UNWAL PACIFIC
Foundation | IIT-JEE | Medical | Repeater

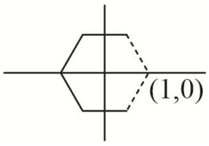
KVPY SX | SOLUTIONS

Part-1: Mathematics

1.(A) $S_1 : \lim\limits_{n\to\infty} \dfrac{2^n + (-2)^n}{2^n}$ can be 0 or 2 so does not exist.

$S_2 : \lim\limits_{n\to\infty} \dfrac{3^n + (-3)^n}{4^n} = 0$ exists.

2.(A) Consider the roots of $z^{10} - 1 = 0$



$z^9 + z^8 + ... + z^2 + z + 1 = (z - z_1)(z - z_2)...(z - z_9)$

Put $z = 1$ and take modulus $10 = |1 - z_1||1 - z_2|...|1 - z_9|$

3.(B) Let $I = \displaystyle\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{\sin^2 x}{1+e^x} dx$

$$I = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{\sin^2 x}{1+e^{-x}} dx = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{e^x \sin^2 x}{1+e^x} dx$$

$$2I = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin^2 x\, dx = 2\int_0^{\frac{\pi}{2}} \sin^2 x\, dx = I = \int_0^{\frac{\pi}{2}} \sin^2 x\, dx = \frac{\pi}{4}$$

4.(A) Consider $g(x) = e^{-\lambda x} f(x)$. It can be seen that g is continuous in $[0, 2\pi]$ and g is differentiable in $(0, 2\pi)$ & $g(0) = g(2\pi)$. Using Rolle's Theorem $C \in (0, 2\pi) : g'(c) = 0$

or $e^{-\lambda C} f'(c) - \lambda e^{-\lambda C} f(c) = 0$ which is true for any value of λ, so $\lambda \in \mathbb{R} \Rightarrow f'(c) = \lambda f(c)$.

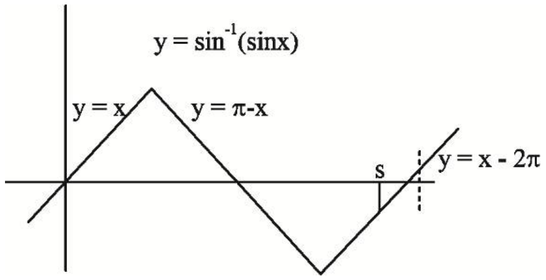
5.(C) $\tan 60 = \dfrac{h + 60\sqrt{3}}{x}$, $\tan 45° = \dfrac{h}{x}$; $h = x$

$\sqrt{3}x = x + 60\sqrt{3}$

$$x = \frac{60\sqrt{3}}{\sqrt{3}-1} = \frac{60\sqrt{3}\left(\sqrt{3}+1\right)}{2} = 30\left(3+\sqrt{3}\right)$$

Height $= 60\sqrt{3} + 30\sqrt{3} + 90 = 90\left(1+\sqrt{3}\right)$

6.(A) $\sin^{-1}(\sin 1 \cos 4 + \cos 1 \sin 4) = \sin^{-1}\sin(1+4) = \sin^{-1}(\sin 5)$



$\therefore \sin^{-1}(\sin 5) = 5 - 2\pi$

The integer closest to it is -1.

7.(B) $f(x) = e^x + x\ln x$ on $1 \le x \le 2$

$f'(x) = e^x + 1 + \ln x > 0 \ \forall \ x \in (1,2)$

So f is strictly increasing on (1, 2)

$\max\{f(x) : x \in [1,2]\} = f(2) = e^2 + 2\ln 2$

8.(C) Given that

$A = \begin{bmatrix} a & b \\ 1 & 1 \end{bmatrix}$ where

a and b are integers and A and A^{-1} contain integer entries; $-50 \le b \le 50$

(i) $a \ne b$ (for the matrix to be invertible)

(ii) $a - b \mid a$ & $a - b \mid b$

(iii) $a - b \mid 1$

$\Rightarrow |a-b| = 1 \quad \Rightarrow a = b+1 \ or \ a = b-1$

So for every value of b there are exactly two values of a.

There are 101 values of b, therefore there must be 202 values of a.

9.(B) Let C_{ij} denote the cofactor of a_{ij}

Then $(i,j)^{th}$ entry of A^{-1} is $\dfrac{C_{ij}}{|A|}$

Claim: For $1 \le i \le 3$,

$$\sum_{j=1}^{3} C_{ji} = |A|$$

Proof: $\sum_{j=1}^{3} C_{ji} = C_{1i} + C_{2i} + C_{3i} = (a_{11} + a_{12} + a_{13})\, C_{1i} + (a_{21} + a_{2_2} + a_{23})\, C_{zi} + (a_{31} + a_{32} + a_{33})\, C_{3i}$

$$= \sum_{u=1}^{3}\sum_{j=1}^{3} a_{kj} \cdot C_{kj}$$

Because $\sum_{j=1}^{3} a_{kj} \cdot C_{kj} = |A| \ for \ k = j \ = 0 \ k \ne i$

10.(C) $\log(x-2y)^2 = \log xy$

$(x-2y)^2 = xy$

$\left(\frac{x}{y}-2\right)^2 = \frac{x}{y}$

$(t-2)^2 = t$

$t^2 + 4 - 5t = 0$

$(t-4)(t-1) = 0$

$t = 4, \quad t = 1 \times \ \frac{x}{y} > 2$

$\frac{x}{y} = 4$

11.(C) $\angle F_1CB = 90°$

$F_1B = a + c$

$F_1C = a$

$BC = \sqrt{a^2 + b^2}$

In ΔF_1CB

$(F_1B)^2 = (a+c)^2 = a^2 + b^2 + a^2$

$c^2 + 2ac = (a+c)^2 = a^2 + b^2 + a^2$

$c^2 + 2ac = a^2 + b^2$

$2ac = 2b^2$

$a^2 e = b^2$

$e = b^2 / a^2$

$e^2 = 1 - e$

$e^2 + e - 1 = 0 \rightarrow e = \frac{-1+\sqrt{5}}{2}$

$e = \frac{\sqrt{5}-1}{2}$

12.(B) $x^3-[x]^3=(x-[x])^3$

$x^3-[x]^3=x^3-[x]^3-3x[x](x-[x])$

$3x[x](x-[x])=0$

$x=0\ or [x]=0 \quad x=[x]$

$x\in[0,1) \quad x\in I$

$x\in[0,1)\ \cup\{I\}$

13.(C) $\lim_{n\to\infty}\sum_{k=0}^{n}\frac{1}{\sqrt{n^2+n}}<S<\lim_{n\to\infty}\sum_{k=0}^{n}\frac{1}{\sqrt{n^2+0}}$

$\lim_{n\to\infty}\frac{1}{\sqrt{n^2+n}}<S<\lim_{n\to\infty}\frac{n}{n}$

$S=1$

14.(D) Say $x_1\neq x_2$, then
$|f(x_1)-f(x_2)|\geq|x_1-x_2|>0$
$\Rightarrow\ |f(x_1)-f(x_2)|>0$
$\Rightarrow\ f(x_1)\neq f(x_2)$, therefore *f* is one-one.
Since, *f* is one-one and continuous it must be strictly increasing or strictly decreasing. Without loss of generality assume that *f* is strictly increasing.
Since, $|f(x)-f(y)|\geq|x-y|$ for all $x,y\in\mathbb{R}$
$|f(x)-f(0)|\geq|x|\ \forall\ x$
$|f(x)|+|f(0)|\geq|f(x)-f(0)|\geq|x|\in x$
or $|f(x)|\geq|x|-|f(0)|\ \forall x$
Notice the value of *x* can be made arbitrarily large, therefore *f* does NOT have a bound.
So *f* takes all real values, *f* is onto.

