

Maharashtra State Board 12th Chemistry Important Questions Chapter 8 Transition and Inner Transition Elements

Question 1.

What are d-block elements? Give their general electronic configuration.

Answer:

Definition : d-block elements are defined as the elements in which the differentiating electron enters d-orbital of the penultimate shell i.e. $(n - 1)$ d-orbital where 'n' is the last shell.

The general electronic configuration can be represented as, $(n - 1) d_{1-10}, ns_{n-2}$

Question 2.

What is the position of the transition elements in the periodic table?

Answer:

The transition elements are placed in periods 4 to 7 and groups 3 to 12 of the periodic table.

Question 3.

In which block of the modern periodic table are the transition elements placed?

Answer:

Transition elements are placed in d-block of the modern periodic table.

Question 4.

Why are most of the d-block elements called transition elements?

Answer:

- d-block elements have electronic configuration, $(n - 1) d_{1-10}, ns_{n-2}$. They are all metals.
- In the periodic table, they are placed between the s-block and p-block elements, i.e., in the groups between 2 and 13.
- They show characteristic properties which are intermediate between those of the elements of s-block and p-block.
- Hence, they show a transition in the properties from those of the most electropositive s-block elements and less
- electropositive (or electronegative) p-block elements.
- Therefore, most of the d-block elements are called transition elements.

Question 5.

How many series of d-block elements are present in the long-form periodic table? Give their general electronic configuration.

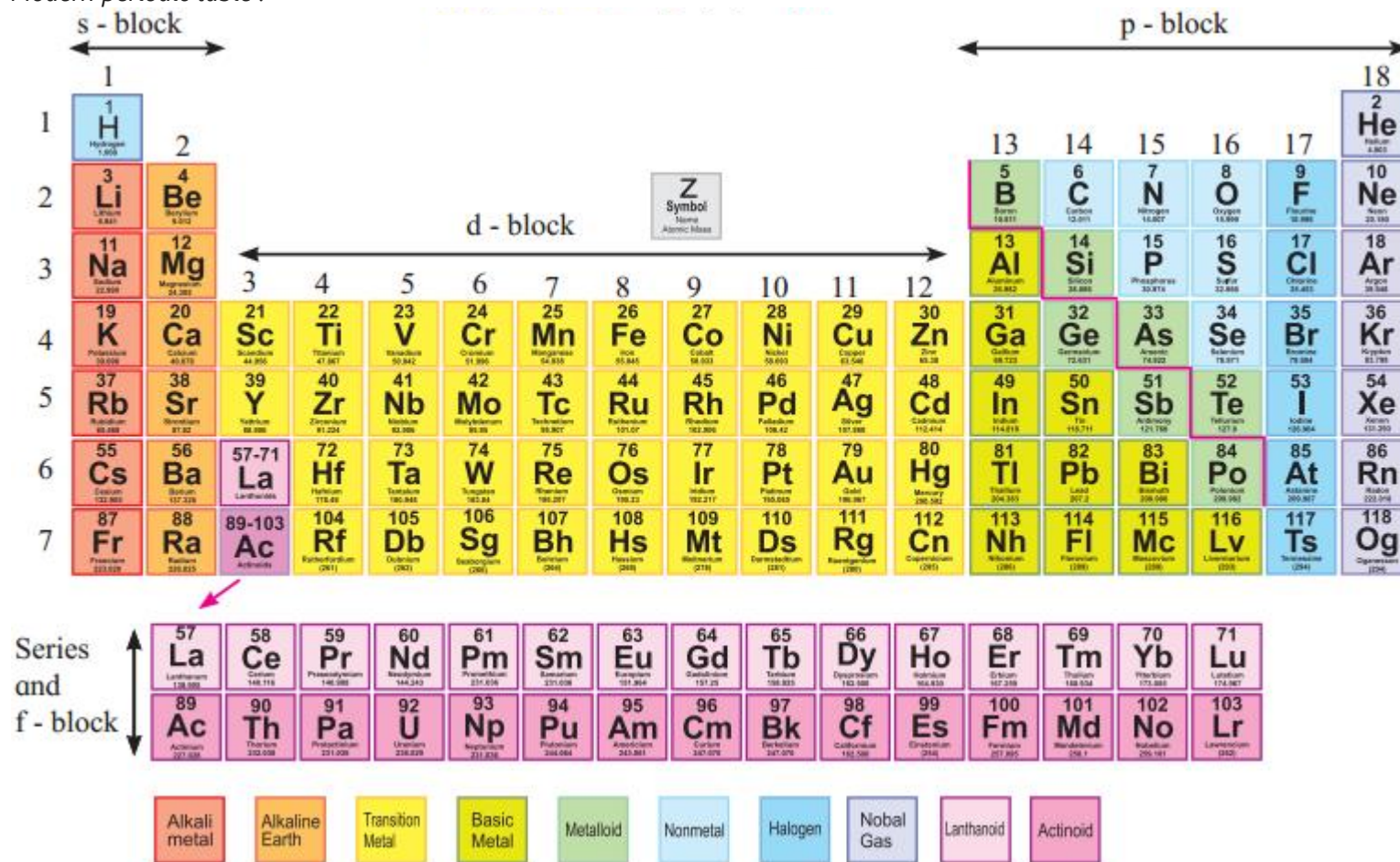
Answer:

There are four series of d-block elements which are placed between s and p-block elements in the long-form periodic table as follows :

d-series	Period	Electronic configuration
(1) 3d-series	fourth	$[\text{Ar}] 3d_{1-10}, 4s_{1-2}$
(2) 4d-series	fifth	$[\text{Kr}] 4d_{1-10}, 5s_{1-2}$
(3) 5d-series	sixth	$[\text{Xe}] 4f_{14} 5d_{1-10} 6s_{1-2}$
(4) 6d-series	seventh	$[\text{Rn}] 5f_{14} 6d_{1-10} 7s_2$

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Modern periodic table :



Question 6.

Represent the elements in the four series of transition elements.

Answer:

The four transition series elements

Group	3	4	5	6	7	8	9	10	11	12
d-series										
3d	Sc(21)	Ti(22)	V(23)	Cr(24)	Mn(25)	Fe(26)	Co(27)	Ni(28)	Cu(29)	Zn(30)
4d	Y(39)	Zr(40)	Nb(41)	Mo(42)	Tc(43)	Ru(44)	Rh(45)	Pd(46)	Ag(47)	Cd(48)
5d	La(57)	Hf(72)	Ta(73)	W(74)	Re(75)	Os(76)	Ir(77)	Pt(78)	Au(79)	Hg(80)
6d	Ac(89)	Rf(104)	Db(105)	Sg(106)	Bh(107)	Hs(108)	Mt(109)	Ds(110)	Rg(111)	Cn(112)

Question 7.

In which period of the periodic table, will an element, be found whose differentiating electron is a 4d-electron?

Answer:

An element whose differentiating electron is a 4d-electron will be present in fifth period of the periodic table.

Question 8.

Write the condensed electronic configuration of each series of transition elements.

Answer:

Condensed Electronic Configuration of Transition Elements

Series	Elements	Symbol	Atomic Number	Electronic Configuration
3d-series (4 th period)	Scandium	Sc	21	[Ar] 3d ¹ 4s ²
	Titanium	Ti	22	[Ar] 3d ² 4s ²
	Vanadium	V	23	[Ar] 3d ³ 4s ²
	Chromium	Cr	24	[Ar] 3d ⁵ 4s ¹
	Manganese	Mn	25	[Ar] 3d ⁵ 4s ²
	Iron	Fe	26	[Ar] 3d ⁶ 4s ²
	Cobalt	Co	27	[Ar] 3d ⁷ 4s ²
	Nickel	Ni	28	[Ar] 3d ⁸ 4s ²
	Copper	Cu	29	[Ar] 3d ¹⁰ 4s ¹
	Zinc	Zn	30	[Ar] 3d ¹⁰ 4s ²
4d-series (5 th period)	Yttrium	Y	39	[Kr] 4d ¹ 5s ²
	Zirconium	Zr	40	[Kr] 4d ² 5s ²
	Niobium	Nb	41	[Kr] 4d ⁴ 5s ¹
	Molybdenum	Mo	42	[Kr] 4d ⁵ 5s ¹
	Tellurium	Tc	43	[Kr] 4d ⁶ 5s ¹
	Ruthenium	Ru	44	[Kr] 4d ⁷ 5s ¹
	Rhodium	Rh	45	[Kr] 4d ⁸ 5s ¹
	Palladium	Pd	46	[Kr] 4d ¹⁰ 5s ⁰
	Silver	Ag	47	[Kr] 4d ¹⁰ 5s ¹
	Cadmium	Cd	48	[Kr] 4d ¹⁰ 5s ²
5d-series (6 th period)	Lanthanum	La	57	[Xe] 5d ¹ 6s ²
	Hafnium	Hf	72	[Xe] 4f ¹⁴ 5d ² 6s ²
	Tantalum	Ta	73	[Xe] 4f ¹⁴ 5d ³ 6s ²
	Tungsten	W	74	[Xe] 4f ¹⁴ 5d ⁴ 6s ²
	Rhenium	Re	75	[Xe] 4f ¹⁴ 5d ⁵ 6s ²
	Osmium	Os	76	[Xe] 4f ¹⁴ 5d ⁶ 6s ²
	Iridium	Ir	77	[Xe] 4f ¹⁴ 5d ⁷ 6s ²
	Platinum	Pt	78	[Xe] 4f ¹⁴ 5d ⁸ 6s ²
	Gold	Au	79	[Xe] 4f ¹⁴ 5d ¹⁰ 6s ¹
	Mercury	Hg	80	[Xe] 4f ¹⁴ 5d ¹⁰ 6s ²
6d-series (7 th period)	Actinium	Ac	89	[Rn] 6d ¹ 7s ²
	Rutherfordium	Rf	104	[Rn] 5f ¹⁴ 6d ² 7s ²
	Dubnium	Db	105	[Rn] 5f ¹⁴ 6d ³ 7s ²
	Seaborgium	Sg	106	[Rn] 5f ¹⁴ 6d ⁴ 7s ²
	Bohrium	Bh	107	[Rn] 5f ¹⁴ 6d ⁵ 7s ²
	Hassium	Hs	108	[Rn] 5f ¹⁴ 6d ⁶ 7s ²
	Meitnerium	Mt	109	[Rn] 5f ¹⁴ 6d ⁷ 7s ²
	Darmstadtium	Ds	110	[Rn] 5f ¹⁴ 6d ⁸ 7s ²
	Roentgenium	Rg	111	[Rn] 5f ¹⁴ 6d ¹⁰ 7s ¹
	Copernicium	Cn	112	[Rn] 5f ¹⁴ 6d ¹⁰ 7s ²

Question 9.

Write expected and observed electronic configuration of 3d-series block elements.

Answer:

Electronic configuration of 3d-series of d-block elements

Elements	Symbol	At. No.	Expected Electronic Configuration	Observed Electronic Configuration
Scandium	Sc	21	[Ar] 3d ¹ 4s ²	[Ar] 3d ¹ 4s ²
Titanium	Ti	22	[Ar] 3d ² 4s ²	[Ar] 3d ² 4s ²
Vanadium	V	23	[Ar] 3d ³ 4s ²	[Ar] 3d ³ 4s ²
Chromium	Cr	24	[Ar] 3d ⁴ 4s ²	[Ar] 3d ⁵ 4s ¹
Manganese	Mn	25	[Ar] 3d ⁵ 4s ²	[Ar] 3d ⁵ 4s ²
Iron	Fe	26	[Ar] 3d ⁶ 4s ²	[Ar] 3d ⁶ 4s ²
Cobalt	Co	27	[Ar] 3d ⁷ 4s ²	[Ar] 3d ⁷ 4s ²
Nickel	Ni	28	[Ar] 3d ⁸ 4s ²	[Ar] 3d ⁸ 4s ²
Copper	Cu	29	[Ar] 3d ⁹ 4s ²	[Ar] 3d ¹⁰ 4s ¹
Zinc	Zn	30	[Ar] 3d ¹⁰ 4s ²	[Ar] 3d ¹⁰ 4s ²

Question 10.

Explain why transition elements with electronic configuration 3d⁴4s² and 3d⁹4s² do not exist.

Answer:

(1) d-orbitals are degenerate orbitals and they acquire extra stability when half-filled (3d⁵) or completely filled (3d¹⁰). Hence 3d⁴ and 3d⁹ electronic configurations are less stable.

(2) The energy difference between 3d and 4s' subshells is very low, hence there arises a transfer of one electron from 4s orbital to 3d orbital.

The electronic configuration changes as,

3d⁴, 4s² → 3d⁵ 4s¹

3d⁹, 4s² → 3d¹⁰ 4s¹

Therefore transition elements, with electronic configurations 3d⁴, 4s² and 3d⁹, 4s² do not exist.

Question 11.

Write observed electronic configuration of elements from first transition series having half-filled d-orbitals.

Answer:

There are two elements namely Cr and Mn which have half-filled d-orbitals.

²⁴Cr [Ar] 3d⁵ 4s¹

²⁵Mn [Ar] 3d⁵ 4s²

Question 12.

Explain the variable oxidation states of metals of first transition series.

Answer:

- The transition metals (or, elements) exhibit variable oxidation states due to their electronic configuration, (n – 1) d¹⁻¹⁰ ns¹⁻² for the first row.
- They show only positive oxidation states due to loss of electrons from outer 4s-orbital and the penultimate 3d-orbital.
- Loss of one 4s electron forms M⁺ ion. Loss of two 4s electrons form M²⁺ ion.
- +2 is the common oxidation state of these elements.
- Higher oxidation states are due to loss of 3 d-electrons along with 4s electrons.
- As the number of unpaired electrons increases, the number of oxidation states shown by the element also increases.
- Sc has only one unpaired electron and it shows two oxidation states (+ 2 and + 3)
- Mn with 5 unpaired d electrons show six different oxidation states. They are +2, +3, +4, +5, +6 and + 7. Thus Mn has the highest oxidation state.
- From Fe onwards variable oxidation states decreases as the number of unpaired electron decreases.
- The last element in the series, Zn shows only one oxidation state (+ 2).

Question 13.

Show different oxidation states of 3d-series of transition elements.

Answer:

The following table shows, different oxidation states of 3d-series of transition elements.

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

Question 14.

Write oxidation states and outer electronic configuration of first transition series elements.

Answer:

Oxidation states of first transition series elements

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

Question 15.

Zinc shows only one oxidation state. Explain.

Answer:

- The electronic configuration of zinc is, $30\text{Zn } 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$ or $[\text{Ar}] 3d^{10} 4s^2$.
- Due to loss of two electrons from 4s subshell Zn shows oxidation state +2. with electronic configuration. $[\text{Ar}] 3d^{10}$.
- Since Zn^{+2} acquires an extra stability of completely filled $3d^{10}$ orbital. it shows only one oxidation state +2.

