Score JEE Main - 1 2025 AIOT 4

PHYSICS

ESJMRT13PH054

Section-I(SC)

Q1. In a process the density of a gas remains constant. If the temperature is doubled, then the change in the pressure will be:

(A) 100 % increase (B) 200 % increase (C) 50 % decrease (D) 25 % decrease

Ans. (A)

Sol. We have $\rho = \frac{PM}{RT}$

$$\frac{P_1M}{RT_1} = \frac{P_2M}{RT_2}$$

$$\frac{P_1}{T_1} = \frac{P_2}{2T_1}$$

$$P_2 = 2P_1$$

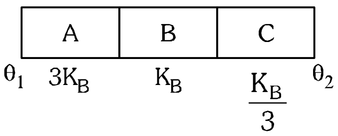
Q2. Three identical metal rods A, B, & C are placed end to end and a temp. difference is maintained between the free ends of A & C. If the thermal conductivity of B (K_B) is thrice that of C (K_C) & one third that of A (K_A), the effective thermal conductivity, of the system will be ___if $K_A = 13Js^{-1}m^{-1}c^{-1}$.

(A) $4Js^{-1}m^{-1}c^{-1}$ (B) $5Js^{-1}m^{-1}c^{-1}$

(C) $3Js^{-1}m^{-1}c^{-1}$ (D) $8Js^{-1}m^{-1}c^{-1}$

Ans. (C)

Sol.



$$K_e = \frac{3K_1K_2K_3}{K_1K_2 + K_2K_3 + K_3K_1}$$

$$\Rightarrow \frac{3 \times 3K \times K \times \frac{K}{3}}{3K^2 + \frac{K^2}{3} + K} \Rightarrow \frac{3K^3}{\frac{13}{3}K^2}$$

$$K_e = \frac{9}{13}K_B$$

$$K_A = 3K_B$$

$$K_B = \frac{K_A}{3}$$

$$K_e = \frac{9}{13}\frac{K_A}{3} = \frac{9}{13} \times \frac{13}{3} = 3Js^{-1}m^{-1}c^{-1}$$

Q3. A nucleus (of nuclear density ρ) disintegrates into two daughter nuclei with masses in the ratio 8 : 27. Density of the smaller nucleus is :

(A) $\frac{2}{3}\rho$ (B) $\frac{2}{5}\rho$ (C) $\frac{8}{27}\rho$ (D) ρ

Ans. (D)

Sol. As the density of nucleus is independent of atomic mass number.

So, it will be same for all nucleus.

$\therefore$ Density of both the daugther nuclei is ρ.

Q4. Three bodies have equal masses m. Body A is solid cylinder of radius R, body B is a square lamina of side R, and body C is a solid sphere of radius R. Which body has the smallest moment of inertia about an axis passing through their centre of mass and perpendicular to the plane (in case of lamina)

(A) A (B) B (C) C (D) A and C both

Ans. (B)

Sol. $I \text{ solid cylinder} = \frac{MR^2}{2}$

$I \text{ square} = \frac{MR^2}{6}$

$I \text{ solid sphere} = \frac{2}{5}MR^2$

Q5. Which of the following observers is/are inertial-

(A) A child revolving in a merry-go-round

(B) A driver in a car moving with a constant velocity

(C) A pilot in an aircraft which is taking off

(D) A passenger in a train which is slowing down to a stop

Ans. (B)

Sol. Non-inertial frame means frames having acceleration.

Q6. In an AC generator, a coil with N turns, all of the same area A and total resistance R, rotates with angular velocity ω in a uniform magnetic field B. The maximum value of ac current generated in the coil is-

(A) NABRω (B) BAN/R (C) BAωN/R (D) BANR

Ans. (C)

Sol. Flux through N turns of the coil

$\phi = N(\vec{B}\cdot\vec{A})$

$\phi = NBA\cos\omega t$

$e = \frac{-d\phi}{dt} = -NBA(-\omega\sin\omega t)$

$e = NBA\omega\sin\omega t$

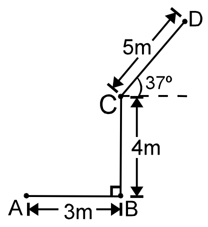
$e_{max} = NBA\omega$

current generated in the coil is,

$$i = \frac{e}{R}$$

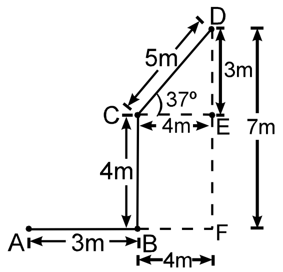
$$= \frac{NBA\omega}{R}$$

Q7. A particle moves along a path ABCD as shown in the figure. Then the magnitude of net displacement of the particle from position A to D is :



(A) 10 m (B) $5\sqrt{2}$ m (C) 9 m (D*) $7\sqrt{2}$ m

Sol. As can be seen from the figure



the displacement is $\sqrt{(AF)^2 + (FD)^2} = 7\sqrt{2}$ m

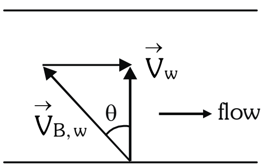
Q8. A man can swim in still water with a speed of 2 m/s. If he wants to cross a river of water current speed $\sqrt{3}$ m/s along shortest possible path, then in which direction should he swim?

