

## FINAL JEE(Advanced) EXAMINATION - 2020

(Held On Sunday 27<sup>th</sup> 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.

1. The 1<sup>st</sup>, 2<sup>nd</sup> and the 3<sup>rd</sup> 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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$n$	1681	3374	6050
$n + 1$	2081	3952	6122
$n + 2$	496	4562	6910
$n + 3$	738	1451	7733

By observing the values of  $I_1$ ,  $I_2$  &  $I_3$  for atomic number  $(n+2)$ , it is observed that  $I_2 \gg I_1$ . This indicates that number of valence shell electrons is 1 and atomic number  $(n+2)$  should be an alkali metal.

Also for atomic number  $(n+3)$ ,  $I_3 \gg I_2$ .

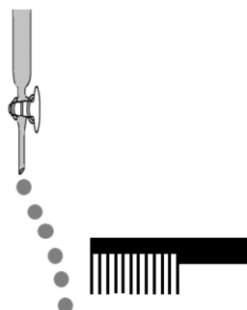
This indicates that it will be an alkaline earth metal which suggests that atomic number  $(n+1)$  should be a noble gas & atomic number  $(n)$  should belong to Halogen family. Since  $n < 10$ ; hence  $n = 9$  (F atom)

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

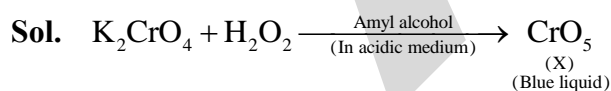
Eq of  $KMnO_4 = Eq$  of  $I_2$

$$4 \times 3 = n \times 2$$

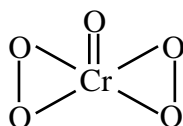
$$n = 6$$

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

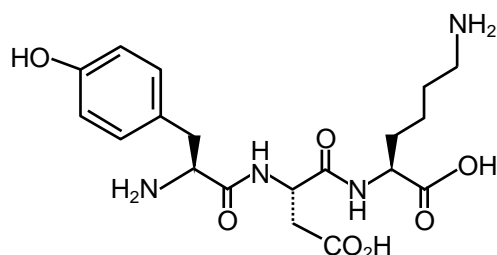


Here the structure of  $CrO_5$  is :-



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

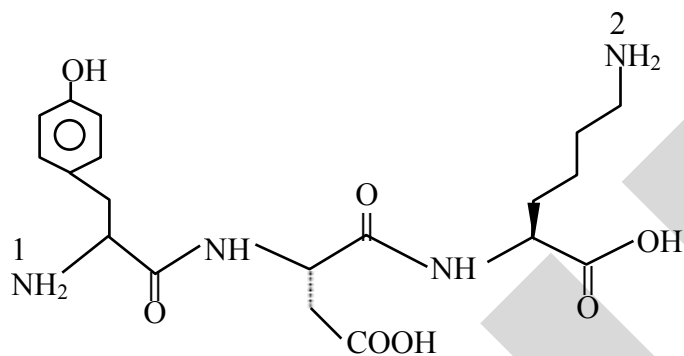
5. The structure of a peptide is given below



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  $\overset{1}{\text{NH}_2}$  and  $\overset{2}{\text{NH}_2}$  of Tyrosine and Lysine is +ve charged (+1 each)

$$+2 |z_1| = 2$$

At pH = 6  $\text{NH}_2$  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)

$$|z_3| = 3$$

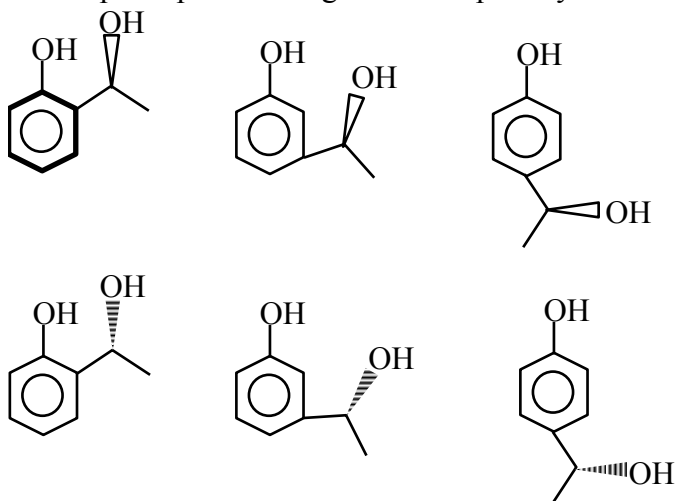
6. An organic compound ( $\text{C}_8\text{H}_{10}\text{O}_2$ ) rotates plane-polarized light. It produces pink color with neutral  $\text{FeCl}_3$  solution. What is the total number of all the possible isomers for this compound?

