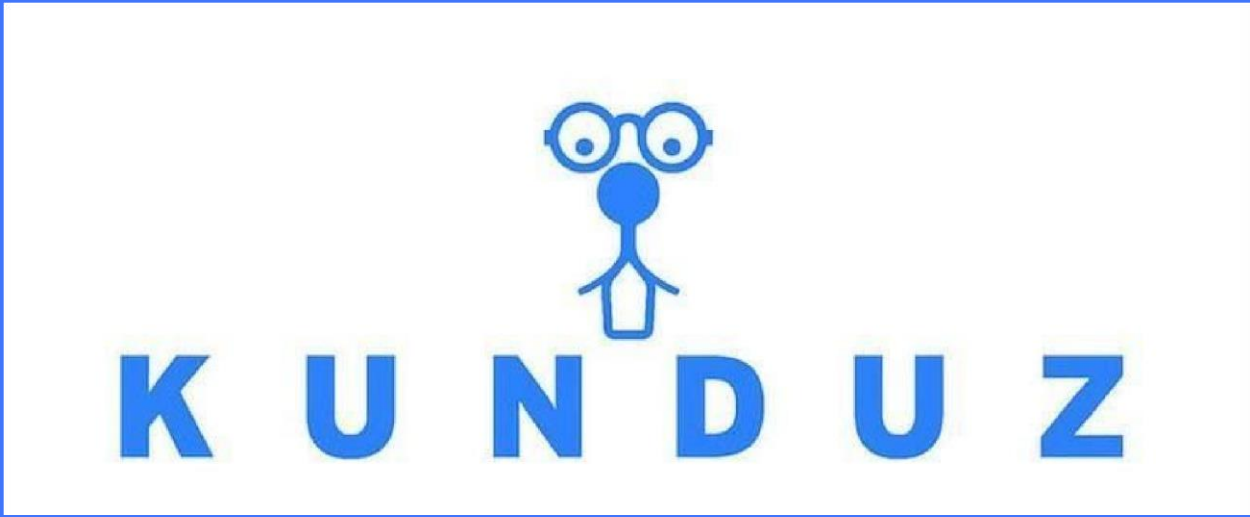


JEE Advanced 2020 Chemistry paper 2 solutions prepared by KUNDUZ tutors

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Question number	Question and Answers
1	

Q.1 The 1st, 2nd, and the 3rd ionization enthalpies, I_1, I_2, and I_3, of four atoms with atomic numbers n, $n+1$, $n+2$, and $n+3$, where $n < 10$, are tabulated below. What is the value of n?

Atomic number	Ionization Enthalpy (kJ/mol)		
	I_1	I_2	I_3
n	1681	3374	6050
$n+1$	2081	3952	6122
$n+2$	496	4562	6910
$n+3$	738	1451	7733

	I_1	I_2	I_3
n	1681	3374	6050
$n+1$	2081	3952	6122
$n+2$	496	4562	6910
$n+3$	738	1451	7733.

from the table, for atomic number $n+2$,

$I_2 >> I_1$

which implies that the valence shell electron must be 1. Thus removing 1 $e^\ominus$ has low I_1 and removing second $e^\ominus$ from fully filled config is difficult and thus have high I_2. So atomic $n+2$ belongs to alkali metal with valency 1

Also for atomic no. $(n+3)$, $I_3 >> I_2$.

$\Rightarrow$ Valence electron = 2. (alkaline earth metal).

These observations shows that n should be halogen and $n+1$ belongs to noble gas family.

$n = 9$ fluorine (first halogen)

$(n+1) = 10$ (Neon)

$(n+2) = 11$ (Sodium)

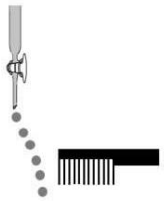
$(n+3) = 12$ (Magnesium).

Ans: $n = 9$

2

Q.2 Consider the following compounds in the liquid form:
O_2, HF, H_2O, NH_3, H_2O_2, CCl_4, $CHCl_3$, C_6H_6, C_6H_5Cl.

When a charged comb is brought near their flowing stream, how many of them show deflection as per the following figure?



When a charged comb is brought near the stream charged (polar molecules) either get attracted or deflected.

HF, H_2O, NH_3, H_2O_2, $CHCl_3$, C_6H_5Cl are polar molecules.

O_2, CCl_4, C_6H_6 are non-polar molecules with dipole moment zero.

