)
5	They do not form oxo cations.	They do not form oxo cations such $U0_2^{2+}$,NpO_2^{2+}.

18. Explain why Cr^{2+} is strongly reducing while Mn^{3+} is strongly oxidizing.

Cr^{2+} is reducing as its configuration changes from d^4 to d^3, the latter having a half filled t_{2g} level. On the other hand, the change from Mn^{2+} to Mn^{3+} results in the half – filled (d^5) configuration which has extra stability.

19. Compare the ionization enthalpies of first series of the transition elements.

Ionization energy of transition elements is intermediate between those of s and p block elements. As we move from left to right in a transition metal series, the ionization enthalpy increases as expected. This is due to increase in nuclear change corresponding to the filling of d electrons.

20. Actinoid contraction is greater from element to element than the Lanthanoid contraction, why?

Actinoid contraction is greater is due to poor shielding effect by 5f electrons as compared to that by 4f electrons in Lanthanoids.

21. Out of $Lu(OH)_3$ and $La(OH)_3$ which is more basic and why?

$La(OH)_3$ is more basic because of the following reasons,

La $(OH)_3$	**$Lu(OH)_3$**
1)1)Size of La^{3+} is large	1) Size of Lu^{3+} is small
2) Ionic characters of La-OH bond is high	2) Ionic characters of Lu-OH bond is low
3) Covalent character of La-OH bond is low.	3) Covalent character of Lu-OH bond is high.
4) $La(OH)_3$ is more basic.	4) $Lu(OH)_3$ is less basic.

22. Why europium (II) is more stable than Cerium (II)?

Eu^{2+} is more stable

Europium (II) is $[Xe]4f^7 5d^0 6s^0$

Cerium (II) is $[Xe]4f^1 5d^1 6s^0$

In Eu^{2+}, 4f sub shell is half filled, Hence Eu^{2+} is more stable.
In Ce^{2+}, 4f and 5d sub shells are partially filled. Hence Ce^{2+} is less stable.

23. Why do Zirconium and Hafnium exhibit similar properties?

Zirconium and Hafnium exhibit similar properties due to Lanthanoid contraction.

Element	**Series**	**Atomic radius**
Zr	4d series	145 pm
Hf	5d Series	144 pm

24. Which is stronger reducing agent Cr^{2+} or Fe^{2+}?

If the standard electrode potential (E_O) of a metal is large and negative, the metal is a powerful reducing agent, because it loses electrons easily.

$Cr^{2+} + 2e^- \ Cr \ E_0 = -0.91V$

$Fe^{2+} + 2e^- \ Fe \ E_0 = -0.44V$

Since Cr^{2+} has larger negative value of E_0, Cr^{2+} is a stronger reducing agent than Fe^{2+}.

25. The $E_0\ M^{2+}/M$ value for copper is positive. Suggest a possible reason for this.

$E_0\ M^{2+}/M$ for any metal depends upon the sum of the enthalpy changes taking place in the following steps.

$M_{(s)} + \Delta H_{(atom)} \longrightarrow M(g)$ ($\Delta H_{(atom)}$ = Enthalpy of atomization)

$M_{(g)} + \Delta H(IE) \longrightarrow M^{2+} + 2e^-$ ($\Delta H(IE)$ =Ionization Enthalpy)

$M_{(g)}^{2+} + H_2O \longrightarrow M_{(aq)}^{2+} + \Delta H_{(HYD)}$ ($\Delta H_{(HYD)}$ = Hydration Enthalpy)

Copper possesses a high enthalpy of atomization and low enthalpy of hydration.

Hence $E_0 Cu^{2+}/Cu$ is positive.

26. predict which of the following will be coloured in aqueous solution Ti^{2+} , V^{3+} Sc^{4+}, Cu^+ ,Sc^{3+}, Fe^{3+}, Ni^{2+} and Co^{3+}

Ti^{2+} : d^2 , Two unpaired electrons, so coloured.
Sc^{4+} : p^5, one unpaired electron, so coloured.
Sc^{3+} : d^0, No Unpaired electrons, so colourless.
Ni^{2+} :d^8, Two unpaired electrons, so coloured.

V^{3+} :d^2, Two unpaired electrons, so coloured.
Cu^+ : d^{10}, No Unpaired electrons, so colourless.
Fe^{3+} : d^5, No Unpaired electrons, so colourless.
Co^{3+}:d^6, Four unpaired electrons, so coloured.

27. Describe the variable oxidation state of 3d series elements.

The first transition metal scandium exhibits only +3 oxidation state, but all other transition elements exhibit variable oxidation states by losing electrons from (n-1)d orbital and ns orbitals as the energy difference between them is very small.