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;

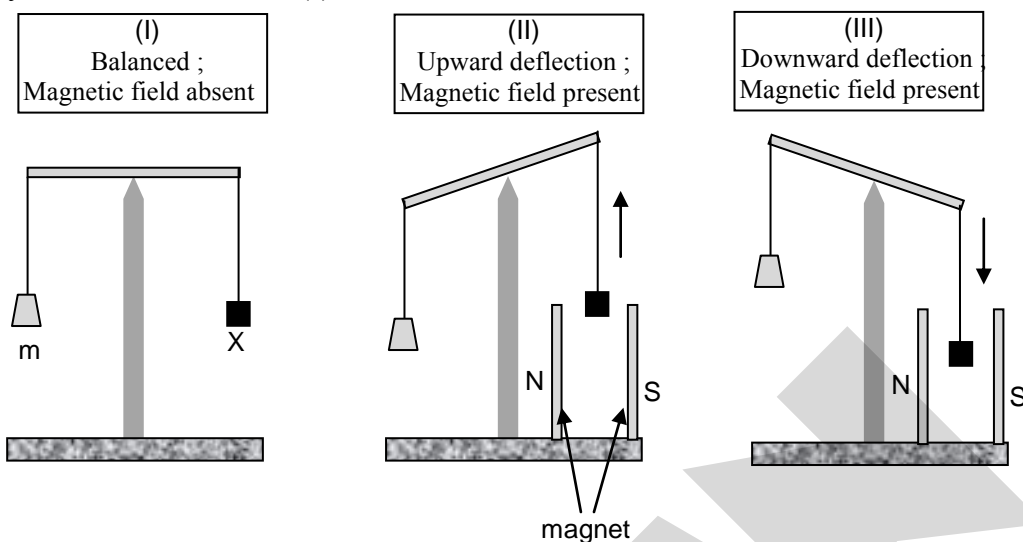
Partial Marks : +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;

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  $\text{H}_2\text{O}(l)$ , deflection of the pan is upwards.  
 (B) If **X** is  $\text{K}_4[\text{Fe}(\text{CN})_6](s)$ , deflection of the pan is upwards.  
 (C) If **X** is  $\text{O}_2(g)$ , deflection of the pan is downwards.  
 (D) If **X** is  $\text{C}_6\text{H}_6(l)$ , 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)  $\text{X} \Rightarrow \text{H}_2\text{O} \rightarrow$  **Diamagnetic** (correct)  
 (B)  $\text{X} \Rightarrow \text{K}_4[\text{Fe}(\text{CN})_6](s) \rightarrow$  **Diamagnetic** (correct)  
 Here  $\text{Fe}^{2+} + \text{Strong field ligand} \rightarrow 3d^6 \Rightarrow [t_2g^6, e_g^0]$   
 (C)  $\text{X} \Rightarrow \text{O}_2 \rightarrow$  **Paramagnetic** (correct)

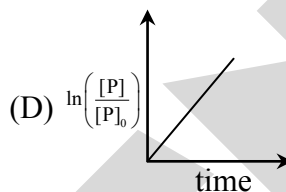
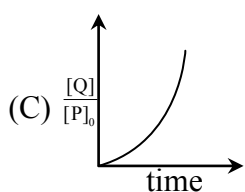
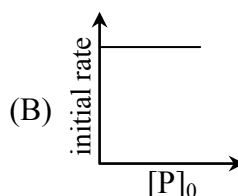
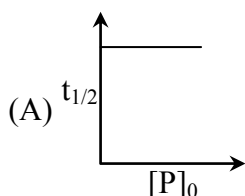
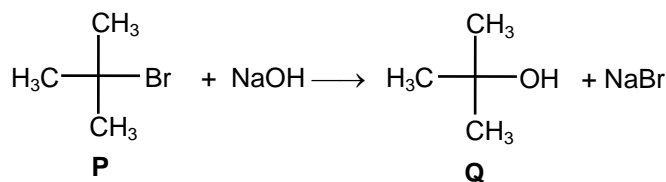
Here  $\text{O}_2(g)$  is paramagnetic due to two-unpaired electrons present in  $\pi^*$  (antibonding orbitals).