15.(B) $f(x)=\begin{cases}\frac{x}{\sin x}, & x\in(0,1)\\ 1, & x=0\end{cases}$

$I_n=\sqrt{n}\int_0^{1/n} f(x)e^{-nx}dx$

To evaluate $\lim_{n\to\infty} I_n$

Notice $\frac{x}{\sin x}$ is increasing in (0,1), therefore

$1<\frac{x}{\sin x}<\frac{1}{\sin 1}$

$$\text{So, } \sqrt{n}\int_0^{1/n} 1\, e^{-nx}dx < \sqrt{n}\int_0^{1/n} f(x)e^{-nx}dx < \sqrt{n}\int_0^{1/n} \frac{1}{\sin 1}e^{-nx}dx$$

Applying limits and invoking sandwich theorem

$$\lim_{n\to\infty}\sqrt{n}\int_0^{1/n} e^{-nx}dx \le \lim_{n\to\infty} I_n \le \lim_{n\to\infty}\int_0^{1/n}\frac{1}{\sin 1}e^{-nx}\,dx$$

$$\lim_{n\to\infty}\frac{\sqrt{n}}{n}\left[1-\frac{1}{e}\right] \le \lim_{n\to\infty} I_n \le \frac{\sqrt{n}}{n}\frac{1}{\sin 1}\left[1-\frac{1}{e}\right]$$

$$0 \le \lim_{n\to\infty} I_n \le 0$$

$$\text{So, } \lim_{n\to\infty} I_n = 0$$

16.(B) $I = \int_0^3 \left((x-2)^4\sin^3(x-2)+(x-2)^{2019}+1\right)dx$

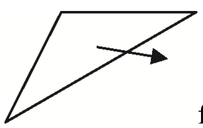
Let $x-2=t \Rightarrow dx = dt$

$$I = \int_{-1}^{1}\left(t^4\sin^3 t + t^{2019}+1\right)dt$$

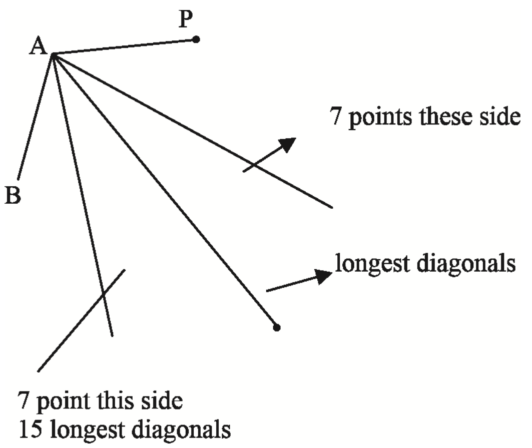
Notice if f is odd then $\int_{-a}^{a} f(t)\,dt = 0$

$$\Rightarrow\ I = \int_{-1}^{1} 1\,dt = 2$$

17.(A)



formed by joining by lining one vertices $\rightarrow$ 15 such diagonals



$$P(E) = \frac{{}^{15}C_2 - 15 - 15 - 15}{{}^{15}C_2 - 15} = \frac{105-45}{105-15} = \frac{60}{90} = \frac{2}{3}$$

18.(B) Given that $M=2^{30}-2^{15}+1$

$M^2=\left(2^{30}-2^{15}+1\right)^2=2^{60}+2^{30}+1-2^{46}-2^{16}+2^{31}$

$=\left\{\left(2^{60}-2^{46}\right)\right\}+\left\{\left(2^{31}\right)\right\}+\left\{\left(2^{30}-2^{16}\right)\right\}+1$

$=\left\{\left(2^{59}+2^{58}+2^{57}+\ldots+2^2+2+1+1\right)-\left(2^{45}+2^{44}+2^{43}+\ldots+2^2+2+1\right)\right\}+2^{31}+\left\{\left(2^{30}+2^{29}+2^{28}+\ldots+2^2+2+1+1\right)\right.$

$\left.-\left(2^{15}+2^{14}+\ldots+2^2+1+1\right)\right\}+1$

$=\underbrace{2^{59}+2^{58}+\ldots+2^{46}}_{14}+\underbrace{2^{31}}_{1}+\underbrace{2^{29}+2^{29}+\ldots+2^{16}}_{14}+\underbrace{1}_{1}$

There are in total $14+1+14+1=30$ 1s used in the representation of M^2.

19.(C) AD is angle bisector

$\frac{\sin\theta}{AD}=\frac{\sin\theta}{BD}\ldots(i)\ /\ \frac{\sin 2\theta}{AD}=\frac{\sin\alpha}{CD}\ldots(ii)$

$\frac{(i)}{(ii)}$

$\frac{1}{2\cos\theta}=\frac{CD}{BD}=\frac{9}{15}$

$\cos\theta=\frac{15}{18}=\frac{5}{6}$

Applying cosine rule

$\cos\theta=\frac{15^2+BC^2-9^2}{2\times 15\times BC}=\frac{5}{6}$

$BC^2+144=25BC$

$BC^2-25BC+144=0$

$\theta=45°$ not possible

$(BC-9)^2(BC-16)=0$

$\times \qquad BC=16$

$BC=\frac{15}{24}\times 16;\ \ BD=10cm$

20.(A) Say $Z=x+iy$

$\overline{Z}=x-iy$

$Z^2=x^2-y^2+2ixy$

$\overline{Z}^2=x^2-y^2-2ixy\ \&\ Z\overline{Z}=x^2+y^2$

$$10Z\overline{Z}-3\left(Z^2+\overline{Z}^2\right)+4i\left(Z^2-\overline{Z}^2\right)=0$$

$$10(x^2+y^2)-6(x^2-y^2)-16xy=0$$

or $x^2+4y^2-4xy=0$

$(x-2y)^2=0 \; or \; x=2y$

Which is a straight line.

Part-1: Physics

21.(A) Relative error is error in measured length to measured length. Student 'A' will report minimum error as he uses tape.

22.(B) External force slows the bicycle, hence Force applied by Road reduces the speed.

23.(A) By Conservation of energy,

$$\frac{-ke^2}{r}+\frac{1}{2}m_p v^2=0$$

$$v_P=\sqrt{\frac{2ke^2}{mr}}=\sqrt{\frac{2\times9\times19^9\times\left(1.6\times10^{-19}\right)^2}{1.6\times10^{-27}\times10\times10^{-2}}}\;\frac{1.6}{\sqrt{5}}=1.17\text{ m/s (A)}$$

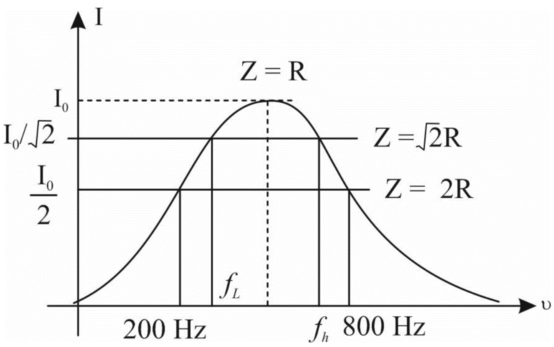
24.(B) $F=-kx^3$

Time period (T) is proportional to $\sqrt{\frac{m}{KA^2}}$

so when amplitude is 2A

Time period becomes T/2.

25.(B) Bandwidth $f_{bw}=f_h-f_L$



Given when Z = 2R

$\Rightarrow X_L-X_C=\sqrt{3}R$

$\Rightarrow 2LC\omega^2-\sqrt{3}RC\omega-1=0$

$2\pi(200+800)=\frac{\sqrt{3}R}{L}$ and $(2\pi)^2\times200\times800=\frac{-1}{LC}$

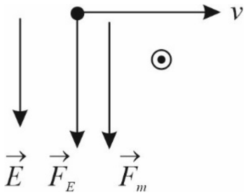
So when $Z=\sqrt{2}R \Rightarrow L\omega_b-\frac{1}{C\omega_b}=R$

$\Rightarrow$ Band width : $f_{b_w} = f_{b_h} - f_{b_\ell} = \left[\sqrt{\left(\frac{R}{L}\right)^2 - \left(\frac{1}{LC}\right)^2}\right]\frac{1}{2\pi}$

$\Rightarrow\ f_{b_h} - f_{\ell_h} = 200\sqrt{3}$ Hz after putting values and solving

26.(C) After electric field $\vec{E}$ and magnetic field $\vec{B}$ is switched on, Electric Force (F_E) and magnetic force (F_m) both acts downward.

So only neutral particles pass through 'P'



27.(B) Let the temperature of hot body be $T\,K$.