Ans = 6 molecules.

3

Q.3 In the chemical reaction between stoichiometric quantities of $KMnO_4$ and KI in weakly basic solution, what is the number of moles of I_2 released for 4 moles of $KMnO_4$ consumed?

$\overset{+7}{K}\overset{+7}{Mn}O_4 + 2K\overset{2(-1)}{I} \longrightarrow \overset{+4}{Mn}O_2 + \overset{0}{I_2}$

n = change in oxidation state

n-factor of $KMnO_4$ = 3

n-factor of I_2 = 2.

Eq. of $KMnO_4$ = Eq of I_2

Equivalents = no. of moles × n-factor.

Eq. of $KMnO_4$ = $4 \times \frac{3}{2} = 12$.

Eq. of I_2 = $n \times 2$.

$12 = n \times 2$

$n = 6$

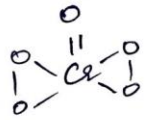
Ans: n = 6

4

Q.4 An acidified solution of potassium chromate was layered with an equal volume of amyl alcohol. When it was shaken after the addition of 1 mL of 3% H_2O_2, a blue alcohol layer was obtained. The blue color is due to the formation of a chromium (VI) compound '**X**'. What is the number of oxygen atoms bonded to chromium through only single bonds in a molecule of **X**?

K_2CrO_4 (Potassium chromate) + H_2O_2 (3% - 1mL) $\xrightarrow{\text{amyl alcohol}}$ CrO_5 (blue layer) (X)

Structure of CrO_5 (X) :

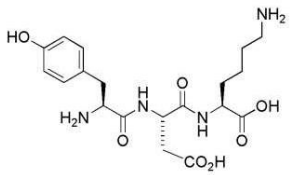


no. of singly bonded oxygen atoms with Cr is 4

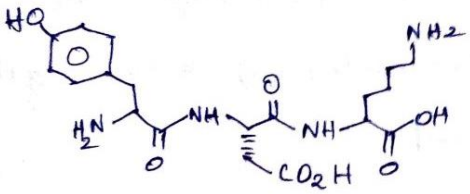
Ans: 4

5

Q.5 The structure of a peptide is given below.



If the absolute values of the net charge of the peptide at pH = 2, pH = 6, and pH = 11 are $|z_1|$, $|z_2|$, and $|z_3|$, respectively, then what is $|z_1| + |z_2| + |z_3|$?



At pH = 2, $|z_1| = 2$ all amino groups exist in the form of $-NH_3^{\oplus}$

The compound contains 2 NH_2 group. Thus

$|z_1| = 2$ (1+1)

At pH = 6, dipolar ion (zwitter ion) exists

$\Rightarrow |z| = 0$. (+1 and -1 cancel each other.

At pH = 11, All COOH and OH exist in the form of $-COO^{\ominus}$ and $-O^{\ominus}$)

So it takes -1 charge.

$|z_3| = |-1-1-1| = |-3| = |3|$ (2 COOH and one OH group)

$|z_1| + |z_2| + |z_3| = 2 + 0 + 3 = 5$

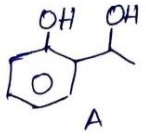
Ans: 5

6

Q.6 An organic compound ($C_8H_{10}O_2$) rotates plane-polarized light. It produces pink color with neutral $FeCl_3$ solution. What is the total number of all the possible isomers for this compound?

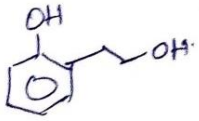
Phenolic group gives pink colour with neutral $FeCl_3$ soln.

So the compound must be,



A

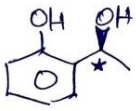
$(C_8H_{10}O_2)$ (or)

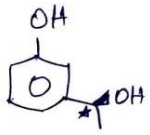


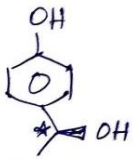
B

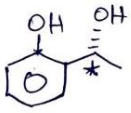
The compound rotates plane polarized light (given) which implies that the compound is optically active

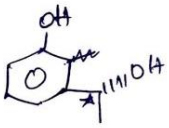
Only structure A is optically active. The possible isomers are

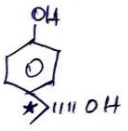








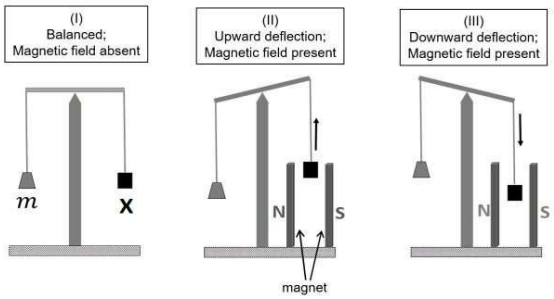




Total = 6.

