# JAM – 2013 – Chemistry

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# JAM – 2013 – CY

**Attempt ALL the questions. Q.1 – Q.10 Multiple Choice Question (MCQ), carry TWO marks each (for each wrong answer: –0.66).**

**1.** **The most polar compound among the following is:**

(a) $SF_4$ (b) $BF_3$ (c) $XeF_4$ (d) $SO_3$

**2.** **Which one of the following order of the carbonates is CORRECT for their decomposition temperature?**

(a) $BaCO_3 > CaCO_3 > SrCO_3 > MgCO_3$

(b) $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3$

(c) $MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$

(d) $MgCO_3 > CaCO_3 > BaCO_3 > SrCO_3$

**3.** **The CORRECT order of CO vibrational stretching frequency in the following complexes is**

$(PF_3)_3Mo(CO)_3$ (I) $(PCl_3)_3Mo(CO)_3$ (II) $\{P(OMe)_3\}_3Mo(CO)_3$ (III)

(a) I < II < III (b) III < II < I

(c) II < I < III (d) III < I < II

**4.** **Among the following, the ligand that BEST stabilizes low oxidation state of tungsten (W) is**

(a) $H_2O$ (b) $NH_3$ (c) CO (d) $F^-$

**5.** **The function $y = x \exp(-x^2)$ has a minimum at $x = -\frac{1}{\sqrt{2}}$. The second derivative of the function at the minimum is**

(a) $2\sqrt{2}\exp\left(-\frac{1}{2}\right)$ (b) $-2\sqrt{2}\exp\left(-\frac{1}{2}\right)$ (c) 0 (d) $-\sqrt{2}\exp\left(-\frac{1}{2}\right)$

**6.** **For a particular reaction at constant temperature, a plot of inverse of reactant concentration $\left(\frac{1}{[A]}\right)$ versus time is a straight line with a slope of $4.0 \times 10^{-2}$ L mol$^{-1}$ s$^{-1}$. The time required (in seconds) for 1.0 M of reactant to decrease to 0.25 M is:**

(a) 18.8 (b) 34.7 (c) 75.0 (d) 187.5

**7.** **For a physisorption process, which one of the following statements is NOT correct?**

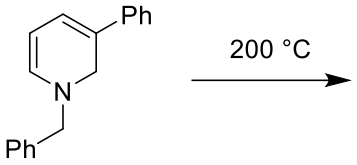
(a) There are van der Waals interactions between the adsorbate and the adsorbent.

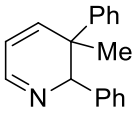
(b) The process predominates at low temperature.

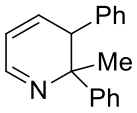
(c) The process cannot proceed beyond a monolayer

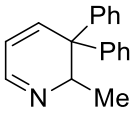
(d) The process is reversible.

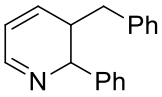
**8. The product of the following reaction is**



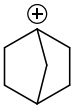

(a) 


(b) 

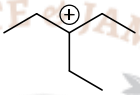

(c) 


(d) 


**9. The CORRECT order of stability of the following carbonium ions is**



**I**



**II**

**III**

(a) II > I > III (b) III > II > I

(c) I > III > II (d) II > III > I

**10. Which one of the following statements is CORRECT?**

(a) Naturally occurring DNA has B-configuration.

(b) Nucleic acids are derived from proteins.

(c) Proteins store genetic information

(d) Vitamins generally act as enzymes.

**Attempt ALL the questions. Q.11 – Q.20 (fill in the blank questions) carry three marks each (No Negative Mark).**

**11. The reaction of anhydrous $FeCl_2$ with sodium-pentadienyl in ether gives an air-stable diamagnetic orange solid, which on oxidation gives an air-sensitive paramagnetic blue-green compound in solution. The blue- green compound is __**

**12. CaO, VO and MnO have octahedral coordination of the metal ions in a rock-salt structure. The correct increasing order of their lattice enthalpies is _____**

**13. The shape of the inter-halide $IF_8^-$ is _____**

**14. The vapour pressures of solid and liquid chlorine are given by**

$$\log_e P^{solid} = 24 - \frac{3900}{T} \text{ and } \log_e P^{liq} = 18 - \frac{2600}{T},$$

**Where $P^{solid}$ and $P^{liq}$ are the vapour pressures (in Torr) of solid and liquid chlorine near the triple point, respectively and T is the absolute temperature.**

