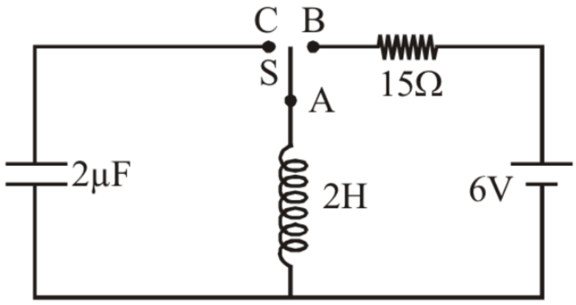
PART-1 : PHYSICS

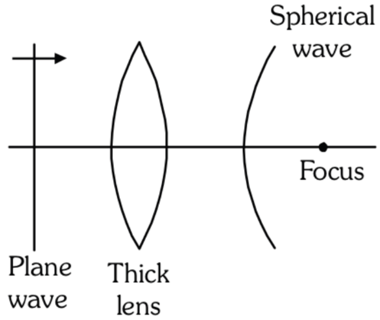
SECTION-I (i)

1) A circuit consists of an inductor (2H), a resistor (15 Ω), a battery with emf 6V, a capacitor (2 μF) and a two-way switch S as shown in the figure. Initially, the switch is open and the capacitor is uncharged. At t = 0, the switch S is set so that points A and B are connected. A long time after the switch has connected A and B, the switch is instantaneously changed to connect points A and C. The maximum charge that will eventually appear on the capacitor is :-

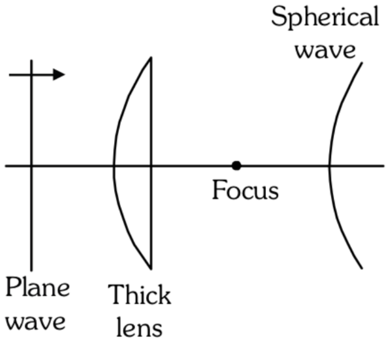


(A) 12 μC
(B) 400 μC
(C) 600 μC
(D) 800 μC

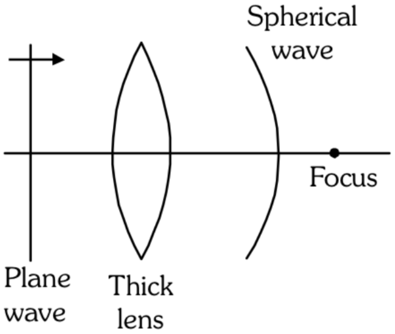
2) Carefully analyse the diagram and choose the correct option :



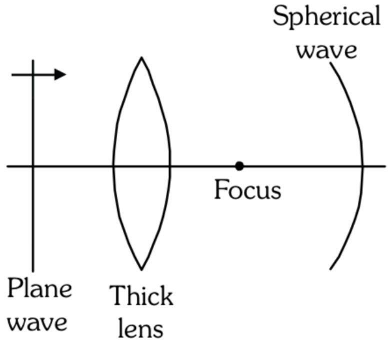
(I)



(II)



(III)



(IV)

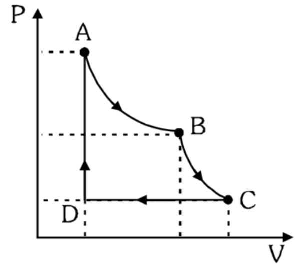
(A) I and II are true

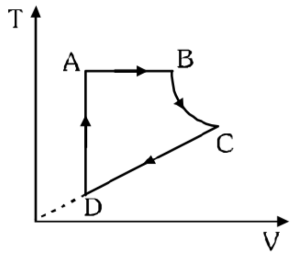
(B) I and III are true

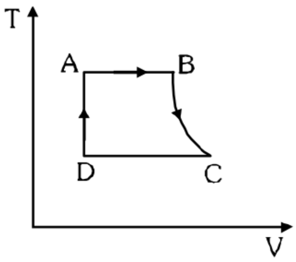
(C) I and IV are true

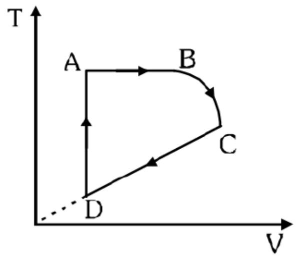
(D) II and IV are true

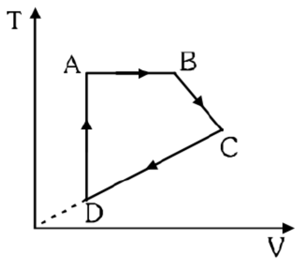
3) Two moles of a diatomic gas are carried through the cycle ABCDA shown in the PV diagram as shown in figure. The segment AB represents an isothermal expansion, the segment BC an adiabatic expansion. The pressure and temperature at A are 5 atm and 600 K respectively. The volume at B is twice that at A. The pressure at D is 1 atm. Find the T versus V graph for this process.



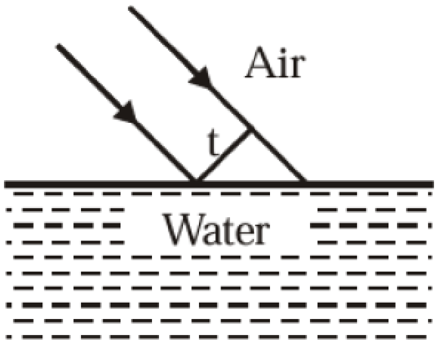
(A) 

(B) 

(C) 

(D) 

4) A monochromatic beam of width t is incident at 45° on an air water interface as shown in the figure. The refractive index of water is μ and that of air is 1. The width of the beam in water is,



(A) (μ -1)T

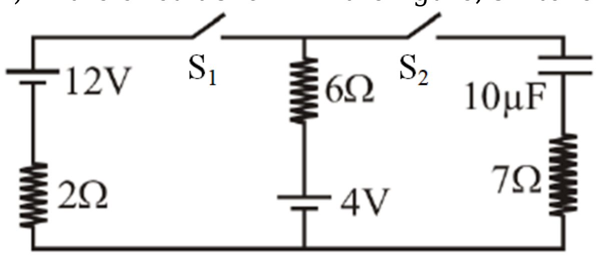
(B) μ T

(C) $\frac{\sqrt{\mu^2-1}}{\mu}$

(D) $\frac{\left(\sqrt{2\mu^2-1}\right)}{\mu}t$

SECTION-I (ii)

1) In the circuit shown in the figure, switches S_1 and S_2 have been closed for a long time, then :-



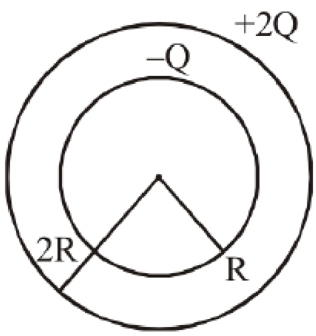
(A) Charge on the capacitor is 100 μC

(B) Charge on the capacitor is 20 μC

(C) Charge on the capacitor increases to 120 μC if one third of the gap of the capacitor's plates is filled with a dielectric (K = 2) of same area.

(D) Charge on the capacitor remains unchanged if one third of the gap of the capacitor's plates is filled with a dielectric (K = 2) of same area.

2) Charge –Q and 2Q are distributed uniformly on surface of two concentric spherical shells of radii 'R' and '2R' respectively as shown in the figure. Select **CORRECT** statement(s) :-



The total electrostatic energy stored is

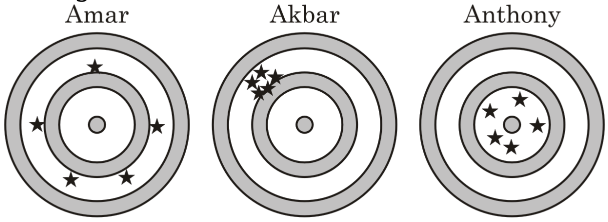
(A) $\frac{3Q^2}{8\pi\epsilon_0 R}$

(B) Electrostatic energy stored outside the system is $\frac{Q^2}{16\pi\epsilon_0 R}$

(C) Electrostatic energy stored outside the system is $\frac{Q^2}{2\pi\epsilon_0 R}$

(D) Electrostatic energy in space between two shells is zero

3) In an archery contest, the aim is to shoot arrows at the center of a board. Three archers, **Amar**, **Akbar** and **Anthony** each shot 5 arrows at the board. The locations of their arrow hits are shown in the figures with red stars. Which of the following statements are true?