7

Q.7 In an experiment, m grams of a compound **X** (gas/liquid/solid) taken in a container is loaded in a balance as shown in figure **I** below. In the presence of a magnetic field, the pan with **X** is either deflected upwards (figure **II**), or deflected downwards (figure **III**), depending on the compound **X**. Identify the correct statement(s).



(A) If **X** is $H_2O(l)$, deflection of the pan is upwards.
(B) If **X** is $K_4[Fe(CN)_6](s)$, deflection of the pan is upwards.
(C) If **X** is $O_2(g)$, deflection of the pan is downwards.
(D) If **X** is $C_6H_6(l)$, deflection of the pan is downwards.

paramagnetic compounds are attracted towards magnetic field and pan is deflected downwards Diamagnetic compounds are repelled and pan is deflected upward.

H_2O - diamagnetic, pan - upwards.

$K_4[Fe(CN)_6]$ Fe^{+2}, $3d^6$ (strong field ligand) $\Rightarrow t_{2g}^6 e_g^0$
diamagnetic, pan-upwards.

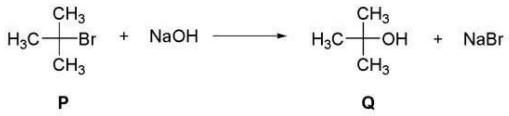
O_2 → paramagnetic (2 unpaired $e^\ominus$ in π^* orbital)
↳ pan-downwards.

C_6H_6 - Diamagnetic (0 unpaired $e^\ominus$) pan- upwards.

Ans: A, B, C are correct

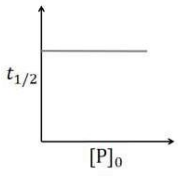
8

Q.8 Which of the following plots is(are) correct for the given reaction?
($[P]_0$ is the initial concentration of **P**)

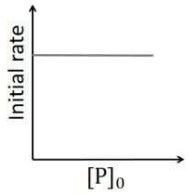


P **Q**

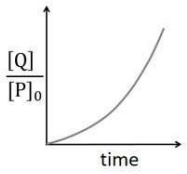
(A)



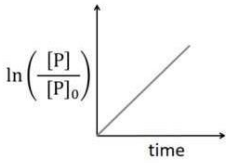
(B)



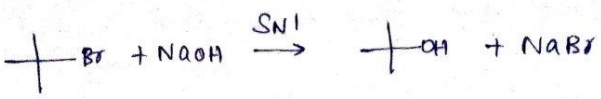
(C)



(D)



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The given reaction follows S_N1 mechanism (3° halides)

For S_N1 reaction,

① Rate = K [Initial conc].

Rate = K [P_0].

Rate is dependent on [P_0].

So graph (B) is incorrect ⇒ shows rate is independent on [P_0]

② $t_{1/2} = \frac{0.6932}{K}$

$t_{1/2}$ independent on initial concentration.

So graph (A) is correct.

③ $\ln \frac{P_0}{P} = kt$.

$\ln \frac{P}{P_0} = -kt$ ⇒ negative slope.

Graph (D) is incorrect it has positive slope

④ $\frac{Q}{[P_0]} = \frac{[P_0]-P}{P_0} = 1 - \frac{P}{P_0}$ $\left[\ln \frac{P}{P_0} = -kt\right]$

$\frac{Q}{P_0} = 1 - e^{-kt}$

Graph C is incorrect

It should exponentially increase



(correct graph).

Ans: Option (A)

9

Q.9 Which among the following statement(s) is(are) true for the extraction of aluminium from bauxite?

(A) Hydrated Al_2O_3 precipitates, when CO_2 is bubbled through a solution of sodium aluminate.
(B) Addition of Na_3AlF_6 lowers the melting point of alumina.
(C) CO_2 is evolved at the anode during electrolysis.
(D) The cathode is a steel vessel with a lining of carbon.

Hall-heroult process is used for extraction of Al from Bauxite

(A) $2\,Na[Al(OH)_4] + CO_2\uparrow \longrightarrow Na_2CO_3 + H_2O + Al_2O_3 \cdot 2H_2O\downarrow$ (ppt)
sodium aluminate $(2\,Al(OH)_3)$

option A is correct.

