25th Feb. 2021 | Shift - 1
CHEMISTRY

SECTION - A

1. Ellingham diagram is a graphical representation of:

(1) ΔG vs T (2) $(\Delta G - T\Delta S)$ vs T (3) ΔH vs T (4) ΔG vs P

Sol. (1)

Ellingham diagram tells us about the spontanity of a reaction with temperature.

2. Which of the following equation depicts the oxidizing nature of H_2O_2?

(1) $Cl_2 + H_2O_2 \rightarrow 2HCl + O_2$ (2) $KIO_4 + H_2O_2 \rightarrow KIO_3 + H_2O + O_2$

(3) $2I^- + H_2O_2 + 2H^+ \rightarrow I_2 + 2H_2O$ (4) $I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H2O + O_2$

Sol. (3)

$2I^- + H_2O_2 + 2H^+ \rightarrow I_2 + 2H_2O$

Oxygen reduces from –1 to –2

So, its reduction will takes place. Hence it will behave as oxidising agent or it shows oxidising nature.

While in other option it change from (–1) to 0.

3. In Freundlich adsorption isotherm at moderate pressure, the extent of adsorption $\left(\frac{x}{m}\right)$ is directly proportional to P^x. The value of x is:

(1) ∞ (2) 1 (3) zero (4) $\frac{1}{n}$

Sol. (4)

$\frac{x}{m} = p^x$

the formula is $\frac{x}{m} = p^{1/n}$

Hence $x = \frac{1}{n}$

The value of 'n' is any natural number.

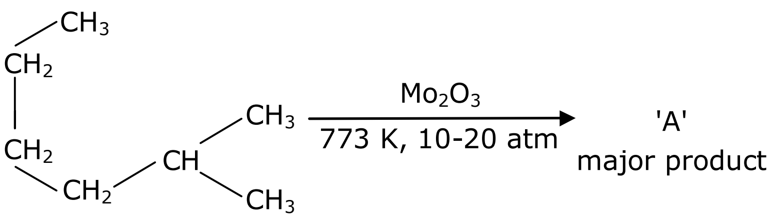
4. According to molecular orbital theory, the species among the following that does not exist is:

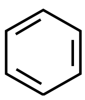
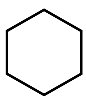
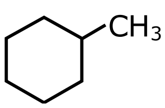
(1) He_2^- (2) He_2^+ (3) O_2^{2-} (4) Be_2

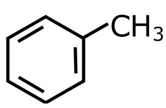
Sol. (4)

B.O. of Be_2 is zero, So it does not exist.

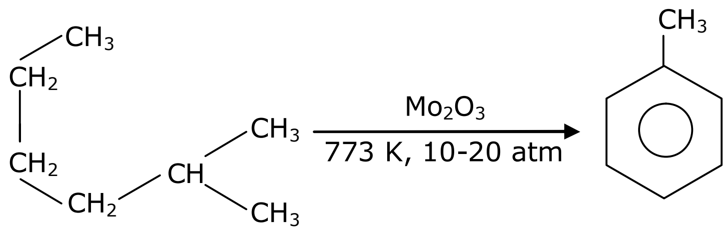
5. Identify A in the given chemical reaction.



(1)  (2)  (3) 

(4) 

Sol. **(4)**



Aromatization reaction or hydroforming reaction.

6. Given below are two statements:
Statement-I : CeO_2 can be used for oxidation of aldehydes and ketones.
Statement-II : Aqueous solution of $EuSO_4$ is a strong reducing agent.
(1) Statement I is true, statement II is false
(2) Statement I is false, statement II is true
(3) Both Statement I and Statement II are false
(4) Both Statement I and Statement II are true

Sol. **(4)**
CeO_2 can be used as oxidising agent like seO_2.
Similarly $EuSO_4$ used as a reducing agent.