$\Rightarrow W = \int \eta\, dQ_H$

$= \int_{600}^{400}\left(1 - \frac{200}{T}\right)1dT$

$= 200 - 200\ell n\left(\frac{600}{400}\right)$

$W = 200\left[1 - \ell\text{n}\left(\frac{3}{2}\right)\right]$ (B)

28.(B) Let the intensity at distance 8km be I_1 and I_2 at distance 80m (at bottom)

$\Rightarrow\ 30dB = 10\log_{10}\left[\frac{I_1}{I_0}\right]$ ...(1)

and $L = 10\log_{10}\left(\frac{I_2}{I_0}\right)$ ...(2)

$\Rightarrow\ L - 30dB = 10\log_{10}\left[\frac{I_2}{I_1}\right]$

Now $I_1 = \frac{P}{4\pi(8000)^2}$ $\quad I_2 = \frac{P}{4\pi(80)^2}$

$\Rightarrow\ L = 30 = 10\log\left[\frac{(8000)^2}{(80)^2}\right]$

$\Rightarrow\ L - 30 + 10\log_{10}\left(10^4\right)$

= 30 + 40 = 70 dB (B)

29.(C) Charge supplied by battery : $Q = \frac{CE}{2}$

energy supplied by battery : $W_B = Q.E$

$$W_B = \frac{1}{2}CE^2$$

energy stored in capacitor : $U = \frac{1}{2}\frac{Q^2}{C}$

$\Rightarrow U = \frac{1}{2}\frac{(CE/2)^2}{C}$

$U = \frac{1}{8}CE^2$

Heat dissipated in 'R', $H = W - U_B$

$= \frac{1}{2}CE^2 - \frac{1}{8}CE^2 = \frac{3}{8}CE^2$

$\Rightarrow$ Ratio = $\frac{W_B}{U} = \frac{\frac{1}{2}CE^2}{\frac{3}{8}CE^2} = \frac{4}{3}$ (C)

30.(B) Electrostatic potential inside solid sphere

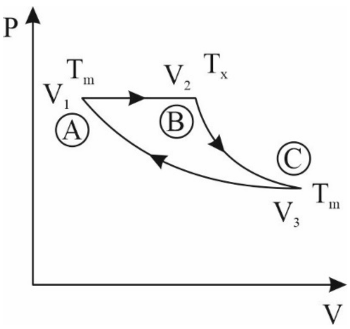
$V = \frac{1}{4\pi\in_0}\frac{Q}{2R^3}\left(3R^2 - r^2\right)$

$V = \frac{1}{4\pi\in_0}\frac{Q}{R}\left[\frac{3R^2}{2R^2} - \frac{r^2}{2R^2}\right]$

$V = \frac{1}{4\pi\in_0}\frac{Q}{R}\left[\frac{3}{2} - \frac{1}{2}\left(\frac{r}{R}\right)^2\right]$

$\Rightarrow a = \frac{3}{2}; b = -\frac{1}{2}; c = 2 (B)$

31.(B) Highest temperature will be at (B) and Lowest temperature will be along (AC)



A to B

$Q_{AB} = nC_p\left(T_x - T_m\right)$

$V_2 = T_x.\frac{V_1}{T_m}$

B to C

$Q_{BC} = O$ and $T_x V_2^{\gamma-1} = T_m V_3^{\gamma-1}$

$$V_2 = \left(\frac{T_m}{T_x}\right)^{\frac{1}{\gamma-1}}.V_3$$

$$\Rightarrow \frac{T_x}{T_m}V_1 = \left(\frac{T_m}{T_x}\right)^{\frac{1}{\gamma-1}}.V_3$$

$$\frac{V_1}{V_3} = \left(\frac{T_m}{T_x}\right)^{1+\frac{1}{\gamma-1}} = \left(\frac{T_m}{T_x}\right)^{\frac{\gamma}{\gamma-1}}$$

C to A

$$Q_{CA} = nRT_m.\ell n\left(\frac{V_1}{V_3}\right) = nRT_m \ell n\left(\frac{T_m}{T_x}\right)^{\frac{\gamma}{\gamma-1}}$$

$$Q_{CA} = nRT_m \frac{\gamma}{\gamma-1}\ell n\left(\frac{T_m}{T_x}\right)$$

$$W = Q_{AB} + Q_{BC} + Q_{CA}$$

$$W = n\frac{\gamma R}{\gamma-1}(T_x - T_m) + 0 + nR\frac{\gamma}{\gamma-1}T_m \ell n\left(\frac{T_m}{T_x}\right)$$

Given : $\frac{W}{Q_{AB}} = \frac{1}{2}$

$$\Rightarrow \left(1 + \frac{Q_{CA}}{Q_{AB}}\right) = \frac{1}{2}$$

$$\Rightarrow 1 + \frac{nR\frac{\gamma}{\gamma-1}T_m \ell n\left(\frac{T_m}{T_x}\right)}{nR\frac{\gamma}{\gamma-1}(T_x - T_m)} = \frac{1}{2}$$

$$\Rightarrow \ell n\left(\frac{T_m}{T_\lambda}\right) = -\frac{1}{2}\left(\frac{T_x - T_m}{T_m}\right)$$

$$\ell n\left(\frac{T_x}{T_m}\right) = \frac{1}{2}\left[\frac{T_x}{T_m} - 1\right]$$

$$\Rightarrow \ell n\ x = \frac{1}{2}[x-1]$$

$$\Rightarrow \ell n\ x^2 = \ell n\ e^{x-1}$$

$$\Rightarrow \boxed{x^2 = e^{x-1}}\ \text{(B)}$$

32.(A) At Prism – Liquid Interface.

$$\frac{\sin\theta_C}{\sin 90^\circ} = \frac{n_L}{n_P} \Rightarrow \sin\theta_C = \frac{C_A(1.5) + (1 - C_A)1.3}{1.5}$$

$\Rightarrow \sin\theta_C = \dfrac{2C_A + 13}{15}$

$\Rightarrow \theta_C = \sin^{-1}\left[\dfrac{2C_A + 13}{15}\right] \Rightarrow$ if $C_A = 0 \Rightarrow \theta_C = 60°$. So (A)

33.(D) Since Energy $E = -\dfrac{E_0}{n}$

$\Rightarrow KE \;\&\; PE$ are also proportional to $\dfrac{1}{n}$

$\Rightarrow PE = -\dfrac{K}{r} = -\dfrac{E_0}{n}$

$\Rightarrow \boxed{r \propto n}$

and $KE = \dfrac{1}{2}mv^2 \propto \dfrac{1}{n}$

$\Rightarrow \boxed{v \propto \dfrac{1}{\sqrt{n}}}$

Angular speed : $\omega = \dfrac{v}{r} \propto \dfrac{1}{\sqrt{n}.n}$

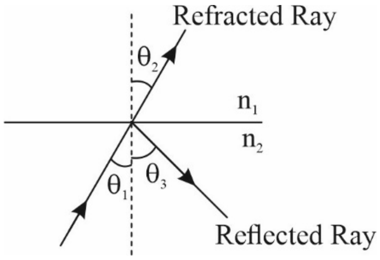
$\Rightarrow \boxed{\omega \propto \dfrac{1}{n^{3/2}}}$

Angular momentum : $L = mvr \propto \dfrac{1}{\sqrt{n}}.n$

$\Rightarrow \boxed{L \propto \sqrt{n}}$ (D)

34.(BCD)

Since $n_1 > n_2$



$\Rightarrow \dfrac{\sin\theta_C}{\sin 90°} = \dfrac{n_2}{n_1} \Rightarrow \sin\theta_C = \dfrac{n_2}{n_1}$

Ray goes from rarer to denser medium. So reflected and refracted ray will be present for all angles of θ_1

$\Rightarrow \theta_1 = \theta_3 \Rightarrow BCD$

There should be marks to all due to misprinting $n_1 > n_2$

35.(B) The maximum distance at which, detectors can be placed, will be the wavelength of modulation wave so.

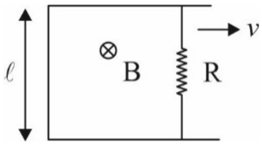
$f \times \lambda = C$

$10^9 \times \lambda = 3 \times 10^{+8}$

$\lambda = 0.3m$

$\lambda = 30$ cm Ans (B)

36.(D) Rate of heat dissipation in 'R' = $\dfrac{B^2\ell^2v^2}{R}$



So if speed is doubled, Rate of heating becomes 4 times (D)

37.(D) $T = P^a D^b S^c$ by dimensional analysis.

$\Rightarrow [T] = \left[ML^{-1}T^{-2}\right]^a \left[ML^{-3}\right]^b \left[MT^{-2}\right]^c$

$\Rightarrow [T] = \left[M^{a+b+c}.L^{-a-3b}.T^{-2a-2c}\right]$

$\Rightarrow a+b+c=0$

$-a-3b=0$

and $-2a-2c=1 \Rightarrow a+c=\dfrac{-1}{2}$

$\Rightarrow b=\dfrac{1}{2} \Rightarrow a=-\dfrac{3}{2} \Rightarrow c=1$ (D)

38.(B) conceptual

39.(C) After prolonged exposure to UV, zinc ball acquire positive potential due to loss of electrons, after loss of some electrons, its potential becomes constant and positive electrons emission stops.