(B) Addition of Na_3AlF_6 lowers the melting point of electrolyte and increases its conductivity. (B is correct).

(C) At anode,

$C + O_2 \longrightarrow CO\uparrow + CO_2\uparrow$ (C is correct)
(graphite)

(D) Steel vessel with carbon lining - cathode
graphite - anode

(D is correct)

Ans: A, B, C, D

10

Q.10 Choose the correct statement(s) among the following.

(A) $SnCl_2 \cdot 2H_2O$ is a reducing agent.
(B) SnO_2 reacts with KOH to form $K_2[Sn(OH)_6]$.
(C) A solution of $PbCl_2$ in HCl contains Pb^{2+} and Cl^- ions.
(D) The reaction of Pb_3O_4 with hot dilute nitric acid to give PbO_2 is a redox reaction.

(A) $\overset{+2}{Sn}Cl_2 \cdot 2H_2O$ is a reducing agent. Because Sn^{2+} converts to more stable Sn^{4+} form.

(B) $SnO_2 + 2KOH_{(aq)} + 2H_2O \rightarrow K_2[Sn(OH)_6]$.

(C) $PbCl_2$ exist as chloroplumbous acid $H_2[PbCl_4]$ in presence of con. HCl.

$$PbCl_2 + 2HCl \rightarrow H_2[PbCl_4].$$

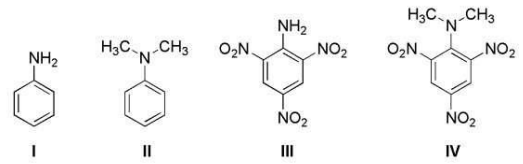
C is incorrect.

(D) $Pb_3O_4 + 4HNO_3 \rightarrow PbO_2(s) + 2Pb(NO_3)_2 + 2H_2O$ is not a redox reaction.

Ans: option A, B.

11

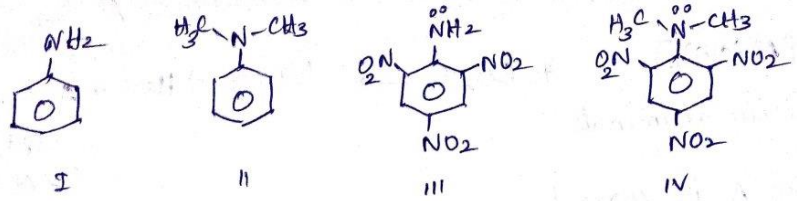
Q.11 Consider the following four compounds **I**, **II**, **III**, and **IV**.



I II III IV

Choose the correct statement(s).

(A) The order of basicity is **II** > **I** > **III** > **IV**.
(B) The magnitude of pK_b difference between **I** and **II** is more than that between **III** and **IV**.
(C) Resonance effect is more in **III** than in **IV**.
(D) Steric effect makes compound **IV** more basic than **III**.

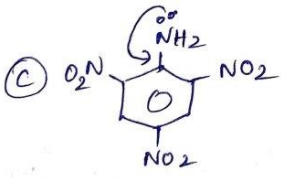
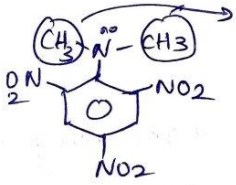


I II III IV

(A) Basicity order : II > I > IV > III

III is least basic due to the presence of NO_2 (EWG) the lone pair on 'N' involves in delocalisation and decreases the basicity (availability of lone pair on N-atom)

(B) There is only slight difference in magnitude of pK_b between I and II than III and IV, So B is incorrect

(C)  >  steric repulsion decreases the resonance effect.

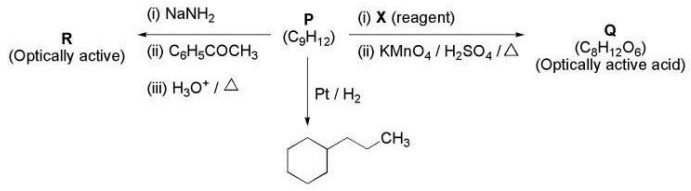
resonance (III) (IV)

Thus (IV) is more basic than (III)

Ans: Option C and D are correct.

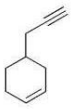
12

Q.12 Consider the following transformations of a compound **P**.



