FINAL JEE(Advanced) EXAMINATION - 2020

(Held On Sunday 27th SEPTEMBER, 2020)

PAPER-2 | **TEST PAPER WITH SOLUTION**

PART-2 : CHEMISTRY

SECTION-1 : (Maximum Marks : 18)

- This section contains **SIX (06)** questions.
- The answer to each question is a **SINGLE DIGIT INTEGER ranging from 0 to 9, BOTH INCLUSIVE**.
- For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- Answer to each question will be evaluated according to the following marking scheme :

Full Marks : +3 If ONLY the correct integer is entered;
Zero Marks : 0 If the question is unanswered;
Negative Marks : –1 In all other cases.

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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

Ans. 9

Sol.

Atomic number	Ionization Enthalpy (kJ/mol)		
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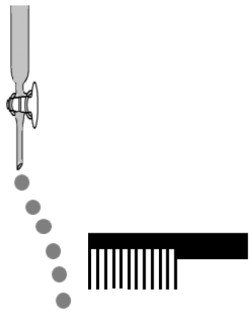
By observing the values of I_1, I_2 & I_3 for atomic number (n+2), it is observed that $I_2 >> I_1$.
This indicates that number of valence shell electrons is 1 and atomic number (n+2) should be an alkali metal.
Also for atomic number (n+3), $I_3 >> I_2$.
This indicates that it will be an alkaline earth metal which suggests that atomic number (n+1) should be a noble gas & atomic number (n) should belong to Halogen family. Since n < 10; hence n = 9 (F atom)

Note : n = 1 (H atom) cannot be the answer because it does not have I_2 & I_3 values.

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?



Ans. 6

Sol. Here polar molecules in the liquid form will be attracted/deflected near charged comb.

Polar molecules : HF, H_2O, NH_3, H_2O_2, $CHCl_3$, C_6H_5Cl (6-polar molecules)

Nonpolar molecules : O_2, CCl_4, C_6H_6

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 ?

Ans. 6

Sol. $KMnO_4 + KI \longrightarrow MnO_2 + I_2$

Eq of $KMnO_4$ = Eq of I_2

$4 \times 3 = n \times 2$

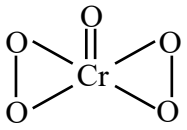
$n = 6$

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**?

Ans. 4

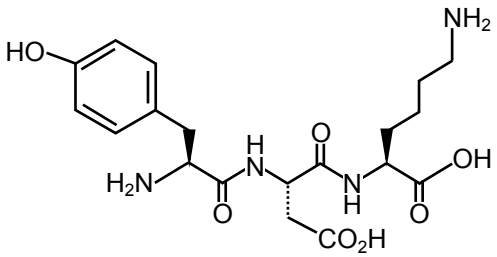
Sol. $K_2CrO_4 + H_2O_2 \xrightarrow[\text{(In acidic medium)}]{\text{Amyl alcohol}} \underset{\substack{\text{(X)}\\\text{(Blue liquid)}}}{CrO_5}$

Here the structure of CrO_5 is :-



Here, single bonded O-atoms with Cr is = 04

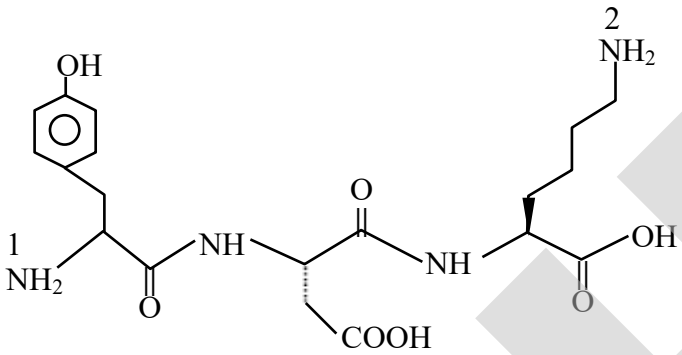
5. The structure of a peptide is given below



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 $|z_1| + |z_2| + |z_3|$?

