NEET Important Questions with Solutions from The d- and f-Block Elements

Q.1. The electronic configuration of $\mathrm{Cu\,(II)}$ is $3\mathrm{d}^9$ whereas that of $\mathrm{Cu\,(I)}$ is $3\mathrm{d}^{10}$. Which of the following is correct?

A) $\mathrm{Cu\,(II)}$ is more stable

B) $\mathrm{Cu\,(II)}$ is less stable

C) $\mathrm{Cu(I)}$ and $\mathrm{Cu(II)}$ are equally stable

D) Stability of $\mathrm{Cu(I)}$ and $\mathrm{Cu(II)}$ depends on nature of copper salts

Answer: $\mathrm{Cu\,(II)}$ is more stable

Solution: The half-filled and completely filled orbitals are more stable than incompletely filled orbitals

$\mathrm{Cu(II)}$ is more stable than $\mathrm{Cu(I)}$ because it has a $+2$ charge and is smaller than $\mathrm{Cu(I)}$.

The charge density is greater for $\mathrm{Cu(II)}$ and it forms stronger bonds (high hydration energy) and releases more energy and is more stable.

Q.2. Metallic radii of some transition elements are given below. Which of these elements will have the highest density?

Element	Fe	Co	Ni	Cu
Metallic radii / pm	126	125	125	128

A) Fe

B) Ni

C) Co

D) Cu

Answer: Cu

Solution: On moving left to right along period, metallic radius decreases while mass increases. Decrease in metallic radius coupled with increase in atomic mass results in increase in density of metal.
Hence, among the given four choices Cu belongs to right side of Periodic Table in transition metal, and it has the highest density $\left(8.9\ \mathrm{g/cm^3}\right)$.

Q.3. Generally transition elements form coloured salts due to the presence of unpaired electrons. Which of the following compounds will be coloured in solid state?

A) $\mathrm{Ag_2SO_4}$

B) $\mathrm{CuF_2}$

C) $\mathrm{ZnF_2}$

D) $\mathrm{Cu_2Cl_2}$

Answer: $\mathrm{CuF_2}$

Solution: Here, copper is in $2+$ oxidation state in which Cu contains one unpaired electron. Hence, it produces colour in solid-state.

Q.4. On addition of small amount of $KMnO_4$ to concentrated H_2SO_4, a green oily compound is obtained which is highly explosive in nature. Identify the compound from the following options.

A) Mn_2O_7

B) MnO_2

C) $MnSO_4$

D) Mn_2O_3

Answer: Mn_2O_7

Solution: When $KMnO_4$ is dissolved in concentrated H_2SO_4, a green-coloured solution is obtained. This solution is manganese heptoxide (Mn_2O_7).

This manganese heptoxide is highly explosive in nature.

$KMnO_4$ reacts with conc. H_2SO_4 as:

$$\underset{\text{Potassium permanganate}}{2\,KMnO_4} + \underset{\text{Sulphuric acid}}{2H_2SO_4} \rightarrow \underset{\text{Manganese heptoxide}}{Mn_2O_7} + \underset{\text{Potassium hydrogen sulphate}}{2\,KHSO_4} + \underset{\text{Water}}{H_2O}$$

Q.5. The magnetic nature of elements depends on the presence of unpaired electrons. Identify the configuration of transition element, which shows highest magnetic moment.

A) $3d^7$

B) $3d^5$

C) $3d^8$

D) $3d^2$

Answer: $3d^5$

Solution: Greater the no. of unpaired electrons higher will be the magnetic moment.
$\mu = \sqrt{n(n+2)}$

where n = Number of unpaired electrons

μ= Magnetic moment in units of Bohr Magneton (BM).

$\mu = \sqrt{5(5+2)} = 5.92\ BM$

That is why $3d^5$ has maximum magnetic moment due to the maximum no. of unpaired electrons.

Q.6. Which of the following oxidation state is common for all lanthanoids?

A) $+2$

B) $+3$

C) $+4$

D) $+5$

Answer: $+3$

Solution: The most common and stable oxidation state of Lanthanoids is $+3$. When it forms compounds in its common oxidation state of $+3$, three Thulium electrons are needed to form the bonds. When three electrons on the lanthanoid atom are used to form compounds in the most stable oxidation state of $+3$, one of them is taken from the $4f$ subshell.