Choose the correct option(s).

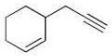
(A) **P** is



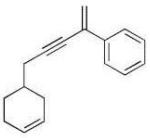
(B) **X** is

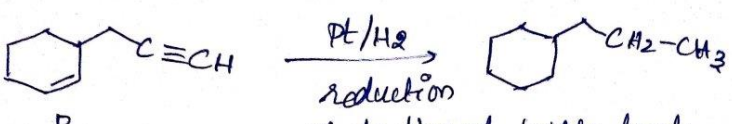
Pd-C/quinoline/H_2

(C) **P** is

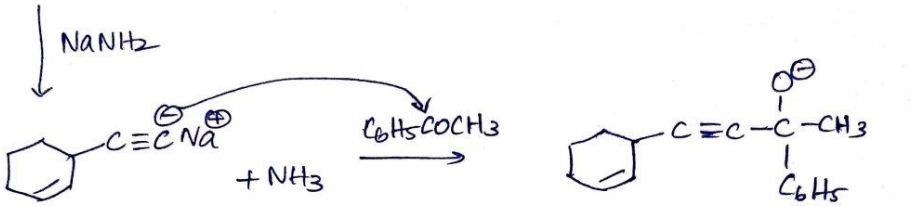


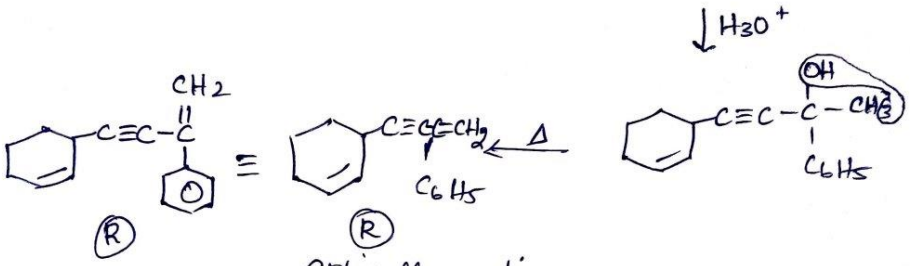
(D) **R** is



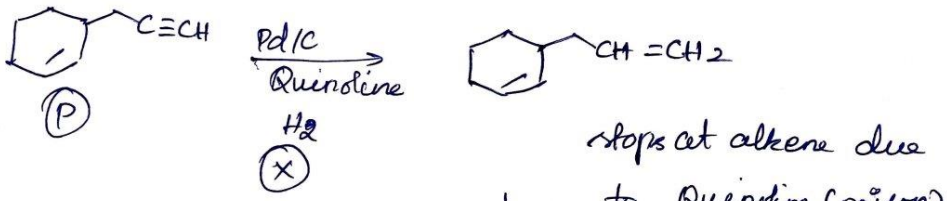


P
(C_9H_{12})



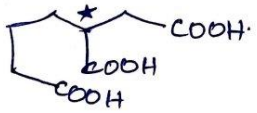


optically active



stops at alkene due to Quinoline (poison)





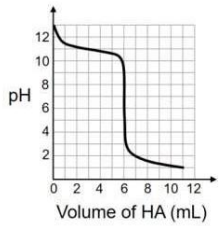
$(C_8H_{12}O_6)$ Q

optically active

Ans: option B, C

13

Q.13 A solution of 0.1 M weak base (B) is titrated with 0.1 M of a strong acid (HA). The variation of pH of the solution with the volume of HA added is shown in the figure below. What is the pK_b of the base? The neutralization reaction is given by $B + HA \rightarrow BH^+ + A^-$.



$B + HA \rightarrow BH^+ + A^{\ominus}$

At equivalence point, volume of HA used = 6 mL

At half equivalence point $\therefore V = 3mL$, $pH = 11$ (basic)

$$pOH = pK_b + \log \frac{[BH^+]}{[B]}$$

At half equivalence point, $[BH^+] = [B]$.

$$pOH = pK_b + \log 1.$$

$pOH = 14 - pH$

$= 14 - 11 = 3$

$pK_b + \log 1 = 3$

$\boxed{pK_b = 3}$

Ans : 3

14

Q.14 Liquids **A** and **B** form ideal solution for all compositions of **A** and **B** at 25 °C. Two such solutions with 0.25 and 0.50 mole fractions of **A** have the total vapor pressures of 0.3 and 0.4 bar, respectively. What is the vapor pressure of pure liquid **B** in bar?

