JEE Advanced 2020

Question Paper With Text Solutions

PAPER-1

CHEMISTRY

MATRIX

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

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JEE ADVANCED SEP 2020 | 27 SEP PAPER-1

CHEMISTRY

SECTION-1 (Maximum Marks : 18)

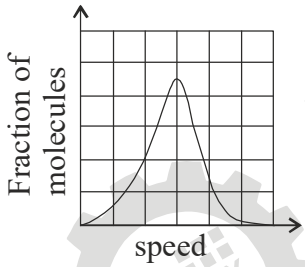
* This section contains **SIX (06)** questions.
* Each question has **FOUR** options **ONLY ONE** of these four options is the correct answer.
* For each question, choose the correct option corresponding to the correct answer.
* Answer to each question will be evaluated according to the following marking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

Full Marks : +3 If ONLY the correct option is chosen.

Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered).

Negative Marks : –1 In all other cases.

1. If the distribution of molecular speeds of a gas is as per the figure shown below, then the ratio of the most probable, the average, and the root mean square speeds, respectively, is



(A) 1 : 1 : 1

(B) 1 : 1 : 1.224

(C) 1 : 1.128 : 1.124

(D) 1 : 1.128 : 1

Ans. (B)

Sol. From the distribution we can say that most probable speed and average speed are equal because distribution is symmetrical and root mean square speed is always greater than average speed.

2. Which of the following liberates O_2 upon hydrolysis ?

(A) Pb_3O_4

(B) KO_2

(C) Na_2O_2

(D) Li_2O_2

Ans. (B)

S. Super oxide liberates O_2 gas on hydrolysis.

* $2KO_2 + 2H_2O \longrightarrow 2KOH + H_2O_2 + O_2$

* $Na_2O_2 + 2H_2O \longrightarrow 2NaOH + H_2O_2$

* $Li_2O_2 + 2H_2O \longrightarrow 2LiOH + H_2O_2$

* $Pb_3O_4 + H_2O \longrightarrow$ No reaction at normal condition

$(2PbO + PbO_2)$

3. A colorless aqueous solution contains nitrates of two metals, **X** and **Y**. When it was added to an aqueous solution of **NaC*l***, a white precipitate was formed. This precipitate was found to be partly soluble in hot water to give a residue **P** and a solution **Q**. The residue **P** was soluble in aq. $\mathbf{NH_3}$ and also in excess sodium thiosulfate. The hot solution **Q** gave a yellow precipitate with **KI**. The metals **X** and **Y**, respectively, are

(A) **Ag** and **Pb**

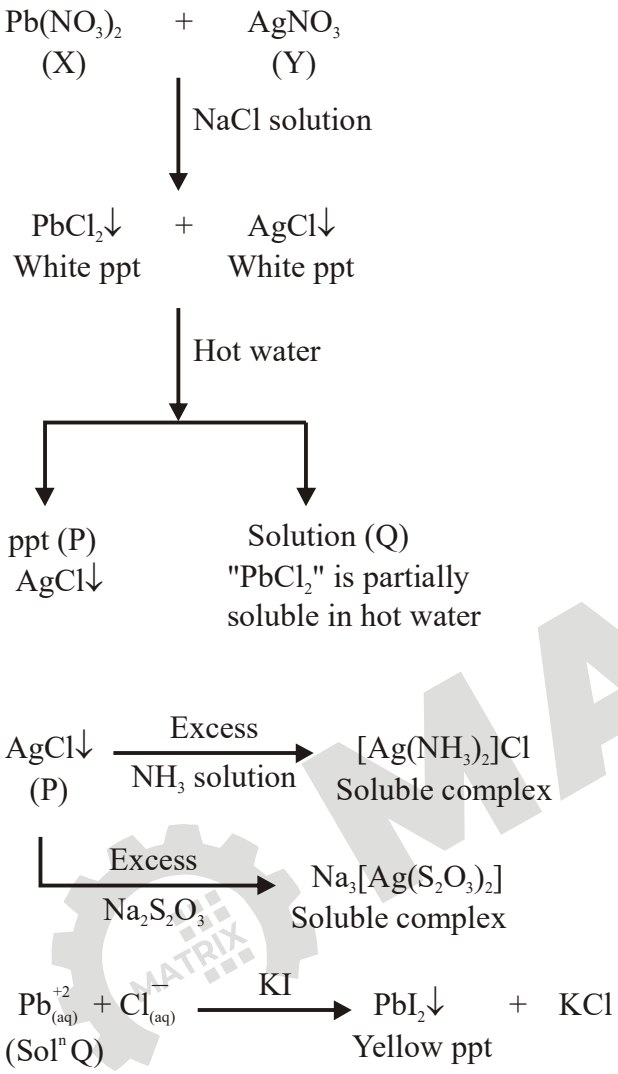
(B) **Ag** and **Cd**

(C) **Cd** and **Pb**

(D) **Cd** and **Zn**

Ans. (A)

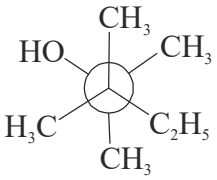
S.


