Important Questions on Inorganic Chemistry- Part V

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1. The CORRECT order of the central metal ion's soft character (as determined by the HSAB principle) is
A. $[CrO_4]^{2-} < [CrCl_4]^{-} < [Cr(bipy)_3] < [Cr(CO)_5]^{2-}$
B. $[CrO_4]^{2-} < [Cr(bipy)_3] < [CrCl_4]^{-} < [Cr(CO)_5]^{2-}$
C. $[CrO_4]^{2-} < [Cr(bipy)_3] < [Cr(CO)_5]^{2-} < [CrCl_4]^{-}$
D. $[CrCl_4]^{-} < [CrO_4]^{2-} < [Cr(CO)_5]^{2-} < [Cr(bipy)_5$

2. Mg^{2+} is preferred in photosynthesis because:
A. It has a weak spin orbit coupling.
B. It has unpaired electrons.
C. It binds strongly with chlorophyll.
D. It has strong spin-orbit coupling.

3. With respect to the covalent character, following is the correct option:
A. CuCl=NaCl; AgCl > KCl
B. CuCl<NaCl; AgCl< KCl
C. CuCl> NaCl; AgCl>KCl
D. CuCl>NaCl; AgCl=KCl

4. Arrange the following in decreasing order of their ionization energy?
A. S>P>Mg>Al
B. S>P>Al>Mg
C. P>S>Al>Mg
D. P>S>Mg>Al

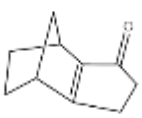
5. Which of the following complexes has the least molar absorptivity (ε) value?
A. $\left[Co(H_2O)_6\right]^{2+}$
B. $[MnCl_4]^{2-}$
C. $\left[Mn(H_2O)_6\right]^{2+}$
D. Both (A)and (C)

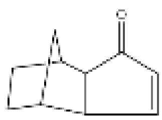
6. The incorrect statement among the following:
(i). A neodymium laser consists of a YAG rod containing a low concentration of Nd^{3+}.
(ii). Metallic radii of Ru and Os are similar.
(iii). The coordination environment of Nd^{3+} in $[Nd(CO_3)_4(OH_2)]^{5-}$ is bicapped square prismatic.
(iv). Lanthanide contraction is an irregular decrease in size along the series of elements of La-Lu.
A. (i) and (ii)
B. (ii) and (iii)
C. (iii) and (iv)
D. (i), (iii), and (iv)

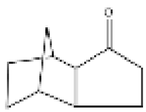
7. In electron spin resonance, conditions for allowed transitions are
A. Nuclear spin should not change.
B. Electron spin should change
C. A compound should contain at least one unpaired electron.
D. All the above

8. The correct order of solubility of first group metal chloride
A. KCl > NaCl> RbCl > CsCl>LiCl
B. KCl < NaCl< RbCl < CsCl<LiCl
C. LiCl > NaCl> KCl> RbCl > CsCl
D. NaCl>LiCl> KCl> RbCl > CsCl

9. The product for the following reaction will be?

A. 

B. 

C. 

D. 

10. Which one of the following oxides is amphoteric in nature?

A. CrO
B. $Cr_2(SO_4)_3$
C. Cr_2O_3
D. All the above

Answer Key

1. A	2. D	3. C	4. D	5. C	6. C	7. D
8. B	9. B	10. C				

Solutions

Solution 1.

The correct order of the soft character (as per HSAB principle) of the central metal ion is

$[CrO_4]^{2-} < [CrCl_4]^{-} < [Cr(bipy)_3] < [Cr(CO)_5]^{2-}$

+6 +3 0 –2 (oxidation states of central atom)

More cationic charge on central atom $\rightarrow$ harder will be the acid

According to the HSAB principle.

Hard acids prefer to bind to hard bases and soft acids prefer to bind to soft bases.

Solution 2.