(A) at an angle 120° to the water current (B) at an angle 150° to the water current

(C) at an angle 90° to the water current (D) none of these

8. **(B)**

8. $V_w = \sqrt{3}$, $V_{B,w} = 2$

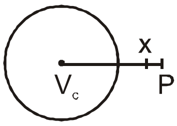


$\sin\theta = \frac{\sqrt{3}}{2}$, $\theta = 60°$

Q9. A solid sphere of radius R is charged uniformly. At what distance from its surface is the electrostatic potential half of the potential at the centre?

(A) R (B) R/2 (C) R/3 (D) 2R

Ans. **(C)**

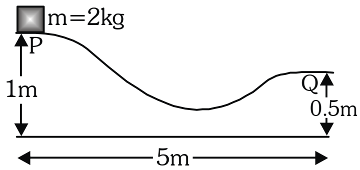
Sol. 

$V_P = \frac{V_C}{2}$

$$V_P = \frac{kq}{(R+x)} = \frac{1}{2}\left(\frac{3}{2}\frac{kq}{R}\right)$$

$$4R = 3\ (R + x) \qquad \Rightarrow x = \frac{R}{3}$$

Q10. Find the horizontal velocity of the particle when it reach the point Q. Assume the block to be frictionless. Take (g = acceleration due to gravity).



(A) 4 m/s (B) 5 m/s (C) $\sqrt{9.8}$ m/s (D) 3.6 m/s

Ans. (C)

Sol. $mg\left(1-\frac{1}{2}\right) = \frac{1}{2}mv^2$

$$\Rightarrow \frac{g}{2} = \frac{v^2}{2} \Rightarrow v = \sqrt{g}\ \text{m/s}$$

Q11. A photon of energy 10.5 eV is allowed to interact with a hydrogen atom in its ground state.

(A) the photon transfers 10.2 eV to the atom

(B) the photon increases the kinetic energy of the electron

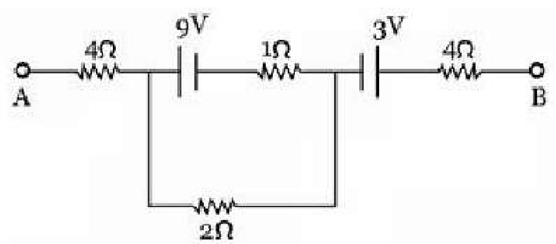
(C) the photon cannot excite the atom

(D) the atom emits a new photon of 0.3 eV

Ans. (C)

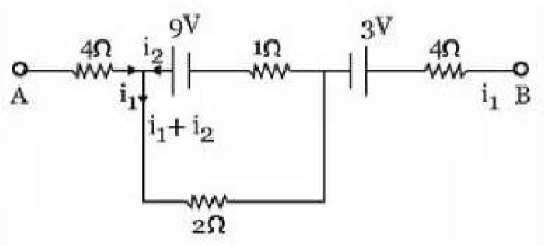
Sol. To excite an electron or atom from the ground state exactly 10.2 eV energy is required to move it at energy level state $n = 2$. But the given energy of photon is 10.5 eV. So it will not be absorbed by the atom.

Q12. In the part of the circuit shown in the figure, the potential difference between points $V_A - V_B = 16V$. The current passing through the 2Ω resistance will be



(A) 2.5A (B) 3.5 A (C) 4.0 A (D) zero

12. (B)

12. 

$V_A - V_B = 16V$

$\therefore 4i_1 + 2(i_1 + i_2) - 3 + 4i_1 = 16V......(i)$

Using Kirchhoff's second law in the closed loops we have

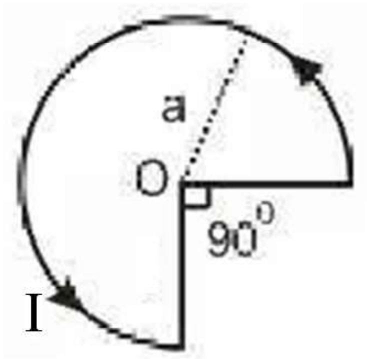
$\Rightarrow 9 - i_2 - 2(i_1 + i_2) = 0.....(ii)$

