OLTS – 1920 – JEEM 2020

FULL TEST - 4

PART – A : PHYSICS

SECTION – A : Single Correct Answer Type

This section contains **20 multiple choice questions.** Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

1. A given LCR series circuit satisfies the condition for resonance with a given AC source. If the angular frequency of the AC source is increased by 100% then in order to establish resonance, without changing the value of inductance, the capacitance must be
(A) increased by 100% (B) reduced by 50%
(C) increased by 75% (D) reduced by 75%

Ans. D

Sol. $\omega L = \frac{1}{\omega c}$ (for resonance)

$\omega^2 = \frac{1}{LC}$ ……. (i)

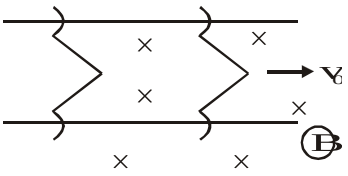
for case (ii)

$(2\omega)^2 = \frac{1}{LC_1}$ ……. (ii)

(ii) divide (i) $\Rightarrow 4 = \frac{C}{C_1} \Rightarrow C_1 = \frac{C}{4}$.

The capacitance is to be reduced by 75%.

2. In figure there are two sliders and they can slide on two frictionless parallel wires in uniform magnetic field B, which is present everywhere. The mass of each slider is m, resistance R and initially these are at rest. Now if one slider is given a velocity v_0, the velocity of other slider after considerably long time will be (neglect the self induction)

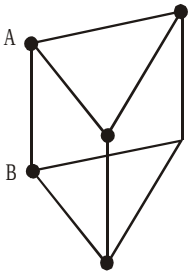


(A) $\frac{v_0}{4}$ (B) $\frac{v_0}{2}$ (C) v_0 (D) Zero

Ans. B

Sol. After long time $mv_0 = 2mv \Rightarrow v = \frac{v_0}{2}$.

3. Nine similar resistors of resistance R are connected as shown in the figure. Equivalent resistance between points A and B is



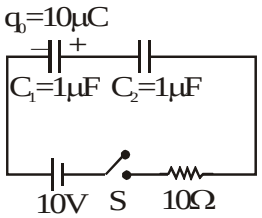
(A) $\frac{3}{5}R$ (B) $\frac{4}{3}R$
(C) $\frac{9}{5}R$ (D) R

Ans. A

Sol. $\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{3R} + \frac{1}{3R} = \frac{1}{R} + \frac{2}{3R} = \frac{3+2}{3R} = \frac{5}{3R}$

$\therefore \quad R_{eq} = \frac{3}{5}R$

4. In the circuit shown, the capacitor C_1 has an initial charge q_0 = 10 μC, when the switch S is closed, and steady state is reached

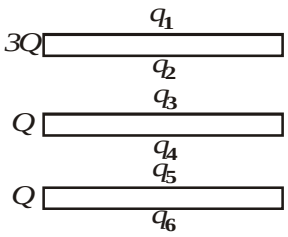


(I) work done by cell is 100 μJ
(II) amount of energy dissipated through resistor is 100 μJ
(III) Charge on C_1 is 10 μC
(IV) Charge on C_2 is 0μC
Select the correct statement
(A) I, II (B) I, III (C) II, IV (D) I, IV

Ans. A

Sol. Total charge of an isolated system is conserved. Use KVL to get the exact charge on each capacitor.

5. A charged plate of charge Q is kept in between two plates. Both the plates have an initial charge of Q and 3Q respectively. The final charges on q_3 & q_5 surfaces of the plate are



(A) $-\frac{Q}{2},-\frac{3Q}{2}$ (B) $-\frac{Q}{2},-\frac{5Q}{2}$

(C) $-\frac{3Q}{2},-\frac{5Q}{2}$ (D) $-\frac{3Q}{2},-\frac{3Q}{2}$

Ans. A

Sol. $q_1+q_2=3Q,\ q_3+q_4=Q, q_5+q_6=Q$

The field inside the metal sheets must be zero

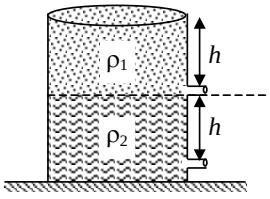
$$-\frac{q_1}{2\varepsilon_0}+\frac{q_2}{2\varepsilon_0}+\frac{Q}{2\varepsilon_0}+\frac{Q}{2\varepsilon_0}=0 \quad \text{.....(i)}$$

$$-\frac{3Q}{2\varepsilon_0}-\frac{q_3}{2\varepsilon_0}+\frac{q_4}{2\varepsilon_0}+\frac{Q}{2\varepsilon_0}=0 \quad \text{.....(ii)}$$

$$-\frac{3Q}{2\varepsilon_0}-\frac{Q}{2\varepsilon_0}-\frac{q_5}{2\varepsilon_0}+\frac{q_6}{2\varepsilon_0}=0 \quad \text{.....(iii)}$$

from (A), (B) and (C) we get $q_3=-\frac{Q}{2}; q_5=-\frac{3Q}{2}$

6. In the figure shown density of lower liquid is three times of density of upper liquid. The cross-sectional areas of openings shown are same. The ratio of mass flow rate from upper opening to lower opening at initial moment is:



(A) $\frac{\sqrt{3}}{2}$ (B) $\frac{1}{3}$

(C) $\frac{1}{2\sqrt{3}}$ (D) $2\sqrt{3}$

Ans. C

Sol. Mass flow rate = ρav and $v_1=\sqrt{2gh}$

For $v_2: \rho_1 gh+\rho_2 gh=\frac{1}{2}\rho_2 v_2^2 \Rightarrow v_2=\sqrt{\frac{8}{3}gh}$

$\therefore$ Required ratio $=\frac{1}{2\sqrt{3}}$

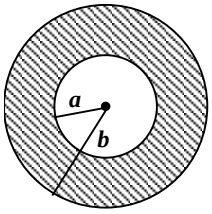
7. Consider three quantities $x = \frac{E}{B}, y = \left(\frac{1}{\mu_0 \varepsilon_0}\right)^{1/2}$ and $z = \frac{RC}{\ell}$. Here ℓ is the length of a wire, C is a capacitance and R is a resistance. All other symbols have standard meanings

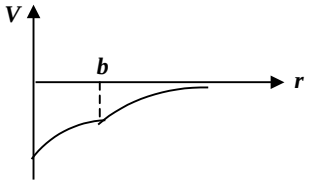
(A) y, z have the same dimensions
(B) z, x have the same dimensions
(C) x, y have the same dimensions
(D) all of the three have the same dimensions

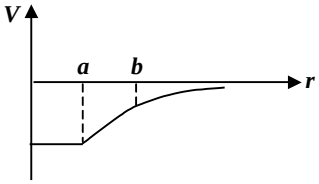
Ans. C

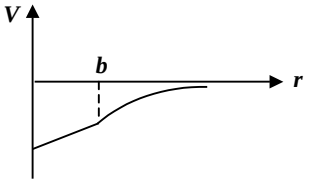
Sol. x and y has same dimensions of velocity. Hence C is the correct answer.