(A) Akbar is more precise than Amar and Anthony.

(B) Anthony is more accurate than Akbar.

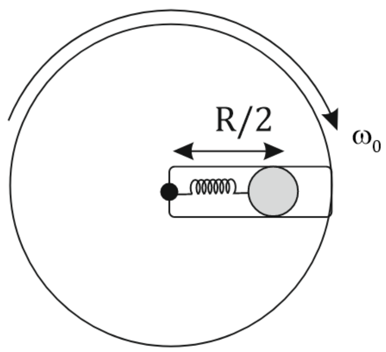
(C) Anthony is less precise than Amar.

(D) Amar is more accurate than Anthony.

SECTION-II (i)

Common Content for Question No. 1 to 2

A uniform disk of mass m and radius 'R' is free to rotate in horizontal plane about a vertical smooth fixed axis passing through its centre. There is a smooth groove of small width along the radius of the disk and one small ball of same mass (m) is attached to one end of a spring as shown in figure. Other end of spring is fixed with centre of disk. Initially spring is in its natural length of $\frac{R}{2}$. The disk is given initial angular velocity ω^0 and released (spring constant $k = \frac{m\omega_0^2}{2}$)

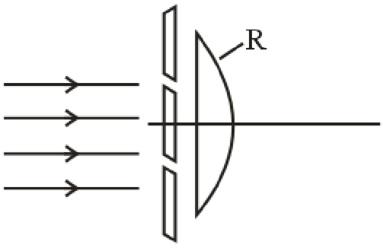


1) Angular velocity of disk when elongation in spring becomes $\frac{R}{2}$ will be $\alpha\omega^0$. Write α.

2) Linear velocity of ball when elongation in spring becomes $\frac{R}{2}$ will be $\frac{\omega_0 R}{2}\beta$. Write β.

Common Content for Question No. 3 to 4

A screen with two slits at d distance apart are placed in path of parallel light beam. A plane convex lens is placed just after the slits. When light is observed in focal plane of lens, interference fringes



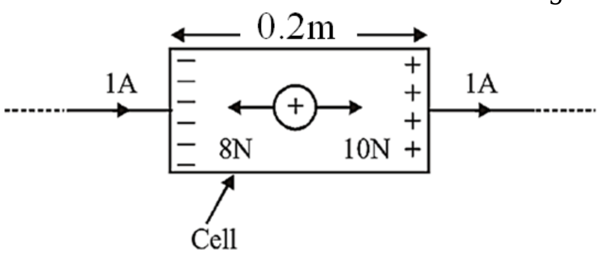
are observed.

3) If focal length of lens is 20 cm & d = 1mm, fringe width obtained with light of wavelength λ = 5000 Å; (in mm) is

4) If light was non-monochromatric having wavelength 4000Å & 5000Å what will distance (in mm) in focal plane of lens between point's of complete darkness. Assume no chormatic aberration in lens.

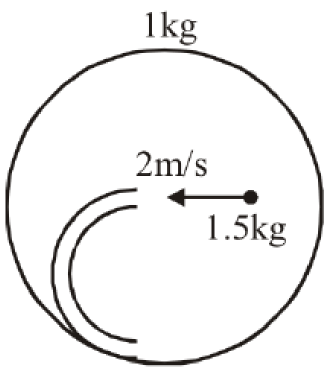
SECTION-II (ii)

1) Figure shows a cell in which unit positive charge experience a constant non electric force of 10N and a constant electric force of 8N in directions shown in the figure. If the internal resistance of the



cell is r ohm, find 10r.

2) A disc of mass 1kg, hinged at its centre in horizontal plane, is free to rotate about its centre. A small disc of mass 1.5 kg moves with speed 2 m/s relative to ground and enters tunnel formed on disc. Suppose formation of tunnel does not make any effect on the mass of disc. The velocity with

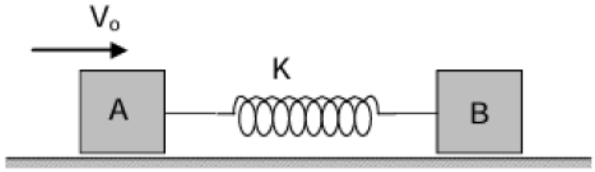


which small disc come out of disc will be (in m/s) :

3) In Young's double slit experiment, a parallel stream of electrons accelerated by a potential

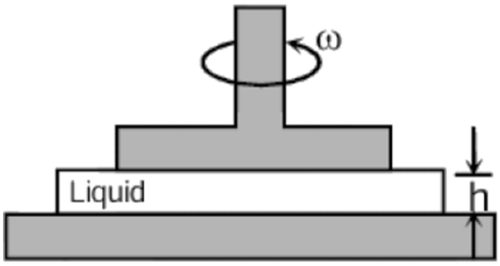
difference V = 45.5 Volts is used to obtain interference pattern. If slits are separated by a distance d = 66.3 μm and distance of screen is D = 109.2 cm from the plane of slits, find the distance (in μm) between two consecutive maxima on the screen. Given, mass of electron, $m = 9.1 \times 10^{-31}$ kg, Planck's constant, $h = 6.63 \times 10^{-34}$ J-sec. (Use $\sqrt{1324.96} = 36.4$)

4) Block A of mass 2kg is given velocity v_0 = 10 m/s towards block of mass 4kg. If spring constant of ideal spring is 150 N/m, find minimum speed (in m/s) attained by block A.



5) The activity of a sample reduces from A^0 to $\frac{A_0}{\sqrt{2}}$ in 10 minutes. The activity of the sample after 30 more minutes will be A_1. Find $\frac{A_0}{A_1}$.

6) A circular disc of a diameter d is slowly rotated in a liquid of large viscosity μ at a small distance h from a fixed surface. An expression for torque τ necessary to maintain an angular velocity ω is $\frac{\mu\pi d^4\omega}{xh}$. Find the value of x.



PART-2 : CHEMISTRY

SECTION-I (i)

1) Which one of following statement is **CORRECT** about Natural Rubber

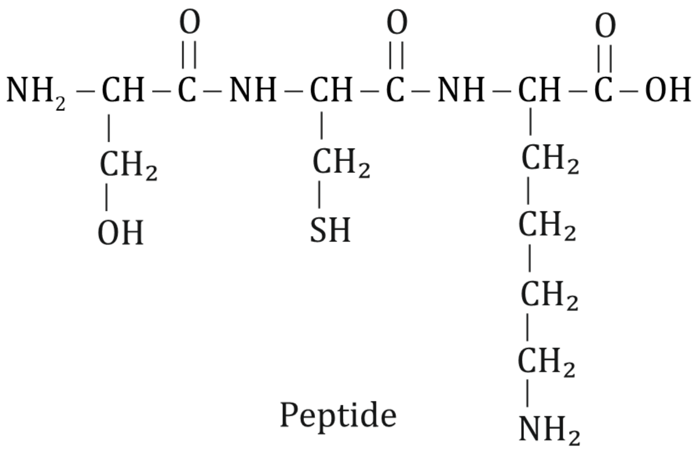
(A) It is a linear Cis-1,4-polychloroprene

(B) In Vulcanization process, sulphur forms cross links between different chains at C_2 and C_3 carbons of monomeric units

(C) Gutta-percha is a naturally occuring isomer of rubber formed via 1, 2-addition polymerisation

(D) Empirical formula weight of natural rubber is 88.5

2) Identify **INCORRECT** statement regarding peptide given below ?