Question 16.

Why is manganese more stable in the +2 state than the +3 state and the reverse is true for iron?

Answer:

- The electronic configuration of Mn is $25\text{Mn } [\text{Ar}] 3d^5 4s^2$
- In +2 and +3 oxidation states, the electronic configuration of Mn is, $\text{Mn}^{2+} [\text{Ar}] 3d^5$ and $\text{Mn}^{3+} [\text{Ar}] 3d^4$
- Since half-filled d-orbital ($3d^5$) has more stability and lower energy than $3d^4$, Mn^{2+} is more stable than Mn^{3+} .
- The electronic configuration of Fe is $26\text{Fe } [\text{Ar}] 3d^6 4s^2$ In +2 and +3 oxidation states of Fe, the electronic configuration is, $\text{Fe}^{2+} [\text{Ar}] 3d^6$ and $\text{Fe}^{3+} [\text{Ar}] 3d^5$ Since half-filled orbital is more stable, +3 state of Fe is more stable than +2 state.

Question 17.

What are the electronic configurations of various ions of 3d-elements?

Answer:

Electronic configuration of various ions of 3d elements

Elements	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Atomic no:	21	22	23	24	25	26	27	28	29	30

Species	Valence shell Electronic Configuration									
M	$3d^1 4s^2$	$3d^2 4s^2$	$3d^3 4s^2$	$3d^5 4s^1$	$3d^5 4s^2$	$3d^6 4s^2$	$3d^1 4s^2$	$3d^8 4s^2$	$3d^{10} 4s^1$	$3d^{10} 4s^2$
M ⁺	$3d^1 4s^1$	$3d^2 4s^1$	$3d^3 4s^1$	$3d^5$	$3d^5 4s^1$	$3d^6 4s^1$	$3d^7 4s^1$	$3d^8 4s^1$	$3d^{10} 4s^0$	$3d^{10} 4s^1$
M ²⁺	$3d^2$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	$3d^8$	$3d^9$	$3d^{10}$
M ³⁺	[Ar]	$3d^1$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	–	–

Question 18.

Scandium shows only two oxidation states. Explain.

Answer:

Scandium has electronic configuration, $_{21}\text{Sc} : 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^1, 4s^2$ Sc shows only two oxidation states namely + 2 and + 3.

- Due to the loss of two electrons from the 4s-orbital, Sc acquires + 2 oxidation state $\text{Sc}^{2+} : 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^1$.
- Due to the loss of one more electron from the 3d-orbital, it acquires + 3 oxidation state with the extra stability of an inert element $_{18}\text{Ar}$.
 $\text{Sc}^{3+} : 1s^2, 2s^2, 2p^6, 3s^2, 3p^6$.
- Since Sc^{3+} acquires extra stability of inert element $[\text{Ar}]_{18}$, it does not form higher oxidation state.

Question 19.

Write different oxidation states of iron.

OR

Write the electronic configurations of

(i) Fe

(ii) Fe^{2+} and

(iii) Fe^{3+} .

Answer:

Oxidation states of iron are +2, +3, +4, +5, +6.

(i) $_{26}\text{Fe} : 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6, 4s^2$

(ii) $\text{Fe}^{2+} : 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6$

(iii) $\text{Fe}^{3+} : 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^5$.

Question 20.

Explain different oxidation states of chromium.

Answer:

- The observed electronic configuration of chromium is, $_{24}\text{Cr} [\text{Ar}] 3d^5 4s^1$.
- Different possible oxidation states of Cr are 4-1 ($3d^5$), + 2 ($3d^4$), + 3 ($3d^3$), + 4 ($3d^2$), + 5 ($3d^1$) and + 6 ($3d^0$).
- Although in + 1 state, Cr gets extra stability of half-filled $3d^5$ -orbital, it does not exhibit + 1 state in common except with pyridine.
- Cr^{+2} has few stable salts like CrCl_2 , CrSO_4 while Cr^{+3} forms very stable salts like CrCl_3 .
- Cr^{+4} and Cr^{+5} are unstable oxidation states.
- Cr^{+6} is the most stable state due to inert gas $[\text{Ar}]$ electronic configuration and form the salts like $\text{K}_2\text{Cr}_2\text{O}_7$.

Question 21.

Manganese shows variable oxidation states. Give reasons.

Answer:

- Manganese ($_{25}\text{Mn}$) has electronic configuration. $_{25}\text{Mn} [\text{Ar}]_{18} 3d^5 4s^2$.
- Mn has stable half-filled d-subshell.
- Due to a small difference in energy between 3d and 4s-orbitals, Mn can lose or share electrons from both the orbitals, hence shows variable oxidation states.
- Mn shows oxidation states ranging from + 2 to + 7.

Question 22.

Write the different oxidation states of manganese. Why is + 2 oxidation state of manganese more stable than Mn^{3+} ?

Answer:

- The different oxidation states of Mn are +2, +3, +4, +5, + 6 and +7.
- The electronic configuration of Mn is $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^5, 4s^2$
- + 2 oxidation state is very stable due to higher stability of half-filled 3d orbital.
- Mn^{3+} has electronic configuration, $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^4$ which is less stable.

Question 23.

Write the physical properties of first transition series.

Answer:

Physical properties of first transition series :

- All transition elements of the first series are metals.
- Except Zn, they are very hard and have low volatility.
- They show characteristic properties of metals. They are lustrous, malleable and ductile.
- They are good conductors of heat and electricity.
- They have high melting points and boiling points.
- Except Zn and Mn, they have one or more typical metallic structures at normal temperatures.

Question 24.

Which elements in the transition elements, 3d-series has

- the lowest density
- the highest density?

Answer:

In 3d transition elements,

- Scandium (Sc) has lowest density and
- Zinc (Zn) has the highest density.

Question 25.

Explain the variation in density of d-block elements.

Answer:

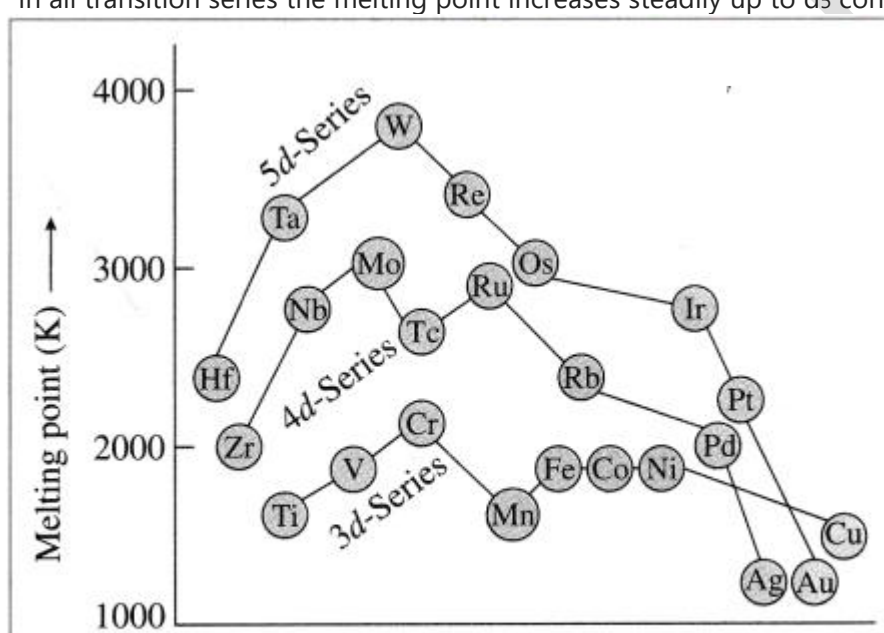
The densities of d-block elements are higher than s-block elements due to higher nuclear charge which results in reduction in atomic size.

Question 26.

Explain the variation in melting points of the transition elements.

Answer:

- All transition elements are metals and the strength of metallic bonding increases as the number of unpaired electrons increases.
- In transition elements as atomic number increases, the number of unpaired electrons increases from $(n-1)d^1$ to $(n-1)d^5$.
For example in 3d-series, melting points increase from $_{21}\text{Sc}$ to $_{24}\text{Cr}$ in 4d-series from $_{39}\text{Y}$ to $_{42}\text{Mo}$, and in 5d-series from $_{72}\text{Hf}$ to $_{74}\text{W}$.
- After $(n-1)d^5$ electronic configuration, the electrons start pairing, hence the number of unpaired electrons decrease, hence metallic character, melting points decrease from $(n-1)d^6$ to $(n-1)d^{10}$.
- In all transition series the melting point increases steadily up to d^5 configuration and after this melting point decreases regularly.



Variation in melting points of some transition metals

Question 27.

The first ionisation enthalpies of third transition series elements are much higher than those of the elements of first and second transition series. Explain.

Answer:

- Third transition series elements have electronic configuration, $4f^{14} 5d^1 - 10 6s^2$.
- Thus, atoms of third series elements possess filled 4f-orbitals.
- 4f-orbitals due to their diffused shape, exhibit poor shielding effect and give rise to lanthanide contraction. Hence the valence electrons experience greater nuclear attraction and greater amount of energy is required to ionise the elements of third transition series namely (Hf to Au).
- Therefore the ionisation enthalpies of third transition series elements are much higher than those of the first and second transition series.

Ionisation enthalpies of first transition series elements

Elements IE	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
IE ₁	632	659	650	652	717	762	756	736	744	906
IE ₂	1245	1320	1376	1635	1513	1563	1647	1756	1961	1736
IE ₃	2450	2721	2873	2994	3258	2963	3237	3400	3560	3838

Question 28.

Explain the metallic character of transition metals.

Answer:

- All the transition elements are metals.
- They are hard, lustrous, malleable, ductile and they have high tensile strength.
- They have high melting points and boiling points.
- Their metallic character is due to vacant or partially filled $(n - 1)$ d-orbitals, and they involve both metallic and covalent bonding.
- Since the strength of metallic bonds depends upon the number of unpaired electrons, it increases up to middle i.e., up to $(n - 1) d_5$, hence accordingly melting points and boiling points also increase.
- After $(n - 1)d_5$ configuration, the electrons start pairing, hence the metallic strength, melting points and boiling points decrease with the increase in atomic number.

Question 29.

How does metallic character vary in 3d transition elements?

Answer:

1. In 3d-series elements as atomic number increases from scandium (Sc [Ar] 3d¹ 4s²) the number of unpaired electrons increases up to 3d₅ in chromium.
2. As the number of unpaired electrons increases, the metallic character increases, hence the melting points and boiling points increase from 21Sc(3d¹) to 24Cr (3d₅).
3. After chromium the number of unpaired electrons goes on decreasing due to the pairing of electrons, hence metallic character, melting points and boiling points decrease from 25Mn to 29Cu.
4. Zinc has all electrons paired, hence it is soft, has a low melting and boiling points.

Question 30.

Which are the common arrangement of the atoms in the structure of transition metals?

Answer:

Most of the transition metals have simple hexagonal closed packed (hcp), cubic closed packed (ccp) or body centred cubic (bcc) lattices.

Question 31.

Why do the compounds of transition metals exhibit magnetic properties?

Answer:

The compounds of transition metals exhibit magnetic properties due to the presence of unpaired electrons in their atoms or ions.

Question 32.

What is the cause of paramagnetism and ferromagnetism?

Answer:

Paramagnetism and ferromagnetism is due to the presence of unpaired electrons in species.

Question 33.

When does species become diamagnetic?

Answer:

When there is no unpaired electron, i.e. all electron spins are paired, the species become diamagnetic.

Question 34.

How do metals Fe, Co, Ni acquire permanent magnetic moment?

Answer:

The transition metals Fe, Co and Ni are ferromagnetic. When the magnetic field is applied, all the unpaired electrons in these metals (and their compounds) align in the direction of the applied magnetic field. Due to this the magnetic susceptibility is enhanced and these metals can be magnetised, that is, they acquire permanent magnetic properties.

Question 35.

In which oxidation state, is vanadium diamagnetic?

Answer:

- The electronic configuration of vanadium is, 23V [Ar] 3d³ 4s².
- In +5 oxidation state, the electronic configuration is, V⁵⁺ [Ar].
- Since in V⁵⁺ state, vanadium has all electrons paired, it is diamagnetic.

Question 36.

How is a magnetic moment expressed?

Answer:

The magnetic moment is expressed in Bohr magneton (B.M.). It is denoted by μ .

Question 37.

What is Bohr magneton (B.M.)?

Answer:

Bohr magneton (B.M.) is a unit of magnetic moment :

$$1 \text{ B.M.} = \frac{eh^4\pi me c}{8m_e^2 c^2 h^2}$$

where, h : Planck's constant ($h = 6.626 \times 10^{-34} \text{ Js}$)

e : electronic charge ($1.60218 \times 10^{-19} \text{ C}$)

m_e : mass of an electron ($9.109 \times 10^{-31} \text{ kg}$)

c : velocity of light. ($2.998 \times 10^8 \text{ ms}^{-1}$)

Question 38.

Explain the magnetic properties of transition (or d-block) elements.

Answer:

- Most of the transition metal ions and their compounds are paramagnetic in nature due to the presence of one or more unpaired electrons in their $(n-1)d$ -orbitals. Hence they are attracted in the magnetic field.
- As the number of unpaired electrons increases from 1 to 5 in d-orbitals, the paramagnetic character and magnetic moment increase.
- The transition elements or their ions having all electrons paired are diamagnetic and they are repelled in the magnetic field.
- Metals like Fe, Co and Ni possess very high paramagnetism and acquire permanent magnetic moment hence they are ferromagnetic.

Question 39.

Explain the effective magnetic moment of the species.

Answer:

- The magnetic moment in the species arises due to the presence of unpaired electrons.
- The magnetic moment depends upon the sum of orbital and spin contribution for each unpaired electron present in the species.
- In transition metal ions, the contribution of orbital magnetic moment is suppressed by the electrostatic field of other atoms, molecules or ions surrounding the metal ion in the compound.
- Hence the net or effective magnetic moment arises mainly due to spin of electrons. The effective magnetic moment μ_{eff} , of a paramagnetic substance is given by 'spin only' formula represented as, $\mu = \sqrt{n(n+2)}$ B.M. where n is the number of unpaired electrons.

Question 40.

What is the importance of magnetic moment (μ)?

Answer:

- From the measurements of the magnetic moment (μ) of the species or metal complexes of the first row of transition elements, the number of unpaired electrons can be calculated with the spin-only formula.
- As magnetic moment is directly related to the number of unpaired electrons, value of μ will vary directly with the number of unpaired electrons.
- In 2nd and 3rd transition series, orbital angular momentum is significant. Hence spin-only formula for the complexes of 2nd and 3rd transition series is not useful.