$La\,(II)$ and $Ln\,(III)$ compounds are predominant species. However, occasionally $+2$ and $+4$ ions in solution or in solid compounds are also obtained. This irregularity (as in ionisation enthalpies) arises mainly from the extra stability of empty, half-filled, or filled f subshell.

Q.7. Which of the following reactions are disproportionation reactions?
(a) $Cu^{+} \rightarrow\ Cu^{2+} +\ Cu$
(b) $3\,MnO_4^{2-}\ +\ 4H^{+}\ \rightarrow\ 2\,MnO_4^{-}\ +\ MnO_2\ +\ 2H_2O$
(c) $2\,KMnO_4\ \rightarrow\ K_2MnO_4 +\ MnO_2\ +\ O_2$
(d) $2\,MnO_4^{-}\ +\ 3\,Mn^{2+}\ +\ 2H_2O\ \rightarrow\ 5\,MnO_2\ +\ 4H^{+}$

A) a, b

B) a, b, c

C) b, c, d

D) a, d

Answer: a, b

Solution: In a disproportionation reaction, an element is simultaneously oxidised and reduced. Copper (I) compounds are unstable in aqueous solution and undergo disproportionation :

$$2\overset{+1}{Cu}^{+}\ \rightarrow\ \overset{+2}{Cu}^{2+} +\ \overset{0}{Cu}$$

MnO_4^{2-} has -6 oxidation state.

$$3\,\overset{+6}{Mn}\,O_4^{2-}\ +\ 4H^{+} \rightarrow\ 2\,\overset{+7}{Mn}\,O_4^{-}\ +\ \overset{+4}{Mn}\,O_2\ +\ 2H_2O$$

Q.8. $KMnO_4$ acts as an oxidising agent in acidic medium. The number of moles of $KMnO_4$ that will be needed to react with one mole of sulphide ions in acidic solution is

A) $\frac{2}{5}$

B) $\frac{3}{5}$

C) $\frac{4}{5}$

D) $\frac{1}{5}$

Answer: $\frac{2}{5}$

Solution: Hydrogen sulphide is oxidised, sulphur being precipitated.

$$H_2S\ \rightarrow\ 2H^{+} +\ S^{2-}$$
$$5S^{2-}\ +\ 2\,MnO_4^{-} +\ 16H^{+}\ \rightarrow 2\ Mn^{2+}\ +8H_2O\ +\ 5S$$

It is clear from the above reaction that 5 moles of sulphide ions needs 2 moles of permanganate ion therefore one mole of sulphide ion requires $\frac{2}{5}$ moles of permanganate ion.

Q.9. Which of the following is amphoteric oxide?
$Mn_2O_7,\ CrO_3,\ Cr_2O_3,\ CrO,\ V_2O_5,\ V_2O_4$

A) $V_2O_5,\ Cr_2O_3$

B) $Mn_2O_7,\ CrO_3$

C) $CrO,\ V_2O_5$

D) $V_2O_5,\ V_2O_4$

Answer: $V_2O_5,\ Cr_2O_3$

Solution: Metal oxides which react with both acids as well as bases to produce salts and water are known as amphoteric oxides.

$V_2O_5,\ Cr_2O_3$ can react with acid as well as base.

Q.10. Gadolinium belongs to $4f$ series. It's atomic number is 64. Which of the following is the correct electronic configuration of gadolinium?

A) $[Xe]\ 4f^7 5d^1 6s^2$

B) $[Xe]\ 4f^6 5d^2 6s^2$

C) $[Xe]\ 4f^8 6d^2$

D) $[Xe]\ 4f^9 5s^1$

Answer: $[Xe]\ 4f^7 5d^1 6s^2$

Solution: Gadolinium belongs to $4f$ series. It has atomic number$=\ 64$. It has extra stability due to half-filled $4f$ subshell.