7. The major product of the following chemical reaction is:

$$CH_3CH_2CN \xrightarrow[\text{3) } Pd/BaSO_4,\ H_2]{\text{1) } H_3O^+,\ \Delta \quad \text{2) } SOCl_2} ?$$

(1) $(CH_3CH_2CO)_2O$ (2) CH_3CH_2CHO (3) $CH_3CH_2CH_3$ (4) $CH_3CH_2CH_2OH$

Sol. **(2)**

$$CH_3CH_2CN \xrightarrow{H_3O^+} CH_3-CH_2-\overset{\overset{\displaystyle O}{\|}}{C}-OH \xrightarrow{SOCl_2} CH_3-CH_2-\overset{\overset{\displaystyle O}{\|}}{C}-Cl$$

$$\xrightarrow{Pd/Ba,SO_4,} CH_3-CH_2-CH=O$$

8. Complete combustion of 1.80 g of an oxygen containing compound ($C_xH_yO_z$) gave 2.64 g of CO_2 and 1.08 g of H_2O. The percentage of oxygen in the organic compound is:
(1) 63.53 (2) 53.33 (3) 51.63 (4) 50.33

Sol. **(2)**

$n_{CO_2} = \frac{2.64}{44} = 0.06$

$n_c = 0.06$

weight of carbon = 0.06 × 12 = 0.72 gm

$n_{H_2O} = \frac{1.08}{18} = 0.06$

$n_H = 0.06 \times 2 = 0.12$

weight of H = 0.12 gm

∴ Weight of oxygen in $C_xH_yO_z$

= 1.8 – (0.72 + 0.12)

= 0.96 gram

% weight of oxygen = $\frac{0.96}{1.8} \times 100$

= 53.3%

9. The correct statement about B_2H_6 is:

(1) All B–H–B angles are of 120°.

(2) Its fragment, BH_3, behaves as a Lewis base.

(3) Terminal B–H bonds have less p-character when compared to bridging bonds.

(4) The two B–H–B bonds are not of same length.

Sol. **(3)**

Terminal bond angle is greater than that of bridge bond angle

Bond angle $\propto$ S-character

$\propto \frac{1}{p - \text{character}}$

10. In which of the following pairs, the outer most electronic configuration will be the same?

(1) Fe^{2+} and Co^{+}

(2) Cr^{+} and Mn^{2+}

(3) Ni^{2+} and Cu^{+}

(4) V^{2+} and Cr^{+}

Sol. **(2)**

$Cr^{+} \rightarrow [Ar]3d^5$

$Mn^{2+} \Rightarrow [Ar]3d^5$

11. Which statement is correct?

(1) Buna-S is a synthetic and linear thermosetting polymer

(2) Neoprene is addition copolymer used in plastic bucket manufacturing

(3) Synthesis of Buna-S needs nascent oxygen

(4) Buna-N is a natural polymer

Sol. **(3)**

Synthesis of Buna-S needs nascent oxygen.

12. Given below are two statements:

Statement-I : An allotrope of oxygen is an important intermediate in the formation of reducing smog.

Statement-II : Gases such as oxides of nitrogen and sulphur present in troposphere contribute to the formation of photochemical smog.

In the light of the above statements, choose the correct answer from the options given below:

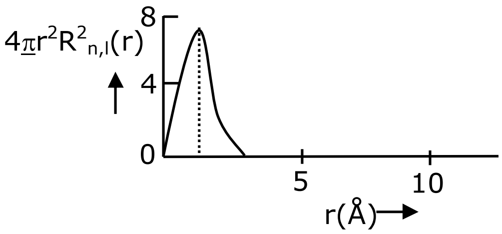
(1) Statement I and Statement II are true
(2) Statement I is true about Statement II is false
(3) Both Statement I and Statement II are false
(4) Statement I is false but Statement II is true

Sol. **(3)**

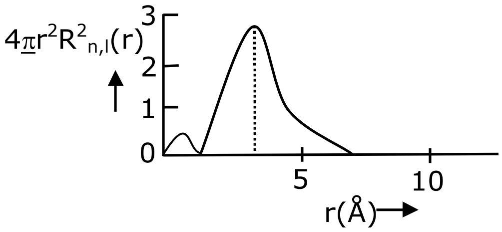
Reducing smog as is acts as reducing agent, the reducing character is due to presence of sulphur dioxide and carbon particles.