Question 41.

Calculate the magnetic moment of the following species :

- (1) Cr^{3+}
- (2) Co
- (3) Co^{3+}
- (4) Cu^{2+} .

Answer:

Species	Electronic configuration	No. of unpaired electrons n	Magnetic moment $\mu = \sqrt{n(n+2)}$ B.M.
(1) Cr^{3+}	$[\text{Ar}] 3d^3$	3	$\mu = \sqrt{3(3+2)} = 3.87$
(2) $_{27}\text{Co}$	$[\text{Ar}] 3d^7 4s^2$	3	$\mu = \sqrt{3(3+2)} = 3.87$
(3) Co^{3+}	$[\text{Ar}] 3d^6$	4	$\mu = \sqrt{4(4+2)} = 4.90$
(4) Cu^{2+}	$[\text{Ar}] 3d^9$	1	$\mu = \sqrt{1(1+2)} = 1.73$

Question 42.

Explain : A slight difference in the calculated and observed values of magnetic moments.

Answer:

Magnetic moments are determined experimentally in solution or in solid state where the central atom or ion is hydrated or bound to ligands. Hence a slight difference is observed in calculated and experimentally obtained values of magnetic moment (μ).

Magnetic moments of ions of first transition series (values in B.M.)

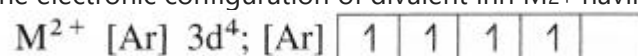
Ion	Outer Electronic Configuration	Number of unpaired electrons	Calculated value of magnetic moment	Experimental value
Sc ³⁺	3d ⁰	0	0	0
Ti ³⁺	3d ¹	1	1.73	1.75
V ³⁺	3d ²	2	2.84	2.76
Cr ³⁺	3d ³	3	3.87	3.86
Cr ²⁺	3d ⁴	4	4.90	4.80
Mn ²⁺	3d ⁵	5	5.92	5.96
Fe ²⁺	3d ⁶	4	4.90	5.3 – 5.5
Co ²⁺	3d ⁷	3	3.87	4.4 – 5.2
Ni ²⁺	3d ⁸	2	2.84	2.9 – 3.0, 4.0
Cu ²⁺	3d ⁹	1	1.73	1.8 – 2.2
Zn ²⁺	3d ¹⁰	0	0	0

Question 43.

Calculate the magnetic moment of a divalent ion in an aqueous solution, if its atomic number is 24.

Answer:

(1) The electronic configuration of divalent ion M²⁺ having atomic number 24 is.



The ion has number of unpaired electrons. n = 4.

By spin only formula, the magnetic μ is given by, $\mu = n(n+2) \dots \dots \dots \sqrt{4(4+2)} \dots \dots \dots \sqrt{4.90} \text{ B.M}$

(This M²⁺ ion is Cr²⁺ ion)

Question 44.

When does a substance appear coloured?

Answer:

A substance appears coloured when it absorbs a portion of visible light. The colour depends upon the wavelength of absorption in the visible region of electromagnetic radiation.

Question 45.

Why do the d-block elements form coloured compounds?

Answer:

- Compounds (or ions) of many d-block elements or transition metals are coloured.
- This is due to the presence of one or more unpaired electrons in (n – 1) d-orbital. The transition metals have incompletely filled (n – 1) d-orbitals.
- The energy required to promote one or more electrons within the d-orbitals involving d-d transitions is very low.
- The energy changes for d-d transitions lie in visible region of electromagnetic radiation.
- Therefore transition metal ions absorb the radiation in the visible region and appear coloured.
- Colour of ions of d-block elements depends on the number of unpaired electrons in (n – 1) d-orbital. The ions having equal number of unpaired electrons have similar colour.
- The colour of metal ions is complementary to the colour of the radiation absorbed.

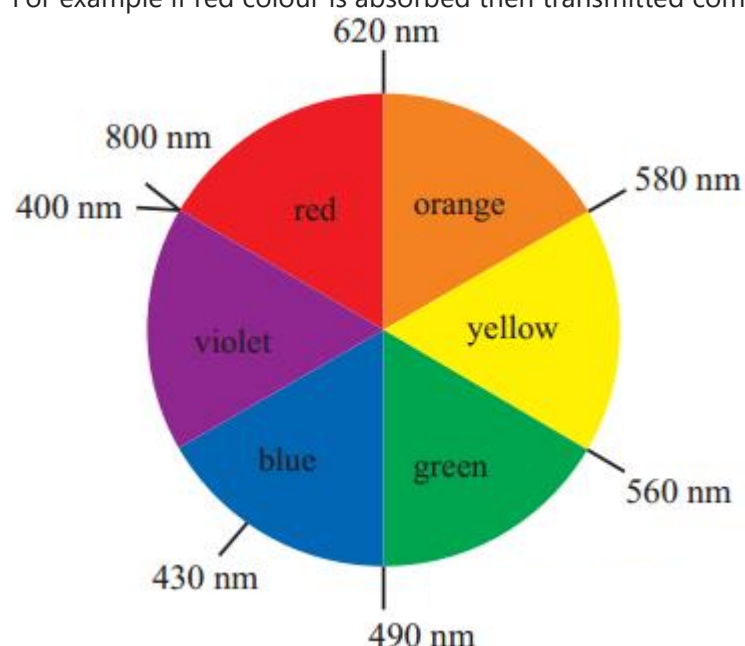
Question 46.

How is complementary colour of a compound identified?

Answer:

1. The transition metal ions absorb the radiation in the visible region and appeared coloured.
2. Metal ion absorbs radiation of certain wavelength from the visible region. Remaining light is transmitted and the observed colour corresponds to the complementary colour of the light observed.
3. The complementary colour can be identified (with the diagram given).

For example if red colour is absorbed then transmitted complementary colour is green.



Question 47.

Write outer electronic configuration (d-orbital) and colour of 3d-series of transition metal ions.

Answer:

Colour of 3d-transition metal ions

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

Question 48.

Mention the factors on which the colour of a transition metal ion depends.

Answer:

The factors on which the colour of transition metal ion depends are as follows :

- The presence of incompletely filled d-orbitals in metal ions. (The compounds with the configuration d⁰ and d¹⁰ are colourless.)
- The presence of unpaired electrons in d-orbitals.
- d → d transitions of electrons due to absorption of radiation in the visible region.
- Nature of groups (anions) (or ligands) linked to the metal ion in the compound or a complex.
- Type of hybridisation in metal ion in the complex.
- Geometry of the complex of the metal ion.

Question 49.

Give reasons : Zinc salts are colourless.

Answer:

- Colour of the ions of d-block elements depends on the number of unpaired electrons in (n – 1) d-orbitals.
- Zinc forms salts of Zn²⁺ ions.
- The electronic configuration of Zn²⁺ is [Ar] 3d¹⁰.
- Since Zn²⁺ does not have unpaired electrons in 3d-orbital, d→d transition cannot take place, hence, Zn²⁺ ions form colourless salts.

Question 50.

Explain : The compounds of Cu(II) are coloured.

Answer:

- The electronic configuration of ^{29}Cu [Ar] $3d^{10} 4s^1$ and Cu^{2+} [Ar] $3d^9$.
- In copper compounds Cu^{2+} ions have incompletely filled 3d-orbital ($3d^9$).
- Due to the presence of one unpaired electron in 3 d-orbital, Cu^{2+} ions absorb red light from visible spectrum and emit blue radiation due to $d \rightarrow d$ transition. Therefore, copper compounds are coloured.

Question 51.

Explain why the solution of Ti^{3+} salt is purple in colour.

OR

Why is Ti^{3+} coloured? (atomic number Ti = 22)

Answer:

- Ti^{2+} ions in the aqueous solution exist in the hydrated complex form as $[\text{Ti}(\text{H}_2\text{O})_6]^{2+}$.
- The electronic configuration of Ti is, ^{22}Ti [Ar] $3d^2 4s^2$ and Ti^{3+} [Ar] $3d^1$. Hence in complex, Ti^{3+} has one unpaired electron in 3d subshell.
- Initially, the 3d electron occupies lower energy d-orbital (in t_{2g} -orbitals).
- On the absorption of radiations of about 500 nm in yellow green region by a complex, 3d1 electron is excited to the higher energy d-orbital (eg-orbitals).
- When the electron returns back to the lower energy d-orbital (t_{2g}), it transmits radiation of complementary colour i.e. red blue or purple colour. Hence, the solution of hydrated Ti^{3+} is purple.

Question 52.

What will be the colour of Cd^{2+} salts? Explain.

Answer:

- The electronic configuration of, ^{48}Cd [Kr] $3d^{10} 5s^2$ and Cd^{2+} [Kr] $3d^{10}$.
- Cd^{2+} ions have completely filled 3d subshell and there are no unpaired electrons in 3d-orbital.
- Hence $d \rightarrow d$ transition is not possible.
- Therefore, Cd^{2+} ions do not absorb radiations in the visible region and the salts of Cd^{2+} ions are colourless (or white).

Question 53.

Indicate which of the ions may be coloured- V^{3+} , Sc^{3+} , Cr^{3+} , Cu^{2+} , Ti^{3+} , Cu^{+}

Answer:

- V^{3+} [Ar] $3d^2$ -(green)
Since there are two unpaired electrons available, for $d \rightarrow d$ transition, it will show a Green colour.
- Sc^{3+} [Ar] $3d^0$ (colourless/white).
Since there are no unpaired electrons in the 3d subshell, it will not show colour.
- Cr^{3+} [Ar] $3d^3$ – (violet)
There are three unpaired electrons in the 3d subshell, hence due to $d \rightarrow d$ transition, it will show violet colour.
- Cu^{2+} [Ar] $3d^9$ (blue)
It has one unpaired electron that can undergo a $d \rightarrow d$ transition, hence it will show the colour blue.
- Ti^{3+} [Ar] $3d^1$ (purple)
It has one unpaired electron that can undergo a $d \rightarrow d$ transition, hence it will show the colour purple.
- Cu^{1+} [Ar] $3d^{10}$ (colourless)
There are no unpaired electrons in the 3d subshell, hence it will not show colour.

Question 54.

Explain why is cobalt chloride pink in colour when dissolved in water but turns deep blue when treated with concentrated hydrochloric acid.

Answer:

- The electronic configuration of ^{27}Co : [Ar] $3d^7 4s^2$ and Co^{2+} [Ar] $3d^7$.
- When dissolved in water cobalt chloride, Co^{2+} forms pink complex, $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$.
- The complex has octahedral geometry.
- Due to absorption of radiation in the visible region and $d - d$ transition, it forms pink coloured solution.
- When CoCl_2 solution is treated with concentrated HCl solution it turns deep blue.
- This change is due to the formation of another complex, $[\text{CoCl}_4]^{2-}$ which has a tetrahedral geometry.
- Thus due to a change in geometry of the complex formed the colour of the solution changes from pink to deep blue.

Question 55.

Explain the catalytic properties of the rf-block or transition metals.

Answer:

- d-block elements or transition metals and their compounds or complexes influence the rate of a chemical reaction and hence act as catalysts.
- In homogeneous catalysis a catalyst forms an unstable intermediate compound which decomposes into products and regenerates the catalyst. But transition metals involve heterogeneous catalysis.
- The transition metals have incompletely filled d-subshells which adsorb reactants on the surface and provide a large surface area for the reactants to react.
- Since transition metals have variable oxidation states they are very good catalysts.
- Hence, compounds of Fe, Co, Ni, Pt, Pd, Cr etc are used as catalysts in many reactions.

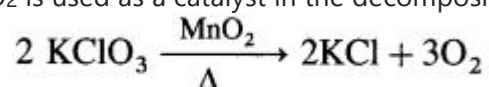
Question 56.

Explain the use of different transition metals as catalysts.

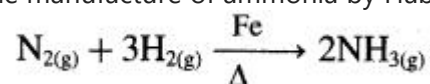
Answer:

The transition metals are very good catalysts.

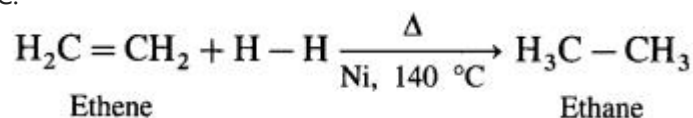
- MnO₂ is used as a catalyst in the decomposition of KClO₃.



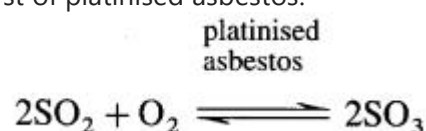
- In the manufacture of ammonia by Haber's process, Mo/Fe is used as a catalyst.



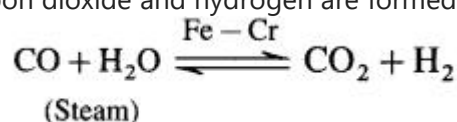
- In the synthesis of gasoline by Fischer Tropsch process, Co-Th alloy is used as a catalyst.
- Finely divided Ni (formed by reduction of heated oxide in hydrogen) is very efficient catalyst in hydrogenation of ethene to ethane at 140 °C.



- Commercially, hydrogenation with Ninkel as catalyst is used to convert inedible oils into solid fat for the production of margarine.
- In the contact process of industrial production of sulphuric acid, sulphur dioxide and oxygen (from air) react reversibly over a solid catalyst of platinised asbestos.



- Carbon dioxide and hydrogen are formed by the reaction of carbon monoxide and steam at 500 °C with Fe-Cr catalyst.



Question 57.

What are interstitial compounds of transition metals?

Answer:

- The interstitial compounds of the transition metals are those which are formed when small atoms like H, C or N are trapped inside the interstitial vacant spaces in the crystal lattices of the metals.
- Sometimes, sulphides and oxides are also trapped in the crystal lattices of transition elements.
- Presence of these elements in the crystal lattices of metals provide new properties to the metals.

Question 53.

Give one example of an interstitial compound.

Answer:

Steel and cast iron are examples of interstitial compounds of carbon and iron.

Question 54.

Give examples of interstitial compounds where the property of the transition metal is changed.

Answer:

Steel and cast iron are interstitial compounds of carbon and iron (carbides of iron). Due to the presence of carbon, the malleability and ductility of iron is reduced while its tenacity increases.

Question 55.

What are the properties of the interstitial compounds of transition metals?

Answer:

- The chemical properties of the interstitial compounds are the same as that of parent transition metals.
- They are hard and show the metallic properties like electrical and thermal conductivity, lustre, etc.
- Since metal-non-metal bonds in the interstitial compounds are stronger than metal-metal bonds in pure metals, the compounds have very high melting points, higher than the pure metals.
- They have lower densities than the parent metal.
- The interstitial compounds containing hydrogen (i.e., hydrides of metals) are powerful reducing agents.
- The compounds containing carbon, hence behaving as carbides, are chemically inert and extremely hard like diamond.
- In these compounds, malleability and ductility are changed. For example steel and cast iron.

