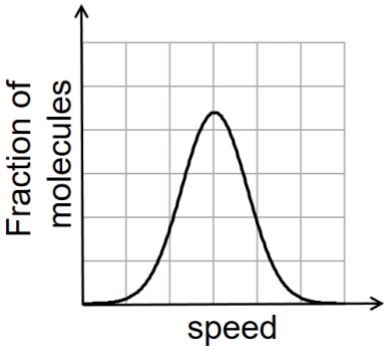
JEE Advanced 2023 paper -1

1. The correct molecular orbital diagram for F_2 molecules in the



ground state

(A) 1 : 1 : 1

(B) 1 : 1 : 1.224

(C) 1 : 1.128 : 1.224

(D) 1 : 1.128 : 1

Answer : B

Solution:

The given graph is symmetrical, so the average speed and most probable speed will coincide. Because the most probable speed is the speed possessed by the maximum number of molecules of the gas, and the average speed is the sum of the speeds of all the molecules divide it by total number of molecules, so it will be in the middle. But the root mean square velocity will remain $\sqrt{\frac{3RT}{M}}$

So, $u_{mp} = \sqrt{\frac{2RT}{M}} = u_{av}$

$u_{mp} : u_{av} : u_{rms} = \sqrt{2} : \sqrt{2} : \sqrt{3}$ = 1:1: $\sqrt{\frac{3}{2}}$ = 1 : 1 : 1.224

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

Solution:

Pb_3O_4 is insoluble in water, KO_2 is superoxide and Na_2O_2 , Li_2O_2 are peroxides. Let's see the hydrolysis of above given oxides

$Pb_3O_4 + H_2O \longrightarrow$ No reaction

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

$Na_2O_2 + H_2O \longrightarrow NaOH + H_2O_2$

$Li_2O_2 + H_2O \longrightarrow LiOH + H_2O_2$

3. A colorless aqueous solution contains nitrates of two metals, X and Y. When it was added to an aqueous solution of NaCl, 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 aqueous 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

   Solution : Let's take X= $AgNO_3$ and Y= $Pb(NO_3)_2$. Upon treating X and Y with NaCl

$$AgNO_3 + NaCl \rightarrow AgCl$$

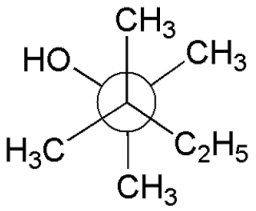
$Pb(NO_3)_2 + NaCl \rightarrow PbCl_2$ (Q) $\xrightarrow{KI} PbI_2$(yellow)

(Partly soluble in hot water)

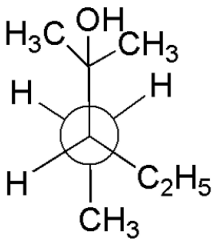
$AgCl + 2NH_3 \rightarrow [Ag(NH_3)_2]Cl$

$AgCl + 2Na_2S_2O_3 \rightarrow Na_3[Ag(S_2O_3)_2] + 2NaCl$

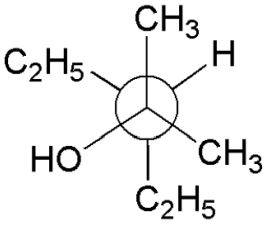
4. Newman projections P, Q, R and S are shown below:



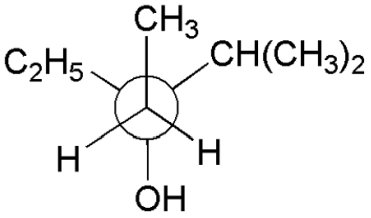
P



Q



R



S

Which one of the following options represents identical molecules?

(A) P and Q

(B) Q and S

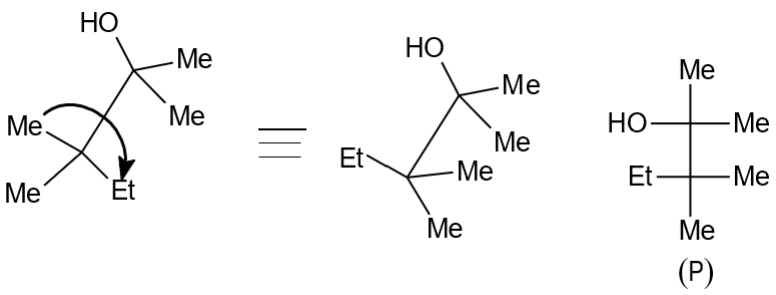
(C) Q and R

(D) R and S

Answer : C

Solution :

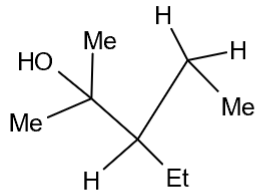
P.

