Chemistry Study Materials for Class 12
(Questions with Answers Based on NCERT)
Ganesh Kumar Date:- 16/08/2021

The d & f - Block Elements

Question 1: Write down the electronic configuration of:

(i) Cr^{3+} □ ***iii()*** Cu^{+} ***(v)*** Co^{2} □ ***v(i)*** Mn^{2+} ***(ii)*** Pm^{3+} ***(iv)*** Ce^{4+} ***(vi)*** Lu^{2+} ***(viii)*** Th^{4+}

Solution 1: (i) Cr^{3+} :$1s^2\ 2s^2\ 2\ p^6\ 3s^2\ 3\ p^6\ 3d^{\ 3}$

(ii)Pm^{3+} :$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3P^6\ 3d^{10}\ 4s^2\ 4P^6\ 4d^{10}\ 5s^2\ 5p^6\ 4f^{\ 4}$

(iii)Cu^{+} :$1s^2\ 2s^2\ 2p^6 3s^2 3P^6 3d^{10}$

~~(iv)~~Ce^{4+} :$1s^2\ 2s^2\ 2p^6 3s^2 3p^6 3d^{10}\ 4s^2\ 4p^6\ 4d^{10} 5s^2 5p^6$

(v) Co^{2+} :$1s^2\ 2s^2\ 2p^6 3s^2 3p^6 3d^{\ 7}$

(vi)Or, $[Ar]^{18}\ 3d^{7}$

(vii) Lu^{2+} :$1s^2\ 2s^2\ 2p^6 3s^2 3p^6 3d^{10}\ 4s^2\ 4p^6\ 4d^{10} 5s^2 5p^6\ 4f^{\ 14} 5d^1$

(viii) Mn^{2+} :$1s^2\ 2s^2\ 2p^6 3s^2 3\ p^6 3d^{\ 5}$

(viii) Th^{4+} :$1s^2\ 2s^2\ 2p^6 3s^2 3p^6 3d^{10}\ 4s^2\ 4p^6\ 4p^{10}\ 4f^{\ 14} 5s^2 5p^6 5d^{10}\ 6s^2\ 6p^6$

Question 2: Why are Mn^{2+}compounds more stable than Fe^{2+} towards oxidation to their +3 state?

Solution 2: Electronic configuration of Electronic configuration of

Mn^{2+} is [Ar] $3d^{\ 6}$ and Fe^{2+} is [Ar] $3d^{\ 6}$

It is known that half-filled and fully-filled orbitals are more stable. Therefore, Mn in (+2) state has a stable d^5 configuration. This is the reason Mn^{2+} shows resistance to oxidation to Mn^{3+}. Also, Fe^{2+} has $3d^6$ configuration and by losing one electron, its configuration changes to a more stable $3d^5$ configuration. Therefore, Fe^{2+} easily gets oxidized to Fe^{2+} oxidation state.

Question 3: Explain briefly how +2 states becomes more and more stable in the first half of the first row transition elements with increasing atomic number?

Solution 3: The oxidation states displayed by the first half of the first row of transition metals are given in the table below.

	Sc	Ti	V	Cr	Mn
Oxidation state		+ 2	+ 2	+ 2	+ 2
	+3	+ 3	+ 3	+ 3	+ 3
		+ 4	+ 4	+ 4	+ 4
			+ 5	+ 5	+ 6
				+ 6	+ 7

It can be easily observed that except Sc, all others metals display +2 oxidation state. Also, on moving from Sc to Mn, the atomic number increases from 21 to 25. This means the number of electrons in the 3d-orbital also increases from 1 to 5.

(i) *Sc* (+2) ⟶ $3d^1$ *(ii)* *Ti* (+2) ⟶ $3d^2$ *(iii)* *V* (+2) ⟶ $3d^3$

(iv) *Cr*(+2) ⟶ $3d^4$ (v) *Mn*(+2) ⟶ $3d^5$

+2 oxidation states is attained by the loss of the two 4s electrons by these metals. Since the number of d electrons in (+2) state also increases from Ti(+2) to Mn(+ 2), the stability of +2 state increases (as d-orbital is becoming more and more half-filled). Mn(+2) has $3d^5$electrons (that is half-filled d shell, which is highly stable).