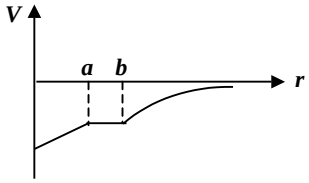
8. A sphere of mass M and radius b has a concentric cavity of radius a as shown in figure. The graph showing variation of gravitational potential V with distance r from the center of sphere is



(A)


(B)


(C)


(D)


Ans. B

Sol. Gravitational potential inside a shell = constant

9. One mole of an ideal monoatomic gas is taken from temperature T_0 to $2T_0$ by the process $PT^{-4} = C$. Considering the following statements choose the correct alternative.

I. Molar heat capacity of the gas is $-\frac{3R}{2}$

II. Molar heat capacity of the gas is $\frac{3R}{2}$

III. Work done is $-3RT_0$

IV. Work done is $3RT_0$

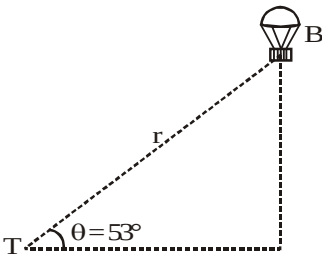
(A) Statements I and IV are correct
(B) Statements I and III are correct
(C) Statements II and IV are correct
(D) Statements II and III are correct

Ans. B

Sol. We know that $PT^{-4} = C, PV^{4/3} = C$

$$C = \frac{R}{\gamma - 1} - \frac{R}{x - 1} = \frac{3R}{2} - \frac{3R}{1} = \frac{-3R}{2} \Rightarrow W = \frac{nR(T_1 - T_2)}{\frac{4}{3} - 1} = -3RT_0$$

10. A balloon B is moving vertically upward and viewed by a telescope T. At a particular angular position θ = 53° measured parameters are r = 1 km, $\frac{dr}{dt} = 3 m/s$ and $\frac{d\theta}{dt} = 0.002$ rad/s. The magnitude of the linear velocity of the balloon at this instant is



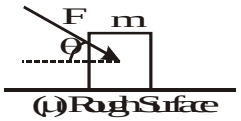
(A) 1.2 m/s (B) 2.4 m/s
(C) 3.6 m/s (D) 4.8 m/s

Ans. C

Sol. $y = r \sin\theta$

$$\frac{dy}{dt} = \frac{dr}{dt}\sin\theta + \cos\theta \frac{d\theta}{dt}.r = 3.6 m/s$$

11. Find minimum value of the angle θ so that block of mass m does not move on rough surface, whatever may be the value of applied force F. The coefficient of state friction between the block and surface is μ.



(A) $\tan^{-1}(\mu)$ (B) $\frac{1}{2}\tan^{-1}(\mu)$ (C) $\cot^{-1}(\mu)$ (D) $\frac{1}{2}\cot^{-1}(\mu)$

Ans. C

Sol. $F\cos\theta = \mu N$ .....(i)

$N = F\sin\theta + mg$ .....(ii)

By (A) and (B)

$F\cos\theta = \mu(F\sin\theta + mg)$

$F\cos\theta - \mu F\sin\theta = mg$

$F(\cos\theta - \mu\sin\theta) = mg$

if F is ∞. Hence $\cos\theta - \mu\sin\theta = 0$

$\cos\theta - \mu\sin\theta = 0 \Rightarrow \cot\theta = \mu \Rightarrow \theta = \cot^{-1}(\mu)$

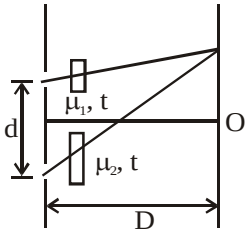
12. Wavelength of K_α X-ray of an element A is λ_1 and wavelength of K_α X-ray element B is λ_2. $\frac{\lambda_1}{\lambda_2}$ is equal to $\frac{1}{4}$ and Z_1 and Z_2 are the atomic numbers of element A and B respectively. Then relation between Z_1 and Z_2 are given by:

(A) $2Z_2 - Z_1 = 1$ (B) $Z_2 - 2Z_1 = 1$ (C) $\frac{Z_2}{Z_1} = 4$ (D) $\frac{Z_1}{Z_2} = 4$

Ans. A

Sol. $\left(\frac{\lambda_2}{\lambda_1}\right)^{1/2} = \frac{(Z_1 - 1)}{(Z_2 - 1)} \Rightarrow (4)^{1/2} = \frac{(Z_1 - 1)}{(Z_2 - 1)} \Rightarrow 2(Z_2 - 1) = (Z_1 - 1) \Rightarrow 2Z_2 - Z_1 = 1$

13. A Young double slit experiment is being carried on. Initially central maxima is found at *O*. Now a slab of a thickness *t* and refractive index μ_1 and a another slab of thickness *t* and refractive index $\mu_2 (<\mu_1)$ is placed in the path of rays as shown in the figure. The fringe is shifted by



(A) $\frac{(\mu_1 + \mu_2)tD}{d}$ upward (B) $\frac{(\mu_1 - \mu_2)tD}{d}$ upward

(C) $\frac{(\mu_1+\mu_2)tD}{d}$ downward (D) $\frac{(\mu_1-\mu_2)tD}{d}$ downward

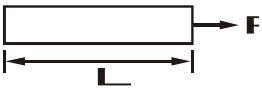
Ans. B

Sol. Shift due to $\mu_1 = \frac{(\mu_1-1)tD}{d}$ upward

Shift due to $\mu_2 = \frac{(\mu_2-1)tD}{d}$ downward

Total shift $= \frac{(\mu_1-\mu_2)tD}{d}$ upward

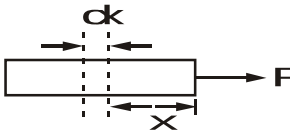
14. A rod of length L is pulled with a force F as shown on a smooth horizontal surface. If A is the area of cross-section and Y the Young's modulus of the material of the rod, the elastic potential energy stored in the rod is:



(A) $\frac{F^2L}{3YA}$ (B) $\frac{F^2L}{2YA}$ (C) $\frac{F^2L}{6YA}$ (D) $\frac{F^2L}{YA}$

Ans. C

Sol. Stress $= \frac{T}{A}$ $E = \frac{1}{2}$ Stress × Strain × Volume



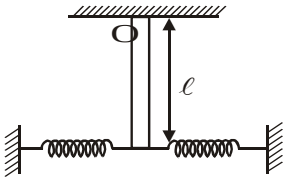
$\frac{\text{Sress}}{\text{Strain}} = Y$ $E = \frac{1}{2}\frac{(\text{Stress})^2}{Y} \times \text{Volume}$

$F - T = ma$ $E = \int_0^L \frac{1}{2}\left(\frac{L-x}{L}\frac{F}{A}\right)^2 \frac{1}{Y} A\, dx$

$F - T = \frac{MX}{L} \times \frac{F}{M}$ $E = \frac{F^2L}{6YA}$

$T = \frac{L-x}{L}F$

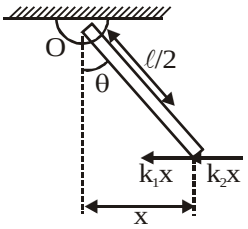
15. A thin uniform vertical rod of mass m and length ℓ pivoted at the point O as shown in figure. The combined stiffness of the springs is equal to k. The mass of the spring is negligible. The frequency of small oscillation is:



(A) $\sqrt{\frac{3k}{2m}+\frac{g}{\ell}}$ (B) $\sqrt{\frac{3k}{2m}+\frac{3g}{\ell}}$ (C) $\sqrt{\frac{3k}{m}+\frac{3g}{2\ell}}$ (D) $\sqrt{\frac{3k}{m}+\frac{2g}{3\ell}}$

Ans. C

Sol. Let the bar be rotated through a small angle θ.