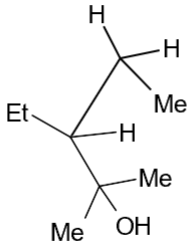


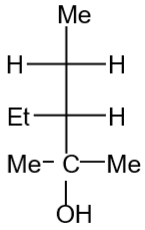
(P)

2,3,3 – trimethyl pentan-2-ol

Q.



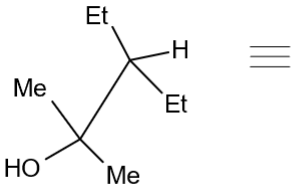




(Q)

3 – ethyl-2 - methyl pentan-2- ol

R.



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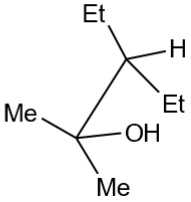
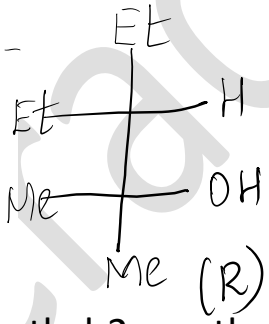
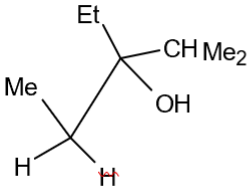
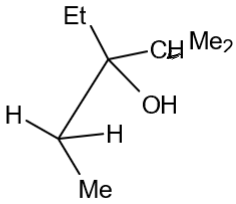


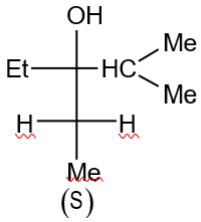


3 – ethyl-2 - methyl pentan-2- ol

S.







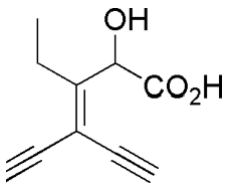
(S)

3 – ethyl- 2 - methyl pentan – 3-ol

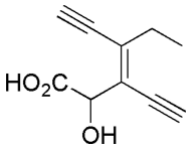
Only (Q & R) are same

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

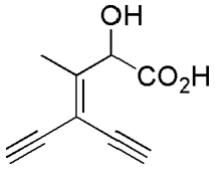
(A)



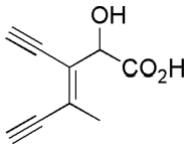
(B)



(C)

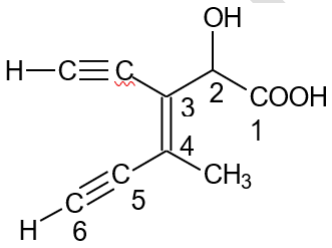


(D)

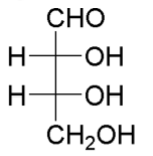


Ans : D

Solution: only option D is 3-ethynyl-2-hydroxy-4-methylhex-3-en-5- ynoic acid other options are different

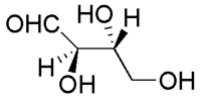
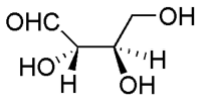
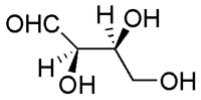
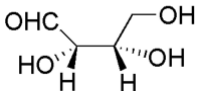


6. The Fischer projection of D-erythrose is shown below:



D-Erythrose

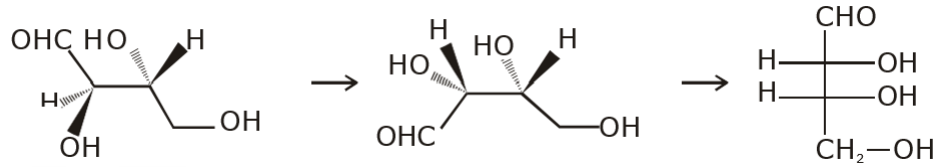
D—Erythrose and its isomers are listed as P, Q, R and S in **Column-I**. Choose the correct relationship of P, Q, R and S with D-erythrose from **Column-II**.