Solving equations (i) and (ii), we get

$i_1 = 1.5\,A$ and $i_2 = 2\,A$

$\therefore$ Current through 2Ω resistor $= 2 + 1.5 = 3.5\,A$

Q13. The figure shows a current-carrying loop having current I, some part of which is circular and some part is a line segment. The magnetic induction at the centre is



(A) $\frac{3\mu_0 I\pi}{4a}$ (B) $\frac{\mu_0 I}{4\pi a}(1+\pi)$ (C) $\frac{\mu_0 I}{8\pi a}$ (D) $\frac{3\mu_0 I}{8a}$

13. (D)

13. $\frac{3\mu_0 I}{8a}$

The magnetic field due to circular arc is

$$B = \frac{\mu_0 I\alpha}{4\pi r} = \frac{\mu_0 I}{4\pi a}\left(\frac{3\pi}{2}\right) = \frac{3\mu_0 I}{8a}$$

Q14. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion (A): If a constant current is flowing through non-uniform cross-sectional wire, drift velocity of electron at different cross sections remains same.

Reason (R): Drift velocity of an electron is given by $\frac{I}{neA}$, where I is current, n is electron density, e is electronic charge and A is area of crosssection.

In the light of the above statements, choose the most appropriate answer from the options given below:

(A) Both A and R are correct and R is NOT the correct explanation of A.

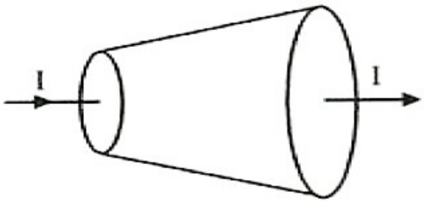
(B) A is correct but R is not correct.

(C) Both A and R are correct and R is the correct explanation of A.

(D) A is not correct but R is correct.

Ans. (D)

Sol.



Current flow is constant.

$\therefore i = neAV_d = \text{constant}$

$\therefore V_d \propto \frac{1}{A}$

$\therefore A \uparrow V_d \downarrow$

Q15. Match the entries of List-I with the entries of List-II :-

List-I	List-II
(A) Characteristic X-ray	(I) Faraday law
(B) Photoelectric effect	(II) Emission of electrons
(C) Thermo-ionic emission	(III) Moseley's law
(D) Induced Electromotive Force	(IV) Coulomb's law

Choose the correct answer from the options given below:

(A) A-I, B-III, C-III, D-II (B) A-III, B-II, C-II, D-I

(C) A-II, B-I, C-II, D-III (D) A-I, B-III, C-II, D-III

Ans. (B)

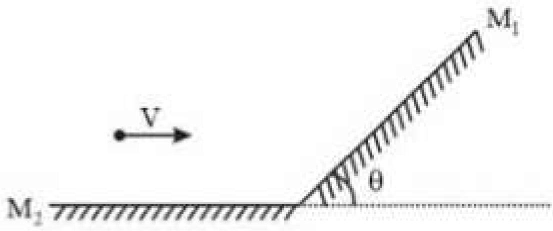
Sol. X-ray production involves the emission of radiations.

Thermo ionic emission involves emission of electrons due to thermal heat.

X -ray production is inverse process of photoelectric effect.

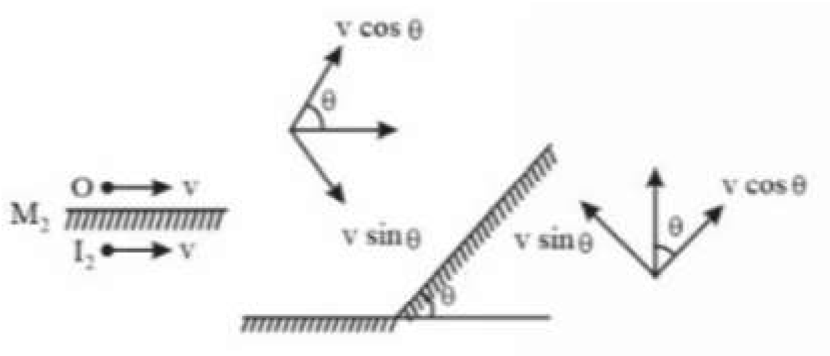
Photoelectric effect involves emission of electrons due to photons.