Pb(NO3)2 + AgNO3
(X) (Y)
NaCl solution
PbCl2↓ + AgCl↓
White ppt White ppt
Hot water
ppt (P)
AgCl↓
Solution (Q)
"PbCl2" is partially
soluble in hot water

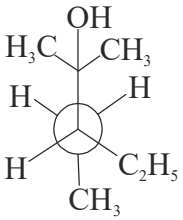
AgCl↓
(P)
Excess
NH3 solution
[Ag(NH3)2]Cl
Soluble complex
Excess
Na2S2O3
Na3[Ag(S2O3)2]
Soluble complex

Pb+2(aq) + Cl−(aq)
(Soln Q)
KI
PbI2↓ + KCl
Yellow ppt

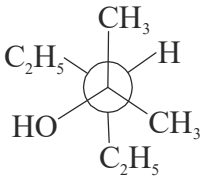
4. Newman projections **P, Q, R** and **S** are shown below :



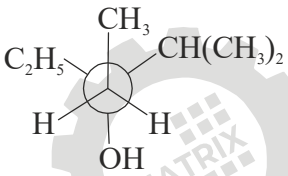
P



Q



R



S

Which one of the folllowing options represents identical molecules ?

(A) **P** and **Q**

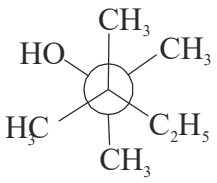
(B) **Q** and **S**

(C) **Q** and **R**

(D) **R** and **S**

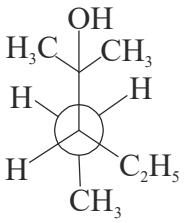
Ans. (C)

Sol.



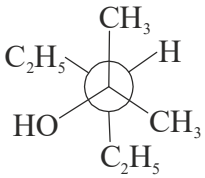
$= H_3C-\underset{C_2H_5}{\overset{CH_3}{C}}-\underset{CH_3}{\overset{OH}{C}}-CH_3$

P



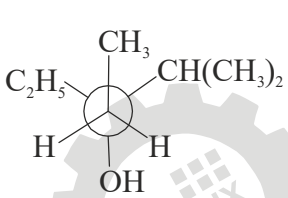
$= H_3C-CH_2-\underset{C_2H_5}{\overset{H}{C}}-\underset{CH_3}{\overset{OH}{C}}-CH_3$

Q



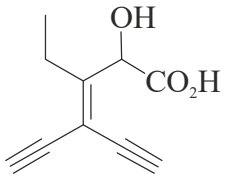
$= H_5C_2-\underset{C_2H_5}{\overset{H}{C}}-\underset{CH_3}{\overset{OH}{C}}-CH_3$

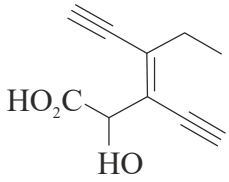
R

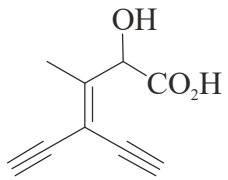


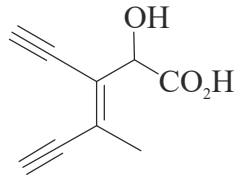
S

5. Which one of the following structures has the IUPAC name 3-ethynyl-2-hydroxy-4-methylhex-3-en-5-ynoic acid ?

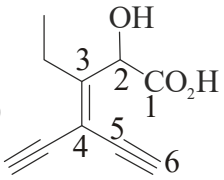
(A) 

(B) 

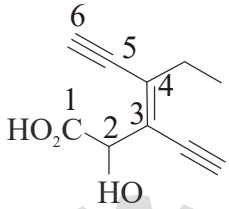
(C) 

(D) 

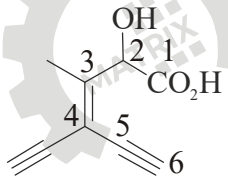
Ans. (D)

Sol. (A) 

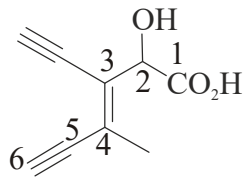
4-Ethynyl-2-hydroxy-3-ethylhex-3-en-5-ynoic acid

(B) 

3-Ethyny1-2-hydroxy-4-ethnylhex-3-en-5-ynoic acid

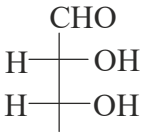
(C) 

4-ethynyl-2-hydroxy-3-methylhex-3-en-5-ynoic acid

(D) 

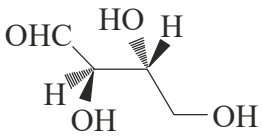
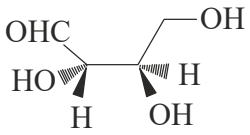
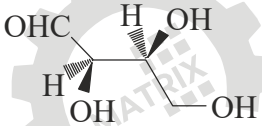
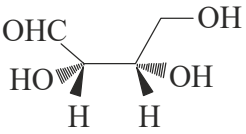
3-ethynyl-2-hydroxy-4-methylhex-3-en-5-ynoic acid

6. The Fischer projection of D-erythrose is shown below.



D-Erythrose

D-Erythrose and its isomers are listed as **P, Q, R,** and **S** in **Column-I**. Choose the correct relationship of **P, Q, R,** and **S** with D-erythrose from **Column II**.