The first and last elements show less number of oxidation states and the middle elements with more number of oxidation states.

3d Series Elements	**Oxidation States**
Sc	+3
Mn	From +2 to +7
Cu	+1 and +2

28. Which metal in the 3d series exhibits +1 oxidation state most frequently and why?

Copper exhibits +1 oxidation state in the 3d series.

Because, Electronic configuration of Cu = [Ar] $3d^{10}4s^1$

It can easily lose $4s^1$ electron to get stable $3d^{10}$ configuration.

Hence, it exhibits +1 oxidation state.

29. Why first ionization enthalpy of chromium is lower than that of zinc?

Chromium (Z=24), [Ar] $3d^5\ 4s^1$

It can easily lose $4s^1$ electron to give stable half filled ($3d^5$) configuration. Hence first ionization enthalpy of chromium is less.

Zinc (Z=30), [Ar] $3d^{10}4s^2$

It is difficult to remove one electron from $4s^2$ (completely filled). Hence first ionization enthalpy of zinc is comparatively more.

30. Transition metals show high melting points why?

a) The melting-points of the transition metals are high due to the **3d electrons** being available for metallic bonding.

b) This strength of the bond is due to the **presence of unpaired or delocalized electrons** in the outer most shell of the atom

c)The **enthalpies of atomization** and the densities of transition elements are also high that leads to high boiling and melting points.

ONE MARK FROM INSIDE THE LESSON

1. Most of the transition metal ions are coloured, because of the ____________
a) Presence of unpaired electrons b) Energy gap between two energy levels is very small.
c) Both (a) and (b) d) Neither (a) nor (b)

2. Identify the paramagnetic specie
a) Cu^+ b) Cr^+ c) MnO_4 d) Zn^{2+}

3. Which of the following is coloured due to charge transfer?
a) MnO_4^- b)CrO_4^{2-} c)Cu_2O d) all of these

4. Which of the following statements is correct for 3d-transition element?
a) all metals except Zn and Sc form ‘MO’ oxide
b) all metals except Sc forms ‘MO’ oxide
c) all metals except Zn forms ‘MO’ oxide
d) all metals except Mn forms ‘MO’ oxide

5. The reaction of aqueous $KMnO_4$ with H_2O_2 in acidic condition gives
a) Mn^{4+} and MnO_2 b) Mn^{4+} and O_2 c) Mn^{2+} and O_2 d) Mn^{3+} and O_2

6. On oxidation with $KMnO_4$ in acidic medium,SO_2 is oxidised to_________
a)SO_2 b)H_2SO_4 c)SO_3^{2-} d)H_2S

7. Value of magnetic moment of a divalent metal ion is 5.92 BM. Total number of electron in its atom would be___________
a) 24 b) 25 c)26 d)27

8. In chromyl chloride test, A____________ precipitate of lead chromate is obtained.
a) White b) Red c) Yellow d) Blue

9. Equivalent weight of $KMnO_4$ in acidic medium is ___________
a) 3.16 b) 31.6 c) 158 d) 52.67

10. The catalytic activity of transition metals is due to ____________
a) The formation of variety of oxidation states
b) The formation of intermediate products
c) The capability of forming interstitial compounds
d) All the above.

11. The common oxidation state for lanthanides is_________
a) +3 b)-3 c) 0 d) +2

12. ___________ is known as Bayer’s reagent.
a) Hot dilute alkaline $KMnO_4$ b) Cold dilute alkaline $KMnO_4$
c) Hot conc. Acidic $KMnO_4$ d) Cold conc. Acidic $KMnO_4$

13. A mixture of $TiCl_4$ and trialkyl aluminium is __________
a) Hydroformylation of obfine. b) Zeigler-Natta catalyst
c) Interstitial compounds d) Ferromagnetic

14. The colour of UO_2^{2+} is
a) red b) green c) yellow d) pink

15. The reagent used for detecting unsaturation
a) Bayer’s reagent b) Tollen’s reagent c) Fenton’s reagent d) Schiff’s reagent