13. The plots of radial distribution functions for various orbitals of hydrogen atom against 'r' are given below:

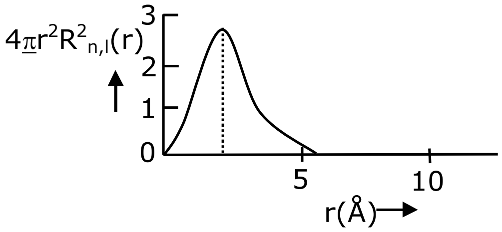
(A)



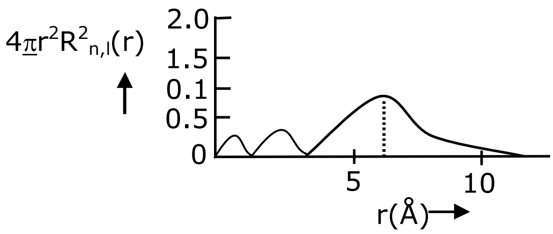
(B)



(C)



(D)



The correct plot for 3s orbital is:

(1) D (2) B (3) A (4) C

Sol. **(1)**

3s orbital

Number of radial nodes = n – ℓ – 1

For 3s orbital n = 3 ℓ = 0

Number of radial nodes = 3 – 0 – 1 = 2

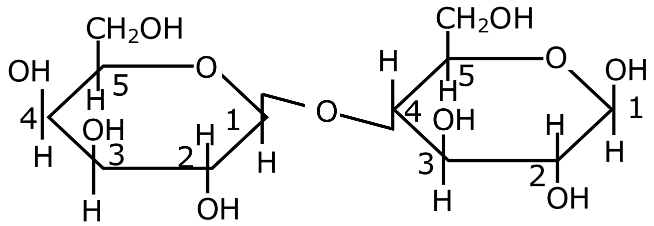
It is correctly represented in graph of option D

14. Which of the glycosidic linkage galactose and glucose is present in lactose?

(1) C-1 of glucose and C-6 of galactose (2) C-1 of galactose and C-4 of glucose

(3) C-1 of glucose and C-4 of galactose (4) C-1 of galactose and C-6 of glucose

Sol. **(2)**



β-D-Galactose β-D-Glucose

15. Which one of the following reactions will not form acetaldehyde?

(1) $CH_3CH_2OH \xrightarrow{CrO_3 - H_2SO_4}$

(2) $CH_3CN \xrightarrow[\text{ii) } H_2O]{\text{i) DIBAL-H}}$

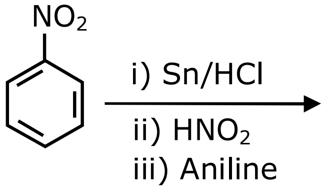
(3) $CH_2 = CH_2 + O_2 \xrightarrow[H_2O]{Pd(II)/Cu(II)}$

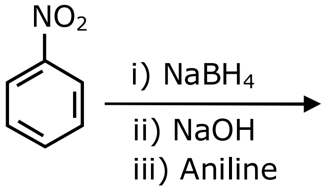
(4) $CH_3CH_2OH \xrightarrow[573\ K]{Cu}$

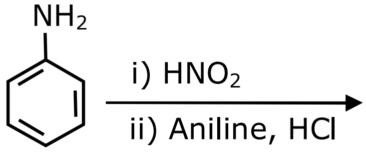
Sol. **(1)**

$$CH_3CH_2OH \xrightarrow{CrO_3 - H_2SO_4} CH_3 - COOH$$

16. Which of the following reaction/s will not give p-aminoazobenzene?

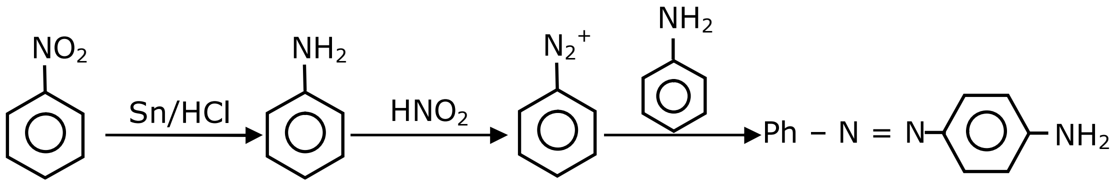
(A) 