Column-I	**Column-II**
P. 	**1.** Diastereomer
Q. 	**2.** Identical
R. 	**3.** Enantiomer
S. 	

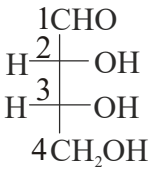
(A) P → 2, Q → 3, R → 2, S → 2

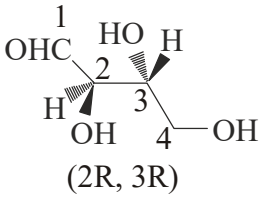
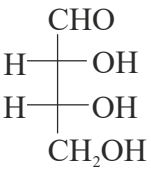
(B) P → 3, Q → 1, R → 1, S → 2

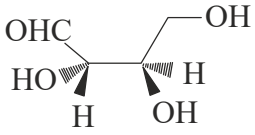
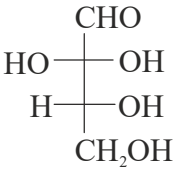
(C) P → 2, Q → 1, R → 1, S → 3

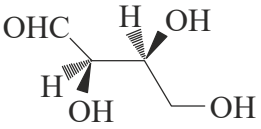
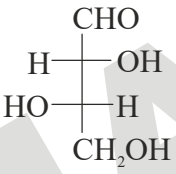
(D) P → 2, Q → 3, R → 3, S → 1

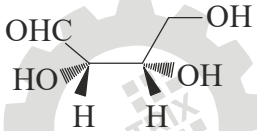
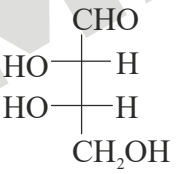
Ans. (C)

Sol.  ⇨ (2R, 3R)

(P) 
(2R, 3R) ⇨ 

(Q) 
(2S, 3R) ⇨ 

(R) 
(2R, 3S) ⇨ 

(S) 
(2S, 3S) ⇨ 

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 thermodynamics, the P–V work done is given by $w = -\int dV\, P_{ext}$.

For a system undergoing a particular process, the work done is, $w = -\int dV \left(\frac{RT}{V-b} - \frac{a}{V^2}\right)$.

This equation is applicable to a

(A) system that satisfies the van der Waals equation of state.

(B) process that is reversible and isothermal.

(C) process that is reversible and adiabatic.

(D) process that is irreversible and at constant pressure.

Ans. (ABC)

Sol. (A) For a vanderwaal gas

$$\left(P + \frac{a}{V_m^2}\right)(V_m - b) = RT$$

$$P = \frac{RT}{V_m - b} - \frac{a}{V_m^2}$$

So $W = -\int dV\left(\frac{RT}{V-b} - \frac{a}{V^2}\right)$ is

applicable to the system that satisfies the Vander waals equation of state.

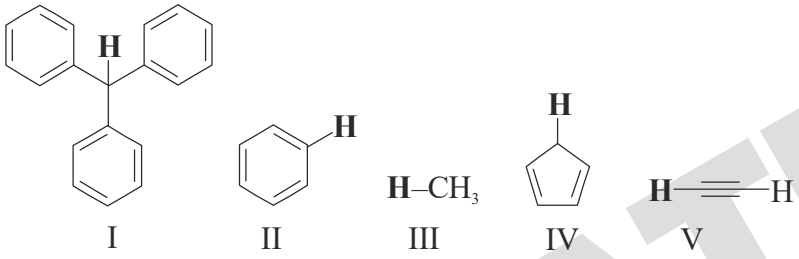
(B) For a reversible process

$P_{ext} = P_{gas}$

and in are irreversible process

$P_{ext} \neq P_{gas}$

8. With respect to the compounds **I-V**, choose the correct statements (s).



I II III IV V

(A) The acidity of compound **I** is due to delocalization in the conjugate base.

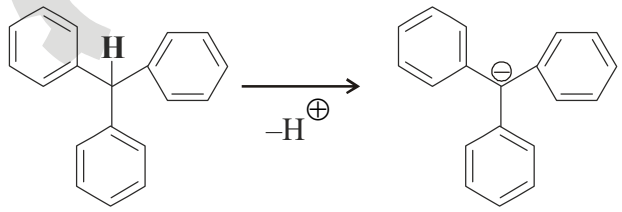
(B) The conjugate base of compound **IV** is aromatic.

(C) Compound **II** becomes more acidic, when it has a $-NO_2$ substituent.