The restoring torque of the forces mg, k_1x and k_2x about O can be given as $\tau = -\left[mg\left(\frac{\ell}{2}\right)\sin\theta + k_1x(\ell\cos\theta) + k_2x(\ell\cos\theta)\right]$

Since θ is small; $\sin\theta \cong \theta$, $x = \ell\ \theta$

and $\cos\theta \cong 1$

Putting $k_1 + k_2 = k$, we obtain

$\tau = -\left[k\ell^2 + mg\left(\frac{\ell}{2}\right)\right]\theta$ or $I\alpha = -\left[k\ell^2 + mg\left(\frac{\ell}{2}\right)\right]\theta$

$$\Rightarrow \quad \omega_{osc.} = \sqrt{\left(\frac{k\ell^2 + mg(\ell/2)}{(m\ell^2/3}\right)} = \sqrt{\frac{3k}{m} + \frac{3g}{2\ell}}\,.$$

16. Given $\vec{F}\left(xy^2\right)\hat{i} + \left(x^2y\right)\hat{j}$ newton. Find the work done by $\vec{F}$ when a particle is taken along the semicircular path OAB where the co-ordinates of 'O' is (0, 0) and co-ordinate of B is (4, 0).

(A) $\frac{65}{3}$J (B) $\frac{75}{2}$J (C) $\frac{73}{4}$J (D) 0 J

Ans. D

Sol. Given $\vec{F} = (xy)^2\,\hat{i} + \left(x^2y\right)\hat{j}$

$$W = \int F_x dx + \int F_y dy = \int xy^2 dx + \int x^2y\, dy = \frac{1}{2}\int d\left(x^2y^2\right) = \left[\frac{x^2y^2}{2}\right]_{0,0}^{4,0} = 0\,J\,.$$

17. In an e.m. wave traveling in air, the amplitudes E_0 and B_0 of the electric and magnetic fields are related as (here c being the speed of wave in air) :

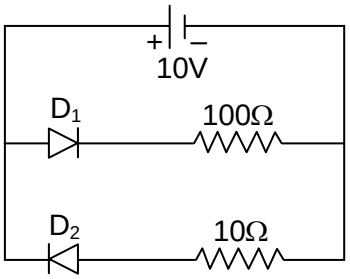
(A) $E_0 = cB_0$ (B) $B_0 = cE_0$ (C) $E_0 = c^2B_0$ (D) $B_0 = c^2E_0$

Ans. A

Sol. $E_0 = cB_0$

18. Two ideal junction diodes D_1 and D_2 are connected to a battery as shown in the figure. The current supplied by the battery is :

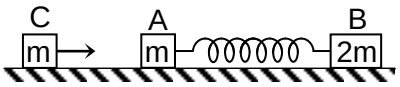
(A) 0.09 A
(B) 0.10 A
(C) 0.11 A
(D) None of these



Ans. B

Sol. $I = \frac{10}{100}$ A

19. Two bodies A and B of masses m and 2m respectively placed on a smooth floor are connected by a spring. A third body C of mass m moves with velocity v_0 along the line joining A and B and collides elastically with A. At a certain instant of time after collision it is found that the instantaneous velocities of A and B are same then compression in the spring at that instant is:



(A) $v_0\sqrt{\frac{2m}{3k}}$ (B) $v_0\sqrt{\frac{2m}{k}}$ (C) $v_0\sqrt{\frac{3m}{2k}}$ (D) $v_0\sqrt{\frac{m}{3k}}$

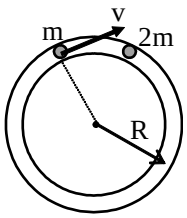
Ans. A

Sol. From conservation of momentum $mv_0 = mv' + 2mv'$

From conservation of energy $\frac{1}{2}mv_0^2 = \frac{1}{2}kx^2 + \frac{1}{2}(3m)\left(\frac{v_0}{3}\right)^2$

$$v_0\sqrt{\frac{2m}{3k}} = x$$

20. A particle of mass m moving with a speed v hits elastically another particle of mass 2m, on a horizontal circular tube of radius R. The time in which the next collision will take place is equal to:



(A) $\frac{6\pi R}{v}$ (B) $\frac{2\pi R}{3v}$

(C) $\frac{2\pi R}{v}$ (D) $\frac{3\pi R}{v}$

Ans. C

Sol. Collision is elastic. So, velocity of separation = velocity of approach. So, relative velocity before and after collision remains same.

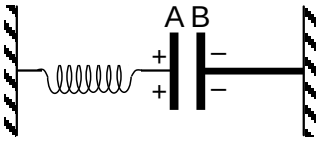
$\therefore$ Time in which the next collision will take place

$\frac{2\pi R}{V}$

SECTION – B : Single digit integer

This section contains **2 questions.** The answer to each question is a **single digit integer** ranging from 0 to 9 (both inclusive).

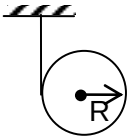
21. Plate A of a parallel plate air filled capacitor is connected to a spring having force constant k and plate B is fixed. They rest on a frictionless table top as shown in the figure. if a charge +q is placed on plate A and a charge –q on plate B, by how much does the spring expand in equilibrium ($q^2 = 6kA\varepsilon_0$, A = Area of plate).



Ans. 3

Sol. $kx = \frac{q^2}{2A\varepsilon_0}$

22. A string is wrapped around a cylinder of radius R=1. If the cylinder is released from rest, the velocity of the cylinder, after it has moved 30m distance will be given by 5K. Find the value of K.



Ans. 4

Sol. $\frac{1}{2}\times\frac{3}{2}\times mR^2\omega^2 = mgh$

Hence, ω = 20 rad/sec.

SECTION – C : Numerical Answer Type

This section contains **3 questions.** The answer to each question is a **Numerical Answer Type XXXXX.XX** (for example if answer is **99999.99** then write the same answer without rounding off any digit).

23. An object moves towards a concave lens with speed 5 mm/s of focal length of lens is 20 cm. Then what is image speed when object is at 30 cm from lens?

Ans. 00000.80

Sol. $\frac{1}{V}-\frac{1}{u}=\frac{1}{f}\quad \frac{1}{V}-\frac{1}{-30}=\frac{1}{-20}\Rightarrow V=-12\,cm$

differentiating $-\frac{1}{V^2}\frac{dV}{dt}+\frac{1}{u^2}\frac{du}{dt}=0$

$\frac{1}{(12)^2}\frac{dV}{dt}-\frac{1}{(30)^2}\times 5=0\quad \frac{dV}{dt}=0.8\ mm/s$

24. A satellite revolves around a heavy planet in a circular orbit. At a point on its orbit an impulse acts suddenly and instantaneously increases its kinetic energy to 1.5 times without change in its direction of motion. Find the ratio of maximum to minimum distance from the planet in subsequent motion.

