Organometallic Chemistry Questions

Q1: What is the oxidation state of Pd in $Pd(OAc)_2$?

a. 0
b. 1
c. 2
d. 4

Answer: (c.)

Explanation: Let the oxidation state of Pd be x. The oxidation state of the (OAc) group is -1. The overall compound is neutral.
Hence, $x + 2(-1) = 0$
$x = 2$ = oxidation state of Pd.

Q2. Among the following complexes, which ligand has only a single bond with the metal?

a. $W(CH_3)_6$
b. $K[PtCl_3(C_2H_4)]$
c. $(\eta^6\text{-}C_6H_6)_2Ru$
d. $(\eta^5\text{-}C_5H_5)_2Fe$

Answer: (a.)

Explanation: Among the given ligands in the compounds, only CH_3 is a σ donor.

Q3. Which statement is incorrect about ferrocene?

a. Ferrocene can be nitrated by conc. HNO_3
b. Cyclopentadienyl rings in ferrocene are in eclipsed conformation
c. Cyclopentadienyl rings in ferrocene are in staggered conformation
d. Decamethyl ferrocene is staggered in solid state

Answer: (c.)

Explanation: Cyclopentadienyl rings in ferrocene are in eclipsed conformation

Q4. Which kind of Borane is B_5H_9?

a. Nido
b. Closo
c. Arachno
d. None of the above

Answer: (d.)

Explanation: The general formula of Nido Boranes is B_nH_{n+4} where n is the number of boron atoms.

Q5. With which of the following compounds $Mn(CO)_5$ is isolobal with

a. CH_4
b. CH_3
c. CH_2
d. CH

Answer: (b.)

Explanation: Two compounds are isolobal when their energy, properties, number of electrons and shape of the frontier orbitals are similar. In order to predict the properties, the valence electron concentration (VEC) is to be calculated.
V.E.C. of $Mn(CO)_5$ = 7 + (5x2) = 17 e^-; 1 e^- less than the stable count of 18 e^-
V.E.C. of CH_3 = 4 +3 = 7 e^-; 1 e^- less than the stable count of 8 e^-
Hence, $Mn(CO)_5$ is isolobal with CH_3.

Q6. Why is cis-platin not considered as an organometallic compound?

Answer: Cis-platin or $[Pt(NH_3)_2Cl_2]$ has no direct carbon-metal bond which is the major condition for a compound to be an organometallic compound.

Q7. Calculate the oxidation state of Pd in $Pd(PPh_3)_4$.

Answer: Let the oxidation state of Pd be x.
The O.S. of PPh_3 is zero.
Hence, x + 4(0) = 0
$\therefore$ x = 0 = O.S. of Pd
So, the oxidation state of Pd in $Pd(PPh_3)_4$ is 0.

Q8. What must be the Hapticity of Cp if the compound $[W(Cp)_2(CO)_2]$ follows the 18 e^- rule?

Answer: To predict the hapticity of both the (Cp) ligands, we must calculate the compound's valence electron concentration (V.E.C.).
Given: V.E.C. of the compound = 18
Let us assume the hapticity of one Cp group be x and that of the another Cp group be y.
Hence, V.E.C. of $[W(Cp)_2(CO)_2]$: 6 + x + y + 2(2) = 18
V.E.C. of $[W(Cp)_2(CO)_2]$: x + y = 8
Hence, the hapticity of the two Cp groups must be a sum of 8.

Q9. Why are organometallic compounds important?

Answer: The organometallic compounds provide a source of nucleophilic carbon that can react with electrophilic carbon and hence generating a new C-C bond. This is an effective method to synthesise complexes from simple reactant materials.

Q10. How many kinds of organometallic compounds are there?

Answer: Based on the metal atom present in the complex, the organometallic compounds are classified into 3 categories namely:

a. Main group Organometallic compounds: these contain metal from either the s or p-block. For example, R-Mg-X
b. Transition metals Organometallic compounds: these contain metal from d-block. For example- Gillman's reagent (R_2CuLi).
c. Lanthanide and Actinide Organometallic compounds: these contain metal from f-block. For example, Uranocene

Q11. List four applications of organometallic compounds.

Answer: The four applications of organometallic compounds are as follows:

a. These are used in the manufacturing of various pharmaceutical drugs such as cisplatin.
b. These are used as catalysts in chemical reactions.
c. These are used in the manufacturing of light emitting diodes (LEDs).
d. These are used in the manufacturing of semiconductors.

Q12. What is the significance of the 18 electron rule in organometallic compounds?

Answer: The 18 electrons rule is followed in order to achieve 18 electrons in the valence shell of the metal. In organometallic compounds, the ligands donate their valence electrons into the valence shell of the metal. The metal's valence shell can accommodate 2 electrons in its s-subshell, 6 electrons in its p-subshell and 10 electrons in its d-subshell. Hence, a metal can accommodate a total of 18 electrons in its valence shell which is also the noble gas configuration. Hence, the total valence electron concentration must be 18 in metal.