- (D)  $\text{X} \Rightarrow \text{C}_6\text{H}_6(l) \rightarrow$  **Diamagnetic** (Incorrect)

It is due to presence of 0 unpaired electrons.

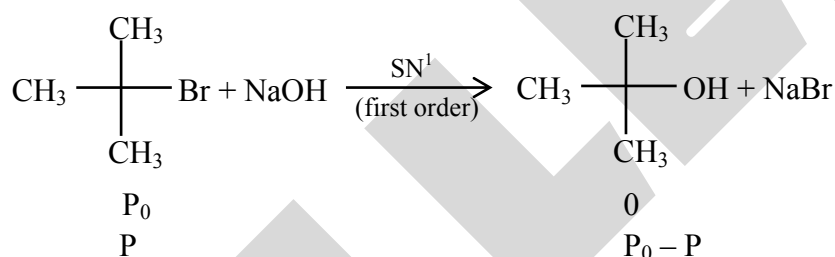
8. Which of the following plots is(are) correct for the given reaction?

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



Ans. A

Sol.



$$\text{rate} = k[\text{P}]$$

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

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

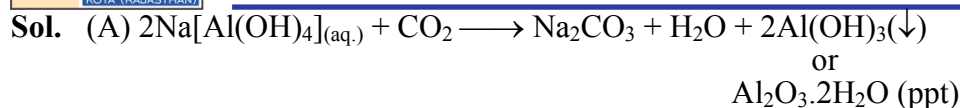
$$\ln \frac{P}{P_0} = -kt$$

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

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

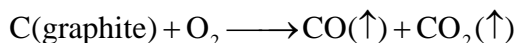
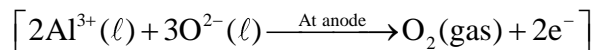
- (A) Hydrated  $\text{Al}_2\text{O}_3$  precipitates, when  $\text{CO}_2$  is bubbled through a solution of sodium aluminate.
- (B) Addition of  $\text{Na}_3\text{AlF}_6$  lowers the melting point of alumina.
- (C)  $\text{CO}_2$  is evolved at the anode during electrolysis.
- (D) The cathode is a steel vessel with a lining of carbon.

Ans. A,B,C,D



(B) Function of  $\text{Na}_3\text{AlF}_6$  is to lower the melting point of electrolyte.

(C) During electrolysis of  $\text{Al}_2\text{O}_3$ , the reactions at anode are :



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

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

(A)  $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$  is a reducing agent.

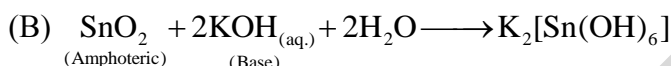
(B)  $\text{SnO}_2$  reacts with  $\text{KOH}$  to form  $\text{K}_2[\text{Sn}(\text{OH})_6]$ .

(C) A solution of  $\text{PbCl}_2$  in  $\text{HCl}$  contains  $\text{Pb}^{2+}$  and  $\text{Cl}^-$  ions.

(D) The reaction of  $\text{Pb}_3\text{O}_4$  with hot dilute nitric acid to give  $\text{PbO}_2$  is a redox reaction.

Ans. A,B

Sol. (A)  $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$  is a reducing agent since  $\text{Sn}^{2+}$  tends to convert into  $\text{Sn}^{4+}$ .

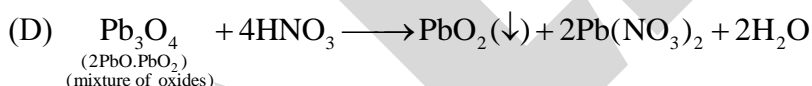


(C) First group cations ( $\text{Pb}^{2+}$ ) form insoluble chloride with  $\text{HCl}$  that is  $\text{PbCl}_2$  however it is slightly soluble in water and therefore lead +2 ion is never completely precipitated on adding hydrochloric acid in test sample of  $\text{Pb}^{2+}$ , rest of the  $\text{Pb}^{2+}$  ions are quantitatively precipitated with  $\text{H}_2\text{S}$  in acidic medium.