$\Rightarrow eV = |KE_{\max}|$

$\Rightarrow V = \dfrac{1}{e}\left[\dfrac{hc}{\lambda} - \dfrac{hc}{\lambda_T}\right] = \dfrac{hc}{e}\left[\dfrac{1}{\lambda} - \dfrac{1}{\lambda_T}\right]$

$V = \dfrac{4.14 \times 10^{-15} \times 3 \times 10^8}{10^{-9}}\left[\dfrac{1}{290} - \dfrac{1}{332}\right] = 0.5417$ volts (C)

40.(D) The maximum intensity on screen will be observed when maxima for both wavelengths coincide at a positive on screen.

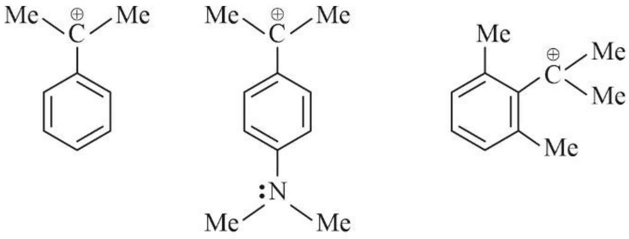
$\Rightarrow I_R = I_{R_1} + I_{R_2}$

$= 4I_0 + 4I_0$

$\boxed{I_R = 8I_0}$ (D)

Part-1: Chemistry

41.(B)



(I) (II) (III)

The stability order: II > I > III

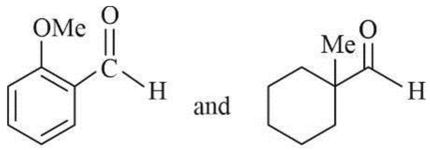
In case of II +M effect is operating

In case of III, the benzene ring and empty p-orbital are perpendicular to each other. So –I effect is operating due to steric inhibition of resonance.

42.(A) Polyacetic acid is a biodegradable polymer among the four given it is also known as PLA.

43.(A) The compound which do not contain $\alpha - H$ will get reduced by formaldehyde and NaOH.

In the given question,



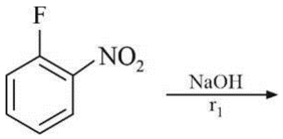
(II) (V)

Do not have $\alpha - H$.

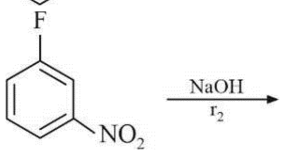
44.(D) cetyltrimethyl ammonium bromide is a quaternary ammonium surfactant, which is used for sanitizing surface due to its antiseptic properties.

45.(C)

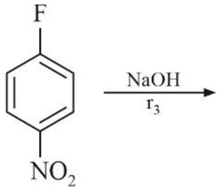
(I)



(II)



(III)

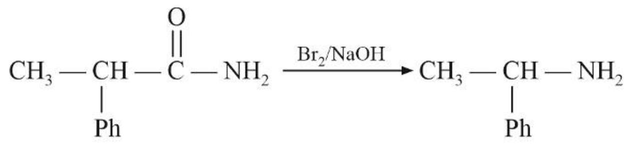


Where r_1, r_2, r_3 are the rates of reaction. These all reactions are S_NAr reactions so the order of the reactions will be $r_1 > r_3 > r_2$.

So the correct order is I > III > II.

The rate of reaction depends upon –M and –I effect.

46.(B)



2-phenylpropanamide 1-phenylethylamine

This reaction is known as Hoffmann bromamide degradation.

47.(A) $CH_3-COOH \xleftarrow[\text{hydrolysis}]{\text{acid}} \underset{(X)}{CH_3-C\equiv N} \xrightarrow[\text{reduction}]{[H]} CH_3-CH_2-NH_2$

48.(D) ${}_{Z}X^{A} \xrightarrow{+\beta} {}_{Z-1}X^{A} \xrightarrow[\gamma\text{ ray}]{-\text{neutron}} {}_{Z-1}Y^{A-1}$

Number of neutrons is $X = A - Z$

Number of neutrons is $Y = A - 1 - (Z - 1)$

$= A - 1 - Z + 1 = A - Z$

Therefore X and Y are isotones.

49.(C) $\Delta T_b = i \times k_f \times m$

i is von't Hoff factor

$i = 2$

$T_b - T_b^\circ = 0.512 \times .1 \times 2$

$T_b - 373 = .1024$

$T_b = 373 + .10$

$T_b = 373.10\ K$

$T_b = 100.1\ °C$

50.(C) When a weak acid and weak base react, the pH of the solution is written by $pH = 7 + \frac{1}{2}(pK_a - pK_b)$

So the pH depends upon pK_a and pK_b of acid and base and it does not depend upon conc. of acid or base.

51.(B) When the products are favored in a chemical reaction taking place at a constant temperature and pressure. The change in Gibbs energy for the reaction is always negative and the total entropy for the reaction and the surrounding will increases for a irreversible process.

52.(A) Let the mole fraction of benzene is X_B and that of toluene is X_T

Then from Raoult's Law

$\Rightarrow \quad P_{total} = X_B P_B^\circ + X_T P_T^\circ$

$= X_B P_B^\circ + (1 - X_B) P_T^\circ$

$P_{Total} = P_T^\circ + (P_B^\circ - P_T^\circ) X_B$

The slope will be $= P_B^\circ - P_T^\circ$

53.(D) $Cu + 2AgNO_3 \longrightarrow \underset{\text{Blue solution}}{Cu(NO_3)_2} + 2Ag\downarrow$

54.(C) $2MnO_4^{\ominus} + I^{\ominus} + H_2O \longrightarrow IO_3^{\ominus} + 2MnO_2 + 2\ddot{O}H$

55.(D) $C_2 + e^- \longrightarrow C_2^{\ominus}$

The electronic configuration of C_2 is

$\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \pi 2p_x^{1+1} = \pi 2p_y^{1+1}$

The electronic configuration of C_2^{Θ} is

$\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \pi 2p_x^{1+1} = \pi 2p_y^{1+1}, \sigma 2p_z^1$

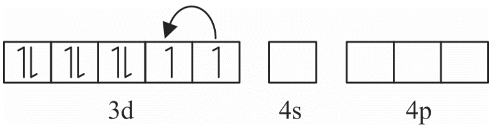
56.(C) $[PdCl_4]^{2-}$ is square planar complex having hybridization dsp^2.

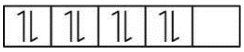
All other have sp^3 hybridization.

57.(A) In metal carbonyl the metal dxy orbital overlaps with π_x^* of carbonyl.

58.(B) $[Ni(dmg)_2]$ is square planar complex having dsp^2 hybridization.

${}_{28}Ni^{+2} \Rightarrow [Ar], 3d^8$




all electrons are paired so magnetic moment $\mu = 0$ BM.

59.(B) In hexagonal close packing N atoms form hexagonal lattice so number of N atoms will be 6.

The number of oh voids = 6

M occupied 2/3 oh voids

Number of M atom/unit all $= \frac{2}{3} \times 6 = 4.$

So the formula will be $M_4N_6 \Rightarrow M_2N_3$

60.(B) The velocity of e^- is an orbit is $\alpha \frac{z}{n}$

The velocity of He^+ is first orbit is = V

Then the velocity of e^- is the second orbit will be $\frac{V}{2} = \cdot 5V.$

Part-1: Biology

61.(D) Because r-selected species are those that emphasize high growth rates, typically exploit less-crowded ecological niches, and produce many offspring, each of which has a relatively low probability of surviving to adulthood.

62.(B) Because urea denatures proteins via both direct and indirect mechanisms. Urea alters water structure and dynamics, thereby diminishing the hydrophobic effect and encouraging solvation of hydrophobic groups in a protein, thus breaking down the ionic bonds. In addition, through urea's weakening of water structure, water molecules become free to compete with intra-protein interactions. Urea also interacts directly with polar residues and the peptide backbone, thereby stabilizing non-native conformations.

63.(D) Because aposematic coloration or aposematism is the advertising by an animal to potential predators that it is not worth attacking or eating. This unprofitability may consist of any defences which make the prey difficult to kill and eat, such as coloration, toxicity, venom, foul taste or smell, sharp spines, or aggressive nature.

64.(A) It has lesser number of chromosomes that reduces the probability of genetic variation by any means.

65.(C) Because the exponent "z" signifies the slope of the species area curve. With an increase in the area from a regional scale to a continental scale the corresponding increase in the number of species rises exponentially, thus increasing the slope of the curve.