Ans. 00003.00

Sol. Total energy just after the impulse is given

$$= -\frac{GMm}{r} + \frac{3}{2}.\left(\frac{1}{2}mv^2\right) = -\frac{GMm}{r} + \frac{3}{4}.\left(\frac{GMm}{r}\right) = -\frac{GMm}{4r}.$$

Satellite will start moving in elliptical orbit having minimum distance r. Let r' be the maximum distance from planet.

Energy during motion along elliptical orbit $-\frac{GMm}{2\left(\frac{r+r'}{2}\right)} = -\frac{GMm}{4r}. \Rightarrow r' = 3r.$

25. A man is watching two trains, one leaving & the other coming with equal speeds of 4m/s, if they sound their whistle each of natural frequency of 240Hz. How many number of beats the man will hear (Speed of sound = 320m/s).

Ans. 00006.00

Sol. $fa_p = \left(\frac{v - v_o}{v - v_s}\right) f$

$V_0 = 0$

$V_s = 320$

$$\left(f_{ap}\right)_1 = \left(\frac{v}{v-4}\right)240$$

$$\left(f_{ap}\right)_1 = \left(\frac{v}{v+4}\right)240 = \frac{320}{324}\times 240 = \left(\frac{320}{324}\right)\times 240$$

$$\left(f_{ap}\right)_1 - \left(f_{ap}\right)_2 \approx 6 \text{ beat/s.}$$

PART–B : CHEMISTRY

Single Correct Choice Type

This section contains 20 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE** is correct.

26. Which is incorrect?
(A) Hexagonal close packed arrangement is ABC ABC…..
(B) Orthorhombic crystal has $a \neq b \neq c, \alpha = \gamma = 90°$ and $\beta \neq 90°$
(C) If Zn crystallizes in HCP structure, the nearest number of atoms is 12
(D) The internal energy of one mole of ideal gas is 3/2 RT.

Ans. B

Sol. Orthorhombic crystal has
$a \neq b \neq c, \alpha = \beta = \gamma = 90°$
The given dimensions are for monoclinic crystal.

27. A student of 10 + 2 made the following observations in his laboratory :
(i) Copper metal did not react with 1 M $Pb(NO_3)_2$ solutions.
(ii) Lead metal dissolved in a 1 M $AgNO_3$ solution and Ag metal is crystallized.
(iii) Silver metal did not react with 1 M $Cu(NO_3)_2$ solution
The order of decreasing reducing character of the these metals is
(A) Cu, Ag, Pb (B) Pb, Ag, Cu (C) Cu, Pb, Ag (D) Pb, Cu, Ag

Ans. D

Sol. Lead is more reactive than copper which in turn is more reactive than silver.

28. A gas has a characteristic fishy odour and blue colour, It restores the colour of blackened lead paintings. It also act as bleaching agent in the absence of moisture. The gas is
(A) O_2 (B) SO_2 (C) Cl_2 (D) O_3

Ans. D

Sol. Ozone restores the colour of blackened lead paintings.

$$O_3 \longrightarrow O_2 + [O] \times 4$$
$$PbS + 4[O] \longrightarrow PbSO_4$$
$$PbS + 4O_3 \longrightarrow PbSO_4 + 4O_2$$

Ozone also acts as bleaching agent in the absence of moisture i.e. why ozone is called dry bleach.

29. A chocolate brown coloured compound is obtained from a salt solution containing…., on treatment with potassium ferrocyanide in acetic acid
(A) Cu (B) Cd (C) Hg (D) Zn

Ans. A

Sol. $2CuSO_4 + K_4[Fe(CN)_6] \xrightarrow{CH_3COOH} \underset{\text{Chocolate ppt}}{Cu_2[Fe(CN)_6]} + 2K_2SO_4$

30. Match List I with List II and select the correct answer using the codes given below this lists List I(Alloys) List II (Constituents)

A Brass	1. Copper + Tin
B Solder	2. Copper + Zinc
C German silver	3. Copper + Zinc + Nickel
D Gun metal	4. Lead + Tin

Codes :

	A	B	C	D
(A)	2	4	1	3
(B)	2	4	3	1

(C) 2 1 3 4
(D) 2 3 1 4

Ans. B

Sol. Factual question.

31. A scarlet compound (A) is treated with conc. HNO_3 to give a black precipitate (B) and a colourless solution of C. On adding KI to this solution, a yellow ppt. (D) is obtained. The precipitate (B) on warming with conc. HNO_3 in the presence of $Mn(NO_3)_2$ produces a light pink coloured solution due to the formation of (E). What is (E)?

(A) $PbCrO_4$ (B) PbI_2 (C) MnO_2 (D) $HMnO_4$

Ans. D

Sol. Scarlet compound (A) is Pb_3O_4.

$$\underset{(A)}{Pb_3O_4} + 4HNO_3 \longrightarrow \underset{\substack{(B)\\ Black}}{PbO_2}\downarrow + 2\underset{(C)}{Pb(NO_3)_2} + 2H_2O$$

$$\underset{(C)}{Pb(NO_3)_2} + 2KI \longrightarrow \underset{yellow(D)}{PbI_2}\downarrow$$

$$PbO_2 + Mn^{2+} + HNO_3 \xrightarrow{\Delta} \underset{like\ Pink(E)}{HMnO_4} + Pb^{2+}$$

32. Which of the following two ions have identical value of spin magnetic moment?

(A) Ni^{2+} and Ni^{4+} (B) Fe^{+} and Fe^{3+} (C) Cr^{+} and Cr^{3+} (D) Cu^{+} and Cu^{2+}

Ans. B

Sol. Each of Fe^{+} and Fe^{3+} contains five unpaired electrons. So they have same magnetic moment.

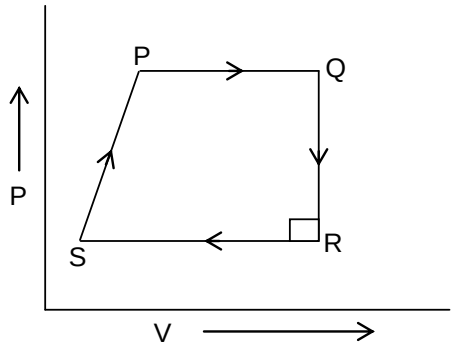
33. Which of the following complex shows ionization isomerism?

(A) $[Co(NH_3)_4Cl_2]Cl$ (B) $[Fe(H_2O)_4(Br)(Cl)]$ (C) $[Cr(NH_3)_5Cl]Br$ (D) $Na[ZnCl_4]$

Ans. C

Sol. The ionization isomer of the complex in(C) is $[Cr(NH_3)_5Br]Cl$.

34.



Along which path of the above cyclic process, the PV-work done is zero?

(A) $P \rightarrow Q$ (B) $Q \rightarrow R$ (C) $R \rightarrow S$ (D) $S \rightarrow P$

Ans. B

Sol. No volume change takes place along the path $Q \rightarrow R$.