Ans. 5

Sol. $|z_1| + |z_2| + |z_3| = 5$



At pH = 2 $\overset{1}{N}H_2$ and $\overset{2}{N}H_2$ of Tyrosine and Lysine is +ve charged (+1 each)

+2 $|z_1| = 2$

At pH = 6 NH_2 of Lysine (+1),

COOH (–1) of glutamic acid,

so because of dipolar ion exist $|z_2| = 0$

At pH = 11 COOH of Glutamic acid (–1)

COOH of Lysine (–1)

OH of phenol (–1)

$|z_3| = 3$

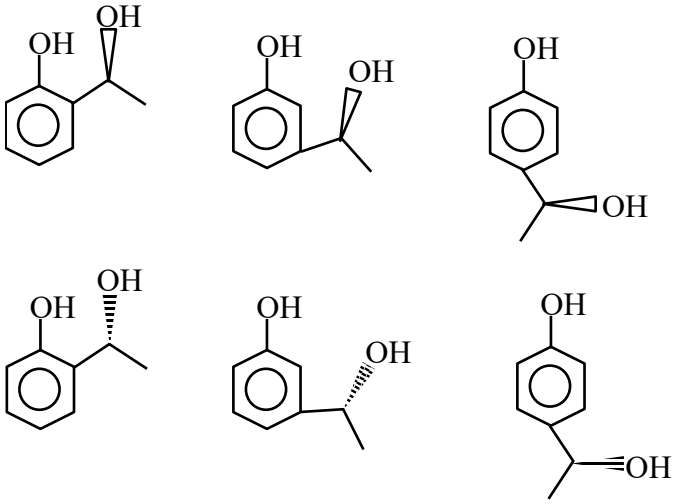
6. An organic compound ($C_8H_{10}O_2$) rotates plane-polarized light. It produces pink color with neutral $FeCl_3$ solution. What is the total number of all the possible isomers for this compound?

Ans. 6

Sol. $C_8H_{10}O_2 \rightarrow$ Gives $FeCl_3$ test means Phenol derivative

↓

Rotate plane polarized light means optically active

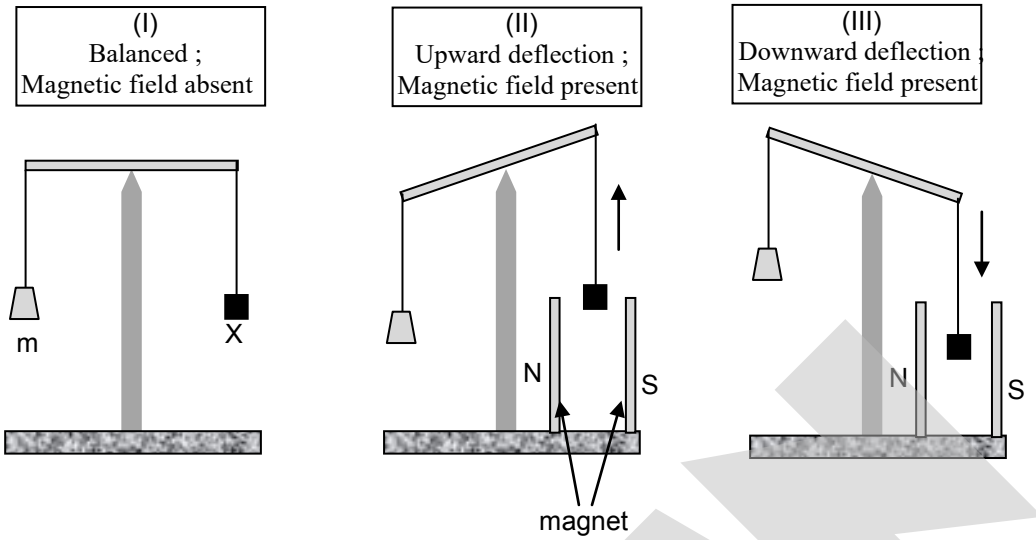


SECTION 2 (Maximum Marks : 24)

- This section contains **SIX (06)** questions.
- Each question has **FOUR** options. **ONE OR MORE THAN ONE** of these four option(s) is (are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated according to the following marking scheme :

Full Marks	: +4	If only (all) the correct option(s) is(are) chosen;
Partial Marks	: +3	If all the four options are correct but ONLY three options are chosen;
Partial Marks	: +2	If three or more options are correct but ONLY two options are chosen, both of which are correct;
Partial Marks	: +1	If two or more options are correct but ONLY one option is chosen and it is a correct option;
Zero Marks	: 0	If none of the options is chosen (i.e. the question is unanswered);
Negative Marks	: –2	In all other cases.

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.