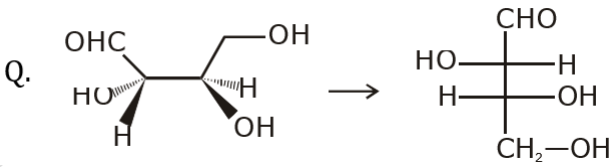
Column-I	Column-II
P. 	1. Diastereomer
Q. 	2. Identical
R. 	3. Enantiomer
S. 	

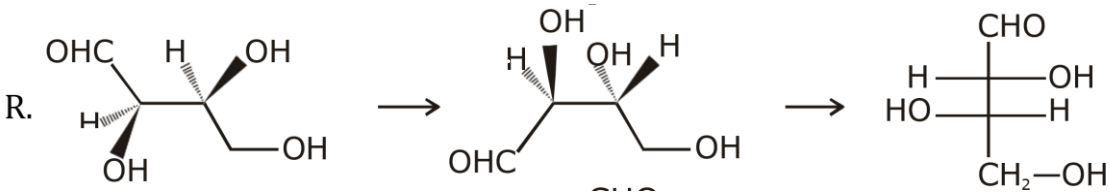
(A) P - 2, Q - 3, R - 2, S-2
(B) P - 3, Q -1, R - 1, S -2
(C) P - 2, Q - 1, R - 1, S -3
(D) P - 2, Q - 3, R - 3, S - 1

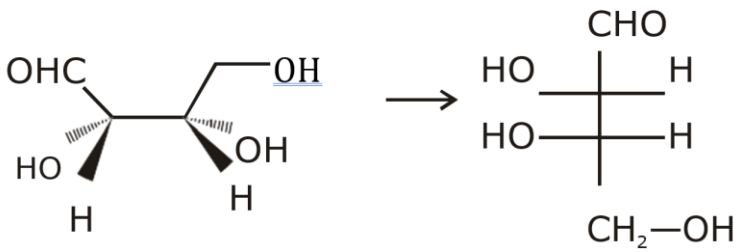
Ans : C

Solution:

P. 

Q. 

R. 

S. 

P - 2R,3R , so, identical. Hence P→ 2
Q -2S,3R , so, Diastereomers. Hence Q → 1
R - 2R,3S , so, Diastereomers. Hence R → 1
S -2S,3S , so, Enantiomers. Hence S → 3

Section – 2

7. In thermodynamics, the P – V work done is given by

$$w = -\int dV P_{ext} .$$

For a system undergoing a particular process , the workdone is $w = -\int dV(\frac{RT}{V-b} - \frac{a}{V^2})$ This equation is applicable to a

(A) system that satisfies the van der Waal's 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

Answer : A,B, C

Solution:

The given workdone is = $w = -\int dV P_{ext}$

We know that, $(P + \frac{a}{V^2})(V - b) = RT$

$$P = (\frac{RT}{V-b} - \frac{a}{V^2})$$

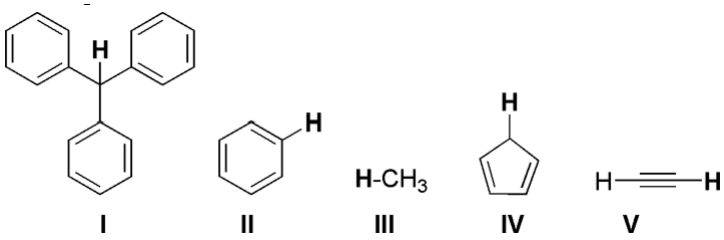
For reversible process,

$$P_{ext} = P_{gas}$$

$$w = -\int(\frac{RT}{V-b} - \frac{a}{V^2})dV$$

So, process is not applicable only for irreversible process.