35. Which of the following solution is accompanied with maximum elevation in boiling point?

(A) 0.2 m NaCl (B) 0.4 m $C_6H_{12}O_6$ (C) 0.1 m $Al_2(SO_4)_3$ (D) 0.2 m $CaCl_2$

Ans. D

Sol. $\Delta T_b \ \alpha$ im

36. The emf of the following electrochemical cell is 0.76 V.

M(s) | M^{2+}(1 M) || H^{+}(1 M) | H_2(1 atm), Pt

What is the standard reduction potential of M/M^{2+} electrode?

(A) 0.38 V (B) -0.76 V (C) 0.76 V (D) -0.38 V

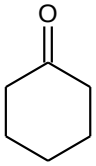
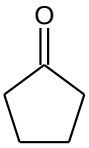
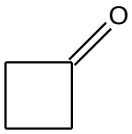
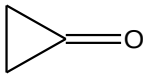
Ans. B

Sol. $E_{Cell} = E_{(C)} - E_{(A)}$ (reduction potential)

$0.76 = 0 - E_A \Rightarrow E_A(M/M^{2+}) = -0.76$ V

Potentials of standard hydrogen electrode is zero.

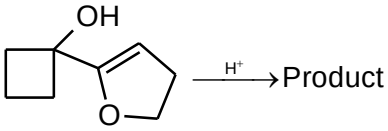
37. Which ketone is most reactive in carbonyl addition reaction?

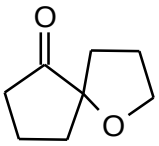
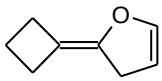
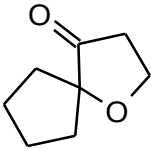
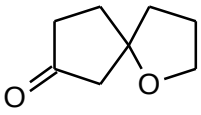
(A)  (B)  (C)  (D) 

Ans. D

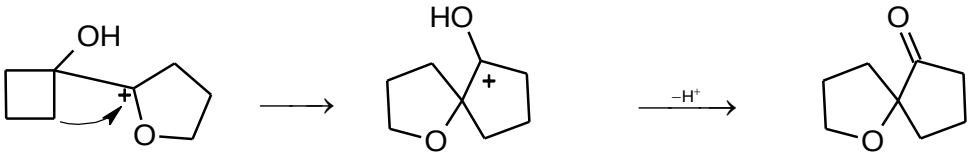
Sol. Cyclopropanon have more angle strain

38. Identify the major product,



(A)  (B)  (C)  (D) 

Ans. A

Sol. 

39. Which statement about the aldol condensation is correct?

(A) A Lewis acid is commonly used as a catalyst

(B) The initial step is probably the formation of a carbanion

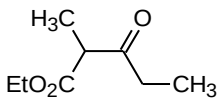
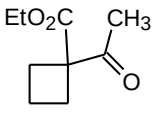
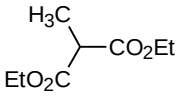
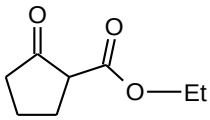
(C) The Lewis base is employed to induce carbocation formation

(D) The carbon chain is lengthened through the elimination of 1 mole of water

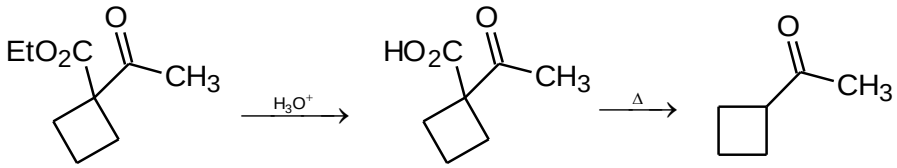
Ans. B

Sol. Enolate ion formed is first step

40. Which of the following compound on hydrolysis followed by heating gives a product, which gives positive iodoform test

(A)  (B)  (C)  (D) 

Ans. B

Sol. 

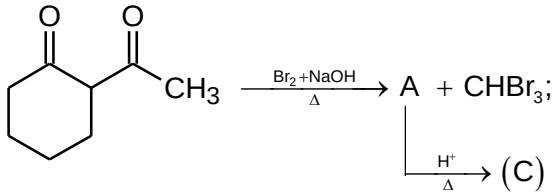
41. Identify the final product (Z) in the following sequence of reactions:

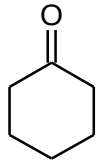
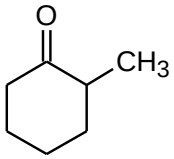
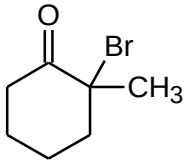
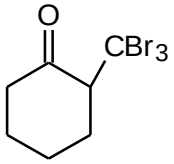
$CH_3NH_2 \xrightarrow[\text{excess}]{CH_3I} X \xrightarrow{AgOH} Y \xrightarrow{\Delta} Z + CH_3OH$

(A) $CH_3 - CH_2 - CH_2 - NH_2$ (B) $(CH_3)_3N$ (C) $(CH_3)_2NH$ (D) $(CH_3)_4N^+OH^-$

Ans. B

Sol. (B) $CH_3NH_2 \xrightarrow{CH_3I\ (excess)} (CH_3)_4\overset{+}{N}I^- \xrightarrow{AgOH} (CH_3)_4\overset{+}{N}-OH^- \xrightarrow{\Delta} (CH_3)_3N + CH_3OH$

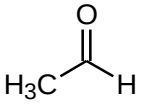
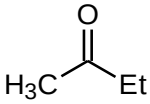
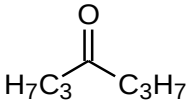
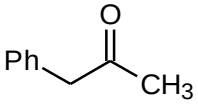
42.  ; Product (C) of the reaction is:

(A)  (B)  (C)  (D) 

Ans. A

Sol. Haloform reaction

43. Which of the following does not react with $NaHSO_3$(sodium bisulphite):

(A)  (B)  (C)  (D) 

Ans. C

Sol. Propyl group provide steric hindrance

44. At -73°C and 400 atm pressure 2.8 Kg N_2 gas is filled up in a cylinder of 100 L capacity then the forces that will dominate among the N_2 molecules is

(A) repulsive (B) attractive (B) both (D) none of these

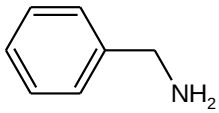
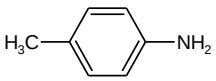
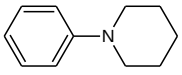
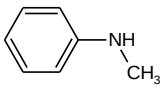
Ans. A

Sol. $400 \times 100 = Z \times 100 \times 0.0821 \times 200$

$z = 2/0.0821 > 1$

Repulsive forces will dominate

45. Which of the following amine yields N–nitrosoamine after treatment with cold nitrous acids ($NaNO_2$/HCl)?

(A)  (B)  (C)  (D) 

Ans. D

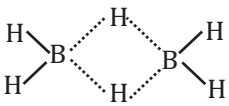
Sol. 2° Amine yields N–nitrosoamine with cold nitrous acid

SECTION–B: Single Digit Integer

This section contains **2 questions.** The answer to each question is a single digit integer ranging from 0 to 9 (both inclusive).