So that we can say that filtrate of first group contain solution of  $\text{PbCl}_2$  in  $\text{HCl}$  which contains  $\text{Pb}^{2+}$  and  $\text{Cl}^-$

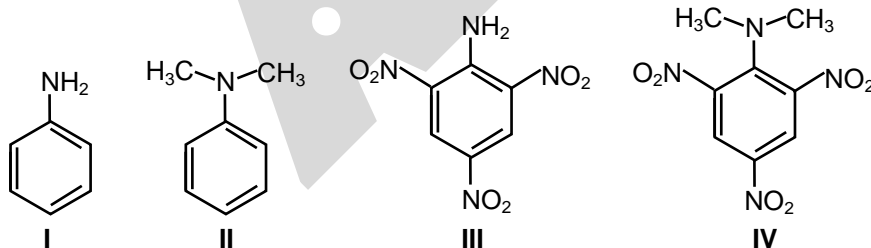
However in the presence of conc.  $\text{HCl}$  or excess  $\text{HCl}$  it can produce  $\text{H}_2[\text{PbCl}_4]$

So, we can conclude A, B or A,B,C should be answers.



It is not a redox reaction.

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



Choose the correct statement(s).

(A) The order of basicity is  $\text{II} > \text{I} > \text{III} > \text{IV}$ .

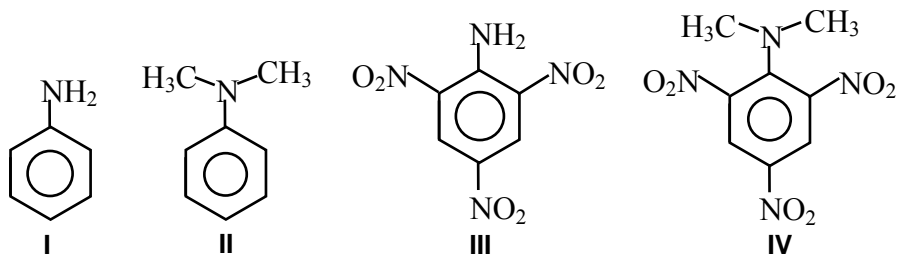
(B) The magnitude of  $\text{p}K_b$  difference between I and II is more than that between III and IV.

(C) Resonance effect is more in III than in IV.

(D) Steric effect makes compound IV more basic than III.

Ans. C,D

Sol.



pK<sub>b</sub> different between I and II is 0.53 and that of III and IV is 4.6.

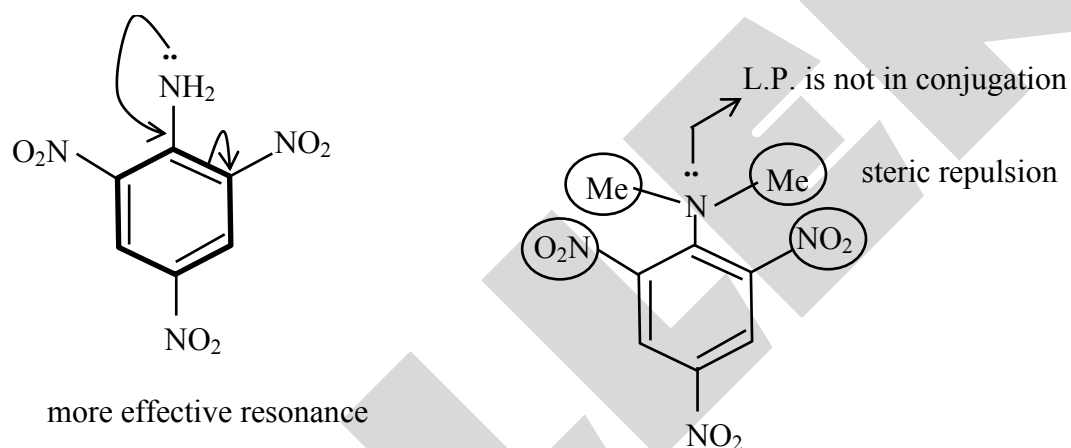
So option (B) is incorrect

Correct Statement (C), (D)