Peptide

(A) It is a tripeptide with two peptide links

(B) Peptide gives black precipitate with $Pb(CH_3COO)_2$ solution, when sodium fusion of this peptide is carried out with excess of sodium

(C) All the Amino acids formed on complete hydrolysis are non-essential

(D) One of the amino acid formed on complete hydrolysis is basic amino acid

3) On heating ammonium dichromate,

(A) O_2 gas is produced

(B) NH_3 gas is produced

(C) Orange solid changes to yellow solid

(D) Valency factor of $(NH_4)_2Cr_2O_7$ is 6 in this process

4)
$K_2Cr_2O_{7(aq)}+H_2SO_{4(aq)}+FeC_2O_{4(aq)} \rightarrow K_2SO_{4(aq)}+Fe_2(SO_4)_{3(aq)}+Cr_2(SO_4)_{3(aq)}+CO_{2(g)}+H_2O_{(\ell)}$
Moles of CO_2(g) formed per mole of H_2SO_4 reacted is :

(A) $\frac{2}{5}$

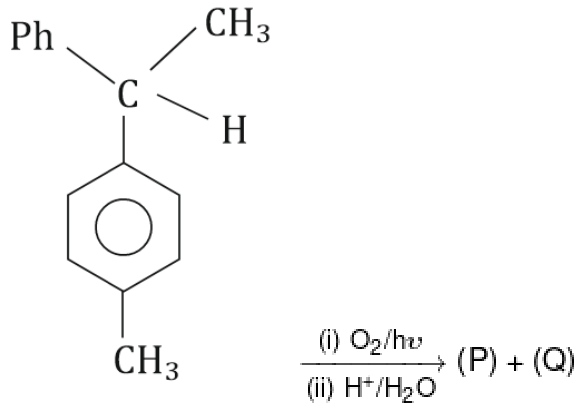
(B) $\frac{3}{7}$

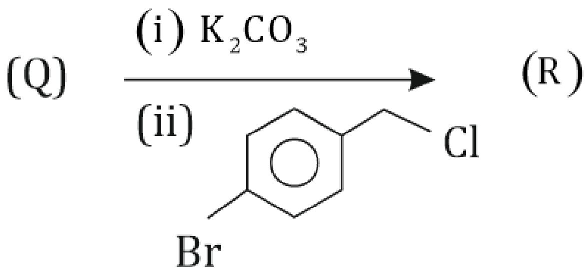
(C) $\frac{4}{7}$

(D) $\frac{4}{5}$

SECTION-I (ii)

1) The **correct** statement(s) about the following reaction sequence is(are)





Given : D.U of (P) is greater than (Q)

(A) (P) gives yellow precipitate with Br_2 / NaOH

(B) (Q) and (R) can be differentiated by neutral $FeC\ell_3$ aqueous solution

(C) (R) gives white precipitate with $AgNO_{3(aq)}$

(D) (P) gives coloured precipitate with Brady's reagent

2) Tollen's reagent is used for the detection of aldehyde. When a solution of $AgNO_3$ is added to glucose with NH_4OH then gluconic acid is formed

Given :

$Ag^+_{(aq)} + e^- \rightarrow Ag_{(s)}$; $E^0_{red} = 0.8V$

$C_6H_{12}O_{6(aq)} + H_2O \rightarrow C_6H_{12}O_{7(aq)} + 2H^+_{(aq)} + 2e^-$; $E^0_{OX} = -0.05V$

$[Ag(NH_3)_2]^+ + e^- \rightarrow Ag_{(s)} + 2NH_3$; $E^0_{red} = 0.0337V$

$2.303 \times \frac{RT}{F} = 0.06$

The **CORRECT** option(s) is / are

(A) $AgNO_{3(aq)}$ is a stronger oxidising agent than Tollen's reagent under standard condition

(B) E_{ox} of Glucose half cell reaction increases with decrease in pH of solution (if concentration of other species = 1M)

(C) Addition of NH_3 has no effect on standard oxidation potential of glucose / gluconic acid electrode

(D) $C_6H_{12}O_6 + 2Ag^+ + H_2O \rightarrow 2Ag\downarrow + C_6H_{12}O_7 + 2H^+$; $E^0_{Cell} = +1.55V$

3) In which of the following reaction(s), H_2O_2 can convert the **underlined atom** into coloured product with its highest possible oxidation state ?

(A) $\underline{Cr}_2(SO_4)_3 + OH^-$

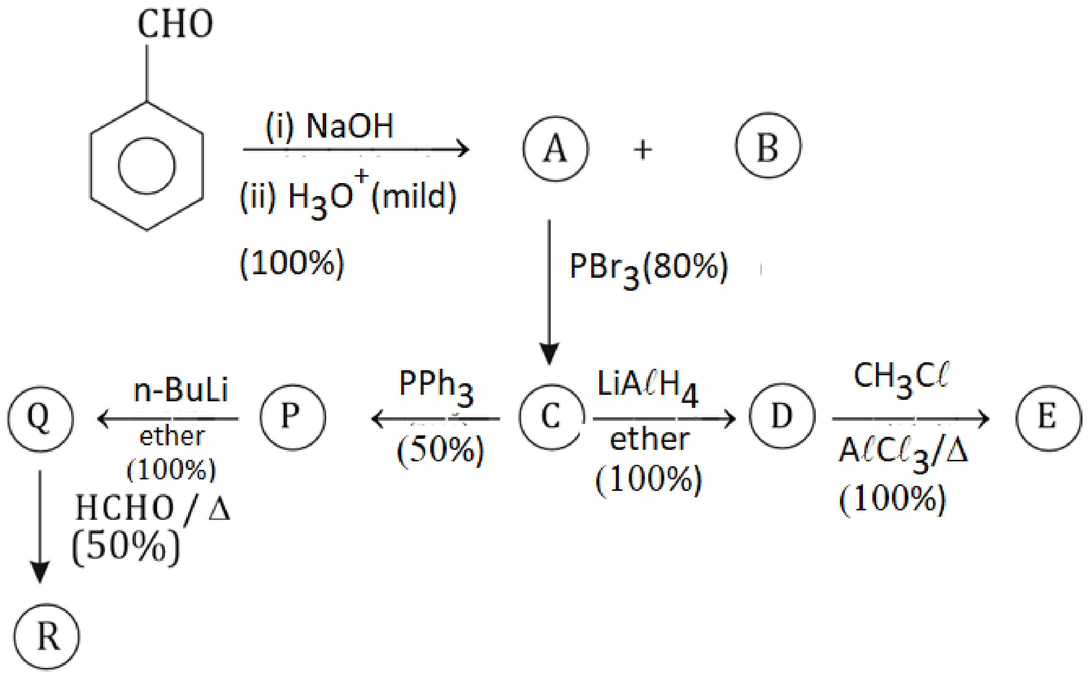
(B) $\underline{Mn}O_2 + H_2SO_4$

(C) $Pb\underline{O}_2$

(D) $\underline{N}H_2OH$

SECTION-II (i)

Common Content for Question No. 1 to 2



Given :

A. **Acidic strength : (B) > (A)**
B. **Consider major organic products in all above reactions**
C. **% yield of each reaction in the given sequence is mentioned in parenthesis**
D. **Atomic mass : C - 12 ; O - 16 ; P - 31 ; H - 1**

1) Determine amount of 'R' (in gram) formed from one mole of Benzaldehyde

2) Find the sum of the locants of substituents as per IUPAC name of compound (E)
(if Benzene ring is considered as parent chain)

Common Content for Question No. 3 to 4

An anion 'P' gives colourless and suffocating odour containing volatile product with dil $HC\ell$ and decolourises acidified permanganate solution. 'P' forms white precipitate (soluble in dil acid) with $BaC\ell_2$ solution.
The same anion (P) liberates $'Q'_{gas}$, when it is treated with a mixture of 'Zn' and $NaOH_{(excess)}$.

3) Sodium salt of 'Q' $\xrightarrow[\text{Prusside solution}]{\text{Sodium nitro}}$ Coloured product (R)

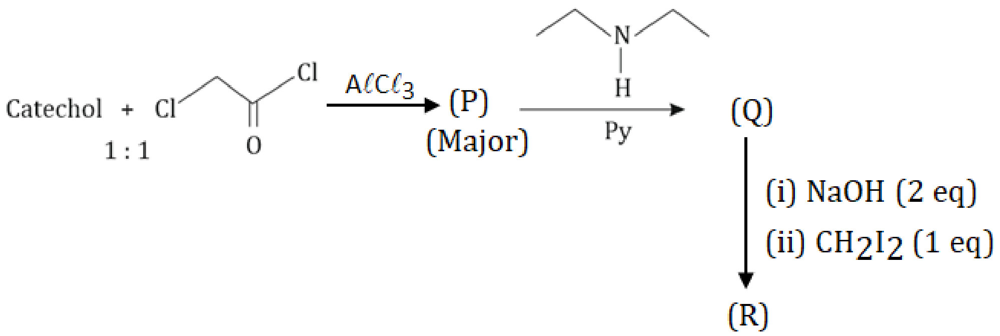
Then the E.A.N of the central metal atom/ion in 'R' is

4) $\underset{(1\ \text{mole})}{(Q)} \xrightarrow[(1\ \text{mole})]{NaOH} (S) \xrightarrow[(1\ \text{mole})]{NaOH} (T)$

Determine the pH of solution obtained, when 1 mole of 'Q', 2 moles of 'S' and '3' moles of 'T' are dissolved in 1 lit of water at 25°C
[if $pKa_1 = 7$ and $pKa_2 = 12$; $\log_{10}(2) = 0.3$]

SECTION-II (ii)

1) Aspartame is an artificial sweetener used in cold drinks. On complete hydrolysis, it gives Aspartic acid, phenyl alanine and methanol.
Then, the number of different functional groups (other than C = C or benzene) present in one molecule of Aspartame is ....