Ans. A,B,C

Sol. **Paramagnetic compound (X)** are attracted towards magnetic field and the pan is deflected downwards.

While the **Diamagnetic compound (X)** are repelled by magnetic field and pan is deflected upward.

(A) $X \Rightarrow H_2O \rightarrow$ **Diamagnetic** (correct)

(B) $X \Rightarrow K_4[Fe(CN)_6](s) \rightarrow$ **Diamagnetic** (correct)

Here Fe^{2+} + Strong field ligand $\rightarrow 3d^6 \Rightarrow [t_2g^6, eg^0]$

(C) $X \Rightarrow O_2 \rightarrow$ **Paramagnetic** (correct)

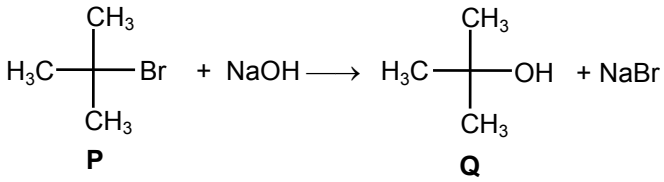
Here $O_2(g)$ is paramagnetic due to two-unpaired electrons present in π^* (antibonding orbitals).

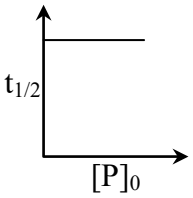
(D) $X \Rightarrow C_6H_6(\ell) \rightarrow$ **Diamagnetic** (Incorrect)

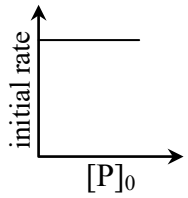
It is due to presence of 0 unpaired electrons.

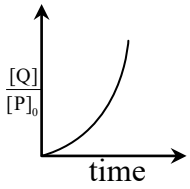
8. Which of the following plots is(are) correct for the given reaction?

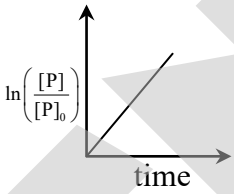
([P]$_0$ is the initial concentration of **P**)



(A) 

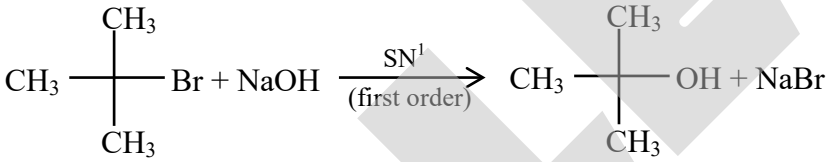
(B) 

(C) 

(D) 

Ans. A

Sol.



t = 0	P_0	0
t	P	$P_0 - P$

rate = k[]

$$\ln \frac{P_0}{P} = kt$$

$$t_{1/2} = \frac{0.693}{k}$$

$$\ln \frac{P}{P_0} = -kt$$

$$\frac{[Q]}{[P]_0} = \frac{[P_0]-[P]}{[P_0]} = 1 - \frac{[P]}{[P_0]} = 1 - e^{-kt}$$

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.

Ans. A,B,C,D

Sol. (A) $2Na[Al(OH)_4]_{(aq.)} + CO_2 \longrightarrow Na_2CO_3 + H_2O + 2Al(OH)_3(\downarrow)$
or
$Al_2O_3.2H_2O$ (ppt)

(B) Function of Na_3AlF_6 is to lower the melting point of electrolyte.

(C) During electrolysis of Al_2O_3, the reactions at anode are :

$$\left[2Al^{3+}(\ell) + 3O^{2-}(\ell) \xrightarrow{\text{At anode}} O_2(\text{gas}) + 2e^-\right]$$

$$C(\text{graphite}) + O_2 \longrightarrow CO(\uparrow) + CO_2(\uparrow)$$

(D) The steel vessel with a lining of carbon acts as cathode.

10. Choose the correct statement(s) among the following.
(A) $SnCl_2.2H_2O$ 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.

Ans. A,B OR A,B,C

Sol. (A) $SnCl_2.2H_2O$ is a reducing agent since Sn^{2+} tends to convert into Sn^{4+}.