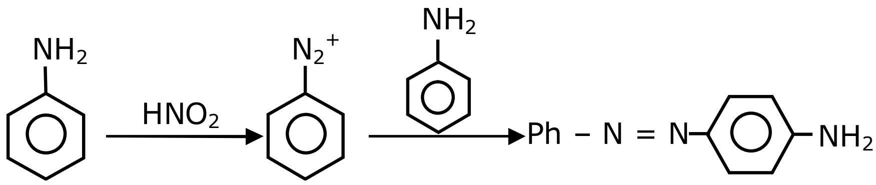
(B) 

(C) 

(1) B only (2) A and B (3) C only (4) A only

Sol. (1)

(A) 

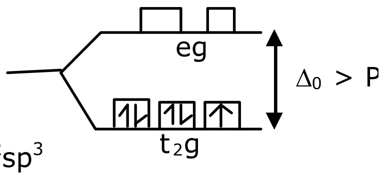
(C) 

17. The hybridization and magnetic nature of $[Mn(CN)_6]^{4-}$ and $[Fe(CN)_6]^{3-}$, respectively are:

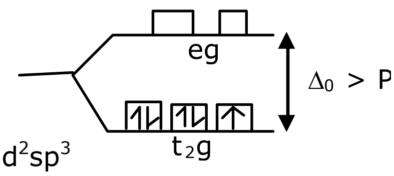
(1) d^2sp^3 and paramagnetic (2) sp^3d^2 and paramagnetic
(3) d^2sp^3 and diamagnetic (4) sp^3d^2 and diamagnetic

Sol. (1)

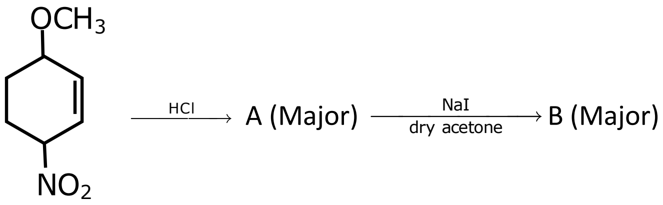
1. $(Mn(CN)_6)^{4-}$
$Mn^{++} = 3d^5$
$\mu = \sqrt{3}$
hybridization = d^2sp^3

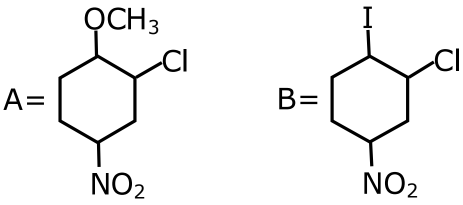


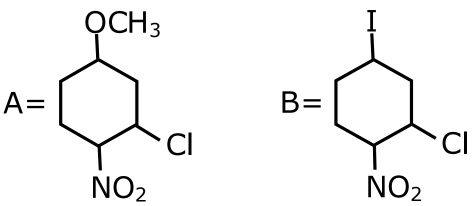
2. $[Fe(CN)_6]^{3-}$
$Fe^{3+} = 3d^5$
$\mu = \sqrt{3}$
Hybridization – d^2sp^3

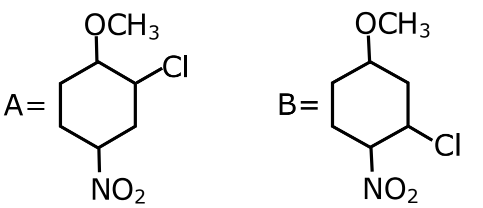


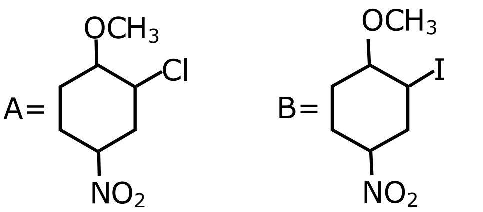
18. Identify A and B in the chemical reaction.