2)
D.U of (R) is ....

3) The rate constant of certain reaction is given by :

$$\log_{10}(k) = 5.4 - \frac{100}{T} + 2.5\ \log_{10}(T)$$

Determine activation energy of reaction at 27°C (in Kcal/mol). (Nearest integer value)
[Given : R = 2 cal mol^{-1} k^{-1} ; $\ln_e(X) = 2.3 \log_{10}(X)$]

4) Calcium dihydrogen salt of ethylene diamine tetraacetate is used to remove lead poison from human body due to formation of stable water soluble complex. If total number of stereo isomers for this complex is/are = **X**
Platinum containing complex which is used for the chemotherapy for the treatment of cancer have total possible stereo isomer = **Y**
Find (X + Y).

5) How many number of following compounds have amphoteric nature
NO_2, PbO, Cr_2O_3, MnO_2, SnO, ZnO, SnO_2, Li_2O, PbO_2, C□O_2 , BeO

6) The Osmotic pressure of 0.01 M monoacidic base solution is 0.015 ST at 'T' kelvin. If pH of this solution is 'X' then find the value of [X + 0.3]
($\log_{10}(5) = 0.7$; S = Solution constant, K_W of water at 'T' Kelvin = 10^{-14})

PART-3 : MATHEMATICS

SECTION-I (i)

1) Let $\alpha_k, \beta_k, \gamma_k$ be complex roots (with multiplicity) of the cubic equation $\left(x-\frac{1}{k-1}\right)\left(x-\frac{1}{k}\right)\left(x-\frac{1}{k+1}\right)=\frac{1}{k}$.

Then $\sum_{k=2}^{\infty}\left(\frac{\alpha_k\beta_k\gamma_k(1+\alpha_k)(1+\beta_k)(1+\gamma_k)}{k+1}\right)$ equals

(A) $\frac{21}{67}$

(B) $\frac{27}{16}$

(C) $\frac{26}{17}$

(D) $\frac{61}{27}$

2) If $f(n)=\int_0^{2025}\left(\frac{2025-x}{x}\right)^n\frac{dx}{2025-x}\ \forall n\in(0,2)$ and f(n) is differentiable in (0, 2), then $f'\left(\frac{1}{2}\right)$ is :

(A) $-\frac{\pi}{2}$

(B) $\frac{\pi}{2}$

(C) $\frac{1}{2}$

(D) 0

3) If P denotes the number of points of intersection of $y^2 = 7x$ and $x^2 + y^2 - 4x + 2 = 0$, then value of $\lim_{x\to p}\frac{x\sin(\sin x)-\sin^2 x}{x^6}$, is

(A) $\frac{1}{6}$

(B) $\frac{1}{18}$

(C) $\frac{1}{12}$

(D) $\frac{1}{24}$

4) If $\vec{a}, \vec{b}, \vec{c}$ are unit vectors satisfying $\left|\vec{a}-\vec{b}\right|^2+\left|\vec{b}-\vec{c}\right|^2+\left|\vec{c}-\vec{a}\right|^2=9$ then

$\left|2\vec{a}+\vec{b}+\vec{c}\right|+\left|\vec{a}+2\vec{b}+\vec{c}\right|+\left|\vec{a}+\vec{b}+2\vec{c}\right|$ equals

(A) 5

(B) 0

(C) 3

(D) 1

SECTION-I (ii)

1) Consider ellipse $E:\dfrac{x^2}{4}+y^2=1$.

$A = \{ (\ell, m) \in Z \times Z \mid \ell x + my + 1 = 0 \text{ is tangent to } E\}$
$L = \{ (\ell, m) \in Z \times Z \mid \ell x + my + 1 = 0 \text{ is normal to } E\}$
$E = \{ (\ell, m) \in R \times Z \mid \ell x + my + 1 = 0 \text{ is tangent to } E\}$
$N = \{ (\ell, m) \in Z \times R \mid \ell x + my + 1 = 0 \text{ is normal to } E\}$

If |X| denotes number of elements in set X then which is of the following is / are TRUE ?

(A) $|A| = 2$

(B) $|L| = 0$

(C) $|E| = 3$

(D) $|N| = 2$

2) Let $f : R \to (0, 1)$ be continuous function. Then which of the following function (s) has (have) the value zero at some point in interval (0, 1) ?

(A) $e^{2025x}-\displaystyle\int_0^{x^2}\left((f(t))^3\sin t\right)dt$

(B) $x^{2025}-\dfrac{f(x)}{e^x+\sin(2025x)+1}$

(C) $f(x)+\displaystyle\int_0^{\frac{\pi}{4}}f(t)\sin t\,dt$

(D) $x^{2025}-\displaystyle\int_0^{\frac{\pi}{2}-x}(f(t))^2\cos t\,dt$

3) Let g(x) be a polynomial of degree 2024 and $f(x)=\begin{cases}g\left(\frac{1}{x^5}\right)e^{-\frac{1}{x^6}}, & x\neq 0\\ 0, & x=0\end{cases}$ then

(A) f(x) is continuous at x = 0

(B) f(x) is non-differentiable at x = 0

(C) $f'(0)=\lim\limits_{x\to 0}f(x)$

(D) $\lim_{x \to 0} f(x)$ does not exist

SECTION-II (i)

Common Content for Question No. 1 to 2

Consider set of Martices 'S' as follows :

$$S = \left\{ \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}, \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}, \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}, \begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} \right\}$$

$T = \{(A, B) \in S \times S \ : \ |I - AB| = |I - BA|\}$

$R = \{(A, B) \in S \times S \ : \ AB - BA = I\}$

If ||X|| denotes number of elements in set X.

|Y| denotes determinant of matrix Y.

I denotes identify matrix.

Then answer the following

1) ||T|| is / are

2) ||R|| is / are

Common Content for Question No. 3 to 4

Consider the following sets of complex numbers

$S = \left\{ Z = a + ib \ : \ |z+2|^2 + |z-2|^2 < 50 \right\}$

$T = \{ Z = a + ib \ : \ (a, b) \in I^+ \times I^+ \}$

$P = \left\{ Z : \left| z^3 + 2 - 2i \right| + \ z\bar{z}\ |z| = 2\sqrt{2} \right\}$

{ Note : I^+ denotes set of positive integers, |z| , $\bar{z}$ denotes modulus and conjugate of complex number z respectively}

Then

3) | S ∩ T | is

4) | P ∩ T | is

(Here |X| denotes number of elements in set X}

SECTION-II (ii)

1) The ellipse with foci F_1 and F_2 passes through A, B, C, D. If ABF_1CDF_2 is a regular hexagon and eccentricity of ellipse is e. Then $e^2 + 2e + 1$ is ....

2) The curve which passes through $\left(-\frac{1}{16}, 1\right)$ and satisfies differential equation $\left(\log_e y^{y^2}\right) \frac{dy}{dx} - y = 2x\frac{dy}{dx}, (y > 0)$ is $16x + ay^2 = b\log_e y^{y^2}$ then value of a + b is

3) Let P_a, Q_b denotes family of planes as :

$$P_a : a\sqrt{2}x + \sqrt{2}y + z = \frac{a^2}{2}$$

$$Q_b : b\sqrt{2}y - z + b = \frac{1}{2}$$

Let V (a_1, a_2, b_1, b_2) denotes volume of the tetrahedron enclosed by planes $P_{a_1}, P_{a_2}, Q_{b_1}, Q_{b_2}$.