66.(B) Because the addition of such a low concentration of HCl would initially decrease the pH but subsequently affect the auto ionization of water (shifting the equilibrium towards left) due to common ion effect making the pH vary between slightly acidic and neutral.

67.(A) Because although invasive species may dominate over other plant species but they don't make the water so nutrient rich that the biomass exceeds to the extent of causing eutrophication.

68.(B) Because 5S rRNA is a molecule of approximately 120 nucleotides typically transcribed by RNA polymerase III.

69.(C) Because Rennin or chymosin (different from Renin of the RAAS) is produced by gastric chief cells present in the lining of the abomasum of young ruminants and some other newborn animals.

70.(A) Because the rhodopsin of rod cells gets converted to the Cis-retinal form in very bright light. After spending sometime in dark, it is regenerated due to reconversion of rhodopsin into its photoactive form.

71.(D) Heterozygosity according to hardy Weinberg equilibrium is equal to 2pq
in (A) 2pq is 0.375
in(B) 2pq is 0.48
in (C) 2pq is 0.48sssss
in(D) 2pq is 0.5
i.e. in (D) option heterozygosity will be maximum.

72.(D) It is released in the stomach that has a very low pH of 1-2 due to secretion of HCl.

73.(B) Because unsaturated fatty acids increase the fluidity of the membrane as the double/triple bond in the carbon chain causes a "kink" in the phospholipid molecule leading to greater inter molecular distance. So at lower temperatures the membrane is prevented from freezing if it has unsaturated fatty acids in its phospholipids, whereas in hot environments the membrane would tend to "melt" which will be prevented if the phospholipid molecules are tightly arranged that becomes possible with straight saturated fatty acids chains.

74.(D) Because tarsals are the bones of the ankle.

75.(C) Because herd immunity implies a condition wherein a majority of the individuals of a population have an immune system capable of fighting a given pathogenic invasion. In such a scenario, introduction of the same pathogen may affect a few non-resistant individuals while the majority will not be affected and the spread will stop.

76.(D) Because chondroblast cells give rise to the cartilage matrix and become the chondrocytes later on, Osteoclast cells are the bone eating cells that demineralize the bone in case of low blood calcium, Microglia are the glial cells of the brain and pneumocyte cells are the surface epithelial cells of the lung alveoli.

77.(D) No. of progeny formed in this bacterial culture $= 2^n$
(n = No of cycles)
$n = 10$ cycles.
$\Rightarrow$ bacterial culture was starded from = 10 cells.
i.e. Total no. of progenies after 10 cycles started with 10 bacterial cells
$= 10 \times 2^n \quad (n = 10)$
$= 10 \times 2^{10}$
i.e. = 10,240

78.(B) This pedigree shows autosomal recessive disorder.

As from femal parent (affected) both male and female progenies in F_1 generation are affected (i.e., Autosomal disorder) and in F_3 generation affected progeny formed from normal parents (i.e., skip the generation) or in other normal progeny formed in F_3 from affected parent (i.e., skip the generation only recessive character can skip the generation.

i.e. It is autosomal recessive disorder.

79.(C) Target site of penicillin antibiotic is cross-linking of tetrapeptrate of bacterial cell wall. It breaks the cross linking of amino-acids and Inhibits cell wall synthesis.

80.(B) Smallest bacterial cell size is $0.25\,\mu m$ (Mycoplasma) .i.e. only viruses can pass through the filters of pore size of $0.05\,\mu m$.

Part-2: Mathematics

81.(A) $a=\sum_{n=101}^{200} 2^n \sum_{k=101}^{n}\frac{1}{k!}$ & $b=\sum_{n=101}^{200}\frac{2^{201}-2^n}{n!}$

Consider $a=\sum_{n=101}^{200} 2^n \sum_{k=101}^{n}\frac{1}{k!}$

$=2^{101}\left(\frac{1}{101!}\right)+2^{102}\left(\frac{1}{101!}+\frac{1}{102!}\right)+2^{103}\left(\frac{1}{101!}+\frac{1}{102!}+\frac{1}{103!}\right)+.....$

$=\frac{1}{101!}\left(2^{200}+2^{199}+....+2^{101}\right)+\frac{1}{102!}\left(2^{200}+2^{199}+...+2^{102}\right)+\frac{1}{103!}\left(2^{200}+2^{199}+....+2^{103}\right)+.....$

$=\frac{1}{101!}\left(2^{201}-2^{101}\right)+\frac{1}{102!}\left(2^{201}-2^{102}\right)+\frac{1}{103!}\left(2^{201}-2^{103}\right)+.....$

$=\sum_{n=|0|}^{200}\frac{\left(2^{201}-2^n\right)}{n!}=b$

So, $a=b\ or\ \frac{a}{b}=1$

82.(C) $x^3+ax^2+bx+c=0$

Roots are a, b, c

$a+b+c=-a\rightarrow b+c=-2a$

$ab+bc+ca=b \qquad c=-2a+\frac{1}{a}$

$abc=-c\rightarrow c\left(ab+1\right)=0$

$c\neq 0$ so $ab+1=0\rightarrow b=\frac{-1}{a}$

$-1+c\left(a+b\right)=b$

$-1+\left(-2a+\frac{1}{a}\right)\left(a-\frac{1}{a}\right)=\frac{-1}{a}$

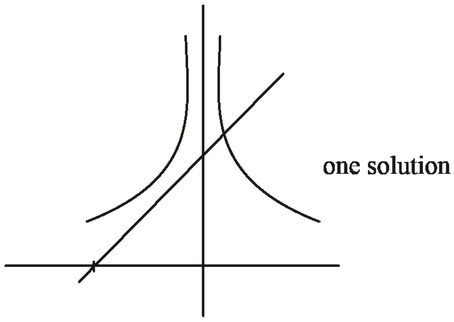
$$-1-2a^2+2+1-\frac{1}{a^2}+\frac{1}{a}=0$$

$$2\left(1-a^2\right)-\frac{1}{a}\left(\frac{1}{a}-1\right)=0$$

$$2(1-a)(1+a)-\frac{1}{a}\left(\frac{1-a}{a}\right)=0$$

$$(1-a)\left[2(1+a)-\frac{1}{a^2}\right]=0$$

$a=1, \frac{1}{2a^2}=1+a \rightarrow$ for this case



So 2 values of a exist.

83.(A) $f'(x)=\cos x+\left(x^3-3x^2+4x-2\right)\times(-\sin x)+\left(3x^2-6x+4\right)\cos x$

$=\cos x\left(3x^2-6x+5\right)+(x-1)\left(x^2-2x+2\right)\times(-\sin x)$

$=3\cos x\left(x^2-2x+1+\frac{2}{3}\right)+(1-x)\left((x-1)^2+1\right)\sin x=3\cos x\left((x-1)^2+\frac{2}{3}\right)+(1-x)\left((x-1)^2+1\right)\sin x$

For $x\in(0,1)$

$f'(x)>0$ so $f(x)$ is increasing

For zeroe's

$f(x)=\sin x+(x-1)\left((x-1)^2+1\right)\cos x=0$

$\tan x=(1-x)\left((1-x)^2+1\right)$

Let $g(x)=(1-x)\left((1-x)^2+1\right)$

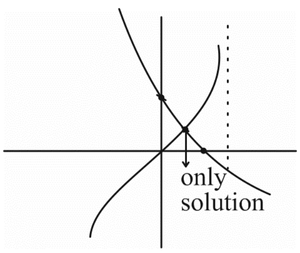
For $x=1$ $g(1)=0$

$x=0$ $g(0)=2$

$g(x)=x^3-3x^2+4x-2$

$g'(x)=3x^2-6x+4$

$D<0$



$g'(x) > 0 \; x = 1$ is only solution of $g(x)$.

