JEE Advanced 2020

Question Paper With Text Solutions

PAPER-2

CHEMISTRY

MATRIX

JEE Main & Advanced | XI-XII Foundation| VI-X Pre-Foundation

Office : Piprali Road, Sikar (Raj.) | Ph. 01572-241911
Website : www.matrixedu.in ; Email : smd@matrixacademy.co.in

JEE ADVANCED SEP 2020 | 27 SEP PAPER-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 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

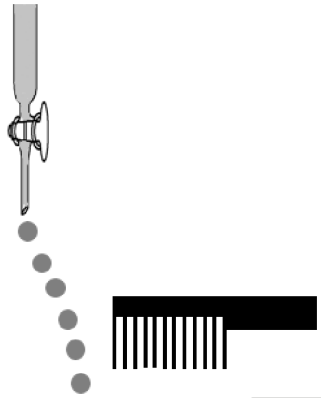
Sol. According to given data element with atomic number (n + 2) is an alkali metal i.e. Na(Z = 11) and atomic number (n + 3) is an alkaline earth metal i.e. Mg (Z = 12). Atomic number (n + 1) is a noble gas i.e. Ne (Z = 10). Hence value of n = 9.

Alkali metal having atomic number n + 2 can not be Li because value of n can not be 1 as H can not have three ionisation enthalpies.

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?



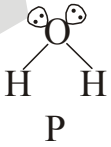
Ans. 6

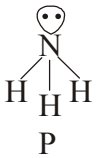
Sol. Only polar molecules will show deflection by charged Comb.

(NP = Non polar, P = Polar)

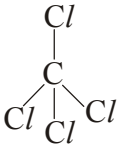

NP

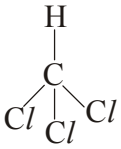

P


P

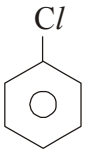

P


P (Open book like structure)


NP


P


NP


P

Total polar molecules = 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. $KMnO_4 + KI \rightarrow I_2 + MnO_2$

equivalents of $KMnO_4$ = equivalents of I_2

$4 \times 3 = x \times 2$

$x = 6$ mole

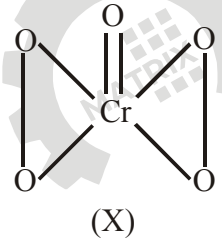
4. An acidified solution of potassium chromate was layered with an equal volume of amyl alcohol. When it was shaken after the addition of 1 mL of 3% H_2O_2, a blue alcohol layer was obtained. The blue color is due to the formation of a chromium (VI) compound 'X'. What is the number of oxygen atoms bonded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

Ans 4

Sol.

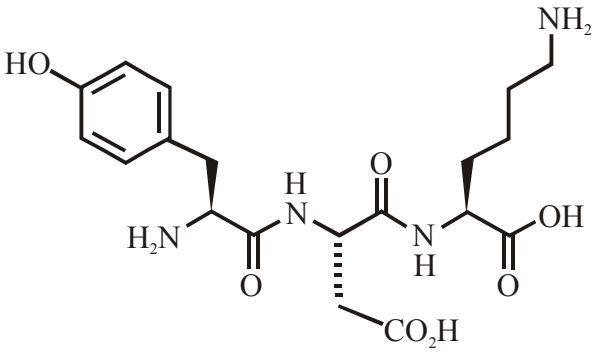
$$K_2CrO_4 \xrightarrow[\text{Amyl alcohol}]{H_2O_2} \underset{\text{(X)}}{CrO_5}$$

Blue colour



(X)

5. The structure of a peptide is given below.



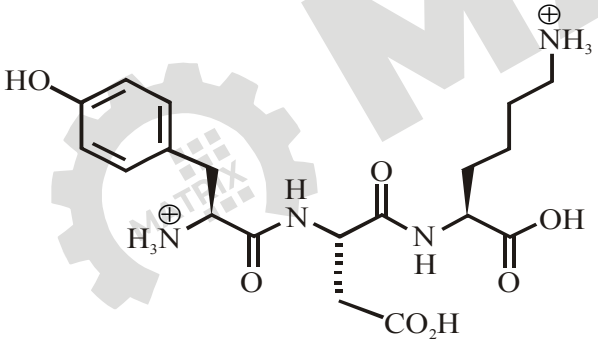
If the absolute values of the net charge of the peptide at pH = 2, pH = 6, and pH = 11 are $|z_1|$, $|z_2|$, and $|z_3|$, respectively, then what is $|z_1| + |z_2| + |z_3|$?