46. The number of two center – two electron bonds i.e. 2c – 2e in diborane is:

Ans. 4

Sol.  (2c-2e) bonds are terminal positions

47. Among the following, the number of compounds, that can act as dehydrating agent is
Conc. H_2SO_4 , anhy. $CaCl_2$, Conc. HNO_3 , CaO , $CuSO_4.5H_2O$, P_4O_{10}

Ans. 4

Sol. Conc. H_2SO_4 , anhy. $CaCl_2$, CaO , P_4O_{10}

SECTION – C : Numerical Answer Type

This section contains **3 questions.** The answer to each question is a **Numerical Answer Type XXXXX.XX** (for example if answer is **99999.99** then write the same answer without rounding off any digit).

48. 0.1890 g of chlorine-substituted substance gave in a Carius method determination, 0.2870 g of silver chloride. What percentage of chlorine did the substance contains? (atomic weight Ag=108, Cl=35.5)

Ans. 00037.57

Sol. wt of Cl in AgCl = $\frac{0.2870}{108+35.5}\times 35.5 = 0.071$

$\therefore$ % Cl= $\frac{0.071}{0.189}\times 100 = 37.57$

49. The density of a mixture of O_2 and N_2 is 1.3 mg/L at NTP. Calculate the volume occupied by 2 mol of He gas at 273 K, having pressure equal to double the partial pressure of the O_2 gas in the 1st mixture (approximately)

Ans. 00080.00

Sol. Molecular weight of mixture=$1.3\times 22.4 = \frac{32n_1+28n_2}{n_1+n_2} = 29.12$

$\therefore$ mole fraction of O_2= 0.28

$\therefore$ p_{O_2} = 1×0.28 = 0.28 atm

$\therefore$ $V = \frac{nRT}{P} = \frac{2\times 0.082\times 273}{0.28\times 2}$

50. In an amino acid the carboxyl group ionizes at pKa_1 =2.34 and ammonium ion at pKa_2=9.6. The isoelectrlc point of the amino acid is at pH

Ans. 00005.97

Sol. Take average of both pKa value

PART – C: MATHEMATICS

SECTION – A : Single Correct Answer Type

This section contains **20 multiple choice questions.** Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

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51. Let f : R→R be a differentiable function satisfying g(x) = g(y) g(x – y) ∀ x, y ∈ R and g′(0) = a and g′(3) = b then g′(–3) is

(A) $\frac{a^2}{b}$ (B) $\frac{a}{b}$ (C) $\frac{b}{a}$ (D) none of these

Ans. A

Sol. Differentiating partially w.r.t. x

$g'(x) = g(x).g'(0) = a\ .g(x) \Rightarrow g(x) = ae^x$ $(\because\ g(0) = 1)$

Now $g'(x) = ae^x$, $g'(3) = ae^3$ and $g'(-3)\ ae^{-3} = \frac{a^2}{b}$.

52. If z be a complex number satisfying $|z|^2 + 2(z + \bar{z}) + 3i(z - \bar{z}) + 4 = 0$, then complex number z + 3 + 2i will lie on

(A) circle with centre 1–5i radius 4 (B) circle with centre 1 +5i radius 4

(C) circle with centre 1+ 5i radius 3 (D) circle with centre 1–5i radius 3

Ans. C

Sol. Given equation of circle

$|z|^2 + z(2+3i) + \bar{z}(2-3i) + 4 = 0$

centre –(2–3i), radius $\sqrt{a\bar{a} - b} = 3$

$\Rightarrow |z + 2 - 3i| = 3$

so, ω lies on circle whose centre is 1 + 5i, radius = 3.

53. A random variable X follows a binomial distribution with n=10 and p 0.4. What value of X is most likely?

(A) 2 (B) 3 (C) 4 (D) 5

Ans. C

Sol. $P(x) = {}^{10}C_x (.4)^x (.6)^{10-x}$

$$\frac{P(x)}{P(x+1)} = \frac{{}^{10}C_x}{{}^{10}C_{x+1}} \frac{(.4)^x (.6)^{10-x}}{(.4)^{x+1} (.6)^{10-(x-1)}}$$

$$= \left(\frac{x+1}{10-x}\right)\frac{3}{2} \geq 1 \Rightarrow 3x + 3 \geq 20 - 2x \geq 5x \geq 17 \Rightarrow x \geq 17/5$$

x = 4

54. The number of solutions of the equations $e^x = x^2$ and $e^x = x^3$ are respectively

(A) 1 and 0 (B) 1 and 2 (C) 2 and 1 (D) 3 and 2

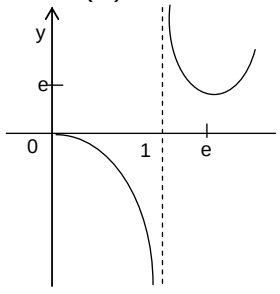
Ans. B

Sol. Clearly for x < 0, $e^x = x^2$ has one solution

Whereas $e^x = x^3$ has no solution

For x > 0, taking log, consider: $y = \frac{x}{\log x} \Rightarrow y' = \frac{\log x - 1}{(\log x)^2}$

Clearly y = 2 won't meet the graph whereas y=3 line meets it at two different points.



55. Let $f(x) = e^{x^2} + \alpha x - \beta, (\alpha, \beta \in R)$. If f(–2)>0 and f(2)>0 then

(A) $|\alpha| < \frac{1}{2}(\beta - e^4)$ (B) $|\alpha| < \frac{1}{2}(e^4 - \beta)$ (C) $|\alpha| > \frac{1}{2}(e^4 - \beta)$ (D) none of these

Ans. B

Sol. As, given $e^4 - 2\alpha - \beta > 0$ and $e^4+2\alpha-\beta>0$

$\Rightarrow e^4 - 2|\alpha| - \beta > 0 \Rightarrow |\alpha| < \frac{1}{2}\left(e^4 - \beta\right)$

56. Let $A_r(r \in N)$ be the area of the bounded region whose boundary is defined by $(6y^2r-x)(6\pi^2y-x)=0$ then the value of $\lim\limits_{n\to\infty}\left(\sqrt{A_1A_2A_3} + \sqrt{A_2A_3A_4} + ...\text{n terms}\right)$, is

(A) π^9 (B) $\frac{1}{2}\pi^9$ (C) $\frac{1}{3}\pi^9$ (D) $\frac{1}{4}\pi^9$

Ans. D

Sol. $y^2 = \frac{x}{6r} = \frac{x^2}{36\pi^4} \Rightarrow x = 0 \text{ or } \frac{6\pi^4}{r}$

So, $A_r = \int\limits_0^{6\pi^4/r}\left(\frac{\sqrt{x}}{\sqrt{6r}} - \frac{x}{6\pi^2}\right)dx = \frac{2}{3\sqrt{6r}}\cdot\left(\frac{6\pi^4}{r}\right)^{3/2} - \frac{\left(\frac{6\pi^4}{r}\right)^2}{12\pi^2} = \frac{\pi^6}{r^2}$

So, $\lim\limits_{n\to\infty}\sum\limits_{r=1}^{n}\left(\sqrt{A_rA_{r+1}A_{r+2}}\right) = \pi^9.\lim\limits_{n\to\infty}\sum\limits_{r=1}^{n}\frac{1}{r(r+1)(r+2)} = \frac{1}{4}\pi^9$