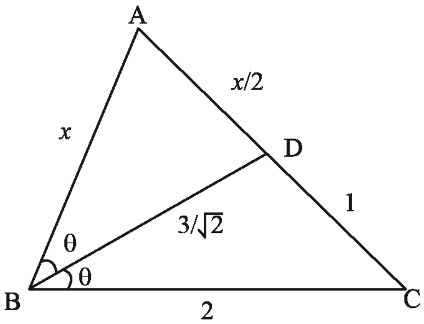
$f(x)$ having only one zero in (0,1)

84.(D) Number of reflexive relations $= 2^{n(n-1)} = 2^{90}$

Number of reflexive and symmetric relations $= 2^{\frac{n(n-1)}{2}} = 2^{45}$

Number of relations which are reflexive but not symmetric $= 2^{90} - 2^{45}$

85.(B)



$$\cos\theta = \frac{4 + \frac{9}{2} - 1}{2 \times 2 \times \frac{3}{\sqrt{2}}} = \frac{3 + \frac{9}{2}}{6\sqrt{2}} = \frac{15}{12\sqrt{2}} = \frac{5}{4\sqrt{2}}$$

$$\cos\theta = \frac{x^2 + \frac{9}{2} - \frac{x^2}{4}}{2 \times x \times \frac{3}{\sqrt{2}}} = \frac{5}{4\sqrt{2}}$$

$$\frac{3x^2}{4} + \frac{9}{2} = \frac{15x}{4}$$

$$3x^2 + 18 - 15x = 0$$

$$3x^2 - 9x - 6x + 18 = 0$$

$$3x(x-3) - 6(x-3) = 0$$

$$x = 2, 3$$

For $x = 2$ Perimeter = 6 (unit) – X $BD \neq \frac{3}{\sqrt{2}}$

For $x = 3$ Perimeter $= 2 + 3 + \frac{3}{2} + 1 = 6 + \frac{3}{2} = \frac{15}{2}$ (unit)

86.(C) $I_n = \int_0^{\pi} \frac{x \sin^{2n}(x)}{\sin^{2n} + \cos^{2n} x} dx$

$$I_n = \int_0^{\pi} \frac{(\pi - x)\sin^{2n}(\pi - x)}{\sin^{2n}(\pi - x) + \cos^{2n}(\pi - x)} dx$$

$$= \pi \int_0^{\pi} \frac{\sin^{2n} x}{\sin^{2n} x + \cos^{2n} x} dx - I_n$$

$$2I_n = \pi \int_0^{\pi} \frac{\sin^{2n} x}{\sin^{2n} x + \cos^{2n} x} dx$$

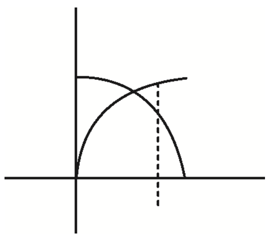
$$2I_n = \pi \cdot \frac{1}{2} \int_0^{\pi} \frac{\sin^{2n} x + \cos^{2n} x}{\sin^{2n} x + \cos^{2n} x} dx$$

$$2I_n = \frac{\pi^2}{2} \ or \ I_n = \frac{\pi^2}{4}$$

So I_n is constant. $\Rightarrow$ $I_n = I_m$ for $n \neq m$.

87. (C) $f(\theta) = \sin(\cos\theta)$

$g(\theta) = \cos(\sin\theta)$



$a = f(\theta)_{\max} = \sin 1$

$b = f(\theta)_{\min} = -\sin 1$

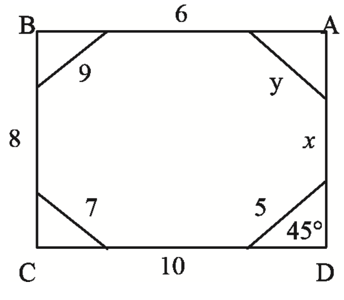
$c = g(\theta)_{max} = 1$

$d = g(\theta)_{\min} = \cos 1$

$\sin 1 > \cos 1$

$c > a > d > b$

88.(B)



Each angle

$$=\frac{(n-2)}{n}\times 180^\circ=\frac{6}{8}\times 180^\circ=135^\circ$$

$AB=CD$ and $AD=BC$

$$\frac{y}{\sqrt{2}}+6+\frac{9}{\sqrt{2}}=\frac{7}{\sqrt{2}}+10+\frac{5}{\sqrt{2}}$$

$$\frac{y}{\sqrt{2}}=4+\frac{3}{\sqrt{2}}$$

$$\frac{y}{\sqrt{2}}=4+\frac{3}{\sqrt{2}}$$

$$y=4\sqrt{2}+3$$

$$\frac{9}{\sqrt{2}}+8+\frac{7}{\sqrt{2}}=\frac{y}{\sqrt{2}}+x+\frac{5}{\sqrt{2}}$$

$$x=8+\frac{11-y}{\sqrt{2}}$$

$$=8+\frac{11-3-4\sqrt{2}}{\sqrt{2}}=8+\frac{8-4\sqrt{2}}{\sqrt{2}}=4+4\sqrt{2}$$

$x+y=7+8\sqrt{2}=7+8\times 1.414=18.312$ nearest integer $=18$

89.(B) $I=\int_1^{\sqrt{2}+1}\frac{x^2-1}{x^2+1}\frac{1}{\sqrt{1+x^4}}dx$

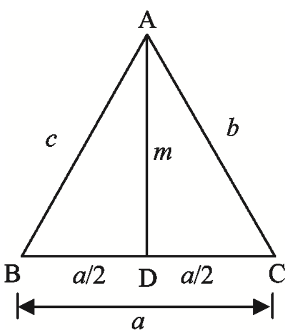
$$=\int_1^{\sqrt{2}+1}\frac{x^2\left(1-\frac{1}{x^2}\right)}{x^2\left(1+\frac{1}{x}\right)}\frac{1}{\sqrt{x^2+\frac{1}{x^2}}}dx$$

$$=\int_2^{2\sqrt{2}}\frac{dt}{t\sqrt{t^2-2}} \qquad x+\frac{1}{x}=t\Rightarrow\left(1-\frac{1}{x^2}\right)dx=dt$$

$$=\frac{1}{\sqrt{2}}\left[\sec^{-1}\frac{t}{\sqrt{2}}\right]_2^{2\sqrt{2}} \qquad x^2+\frac{1}{x^2}=t^2-2$$

$$=\left(\sec^{-1}2-\sec^{-1}\sqrt{2}\right)\frac{1}{\sqrt{2}}=\frac{1}{\sqrt{2}}\left(\frac{\pi}{3}-\frac{\pi}{4}\right)=\frac{\pi}{12\sqrt{2}}$$

90.(B)



$a=8,\ b-c=2,\ m=6$

$b+c>a \qquad c=b-2$

$b+c>8$

$2b-2>8$

$2b>10 \rightarrow b>5$

Using apollonius theorem

$$b^2+c^2=2\left(\frac{a^2}{4}+m^2\right)$$

$$b^2+(b-2)^2=2(16+36)$$

$$2b^2-4b+4=104$$

$$2b^2-4b-100=0$$

$$b^2-2b-50=0$$

$$(b-1)^2=51$$

$$b=1+\sqrt{51}$$

Nearest integer

$=(1+7.14)=8.14=8$

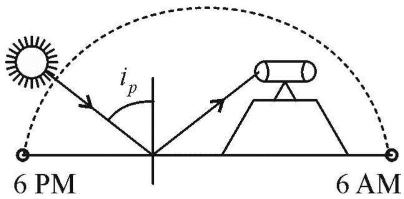
Part-2: Physics

91.(B) Camera will record image with lowest intensity corresponding to Brewster's angle of incidence so that reflected light is plane polarized,

By Brewster's Law

$$\tan i_p=\mu_w \Rightarrow \tan i_p=\frac{4}{3}$$

$\Rightarrow \quad i_p=53°$



So angle with east = $90°+53°=143°$

Time taken : $t=\frac{12\text{ hrs}}{180°}\times 143°$

= 9.53hrs

= 9 hrs 31.999 minutes

$\Rightarrow$ Time in clock is 6 AM + 9 hrs 32 Minutes

= 3 : 32 PM

92.(B) At any time 't'= t when distance of left arm is at distance 'x' from origin.

Flux through Loop = $B\times(\ell-x)\omega.\cos 180°$

$$\Rightarrow \quad LI=-B(\ell-x)\omega$$

$$\Rightarrow \quad I=\frac{B\omega x}{L}-\frac{B\ell\omega}{L}$$

'ℓ' is distance of origin from right edge of magnetic field.