Ans 5

Sol. The amino acids present in peptide given above are Tyrosine, Aspartic acid and Lysine respectively.

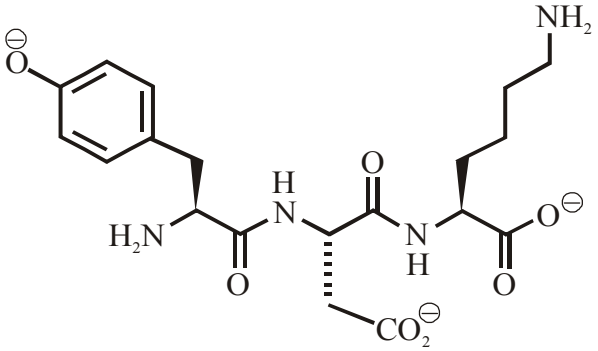
Tyrosine is neutral, Aspartic acid is acidic and Lysine is basic amino acid.

In highly acidic medium amine group gets protonated.



convert $-NH_2$ into $-NH_3^{\oplus}$ $Z_1 = 2$ $|Z_1| = 2$

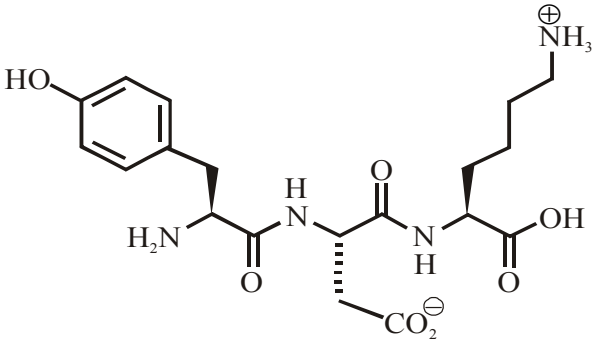
In highly basic medium carboxylic acid and phenolic group gets deprotonated.



convert $-COOH$ into $-COO^{\ominus}$ $Z_3 = -3$ $|Z_3| = 3$

and $-OH$ into $-O^{\ominus}$

at pH = 6 Aspartic acid loses H^+ from –COOH group and Lysine gains H^+ and zwitter ion form exist so total charge will be zero.



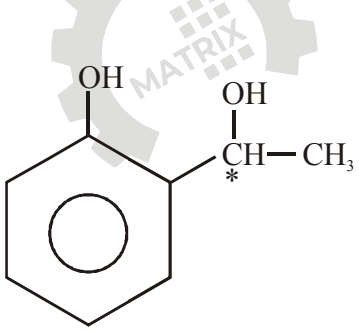
$|Z_2| = 0$

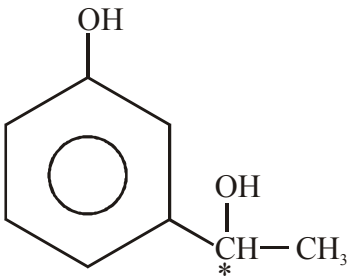
$|z_1| + |z_2| + |z_3| = 5$

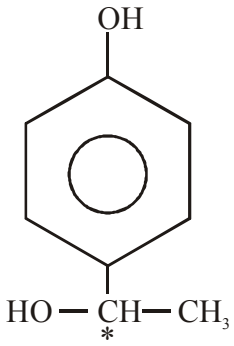
6. An organic compound ($C_8H_{10}O_2$) rotates plane-polarized light. It produces pink color with neutral $FeCl_3$ solution. What is the total number of all the possible isomers for this compound?

Ans 6

Sol. It gives pink colour with neutral $FeCl_3$ because it has phenolic group in its structure and it will be aromatic in nature.







Every isomer has one chiral carbon in its structure therefore every structure has two optically active isomers which can rotate plane–polarized light. So total number of isomers will be six.

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 and both of which are correct.