Using Raoult's Law

$$P_T = P_A^\circ X_A + P_B^\circ X_B$$

(P_T = Total)

Given:

At 0.3 Pressure $X_A = 0.25$

$X_B = 1.00 - 0.25 = 0.75$

At 0.4 bar, $X_A = 0.5$

$X_B = 0.5$

$0.3 = P_A^\circ (0.25) + P_B^\circ (0.75)$ — (1)

$0.4 = P_A^\circ (0.5) + P_B^\circ (0.5)$ — (2)

$0.8 = P_A^\circ + P_B^\circ$ — (2)

On solving (1) and (2)

(2) × 0.25

$0.3 = P_A^\circ (0.25) + P_B^\circ (0.75)$ — (1)

(−) $0.2 = P_A^\circ (0.25) + P_B^\circ (0.25)$ — (2)

(1) − (2)

$0.1 = P_B^\circ (0.5)$

$P_B^\circ = 0.2$.

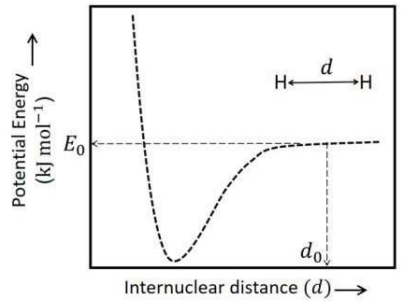
Sub in (2)

$P_B^\circ = 0.8 - 0.2 = 0.6$.

Ans: $P_B^\circ = 0.2$

15

Q.15 The figure below is the plot of potential energy versus internuclear distance (d) of H_2 molecule in the electronic ground state. What is the value of the net potential energy E_0 (as indicated in the figure) in kJ mol^{-1}, for $d = d_0$ at which the electron-electron repulsion and the nucleus-nucleus repulsion energies are absent? As reference, the potential energy of H atom is taken as zero when its electron and the nucleus are infinitely far apart.
Use Avogadro constant as 6.023×10^{23} mol^{-1}.



At $d = d_0$, nucleus-nucleus and $e^{\ominus}$-$e^{\ominus}$ repulsion is absent.

P.E will be calculated for 2 H atoms.

$$P.E = \frac{-Kq_1q_2}{r}$$

(Bohr radius) for n = 1

where K = force const
q = charge of $e^{\ominus}$

$$= \frac{-(9 \times 10^9) \times (1.6 \times 10^{-19})^2}{0.529 \times 10^{-10}} = -4.355 \times 10^{-21} \text{ KJ}$$

For 1 mol of H atom P.E = $-4.355 \times 10^{-21} \times 6.023 \times 10^{23}$ (NA)

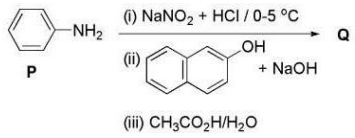
$= -2623.249$ KJ/mol.

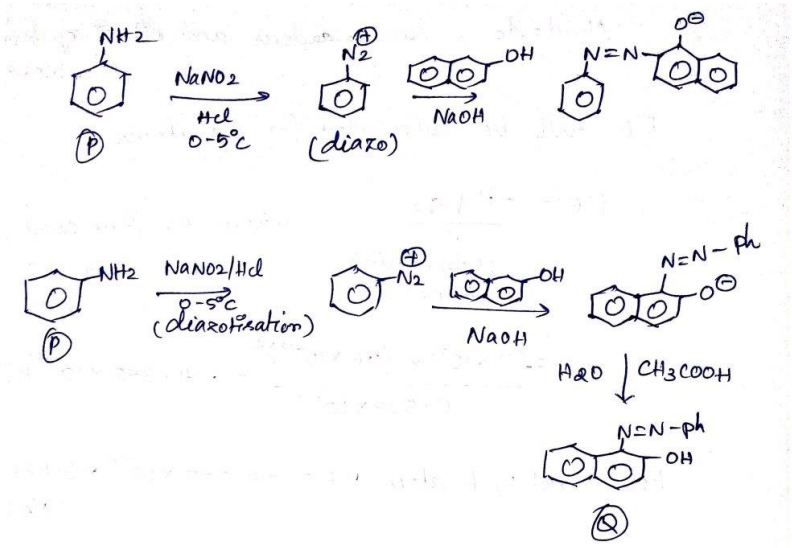
For 2 H atoms, P.E = -2623.249×2

Ans = -5246.498 KJ/mol

16

Q.16 Consider the reaction sequence from **P** to **Q** shown below. The overall yield of the major product **Q** from **P** is 75%. What is the amount in grams of **Q** obtained from 9.3 mL of **P**? (Use density of **P** = 1.00 g mL^{-1}; Molar mass of C = 12.0, H =1.0, O =16.0 and N = 14.0 g mol^{-1})





Molecular mass of Q ($C_{16}H_{12}ON_2$) = 248 g.