Then $\left|V\left(\sqrt{3}, -\sqrt{3}, 2, 0\right)\right|^2$ is

4) There is a test for the HMPV virus that is 99% accurate. In other words, if someone has the HMPV virus and undergoes the test, there is a 99% chance that the test will show positive and 1% percent chance that the test will show negative and if someone does not have it and undergoes the test then there is a 99% chance that test will show negative and 1% chance that test will show positive. Assume that 1% of the general population has the HMPV virus. Given an individual has tested positive from test. If the probability that the individual actually has the HMPV virus is P then [33 P] is ([.] represents G.I.F)

5) The parabola $f(x) = x^2$ intersects the graph of $g(x) = x^4 + ax^3 - 2x^2 + bx + 1$ at four distinct points. If these four points lie on a circle, the value of 2025 ab is

6) Number of solutions of the trigonometric equation $5\left(\sin x + \frac{\cos 3x + \sin 3x}{1 + 2\sin 2x}\right) = \cos 2x + 3$, lying in the interval [0, 2π], is

ANSWER KEYS

PART-1 : PHYSICS

SECTION-I (i)

Q.	1	2	3	4
A.	**D**	**C**	**A**	**D**

SECTION-I (ii)

Q.	5	6	7
A.	**A,C**	**B**	**A,B**

SECTION-II (i)

Q.	8	9	10	11
A.	**0.50**	**1.41**	**0.10**	**0.40**

SECTION-II (ii)

Q.	12	13	14	15	16	17
A.	**4**	**1**	**3**	**0**	**4**	**32**

PART-2 : CHEMISTRY

SECTION-I (i)

Q.	18	19	20	21
A.	**B**	**C**	**D**	**C**

SECTION-I (ii)

Q.	22	23	24
A.	**B,D**	**A,C**	**A,D**

SECTION-II (i)

Q.	25	26	27	28
A.	**10.40**	**4.00**	**36.00**	**11.70**

SECTION-II (ii)

Q.	29	30	31	32	33	34
A.	**4**	**6**	**2**	**4**	**8**	**12**

PART-3 : MATHEMATICS

SECTION-I (i)

Q.	35	36	37	38
A.	**B**	**D**	**B**	**C**

SECTION-I (ii)

Q.	39	40	41
A.	**A,B**	**B,D**	**A,C**

SECTION-II (i)

Q.	42	43	44	45
A.	**36.00**	**0.00**	**13.00**	**1.00**

SECTION-II (ii)

Q.	46	47	48	49	50	51
A.	**3**	**5**	**3**	**16**	**0**	**2**

SOLUTIONS

PART-1 : PHYSICS

1) $I = \frac{6}{15} = \frac{2}{3} = 0.4$

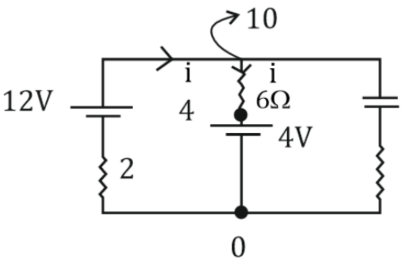
$\frac{q^2}{2 \times 2 \times 10^{-6}} = \frac{1}{2} \times 2 \times 0.16$

$q^2 = 4 \times 0.16 \times 10^{-6}$

$q^2 = 0.64 \times 10^{-6}$

$q = 0.8 \times 10^{-3}$

5) At $t \to \infty$



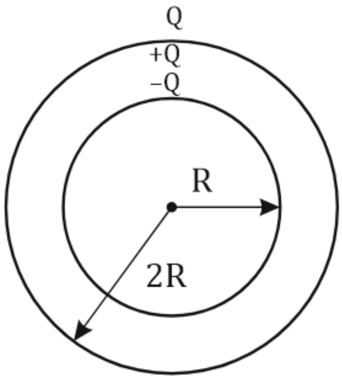
$i = \frac{8}{8} = 1A$

q = 10 × 10

= 100 μC

$C_1 = \frac{\epsilon_0 A}{d - t + \frac{t}{k}} = \frac{\epsilon_0 A}{d - \frac{d}{3} + \frac{d}{3 \times 2}} = \frac{\epsilon_0 A}{\frac{2d}{3} + \frac{d}{6}}$

$C_1 = \frac{6\epsilon_0 A}{5d} = 12\mu F$



6)

$U_1 = \frac{Q^2}{8\pi\epsilon_0 (2R)}$

$U_2 = \frac{Q^2}{2 \times 4\pi \frac{\epsilon_0 2R^2}{R}} = \frac{Q^2}{16\pi\epsilon_0 R}$ (between the shells)

$U_2 = \frac{Q^2}{2 \times 4\pi\epsilon_0 2R} = \frac{Q^2}{16\pi\epsilon_0 R}$

9) Conserve angular momentum

$$\frac{mR^2}{2}\omega_0 + \frac{mR^2}{4}\omega_0 = \left(\frac{mR^2}{2} + mR^2\right)\omega$$

Conserve energy $\omega = \frac{\omega_0}{2}$

$$\frac{1}{2} \times \frac{mR^2}{2}\omega_0^2 + \frac{1}{2}\frac{mR^2}{4}\omega_0^2 = \frac{1}{2}k\left(\frac{R}{2}\right)^2 + \frac{1}{2}\frac{3mR^2}{2}\omega^2 + \frac{1}{2}mv_r^2$$

$$V_r = \frac{\omega_0 R}{2}$$

$$V_t = \frac{\omega_0}{2} \times R$$

$$\therefore V_{net} = \frac{\omega_0 R}{2}\sqrt{2}$$

10) $\beta = \frac{\lambda f}{d} = \frac{5 \times 10^{-7} \times 20 \times 10^{-2}}{1 \times 10^{-3}} = 0.1\text{ mm}$

11) $n_1 B_1 = n_2 B_2$

$$n_1 \times \frac{4000f}{d} = n_2 \times \frac{5000f}{d}$$

$\Rightarrow \frac{n_1}{n_2} = \frac{5}{4}$ or $n_1 = 5 \& n_2 = 4$

$\Rightarrow$ distance 0.4 mm

13) Use angular momentum conservation and energy conservation.

$$\Rightarrow \left(\frac{1 \times R^2}{2}\right)\omega = (1.5) \times V \times R \text{ .... (i)}$$

$$\frac{1}{2} \times 1.5 \times (2)^2 = \frac{1}{2} \times \left(\frac{1 \times R^2}{2}\right) \times \left(\omega^2\right) + \frac{1}{2} \times 1.5 \times V^2 \text{ .... (ii)}$$

14) $\lambda = \frac{h}{\sqrt{2meV}}$

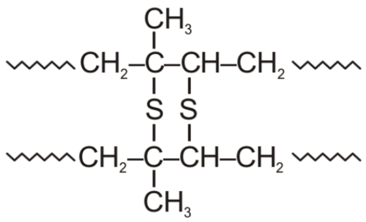
$$\beta \Rightarrow \frac{D\lambda}{d}$$

$$\Rightarrow \frac{109.2 \times 10^{-2}}{66.3 \times 10^{-6}} \times \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 45.5}} = 3$$

PART-2 : CHEMISTRY

18)

A. Natural rubber is a linear Cis-1, 4-polyisoprene and Empirical formula is C_5H_8
B. Gutta-Percha rubber is formed via 1,4-addition
C. Vulcanized rubber contains sulphur cross links at the reactive sites of double bonds



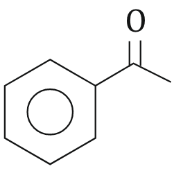
- $NaSCN_{(aq)} + Na \xrightarrow{\Delta} NaCN_{(aq)} + Na_2S_{(aq)} \xrightarrow{Pb(CH_3COO)_2} \underset{(black)}{PbS\downarrow}$

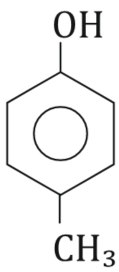
19) • Lysine is a basic and essential amino acid

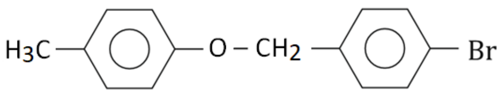
20) $\underset{(Orange)}{(NH_4)_2Cr_2O_7} \xrightarrow{\Delta} N_2\uparrow + \underset{(green)}{Cr_2O_3\downarrow} + H_2O$