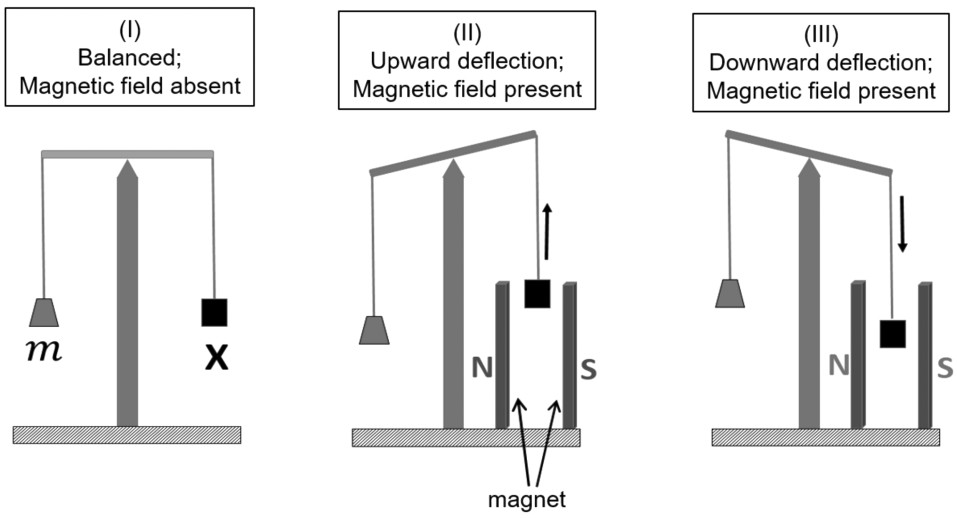
Partial Marks : +1 If two or more options are correct but ONLY one option is chosen and it is a correct option.

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.

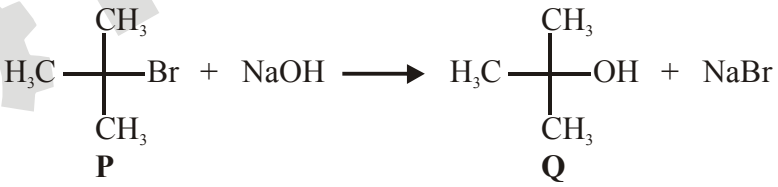
Ans. ABC

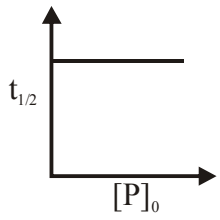
Sol. Diamagnetic compounds deflected upwards (as figure II) and paramagnetic compounds deflected down wards (as figure III)

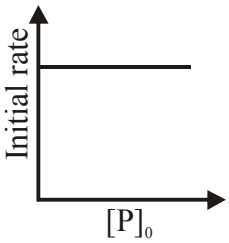
Molecules	Magnetic nature	Deflection
(A) $H_2O(l)$	Diamagnetic	Upwards
(B) $K_4[Fe(CN)_6]_{(s)}$	Diamagnetic	Upwards
(C) $O_2(g)$	Paramagnetic	Down wards
(D) $C_6H_6(l)$	Diamagnetic	Upwards

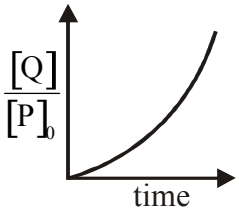
8. Which of the following plots is(are) correct for the given reaction?

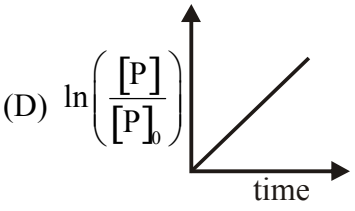
($[P]_0$ is the initial concentration of **P**)



(A) 

(B) 

(C) 

(D) 

Ans A

Sol. Since P is a 3° alkyl halide above nucleophilic substitution reaction is a S_N1 reaction which is a first order reaction.

(A) for a first order reaction

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

Hence (A) is correct

(B) $r = k[P_0]$, Hence B is incorrect

(C) $[Q] = P_0 - P_t$

$$\frac{[Q]}{P_0} = \frac{P_0 - P_0 e^{-kt}}{P_0} = 1 - e^{-kt}$$ hence C is incorrect

(D) $\ln \frac{P_0}{[P]} = kt \Rightarrow \ln \frac{P}{P_0} = -kt$ hence D is incorrect.

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. ABCD

Sol. (A) $NaAlO_2 \xrightarrow[\text{Water}]{CO_2} Al(OH)_3\downarrow + Na_2CO_3$

Sodium aluminate White PPT

(B) Cryolite (Na_3AlF_6) lowers the melting point of alumima (Al_2O_3).