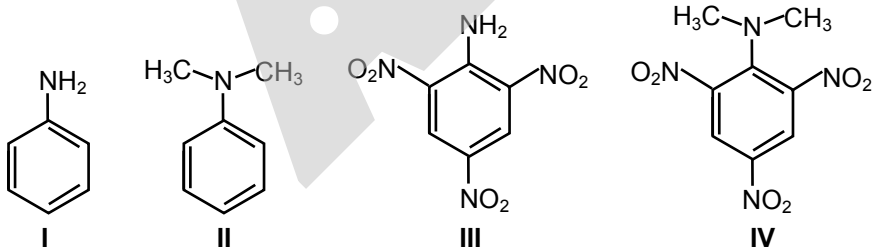
(B) $\underset{\text{(Amphoteric)}}{SnO_2} + 2KOH_{(aq.)} + 2H_2O \longrightarrow K_2[Sn(OH)_6]$
(Base)

(C) First group cations (Pb^{2+}) form insoluble chloride with HCl that is $PbCl_2$ however it is slightly soluble in water and therefore lead +2 ion is never completely precipitated on adding hydrochloric acid in test sample of Pb^{2+}, rest of the Pb^{2+} ions are quantitatively precipitated with H_2S in acidic medium.
So that we can say that filtrate of first group contain solution of $PbCl_2$ in HCl which contains Pb^{2+} and Cl^-
However in the presence of conc. HCl or excess HCl it can produce $H_2[PbCl_4]$
So, we can conclude A, B or A,B,C should be answers.

(D) $\underset{\substack{(2PbO.PbO_2)\\ \text{(mixture of oxides)}}}{Pb_3O_4} + 4HNO_3 \longrightarrow PbO_2(\downarrow) + 2Pb(NO_3)_2 + 2H_2O$

It is not a redox reaction.

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

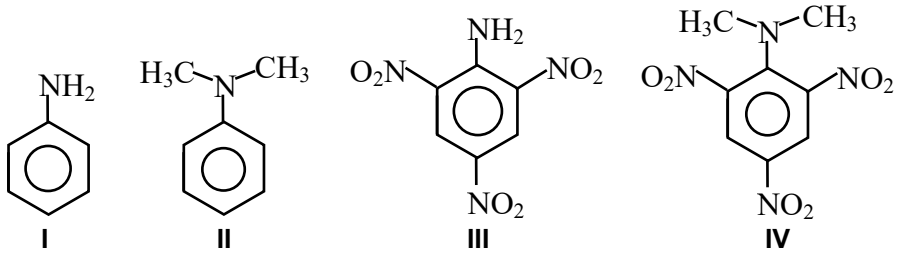


I **II** **III** **IV**

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**.

Ans. C,D

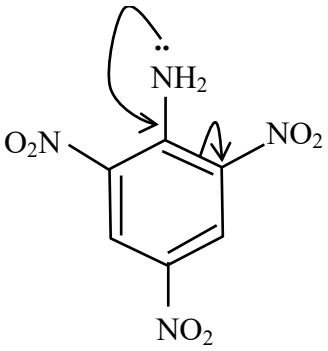
Sol.



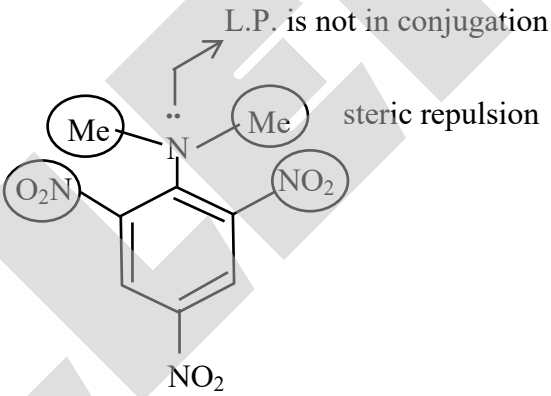
I II III IV

pKb different between I and II is 0.53 and that of III and IV is 4.6.
So option (B) is incorrect
Correct Statement (C), (D)
The most basic compound in the given option is (II) and least basic compound is (III)
In 2,4,6-trinitro aniline (III) due to strong –R effect of $-NO_2$ groups, the ℓ.p. of $-NH_2$ is more involved with benzene ring hence it has least basic strength.