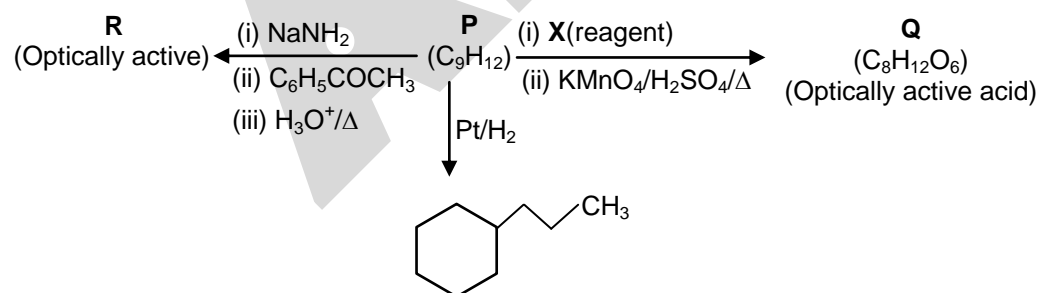
The most basic compound in the given option is (II) and least basic compound is (III)

In 2,4,6-trinitro aniline (III) due to strong -R effect of -NO<sub>2</sub> groups, the l.p. of -NH<sub>2</sub> 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

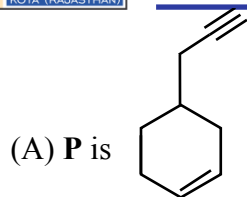


12. Consider the following transformations of a compound **P**.

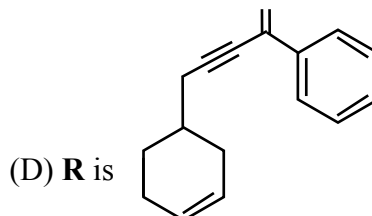
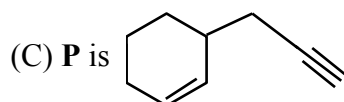


Choose the correct option(s).