Question 4: To what extent do the electronic configurations decide the stability of oxidation states in the first series of the transition elements? Illustrate your answer with examples.

Solution 4: The elements in the first-half of the transition series exhibit many oxidation states with Mn exhibiting maximum number of oxidation states (+2 to +7). The stability of +2 oxidation state increases with the increase in atomic number. This happens as more electrons are getting filled in the d-orbital. However, Sc does not show +2 oxidation state. Its electronic configuration is $4s^2\ 3d^1$. It loses all the three electrons to form Sc^{3+}. +3 oxidation state of Sc is very stable as by losing all three electrons, it attains stable noble gas configuration, [Ar]. Ti (+ 4) and V(+5) are very stable for the same reason. For Mn, +2 oxidation state is very stable as after losing two electrons, its d-orbital is exactly half-filled, [Ar] $3d^6$

Question 5: What may be the stable oxidation state of the transition element with the following d electron configurations in the ground state of their atoms: and $3d^3$, $3d^5$, $3d^8$ and $3d^4$?

Solution 5:

	Electronic configuration in ground state	Stable oxidation state
(i)	$3d^3$? (vanadium)	+2,+3,+4 and +5
(ii)	$3d^5$ (chromium)	+3,+4,6+
(iii)	$3d^5$ (manganese)	+2,+4,+6,+7
(iv)	$3d^8$ (cobalt)	+2,+3
(v)	$3d^4$	There is no $3d^4$ configuration in ground state.

Question 6: Name the Oxo metal anions of the first series of the transition metals in which the metal exhibits the oxidation state equal to its group number.

Solution 6: (i) Vanadate, VO_3^- Oxidation state of V is +5.

(ii)Chromate, CrO_4^{2-} Oxidation state of Cr is +6.

(iii) Permanganate, MnO_4^{-1} Oxidation state of Mn is +7

Question 7: What is lanthanoid contraction? What are the consequences of lanthanoid contraction?

Solution 7: As we move along the lanthanoid series, the atomic number increases gradually by one. This means that the number of electrons and protons present in an atom also increases by one. As electrons are being added to the same shell, the effective nuclear charge increases. This happens because the increase in nuclear attraction due to the addition of proton is more pronounced than the increase in the interelectronic repulsions due to the addition of electron. Also, with the increase in atomic number, the number of electrons in the 4*f* orbital also increases. The 4*f* electrons have poor shielding effect. Therefore, the effective nuclear charge experienced by the outer electrons increases. Consequently, the attraction of the nucleus for the outermost electrons increases. This results in a steady decrease in the size of lanthanoids with the increase in the atomic number. This is termed as lanthanoid contraction

Consequences of lanthanoid contraction

(i) There is similarity in the properties of second and third transition series.

(ii) Separation of lanthanoids is possible due to lanthanide contraction.

It is due to lanthanide contraction that there is variation in the basic strength of lanthanide hydroxides. (Basic strength decreases from $La(OH)_3$ *to* $Lu(OH)_3$

Question 8: What are the characteristics of the transition elements and why are they called transition elements? Which of the *d*-block elements may not be regarded as the transition elements?

Solution 8: Transition elements are those elements in which the atoms or ions (in stable oxidation State) contain partially filled *d*-orbital. These elements lie in the *d*-block and show a transition of properties between *s*-block and *p*-block. Therefore, these are called transition elements. Elements such as Zn, Cd, and Hg cannot be classified as transition elements because these have completely filled *d*-subshell.

Question 9: In what way is the electronic configuration of the transition elements different from that of the non-transition elements?

Solution 9: Transition metals have a partially filled *d*−orbital. Therefore, the electronic configuration of transition elements is $(n-1)d^{1\ \text{to}\ 10}ns^2$. The non-transition elements either do not have a *d*−orbital or have a fully filled *d*−orbital.Therefore, the electronic configuration of non-transition elements is $ns^{1\ \text{or}\ 2}$ or $ns^2ns^{1\ \text{to}\ 6}$.

Question 10: What are the different oxidation states exhibited by the lanthanoids?

Solution 10: In the lanthanide series, +3 oxidation state is most common i.e., Ln(III) compounds are Predominant. However, +2 and +4 oxidation states can also be found in the solution or in solid compounds.

****