Question 56.

What are interstitial compounds? Why do these compounds have higher melting points than corresponding pure metals?

Answer:

- The interstitial compounds of the transition metals are those which are formed when small atoms like H, C or N are trapped inside the interstitial vacant spaces in the crystal lattice of the metals.
- Since metal-nonmetal bonds in the interstitial compounds are stronger than metal-metal bonds in pure metals, the compounds have very high melting points, higher than the pure metals.

Question 57.

Explain the formation of alloys of transition metals.

Answer:

- The transition metals form a large number of alloys among themselves, which are hard with high melting points.
- During alloy formation atoms of one metal are distributed randomly in the lattice of another metal.

- The metals with similar atomic radii and similar properties readily form alloys.
- These alloys have industrial importance.
- The alloys can be ferrous alloys or nonferrous alloys.

Question 58.

How are the transition metal alloys classified?

Answer:

The transition metal alloys are classified into

- Ferrous alloys
- Nonferrous alloys.

Question 59.

Explain what are

(1) ferrous alloys and

(2) nonferrous alloys.

Answer:

1. Ferrous alloys: In ferrous alloys, atoms of other elements are distributed randomly in atoms of iron in the mixture. As the percentage of iron is more in these alloys, they are termed as ferrous alloys. For example : nickel steel, chromium steel, stainless steel, (All steels have about 2% carbon)
2. Nonferrous alloys : These are formed by mixing atoms of transition metal other than iron with a non transition element. For example, brass is an alloy of Cu and Zn. Bronze is an alloy of Cu and Sn.

Question 60.

What are the uses of alloys?

Answer:

Name of alloy	Important use in industry
(1) Bronze (Cu + Sn)	In making statues, medals and trophies (as it is tough, strong and corrosion-resistant)
(2) Cupra-nickel (Cu + Ni)	In making machinery parts of marine ships, boats, marine condenser tubes.
(3) Stainless steel	In the construction of the outer fuselage of ultra-high-speed aircraft.
(4) Nichrome : (Ni+ Cr in the ratio 80 : 20)	For gas turbine engines.
(5) Titanium alloys	For ultra-high-speed flight, fireproof bulkheads and exhaust shrouds (as they withstand high temperatures).

Question 61.

Write the preparation of potassium permanganate.

Answer:

Potassium permanganate (KMnO₄) is prepared in the following steps,

(1) Chemical Oxidation : When finely divided manganese dioxide (MnO₂) is heated strongly with fused caustic potash (KOH) and an oxidising agent potassium chlorate (KClO₃), dark green potassium manganate (K₂MnO₄) is obtained. (In neutral or acidic medium K₂MnO₄ disproportionates.)

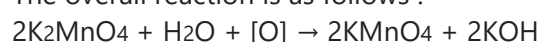


The liquid is filtered through glass wool or sintered glass and evaporated. Potassium manganate crystallises as small, blackish crystals.

(2) Oxidation of K₂MnO₄ by

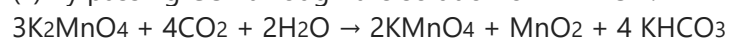
(i) Electrolytic oxidation : An alkaline solution of manganate ion is electrolysed between iron electrodes separated by a diaphragm. Manganate ion (MnO_2^-) undergoes oxidation at anode forming permanganate ion (MnO_4^-). Oxygen evolved at anode converts (MnO_2^-) to (MnO_4^-).

The overall reaction is as follows :



The electrolytic solution is filtered and evaporated to obtain deep purple black crystals of KMnO₄.

(ii) By passing CO₂ through the solution of K₂MnO₄ :



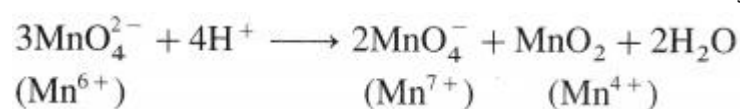
Question 62.

What is meant by the disproportionation of an oxidation state? Explain giving example of manganese.

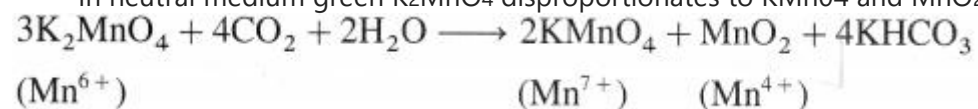
Answer:

1. Disproportionation reaction is a chemical reaction in which atom or an ion of an element forms two or more species having different oxidation states, one lower and one higher.
2. Manganese (Mn) shows different oxidation states + 2 to +7.
3. When one oxidation state, lower or higher oxidation state becomes unstable as compared to another oxidation state, it undergoes disproportionation reaction.
4. For example, + 6 oxidation state of Mn is less stable than + 7 and + 4.

- Hence, in acidic medium Mn^{6+} in MnO_{2-4} undergoes disproportionation reaction.



- In neutral medium green K_2MnO_4 disproportionates to $KMnO_4$ and MnO_2 .



Question 63.

Give examples of oxidising reactions of $KMnO_4$.

Answer:

(1) $KMnO_4$ in acidic medium :

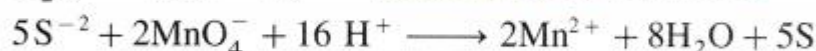
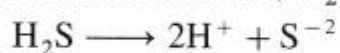
(i) In acidic medium iodine is liberated from potassium iodide.



(ii) In acidic medium, Fe^{2+} ion is converted to Fe^{3+} ion.



(iii) In acidic medium, H_2S is oxidised to S.



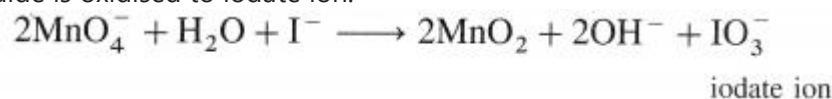
(iv) Oxalic acid, in acidic medium is oxidised to CO_2 .



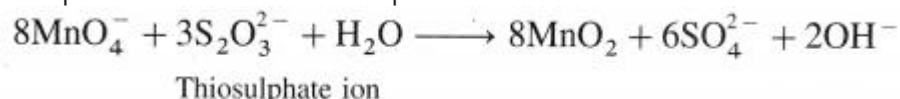
Oxalic acid

(2) $KMnO_4$ in neutral or alkaline medium in neutral or weakly alkaline medium :

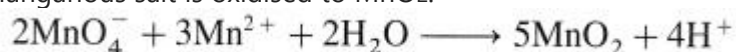
(i) Iodide is oxidised to iodate ion.



(ii) Thiosulphate ion is oxidised to sulphate ion.

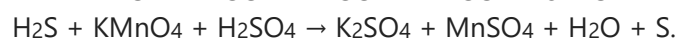


(iii) Manganous salt is oxidised to MnO_2 .



Question 64.

Balance the following equations :



Answer:



Question 65.

Give the uses of potassium permanganate.

Answer:

Uses of potassium permanganate :

- as an antiseptic.
- as a powerful oxidising agent in laboratory and industry.
- in the detection of unsaturation in organic compounds in the laboratory. (Baeyer's reagent, alkaline $KMnO_4$).
- for detecting halides in qualitative analysis.
- in volumetric analysis for the estimation of H_2O_2 , $FeSO_4$ etc.)

Question 66.

Write the formula of chromite ore.

Answer:



Question 67.

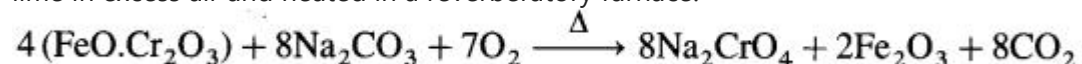
How is potassium dichromate manufactured from chromite ore ($FeOCr_2O_3$)?

Answer:

Manufacture of potassium dichromate ($K_2Cr_2O_7$) from chrome iron ore ($FeOCr_2O_3$) involves following steps :

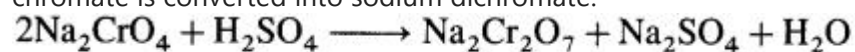
(1) Concentration of ore : The chromite ore ($\text{FeO} \cdot \text{Cr}_2\text{O}_3$) is powdered and washed with current of water.

(2) Conversion of chromite ore into sodium chromate : The concentrated ore is mixed with anhydrous sodium carbonate (Na_2CO_3) and a flux of lime in excess air and heated in a reverberatory furnace.



Sodium chromate (Na_2CrO_4) formed in the reaction is then extracted with water so that Na_2CrO_4 dissolves into solution and insoluble substances separate out.

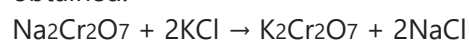
(3) Conversion of Na_2CrO_4 into sodium dichromate ($\text{Na}_2\text{Cr}_2\text{O}_7$) : Na_2CrO_4 solution is acidified with concentrated H_2SO_4 , so that sodium chromate is converted into sodium dichromate.



concentrated

Less soluble sodium sulphate crystallises out as $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$, which is filtered off.

(4) Conversion of $\text{Na}_2\text{Cr}_2\text{O}_7$ into $\text{K}_2\text{Cr}_2\text{O}_7$: Concentrated solution of $\text{Na}_2\text{Cr}_2\text{O}_7$ is treated with KCl on by double decomposition, $\text{K}_2\text{Cr}_2\text{O}_7$ is obtained.



On concentrating and cooling the solution, less soluble orange coloured $\text{K}_2\text{Cr}_2\text{O}_7$ crystallises out which is filtered and purified by recrystallisation.

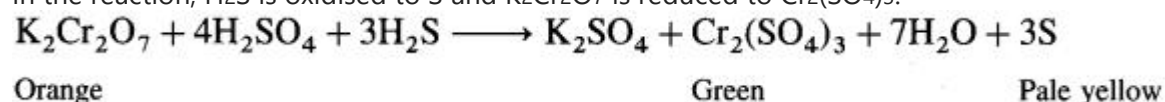
Question 68.

What happens when hydrogen sulphide gas (H_2S) is passed through acidified $\text{K}_2\text{Cr}_2\text{O}_7$ solution?

Answer:

When hydrogen sulphide (H_2S) gas is passed into solution of $\text{K}_2\text{Cr}_2\text{O}_7$, H_2S is oxidised to a pale yellow solid (precipitate) of sulphur. Orange coloured solution becomes green due to formation of chromic sulphate (green coloured).

In the reaction, H_2S is oxidised to S and $\text{K}_2\text{Cr}_2\text{O}_7$ is reduced to $\text{Cr}_2(\text{SO}_4)_3$.



Question 69.

What are the common physical properties of d-block elements?

Answer:

The common physical properties of d-block elements are :

- All d-block elements are lustrous and shining.
- They are hard and have high density
- They have high melting and boiling points.
- They are good electrical and thermal conductors.
- They have high tensile strength and malleability.
- They can form alloys with transition and nontransition elements
- Many metals and their compounds are paramagnetic.
- Most of the metals are efficient catalysts.

Question 70.

What are the common chemical properties of d-block elements?

Answer:

The common chemical properties of the d-block elements are :

- All d-block elements are electropositive metals.
- They exhibit variable oxidation states and form coloured salts and complexes.
- They are good reducing agents.
- They form insoluble oxides and hydroxides.
- Iron, cobalt, copper, molybdenum and zinc are biologically important metals.
- They catalyse biological reactions.

Question 71.

Give examples to show that elements of first row of d-block elements differ from second and third row with respect to the stabilisation of higher oxidation states.

Answer:

- Highest oxidation state for the first row element is + 7 as in Mn.
For the second row, the highest oxidation state is + 8 as in Ru (RuO_4).
For the third row, the highest oxidation state is + 8 as in Os (OsO_4).
- Compounds of Mo(V) of 2nd row and W(VI) of 3rd row of transitional elements are more stable than Cr(VI) and Mn (VIII) of first row elements.

Question 72.

How do metals occur in nature?

Answer:

In nature, few metals occur in earth's crust in free state or native state while other metals occur in the combined form.

(1) Elements in free state or native state : The metals which are non-reactive with air, water, CO_2 and non-metals occur in free state or native state. For example, gold, platinum, palladium occur in free state. Metals like Cu, Ag and Hg occur partly in the free state.

(2) Combined form : The metals which are reactive occur in the combined state with other elements forming compounds like oxides, sulphides, sulphates, carbonates, silicates, etc.

Question 73.

What are minerals?

Answer:

Minerals : They are naturally occurring chemical substances in the earth's crust containing metal in free state or in combined form and obtainable from mining are called minerals. For example, haematite Fe_2O_3 , galena PbS , etc.

Question 74.

What are ores?

Answer:

Ores : The minerals containing a high percentage of metals from which metals can be profitably extracted are called ores.

[Note : Every ore is a mineral but every mineral is not an ore.]

Question 75.

Write names of minerals and ores of Iron, Copper and Zinc.

Answer:

Metals	Mineral	Ore
Iron	Haematite Fe_2O_3 Magnetite Fe_3O_4 Limonite $2\text{Fe}_2\text{O}_3, 3\text{H}_2\text{O}$ Iron pyrites FeS_2 Siderite FeCO_3	Haematite
Copper	Chalcopyrite CuFeS_2 Chalcocite Cu_2O	Chalcopyrite Chalcocite
Zinc	Zinc blende ZnS Zincite ZnO Calamine ZnCO_3	Zinc blende

Question 76.

What is metallurgy?

Answer:

Metallurgy : The process of extraction of metal in a pure state from its ore is called metallurgy.

Question 77.

Define the following:

- (1) Pyrometallurgy
- (2) Hydrometallurgy
- (3) Electrometallurgy.

Answer:

1. Pyrometallurgy : It is a process of extraction of metal from metal oxide from concentrated ore by reduction with a suitable reducing agent like carbon, hydrogen, aluminium, etc. at high temperature.
2. Hydrometallurgy : It is a process of extraction of metals by converting their ores into aqueous solutions of metal compounds and reducing them by suitable reducing agents.
3. Electrometallurgy : It is a process of extraction of highly electropositive metals like Na, K, Al, etc. by electrolysis of fused compounds of the metals where metal ions are reduced at cathode forming metals.

Question 78.

What is gangue?

Answer:

Gangue : The earthly and undesired impurities of various substances like sand (SiO_2), metal oxides, etc. present in the ore are called gangue or matrix.

Question 79.

Define concentration of an ore.

Answer:

Concentration : A process of removal of gangue or unwanted impurities from the ore is called concentration of an ore. It is also called benefaction or dressing of an ore.

Question 80.

What are common methods of concentration of an ore?

Answer:

The concentration of an ore involves different methods depending upon the differences in physical properties of compounds or the metal present and the nature of the gangue.