(C) At anode

$C + O_2 \longrightarrow CO/CO_2$

Carbon monoxide and carbon dioxide both gases are evolved at anode.

(D) Iron (or) steel cathode with carbon lining and carbon (or) graphite anode are used in case of electrolytic reduction of alumima.

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

(A) $SnCl_2.H_2O$ 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. AB

Sol. (A) Divalent compounds of tin act as strong reducing agent

(B) SnO_2 being amphoteric react with base.

$$SnO_2 + 2KOH + 2H_2O \longrightarrow K_2[Sn(OH)_6]$$

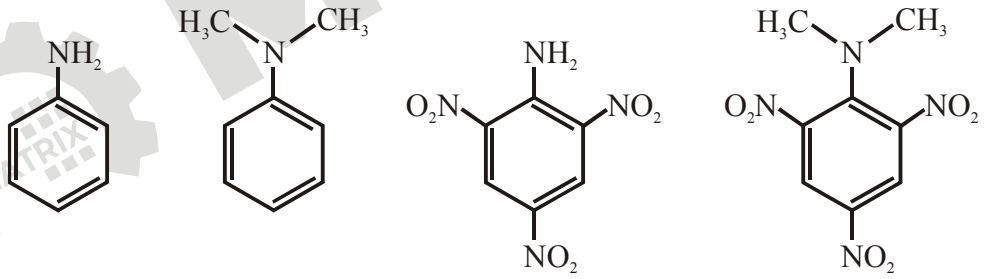
(C) White ppt of $PbCl_2$ is soluble in conc HCl

$$PbCl_2 + 2HCl \longrightarrow 2H^+ + [PbCl_4]^{2-}$$

(D) $Pb_3O_4 + 4HNO_3 \xrightarrow[\text{Reaction}]{\text{Non Redox}} 2Pb(NO_3)_2 + PbO_2\downarrow + 6H_2O$

$(2PbO + PbO_2)$ Dark Brown

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 CD

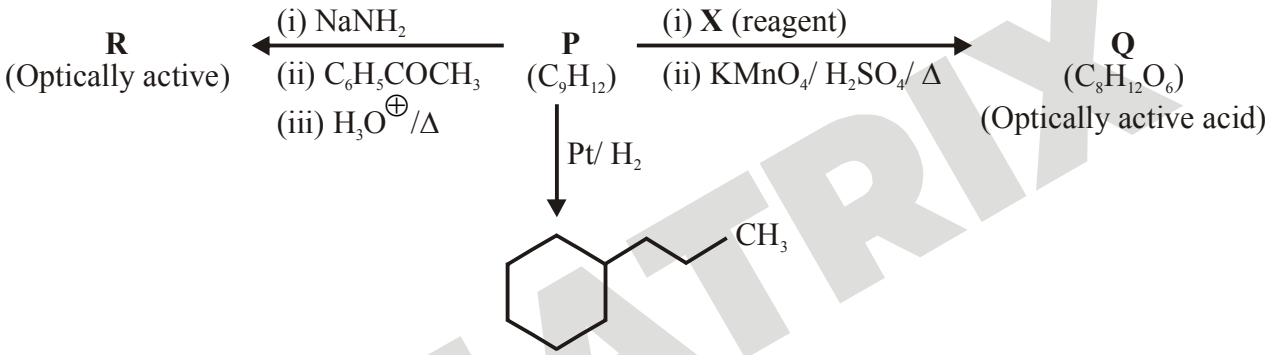
Sol. The correct order of basicity is **IV > II > I > III.**

Difference of pK_b between **I** and **II** is only due to +I of CH_3 group and between **III** and **IV** is due to resonance therefore the difference of pK_b between **I** and **II** won't be much compared to **III** and **IV**.

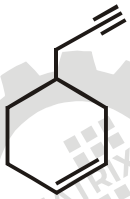
IV has steric inhibition of resonance (SIR) effect which makes it most basic where as in **III** –R effect of $-NO_2$ makes it least basic and it is 4×10^4 times less basic then **IV**.

Resonance effect is observed in **III** which is not in **IV** due to SIR effect.

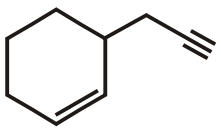
12. Consider the following transformations of a compound **P**.