The ratio of the slope of the solid-gas curve to the slope of the liquid gas curve at the triple point in the P-T diagram is _____

15. For unnormalized wave-function,

$$\varphi(r,\theta,\phi) = \sin\theta\cos\phi\left(\frac{2r}{a_0} - \left(\frac{r}{a_0}\right)^2\right)\exp\left(-\frac{r}{a_0}\right),$$

the number of radial node(s) is _____

16. A hypothetical element (atomic weight = 300) crystallizes in a simple cubic lattice. For this crystal, the first order X-ray diffraction with wavelength of 5 Å appears at an angle of 30°. The density of the crystal is _____ g $cm^{-3}$.

[Avogadro number, $N_A = 6.02 \times 10^{23}$]

17. $MnO_4^-(aq) + Zn(s) + H_3O^+(aq) \longrightarrow Mn^{2+}(aq) + Zn^{2+}(aq) + H_2O\,(\ell)$

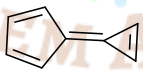
For the above reaction if the equilibrium constant at 298 K is represented by $10^X$, then the value of X is _____

[Given: The standard cell potential $E^0 = 2.4$ V and $\frac{2.303RT}{F} = 0.06$V at 298 K]

18. The rotational energy barrier between the most stable and the least stable conformations of 2, 3-dimethylbutane along C2–C3 bond is _____ kcal $mol^{-1}$.

[Given: The energies (kcal $mol^{-1}$) for $H/CH_3$ eclipsing = 1.8, $CH_3/CH_3$ eclipsing = 2.9 and $CH_3/CH_3$ gauche = 0.9]

19. The number of peaks or signals in $^1$H-NMR of N,N-dimethylformamide (DMF) at 25 ℃ is _____

20. 

calixene

Calixene is a polar hydrocarbon with a high dipole moment. The most stable dipolar canonical structure is _____

**Attempt ALL the questions. Questions 21 – 30 (subjective questions) carry five marks each.**

21. A mixture of $C_3H_8$ and oxygen in 1L closed vessel has an internal pressure of 4 atm at 100 ℃. When the mixture is ignited, the reaction produces $CO_2$(g) and $H_2O$ (g) until all oxygen is consumed. After the reaction, pressure of the vessel is 4.2 atm at the same temperature. Calculate the weight of oxygen present before the reaction.

[Gas constant, R = 0.082 L atm $mol^{-1}K^{-1}$].

22. The following reaction is carried out at 1 atm and 300 K.

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(\ell)$$

$\Delta U$ for the above reaction is 550 kJ. Assuming ideal gas behaviour for $H_2$ and $O_2$, calculate the value of $\Delta H$.

[Given: The value of gas constant, $R = 0.082\ L\ atm\ mol^{-1}\ K^{-1} = 8.314\ mol^{-1}K^{-1}$. The volume of 1 mole of liquid water is 18 mL under the above reaction condition]

23. At 298K, calculate the solubility of metal sulfide, MS(s), in a saturated solution of $H_2S$ where the concentration of $H_2S$ and pH are maintained at 0.1 M and 3.0, respectively

Given at 298 K,

$H_2S(aq) + H_2O(liq) \leftrightharpoons H_3O^+(aq) + HS^-(aq)$ $\quad K = 10^{-7}$

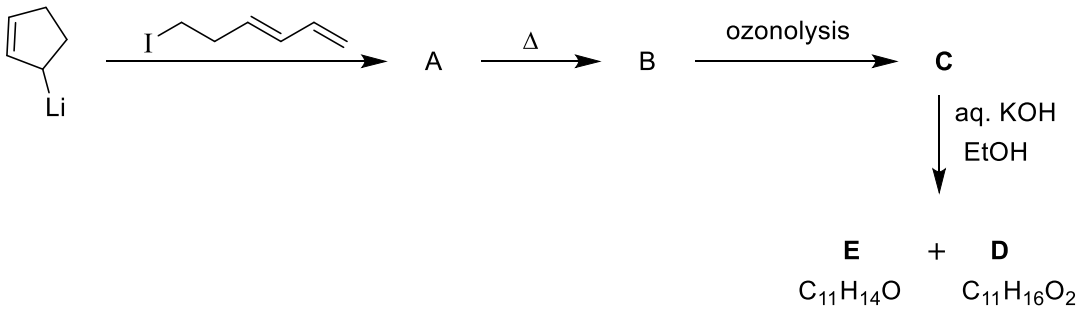
$MS(s) + H_2O(liq) \leftrightharpoons M^{2+}(aq) + HS^-(aq) + {}^-OH\,(aq)$ $\quad K = 5 \times 10^{-19}$

24. For each of the following metallo-proteins identify the metal-ion at the active-site and the function of the proteins: deoxy-hemoglobin, deoxy-myoglobin, oxy-hemocyanin, cytochrome-C and carbonic anhydrase.