8. With respect to the compounds I – V, choose the correct statement(s).



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

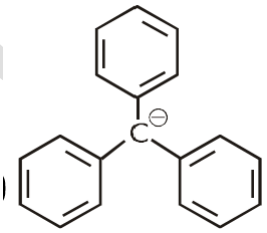
(B) The conjugate base of compound IV is aromatic

(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: A,B,C

Solution:

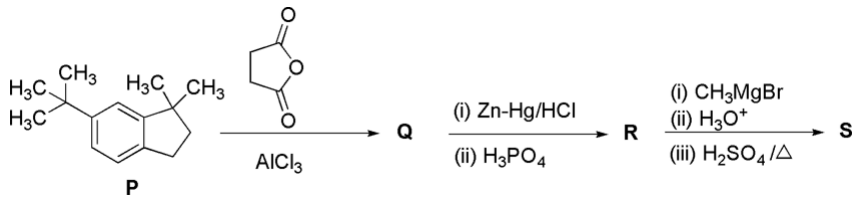
A)  is the conjugate base of option I, which is stabilised by delocalisation or resonance

B)  is the conjugate base of compound IV, which is an aromatic compound

C) -NO_2 group is strong EWG, which increases acidic strength of compound II.

D) Correct order and acidity IV > V > I > II > III (Decreasing acidity)

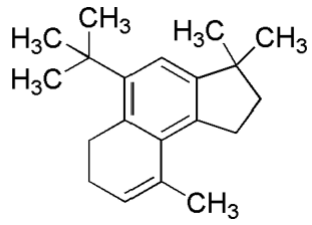
9. In the reaction scheme shown below, Q, R and S are the major products.



The correct structure of

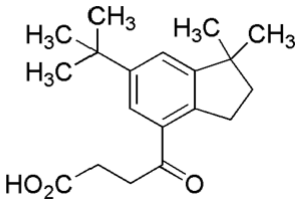
A)

S is



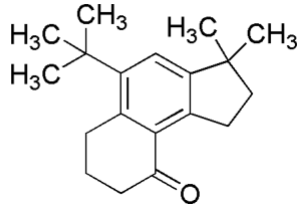
B)

Q is



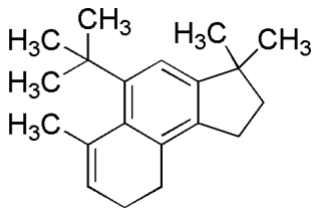
C)

R is



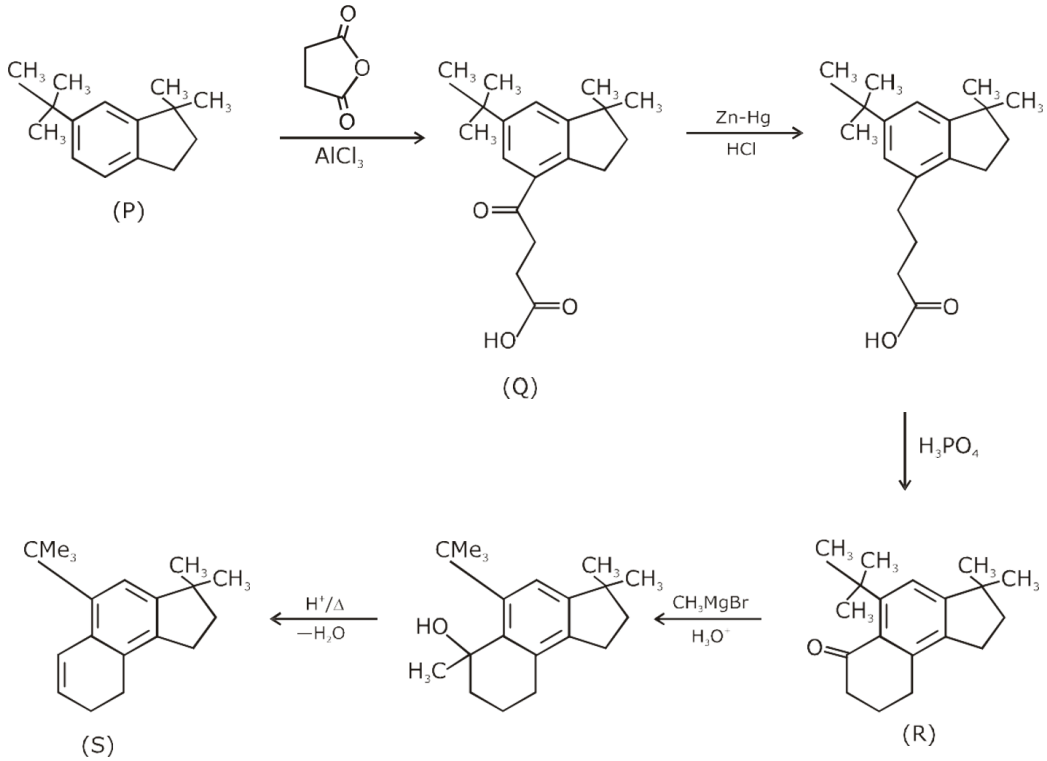
D)