The common methods of concentration of ore are as follows :

1. Gravity separation or hydraulic washing :
This can be carried out by two processes as follows :
2.
 - Hydraulic washing by using Wilfley's table method
 - Hydraulic classifier methods.
3. Magnetic separation
4. Froth floatation process.
5. Leaching.

The method depends upon the nature of ore.

Question 81.

What is leaching?

Answer:

Leaching : It is a (chemical) process used in the concentration of an ore by extracting soluble material from an insoluble solid by dissolving in a suitable solvent. This method is used in the concentration process of ores of Al, Ag, Au, etc.

Question 82.

What is roasting of an ore?

Answer:

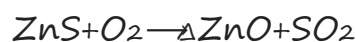
Roasting : It is a process of strongly heating a concentrated ore in the excess of air below melting point of metal, to convert it into oxide form. It is used for a sulphide ore. For example, ZnS ore on roasting forms ZnO.

Question 83.

Write an equation to show how zinc blende (ZnS) is converted to ZnO.

Answer:

When zinc blende is roasted, it is converted to ZnO.



Question 84.

Explain the term : Smelting

Answer:

Smelting : The process of extraction of a metal from its ore by heating and melting at high temperature is called smelting. Reduction of ore is carried out during smelting.

Question 85.

What is calcination?

Answer:

Calcination is a process in which the ore is heated to a high temperature below the melting point of the metal in the absence of air or limited supply of air in a reverberatory furnace.

It is generally used for carbonate and hydrated oxides to convert them into anhydrous oxides.

Question 86.

Define the terms :

(1) Flux

(2) Slag

Answer:

(1) Flux : A flux is a chemical substance which is added to the concentrated ore during smelting in order to remove the gangue or impurities by chemical reaction forming a fusible mass called slag.

(2) Slag : It is a waste product formed by combination of a flux and gangue (or impurities) during the extraction of metals by smelting process.

Iron is the fourth most abundant element in the earth's crust.

Question 87.

What is the composition of haematite ore?

Answer:

Composition of Haematite ore is $\text{Fe}_2\text{O}_3 + \text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{phosphates}$

Question 88.

Which impurities (gangue) are present in haematite ore?

Answer:

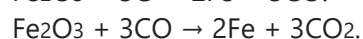
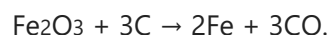
SiO_2 and Al_2O_3 are the impurities present in the haematite ore.

Question 89.

Which reducing agents are used to reduce haematite ore into metallic iron?

Answer:

Haematite ore is reduced using coke and CO. Carbon in the coke is converted to carbon monoxide. Carbon and carbon monoxide together reduce Fe_2O_3 to metallic iron.

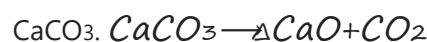


Question 90.

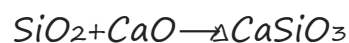
Why is limestone used in the extraction of iron?

Answer:

- The ore of iron contains acidic gangue or impurity of silica, SiO_2 .
- To remove silica gangue, basic flux like calcium oxide CaO , is required, which is obtained from the decomposition of limestone,



- Silica reacts with CaO and forms a fusible slag of CaSiO_3 .



Therefore in the extraction of iron, lime is used.

Question 91.

Name the furnace in which iron is extracted from Haematite ore.

Answer:

Extraction of iron is carried out in Blast furnace.

Question 92.

Explain the extraction of iron from haematite.

Answer:

Iron is mainly extracted from haematite, Fe_2O_3 by reduction process.

Haematite ore contains silica (SiO_2), alumina (Al_2O_3) and phosphates as impurity or gangue.

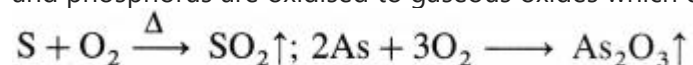
Coke is used for the reduction of ore.

To remove acidic gangue SiO_2 , a basic flux CaO is used which is obtained from lime stone CaCO_3 .

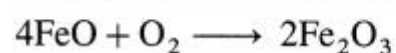
The extraction process involves following steps :

(1) Concentration of an ore : The powdered ore is concentrated by gravity separation process by washing it in a current of water. The lighter impurities (gangue) are carried away leaving behind the ore.

(2) Roasting : The concentrated ore is heated strongly in a limited current of air. During this, moisture is removed and the impurities like S, As and phosphorus are oxidised to gaseous oxides which escape.

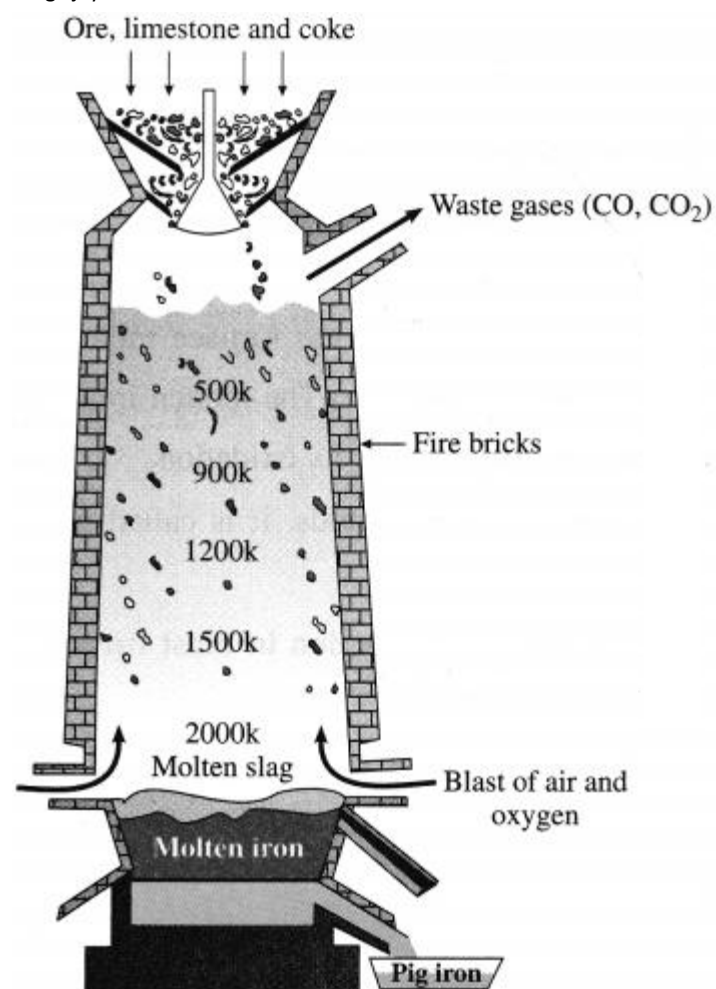


FeO present in the ore is oxidised to Fe_2O_3 .



After roasting, the ore is sintered to form small lumps.

(3) Reduction (or smelting) : The roasted or calcined ore is then reduced by heating in a blast furnace.



Blast furnace

The blast furnace is a tall cylindrical steel tower about 25 m in height and has a diameter about 5-10m lined with fire bricks inside.

Blast furnace has three parts :

- the hearth,
- the bosh and
- the stack.

At the top, there is a cup and cone arrangement to introduce the ore and at the bottom, tapping hole for withdrawing molten iron and an outlet to remove a slag.

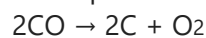
The roasted ore is mixed with coke and limestone in the approximate ratio of 12 : 5 : 3.

A blast of hot air at about 1000 K is blown from downwards to upwards by layers arrangement. The temperature range is from bottom 2000 K to 500 K at the top. The charge of ore from top and the air blast from bottom are sent simultaneously. There are three zones of temperature in which three main chemical reactions take place.

(i) Zone of combustion : The hot air oxidises coke to CO which is an exothermic reaction, due to which the temperature of furnace rises.

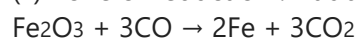


Some part of CO dissociates to give finely divided carbon and O₂.

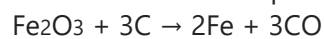


The hot gases with CO rise up in the furnace and heats the charge coming down. CO acts as a fuel as well as a reducing agent.

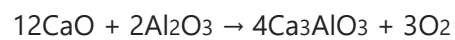
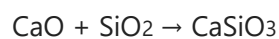
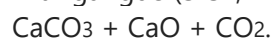
(ii) Zone of reduction : At about 900 °C, CO reduces Fe₂O₃ to spongy (or porous) iron.



Carbon also reduces partially Fe₂O₃ to Fe.



(iii) Zone of slag formation : At 1200 K limestone, CaCO₃ in the charge, decomposes and forms a basic flux CaO which further reacts at 1500 K with gangue (SiO₂, Al₂O₃) and forms a slag of CaSiO₃ and Ca₃AlO₃.



The slag is removed from the bottom of the furnace through an outlet.

(iv) Zone of fusion : The impurities in ore like MnO₂ and Ca₃(PO₄)₂ are reduced to Mn and P while SiO₂ is reduced in Si. The spongy iron moving down in the furnace melts in the fusion zone and dissolves the impurities like C, Si, Mn, phosphorus and sulphure. The molten iron collects at the bottom of furnace. The lighter slag floats on the molten iron and prevents its oxidation.

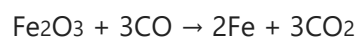
The molten iron is removed and cooled in moulds. It is called pig iron or cast iron. It contains about 4% carbon.

Question 93.

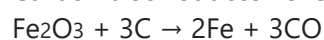
Write the reaction involved in the zone of reduction in blast furnace during extraction of iron.

Answer:

Zone of reduction : At about 900 °C, CO reduces Fe₂O₃ to spongy (or porous) iron.



Carbon also reduces Fe₂O₃ to Fe.



Question 94

Write reactions involved at different temperatures in the blast furnace.

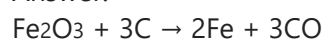
Answer:

Temperature K	Change taking place in the blast furnace	Reactions
1. 500 K	Haematite ore loses moisture	ore xH ₂ O → ore
2. 900 K	Reduction of ore by CO	Fe ₂ O ₃ + 3CO → 2Fe + 3CO
3. 1200K	Limestone decomposes	CaCO ₃ → CaO + CO ₂
4. 1500K	Reduction of ore by C	Fe ₂ O ₃ + 3C → 2Fe + 3CO
5. 1600 K	(i) Reduction of FeO by C (ii) Fusion of iron and slag formation	FeO + C → Fe + CO CaO + SiO ₂ → CaSiO ₃
6. 2000 K	Combustion of coke	2C + O ₂ → CO

Question 95.

What is the action of carbon on Fe₂O₃ in blast furnace?

Answer:



Question 96.

What is refining of metals?

Answer:

Refining of metals : The purification of impure or crude metals by removing metallic and nonmetallic impurities is known as refining of metals.

H

Question 97.

How is pure iron obtained from crude iron?

Answer:

Pure iron can be obtained by electrolytic refining.

Question 98.

Name the methods of refining of metals.

Answer:

Methods of refining of metals :

- Electrowinning
- Liquefaction
- Distillation
- Oxidation m

Question 99.

What are the factors that govern the choice of extraction technique of metals?

Answer:

The choice of extraction technique is governed by the following factors.

- Nature of ore
- Availability and cost of reducing agent. (Generally, cheap coke is used).
- Availability of hydraulic power.
- Purity of metal required.
- Value of by-products. For example. SO₂ obtained during the roasting of sulphide ores is important for the manufacture of H₂SO₄.

Question 100.

Which are the commercial forms of iron?

Answer:

Commercial forms of iron are :

- Cast iron
- wrought iron
- steel. H

Question 101.

(A) What are f-block elements?

(B) What are inner transition elements?

Answer:

(A)

- Elements in which differentiating electron enters into the pre-penultimate shell the $(n - 2)$ f-orbital are known as f.block elements.
- They include 28 elements with atomic numbers ranging from 58-71 and atomic numbers 90 to 103 collectively.
- There are two f-series or two f-block elements, namely 4f and 5f series.
- The f-block includes two inner transition series namely the lanthanoid series. Cerium (58) to LuteUum (71) or the 4 f-block elements and the actinoid series. Thorium (90) to Lawrencium (103) or the 5f block elements.

(B) f-block elements are called inner transition elements since f-orbital lies much inside the f-orbital in relation to the transition metals, These elements have 1 to 14 electrons in their f-orbital.

Question 102.

What are first inner transition elements?

Answer:

1. 4f-block elements are called (first) inner transition elements and have partly filled inner orbitals or (4f) orbitals.
2. They have general outer electronic configuration $(n-2)f^{1-14}, (n-1)d^{0-1}, ns^2$.
3. There are two f-series, namely 4f and 5f series, called lanthanoids and actinoids respectively.
4. They show intermediate properties as compared to electropositive s-block elements and electronegative p-block elements. Hence they are called (first) inner transition elements.

Question 103.

What are lanthanoids (or lanthanides)?

OR

What is the lanthanoid series?

Answer:

- Lanthanoids or Lanthanoid series or Lanthanones : The series of fourteen elements from ^{58}Ce to ^{71}Lu in which a differentiating electron enters 4f sub-shell and follows lanthanum is called lanthanoid series and the elements are called lanthanoids.
- They have general electronic configuration, $[\text{Xe}] 4f^{1-14}, 5d^{0-1}, 6s^2$.
- They follow Lanthanum ($Z = 57$) in 3d-series.

Question 104.

What are rare earths?

Answer:

- Lanthanoids or 4f-block elements are called rare earths.
- Lanthanoids are never found in free state, and their minerals are not pure.
- They exhibit similar chemical properties hence cannot be extracted and separated by normal metallurgical processes.
- Lanthanoid metals are available on small scale. Therefore they are called rare earths.

Question 105.

Explain the position of lanthanoids in the periodic table.

OR

How is the position of lanthanoids justified?

Answer:

1. Position of Lanthanoids in the periodic table : Group – 3; Period – 6.
2. They interrupt the third transition series of t/-block elements (i.e. 5 d series) in the sixth period.
3. They are 14 elements from ^{58}Ce to ^{71}Lu and their position is in between La and Hf. Since they follow lanthanum, they are called lanthanoids.
4. They are called 4f-series elements and for the convenience, they are placed separately below the main periodic table.
5. The actual position of lanthanoids is in between Lanthanum ($Z = 57$) and Hafnium ($Z = 72$).
6. Their position is justified due to following reasons :
 - All these elements have the same electronic configuration in ultimate and penultimate shells, one electron in 5d-orbital and two electrons in 6s-orbital.
 - Group valence of all lanthanoids is 3.
 - All lanthanoids from ^{58}Ce to ^{71}Lu have similar physical and chemical properties.

Question 106.

Explain the meaning of inner-transition series.