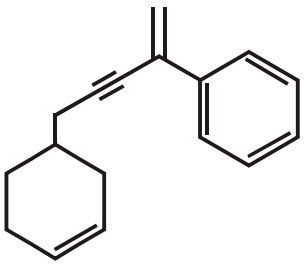


Choose the correct option(s).

(A) **P** is 

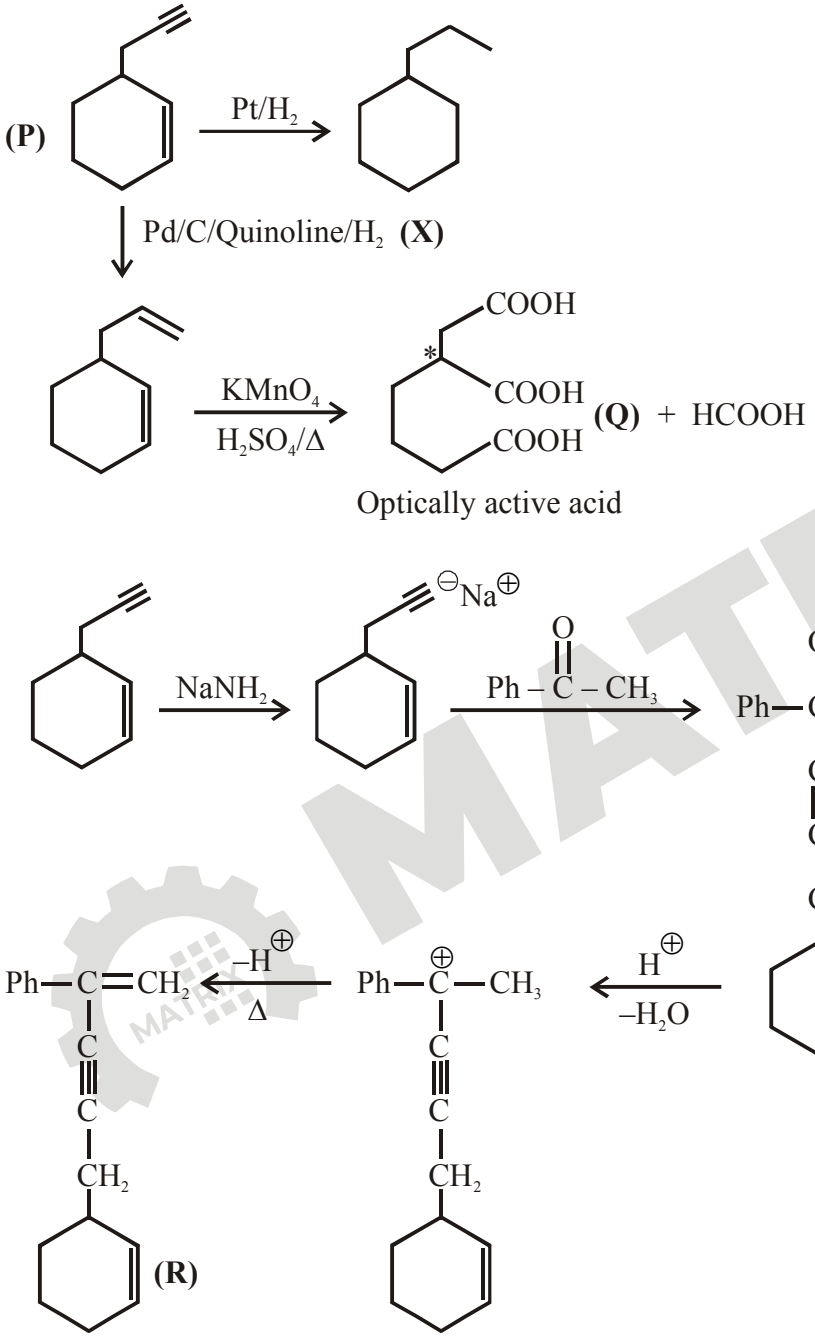
(B) **X** is Pd-C/quinoline/H_2

(C) **P** is 

(D) **R** is 

Ans BC

S.