Given: P = 9.3 mL

Mass of P = Density × Volume

= 1 × 9.3 = 9.3 g.

No. of moles of P = $\frac{9.3}{9.3}$ = 0.1

(molecular mass of aniline (P) = 93)

Moles of Q obtained = $0.1 \times \frac{75}{100}$

= 0.075

[1 mole of P gives 1 mole of Q ;
0.1 mole of P gives 0.1 mole of Q].

Mass of Q formed = 248 × 0.075

(mol. wt × no. of moles)

Ans = 18.6 g.

17

Q.17 Tin is obtained from cassiterite by reduction with coke. Use the data given below to determine the minimum temperature (in K) at which the reduction of cassiterite by coke would take place.
At 298 K: $\Delta_f H^0(SnO_2(s)) = -581.0\ kJ\ mol^{-1}$, $\Delta_f H^0(CO_2(g)) = -394.0\ kJ\ mol^{-1}$,
$S^0(SnO_2(s)) = 56.0\ J\ K^{-1}mol^{-1}$, $S^0(Sn(s)) = 52.0\ J\ K^{-1}mol^{-1}$,
$S^0(C(s)) = 6.0\ J\ K^{-1}mol^{-1}$, $S^0(CO_2(g)) = 210.0\ J\ K^{-1}mol^{-1}$.
Assume that the enthalpies and the entropies are temperature independent.

$$SnO_2 + C_{(s)} \longrightarrow Sn_{(s)} + CO_2\ g.$$

given :

$\Delta f \Delta H^\circ\ SnO_2 = -581.0\ KJ/mol$

$CO_2 = -394\ KJ/mol.$

$S^\circ(SnO_2) = 56\ J/K/mol$

$Sn = 52\ JK^{-1}mol^{-1}$

$C = 6\ J/K/mol$

$CO_2 = 210\ J/K/mol.$

Soln

$$\Delta_r H^\circ = \Delta_f H^\circ_{product} - \Delta_f H^\circ_{(reactant)}$$

$$= -394 - (-581)$$

$$= 187\ KJ/mol.$$

$$\Delta_r S^\circ = \Delta_f S^\circ_{product} - \Delta S^\circ_{reactant}.$$

$$= [52 + 210] - [56 + 6]$$

$$= 200\ J/K/mol.$$

$$T = \frac{\Delta H^\circ}{\Delta S^\circ} = \frac{187 \times 1000\ J/mol}{200\ J/K/mol}$$

Ans $= 935\ K.$

18

Q.18 An acidified solution of 0.05 M Zn^{2+} is saturated with 0.1 M H_2S. What is the minimum molar concentration (M) of H^+ required to prevent the precipitation of ZnS?
Use K_{sp} (ZnS) $= 1.25 \times 10^{-22}$ and
overall dissociation constant of H_2S, $K_{NET} = K_1K_2 = 1 \times 10^{-21}$.

$ZnS \rightleftharpoons Zn^{2+} + S^{2-}$

$K_{sp} = [Zn^{2+}][S^{2-}]$

$[S^{2-}] = \dfrac{K_{sp}}{[Zn^{2+}]}$

$= \dfrac{1.25 \times 10^{-22}}{0.05} = 2.5 \times 10^{-21}$

$H_2S \rightleftharpoons 2H^+ + S^{2-}$

given: $K_{net} = 1 \times 10^{-21}$

$[H_2S] = 0.1$

$K_{net} = \dfrac{[H^+]^2[S^{2-}]}{[H_2S]}$

$K_{net} = \dfrac{[H^+]^2 (2.5 \times 10^{-21})}{0.1}$

$[H^+]^2 = \dfrac{1 \times 10^{-21} \times 0.1}{2.5 \times 10^{-21}} = 0.04$

$[H^+] = \sqrt{0.04} = 0.2\ M$

Ans : 0.2M

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