93.(D) Magnetic emf should be line integral of magnetic field. Produced, so by Maxwell, Law

$$\oint \vec{B}.\overrightarrow{dl} = \mu_0\left[I + \left\{\frac{d}{dt}\left(\epsilon_0 \int \vec{E}.d\vec{A}\right)\right\}\right]$$

$\Rightarrow \quad \oint \vec{B}.\overrightarrow{dl} \Rightarrow$ Magnetic emf

$\Rightarrow \quad$ Magnetic emf $= \mu_0\left[0 + \frac{d}{dt}\left(\epsilon_0 E_0 \ell x \cos 0°\right)\right]$

$$= \mu_0 \epsilon_0 E\ell\frac{dx}{dt} = \mu_0 \epsilon_0 E\ell v$$

$= \frac{E\ell v}{c^2}$ Positive so counterclockwise

94.(A) Let us consider the capacitor is fully charged

So $V_c = V_0$

And from diagram

$V- = V_c = V_0$

For $V+$ we can say

$$V+ = V_0 \times \frac{R}{2R} = \frac{V_0}{2}$$

Now it is given that

$$V_0\begin{cases} +10 & if\ V+ > V- \\ -10 & if\ V- > V+ \end{cases}$$

Since $V- > V+$ indicates that $V_0 = -10V$

And $V+ = \frac{-10}{2} = -5V$ and $V- = V_c = -10V$

It shows it is going is a cycle and plot A represents it best.

95.(B) Let the velocity with which the fluid is coming out of nozzle is v. It hits the ground at 2m. we can say.

$$2 = v\sqrt{\frac{2\times 1}{g}}$$

$$v = \sqrt{2g}$$

Let due to squeezing extra pressure generated inside the bottle is Δp. Using Bernoulli's equation for inside and outside the bottle

$$P_0 + \Delta p = P_0 + \frac{1}{2}p v^2$$

$$\Delta p = \frac{1}{2}\times 1000\times 2g = 10000\ Pa$$

This extra pressure is generated due to squeezing. Let the force is F

So $\quad F = \Delta p \times A$

$$= 10^4 \times 10 \times 10^{-4}$$

$$= 10N$$

96.(B) While going from b to a is path 1 the direction is anticlockwise and because it is enclosing the solenoid so the value of

$V_b - V_a = -\in_0$

For path 2 it is not having only magnetic field enclosed so

$V_a - V_b = 0$

97.(C) Potential energy U of a magnetic dipole is defined as

$U = -\vec{\mu}.\vec{B}$ and $F = -\frac{dU}{dr}$

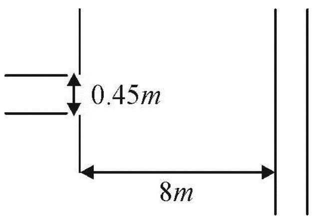
So $F = \mu\frac{dB}{dr}$ and $F = \frac{mv^2}{r}$

So $dB = \frac{mv^2}{r\mu}dr$

$$dB = \frac{1.67\times10^{-27}\times54^2}{1\times9.67\times10^{-27}}\times0.01$$

$dB = 5.04T$

98.(A)



First diffraction minima = $\frac{1.22\lambda}{a}D$

$= 1.22\times\frac{320}{1280}\times\frac{8}{0.45}$

= 5.42 m

Width of central maxima = 10.84 m

Δt for which sound will be heard $= \frac{W}{v}$

= 7.23 sec.

99.(A) $1.5eV$ are ideal for solar cell

100.(B) Rate of heat emission = $\sigma A\left(\theta^4 - \theta_0{}^4\right)$

Heat produced = $\eta\times m\times(\text{calorific value})$

$$\Delta t = \frac{\text{Heat produced}}{\text{Rate of transmission}}$$

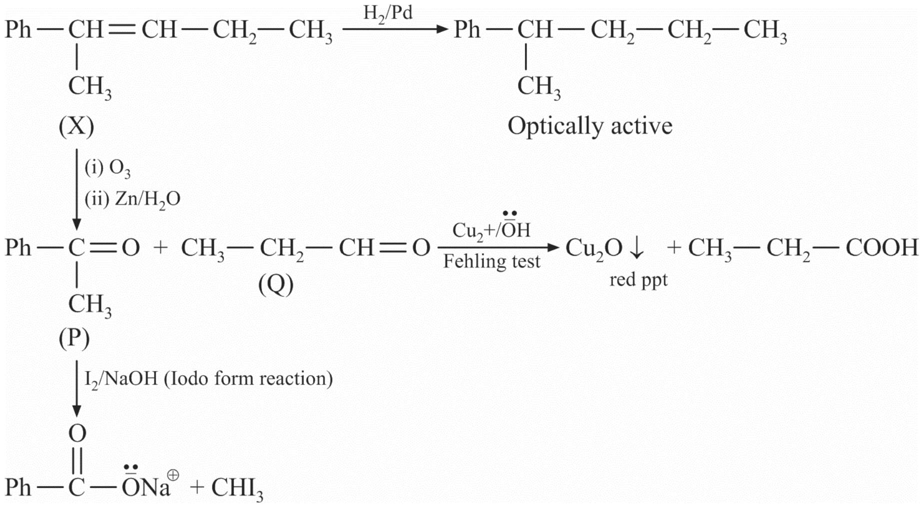
$$= \frac{0.1\times300\times30\times1000}{5.670367\times10^{-8}\times7\times10^{-2}\times\left(333^4 - 273^4\right)}$$

$$= \frac{900\times10^3}{5.670367\times7\times6741798480}$$

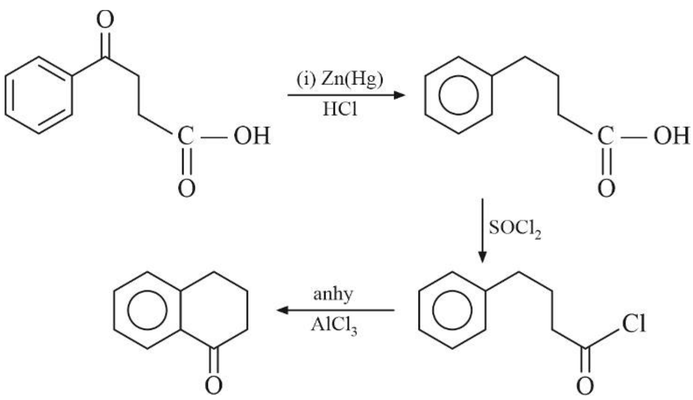
$$= 33.6323 \times 10^3 \text{ sec.}$$
$$= \frac{33.6323 \times 10^3}{3600} hr$$
$$= 9.3423\, hr$$
$$\approx 10\, hr$$

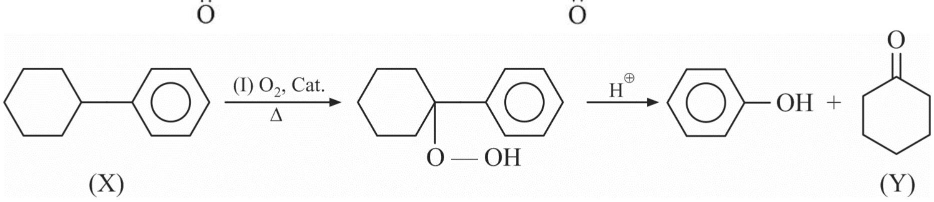
Part-2: Chemistry

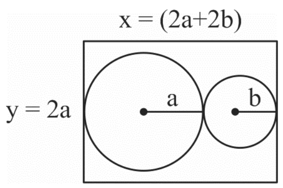
101.(A)



102.(C)



103.(D) 

104.(A) 

Area of the rectangle = xy = (2a + 2b) × 2a

The area occupied by the circle $=\pi a^2+\pi b^2$

The packing fraction $=\dfrac{\pi a^2+\pi b^2}{2a(2a+2b)}$

$$=\frac{\pi\times a^2\left(1+\dfrac{b^2}{a^2}\right)}{4\times a^2(1+b/a)}$$

$r=\dfrac{a}{b}$ given in the question

$$P(r)=\frac{3.14}{4}\times\frac{(1+r^2)}{(1+r)}$$

$$\frac{dp}{dr}=0=\frac{3.14}{4}\times\frac{(1+r)\times 2r-(1+r^2)\times 1}{(1+r)^2}$$

$(1+r)\times 2r=(1+r^2)$

$2r+2r^2=1+r^2$

$r^2+2r-1=0$

$$r=\frac{-2+\sqrt{4+4}}{2}$$

$$=\frac{-2+\sqrt{8}}{2}=-1+\sqrt{2}$$

$r=\cdot 414$

105.(C)

$$A \underset{k_b}{\overset{k_f}{\rightleftharpoons}} B$$

A_0	0
A_0-x	x

$$\frac{-d[A]}{dt}=k_f[A]-k_b[B]$$

$$\frac{-d[A]}{dt}=k_f(A_0-x)-k_b x$$

At equilibrium $\boxed{k_f(A_0-x_{eq})=k_b x_{eq}}$

$$\frac{-d[A]}{dt}=k_f(A_0-x)-k_f\frac{(A_0-x_{eq})x}{x_{eq}}$$

$$\frac{-d[A]}{dt}=\frac{k_f(A_0-x)x_{eq}-k_f(A_0-x_{eq})x}{x_{eq}}$$

$$=k_f\frac{(A_0x_{eq}-xx_{eq}-A_0x+xx_{eq})}{x_{eq}}$$

$$\frac{dx}{dt} = \frac{k_f\ A_0(x_{eq} - x)}{x_{eq}}$$

$$\int_0^x \frac{dx}{x_{eq} - x} = \frac{k_f\ A_0 t}{x_{eq}}$$

$$\ln\left(\frac{x_{eq}}{x_{eq} - x}\right) = \frac{k_f\ A_0 t}{x_{eq}} \qquad \text{....(i)}$$