Q13. What is the nature of the carbon atom that is bonded to the central metal in an organometallic compound?

Answer: Due to the high electropositive character of the metal, the carbon atom directly bonded to the metal attains a carbanionic nature.

Q14. Mention five properties of the organometallic compounds.

Answer: The five properties of the organometallic compounds are:

a. Organometallic compounds are insoluble in water but are soluble in organic solvents such as ether. This is because the organometallic compounds are bonded by covalent bonds which are non-polar bonds. Since, non-polar compounds dissolve only in non-polar solvents, organometallic compounds only dissolve in organic solvents.
b. These compounds contain at least one characteristic metal-carbon bond.
c. Organometallic compounds are extremely reactive which is why they are stored in organic solvents. This reactivity is observed in Organometallic compounds that contain metals from either the main group or the transition metals. The reason for reactivity is the polar nature of the metal-carbon bond.
d. Organometallic compounds containing electropositive metals act as reducing agents.
e. Organometallic compounds formed by highly electropositive metals are volatile and hence, catch fire easily.

Q15. What properties of organometallic compounds get affected due to the carbon-metal bond strength?

Answer: The thermal stability and reactivity of the organometallic compounds get affected due to the metal-carbon bond strength. The main group metal containing organometallic compounds are the most reactive and most thermally stable compounds among the organometallic compounds of other metals.

Practise Questions on Organometallic Chemistry

Q1. Which of the following is not an Organometallic compound?
a. Trimethyl borate
b. Trimethyl Titanium chloride
c. Sodium ethoxide
d. None of the above

Answer: (d.)

Explanation: None of Trimethyl borate [$B(OCH_3)_3$], Trimethyl Titanium chloride [$Ti(CH_3)_3Cl$] and Sodium ethoxide $NaOCH_3$ contain a metal-carbon bond.

Q2. Which catalyst is used in Ziegler Natta catalysis?

Answer: The Ziegler Natta catalyst consists either a transition metal compound or an organoaluminium compound.

Q3. Arrange the following in decreasing order of basicity.

CH_3CH_2OH, $CH_3CH_2O^-$, $CH_3C{\equiv}C^-$, $CH_2{=}CH^-$, $CH_3CH_2^-$

Answer: Among CH_3CH_2OH and $CH_3CH_2O^-$, $CH_3CH_2O^-$ is more basic as it has an extra electron which can be donated. However, both of these are less basic than the other given ions as oxygen is highly electronegative and releases an electron with difficulty. Now, as we know that sp hybridised carbon is more electronegative than the sp^2 and sp^3 hybridised carbon. This happens because of the highest s-orbital character in the sp hybridised carbon as the s-orbitals are more close to the nucleus. Hence, the decreasing order of basicity is:

$$CH_3CH_2^- > CH_2{=}CH^- > CH_3C{\equiv}C^- > CH_3CH_2O^- > CH_3CH_2OH$$

Q4. Write a reaction to prepare diphenyl lithium cuprate.

Answer: The cuprates can be formed by adding CuX to organolithium reagents. Organolithium is prepared as:

Hence, diphenyl lithium cuprate can be prepared as:

Q5. What will be the products when propanal reacts with ethyl magnesium bromide?

Answer: The product of the reaction will be 3-pentanol.

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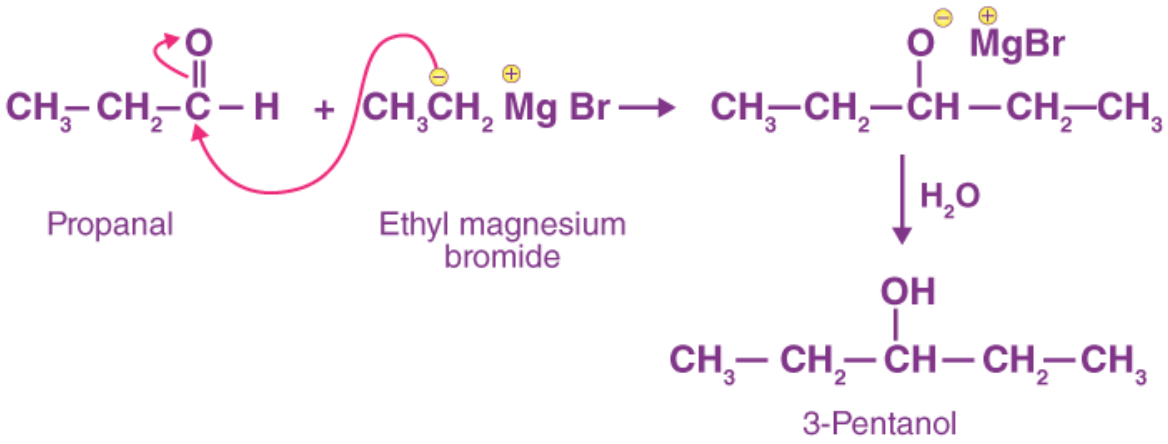

Propanal

Ethyl magnesium bromide

3-Pentanol