D and F block Elements Questions with Solutions

Q1. The colour of d block elements is due to:

a.) nd–(n+1)s transition
b.) nd–(n+1)s transition
c.) nd-nd transition
d.) nd-(n+1)d transition

Correct Answer– (c.) nd-nd transition

Q2. Zr and Hf have almost equal atomic and ionic radii because of:

a.) diagonal relationship
b.) lanthanoid contraction
c.) actinoid contraction
d.) All of the above

Correct Answer– (b.) lanthanoid contraction

Q3. The maximum oxidation state shown by Mn in its compound is:

a.) +4
b.) +5
c.) +6
d.) +7

Correct Answer– (d.) +7

Q4. Which of the following lanthanoid ions is diamagnetic?

a.) Eu^{2+}
b.) Yb^{2+}
c.) Ce^{2+}
d.) Sm^{2+}

Correct Answer– (b.) Yb^{2+}

Q5. Name the gas that can readily decolourise acidified $KMnO_4$ solution.

a.) SO_2
b.) NO_2

c.) P_2O_5
d.) CO_2

Correct Answer– (a.) SO_2

Q6. Why are the ionisation energies of 5d elements greater than 3d elements?

Answer. In the 5d series, after lanthanum (Z=57), there is lanthanide contraction. As a result, in each group the atomic size of 5d elements is small and its nuclear charge is large. Hence, the ionisation energies of 5d elements are larger than 3d elements.

Q7. Which metal in the first transition series exhibits +1 oxidation state most frequently and why?

Answer. Copper has electronic configuration $3d^{10}4s^1$. It can easily lose one ($4s^1$) electron to give a stable $3d^{10}$ configuration.

Q8. What are the different oxidation states exhibited by the lanthanoids?

Answer. The principal oxidation state of lanthanoids is +3. In addition, they exhibit oxidation states of +2 and +4.

Q9. What are the characteristics of transition elements?

Answer. The general characteristics of transition elements are:

- Nearly all transition elements have typical metallic properties.
- They have high melting and boiling points.
- They are electropositive in nature.
- Most of them form coloured compounds.
- They have a good tendency to form complexes.
- They exhibit several oxidation states.
- Their compounds are generally paramagnetic in nature.
- They form alloys with other metals.
- They form interstitial compounds.

Q10. Define lanthanoid contraction.

Answer. Lanthanide contraction is the gradual decrease in atomic and ionic size of lanthanoids as their atomic number increases. Lanthanide contraction causes include: The positive charge on the nucleus increases by one unit as the atomic number increases, and one more electron enters the same 4f subshell.
Consequences of lanthanoid contraction:

- Resemblance of second and third transition series.

- Similarity among lanthanoids.
- The basic strength of the hydroxides decreases with an increase in atomic number.

Q11. Write down similarities between lanthanoids and actinoids.

Answer. Lanthanides and actinides have the following similarities:
- Lanthanides and actinides both have a + 3 oxidation state.
- The f-orbitals in both series are gradually filled.
- The ionic radius of the elements in both series decreases as the atomic number increases.
- Electronegativity is low for all elements in both series.
- They are all extremely reactive.
- The nitrates, perchlorates, and sulphates of all elements are soluble, whereas their hydroxides, chlorides, and carbonates are insoluble.

Q12. The silver atom has completely filled 'd' orbitals ($4d^{10}$) in its ground state. How can you say that it is a transition element?

Answer. The silver atom has a $4d^{10}$ configuration in its ground state, indicating that its d- orbitals are completely filled.
However, in its most stable oxidation state +1, the configuration is $4d^9$ with a partially filled d-orbital. As a result, it can be considered a transition element according to the definition of transition elements.

Q13. Which of the two Na^+ or Ag^+ is stronger Lewis acid and why?

Answer. Ag^+ is a stronger Lewis acid because it has a pseudo inert gas configuration i.e., 18-electron shell configuration (high polarising power due to less screening effect of inner d-electrons), whereas Na^+ is a weaker acid because it has an inert gas configuration 8-electron shell configuration (less polarising power).
In the case of an 18-electron shell configuration, there are 10 d-electrons in addition to 8s and p electrons. The d-electrons do not shield the nuclear charge effectively and therefore, they have increased effective nuclear charge. Hence, they cause greater polarisation.

Q14. Why is hydrated copper sulphate blue while anhydrous copper sulphate white?

Answer. In hydrated copper sulphate, four water molecules are present as ligands. In the presence of these ligands, the d-orbitals split up into different levels and hence these are no longer degenerate. Hence, d-d transitions take place absorbing the red wavelength and complementary blue colour is reflected. On the other hand, in anhydrous $CuSO_4$, d-d orbitals remain degenerate because of the absence of ligands, Hence, no d-d transition can occur and anhydrous copper sulphate is white.

Q15. Explain why mercury (I) ion exists as Hg_2^{2+} ion while copper (I) exists as Cu^+ ion.

Answer. The electronic configuration of Hg (I) is [Xe] $4f^{14}$ $5d^{10}$ $6d^2$. It has one unpaired electron in the valence 6s-subshell. Because of the presence of unpaired electrons, it is expected to be paramagnetic but actually, Hg(I) compounds are diamagnetic. This behaviour can be explained by assuming that the two Hg^+ ions singly filled 6s-orbitals overlap to form a Hg^+–Hg^+ covalent bond. As a result, Hg^+ ions exist as dimeric species, namely Hg_2^{+2}. On the other hand Cu (I) ion, has the electronic configuration [Ar]$3d^{10}$. As a result, it lacks the unpaired electrons required to form dimeric species, i.e., Cu_2^{+2}, and thus always exists as a C^++ ion.

Practise Questions on D and F block Elements

Q1. The maximum oxidation state exhibited by actinide ion is:

a.) +5
b.) +4
c.) +7
d.) +6

Correct Answer– (d.) +6

Q2. What is the shape and magnetic nature of permanganate ion?

a.) Tetrahedral, diamagnetic
b.) Pyramidal, diamagnetic
c.) Planar, paramagnetic
d.) Tetrahedral, paramagnetic

Correct Answer– (a.) Tetrahedral, diamagnetic

Q3. Which is the last element in the series of actinoids? Write the electronic configuration of this element. What can be the possible oxidation state?

Answer. The last actinoid is Lawrencium (Z=103)
Electronic configuration: [Rn] $5f^{14}$ $6d^1$ $7s^2$.
The possible oxidation state is +3

Q4. Explain why does the colour of $KMnO_4$ disappear when oxalic acid is added to its solution in an acidic medium.

Answer. $KMnO_4$ acts as an oxidising agent. It oxidises oxalic acid to CO_2 and itself changes to Mn^{2+} ions which are colourless.

$5C_2O_4^{2-} + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$

Q5. Why do transition metals form coloured complexes?

Answer. Transition metal ions usually have one or more unpaired electrons. When visible light strikes a transition metal compound or ion, the unpaired electrons in the lower energy d-orbital are promoted to higher energy d-orbitals, a process known as the d-d transition. Because the energy involved in the d-d transition is quantized, only a specific wavelength is absorbed, while the remaining wavelengths in the visible region are transmitted. As a result, transmitted light contains some complementary colour to the absorbed colour.