At equilibrium

$$k_f(A_0 - x_{eq}) = k_b x_{eq}$$

$$k_f\ A_0 - k_f x_{eq} = k_b x_{eq}$$

$$k_f A_0 = (k_f + k_b)x_{eq}$$

$$k_f \frac{A_0}{x_{eq}} = (k_f + k_b)$$

Substituting in equation (i)

$$\ln\left(\frac{x_{eq}}{x_{eq} - x}\right) = (k_f + k_b) \times t$$

$$A_0 - x_{eq} = A_{eq} \qquad \text{....(ii)}$$

$$A_0 - x = A_t$$

So $x_{eq} - x = A_t - A_{eq}$ ....(iii)

Using relation (ii) and (iii)

$$\ln\left(\frac{A_0 - A_{eq}}{A_t - A_{eq}}\right) = (k_f + k_b)t$$

$$\ln \frac{A_0 - A_{eq}}{\left(\frac{A_0 + A_{eq}}{2} - A_{eq}\right)} = (k_f + k_b)t$$

$$\ln\left(\frac{2(A_0 - A_{eq})}{A_0 + A_{eq} - 2A_{eq}}\right) = (k_f + k_b)t$$

$$\ln\left(\frac{2(A_0 - A_{eq})}{A_0 - A_{eq}}\right) = (k_f + k_b)t$$

$$t = \left(\frac{\ln 2}{k_f + k_b}\right)$$

106.(A) $CaCO_{3(s)} \rightleftharpoons CaO(s) + CO_2(g)$

$$\Delta G_r = \Delta G_p - \Delta G_r$$

$= [-603.501 - 394.389] + 1128.79$

$= +130.9$ kJ/mol

$$\Delta G = -RT \ln K$$

$$10^3 \times 130.9 = -2.303 \times 8.314 \times 298 \times \log K$$

$$\log K = \frac{-130.9 \times 10^3}{2.303 \times 8.314 \times 298}$$

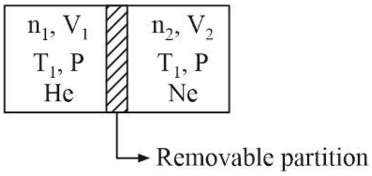
$\log K = -22.941$

$K_{eq} = P_{CO_2}$ for this equilibrium

$\log P_{CO_2} = -22.941$

$P_{CO_2} = 10^{-22.941} = 1.13 \times 10^{-23}$

107.(B)



Entropy $\int_{S_1}^{S_2} ds = R\int_{V_1}^{V_2} d\ln V$ $\Rightarrow$ This is the entropy of expansion of and mole of ideal gas

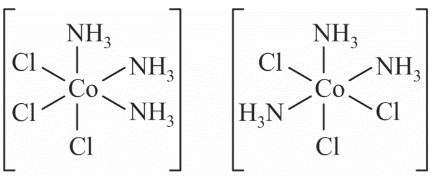
If the gases He and Ne are initially separate and then He is allowed to expand into total volume of both the containers then entropy of this expansion per mole is.

$$\Delta S = R \ln\left(\frac{V_1 + V_2}{V_1}\right)$$

So total change in entropy will be

$$\Delta S_T = n_1 R \ln\left(\frac{V_1 + V_2}{V_1}\right) + n_2 R \ln\left(\frac{V_1 + V_2}{V_2}\right)$$

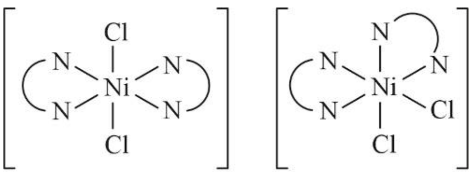
108.(D) Number of stereoisomers of $[Co(NH_3)_3Cl_3]$ will be 2.



Facial   Meridional

Both are optically inactive

Number of stereoisomers of $[Ni(en)_2Cl_2]$ is 3.



Optically inactive

Optically active so its mirror image will also exist

109.(C) $K_2Cr_2O_7 + 4NaCl + 6H_2SO_4 \xrightarrow{\text{heat}} 2KHSO_4 + 4NaHSO_4 + \underset{(x)}{2CrO_2Cl_2} + 3H_2O$

(chromyl chloride)

(Orange Red vapours)

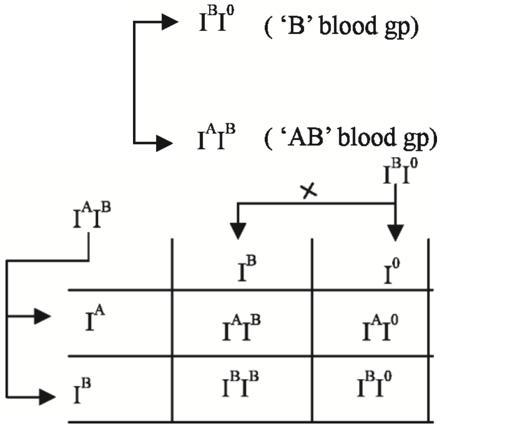
$$CrO_2Cl_2 + 4NaOH \longrightarrow \underset{\text{yellow}}{Na_2CrO_4} + 2NaCl + 2H_2O$$

110.(B) $2NaBH_4 + I_2 \longrightarrow \underset{(X)}{B_2H_6} + 2NaI + H_2$

$3B_2H_6 + 6NH_3 \longrightarrow \underset{(Y)}{2B_3N_3H_6} + \underset{(Z)}{12H_2}$

Part-2: Biology

111.(C) Genotype of parents



Ratio of A : B : AB

→ 1 : 2 : 1 (i.e. 0.25:0.5:0.25)

112.(A)

Option (A) is correct as

-Rice is C_3 plant, pineapple is CAM plant and sugarcane is C_4 plant.

-In CAM plants scotoactive stomata (night active) are present.

-In C_3 and CAM plants site of calvin cycle is mesophyll cells and in C_4 plants site of calvin cycle is Bundle sheath cell.

113.(D) Because the number of nucleotides in the genome would be $1.2X10^8$ / 330 Da=$3.63X10^5$ Da. Because these nucleotides are present as two strands, therefore in one strand the no. of nucleotides would be half, that is 1.31 X 10^5 nucleotides. The approximate length of a single nucleotide is 0.6 nm giving the total length of the genome to be 1.31 X 10^5 X 0.6 = 7.8 X 10^4. But the length of the head of the phage is only 210 nm which means that the DNA will need to go through multiple turns. Accounting for 5 such turns, the length of the genome would come somewhere between 6 X 10^4 to $6.4X10^4$ nm.

114.(C) M represents carrying capacity.

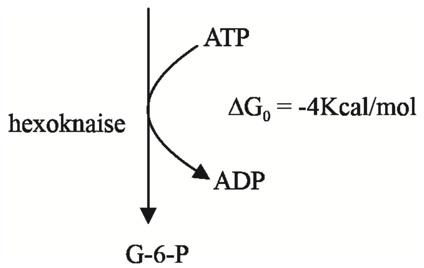
115.(A) Option A is correct with respect to metabolic pathways and their intermediates.

116.(B) The chromosome number is halved after meiosis I (reductional division).

117.(D) Because a higher temperature breaks the hydrogen bonds that stabilize the tertiary structure of a protein. This temperature is not enough to break the covalent bonds responsible for secondary or primary structure.

118.(B) $\text{Glucose} + \text{ATP} \xrightarrow{\text{hexokniase}} \text{Glucose} - 6 - \text{phosphate} + \text{ADP}$

-It is first step of Glycolysis pathway D-glucose



It is exergonic reaction

119.(A) Plotting a bar graph of the number of new tree species in each successive sampling plot will help to determine the adequacy of sampling effort.

120.(D) Because if the specificity is 0.9, that implies that in 10% of the cases when the individual tests negative, they might still have the disease, making the probability 0.1.