(D) The acidity of compounds follows the order **I > IV > V > II > III.**

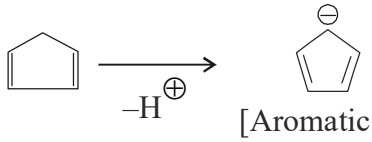
Ans. (ABC)

S. (A)



conjugate base
[stabilised by conjugation]

(B)

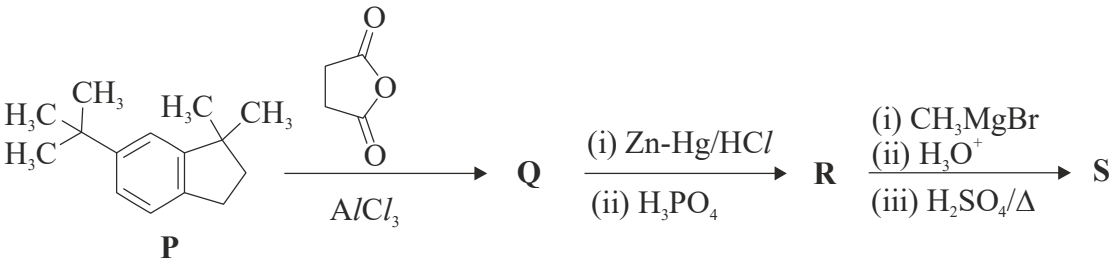


[Aromatic anion]

(C) $-NO_2$ group is electron withdrawing group. It increases acidic strength.

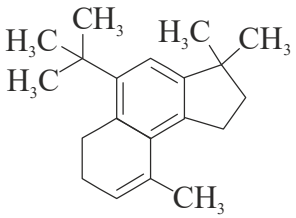
(D) Acidic strength order $\Rightarrow$ IV > V > I > II > III.

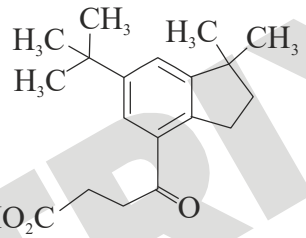
9. The the reaction scheme shown below, **Q, R,** and **S** are the major products.