S is



Answer :B, D

Solution:



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.

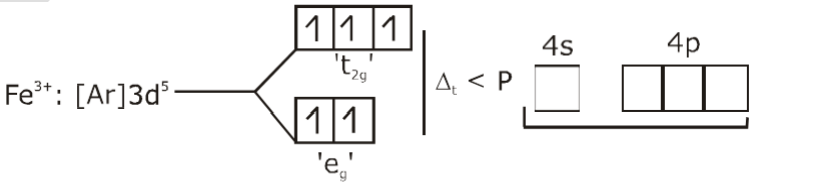
C) $[FeCl_4]^-$ has higher spin-only magnetic moment than $[Co(en)(NH_3)_2Cl_2]^+$.

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

Ans: A,C

Solution:

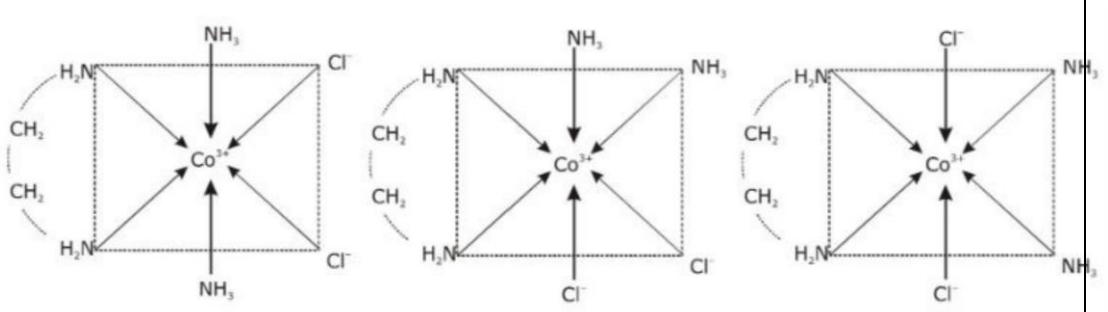
A) $FeCl_4]^-$: $Cl^-$is weak field ligand So, it cannot be paired (unpaired electrons)



sp^3– hybridization

$FeCl_4]^-$ is sp^3hybridized and has tetrahedral geometry with number of unpaired electrons (n) = 5

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

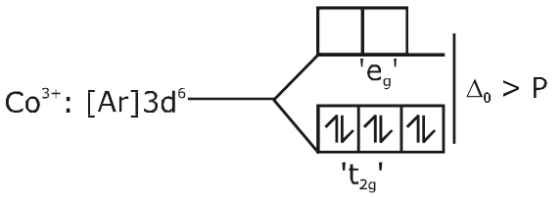


C) Number of unpaired electron (n)= 5

So, spin-only magnetic moment $\mu_s=\sqrt{n(n+2)}$

$\mu_s= \sqrt{5(5+2)} = \sqrt{35} = 5.92\ BM$

D)$[Co(en)(NH_3)_2Cl_2]^+$: NH_3, en are strong field ligand so all unpaired electrons get paired.



d^2sp^3 hybridization (octahedral geometry)

So, the spin only magnetic moment is 0

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

A) The hypochlorite ion is strongest conjugate base

B) The molecular shape of only chlorate ion is influenced by the lone pair of electrons of Cl

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

D) The hypochlorite ion oxidizes the sulfite ion

Ans:A,B, D

Solution:

Hypochlorite ion - ClO^-

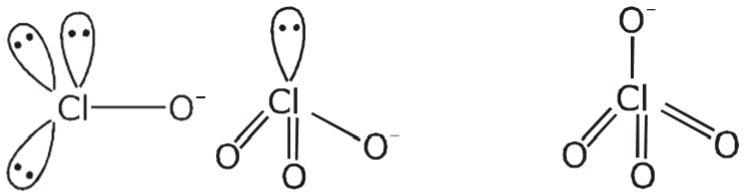
Chlorate ion - ClO_3^-

Perchlorate ion – ClO_4^-

Acidic nature - $HClO < HClO_3 < HClO_4$

Conjugate Base order will be $ClO^- > ClO_3^- > ClO_4^-$

B)



sp^3 (Linear) sp^3 (pyramidal) sp^3 (tetrahedral)

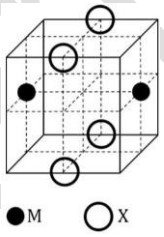
In chlorate ion bond angle changes due to presence of lone pair on chlorine atom while hypochlorite ion is linear and perchlorate ion is tetrahedral and there is no effect of lone pair on hypochlorite ion

C) $3OCl^- \rightarrow 2Cl^- + ClO_3^-$

$4ClO_3 \rightarrow 3ClO_4^- + Cl^-$

D) $ClO^- + SO_3^- \rightarrow Cl^- + SO_4^{2-}$

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

Answer : A,C

Solution :

According to the given diagram, structure seems to be B.C.C.

(1)Empirical formula - MX

(2)C. No. of 'M' ion = 8 [same co-ordination Geometry]

C. No. of 'X' ion = 8 [same co-ordination Geometry]

(3) M–X Bond Length = $\sqrt{(\frac{a}{2})^2 + (\frac{a}{\sqrt{2}})^2}$

M–X Bond Length = a $\sqrt{\frac{1}{4} + \frac{1}{2}}$

$$\frac{M - X\ bond\ length}{a\ (edge\ length)} = \frac{\sqrt{3}}{2} = 0.866$$

(4)As it is B.C.C.

$r_{x^-} + r_{M^+} = \frac{\sqrt{3}}{2}\ a$

$0.732 \leq \frac{r_{M^+}}{r_{x^-}} \leq 1$

Section – 3

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 : 0.11

$H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$

By law of equivalence

Number of eq. of NaOH = Number of eq. of oxalic acid

M= [NaOH] = $\frac{[H_2C_2O_4]x\ Vol.H_2C_2O_4}{Volume\ of\ NaOH}$

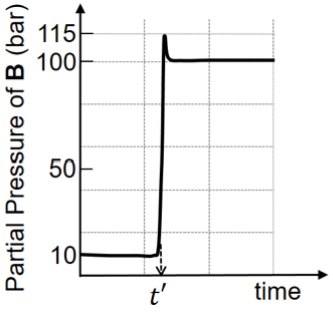
$[NaOH]_1 = \frac{5\ x\ 0.1\ x2}{12.5}$

$[NaOH]_2 = \frac{5\ x\ 0.1\ x2}{10.5}$

$[NaOH]_3 = \frac{5\ x\ 0.1\ x2}{9} = [NaOH]_4 = [NaOH]_5$

So final concentration of NaOH = $\frac{\frac{1}{12.5}\ x\ \frac{1}{10.5}\ x\frac{1}{9}x3}{5}$ = 0.11

14. Consider the reaction A →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 standard Gibbs energy of the reaction at 1000 K to that at 2000 K?