16. The chemical formula for pyrolusite
a) $KMnO_4$ b) K_2MnO_4 c) MnO_2 d) $K_2Cr_2O_7$

17. Equivalent weight of $KMnO_4$ in acid medium
a) 31.6 b) 158 c)52.67 d) 316

18. Permanganate ion has ....l geometry.
a) Pentagonal b) Tetrahedral c) Trigonal bipyramidal d) T-shape

19. Mostly higher oxides of transition metals are .... in nature.
a) acidic b) basic c) Neutral d) Amphoteric

20. Hydroformylation of olefins catalysed by
a) Rh / Ir complex b) $Co_2(CO)_9$ c) V_2O_5 d) $Co_2(CO)_8$

ANSWER

1	2	3	4	5	6	7	8	9	10
c	*b*	*d*	*b*	*c*	*b*	*b*	*c*	*b*	*d*
11	12	13	14	15	16	17	18	19	20
a	*b*	*b*	*c*	*a*	*c*	*a*	*b*	*a*	*d*

ADDITIONAL QUESTIONS AND ANSWERS

1. Write a note about Diamagnetism.

Materials with no elementary magnetic dipoles are diamagnetic, in other words a species with all paired electrons exhibits diamagnetism. This kind of materials are repelled by the magnetic field because the presence of external magnetic field, a magnetic induction is introduced to the material which generates weak magnetic field that oppose the applied field.

2. Why transition metals form number of alloys ?

Atomic sizes of transition metals are similar and one metal atom can be easily replaced by another metal atom from its crystal lattice to form an alloy.

3. Why transition metal and its compound act as good catalyst?

Transition metal has energetically available d orbitals.

d-orbitals can accept electrons from reactant molecule and form bond with reactant molecule using its d electron.

4. Why transition elements form complexes?

i. Transition metal ions are small and highly charged

ii. They have vacant low energy orbitals to accept an electron pair donated by other group.

Examples: $[Fe(CN)_6]^{4-}$, $[Co(NH_3)_6]^{3+}$, etc..

5. Under what oxidation state do transition metals form ionic oxide and covalent oxides?

Metals in lower oxidation state form ionic oxides.

Metals in higher oxidation state form covalent oxides

Example Mn_2O_7 is covalent. Oxidation state is +7.

6. Zn, Cd and Hg do not have partially filled d-orbitals why they are treated as transition elements?

They are treated as transition elements because their properties are an extension of the properties of the respective transition elements.

7. Give reason for the slight increase in atomic radius of Zn

The **d** orbitals of Zn contain 10 electrons in which the repulsive interaction between the electrons is more than the effective nuclear charge and hence the orbitals slightly expand and atomic radius slightly increases.

8. What are the properties of Interstitial compound?

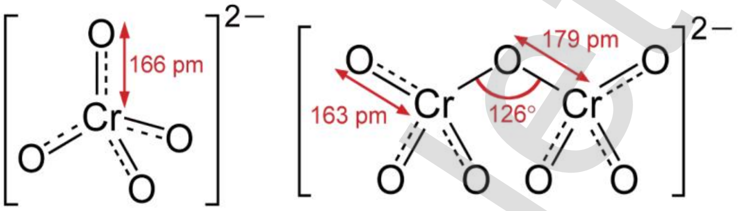
i.They are hard and show electrical and thermal conductivity

ii. They have high melting points higher than those of pure metals
iii. Transition metal hydrides are used as powerful reducing agents
iv. Metallic carbides are chemically inert.

9. What is Hume- Rothery rule to form a substitute alloy?

i. The difference between the atomic radius of solvent and solute is less than 15%
ii. Both the solvent and solute must have the same crystal structure and valence.
iii. The eletronegativity difference between solvent and solute must be close to zero.

10. Draw the structure of Dichromate ion.



11. What is Chromyl chloride test?

When potassium dichromate is heated with any chloride salt in the presence of Conc-H_2SO_4, orange red vapours of chromyl chloride (CrO_2Cl_2) is evolved. This reaction is used to confirm the presence of chloride ion in inorganic qualitative analysis.

$$K_2Cr_2O_7 + 4NaCl + H_2SO_4 \longrightarrow 2KHSO_4 + 4NaHSO_4 + \underset{\textbf{Chromyl chloride}}{2CrO_2Cl_2\uparrow} + 3H_2O$$

12. Write the uses of potassium dichromate:

1. It is used as a strong oxidizing agent.
2. It is used in dyeing and printing.
3. It used in leather tanneries for chrome tanning.
4. It is used in quantitative analysis for the estimation of iron compounds and iodides.

13. What is the action of heat on potassium permanganate?

When heated, potassium permanganate decomposes to form potassium manganate and manganese dioxide.

$$2KMnO_4 \longrightarrow 2K_2MnO_4 + MnO_2 + O_2$$

14. How neutral $KMnO_4$ oxidizes thio sulphate ion? Give equation?

Neutral $KMnO_4$ oxidizes thio sulphate into sulphate

$$8MnO_4^- + 3S_2O_3^{2-} + H_2O \longrightarrow 6SO_4^{2-} + 8MnO_2 + 2\,OH^-$$

15. What is Bayer's reagent?

Cold dilute alkaline KMnO4 is known as Bayer's reagent. It is used to oxidise alkenes into diols.