Answer:

A series of f-block elements having electronic configuration $(n - 2)f^{1-14} (n - 1) d^{0-1} ns^2$ placed separately in the periodic table represents inner transition series. The f-orbitals lie much inside the e/ orbitals.

Since the last electron enters pre-penultimate shell, these elements are inner transition elements.

There are two inner transition series as follows :

4f-series $^{58}\text{Ce} \rightarrow ^{71}\text{Lu}$

5f-series $^{90}\text{Th} \rightarrow ^{103}\text{Lr}$

Question 107.

Draw a skeletal diagram of the periodic table to show the position of d and/- block elements.

Answer:

Periodic Table

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1																		
2																		
3																		
4																		
5																		
6																		
7																		

s-Block (Groups 1 and 2)

d-Block Elements (Groups 3 to 10)

p-Block (Groups 13 to 18)

f-Block Elements (Lanthanoids and Actinoids)

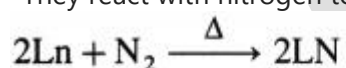
* Lanthanoids (4f-series)	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
** Actinoids (5f-series)	90	91	92	93	94	95	96	97	98	99	100	101	102	103
	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Question 108.

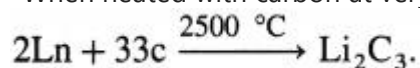
What are the properties of lanthanoids?

Answer:

- Lanthanoids are soft metals with silvery white colour, Colour and brightness reduces on exposure to air.
- They are good conductors of heat and electricity.
- Except promethium (Pm), all are non-radioactive in nature.
- The atomic and ionic radii decrease from La to Lu. (Lanthanoid contraction).
- Coordination numbers are greater than 6.
- They are paramagnetic.
- They become ferromagnetic at lower temperature.
- Their magnetic and optical properties are independent of environment.
- They are called rare earths as their extraction was difficult.
- They are abundant in earth's crust
- All lanthanoids form hydroxides which are ionic and basic. Basicity decreases with atomic number,
- They react with nitrogen to give nitrides and with halogen to give halides.



- When heated with carbon at very high temperature give carbides



Question 109.

Explain the variations in ionisation enthalpy of lanthanoids.

Answer:

- The first ionisation enthalpy of lanthanoids is nearly same. It is very high for Gd and Yb.
- The ionisation enthalpy increases from first (IE₁) to third (IE₃).

First, second and third ionization enthalpies of lanthanoids in kJ/mol

Lanthanoid	IE ₁	IE ₂	IE ₃
La	538.1	1067	1850.3
Ce	528.0	1047	1949
Pr	523.0	1018	2086
Nd	530.0	1034	2130
Pm	536.0	1052	2150

Sm	543.0	1068	2260
Eu	547.0	1085	2400
Gd	592.0	1170	1990
Tb	564.0	1112	2110
Dy	572.0	1126	2200
Ho	581.0	1139	2200
Er	589.0	1151	2190
Tm	596.7	1163	2284
Yb	603.4	1175	2415
Lu	523.5	1340	2022

Question 110.

Give the general electronic configuration of 4f-series elements (OR lanthanoids).

Answer:

- The general electronic configuration of 4f-series elements is, $\text{Ln}[\text{Xe}]_{54} 4f^{1-14} 5d^{0-1} 6s^2$ where Ln is a lanthanoid.
- Xenon has electronic configuration, $[\text{Xe}] : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6$.
- In lanthanoids, the differentiating electron enters prepenultimate shell, 4f m

Question 111.

What are the important features of the electronic configuration of lanthanoids?

Answer:

1. Lanthanoids show two types of electronic configurations
(a) an expected or idealized
(b) an observed electronic configuration.
In the idealized electronic configuration, the filling of the 4f-orbitals is regular but in the observed configuration, there is the shift of a single electron from 5d to 4f sub-shell.
2. Lanthanum (57) has an electronic configuration $[\text{Xe}] 4f^0 5d^1 6s^2$. It does not have any f-electron.
3. The next incoming electron does not enter the 5d sub-shell but goes to the 4f sub-shell.
4. 14 electrons are progressively filled in the 4f sub-shell as the atomic number increases by one unit from La to Lu.
5. La, Gd and Lu are the only elements which possess one electron in a 5d orbital, while in all other lanthanoids the 5d sub-shell is empty.
6. La-(4f⁰), Gd-(4f⁷) and Lu-(4f¹⁴) possess extra stability due to their empty, half-filled and completely filled 4f-orbitals respectively.
7. The 4f-electrons in the prepenultimate shell are shielded by the outermost higher orbitals, 5s², 5p⁶, 5d¹, 6s², i.e. by eleven electrons, hence they are less effective in chemical bonding.

Electronic configuration (Idealised and observed)

Elements	Symbol	Atomic number	Electronic configuration	
			Expected (Idealised)	Observed
Lanthanum	La	57	[Xe] $4f^0 5d^1 6s^2$	[Xe] $4f^0 5d^1 6s^2$
Cerium	Ce	58	[Xe] $4f^1 5d^1 6s^2$	[Xe] $4f^2 5d^0 6s^2$
Praseodymium	Pr	59	[Xe] $4f^2 5d^1 6s^2$	[Xe] $4f^3 5d^0 6s^2$
Neodymium	Nd	60	[Xe] $4f^3 5d^1 6s^2$	[Xe] $4f^4 5d^0 6s^2$
Promethium	Pm	61	[Xe] $4f^4 5d^1 6s^2$	[Xe] $4f^5 5d^0 6s^2$
Samarium	Sm	62	[Xe] $4f^5 5d^1 6s^2$	[Xe] $4f^6 5d^0 6s^2$
Europium	Eu	63	[Xe] $4f^6 5d^1 6s^2$	[Xe] $4f^7 5d^0 6s^2$
Gadolinium	Gd	64	[Xe] $4f^7 5d^1 6s^2$	[Xe] $4f^7 5d^1 6s^2$
Terbium	Tb	65	[Xe] $4f^8 5d^1 6s^2$	[Xe] $4f^9 5d^0 6s^2$
Dysprosium	Dy	66	[Xe] $4f^9 5d^1 6s^2$	[Xe] $4f^{10} 5d^0 6s^2$
Holmium	Ho	67	[Xe] $4f^{10} 5d^1 6s^2$	[Xe] $4f^{11} 5d^0 6s^2$
Erbium	Er	68	[Xe] $4f^{11} 5d^1 6s^2$	[Xe] $4f^{12} 5d^0 6s^2$
Thulium	Tm	69	[Xe] $4f^{12} 5d^1 6s^2$	[Xe] $4f^{13} 5d^0 6s^2$
Ytterbium	Yb	70	[Xe] $4f^{13} 5d^1 6s^2$	[Xe] $4f^{14} 5d^0 6s^2$
Lutetium	Lu	71	[Xe] $4f^{14} 5d^1 6s^2$	[Xe] $4f^{14} 5d^1 6s^2$

[Xe] $5s^2 5p^6 3d^5 4s^2 4p^6 4d^1 5s^2 5p^6$

Question 112.

Write the expected electronic configuration of (a) Nd (Z = 60) (b) Tm (Z = 69).

Answer:

Expected electronic configuration :

(a) Nd = [Xe] $4f^3 5d^1 6s^2$

(b) Tm = [Xe] $4f^{14} 5d^1 6s^2$

Question 113.

Write electronic configurations of

(i) Gd

(ii) Yb.

Answer:

(i) ^{64}Gd [Xe] $4f^7 5d^1 6s^2$ (Observed)

(ii) ^{70}Yb [Xe] $4f^{14} 5d^0 6s^2$ (Observed)

Question 114.

Write expected and observed electronic configurations of

(i) Ce

(ii) Tb.

Answer:

Element	Expected (Idealised)	Observed
(i) ^{58}Ce	[Xe] $4f^1 5d^1 6s^2$	[Xe] $4f^2 5d^0 6s^2$
(ii) ^{65}Tb	[Xe] $4f^8 5d^1 6s^2$	[Xe] $4f^9 5d^0 6s^2$

Question 115.

Why are the expected and observed ground state electronic configurations of gadolinium and lawrencium same?

Answer:

- The degenerate orbitals like $4f$ and $5f$ acquire extra stability when they are half filled ($4f^7$) or completely filled ($5f^{14}$).
- The expected and observed electronic configuration of gadolinium is, ^{64}Gd [Xe] $4f^7 5d^1 6s^2$.
- The expected and observed electronic configuration of lawrencium is ^{103}Lr [Rn] $5f^{14} 6d^1 7s^2$.

Question 116.

Explain oxidation states of lanthanoids.

Answer:

- The common oxidation state of the Lanthanoids is 3 + due to the loss of 2 electrons from outermost 6s orbital and one electron from the penultimate 5d sub-shell.
- Gd³⁺ and Lu³⁺ show extra stability due to their half-filled and completely filled f-orbitals, Gd³⁺ = [Xe]4f⁷, Lu³⁺ = [Xe]4f¹⁴
- Ce and Tb attain the 4f⁰ and 4f⁷ configurations in the 4 + oxidation states. Eu and Yb attain the 4f⁷ and 4f¹⁴ configurations in the 2 + oxidation states. Sm and Tm also show the 2+ oxidation state although their stability can be explained based on thermodynamic factors.
- Some lanthanoids show 2 + and 4 + oxidation states even though they do not have stable electronic configuration of 4f⁰, 4f⁷ or 4f¹⁴.
E.g. Pr⁴⁺ (4f¹), Nd²⁺ (4f⁴), Sm²⁺ (4f⁶), Dy⁴⁺ (4f⁸) etc

Question 117.

Write the electronic configuration of the following ions :

(1) La³⁺ ;

(2) Gd³⁺;

(3) Eu³⁺;

(4) Ce³⁺.

Answer:

(1) La³⁺ = [Xe]

(2) Gd³⁺ = [Xe] 4f⁷

(3) Eu³⁺ = [Xe] 4f⁶

(4) Ce³⁺ = [Xe] 4f¹

Question 118.

Write the electronic configuration of

(1) Nd²⁺

(2) Nd³⁺

(3) Nd⁴⁺.

Answer:

(1) Nd²⁺ [Xe] 4f⁴

(2) Nd³⁺ [Xe] 4f³

(3) Nd⁴⁺ [Xe] 4f²

Question 119.

Among the following lanthanoids, which elements show only one oxidation state 3 +? Why? Dy, Gd, Yb, Lu.

Answer:

Gd and Lu show only one oxidation state 3 +, since they acquire electronic configurations with extra stability namely 4f⁷ and 4f¹⁴ respectively.

Question 120.

Write the expected electronic configurations of :

(1) europium (Z = 63),

(2) erbium (Z = 68).

Answer:

(1) Europium (63Eu) [Xe]544f⁶ 5d¹ 6s²

(2) Erbium (68Er) [Xe]544f¹¹ 5d¹ 6s²

Question 121.

Why does lanthanum form La³⁺ ion, while cerium forms Ce⁴⁺ ion? (Atomic number La = 57 and Ce = 58).

Answer:

- Electronic configuration Lanthanum is La [Xe] 4f⁰ 5d¹ 6s². By losing three electrons, La acquires stable electronic configuration of Xe and forms La³⁺.
- Electronic configuration of Cerium is Ce [Xe] 4f¹ 5d¹ 6s². By losing four electrons, Ce acquires stable electronic configuration of Xe and forms Ce⁴⁺.

Question 122.

⁶³Eu and ⁷⁰Yb show 2 + oxidation state. Explain.

Answer:

⁶³Eu has electronic configuration, [Xe] 4f⁷ 5d⁰ 6s². By losing 2 electrons from 6s orbital, it acquires stable configuration and 4f-orbital is half-filled.

⁷⁰Yb has electronic configuration, [Xe] 4f¹⁴ 5d⁰ 6s². By losing 2 electrons from 6 s orbital, it acquires stable configuration and 4f-orbital is completely filled.

Hence Eu and Yb show 2 + oxidation states.

Question 123.

Display electronic configuration, atomic and ionic radii of lanthanoids.

Answer:

Answers are given in bold.

Electronic configuration and atomic ionic radii of lanthanoids

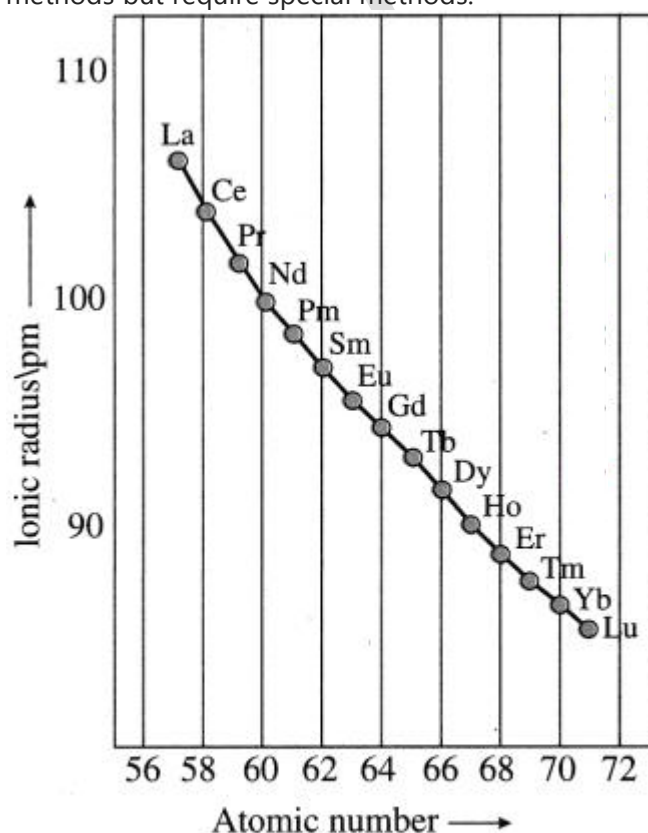
Element	Symbol	Atomic number	Electronic configuration				Atomic radii, pm	Ionic radii (Ln^{+3} , 6-coordinate), pm
			Expected (ground state)	Observed (ground state)	(+2 oxidation state)	(+3 oxidation state)		
Lanthanum	La	57	$[\text{Xe}]4f^0 5d^1 6s^2$	$[\text{Xe}]4f^0 5d^1 6s^2$	$4f^0, 5d^1$	$4f^0$	187	103
Cerium	Ce	58	$[\text{Xe}]4f^2 6s^2$	$[\text{Xe}]4f^1 5d^1 6s^2$	$4f^2$	$4f^1$	183	102
Praseodymium	Pr	59	$[\text{Xe}]4f^3 6s^2$	$[\text{Xe}]4f^3 6s^2$	$4f^3$	$4f^2$	182	99
Neodymium	Nd	60	$[\text{Xe}]4f^4 6s^2$	$[\text{Xe}]4f^4 6s^2$	$4f^4$	.....	181	98.3
Promethium	Pm	61	$[\text{Xe}]4f^5 6s^2$	$[\text{Xe}]4f^5 6s^2$	$4f^5$	.....	181	97
Samarium	Sm	62	$[\text{Xe}]4f^6 6s^2$	$[\text{Xe}]4f^6 6s^2$	$4f^6$	$4f^5$	180	95.8
Europium	Eu	63	$[\text{Xe}]4f^7 6s^2$	$[\text{Xe}]4f^7 6s^2$	$4f^7$	$4f^6$	199	94.7
Gadolinium	Gd	64	$[\text{Xe}]4f^8 6s^2$	$[\text{Xe}]4f^7 5d^1 6s^2$	$4f^7, 5d^1$	.....	178	93.8
Terbium	Tb	65	$[\text{Xe}]4f^9 6s^2$	$[\text{Xe}]4f^9 6s^2$	$4f^9$	$4f^8$	177	92.3
Dysprosium	Dy	66	$[\text{Xe}]4f^{10} 6s^2$	$[\text{Xe}]4f^{10} 6s^2$	$4f^{10}$	$4f^9$	176	91.2
Holmium	Ho	67	$[\text{Xe}]4f^{11} 6s^2$	$[\text{Xe}]4f^{11} 6s^2$	$4f^{11}$	$4f^{10}$	175	90.1
Erbium	Er	68	$[\text{Xe}]4f^{12} 6s^2$	$[\text{Xe}]4f^{12} 6s^2$	$4f^{12}$	.....	174	89
Thulium	Tm	69	$[\text{Xe}]4f^{13} 6s^2$	$[\text{Xe}]4f^{13} 6s^2$	$4f^{13}$	$4f^{12}$	173	88
Ytterbium	Yb	70	$[\text{Xe}]4f^{14} 6s^2$	$[\text{Xe}]4f^{14} 6s^2$	$4f^{14}$	.....	-	86.8
Lutetium	Lu	71	$[\text{Xe}]4f^{14} 5d^1 6s^2$	$[\text{Xe}]4f^{14} 5d^1 6s^2$	$4f^{14}, 5d^1$	$4f^{14}$	-	86.1

Question 124.