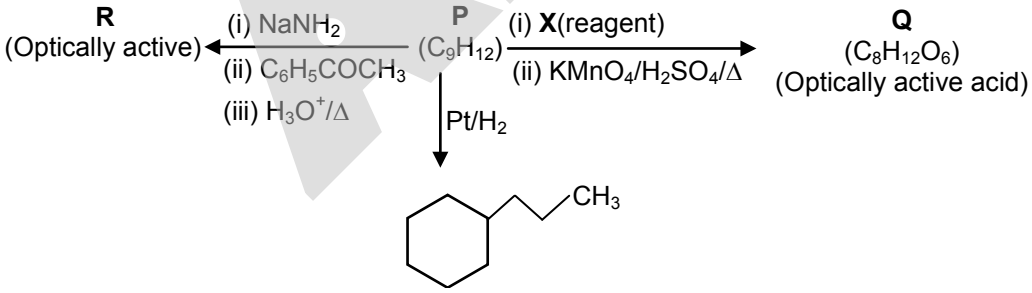
Whereas (IV) N,N-Dimethyl 2,4,6-trinitro aniline, due to steric inhibition to resonance (SIR) effect; the lone pair of nitrogen is not in the plane of benzene, hence make it (ℓ.p.) more free to protonate



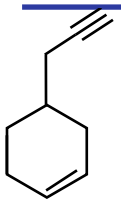
more effective resonance



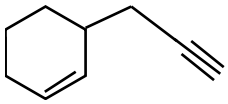
12. Consider the following transformations of a compound **P**.

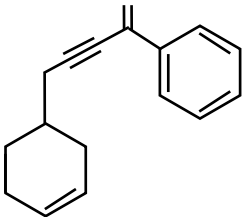


Choose the correct option(s).

(A) **P** is 

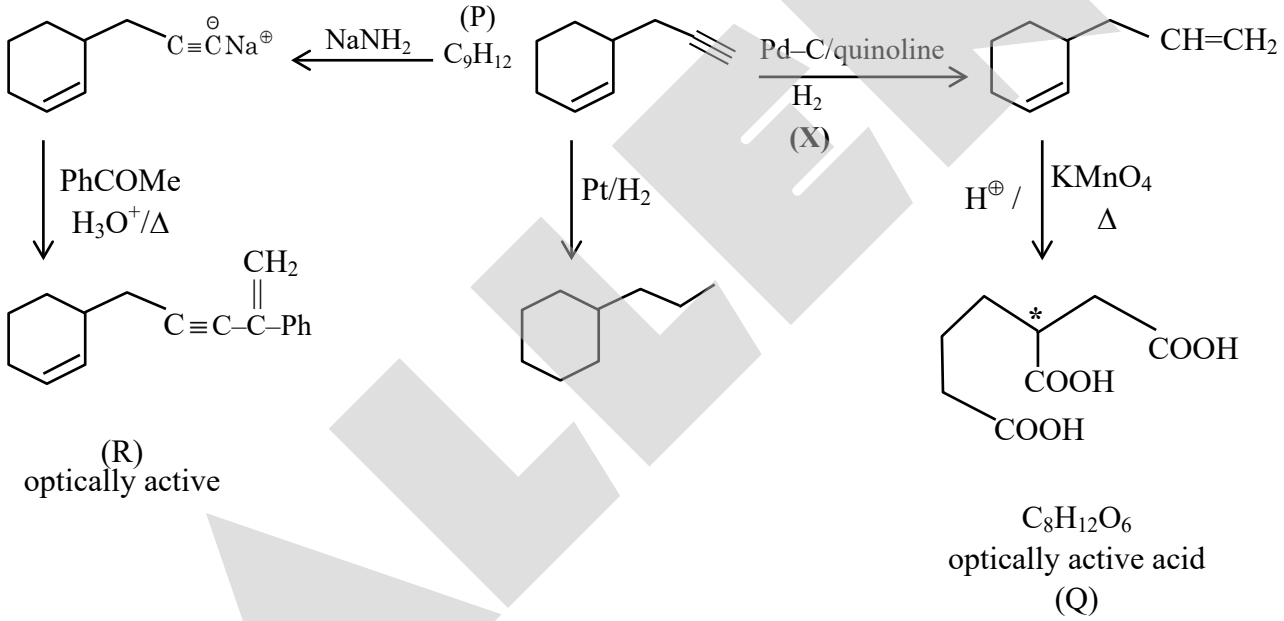
(B) **X** is Pd-C/quinoline/H_2

(C) **P** is 

(D) **R** is 

Ans. B,C

Sol.