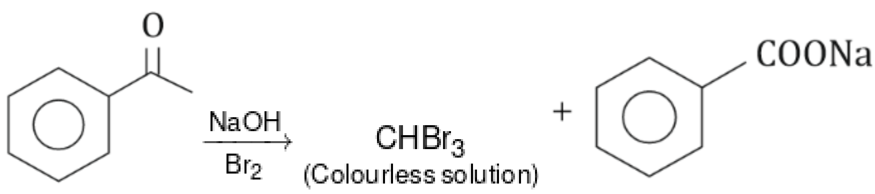
21) $K_2Cr_2O_7 + 2FeC_2O_4 + 7H_2SO_4 \rightarrow$
$K_2SO_4 + Fe_2(SO_4)_3 + 4CO_2 + Cr_2(SO_4)_3 + 7H_2O$

22)

(P) is 

(Q) is 

(R) is 



23)

A. $E^0_{Ag^+/Ag} > E^0_{[Ag(NH_3)_2]^+/Ag, NH_3}$

 $AgNO_{3(aq)}$ is a S.O.A than Tollen's reagent

A. $$E_{OX} = E^0_{OX} - \frac{0.06}{2}\log\frac{[C_6H_{12}O_7]\,[H^+]^2}{[C_6H_{12}O_6]}$$

if $pH\downarrow\ \Rightarrow [H^+]\uparrow$

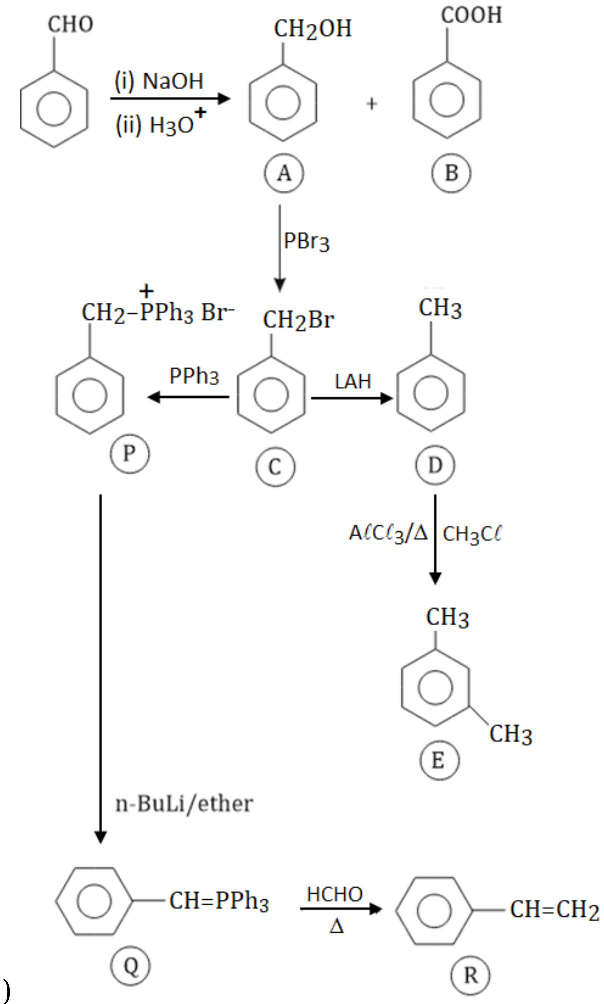
$\Rightarrow E_{OX}\downarrow$ but E^0_{OX} remain same

24) $Cr_2(SO_4)_3 \xrightarrow[OH^-]{H_2O_2} \underset{\text{(yellow solution)}}{CrO_4^{2-}}$

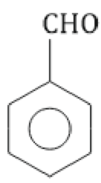
$MnO_2 \xrightarrow[H^+]{H_2O_2} Mn^{2+}$

$PbO_2 \xrightarrow{H_2O_2} PbO$

$NH_2OH \xrightarrow{H_2O_2} HNO_3$

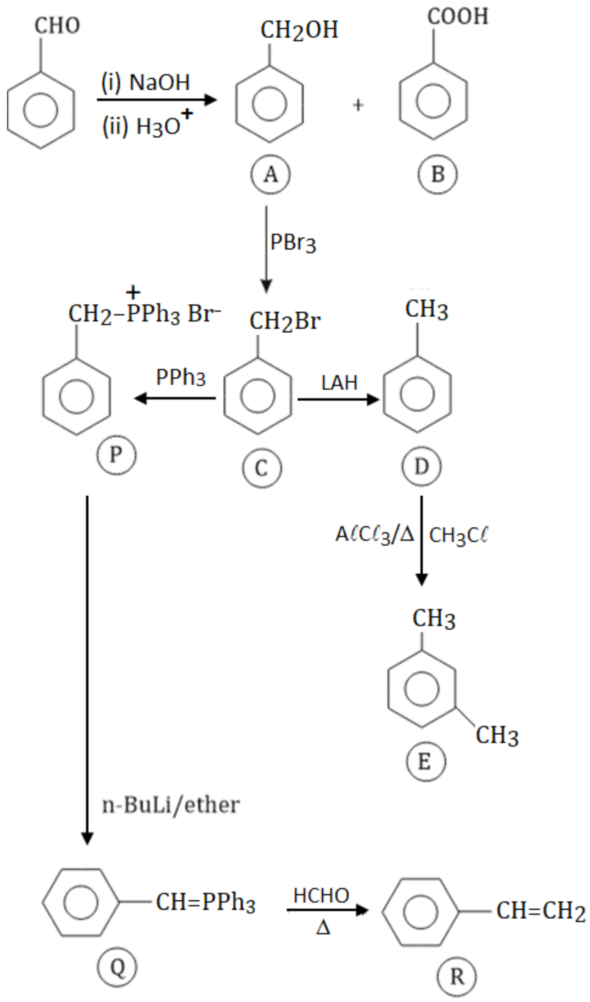


25)

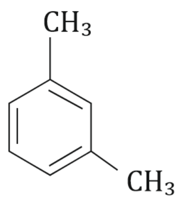


$\underset{(1\text{ mole})}{} \xrightarrow{100\%} \underset{(0.5\text{ mole})}{(A)} \xrightarrow{80\%} \underset{(0.4\text{ mole})}{(C)} \xrightarrow{50\%} \underset{(0.2\text{ mole})}{(P)} \xrightarrow{100\%} \underset{(0.2\text{ mole})}{(Q)} \xrightarrow{50\%} \underset{(0.1\text{ mole})}{(R)}$

 mass of (R) = 0.1 × 104 = 10.4 g



26)



E is
1,3-dimethyl benzene

27) $\underset{(P)}{SO_3^{2-}} \xrightarrow{Zn+NaOH} \underset{(Q)}{H_2S}$

$Na_2S \xrightarrow{Na_2[Fe(CN)_5(NO)]} \underset{(R)}{Na_4[Fe(CN)_5(NOS)]}$

E.A.N = 26 – 2 + 6 × 2 = 36

28) $\underset{(Q)}{H_2S} \xrightarrow{NaOH} \underset{(S)}{NaHS} \xrightarrow{NaOH} \underset{(T)}{Na_2S}$

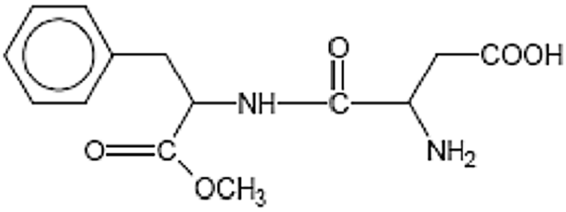
$H_2S + Na_2S \quad \rightarrow \quad 2NaHS$