(P)
Pt/H2
Pd/C/Quinoline/H2
(X)
KMnO4
H2SO4/Δ
COOH
COOH
COOH
(Q) + HCOOH
Optically active acid
NaNH2
Na⊕
Ph – C – CH3
O
OH
Ph
CH3
CH2
H⊕
–H2O
–H⊕
Δ
(R)

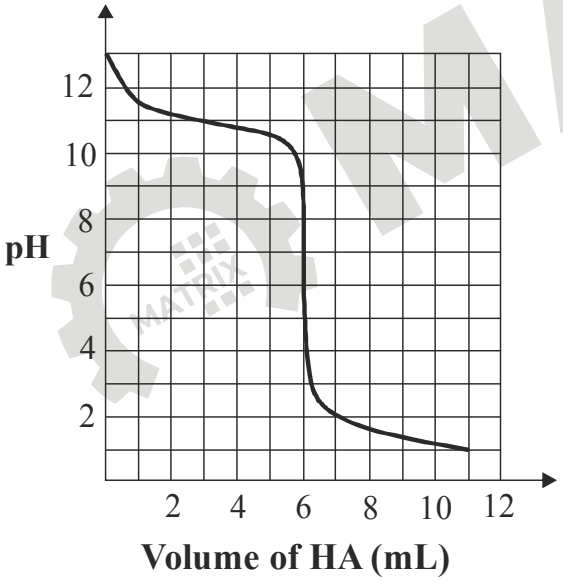
SECTION-3 (Maximum Marks : 24)

* 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 placed.
* 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 3

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

Let the intial volume of B is V mL

from the given graph, volume of HA added till the equivalence point = 6 mL

Hence, $0.1 \times V = 0.1 \times 6 \Rightarrow V = 6$ mL

$p^H = 11$ when volume of HA added is 3 mL, hence

$$B + HA \rightleftharpoons BH^+ + A^-$$

0.1×6	0.1×3		
0.3	0	0.3	0.3

$$p^{OH} = pk_b + \log \frac{0.3}{0.3}$$

$$3 = pk_b$$

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 0.2

Sol. P_A^0 = vapour pressuse of pure liquid A

P_B^0 = vapour pressuse of pure liquid B

For Solution - 1

$P_T = 0.3$ $X_A = 0.25$ $X_B = 0.75$

$P_T = P_A^0 X_A + P_B^0 X_B$

$0.3 = P_A^0(0.25) + P_B^0(0.75)$ .....(i)

For Solution - 2

$P_T = 0.4$ $X_A = 0.50$ $X_B = 0.50$

$P_T = 0.4 = P_A^0(0.50) + P_B^0(0.50)$

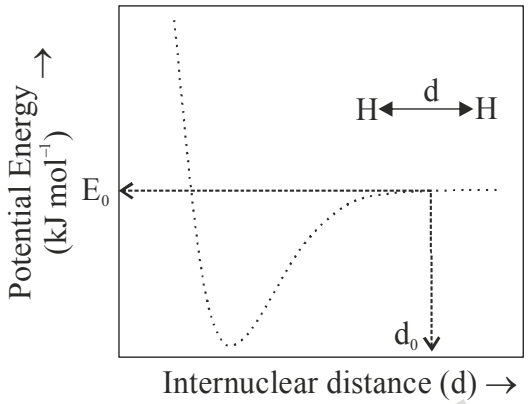
$0.4 = P_A^0(0.50) + P_B^0(0.50)$ .....(ii)

From equation (i) and equation (ii)

$P_B^0 = 0.2$

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 – 5246.48

Sol. At $d = d_0$ only two hydrogen atoms are present and electron-electon repulsion and nucleas-nucleas repulsion energies are absent.

Hence potential energy of system is only due to 2 hydrogen atoms

Potential energy of hydrogen atom in ground state = $- -\frac{kq_1q_2}{r}$

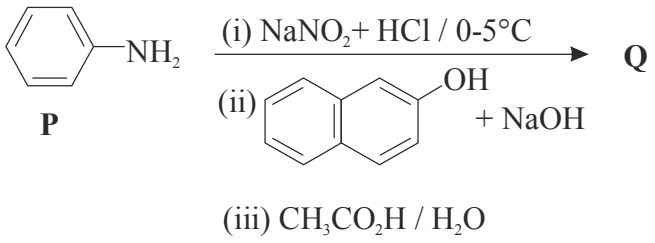
Potential energy of 2 H–atom = $-\frac{2kq_1q_2}{r}$