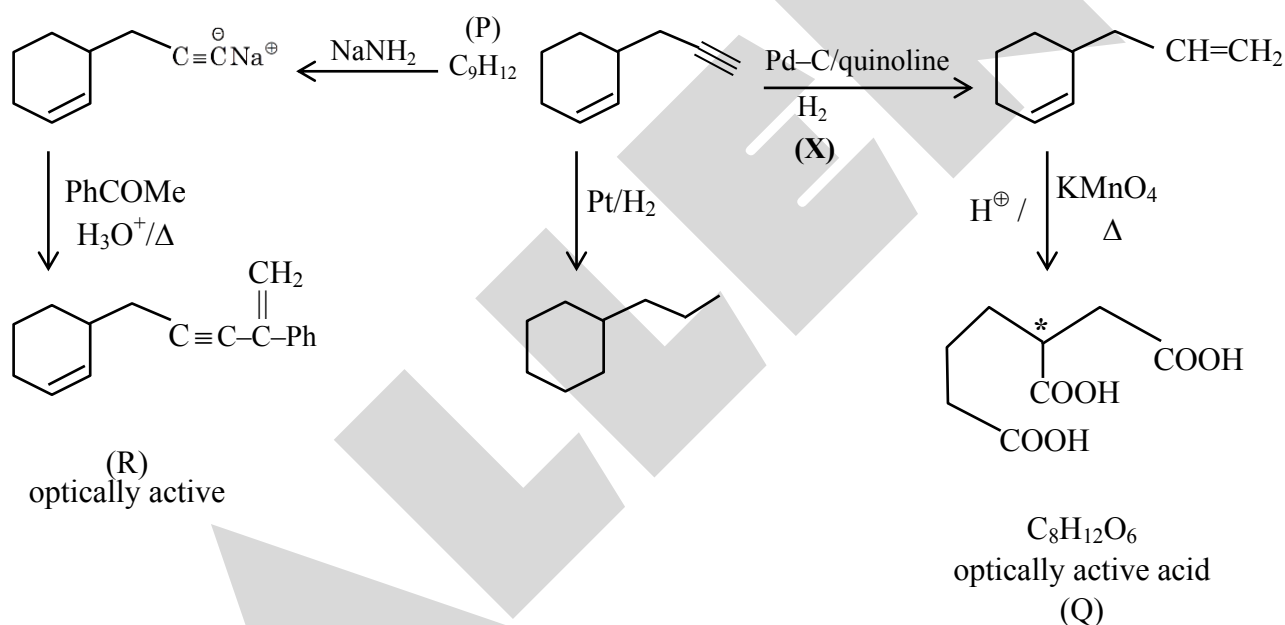


(B) X is Pd-C/quinoline/H<sub>2</sub>



Ans. B,C

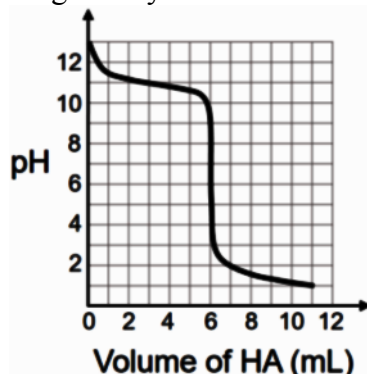
Sol.



### 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 according to the following marking scheme :  
 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. 2.80 TO 3.20



0.1 M, V ml

0.1 V m mol    0.1V m mol    0.1 V 0.1 V

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

pH at eq. pt = 6 to 6.28

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

So  $pK_b = 2.30 - 2.80$

Possible

**Solution-2**

at V = 6 ml    rxn is complete

So V = 3 ml    is half of eq. pt

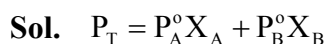
at which    pH = 11

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

$pK_b = 3$

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



$$0.3 = P_A^\circ \times 0.25 + P_B^\circ \times 0.75 \quad \dots(i)$$

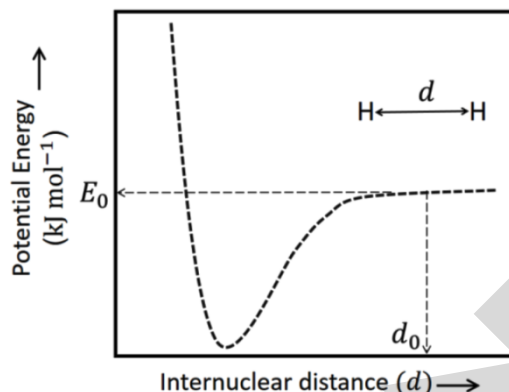
$$0.4 = P_A^\circ \times 0.5 + P_B^\circ \times 0.5$$

$$0.8 = P_A^\circ + P_B^\circ \quad \dots(ii)$$

on solving eq<sup>n</sup> (i) & (ii)

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

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  $\text{kJ mol}^{-1}$ , 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  $6.023 \times 10^{23} \text{ mol}^{-1}$ .



Ans. -2640.00 TO -2620.00 OR -5280.00 TO -5240.00

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

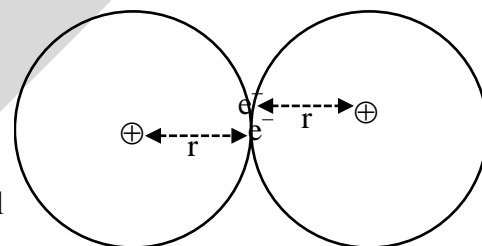
Hence potential energy will be calculated for 2 H atoms. (P.E. due to attraction of proton & electron)

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

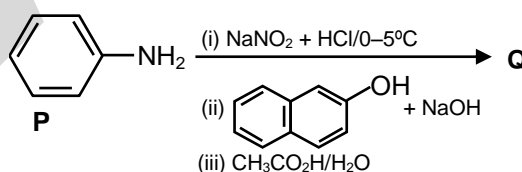
(Bohr radius)