Q.11. When acidified $K_2Cr_2O_7$ solution is added to Sn^{2+} salts then Sn^{2+} changes to

A) Sn

B) Sn^{3+}

C) Sn^{4+}

D) Sn^{+}

Answer: Sn^{4+}

Solution: When the acidified $K_2Cr_2O_7$ solution is added to Sn^{2+}Thus, Acidified potassium dichromate will oxidise $tin(II)$ to $tin(IV)$

$$Cr_2O_7^{2-} + 14H^+ + 3Sn^{2+} \rightarrow 2Cr^{3+} + 3Sn^{4+} + 7H_2O$$

Q.12. Oxidation states shown by Eu are _____.

A) $+2, +3$

B) $+2, +3, +4$

C) $+2, +4$

D) $+3, +4$

Answer: $+2, +3$

Solution: The electronic configuration of europium is:

$_{64}\mathrm{Eu} = [\mathrm{Xe}]4\mathrm{f}^7 5\mathrm{d}^0 6\mathrm{s}^2$

$\mathrm{Eu}^{2+} = [\mathrm{Xe}]4\mathrm{f}^7$

It is a half filled configuration, which is a stable electronic configuration.

Generally, all the lanthanide elements have the most stable, $+3$ oxidation state.

Q.13. 'Chemical Twins' are present in which transition series?

A) 2^{nd} and 3^{rd}

B) 3^{rd} and 4^{th}

C) 1^{st} and 2^{nd}

D) 1^{st} and 3^{rd}

Answer: 2^{nd} and 3^{rd}

Solution: The pair of elements which have similar properties, due to their similar atomic radii, are called as chemical twins.

In transition series, the atomic sizes are almost equal for the 2^{nd} and the 3^{rd} transition series, due to lanthanide contraction.

Q.14. Nb and Ta have almost the same atomic size due to _____.

A) diagonal relationship

B) their presence in the same group

C) lanthanoid contraction

D) same chemical properties

Answer: lanthanoid contraction

Solution: Niobium and tantalum belong to the 5^{th} and the 6^{th} period of the periodic table. Due to lanthanoid contraction in tantalum, the atomic size of both the elements are almost equal.

Q.15. The first member of the actinoid series is _____.

A) actinium

B) cerium

C) thorium

D) uranium

Answer: thorium

Solution: The first member of the actinide series is thorium, which belongs to the f-block and has a $5\mathrm{f}$ electron shell configuration. Actinide series encompasses the atomic numbers from 89 to 103, i.e., actinium to lawrencium. Actinium belongs to the d-block, of the 3^{rd} group and the 7^{th} period.

The symbol of thorium is $^{232}_{90}\mathrm{Th}$.

Q.16. Actinoid series starts from the atomic number _____.

A) 88 to 101

B) 89 to 102

C) 89 to 103

D) 91 to 104

Answer: 89 to 103

Solution: The modern periodic table divides the elements on the basis of blocks. It mainly consists of s-block, p-block, d-block and f-block. The division takes place on the basis whether the last electron enters into which block. f-block mainly consists of Lanthanoid and Actinoid. Here, the actinoids starts from the atomic number 89 to 103.

Q.17. Which one of the following statements concerning lanthanoid elements is false?

A) lanthanoids are separated from one another by the ion-exchange method.

B) The ionic radii of trivalent lanthanoid steadily increase with an increase in atomic number.

C) All lanthanoid are highly dense metals.

D) Most typical oxidation state of lanthanoid is $+3$.

Answer: The ionic radii of trivalent lanthanoid steadily increase with an increase in atomic number.

Solution: The lanthanoids are highly dense elements. They all mostly form a trivalent compound. The atomic and ionic radii of tri positive lanthanoid ions decrease steadily from $\mathrm{La}-\mathrm{Lu}$ due to the increasing nuclear charge and electrons entering inner pre-penultimate orbital. This gradual decrease in the size with increasing atomic number is called lanthanoid contraction. As there is only a small change in the ionic radii of lanthanoid, their chemical properties are similar. It makes the separation of elements in the pure state difficult. Hence, the ion exchange process is used to separate the lanthanoid from each other. In this process, the solution of lanthanoid in an ionic soluble form is passed down a long column containing a resin. The lanthanide ions "stick" to the resin with different strengths based on the size of the ions.

Q.18. Europium is

A) $\mathrm{s}-$block element.