Ans: 0.25

Solution : Keq. = $\frac{P_A}{P_B}$

$$K_{eq}\ at\ temperature\ 2000K = 100$$

$$K_{eq}\ at\ temperature\ 1000K = 10$$

$\frac{\Delta G_1^o}{\Delta G_2^o} = \frac{-(RT\_1ln\ K\_eq)}{-(RT\_2ln\ K\_eq)} = \frac{1000\ ln\ 10}{2000ln\ 100}$ = 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 $H_2 + 1/2O_2 \rightarrow H_2O$

    The work derived from the cell on the consumption of 1.0 x10^{-3} mol of H 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

$$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l), E_0 = 1.23V,$$

$$2H^+(aq) + 2e^- \rightarrow H_2(g), E_0 = 0.00V$$

$$Use: F = 96500C\ mol^{-1}, R = 8.314Jmol^{-1}K^{-1}$$

    Ans: 13.32

$$E_{cell} = 1.23\ volt$$

$$\Delta G^0 = -nFE^o_{cell} = -2x96500x1.23$$

    Work derived from this fuel cell = 70 / $100\ x\ (-\Delta G^0)\ x\ 1.0\ x10\text{^}(-3) = 166.173$

    For adiabatic gas, $W_{(adiabatic)} = \frac{nR}{\gamma - 1}(T_2 - T_1)$

$$\Delta T = \frac{166.173x\ 2}{8.314x3} = 13.32$$

16. Aluminium reacts with sulfuric acid to form aluminium sulfate and hydrogen. What is the volume of hydrogen gas in litre (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 L

Solution:

$$2\mathrm{Al} + 3\mathrm{H_2SO_4} \rightarrow \mathrm{Al_2(SO_4)_3} + 3\mathrm{H_2}$$

Mole of Al taken = 0.2 mol

Mole of H_2SO_4 taken = $\frac{50\ x\ 5}{1000} = 0.25$

As, $\frac{0.2}{2} > \frac{0.25}{3}$, H_2SO_4 is limiting agent

Now, moles of H_2 formed = $\frac{3}{3} x\ 0.25 = 0.25$

Volume = $\frac{0.25\ x\ 0.082\ x300}{1} = \frac{24.6}{4} = 6.15\ L$

17. U_{92}^{238} is known to undergo radioactive decay to form Pb_{82}^{206} by emitting alpha and beta particles. A rock initially contained $68x10^{-6}$ of U_{92}^{238} . If the number of alpha particles that it would emit during its radioactive decay of U_{92}^{238} to Pb_{82}^{206}in three half – lives is $Zx10^{-18}$, then what is the value of Z?

Ans: 1.21

Solution :

$U_{92}^{238} \rightarrow Pb_{82}^{206} + 8He_2^4 + 6\beta_{-1}^{o}$ (antineutrino)

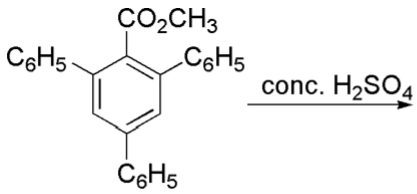
Initial mole of $U^{238} = \frac{68x10^{-6}}{238}$ = x

Mole of U^{238} decayed in three half-lives =$\frac{7}{8}\ x$

In decay from U_{92}^{238} to Pb_{82}^{206}, each U_{92}^{238} atom decays and produces 8α-particles and hence, total number of α-particles emitted out = $\frac{7}{8}x8xN_A$

= $\frac{7}{8}x\frac{68x10^{-6}}{238}x8x6.022x10^{23} = 1.2046x10^{18} = 1.21$

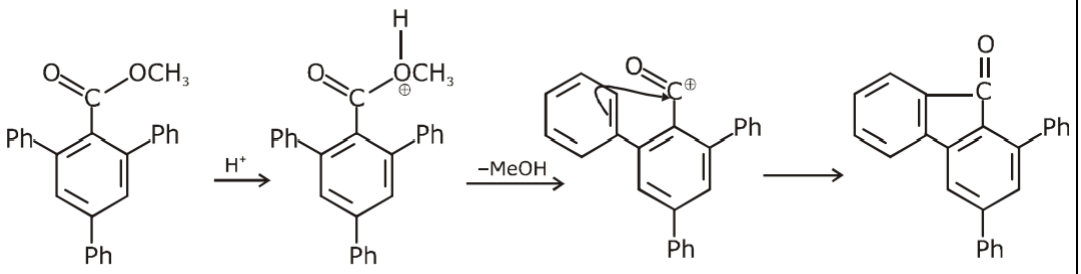
18. In the following reaction, compound Q is obtained from compound P via an ionic intermediate. What is the degree of unsaturation of Q?



P

What is the degree of unsaturation of Q?

Answer : 18



Total degree of unsaturation = 18