57. If sets A and B are defined as $A = \{(x, y): y = e^x, x \in R\}$, $B = \{(x, y): y = x, x \in R\}$ then

(A) $B \subset A$ (B) $A \subset B$ (C) $A \cap B = \phi$ (D) $A \cup B = A$

Ans. C

Sol. $e^x > x \ \forall x \in R$

$\therefore A \cap B = \phi$

58. The value of ${}^{40}C_0\,{}^{100}C_{40} - {}^{40}C_1\,{}^{99}C_{40} + {}^{40}C_2\,{}^{98}C_{40} - ... + {}^{40}C_{40}\,{}^{60}C_{40}$ is equal to

(A) ${}^{100}C_{40}$ (B) ${}^{102}C_{40}$ (C) ${}^{140}C_{40}$ (D) ${}^{40}C_{40}$

Ans. D

Sol. Sum is equal to coefficient of x^{40} in ${}^{40}C_0(1+x)^{100} - {}^{40}C_1(1+x)^{99} + ... + (-1)^{40}\,{}^{40}C_{40}(1+x)^{60} = 1$

59. Number of ways to select 4 persons out of 6 married couple so that exactly one couple is selected.

(A) 480 (B) 120 (C) 360 (D) none of these

Ans. D

Sol. Number of ways of selecting 4 persons such that exactly one is couple is

$\frac{{}^6C_1 \times {}^{10}C_1 \times {}^8C_1}{2} = 240$

60. Let PQRS be a square with length of the side 10. The points A and B are taken on the side PQ and C is taken on the side RS. Then the circumradius of the triangle ABC can be

(A) 3.1 (B) 4.2 (C) 5.5 (D) 8

Ans. C

Sol. Let AB + BC ≥ AC ≥ SP = 10

$\therefore$ The minimum value of circumradius = 5

Now a circle through PQRS has the radius $5\sqrt{2}$ and the points P, Q, R lie on or inside the square

$\therefore$ R>5 radius ≤ $5\sqrt{2}$

61. The equation of the plane passing through the straight line $\frac{x-1}{2}=\frac{y+1}{-1}=\frac{z-3}{4}$ and perpendicular to the plane x + 2y + z = 12 is

(A) 9x + 2y– 5z + 4 = 0 (B) 9x–2y–5z+4=0 (C) 9x + 2y + 5z + 4 = 0 (D) none of these

Ans. B

Sol. The required equation of plane is a(x–1)+b(y+1)+c(z-3)=0

$\therefore$ 2a – b + 4c = 0 and a + 2b + c = 0

$\frac{a}{9}=\frac{b}{-2}=\frac{c}{-5}$

$\therefore$ equation of plane is 9x–2y–5z+4=0

62. The mean of the values 0, 1, 2, 3, ….,n with the corresponding weighs ${}^nC_0, {}^nC_1, {}^nC_2, {}^nC_3,..., {}^nC_n$ respectively is

(A) $\frac{2^n}{(n+1)}$ (B) $\frac{2^{n+1}}{n(n+1)}$ (C) $\frac{n+1}{2}$ (D) $\frac{n}{2}$

Ans. D

Sol. $\frac{{}^nC_1+2{}^nC_2+3{}^nC_3+.....+n{}^nC_3}{{}^nC_0+{}^nC_1+{}^nC_2+.....+{}^nC_n}=\frac{n.2^{n-1}}{2^n}=\frac{n}{2}$

63. If a curve is such that line joining origin to any point P(x, y) on the curve and line parallel to y-axis through P are equally inclined to tangent inclined to tangent to curve at P, then the differential equation of the curve is

(A) $x\left(\frac{dy}{dx}\right)^2-2y\frac{dy}{dx}=x$ (B) $\left(\frac{dy}{dx}\right)^2+2y\frac{dy}{dx}=x$

C) $y\left(\frac{dy}{dx}\right)^2+2y\frac{dy}{dx}=x$ (D) $y\left(\frac{dy}{dx}\right)^2-2y\frac{dy}{dx}=y$

Ans. A

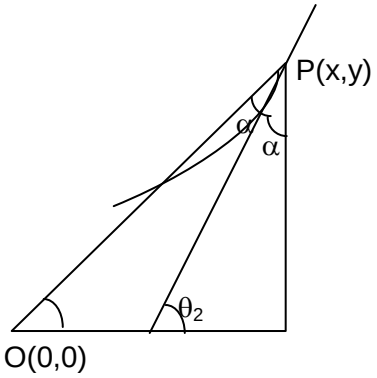
Sol. $\theta_1+\alpha=\theta_2$

$\theta_1+2\alpha=\frac{\pi}{2}$

$\theta_1+2(\theta_2-\theta_1)=\frac{\pi}{2} \Rightarrow 2\theta_2-\theta_1=\frac{\pi}{2}$

$\frac{2\tan(\theta_2)}{1-(\tan(\theta_2))^2}=\frac{-1}{\tan\theta_1}\Rightarrow \frac{2\frac{dy}{dx}}{1-\left(\frac{dy}{dx}\right)^2}=-\frac{x}{y}$

$2y\frac{dy}{dx}=+x\left(\frac{dy}{dx}\right)^2-x\Rightarrow x\left(\frac{dy}{dx}\right)^2-2y\frac{dy}{dx}=x$



64. Let $f(x)=(x+1)^2+\frac{1}{x}(x+1)$ then the value of $\int_{-2}^{1} f(x)f(-x)dx$

(A) is equal to 2 (B) is equal to $-\frac{81}{10}$ (C) is equal to $\frac{81}{10}$ (D) does not exist

Ans. D

Sol. $f(x)=(x^2+2)+\left(2x+\frac{1}{x}\right)$

So, $f(x)f(-x) = (x^2+2)^2 - \left(2x+\frac{1}{x}\right)^2 = x^4 - \frac{1}{x^2}$

So, $\int_{-2}^{1}\left(x^4 - \frac{1}{x^2}\right)dx = \left(\frac{x^5}{5}+\frac{1}{x}\right)\Big|_{-2}^{0^-} + \left(\frac{x^5}{5}+\frac{1}{x}\right)\Big|_{0^+}^{1} = -\infty$

65. Let f(x) be such that $(1-x)2^{-f(x)} = (x+1)\left(\sqrt{x^2+1}+x\right)$, then

(A) the graph of y=f(x) is symmetrical about y-axis
(B) f(0) = 1
(C) f′(0) = 0
(D) f″(0) = 0

Ans. D

Sol. $2^{-f(x)} = \frac{1+x}{1-x}\cdot\left(\sqrt{x^2+1}+x\right)$

$\Rightarrow f(x) = \log_2\left(\frac{1-x}{1+x}\right) - \log_2\left(\sqrt{x^2+1}+x\right)$, which is an odd function

So, f″(0) = 0

66 If a tangent of slope 2 of the ellipse $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$ is a normal to the circle $x^2+y^2+4x+1=0$, then the maximum value of ab, is

(A) 4 (B) 2 (C) 1 (D) none of these

Ans. A

Sol. Equation of tangent is $y = 2x \pm \sqrt{4a^2+b^2}$

It passes through (–2, 0)

$\Rightarrow 0 = -4 \pm \sqrt{4a^2+b^2} \Rightarrow 4a^2+b^2 = 16$

Now AM ≥ GM

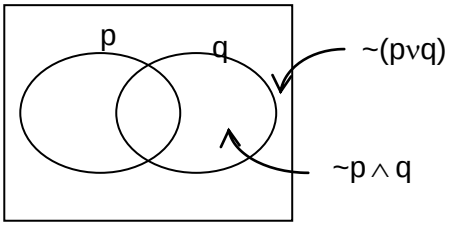
$\frac{4a^2+b^2}{2} \geq \sqrt{4a^2b^2} \Rightarrow ab \leq 4$

67. The Boolean expression : $\sim(p \vee q) \vee (\sim p \wedge q)$ is equivalent to

(A) p (B) ~q (C) q (D) ~p

Ans. D

Sol.