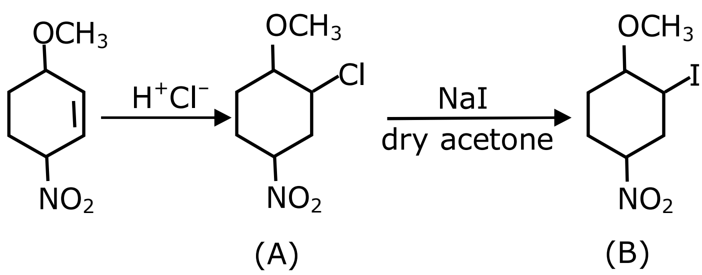
(1) 

(2) 

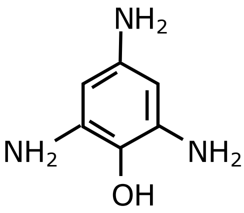
(3) 

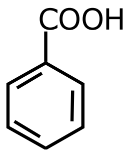
(4) 

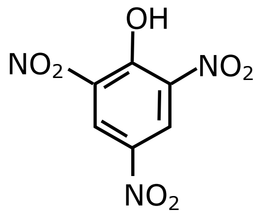
Sol. **(4)**



19. Compound(s) which will liberate carbon dioxide with sodium bicarbonate solution is/are:

A = 

B = 

C = 

(1) B and C only (2) B only (3) A and B only (4) C only

Sol. **(1)**

Compounds which are more acidic then H_2CO_3, gives CO_2 gas on reaction with $NaHCO_3$. Compound B i.e. Benzoic acid and compound C i.e. picric acid both are more acidic than H_2CO_3.

20. The solubility of AgCN in a buffer solution of pH = 3 is x. The value of x is:
[Assume: No cyano complex is formed; $K_{sp}(AgCN) = 2.2 \times 10^{-16}$ and K_a (HCN) = 6.2×10^{-10}]

(1) 0.625×10^{-6} (2) 1.6×10^{-6} (3) 2.2×10^{-16} (4) 1.9×10^{-5}

Sol. **(4)**

Let solubility is x

$$\underset{}{AgCN} \rightleftharpoons \underset{x}{Ag^+} + \underset{x}{CN^-} \qquad K_{sp} = 2.2 \times 10^{-16}$$

$$H^+ + CN^- \rightleftharpoons HCN \qquad K = \frac{1}{K_a} = \frac{1}{6.2 \times 10^{-10}}$$

$$K_{sp} \times \frac{1}{K_a} = [Ag^+][CN^-] \times \frac{[HCN]}{[H^+][CN^-]}$$

$$2.2 \times 10^{-16} \times \frac{1}{6.2 \times 10^{-10}} = \frac{[S][S]}{10^{-3}}$$

$$S^2 = \frac{2.2}{6.2} \times 10^{-9}$$

$$S^2 = 3.55 \times 10^{-10}$$

$$S = \sqrt{3.55 \times 10^{-10}}$$

$$S = 1.88 \times 10^{-5} \Rightarrow 1.9 \times 10^{-5}$$

SECTION - B

1. The reaction of cyanamide, $NH_2CN_{(s)}$ with oxygen was run in a bomb calorimeter and ΔU was found to be -742.24 kJ mol^{-1}. The magnitude of ΔH_{298} for the reaction

$NH_2CN_{(s)} + \frac{3}{2}O_2(g) \rightarrow N_{2(g)} + O_{2(g)} + H_2O_{(l)}$ is _______ kJ. (Rounded off to the nearest integer)

[Assume ideal gases and R = 8.314 J mol^{-1} K^{-1}]

Sol. **741 kJ/mol**

$$NH_2CN(s) + \frac{3}{2}O_2(g) \longrightarrow N_2(g) + CO_2(g) + H_2O(\ell)$$

$$\Delta ng = (1 + 1) - \frac{3}{2} = \frac{1}{2}$$

$\Delta H = \Delta U + \Delta ng\ RT$

$= -742.24 + \frac{1}{2} \times \frac{8.314 \times 298}{1000}$

$= -742.24 + 1.24$

$= 741$ kJ/mol

2. In basic medium CrO_4^{2-} oxidizes $S_2O_3^{2-}$ to form SO_4^{2-} and itself changes into $Cr(OH)_4^-$. The volume of 0.154 M CrO_4^{2-} required to react with 40 mL of 0.25 M $S_2O_3^{2-}$ is _______ mL. (Rounded-off to the nearest integer)