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

$$\text{For 2 H atoms} = -5246.49 \text{ kJ/mol}$$

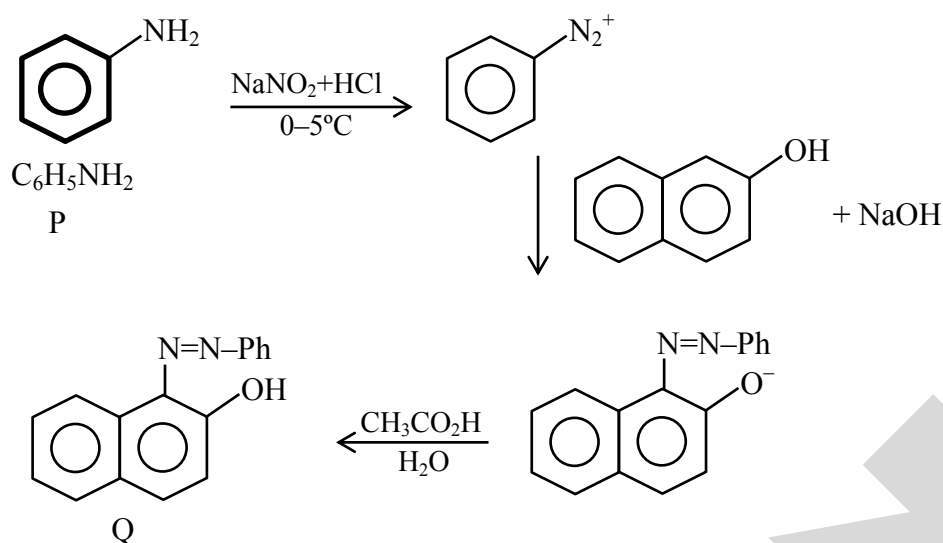


16. Consider the reaction sequence from **P** to **Q** shown below. The overall yield of the major product **Q** from **P** is 75%. What is the amount in grams of **Q** obtained from 9.3 mL of **P**? (Use density of **P** =  $1.00 \text{ g mL}^{-1}$ , Molar mass of C = 12.0, H = 1.0, O = 16.0 and N =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



Ans. 18.60

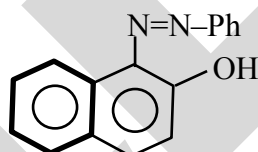
Sol.



Molecular weight of  
 aniline = M.wt. of  $\text{C}_6\text{H}_7\text{N}$   
 $= 72 + 7 + 14 = 93$   
 density of P =  $1 \text{ gm ml}^{-1}$   
 9.3 ml of P = 9.3 gm P

$$= \frac{9.3}{93} = 0.1 \text{ mole P}$$

The mole ratio  $\text{PhNH}_2 : \text{PhN}_2^+ :$



$$= 1 : 1 : 1$$

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

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

The molecular formula of Q =  $\text{C}_{16}\text{H}_{12}\text{ON}_2$   
 so M.wt. of Q =  $16 \times 12 + 12 \times 1 + 16 + 2 \times 14$   
 $= 192 + 12 + 16 + 28$   
 $= 248 \text{ gm}$

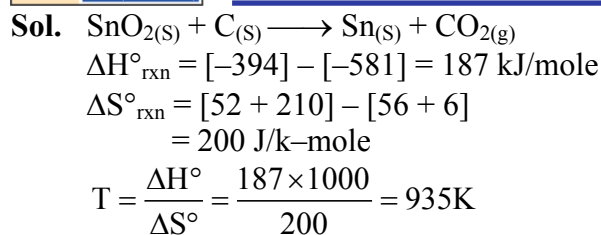
$$\text{so amount of Q} = 248 \times 0.075 = 18.6 \text{ gm}$$

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 :  $\Delta_f H^\circ(\text{SnO}_2(\text{s})) = -581.0 \text{ kJ mol}^{-1}$ ,  $\Delta_f H^\circ(\text{CO}_2(\text{g})) = -394.0 \text{ kJ mol}^{-1}$   
 $S^\circ(\text{SnO}_2(\text{s})) = 56.0 \text{ J K}^{-1} \text{ mol}^{-1}$ ,  $S^\circ(\text{Sn}(\text{s})) = 52.0 \text{ J K}^{-1} \text{ mol}^{-1}$ ,  
 $S^\circ(\text{C}(\text{s})) = 6.0 \text{ J K}^{-1} \text{ mol}^{-1}$ ,  $S^\circ(\text{CO}_2(\text{g})) = 210.0 \text{ J K}^{-1} \text{ mol}^{-1}$ .

Assume that the enthalpies and the entropies are temperature independent.

Ans. 935.00



**18.** An acidified solution of  $0.05 \text{ M Zn}^{2+}$  is saturated with  $0.1 \text{ M H}_2\text{S}$ . What is the minimum molar concentration (M) of  $\text{H}^+$  required to prevent the precipitation of  $\text{ZnS}$  ?

Use  $K_{\text{sp}}(\text{ZnS}) = 1.25 \times 10^{-22}$  and

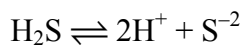
Overall dissociation constant of  $\text{H}_2\text{S}$ ,  $K_{\text{NET}} = K_1 K_2 = 1 \times 10^{-21}$

**Ans. 0.20**

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

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

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



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

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

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