For example: Ethylene can be converted into ethylene glycol and this reaction is used as a test for unsaturation.

16. Uses of potassium permanganate:

1. It is used as a strong oxidizing agent.
2. It is used for the treatment of various skin infections and fungal infections of the foot.
3. It used in water treatment industries to remove iron and hydrogen sulphide from well water.
4. It is used as a Bayer's reagent for detecting unsaturation in an organic compound.
5. It is used in quantitative analysis for the estimation of ferroussalts, oxalates, hydrogen peroxide and iodides.

17. In first transition series from Sc to V atomic radius decreases, thereafter up to Cu atomic radius

nearly the same. Why ?

The added 3d electrons only partially shield the increased nuclear charge and hence the effective nuclear change increases slightly. At the same time the extra electrons added to the 3d sub shell strongly repel the 4s electron These two forces are operated in opposite direction As they tend to balance each other it leads to constancy in atomic radius

18. a) What is the oxidation state of chromium in chromate and dichromate ion?
b) Which is predominant in alkaline and acidic solution?

a) In both chromate and dichromate ion, oxidation state of chromium is +6

b) In aqueous solution chromate and dichromate ions are inter convertible.
In alkaline solution chromate ion is predominant.
In acidic solution dichoromate ion is predominant.

19. Which is more acidic in nature MnO (Mn^{2+}) or Mn_2O_7 (Mn^{7+}) why?

Mn_2O_7 is more acidic in nature. Acidic strength increases with increase in oxidation state of the element. In higher oxidation state there is no scope for further loss of electron, rather it can accept electrons. So it is more acidic in nature.

20. Classify the following oxides as acidic, basic and amphoteric oxides?

i. CrO ii. Cr_2O_3 iii.CrO_3

i.CrO − Basic oxide
ii.Cr_2O_3 − Amphoteric oxide
iii. CrO_3 − Acidic oxide

21. Calculate spin magnetic moment of Co^{2+}?

Electronic configuration of Co^{2+} **:** [Ar] $3d^7$
Number of unpaired electrons n=3

Magnetic moment $\mu_s = \sqrt{n(n+2)}$
$= \sqrt{3(3+2)}$
$= \sqrt{15} = 3.87$ BM

22. Write a note about the Oxidation state of lanthanoids and Actinoids.

The common oxidation state of Lanthanoids is +3. In addition to that some of the Lanthanoids also show either +2 or +4 oxidation states.

Like Lanthanoids, the most common state of Actinoids is +3. In addition to that Actinoids show variable oxidation states such as +2 , +3 , +4 ,+5,+6 and +7.

23. What is the Action of con -H_2SO_4 with Potassium permanganate?

On treating with cold con- H_2SO_4, it decomposes to form manganese heptoxide, which subsequently decomposes explosively.

$$2KMnO_4 + \underset{\textbf{(cold)}}{2H_2SO_4} \longrightarrow Mn_2O_7 + 2KHSO_4 + H_2O$$

$$Mn_2O_7 \longrightarrow 2MnO_2 + 3O_2$$

But with hot conc H_2SO_4, potassium permanganate give MnSO4

$$4KMnO_4 + \underset{\textbf{(hot)}}{6H_2SO_4} \longrightarrow 4MnSO_4 + 2K_2SO_4 + 6H_2O + 5O_2$$

24. Complete the reaction:

a) $2MnO_2 + 4KOH + O_2 \longrightarrow$

$2MnO_2 + 4KOH + O_2 \longrightarrow 2\,K_2MnO_4 + 2H_2O$

***potassium manganate* (*Green*)**

b) $Cr_2O_7^{2-} + 6I^- + 14H^+ \longrightarrow$

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

25. Cr^{2+} is Strong reducing agent but Mn^{3+} is strong oxidising agent:

Cr^{2+} Had a d^4 configuration. Due to its stability , it easily lose its electron and become Cr^{3+} . Which is d^3 configuration. This d^3 filled like $t_{2g}^{\;3}$, eg^1. This is an half filled and highly stable. So it acts as a reducing agent.

Where Mn^{3+} had d^4 configuration $t_{2g}^{\;3}$, $eg^{\;1}$. This is an unstable, and easily accept one electron and become Mn^{2+} . Hence it act as a oxidizing agent.