Explain the trend in atomic and ionic sizes of lanthanoids.

Answer:

- From 57La (187 pm) to first element of 4f-series 58Ce (183 pm), the contraction in atomic radius is very large, 4 pm.
- But from Ce onwards as atomic number increases atomic radius decreases very steadily so that total decrease in atomic radius from Ce to Lu is only 10 pm.
- In case of tripositive ions due to large pull by nucleus, the decrease in ionic radii is slightly more, i.e. 18 pm. For example, Ce^{3+} (103 pm) to Lu^{3+} (85 pm).
- Hence all lanthanoids have similar properties. Therefore they cannot be separated from each other easily by normal metallurgical methods but require special methods.



Trends in ionic radii of trivalent lanthanoids

Question 125.

What is meant by lanthanoid contraction?

Answer:

Lanthanoid contraction : The gradual decrease in atomic and ionic radii of lanthanoids with the increase in atomic number is called lanthanoid contraction.

Question 153.

Explain the causes of the lanthanoid contraction.

Answer:

The causes of the lanthanoid contraction are as follows :

- As the atomic number of lanthanoids or 4f-block elements increases the positive nuclear charge increases and correspondingly electrons are added to the penultimate 4f sub-shell.
- The attraction of nucleus on 4 f-electrons increases with the increase in atomic number.
- The outer eleven electrons namely, 5s², 5p⁶, 5d³ and 6s² do not shield inner 4 f-electrons from the nucleus.
- There is imperfect shielding of each 4f-electron from other 4 f-electrons.
- As compared to d sub-shell, the extent of shielding for 4 f-electrons is less.
- Due to these cumulative effects, 4 f-electrons experience greater nuclear attraction and hence valence shell is pulled towards the nucleus to the greater extent decreasing atomic and ionic radii appreciably.
- From 57La to 58Ce, there is a sudden contraction in atomic radius from 187 pm to 183 pm but the further decrease up to the last 4f-element, 71Lu is comparatively low (about 10 pm).

Question 126.

Explain lanthanoid contraction effect with respect to (1) decrease in basicity, (2) ionic radii of post-lanthanoids.

Answer:

The lanthanoid contraction has a definite effect on the properties of lanthanoids as well as on the properties of post-lanthanoid elements.

(1) Decrease in basicity :

- In lanthanoids due to lanthanoid contraction, as the atomic number increases, the size of the lanthanoid atoms and their trivalent positive ions decreases, i.e. from La³⁺ to Lu³⁺.
- As size of the cation decreases, according to Fajan's rule, the polarizability increases and thus the covalent character of the M-OH bond increases, and ionic character decreases.
- Therefore the basic nature of the hydroxides decreases.
- Basicity and ionic character decrease in the order La(OH)₃ > Ce(OH)₃ > ... Lu(OH)₃.

(2) Ionic radii of post-lanthanoids :

- Elements following the lanthanoids in the 6th period (third transition series, i.e. 5d-series) are known as post-lanthanoids.
- Due to lanthanoid contraction the atomic radii (size) of elements which follow lanthanum in the 6th period (3rd transition series – Hf, Ta, W, Re)-are similar to the elements of the 5th period (4d-series Zr, Nb, Mo, Tc).
- Due to similarity in their size, post-lanthanoid elements (5d-series) have closely similar properties to the elements of the 2nd transition series (4d-series) which lie immediately above them.
- Pairs of elements namely Zr-Hf (Gr-4), Nb-Ta (Gr-5), Mo-W (Gr-6), Tc-Re (Gr-7) are called chemical twins since they possess almost identical sizes and similar properties.

Question 127.

Why do lanthanoids form coloured compounds?

Answer:

- The colour in lanthanoid ions is due to the presence of unpaired electrons in partially filled 4f sub-shells.
- Due to the absorption of radiations in the visible region there arises the excitations of the unpaired electrons from f-orbital of lower energy to the f-orbital of higher energy-giving f → f transitions.
- The observed colour is complementary to the colour of the light absorbed.
- The colour of trivalent positive ions (M³⁺) depends upon the number of unpaired electrons in f-orbitals. Hence the lanthanoid ions having equal number of unpaired electrons have similar colour.
- The colours of M³⁺ ions of the first seven lanthanoids, La³⁺ to Eu³⁺ are similar to those of seven elements Lu³⁺ to Tb³⁺ in the reverse order.

Question 128.

Explain, why Ce³⁺ ion is colourless.

Answer:

- The electronic configuration of Ce³⁺ is, [Xe] 4f⁷
- Even though there is one unpaired electron in 4f sub-shell, the f → f transition involves very low energy. Hence, Ce³⁺ ion does not absorb radiation in the visible region.

Therefore Ce³⁺ ion is colourless.

Question 129.

Explain why Gd³⁺ is colourless.

Answer:

- Gd³⁺ has electronic configuration, [Xe] 4f⁷
- Due to extra stability of half filled orbital, it does not allow f → f transition, and hence does not absorb radiations in the visible region.

Hence Gd³⁺ is colourless.

Question 130.

The salts of (1) La^{3+} and (2) Lu^{3+} are colourless. Explain.

Answer:

(1) (i) La^{3+} has electronic configuration, $[\text{Xe}] 4f^0$

(ii) Since there are no unpaired electrons in 4 f-orbital, $f \rightarrow f$ transition is not possible. Hence La^{3+} ions do not absorb radiations in visible region, and they are colourless.

(2) (i) Lu^{3+} has electronic configuration $[\text{Xe}] 4f^{14}$

(ii) Since there are no unpaired electrons in 4f-orbital, $f \rightarrow f$ transition is not possible. Hence Lu^{3+} ions do not absorb radiations in visible region and they are colourless.

Question 131.

Explain giving examples, the colour of nf electrons is about the same as those having $(14-n)$ electrons.

Answer:

(1) Consider Pr^{3+} and Tm^{3+} ions.

Tm^{3+} ($4f^{12}$) has nf electron 12 electrons.

Pr^{3+} ($4f^2$) has $(14 - n) = (14 - 2) = 12$ electrons. Both, Tm^{3+} and Pr^{3+} are green.

(2) Consider Nd^{3+} and Er^{3+} ions. Er^{3+} ($4f^{11}$) has nf electrons 11.

Nd^{3+} ($4f^3$) has $(14 - n)$ is $(14 - 3) = 11$ electrons. These both ions Er^{3+} , Nd^{3+} are pink in colour.

Question 132.

Lu^{3+} has observed magnetic moment zero. How many unpaired electrons are present?

Answer:

Since magnetic moment is zero, it has no unpaired electrons.

Question 133.

What are the application of lanthanoids?

Answer:

1. Lanthanoid compounds are used inside the colour television tubes and computer monitor. For example mixed oxide (Eu, Y)₂ O₃ releases an intense red colour when bombarded with high energy electrons.
2. Lanthanoid ions are used as active ions in luminescent materials. (Optoelectronic application)
3. Nd : YAG laser is the most notable application. (Nd : YAG = neodymium doped yttrium aluminium garnet)
4. Erbium doped fibre amplifiers are used in optical fibre communication systems.
5. Lanthanoids are used in cars, superconductors and permanent magnets.

Question 134.

What are actinoids? Give their general electronic configuration.

Answer:

- Actinoids : The series of fourteen elements from ^{90}Th to ^{103}Lr which follow actinium (^{89}Ac) and in which differentiating electrons are progressively filled in 5f-orbitals in penultimate shell are called actinoids.
- Their general electronic configuration is, $[\text{Rn}] 5f^{1-14} 6d^{0-1} 7s^2$.

Question 135.

Why are actinoids called inner transition elements?

Answer:

- Actinoids are 5f-series elements in which electrons progressively enter into 5f-orbitals, which are inner orbitals.
- They have electronic configuration $[\text{Rn}] 5f^{1-14} 6d^{0-1} 7s^2$.
- They show intermediate properties as compared to electropositive s-block elements and electronegative p-block elements. Hence they are called second inner transition elements.

Question 136.

Explain the position of actinoids in the periodic table.

OR

What is the position of actinoids in the periodic table?

Answer:

- Position of actinoids in the periodic table : Group-3; Period-7.
- They interrupt the fourth transition series (6d series) in the seventh period in the periodic table.
- After Actinium, ^{89}Ac which has electronic configuration $[\text{Rn}] 6d^1 7s^2$, the electrons enter progressively 5f orbital and they have general electronic configuration, $[\text{Rn}] 5f^{1-14} 6d^{0-1} 7s^2$.
- They are fourteen elements from ^{90}Th to ^{103}Lr and since they follow actinium, they are called actinoids.
- They are called 5f series or second inner transition series elements and for the convenience they are placed separately below the periodic table.

Question 137.

Write idealised and observed electronic configuration of actinoids.

Electronic configuration of actinoids

Elements	Symbol	Atomic number	Electronic configuration	
			Expected (Idealised)	Observed
Actinium	Ac	89	$[\text{Rn}] 5f^0 6d^1 7s^2$	$[\text{Rn}] 5f^0 6d^1 7s^2$
Thorium	Th	90	$[\text{Rn}] 5f^1 6d^1 7s^2$	$[\text{Rn}] 5f^0 6d^2 7s^2$
Protactinium	Pa	91	$[\text{Rn}] 5f^2 6d^1 7s^2$	$[\text{Rn}] 5f^2 6d^1 7s^2$
Uranium	U	92	$[\text{Rn}] 5f^3 6d^1 7s^2$	$[\text{Rn}] 5f^3 6d^1 7s^2$
Neptunium	Np	93	$[\text{Rn}] 5f^4 6d^1 7s^2$	$[\text{Rn}] 5f^4 6d^1 7s^2$
Plutonium	Pu	94	$[\text{Rn}] 5f^5 6d^1 7s^2$	$[\text{Rn}] 5f^6 6d^0 7s^2$
Americium	Am	95	$[\text{Rn}] 5f^7 6d^0 7s^2$	$[\text{Rn}] 5f^7 6d^0 7s^2$
Curium	Cm	96	$[\text{Rn}] 5f^7 6d^1 7s^2$	$[\text{Rn}] 5f^7 6d^1 7s^2$
Berkelium	Bk	97	$[\text{Rn}] 5f^8 6d^1 7s^2$	$[\text{Rn}] 5f^9 6d^0 7s^2$
Californium	Cf	98	$[\text{Rn}] 5f^9 6d^1 7s^2$	$[\text{Rn}] 5f^{10} 6d^0 7s^2$
Einsteinium	Es	99	$[\text{Rn}] 5f^{10} 6d^1 7s^2$	$[\text{Rn}] 5f^{11} 6d^0 7s^2$
Fermium	Fm	100	$[\text{Rn}] 5f^{11} 6d^1 7s^2$	$[\text{Rn}] 5f^{12} 6d^0 7s^2$
Mendelevium	Md	101	$[\text{Rn}] 5f^{12} 6d^1 7s^2$	$[\text{Rn}] 5f^{13} 6d^0 7s^2$
Nobelium	No	102	$[\text{Rn}] 5f^{14} 6d^0 7s^2$	$[\text{Rn}] 5f^{14} 6d^0 7s^2$
Lawrencium	Lr	103	$[\text{Rn}] 5f^{14} 6d^1 7s^2$	$[\text{Rn}] 5f^{14} 6d^1 7s^2$

Question 138.

Explain the oxidation states of actinoids.

Answer:

- Due to availability of electrons in 5f, 6d and 7s sublevels, lanthanoids show varied oxidation states.
- The most common oxidation state is + 3 due to loss of one electron from 6d and two electrons from 6s-orbitals.
- Ac, Th and Am show + 2 oxidation state.
- Th, Pa, U, Np, Pu, Am and Cm show + 4 oxidation state.
- Np and Pu show the highest oxidation state + 7.
- U, Np, Bk, Cm and Am show stable oxidation state + 4.
- In + 6 oxidation state, due to high charge density the actinoid ions form oxygenated ions, e.g. UO_{+2} , NpO_{+2} , etc.

Oxidation states of actinium and actinoids

Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
2	2					2								
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4						
	5	5	5	5	5	5								
			6	6	6	6								
				7	7									

Question 139.

Why do actinoids show variable oxidation states?

Answer:

- The large number of variable oxidation states of actinoids is due to very small energy difference between 5f, 6d and 7s subshells.
- The electronic configuration of actinoids is, [Rn] 5f¹⁻¹⁴ 6d⁰⁻¹ 7s²
- Due to the loss of three electrons from 6d¹ and 7s², the common oxidation state is + 3, but due to further loss of electrons from 5f subshell, actinoids show higher oxidation states.
- The variable oxidation states are + 2 to + 7.