Result is ~p

68. $\int \frac{dx}{x(x+1)(\ln(x+1)-\ln x)^{11}}$ equals (Where C is constant of integration)

(A) $\frac{1}{10(\ln(x+1)-\ln x)^{10}}+C$ (B) $\frac{(\ln(x+1)-\ln x)^{10}}{10}+C$

(C) $\frac{1}{11(\ln(x+1)-\ln x)^{11}}+C$ (D) $\frac{(\ln(x+1)-\ln x)^{11}}{11}+C$

Ans. A

Sol. Let $\ln(x+1) - \ln x = t$

$\Rightarrow \left[\frac{1}{x+1} - \frac{1}{x}\right]dx = dt$

$\Rightarrow \frac{dx}{x[x+1]} = -dt$

$I = -\int \frac{dt}{t^{11}}$

69. If $\sum_{n=1}^{\infty} \cot^{-1}\left(2 + \frac{n(n+1)}{2}\right) = \tan^{-1} a$, then 'a' is equal to

(A) 1 (B) 2 (C) 3 (D) 4

Ans. B

Sol. $t_n = \cot^{-1}\left(2 + \frac{n(n+1)}{2}\right)$

$= \tan^{-1}\left(\frac{2}{4+n(n+1)}\right) = \tan^{-1}\left(\frac{\frac{1}{2}}{1+\frac{n}{2}\left(\frac{n+1}{2}\right)}\right) = \tan^{-1}\left(\frac{n+1}{2} - \tan^{-1}\frac{n}{2}\right)$

$\Rightarrow S_{\infty} = \frac{\pi}{2} - \tan^{-1}\frac{1}{2} = \cot^{-1}\frac{1}{2} = \tan^{-1} 2$

70. Let A be a 2×2matrix with real entries and det(A) = d ≠ 0 such that det(A+d(adjA)=0. Find the value of det(A–d(adjA))

(A) 8 (B) 7 (C) 4 (D) none of these

Ans. C

Sol. Let $A = \begin{bmatrix} x & y \\ z & w \end{bmatrix}$ then adj $A = \begin{bmatrix} w & -y \\ -z & x \end{bmatrix}$

$A + d(adjA) = \begin{bmatrix} x+dw & y(1-d) \\ z(1-d) & w+dx \end{bmatrix}$

$|A+d(adjA)| = (x+dw)(w+dx) - yz(1-d)^2$

$\Rightarrow xw + (w^2+x^2)d + d^2xw - yz + 2yzd - d^2yz$

$= d + (w+x)^2 d + d^3 - 2d^2 = 0$

$\Rightarrow 1 + (w+x)^2 + d^2 - 2d = 0 \Rightarrow d = 1,\ w+x = 0$

$|A - d \text{ adj } A| = d[1+d^2+2d] = 4$

SECTION – B : Single digit integer

This section contains **2 questions.** The answer to each question is a **single digit integer** ranging from 0 to 9 (both inclusive).

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71. If for some natural number 'n'$(1+2+3+\ldots..+n)+k=2013$ where 'k' is one of the numbers 1, 2, 3 ….n, then n–k is equal to

Ans. 2

Sol. $1+2+3\ldots\ldots n+k=2013$

$\frac{n(n+1)}{2} + k = 2013$

$n^2+n+2k=4026$

$n = \frac{4026 - (n)(n+1)}{2} > 0$

On solving, we get $61.9 < n < 62.9$

$\Rightarrow n = 62 \Rightarrow \frac{62 \times 63}{2} + k = 2013$

$k = 60$

$n - k = 2$

72. The number of ordered pairs (x,y) satisfying $|x| + |y| = 3$ and $\sin\left(\frac{\pi}{3}x^2\right) = 1$ will be

Ans. 8

Sol. $\sin\left(\frac{\pi}{3}x^2\right) = 1$

$\Rightarrow x^2 = \frac{3}{2}(4n+1)$ for n = 0, 1 only

$\Rightarrow x = \pm\sqrt{\frac{3}{2}}, \pm\sqrt{\frac{15}{2}}$ and for each x, there are two values of y

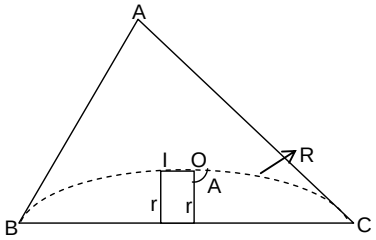
$\therefore$ The number of ordered pairs = 8

SECTION – C : Numerical Answer Type

This section contains **3 questions.** The answer to each question is a **Numerical Answer Type XXXXX.XX** (for example if answer is **99999.99** then write the same answer without rounding off any digit).

73. In triangle ABC, the line joining circumcentre to the incentre is parallel to BC, then (cos B + cos C) = k , then find the value of $\frac{5k}{2}$ is

Ans. 00002.50



Sol. Here $\cos A = \frac{r}{R}$

$\Rightarrow \cos A = 4\sin\frac{A}{2}.\sin\frac{B}{2}.\sin\frac{C}{2}$

$\Rightarrow$ cos A = cos A + cos B + cos C – 1

$\Rightarrow$ cos B + cos C = 1

74. The value of $\frac{\int_0^1 \frac{dt}{\sqrt{1-t^4}}}{\int_0^1 \frac{1}{\sqrt{1+t^4}}dt}$ is

Ans. 00001.41

Sol. Put $t^2 = \sin\theta$ in numerator (Nr.)

$\therefore I_1 = \frac{1}{2}\int_0^{\frac{\pi}{2}} \frac{1}{\sqrt{\sin\theta}}d\theta$

Put $t^2 = \tan\alpha$ in denominator

$$\therefore\ I_2 = \frac{1}{2}\int_0^1 \frac{1}{\sqrt{1+t^4}}dt = \frac{1}{2}\int_0^{\frac{\pi}{4}} \frac{\sqrt{2}}{\sqrt{\sin 2\alpha}}d\alpha = \frac{1}{\sqrt{2}}I_1$$

75. The probability that $\sin^{-1}(\sin x) + \cos^{-1}(\cos y)$ is an integer x, y $\in\{1, 2, 3, 4\}$ is $\frac{k}{2}$, then k+3 is

Ans. 00003.37

Sol. For expression $\sin^{-1}(\sin x) + \cos^{-1}(\cos y)$ to be an integer, x should lie between $\left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$ and y should lie between $[0, \pi]$
x = 1 and y = 1, 2, 3.

$\therefore$ Required probability = $\frac{3}{16}$