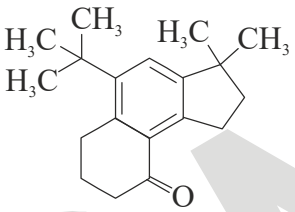


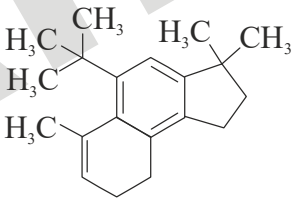
P

The correct structure of

(A) **S** is 

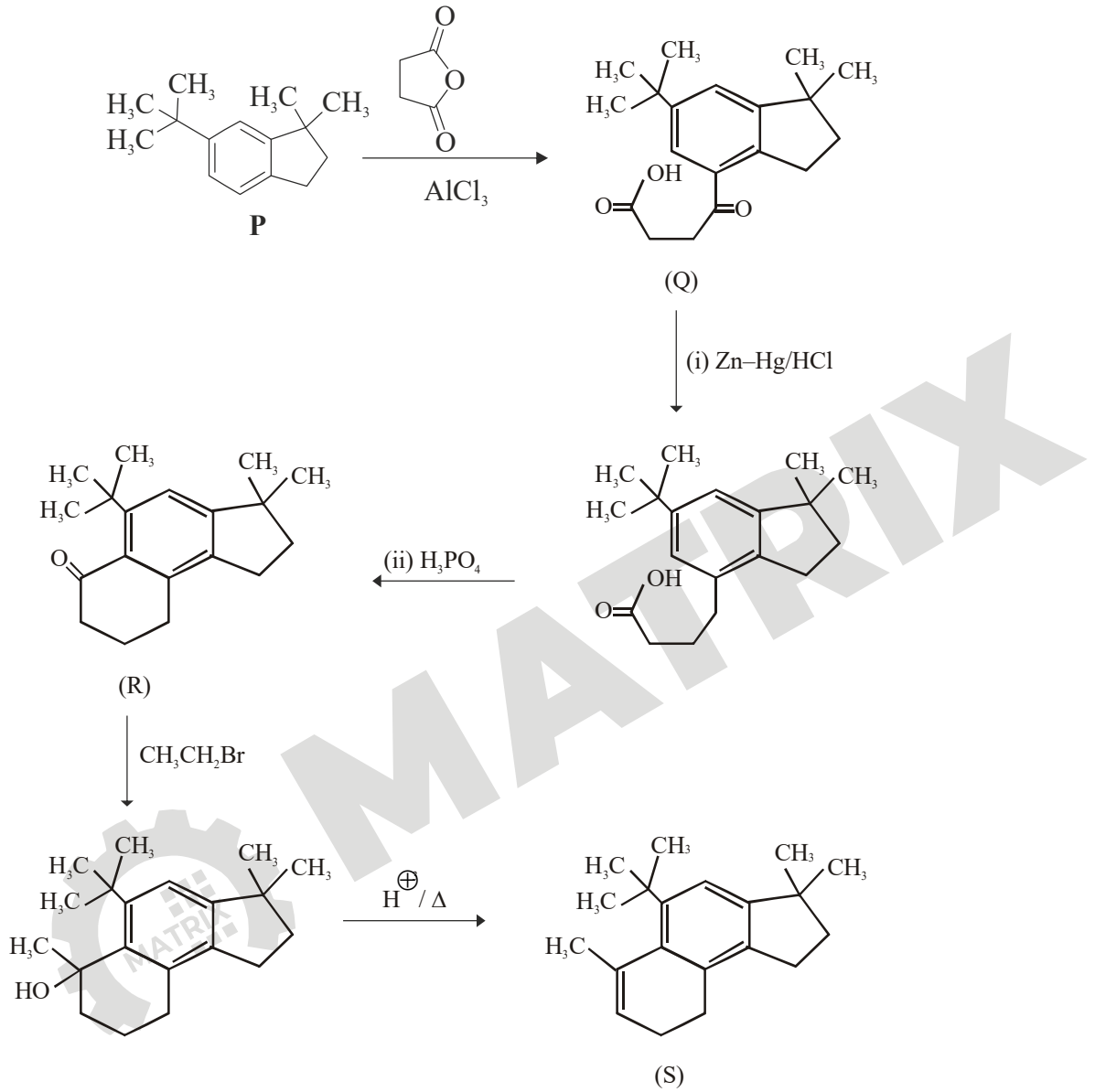
(B) **Q** is 

(C) **R** is 

(D) **S** is 

Ans. (BD)

Sol.



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

(A) $[FeCl_4]^-$ has tetrahedral geometry.

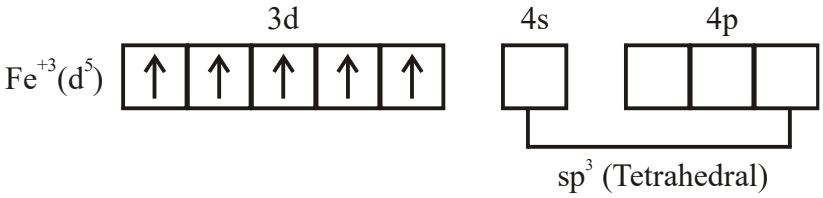
(B) $[Co(en)(NH_3)_2Cl_2]^+$ has 2 geometrical isomers.

(C) $[FeCl_4]^-$ has higher spin-only magnetic moment than $[Co(en)(NH_3)_2Cl_2]^+$.

(D) The cobalt ion in $[Co(en)(NH_3)_2Cl_2]^+$ has sp^3d^2 hybridization.

Ans. (AC)

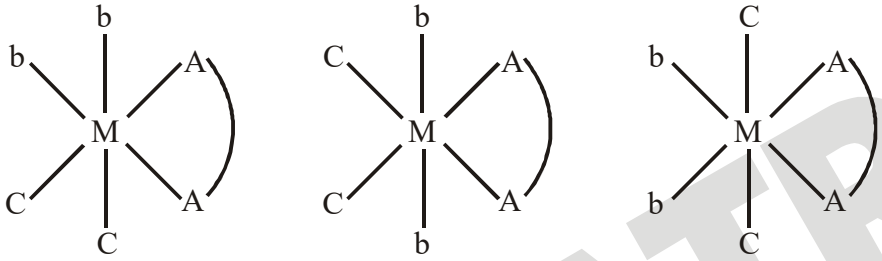
S. (A) $[FeCl_4]^-$



Number of unpaired e^- (n) = 5

$\mu = \sqrt{35}$ BM

(B) $[Co(en)(NH_3)_2Cl_2]^+$ or $\left[M(AA)b_2C_2\right]^{\pm n}$ has three geometrical isomers.



(C) $[FeCl_4]^-$

Number of unpaired e^-

(n) = 5

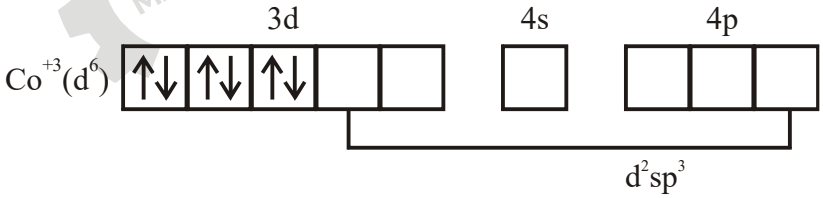
$[Co(en)(NH_3)_2Cl_2]^+$

Number of unpaired e^-

(n) = 0

Spin only magnetic moment : $[FeCl_4]^- > [Co(en(NH_3)_2Cl_2]^+$

(D) $[Co(en)(NH_3)_2Cl_2]^+$ $(\Delta_0 > P)$



11. With respect to hypochlorite, chlorate and perchlorate ions, choose the correct statement(s).

(A) The hypochlorite ion is the strongest conjugate base.