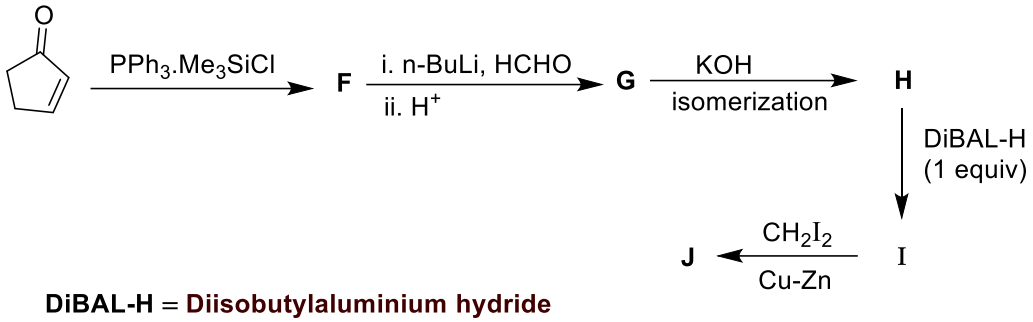
25. A solution containing 250 ppm of $CuSO_4.5H_2O$ (formula weight = 250) has an absorbance of 0.1 measured in 1 cm cell at 600 nm. Calculate the molar absorptivity ($\varepsilon$) of $CuSO_4.5H_2O$ in $L\ M^{-1}cm^{-1}$. When 25 mL of the above solution is titrated against $Na_2EDTA$ (aq) solution, it consumes 50 mL of $Na_2EDTA$ (aq) solution. Calculate the concentration of $Na_2EDTA$ (aq) solution in moles $L^{-1}$.

26. Assume the complex $[Ni(PPh_3)_2(SCN)_2]$ is paramagnetic. The analogous complex of Pd(II) is diamagnetic. Draw all the probable isomers for both the complexes considering $SCN^-$ is an ambidentate ligand.

27. Write the structures of A to E in the following reaction sequence:



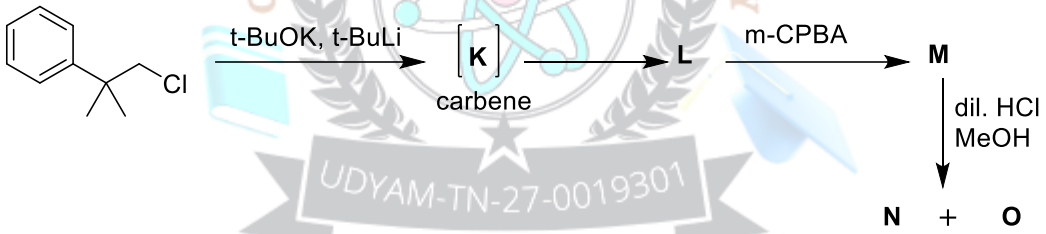
**28. Write the structures of F to J in the following reaction scheme:**



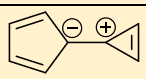

**DiBAL-H = Diisobutylaluminium hydride**

**29. Propose a mechanism for the following reaction. Show stepwise correct reactive intermediates.**


**30. Complete the following reaction sequence and write structures of K to O.**




## Answer Key

| Q.No | Ans | | Q.No | Ans |
|---|---|---|---|---|
| 1. | a | | 11. | Ferricinium cation |
| 2. | b | | 12. | VO > MnO > CaO |
| 3. | b | | 13. | Square antiprismatic |
| 4. | c | | 14. | 3:2 |
| 5. | a | | 15. | 2 |
| 6. | c | | 16. | 3.985 g $cm^{-3}$ |
| 7. | c | | 17. | 400 |
| 8. | d | | 18. | 4.7 Kcal/mol |
| 9. | d | | 19. | Three |
| 10. | a | | 20. |  |