Sol. **173 mL**

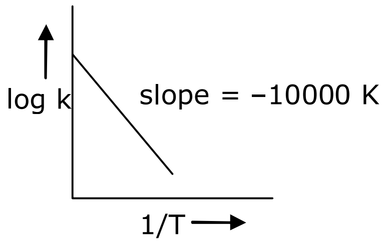
$17H_2O + 8CrO_4 + 3S_2O_3 \longrightarrow 6SO_4 + 8Cr(OH)_4^- + 2OH^-$

Applying mole-mole analysis

$\frac{0.154 \times v}{8} = \frac{40 \times 0.25}{3}$

V = 173 mL

3. For the reaction, aA + bB → cC + dD, the plot of log k vs $\frac{1}{T}$ is given below:



The temperature at which the rate constant of the reaction is $10^{-4}s^{-1}$ is _________ K.
[Rounded off to the nearest integer)
[Given: The rate constant of the reaction is $10^{-5}\ s^{-1}$ at 500 K]

Sol. **526 K**

$\log_{10}K = \log_{10}A - \frac{E_a}{2.303RT}$

$\text{Slope} = \frac{E_a}{2.303R} = -10000$

$\log_{10}\frac{K_2}{K_1} = \frac{E_a}{2.303R} \times \left[\frac{1}{T_1} - \frac{1}{T_2}\right]$

$\log_{10}\frac{10^{-4}}{10^{-5}} = 10000 \times \left[\frac{1}{500} - \frac{1}{T}\right]$

$1 = 10000 \times \left[\frac{1}{500} - \frac{1}{T}\right]$

$\frac{1}{10000} = \frac{1}{500} - \frac{1}{T}$

$$\frac{1}{T} = \frac{1}{500} - \frac{1}{10000}$$

$$\frac{1}{T} = \frac{20-1}{10000} = \frac{19}{10000}$$

$$T = \frac{10,000}{19} \Rightarrow 526 \text{ K}$$

4. 0.4g mixture of NaOH, Na_2CO_3 and some inert impurities was first titrated with $\frac{N}{10}$ HCl using phenolphthalein as an indicator, 17.5 mL of HCl was required at the end point. After this methyl orange was added and titrated. 1.5 mL of same HCl was required for the next end point. The weight percentage of Na_2CO_3 in the mixture is ______. (Rounded-off to the nearest integer)

Sol. **3%**

1st end point reaction

$NaOH + HCl \longrightarrow NaCl + H_2O$

nf = 1

$NaCO_3 + HCl \longrightarrow NaHCO_3$

nf = 1

Eq of HCl used $= n_{NaOH} \times 1 + n_{Na_2CO_3} \times 1$

$$17.5 \times \frac{1}{10} \times 10^{-3} = n_{NaOH} + n_{Na_2CO_3}$$

2nd end point

$NaHCO_3 + HCl \longrightarrow H_2CO_3$

$$1.5 \times \frac{1}{10} \times 10^{-3} = n_{NaHCO_3} \times 1 = n_{NaHCO_3}$$

0.15 mmol $= n_{Na_2CO_3}$

$0.15 = n_{Na_2CO_3}$

$$w_{Na_2CO_3} = \frac{0.15 \times 106 \times 10^{-3}}{0.5} \times 100 \times 10$$

$= 3 \times 106 \times 10^{-2}$

$= 3 \times 1.06 = 3.18\%$

5. The ionization enthalpy of Na^+ formation from $Na_{(g)}$ is 495.8 kJ mol^{-1}, while the electron gain enthalpy of Br is –325.0 kJ mol^{-1}. Given the lattice enthalpy of NaBr is –728.4 kJ mol^{-1}. The energy for the formation of NaBr ionic solid is (–)_____ × 10^{-1} kJ mol^{-1}.