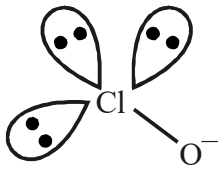
(B) The molecular shape of only chlorate ion is influenced by the lone pair of electrons of C*l*.

(C) The hypochlorite and chlorate ions disproportionate to give rise to identical set of ions.

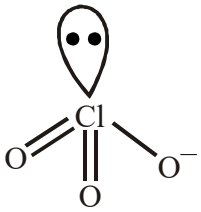
(D) The hypochlorite ion oxidizes the sulfite ion

Ans. (ABD)

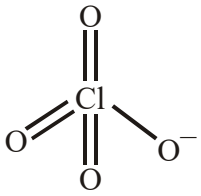
S.



Hypochlorite ion



Chlorate ion

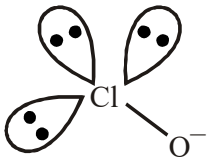
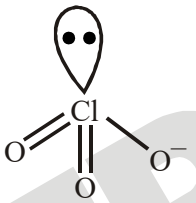
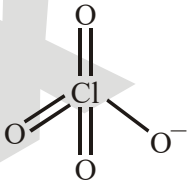


Perchlorate ion

(A) Order of acidic strength :– $HClO < HClO_3 < HClO_4$.

Order of basic strength of conjugate base :– $ClO^- > ClO_3^- > ClO_4^-$.

(B)

Molecular shape effect of ℓ. p.	 linear No effect	 Pyramidal Bond angle decreases	 Regular tetrahedral No effect

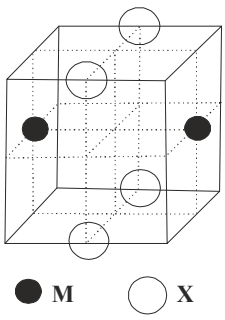
(C) $3ClO^- \xrightarrow[\text{Disproportionation}]{} 2Cl^- + ClO_3^-$

$4ClO_3^- \xrightarrow[\text{Disproportionation}]{} Cl^- + 3ClO_4^-$

(D) Hypochlorite ion act as good oxidizing agent

$SO_3^{2-} + OCl^- \longrightarrow SO_4^{2-} + Cl^-$.

12. The cubic unit cell structure of a compound containing cation M and anion X is shown below. When compared to the anion, the cation has smaller ionic radius. Choose the correct statement(s).



(A) The empirical formula of the compound is MX.

(B) The cation M and anion X have different coordination geometries.

(C) The ratio of M-X bond length to the cubic unit cell edge length is 0.866.

(D) The ratio of the ionic radii of cation M to anion X is 0.414.

Ans. (AC)

Sol. (A) Cation M is present at two face centres and anion X is present at 4 edge centres hence

Empirical formula of compound is

$= M_{2\times\frac{1}{2}} X_{4\times\frac{1}{4}} = MX$

(B) Coordination number of cation M = 8

Coordination number of anion X = 8

(C) If MX bond length is L and edge length of unit cell = a then

$$\left(\frac{a}{\sqrt{2}}\right)^2 + \left(\frac{a}{2}\right)^2 = L^2$$

$$= \frac{a^2}{2} + \frac{a^2}{4} = L^2$$

$$= \frac{L}{a} = \frac{\sqrt{3}}{2}$$

$$= \frac{3a^2}{4} = L^2$$

$$\Rightarrow \frac{L}{a} = \frac{\sqrt{3}}{2} = 0.866$$

(D) From the arrangement given, we can conclude cation M is present in cubical voids of X hence

$$\frac{r_M}{r_X} = 0.732$$

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. 5.00 mL of 0.10 M oxalic acid solution taken in a conical flask is titrated against NaOH from a burette using phenolphthalein indicator. The volume of NaOH required for the appearance of permanent faint pink color is tabulated below for five experiments. What is the concentration, in molarity, of the NaOH solution?

Exp. No.	Vol. of NaOH (mL)
1	12.5
2	10.5
3	9.0
4	9.0
5	9.0

Ans. (0.1)

Sol. $H_2C_2O_4 + NaOH \rightarrow NaHC_2O_4 + H_2O$

5×0.1

$NaHC_2O_4 + NaOH \rightarrow Na_2C_2O_4 + H_2O$

At second equivalance point, after the formation of $Na_2C_2O_4$, permanent faint pink colour, is obtained.