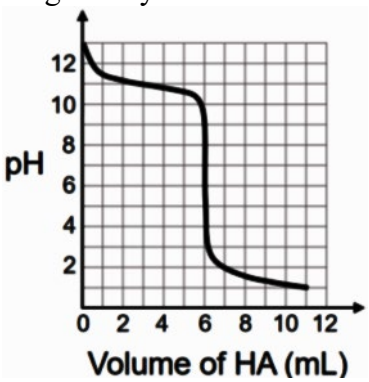
SECTION 3 (Maximum Marks : 24)

- This section contains **SIX (06)** questions. The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated <u>according to the following marking scheme :</u>

  Full Marks : +4 If ONLY the correct numerical value is entered;

  Zero Marks : 0 In all other cases.

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 $B+HA \rightarrow BH^+ + A^-$.



Ans. 2.30 TO 3.00

Sol. $B + HA \longrightarrow BH^+ + A^-$

0.1 M, V ml

0.1 V m mol 0.1V m mol 0.1 V0.1 V

$$[BH^+] = \frac{0.1\ V}{2\ V} = 0.05\ M$$

pH at eq Pt = 500 to 0.2

$$pH = 7 - \frac{1}{2}\ [pK_b + \log 0.05]$$

So $pK_b = 2.30 - 2.80$

Possible

Solution-2

at V = 6 mlrxn is complete

So V = 3 ml is half of eq Pt

at which pH = 11

$pOH = (14 - 11) = pK_b + \log 1$

$pK_b = 3$

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?

Ans. 0.20

Sol. $P_T = P_A^o X_A + P_B^o X_B$

$0.3 = P_A^o \times 0.25 + P_B^o \times 0.75$ …(i)

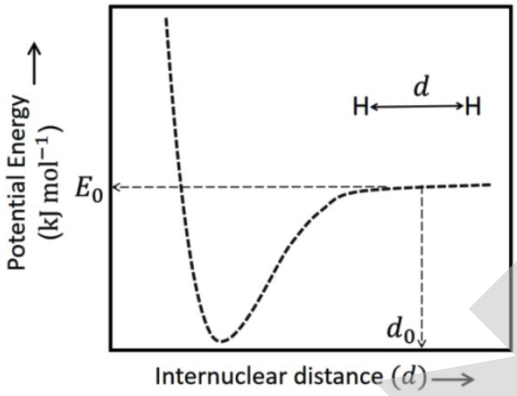
$0.4 = P_A^o \times 0.5 + P_B^o \times 0.5$

$0.8 = P_A^o + P_B^o$ …(ii)

on solving eq^n (i) & (ii)

$P_A^o = 0.6,\quad P_B^o = 0.2$

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}.

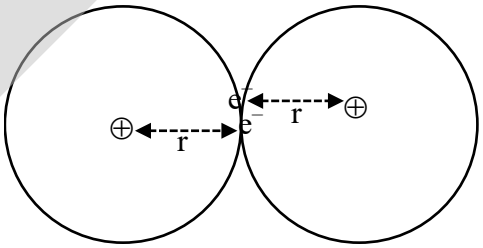


Ans. –5246.49

Sol. At d = d_0, nucleus-nucleus & electron-electron repulsion is absent.

Hence potential energy will be calculated for 2 H atoms. (P.E. due to attraction of proton & electron)

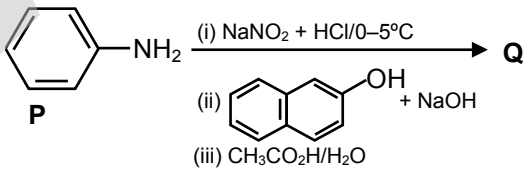
$$\text{P.E.} = \underset{\text{(Bohr radius)}}{\frac{-Kq_1q_2}{r}} = \frac{(9\times10^{9})(1.6\times10^{-19})^2}{0.529\times10^{-10}} = -4.355\times10^{-21}\text{kJ}$$



For 1 mol = $-4.355 \times 10^{-21} \times 6.023 \times 10^{23} = -2623.249$ kJ/mol