Sol. **5576 kJ**

$Na(s) \longrightarrow Na^+(g)$ $\quad \Delta H = 495.8$

$\frac{1}{2}Br_2(\ell) + e^- \longrightarrow Br^-(g)$ $\quad \Delta H = 325$

$Na^+(g) + Br^-(g) \longrightarrow NaBr(s)$ $\quad \Delta H = -728.4$

$Na(s) + \frac{1}{2}Br_2(\ell) \longrightarrow NaBr(s).$ $\quad \Delta H = ?$

$\Delta H = 495.8 - 325 - 728.4$

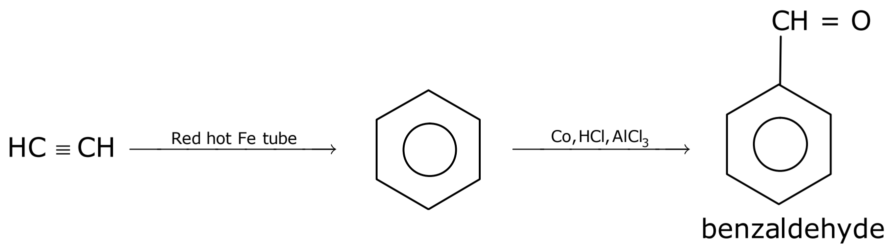
$-557.6 \text{ kJ} = -5576 \times 10^{-1} \text{ kJ}$

6. Consider the following chemical reaction.

$$HC \equiv CH \xrightarrow[(2)\,CO+HCl/AlCl_3]{(1)\,\text{Red hot Fe tube, }873\,K} \text{Product}$$

The number of sp^2 hybridized carbon atom(s) present in the product is ________.

Sol. **7**



All carbon atoms in benzaldehyde are sp^2 hybridised

7. A car tyre is filled with nitrogen gas at 35 psi at 27°C. It will burst if pressure exceeds 40 psi. The temperature in °C at which the car tyre will burst is _______. (Rounded-off to the nearest integer)

Sol. **69.85°C ≃ 70°C**

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{35}{300} = \frac{40}{T_2}$$

$$T_2 = \frac{40 \times 300}{35}$$

= 342.86 K

= 69.85°C ≃ 70°C

8. Among the following, the number of halide(s) which is/are inert to hydrolysis is _______.

(A) BF_3 (B) $SiCl_4$ (C) PCl_5 (D) SF_6

Sol. **1**

Due to crowding SF_6 is not hydrolysed.

9. 1 molal aqueous solution of an electrolyte A_2B_3 is 60% ionised. The boiling point of the solution at 1 atm is ______ K. (Rounded-off to the nearest integer)

[Given K_b for (H_2O) = 0.52 K kg mol^{-1}]

Sol. **375 K**

$A_2B_3 \longrightarrow 2A^{+3} + 3B^{-2}$

No. of ions = 2 + 3 = 5

$i = 1 + (n - 1)\,\alpha$

$= 1 + (5 - 1) \times 0.6$

$= 1 + 4 \times 0.6 = 1 + 2.4 = 3.4$

$\Delta T_b = K_b \times m \times i$

$= 0.52 \times 1 \times 3.4 = 1.768°C$

$\Delta T_b = (T_b)_{solution} - [(T_b)_{H_2O}]_{Solution}$

$1.768 = (T_b)_{solution} - 100$

$(T_b)_{solution} = 101.768\ °C$

$= 375\ K$

10. Using the provided information in the following paper chromatogram:

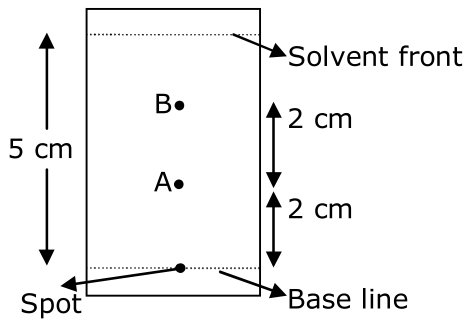


Fig: Paper chromatography for compounds A and B

the calculated R_f value of A _______ $\times 10^{-1}$.

Sol. **4**

$$R_f = \frac{\text{Distance travelled by compound}}{\text{Distance travelled by solvent}}$$

On chromatogram distance travelled by compound is $\rightarrow$ 2 cm

Distance travelled by solvent = 5 cm

So $R_f = \frac{2}{5} = 4 \times 10^{-1} = 0.4$