So milimoles of NaOH required to reach the equivalance point

$= 0.5 \times 2 = 1$

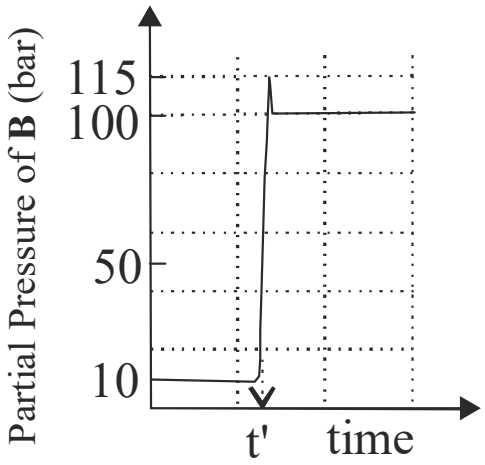
From the readings given, we can say that volume of NaOH consumed = 9 mL

$1 = M \times 9$

$\Rightarrow M = \frac{1}{9}$

$= 0.11$

14. Consider the reaction A $\rightleftharpoons$ B at 1000 K. At time t', the temperature of the system was increased to 2000 K and the system was allowed to reach equilibrium. Throughout this experiment the partial pressure of A was maintained at 1 bar. Given below is the plot of the partial pressure of B with time. What is the ratio of the standard Gibbs energy of the reaction at 1000 K to that at 2000 K?



Ans. (0.25)

Sol. A $\rightleftharpoons$ B

$\Delta G^\circ = -RT\, ln\, K_{eq}$

at T = 1000 K

$\Delta G_1^0 = -R \times 1000\, ln\, \frac{P_B}{P_A}$

$\Delta G_1^0 = -R \times 1000\, ln\, \frac{10}{1}$

at T = 2000 K

$\Delta G_2^0 = -R \times 2000\, ln\, \frac{100}{1}$

$\frac{\Delta G_1^0}{\Delta G_2^0} = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4} = 0.25$

15. Consider a 70% efficient hydrogen-oxygen fuel cell working under standard conditions at 1 bar and 298 K. Its cell reaction is

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$$

The work derived from the cell on the consumption of 1.0×10^{-3} mol of $H_2(g)$ is used to compress 1.00 mol of a monoatomic ideal gas in a thermally insulated container. What is the change in the temperature (in K) of the ideal gas?

The standard reduction potentials for the two half-cells are given below.

$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l), E^\circ = 1.23V$,

$2H^+(aq) + 2e^- \rightarrow H_2(g), E^\circ = 0.00V$

Use F = 96500 C mol^{-1}, R = 8.314 J mol^{-1} K^{-1}.

Ans. (13.32)

Sol. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ .....(i)

$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l), E^\circ = 1.23V$, ...(ii)

$2H^+(aq) + 2e^- \rightarrow H_2(g), E^\circ = 0.00V$ .....(iii)

(i) = (ii) $\times \frac{1}{2}$ – (iii)

$$\Delta G_1^0 = \frac{1}{2} \times \Delta G_2^0 - \Delta G_3^0$$

$$\Delta G_1^0 = \frac{1}{2} \times (-4 \times F \times 1.23)$$

$$\Delta G_1^0 = -2 \times 96500 \times 1.23 J\,mole^{-1}$$

Work done from the consumption of 10^{-3} moles of H_2 = $2 \times 96500 \times 1.23 \times 10^{-3} \times 0.7$ J

= $1.4 \times 965 \times 1.23 \times 0.1$ J

for an adiabatic process

$\Delta U = w$

$$1.4 \times 965 \times 1.23 \times 0.1 = 1 \times \frac{3R}{2}(\Delta T)$$

$$\Delta T = \frac{2\times1.4\times965\times1.23\times0.1}{3\times8.314}$$

= 13.32 K

16. Aluminium reacts with sulfuric acid to form aluminium sulfate and hydrogen. What is the volume of hydrogen gas in liters (L) produced at 300 K and 1.0 atm pressure, when 5.4 g of aluminium and 50.0 mL of 5.0 M sulfuric acid are combined for the reaction?

(Use molar mass of aluminium as 27.0 g mol^{-1}, R = 0.082 atm L mol^{-1} K^{-1})

Ans. (6.15)

Sol. $2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$

$\frac{5.4}{54} = 0.1$ mole

= 50 × 5

= 0.25 mole

moles of H_2 obtained = 0.25 mole

PV = nRT

1 × V = 0.25 × 0.082 × 300

V = 25 × 0.082 × 3

= 6.15 Litre

17. $^{238}_{92}U$ is known to undergo radioactive decay to form $^{206}_{82}Pb$ by emitting alpha and beta particles. A rock initially contained 68 × 10^{-6} g of $^{238}_{92}U$. If the number of alpha particles that it would emit during its radioactive decay of $^{238}_{92}U$ to $^{206}_{82}Pb$ in three half-lives is Z × 10^{18}, then what is the value of Z ?

Ans. (1.20)

Sol. $^{238}_{92}U \rightarrow {}^{206}_{82}Pb + 8\ {}_2He^4 + 6\ {}_{-1}e^0$

68 × 10^{-6} gm

Amount of U^{238} remaining after three half lives = $\frac{38\times10^{-6}}{8} = 8.5\times10^{-6}$

So amount of U^{238} reacted = 68 × 10^{-6} – 8.5 × 10^{-6}

= 59.5 × 10^{-6}.