B) $\mathrm{p}-$block element.

C) $\mathrm{d}-$block element.

D) $\mathrm{f}-$block element.

Answer: $\mathrm{f}-$block element.

Solution: Europium is a $\mathrm{f}-$block elements as it follows the general electronic configuration of the $\mathrm{f}-$block elements $\left(4\mathrm{f}^{1-14}5\mathrm{d}^{0-1}6\mathrm{s}^{2}\right)$.

Atomic number of europium (Eu) is 63.

Electronic configuration of $\mathrm{Eu}=\left[\mathrm{Xe}\right]4\mathrm{f}^{7}6\mathrm{s}^{2}$

Q.19. Which one of the following ion is colourless?

A) Cu^{+}

B) Co^{2+}

C) Ni^{2+}

D) Fe^{3+}

Answer: Cu^{+}

Solution: Transition metal ions exhibit colour due to the presence of unpaired electrons.

$$Cu(29) = [Ar]\, 3d^{10}\, 4s^{1}$$

$$Cu^{+1} = [Ar]\, 3d^{10}\, 4s^{0}\ (\text{no unpaired } e^{-})$$

$$Co(27) = [Ar]\, 3d^{7}\, 4s^{2}$$

$$Co^{+2} = [Ar]\, 3d^{7}\, 4s^{0}\ (3 \text{ unpaired } e^{-})$$

$$Ni(28) = [Ar]\, 3d^{8}\, 4s^{2}$$

$$Ni^{+2} = [Ar]\, 3d^{8}\, 4s^{0}\ (2 \text{ unpaired } e^{-})$$

$$Fe(26) = [Ar]\, 3d^{6}\, 4s^{2}$$

$$Fe^{+3} = [Ar]\, 3d^{5}\, 4s^{0}\ (5 \text{ unpaired } e^{-})$$

In Cu^{+}, it is completely filled in the d-level. Hence, it does not have any unpaired electrons. So it is colourless.

Q.20. Cuprous ion is colourless while cupric ion is coloured because

A) cuprous ion has fully-filled $d-$orbitals while cupric ion has partially-filled $d-$orbitals.

B) cuprous ion has exactly half-filled $d-$orbitals.

C) cupric ion has fully-filled $d-$orbitals while cuprous ion has partially filled $d-$ orbitals.

D) cupric ion has half-filled $d-$orbitals.

Answer: cuprous ion has fully-filled $d-$orbitals while cupric ion has partially-filled $d-$orbitals.

Solution: The transition metal ions exhibit colour due to the excitation of electrons from the lower energy $d-$orbitals to the higher energy $d-$orbitals. This is known as $d-d$ transition.

The transition metal ions with completely-filled or completely empty $d-$orbitals do not exhibit colour due to the absence of unpaired electrons.

$$\text{Copper } (Cu) \rightarrow [Ar]\ 3d^{10}\, 4s^{1}$$

$$\text{Cuprous ion } (Cu^{+1}) \rightarrow [Ar]\ 3d^{10}\, 4s^{0}$$

$$\text{Cupric ion } (Cu^{+2}) \rightarrow [Ar]\ 3d^{9}\, 4s^{0}$$

Cuprous ion has fully-filled $d-$ configuration; whereas, cupric ion has partially-filled $d-$orbitals. Hence, cupric ions exhibit blue colour.

Q.21. Which of the following is the most suitable description of transition elements?

A) Low melting points

B) No catalytic activity

C) Show variable oxidation states

D) Exhibit inert pair effect

Answer: Show variable oxidation states

Solution: (A) Have higher enthalpy of atomization because of the involvement of greater number of valence electrons in the bonding. The bonding is metallic as well as covalent in nature. So, their melting points are very high.

(B) They show catalytic activity due to their variable oxidation states, availability of vacant d orbitals, and the tendency to form ionic as well as covalent bonds.

(C) Energy of ns and $(\mathrm{n}-1)\mathrm{d}$ orbitals are nearly same and thus, electrons of ns and $(\mathrm{n}-1)\mathrm{d}$ orbitals can take part in bonding, and they show variable oxidation states.

(D) Only heavier p-block elements show inert pair effect, not d-block elements.