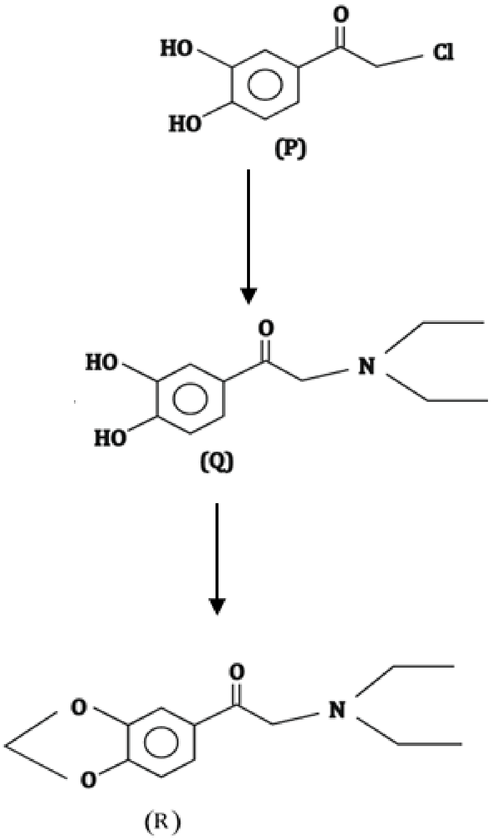
moles at t = 0 : 1 3 2
final no.of moles : ~0 ~2 ~4

$\therefore$ $pH = p^{Ka_2} + \log\frac{[S^{2-}]}{[HS^-]}$

$$= 12 + \log\left(\frac{2}{4}\right)$$

$= 12 - 0.3 = 11.70$

29) 

30) 

31) $2.3\log(k) = 2.3 \times 5.4 - \frac{100 \times 2.3}{T} + 2.5 \times 2.3\log(T)$

$$\ln(k) = 2.3 \times 5.4 - \frac{230}{T} + 2.5\ln(T)$$

$$\frac{d}{dT}(\ln k) = \frac{230}{T^2} + \frac{2.5}{T}$$

$$= \frac{230 + 2.5T}{T^2}$$

But $\frac{d}{dT}(\ln k) = \frac{E_a}{RT^2}$

$\therefore \frac{E_a}{R} = 230 + 2.5T$

$\Rightarrow E_a = (230 + 2.5 \times 300)R$

= 980 × 2 = 1960 cal/mol

32) $\left[Pb(EDTA)^{-2}\right]$ exists in two forms (d &) and $Pt(NH_3)_2Cl_2$ have two stereoisomer

33) Except NO_2 - acidic , Li_2O - basic, CO_2 - acidic

34) π = i. CST
0.015 ST = i (0.01) ST
⇒ i = 1.5
∴ α = 0.5
$[OH^-] = C.\alpha = 5 \times 10^{-3} M$
pOH = 2.3
 pH = 11.7

PART-3 : MATHEMATICS

35) Let $P(x) = \left(x - \frac{1}{k-1}\right)\left(x - \frac{1}{k}\right)\left(x - \frac{1}{k+1}\right) - \frac{1}{k}$
$= (x - \alpha_k)(x - \beta_k)(x - \gamma_k)$
$\Rightarrow -P(0) = \alpha_k \beta_k \gamma_k$ and
$-P(1) = (1 + \alpha_k)(1 + \beta_k)(1 + \gamma_k)$
Hence given expression
$$= \sum_{k=2}^{\infty}\left(\frac{k^2 + 3k - 1}{k(k-1)(k+1)} \cdot \frac{k}{k^2 - 1}\right)$$
$$= \sum_{k=2}^{\infty}\frac{k^2 + 3k - 1}{(k-1)^2(k+1)^2}$$
$$= \sum_{k=2}^{\infty}\left(\frac{\frac{1}{2}}{k-1} - \frac{\frac{1}{2}}{k+1}\right) + \left(\frac{\frac{3}{4}}{(k-1)^2} - \frac{\frac{3}{4}}{(k+1)^2}\right)$$
$$= \frac{1}{2}\left(1 + \frac{1}{2}\right) + \frac{3}{4}\left(\frac{1}{1^2} + \frac{1}{2^2}\right) = \frac{27}{16}$$

36) $f(n) = \int_0^{2025}\left(\frac{x}{2025 - x}\right)^n \frac{dx}{x}$
$$f(1-n) = \int_0^{2025}\left(\frac{2025 - x}{x}\right)^{n-1}\frac{dx}{x}$$
$f(1-n) = f(n) \Rightarrow f'(n) = -f'(1-n)$
$f'\left(\frac{1}{2}\right) = 0$

37) $L = \lim_{x \to 0}\frac{\sin^2 x}{x^2}\left[\frac{x\sin(\sin x)}{\sin^2 x} - 1\right]\frac{1}{x^4}$

$$= \lim_{x \to 0} \frac{1}{x^4}\left[\frac{x}{\sin x}\left\{1 - \frac{\sin^2 x}{6} + \frac{\sin^4 x}{120}\right\} - 1\right]$$

$$= \lim_{x \to 0} \frac{1}{x^4} \frac{\left(1 - \frac{\sin^2 x}{6} + \frac{\sin^4 x}{120} + \ldots\ldots\right) - \left(1 - \frac{x^2}{6} + \frac{x^4}{120} \ldots\right)}{1 - \frac{x^2}{6} + \ldots\ldots}$$

$$= \lim_{x \to 0} \frac{1}{x^4}\left[-\frac{x^2}{6}\left(1 - \frac{x^2}{6} + \ldots\ldots\right)^2 + \frac{x^4}{120} + \frac{x^6}{6} - \frac{x^4}{120} + \ldots\ldots\right]$$

$$= \lim_{x \to 0} \frac{1}{x^4}\left[\frac{x^4}{18} + \ldots\ldots\right] = \frac{1}{18}$$

38) Since $\vec{a}\,.\,\vec{b} + \vec{b}\,.\,\vec{c} + \vec{c}\,.\,\vec{a} = -\frac{3}{2}$

$\Rightarrow \left(\vec{a} + \vec{b} + \vec{c}\right)^2 = a^2 + b^2 + c^2 + 2\left(\vec{a}\,.\,\vec{b} + \vec{b}\,.\,\vec{c} + \vec{c}\,.\,\vec{a}\right)$

$= 0$

$\Rightarrow \vec{a} + \vec{b} + \vec{c} = 0$

$\left|2\vec{a} + \vec{b} + \vec{c}\right| = \left|\vec{a}\right| = 1$ and so on.

39) For $\ell x + my + n = 0$ to be tangent to E : $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$

We have $a\ell^2 + bm^2 = n^2$.

Hence $4\ell^2 + m^2 = 1 \Rightarrow \ell = 0$, $m = \pm 1$ (Integer Sol)

Similarly for $\ell x + my + n = 0$ to be normal to E we have $\frac{a^2}{\ell^2} + \frac{b^2}{m^2} = \frac{\left(a^2 - b^2\right)}{n^2}$

$\Rightarrow \frac{4}{\ell^2} + \frac{1}{m^2} = 9$

40) (A) Let

$$g(x) = \underbrace{e^{2025x}}_{>1} - \underbrace{\int_0^{x^2}\left((f(t))^3 \sin t\right) dt}_{\leqslant 1} \qquad \forall x \in (0, 1)$$

So $g(x) > 0 \;\; \forall\, x \in (0, 1)$

Hence No zeroes

(B) Let $g(x) = x^{2025} - \frac{f(x)}{e^x + \sin(2025x) + 1}$

Then $g(0) = 0 - \frac{f(0)}{2} < 0$

Since $f(0) > 0$ while

$g(1) = 1 - \frac{f(1)}{e + 1 + \sin(2025)} > 0$

Since $\frac{f(1)}{e + 1 + \sin 2025} < 1$

So by I.V.P. Since g is continuous in (0, 1) and we at least one zero in (0, 1)

(C) Let $g(x) = f(x) + \int_0^{\frac{\pi}{4}} f(t)\ \sin t\, dt$

Since $f(x) \in (0,1)$ and f(t) sin t > 0 for $t \in \left(0, \frac{\pi}{4}\right)$ hence g > 0 ∀ x ∈ (0, 1). So, No Root

(D) Let $g(x) = x^{2025} - \int_0^{\frac{\pi}{2}-x} (f(t))^2 \cos t\, dt$

$g(0) = 0 - \int_0^{\frac{\pi}{2}} \underbrace{f(t)^2 \cos t\, dt}_{\geqslant 0} < 0$

$g(1) = 1 - \int_0^{\frac{\pi}{2}-1} \underbrace{f(t)^2 \cos t\, dt}_{<1} > 0$

So by I.V.P there exists at least one zero in (0, 1)