From stoichiometry, moles of α – particles obtained

$= 8 \times \frac{59.5 \times 10^{-6}}{238}$

$= 2 \times 10^{-6}$

No of α-particles $= 2 \times 10^{-6} \times N_A$

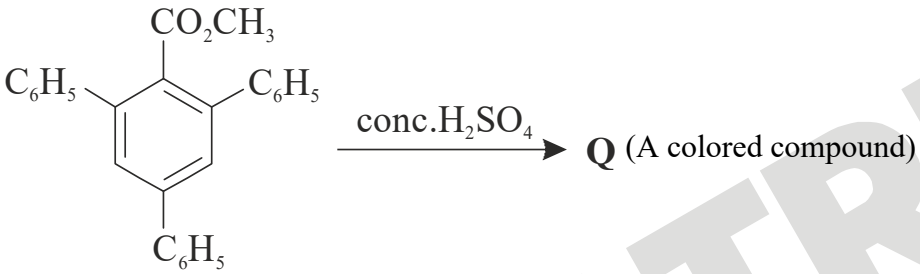
$= 2 \times 10^{-6} \times 6.022 \times 10^{23}$

$= 12.044 \times 10^{17}$

$= 1.2044 \times 10^{18}$.

$Z = 1.20$

18. In the following reaction, compound Q is obtained from compound P via an ionic intermediate.

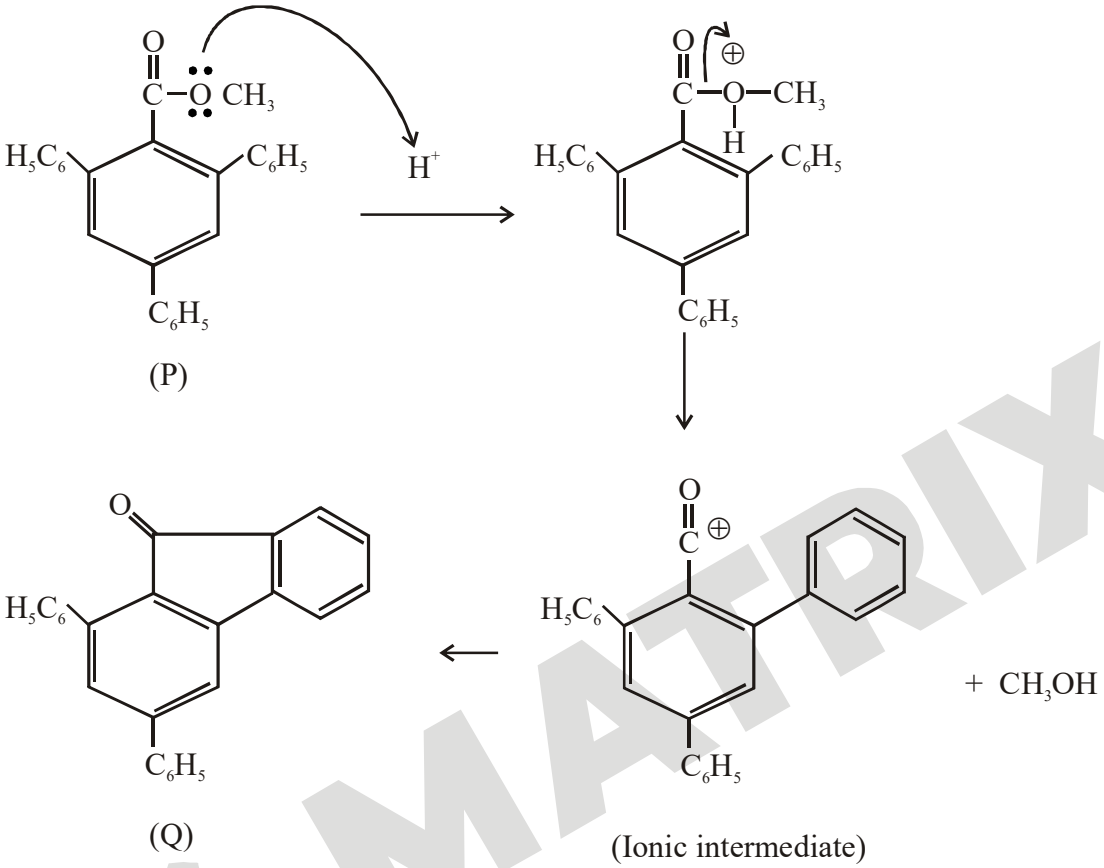


P

What is the degree of unsaturation of Q ?

Ans. (18)

Sol.


O
C
O
CH3
H5C6
C6H5
C6H5
H+
(P)
O
C
O
CH3
H
H5C6
C6H5
C6H5
O
H5C6
C6H5
(Q)
O
C
H5C6
C6H5
+ CH3OH
(Ionic intermediate)