Q.22. Which one of the ionic species will impart colour to an aqueous solution?

A) Ti^{4+}

B) Cu^{+}

C) Zn^{2+}

D) Cr^{3+}

Answer: Cr^{3+}

Solution: $\mathrm{Ti}^{4+}=[\mathrm{Ar}]$, $\mathrm{Cu}^{+}=[\mathrm{Ar}]\ 3\mathrm{d}^{10}$ and $\mathrm{Zn}^{2+}=[\mathrm{Ar}]\ 3\mathrm{d}^{10}$. All have paired electrons. So, all are diamagnetic and will not impart any colour in an aqueous solution, since they can not show any $\mathrm{d}-\mathrm{d}$ transition.

Cr^{3+} has the electron configuration $[\mathrm{Ar}]^{18}3\mathrm{d}^{3}$. It has three unpaired electrons. So it undergoes $\mathrm{d}-\mathrm{d}$ transition of electrons in the presence of ligands according to the crystal field theory (CFT) and thus, it is coloured.

Q.23. For the process $\mathrm{Cu}\,(\mathrm{g}) \rightarrow \mathrm{Cu}^{+}\,(\mathrm{g})+\mathrm{e}^{-}$, the electron is to be removed from _____

A) $3\mathrm{d}$ sub-shell

B) $4\mathrm{s}$ sub-shell

C) $3\mathrm{p}$ sub-shell

D) Any of the above

Answer: $4\mathrm{s}$ sub-shell

Solution: Electrons are always removed from the outermost shell($4\mathrm{s}-$electron is farther from nucleus than the $3\mathrm{d}-$ electron).

Electronic configuration of ${}_{29}\mathrm{Cu}$ is $[\mathrm{Ar}]^{18}3\mathrm{d}^{10}4\mathrm{s}^{1}$. As $4\mathrm{s}-$electron is farther from $3\mathrm{d}-$ electron, it is less attracted by the nucleus than that of the $3\mathrm{d}$. Hence, it is loosely bound with the nucleus and is easily removed.

Q.24. In general, the melting and the boiling points of transition metals:

A) increase gradually across the period from left to right

B) decrease gradually across the period from left to right

C) first increase till the middle of the period and then decrease towards the end

D) first decrease regularly till the middle of the period and then increase towards the end

Answer: first increase till the middle of the period and then decrease towards the end

Solution: Along the period, the number of unpaired electrons increase and then decrease due to pairing of electrons so, inter-atomic forces (i.e., metallic bond as well as covalent bonds between unpaired electrons) increase up to middle of the series and then decrease.

Boiling and melting points are directly proportionate to strength of bond.

Q.25. Knowing that the chemistry of lanthanides (Ln) is dominated by their $+3$ oxidation state, which of the following statements is incorrect?

A) The ionic size of $\mathrm{Ln}\ (\mathrm{III})$ decreases in general with an increasing atomic number.

B) $\mathrm{Ln}\ (\mathrm{III})$ compounds are generally colourless.

C) $\mathrm{Ln}\ (\mathrm{III})$ hydroxides are mainly basic in character.

D) Because of the large size of $\mathrm{Ln}\ (\mathrm{III})$ ions, the bonding in its compounds is predominantly ionic in character.

Answer: $\mathrm{Ln}\ (\mathrm{III})$ compounds are generally colourless.

Solution: The lanthanides are $\mathrm{f}-$block elements. These are known as rare earth elements. The valence electrons of these elements lie in the $4\mathrm{f}-$orbital.

The atomic size or the ionic radii of the tripositive lanthanide ions decrease steadily from $\mathrm{La}-\mathrm{Lu}$ due to the increasing nuclear charge and the electrons entering the inner $(\mathrm{n}-2)\mathrm{f}$ orbital. This gradual decrease in the size with an increasing atomic number is called lanthanide contraction.

Their compounds are predominantly ionic due to the large size of the cation. Therefore, their hydroxides are basic in nature.

Most of the trivalent lanthanide compounds except that of La^{+3} and Lu^{+3} are coloured, both in the solid state and in the aqueous solution. The colour of these ions is due to the presence of unpaired $\mathrm{f}-$electrons.

Practice more on The d- and f-Block Elements