Electronic configuration of actinoids and their ionic radii in + 3 oxidation state

Electronic configuration of actinoids

Element	Symbol	Atomic number	Electronic configuration		* Atomic radii, pm	* Ionic radii (Ac ³⁺), pm
			ground state	+ 3 oxidation state		
Actinium	Ac	89	[Rn] 5f ⁰ 6d ¹ 7s ²	5f ⁰	203	126
Thorium	Th	90	[Rn] 5f ⁰ 6d ² 7s ²	5f ¹	180	—
Protactinium	Pa	91	[Rn] 5f ² 6d ¹ 7s ²	5f ²	162	118
Uranium	U	92	[Rn] 5f ³ 6d ¹ 7s ²	5f ³	153	118
Neptunium	Np	93	[Rn] 5f ⁴ 6d ¹ 7s ²	5f ⁴	150	116
Plutonium	Pu	94	[Rn] 5f ⁶ 6d ⁰ 7s ²	5f ⁵	162	115
Americium	Am	95	[Rn] 5f ⁷ 6d ⁰ 7s ²	5f ⁶	173	114
Curium	Cm	96	[Rn] 5f ⁷ 6d ¹ 7s ²	5f ⁷	174	112
Berkelium	Bk	97	[Rn] 5f ⁹ 6d ⁰ 7s ²	5f ⁸	170	110
Californium	Cf	98	[Rn] 5f ¹⁰ 6d 7s ²	5f ⁹	186	109
Einsteinium	Es	99	[Rn] 5f ¹¹ 6d ⁰ 7s ²	5f ¹⁰	186	98
Fermium	Fm	100	[Rn] 5f ¹² 6d ⁰ 7s ²	5f ¹¹	198	91
Mendelevium	Md	101	[Rn] 5f ¹³ 6d ⁰ 7s ²	5f ¹²	194	90
Nobelium	No	102	[Rn] 5f ¹⁴ 6d ⁰ 7s ²	5f ¹³	197	95
Lawrencium	Lr	103	[Rn] 5f ¹⁴ 6d ¹ 7s ²	5f ¹⁴	171	88

Question 140.

What is meant by actinoid contraction?

Answer:

Actinoid contraction: The gradual decrease in atomic and ionic radii of actinoids with the increase in atomic number is called actinoid contraction.

Question 141.

The extent of actinoid contraction is greater than lanthanoid contraction. Explain Why?

Answer:

- The electronic configurations of :
Lanthanoids [Xe] 4f¹⁻¹⁴ 5d⁰⁻¹ 6s²
Actinoids [Rn] 5f¹⁻¹⁴ 6d⁰⁻¹ 7s²
- The mutual screening offered in case of 5f-electrons is less than that in the 4f-electrons.
- Hence, the outer orbitals are pulled to the greater extent by nuclei in actinoids (5f-series) than in lanthanoids (4f-series).
- Therefore, actinoid contraction is greater than lanthanoid contraction.

Question 142.

Describe the important properties of actinoids.

Answer:

Properties of actinoids :

- Actinoids are silvery white (similar to lanthanoids).
- They are highly reactive radioactive elements.
- Most of these elements are not found in nature. They are radioactive and man made.
- They experience decrease in the atomic and ionic radii from Ac to Lw, known as actinoid contraction.

- The common oxidation state is +3. Elements of the first half of the series exhibit higher oxidation states.

Question 143.

What are the applications of actinoids?

Answer:

- Thorium oxide (ThO_2) with 1% CeO_2 is used as a major source of indoor lighting, as well as for outdoor camping.
- Uranium is used in the nuclear reactors.
- The isotopes of Thorium and Uranium have very long half-life, so that we get very negligible radiation from them: Hence they can be used safely.

Question 144.

What are transuranic elements?

Answer:

- The man-made elements heavier than Uranium ($Z = 92$) in the Actinoid series are called transuranic elements.
- These are synthetically or artificially prepared (man-made) elements starting from Neptunium ($Z = 93$).
- Transuranic elements are generally considered to be from Neptunium ($Z = 93$) to Lawrencium ($Z = 103$).
- Recently elements from atomic number 104 (Rf) to atomic number 118 (Og) or (Uuo) in 6 d series have also been identified as transuranic elements.
- All transuranic elements are radioactive.

Question 145.

What are post actinoid elements?

Answer:

- Elements from atomic number 104 to 118 are called postactinoid elements.
- The post actinoid elements known so far are transition metals.
- They can be synthesised in the nuclear reactions.
- As they have very short half life period, it is difficult to study their chemistry.
- Rutherfordium forms a chloride (RfCl_4) similar to zirconium and hafnium in + 4 oxidation state.
- Dubnium resembles niobium and protactinium.

Question 146.

Name the transuranic elements.

Answer:

Names of transuranic elements

Name	Symbol	Atomic number
Neptunium	Np	93
Plutonium	Pu	94
Americium	Am	95
Curium	Cm	96
Berkelium	Bk	97
Californium	Cf	98
Einsteinium	Es	99
Ferminum	Fm	100
Mendelevium	Md	101
Nobelium	No	102
Lawrencium	Lr	103
Rutherfordium	Rf	104
Dubnium	Db	105
Seaborgium	Sg	106
Bohrium	Bh	107
Hassium	Hs	108
Meitnerium	Mt	109
Darmstadtium	Uun/Ds	110
Roentgenium	Uuu/Rg	111

Copernicium	Uub/Cn	112
Ununtrium	Uut	113
Ununquadium	Uuq	114
Ununpentium	Uup	115
Ununhexium	Uuh	116
Ununseptium	Uus	117
Ununoctium	Uuo	118

In the transuranic elements, elements from atomic number 93 to 103 are actinoids and from atomic number 104 to 118 are called postactinoid elements.

Question 147.

What are the similarities between lanthanides and actinides.

Answer:

Lanthanides and actinides show similarities as follows :

- Both, lanthanides and actinides show + 3 oxidation state.
- In both the series, the f-orbitals are filled gradually.
- Ionic radius of the elements in both the series decreases with increase in atomic number.
- Electronegativity in both the series is low for all the elements.
- They all are highly reactive.
- The nitrates, perchlorates and sulphates of all elements are soluble while their hydroxides, chlorides and carbonates are insoluble.

Question 148.

Differentiate between lanthanoids and actinoids.

Answer:

Lanthanoids	Actinoids
Electronic configuration [Xe] 4f ¹⁻¹⁴ 5d ⁰⁻¹ , 6s ²	Electronic configuration [Rn] 5f ¹⁻¹⁴ 6d ⁰⁻¹ , 7s ²
The differentiating electron enters the 4f subshell.	The differentiating electron enters the 5f subshell.
Except for Promethium all other elements occur in nature.	Except for Uranium and Thorium, all others are synthesized in the laboratory.
The binding energy of 4f electrons is higher.	5f-orbitals have lower binding energy.
Only Promethium is radioactive.	All elements are radioactive.
Besides 3 + oxidation state they show 2 + and 4 + oxidation states.	Besides 3 + oxidation state they show 2 + , 4 + , 5 + , 6 + , 7 + oxidation states.
They have a less tendency to form complexes.	They have greater tendency to form complexes.
Many lanthanoid ions are colourless. Their colour is not as deep and sharp as actinoids.	Actinoids are coloured ions. Their colour is deep, e.g. U ³⁺ is red and U ⁴⁺ is green.
Lanthanoids cannot form oxo-cations.	Actinoids form oxo-cations such as – UO ₂ ⁺ , PuO ₂ ⁺ , UO ₂ ²⁺ , PuO ₂ ²⁺ .
Lanthanoid hydroxides are less basic.	Actinoid hydroxides are more basic.
Lanthanoid contraction is relatively less.	Actinoid contraction from element to element is comparatively more.
Mutual shielding of 4f electrons is more.	Mutual shielding effect of 5f electrons is less.

Question 149.

Compare Pre-transition metals, Lanthanoid and transition metals.

Answer:

Pre-Transition Metals	Lanthanoids	Transition Metals
Essentially monovalent show group ($n +$) oxidation state or divalent ($+ 2$) oxidation state	Essentially in ($+ 3$) oxidation state ($+ 2/ + 4$ for certain configurations)	Show variable oxidation states
Periodic trends dominated by effective nuclear charge at noble gas configuration	Lanthanoid contraction of Ln^{3+}	Size changes of M^{n+} , less marked
Similar properties for a given group	Similar properties	Substantial changes in properties
Always form 'hard' acids (O,X, N donors, preferably negatively charged)	Always form 'hard' acids (O,X,N donors, preferably negatively charged)	Heavier metals (increasingly from Fe-Cu) may show a 'soft' character
No ligand field effects	Insignificant ligand field effects	Substantial ligand field effects
Poor coordination properties (C.N. determined by size) C.N. is coordination number	High coordination numbers (C.N. determined by size)	Coordination number 6 is typical maximum (many exceptions)
Flexibility in geometry	Flexibility in geometry	Fixed geometries (ligand field effects)
No magnetism	Show magnetism	Show magnetism

Multiple Choice Questions

Question 150.

Select and write the most appropriate answer from the given alternatives for each sub-question :

1. In transition elements, the different electron enters into

- (a) ns subshell
- (b) np subshell
- (c) $(n - 1)$ d subshell
- (d) $(n - 2)$ f subshell

Answer:

- (c) $(n - 1)$ d subshell

2. Chromium ($Z = 24$) has electronic configuration

- (a) $[\text{Ar}]4d^4 4s^2$
- (b) $[\text{Ar}] 4d^5 4s^1$
- (c) $[\text{Ar}] 3d^5 3s^1$
- (d) $[\text{Ar}] 3d^5 4s^1$

Answer:

- (d) $[\text{Ar}] 3d^5 4s^1$

3. Manganese achieves the highest oxidation state in its compounds

- (a) Mn_3O_4
- (b) KMnO_4
- (c) K_2MnO_4
- (d) MnO_2

Answer:

- (b) KMnO_4

4. The group which belongs to transition series is

- (a) 2
- (b) 7
- (c) 13
- (d) 15

Answer:

- (b) 7

5. The last electron of transition element is called

- (a) s-electron
- (b) p-electron
- (c) d-electron

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(d) *f*-electron

Answer:

(c) *d*-electron

6. Which one of the following elements does NOT belong to first transition series?

(a) Fe

(b) V

(c) Ag

(d) Cu

Answer:

(c) Ag

7. The incomplete d-series is

(a) 3d

(b) 4d

(c) 5d

(d) 6d

Answer:

(d) 6d

8. The electronic configuration of Sc is

(a) [Ar] 3d² 4s²

(b) [Ar] 3d¹ 4s²

(c) [Kr] 3d¹ 4s²

(d) [Kr] 3d² 4s¹

Answer:

(b) [Ar] 3d¹ 4s²

9. The observed electronic configuration of copper is

(a) [Ar]₁₈ 3d⁹ 4s²

(b) [Kr] 3d¹⁰ 4s¹

(c) [Kr] 3d⁹ 4s²

(d) [Ar] 3d¹⁰ 4s¹

Answer:

(d) [Ar] 3d¹⁰ 4s¹

10. Fe belongs to the

(a) 3d-transition series elements

(b) 4d-transition series elements

(c) 5d-transition series elements

(d) 6d-transition series elements

Answer:

(a) 3d-transition series elements

11. Which one of the following elements does not exhibit variable oxidation states?

(a) Iron

(b) Copper

(c) Zinc

(d) Manganese

Answer:

(c) Zinc

12. In KMnO₄, oxidation number of Mn is

(a) 2+

(b) 4 +

(c) 6 +

(d) 7+

Answer:

(d) 7+

13. Which one of the following transition elements shows the highest oxidation state?

(a) Sc

(b) Ti

(c) Mn

(d) Zn

Answer:

(c) Mn

14. The colour of transition metal ions is due to

(a) $s \rightarrow s$ transition

(b) $d \rightarrow d$ transition

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(c) $p \rightarrow p$ transition

(d) $f \rightarrow f$ transition

Answer:

(b) $d \rightarrow d$ transition

15. Which one of the following compounds is expected to be coloured?

(a) AgNO_3

(b) CuSO_4

(c) ZnCl_2

(d) CuCl

Answer:

(b) CuSO_4

16. The metal ion which is NOT coloured, is

(a) Fe^{3+}

(b) V^{2+}

(c) Zn^{2+}

(d) Ti^{3+}

Answer:

(c) Zn^{2+}

17. A pair of coloured ion is

(a) Cu^{2+} , Zn^{2+}

(b) Cr^{3+} , Cu^{+}

(c) Cd^{2+} , Mn^{5+}

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

Answer:

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

18. The highest oxidation state is shown by

(a) Fe

(b) Mn

(c) Os

(d) Cr

Answer:

(c) Os

19. Transition elements are good catalysts since

(a) they show variable oxidation states

(b) they have partially filled d-orbitals

(c) they have low I.P

(d) they have small atomic radii

Answer:

(a) they show variable oxidation states

20. Highest magnetic moment is shown by the ion

(a) V^{3+}

(b) Co^{3+}

(c) Fe^{3+}

(d) Cr^{3+}

Answer:

(c) Fe^{3+}

21. The most common oxidation state of lanthanoids is

(a) +4

(b) +3

(c) +6

(d) +2

Answer:

(b) +3

22. Which one of the following elements belong to the actinoid series?

(a) Cerium

(b) Lutetium

(c) Thorium

(d) Lanthanum

Answer:

(c) Thorium

23. The total number of elements in each of f-series is

(a) 10

(b) 12

(c) 14

(d) 15

Answer:

(c) 14

24. The general electronic configuration of Lanthanoids is

(a) $[\text{Xe}] 4f^1 - 14 5d^0 - 1 6s^2$

(b) $[\text{Xe}] 4f^2 - 14 5d^0 - 1 6s^2$

(c) $[\text{Xe}] 4f^1 - 13 5d^0 - 1 6s^2$

(d) $[\text{Xe}] 4f^0 - 14 5d^0 - 1 6s^1$

Answer:

(a) $[\text{Xe}] 4f^1 - 14 5d^0 - 1 6s^2$

25. f-block elements are called

(a) transition elements

(b) representative elements

(c) inner transition elements

(d) alkaline earth metals

Answer:

(c) inner transition elements

26. Actinoids form coloured salts due to the transition of electrons in

(a) d – d

(b) f – f

(c) f – d

(d) s – f

Answer:

(b) f – f

27. In the periodic table, Gadolinium belongs to

(a) 4th Group 6th period

(b) 4th group 4th period

(c) 3rd group 5th period

(d) 3rd group 7th period.

Answer:

(d) 3rd group 7th period.

28. The transuranic elements are prepared by

(a) addition reaction

(b) substitution reactions

(c) decomposition reaction

(d) nuclear reactions

Answer:

(d) nuclear reactions