In photosynthesis Mg^{2+} is preferred by chlorophyll as it has a very small spin orbit coupling constant, so inter system crossing is inhibited which favours the energy transfer from the excited singlet state.

Solution 3.

Referring to the Fajan's Rule,

Ag^{+} has $18e^{-}$ in valence shell; which is pseudo inert gas electronic configuration.

K^{+} has inert gas electron configuration.

So, AgCl>KCl

Similarly, Cu^{+1} is $3s^2\ 3p^6\ 3d^{10}$ which is 18 electrons, pseudo inert gas electron configuration.

Na^{+} is $2s^2\ 2p^6$ which is 8 electrons, inert gas configuration.

So, CuCl> NaCl

Solution 4.

Order of ionization energy according to nuclear charge should be:

S>P>Al>Mg But there are some exceptions.

The configuration of P is:

P: $[Ne]3s^23p^3$

An electron is removed from half-filled p orbital, therefore, requires highest energy. So, P>S

Similarly, configuration of Mg is:

Mg=$[Ne]\ 3s^2$

An electron in Mg is removed from a full filled 3s orbital, while in Al, an electron is removed from 3p orbital so, Mg>Al.

Hence, actual order is:

P>S>Mg>Al

Solution 5.

Selection rules

1. Spin selection rule: $\Delta s = 0$
2. Laporte selection rule: $\Delta l = \underline{+}1$

$\left[Co(H_2O)_6\right]^{2+}$ = Co in +2 oxidation state in octahedral field.

Configuration of Co^{+2} : t_{2g^6} or e_{g^2} Spin allowed but Laporte forbidden.

$[MnCl_4]^{2-}$ = Mn is in +2 oxidation state in a tetrahedral field.

Configuration of Mn^{+2} : $t_2^{\,3}$ or e^2 Spin forbidden but Laporte partially allowed because of unsymmetrical tetrahedral geometry.

$\left[Mn(H_2O)_6\right]^{2+}$ = Mn is in +2 oxidation state in octahedral field

Configuration of Mn^{+2}: $t_2^{\,3}$ or e^2 Spin forbidden and Laporte forbidden because of symmetrical octahedral geometry. This results in zero electronic transitions and least molar absorptivity.

Solution 6.

The coordination environment of Nd^{3+} in $[Nd(CO_3)_4(OH_2)]^{5-}$ is mono-capped square prismatic. Lanthanide contraction is a regular decrease in size along the series of elements of La-Lu.

Solution 7.

A molecule is ESR active only if it has an unpaired electron.

Also, $\Delta m_l = 0$ and $\Delta m_S = \pm 1$ for allowed transitions.

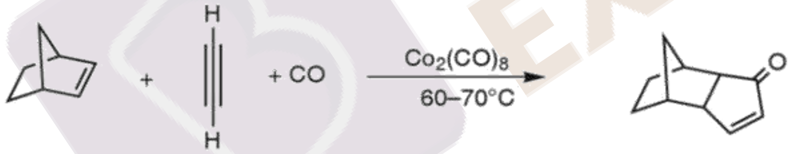
Solution 8.

Solubility in water is specifically directly proportional to the size difference of the cation and anion. Here, anion is common, that is Cl^- and cations are from group 1.

As we move down the group, the size of the cation increases. The size of cation is larger than size of anion (Cl^-) so the interaction between cation and anion is weak and the solubility of the compound increases. But LiCl has the highest solubility due the size of Li^+ which is very small as compared to the Cl^-. The force of interaction is very weak, so it is easily soluble.

Solution 9.

This is Pauson-Khand reaction, which involves the catalytic addition of an alkyne and CO in the presence of cobalt catalysts to yield substituted cyclopentanones.



Solution 10.

Chromic oxide (or chromium (III) oxide) is an amphoteric compound. It has the ability to dissolve in acids, liberating hydrated chromium ions in the process because it acts like an intermediate oxidation state and can easily undergo oxidation and reduction and hence Cr_2O_3 is an amphoteric oxide.