So $E_0 = \frac{-2kq_1q_2}{r} \times N_A$

$= \frac{-2 \times (9 \times 10^9)(1.6 \times 10^{-19})^2}{0.529 \times 10^{-10}} \times 6.02 \times 10^{23}$

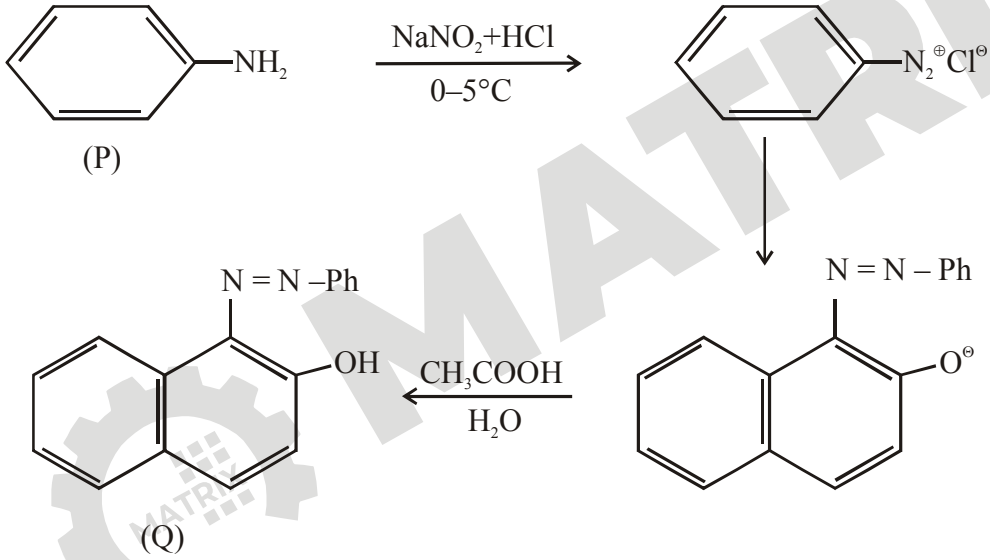
= – 5246.48 kJ/mole

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. 18.6

S.



Molar mass of P (C_6H_7N) is = 93

Since density is 1 g/ml

$\therefore$ Mass of P used is 9.3 g.

Moles of P = 0.1

Since stoichiometry of P : Q is 1 : 1 then moles of Q produced are 0.1.

Mass of Q ($C_{16}H_{12}N_2O$) = 0.1 × Molar mass × Yield

$$= 0.1 \times 248 \times \frac{75}{100} = 18.6 \text{ gm}$$

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 : $\Delta_f H^0(SnO_2(s)) = -581.0$ 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.

Ans. 935

Sol. $SnO_2(s) + C(s) \longrightarrow Sn(s) + CO_2(g)$

$\Delta H^0 = \Delta_f H^0(CO_2(g)) - \Delta_f H^0(SnO_2(s))$

$\Delta H^0 = -394 - (-581)$

$\Delta H^0 = 187$ kJ/mole

$\Delta S^0 = S^0(Sn(s)) + S^0(CO_2(g)) - (S^0(SnO_2(s)) + S^0(C(s)))$

$\Delta S = 52 + 210 - (56 + 6)$

$= 262 - 62$

$= 200$

For the reaction to be spontaneous

$\Delta G^0 = \Delta H^0 - T\Delta S^0 < 0$

$T < 935$ K

So minimum temperature is 935 K.

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, $K_{NET} = K_1K_2 = 1 \times 10^{-21}$.

Ans 0.2

Sol. $ZnS(S) \rightleftharpoons Zn^{2+}(aq.) + S^{2-}(aq.)$

To prevent precipitation of ZnS

$\left[Zn^{2+}\right]\left[S^{2-}\right] < K_{sp}$

$\left[0.05\right]\left[S^{2-}\right] < 1.25\times10^{-22}$

$S^{2-} < 25\times10^{-22}$

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

$$1\times10^{-21}=\frac{\left[H^+\right]^2\left[S^{2-}\right]}{\left[H_2S\right]}$$

$$10^{-21}=\frac{\left[H^+\right]^2\left(25\times10^{-22}\right)}{0.1}$$

$$\left[H^+\right]=0.2$$