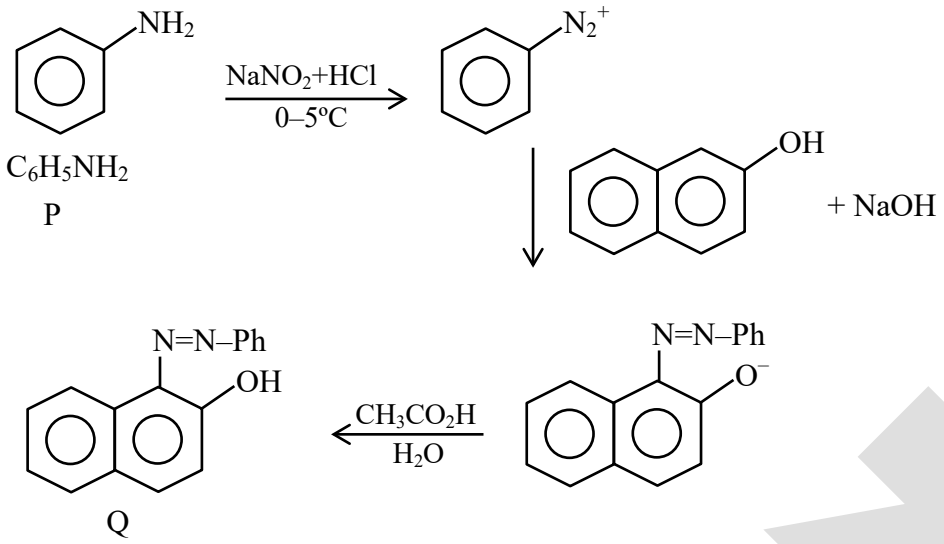
For 2 H atoms = –5246.49 kJ/mol

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})



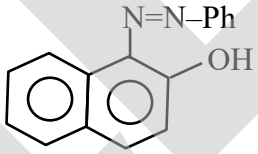
Ans. 18.60

Sol.



Molecular weight of
aniline = M.wt. of C_6NH_7
$= 72 + 7 + 14 = 93$
density of P = 1 gm ml^{-1}
9.3 ml of P = 9.3 gm P

$$= \frac{9.3}{9.3} = 0.1 \text{ mole P}$$

The mole ratio $PhNH_2 : PhN_2^+$: 

$= 1 : 1 : 1$
so the mole of Q formed will be 0.1 mole and extent of reaction is 100% but if it is 75% yield.

Then amount of Q $= 0.1 \times \frac{75}{100} = 0.075$ mol

The molecular formula of Q = $C_{16}H_{12}ON_2$
so M.wt. of Q = $16 \times 12 + 12 \times 1 + 16 + 2 \times 14$
$= 192 + 12 + 16 + 28$
$= 248$ gm
so amount of Q = 248×0.075
$= 18.6$ gm

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 : $\Delta_f H°(SnO_2(s)) = -581.0$ kJ mol^{-1}, $\Delta_f H°(CO_2(g)) = -394.0$ kJ mol^{-1}
$S°(SnO_2(s)) = 56.0$ J K^{-1} mol^{-1}, $S°(Sn(s)) = 52.0$ J K^{-1} mol^{-1} ,
$S°(C(s)) = 6.0$ J K^{-1} mol^{-1} , $S°(CO_2(g)) = 210.0$ J K^{-1} mol^{-1}.

Assume that the enthalpies and the entropies are temperature independent.

Ans. 935.00

Sol. $SnO_{2(S)} + C_{(S)} \longrightarrow Sn_{(S)} + CO_{2(g)}$

$\Delta H°_{rxn} = [-394] - [-581] = 187$ kJ/mole

$\Delta S°_{rxn} = [52 + 210] - [56 + 6]$

$= 200$ J/k–mole

$$T = \frac{\Delta H°}{\Delta S°} = \frac{187 \times 1000}{200} = 935K$$

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) = 1.25×10^{-22} and

Overall dissociation constant of H_2S , $K_{NET} = K_1K_2 = 1 \times 10^{-21}$

Ans. 0.20

Sol. For ppt, $[Zn^{+2}]\,[S^{-2}] = K_{sp}$

$$[S^{-2}] = \frac{1.25 \times 10^{-22}}{0.05}$$

$= 2.5 \times 10^{-21}$ M

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

$$K_{Net} = 10^{-21} = \frac{[H^+]^2 \times 2.5 \times 10^{-21}}{0.1}$$

$$[H^+]^2 = \frac{1}{25}$$

$$[H^+] = \frac{1}{5}M = 0.2\ M$$

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