41) $f(x) = g\left(\frac{1}{x^5}\right) e^{-\frac{1}{x^6}}$

$\lim_{x\to 0} f(x) = \lim_{x\to 0} \frac{g\left(\frac{1}{x^5}\right)}{e^{\frac{1}{x^6}}}$

$= \lim_{t\to\infty} \frac{g\left(t^5\right)}{e^{t^6}} = 0$

$f'(x) = \lim_{x\to 0} \frac{f(x) - f(0)}{x}$

$= \lim_{x\to 0} \frac{g\left(\frac{1}{x^5}\right) e^{-\frac{1}{x^6}}}{x} = \lim_{x\to 0} \frac{g\left(\frac{1}{x^5}\right)}{x e^{\frac{1}{x^6}}}$

$= \lim_{t\to\infty} \frac{t g\left(t^5\right)}{e^{t^6}} = 0$

⇒ f(x) is continuous and differentiable at x = 0

42) | I – AB| = | I – BA| ∀ A, B if both are square matricy of same order.
Hence ||T|| = 6 × 6 = 36
(2) ||R|| = 0 since T_r (AB – BA) = T_r (AB) – T_r (BA) = 0 but Tr (I) = 3
R is an empty set

43) | I – AB| = | I – BA| ∀ A, B if both are square matricy of same order.
Hence ||T|| = 6 × 6 = 36
(2) ||R|| = 0 since T_r (AB – BA) = T_r (AB) – T_r (BA) = 0 but Tr (I) = 3
R is an empty set

44) Put z = a + ib we get $(z+2)(\bar{z}+2) + (2-z)(2-\bar{z}) < 50$
$\Rightarrow 8 + 2|z|^2 < 50$
$\Rightarrow a^2 + b^2 < 21$
Cases :

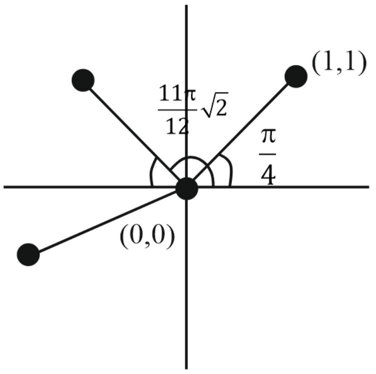
a = 1, b = 1, 2, 3, 4
a = 2 , b = 1, 2, 3, 4
a = 3, b = 1, 2, 3
a = 4, b = 1 , 2
So total (a, b) pairs are 13.
Hence | S ∩ T | = 13

45) $\left|z^3+2-2i\right|+\left|z^3\right|=2\sqrt{2}$

Let u = z^3 ⇒ | u – (–2 + 2i) | + |u| = $2\sqrt{2}$

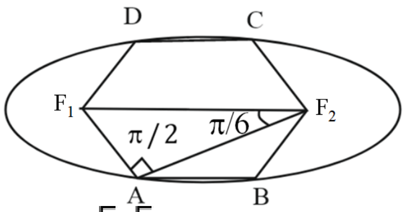
Hence u lies on line segment joining 0 and $\sqrt{8}\,e^{\frac{i3\pi}{4}}$

By De-moivre's theorem z lies on the three line segment joining origin (0) to $\sqrt{2}\,e^{\frac{i\pi}{4}}$, $\sqrt{2}\,e^{\frac{i11\pi}{12}}$, $\sqrt{2}e^{i\frac{19\pi}{12}}$



So | P ∩ T | = 1

46) Let C = F_1F_2



$e=\dfrac{F_1F_2}{AF_1+AF_2}$

$=\dfrac{2C}{C\left(\sqrt{3}+1\right)}$

$=\sqrt{3}-1$

47) $y\dfrac{dx}{dy}+2x=y^2\ln y$

$\dfrac{dx}{dy}+\left(\dfrac{2}{y}\right)x=y\ln y$

$I.F=e^{\int\frac{2}{y}}=y^2$

$\Rightarrow y^2x=\int(y\ \ln\ y)\,y^2dy$

$xy^2=\dfrac{y^4(\ln y)}{4}-\dfrac{y^2}{16}+c$

Curve passes through $\left(-\frac{1}{16}, 1\right) \Rightarrow c = 0$

$\Rightarrow x = \frac{y^2 \ln y}{4} - \frac{y^2}{16}$

$\Rightarrow 16x + y^2 = 4y^2 \ln y$

a = 1 , b = 4

48) $P_{\sqrt{3}} : \sqrt{6}x + \sqrt{2}y + z = \frac{3}{2}$

$P_{-\sqrt{3}} : -\sqrt{6}x + \sqrt{2}y + z = \frac{3}{2}$

$Q_2 : 2\sqrt{2}y - z = -\frac{3}{2}$

$Q_0 : z = \frac{-1}{2}$

We can blindly solve for vertex and find volume but there is a nicer way below :

Notice that all planes are at 1/2 unit from origin also angle between any two pairs is $\cos^{-1}$ (1/3).

That is feel of regular tetrahedron.

We need just two point of intersection which is $\left(\sqrt{\frac{3}{2}}, \frac{-1}{\sqrt{2}}, \frac{-1}{2}\right)$ and $\left(-\sqrt{\frac{3}{2}}, \frac{-1}{\sqrt{2}}, \frac{-1}{2}\right)$

Volume $= \frac{1}{3} \times A \times h = \frac{1}{3} \times \frac{\sqrt{3}}{4} \times \left(\sqrt{6}\right)^2 \times \sqrt{6}.\ \sqrt{\frac{2}{3}}$

49) Let $T^{+/-}$ indicate the test result and $B^{+/-}$ indicate whether the person actually does or does not have virus. The probability that someone has the virus, given that their test is positive, is equal to the probability that a given person tests positive and has it over the total probability of testing positive,

In statistical notation.

$$P\left(B^{+}/T^{+}\right) = \frac{P\left(T^{+}/B^{+}\right) . P\left(B^{+}\right)}{P\left(T^{+}/B^{+}\right) . P\left(B^{+}\right) + P\left(T^{+}/B^{-}\right) . P\left(B^{-}\right)}$$

$$= \frac{(0.99)(0.01)}{(0.99)(0.01) + (1 - 0.99).(1 - 0.01)}$$

= 1/2

50) Suppose the equation of the circle is

$(x-h)^2 + (y-k)^2 = r^2$

Since it intersects with the graph $f(x) = x^2$, the above equation be rewritten as

$(x-h)^2 + \left(x^2 - k\right)^2 = r^2$

Note that the coefficient of x^3 of above quartic equation is 0.

Let the x-coordinates of 4 intersection points be α_1, α_2, α_3 and α_4 . Then $\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 = 0$.

On the other hand, from $g(x) = x^4 + ax^3 - 2x^2 + bx + 1$, the sum of roots is $-\frac{a}{1}$. So a = 0 and hence 2025 ab = 0.

51) We have

$5(\sin x + 2\sin 2x \sin x + \cos 3x + \sin 3x) = (1 + 2\sin 2x)(3 + \cos 2x)$

$\Rightarrow 5(\sin x + \cos x - \cos 3x + \cos 3x + \sin 3x) = (1 + 2\sin 2x)(3 + \cos 2x)$
$\Rightarrow 5(\cos x + 2\sin 2x \cos x) = (1 + 2\sin 2x)(3 + \cos 2x)$
$\Rightarrow 5\cos x(1 + 2\sin 2x) = (1 + 2\sin 2x)(3 + \cos 2x)$

 Either (1 + 2 sin 2x) = 0

$\Rightarrow \sin 2x = \frac{-1}{2}$ (Not possible)

or $5\cos x = 3 + \cos 2x = 3 + 2\cos^2 x - 1$

$\Rightarrow 2\cos^2 x - 5\cos x + 2 = 0$
$\Rightarrow 2\cos^2 x - 4\cos x - \cos x + 2 = 0$
$\Rightarrow 2\cos x(\cos x - 2) - (\cos x - 2) = 0$

$\Rightarrow \cos x = 2$ or $\cos x = \frac{1}{2}$ (But cos x ≠ 2)

 $x = \frac{\pi}{3}$ or $\frac{5\pi}{3}$

As x ∈ [0, 2π], so we have only 2 solutions.