Q16. A point object is moving with a speed v in front of an arrangement of two mirrors as shown in the figure. The magnitude of velocity of the image in mirror M_1 with respect to the image in mirror M_2 is



(A) $2v\sin\theta$ (B) $v\sin\theta$ (C) $3v\sin\theta$ (D) $4v\sin\theta$

16. Angle between v_{I_1} and v_{I_2} is 2θ



$\therefore \left|\vec{v}_{I_1} - \vec{v}_{I_2}\right| = \sqrt{v^2 + v^2 - 2v \cdot v \cdot \cos 2\theta}$

$= 2v\sin\theta$

Q17. In an electromagnetic wave, the maximum value of the electric field is $100\,Vm^{-1}$. The average intensity is $\left[\varepsilon_0 = 8.8\times10^{-12}C^{-2}N^{-1}m^2\right]$

(A) $13.2\,Wm^{-2}$ (B) $36.5\,Wm^{-2}$ (C) $46.7\,Wm^{-2}$ (D) $765\,Wm^{-2}$

17. (A)

17. $I_{avg} = \frac{1}{2}c\varepsilon_0\left(E_0\right)^2$

$\Rightarrow I_{avg} = \frac{1}{2}\times3\times10^8\times8.8\times10^{-12}\times(100)^2$

$\Rightarrow I_{avg} = 13.2\,Wm^{-2}$

Q18. Give the number of significant figures of 0.05×10^5

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

18. **(A)**

18. Here zero is not significant digit.

Q19. An unpolarized light of intensity I_0 passes through three polarizers, such that the transmission axis of last polarizer is perpendicular to that of first. If the intensity of emergent light is $\frac{3I_0}{32}$ and the angle between the transmission axis of first two polarizers is θ, then

(A) $\theta = 45^\circ$ (B) $\theta = 37^\circ$ (C) $\theta = 30^\circ$ (D) $\theta = 53^\circ$

19. $\frac{3I_0}{32} = \frac{I_0}{2}\cos^2\theta\sin^2\theta$

$4\cos^2\theta\sin^2\theta = \frac{3}{4}$

$\text{or} \sin 2\theta = \sqrt{\frac{3}{4}} = \frac{\sqrt{3}}{2}$

$\theta = 30^\circ$

Q20. Plates of a parallel plate capacitor, having a potential difference 100V applied across them, carry a surface charge density of 50nC cm^{-2}. Spacing between the plates is

(A) 329μm (B) 259μm (C) 1.77μm (D) 125μm

20. (C)

20. $E = \frac{\sigma}{\varepsilon_0}$

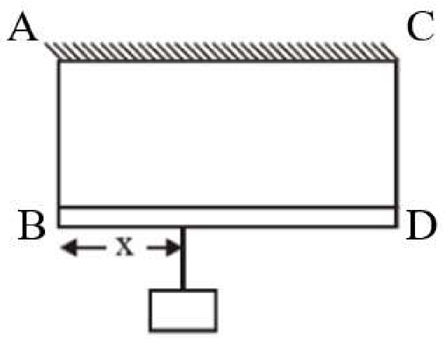
Potential difference $V = Ed$

$\therefore d = \frac{V}{E} = \frac{100}{50\times10^{-7}} \times 8.85\times10^{-12}$

$= 177\times10^{-6}\text{ m} = 177\mu\text{m}$

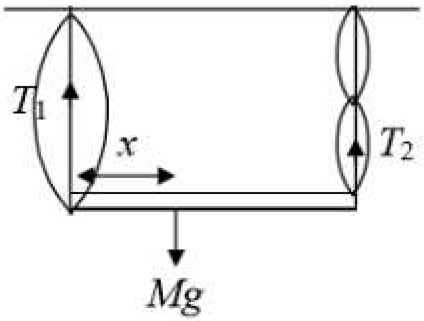
Section-II(NV)

Q21. A massless rod BD of length l is hung from the ceiling with the help of two identical wires attached at its ends. A block of mass m is suspended at point P such that BP is equal to X, the frequency of the 1^{st} harmonic of the wire on the left end is equal to the frequency of the 2^{nd} harmonic of the wire on the right. then the value of X is $\frac{\ell}{N}$. Find the value of N.



21. (5)

21. $v = \lambda f$



$$\frac{\sqrt{\frac{T_1}{\mu}}}{\sqrt{\frac{T_2}{\mu}}} = \frac{2\ell f}{\ell f}$$

$$\frac{T_1}{T_2} = 4$$

$$T_1 + T_2 = Mg; T_2 = \frac{Mg}{5}$$

$$\Sigma t_B = 0 \Rightarrow Mg \times X = \left(\frac{Mg}{5}\right) \times \ell$$

$$X = \frac{\ell}{5}$$

Q22. Two particles are projected vertically upwards from the surface of the earth with velocities $v_1 = \sqrt{\frac{2gR}{3}}$ and $v_2 = \sqrt{\frac{4gR}{3}}$ respectively, where R is radius of earth . If the maximum heights attained by the two particles above earth's surface are h_1 and h_2 respectively, then calculate the ratio $\frac{h_2}{h_1}$

22. 4

22. Loss of KE = Gain in PE

$$\Rightarrow \frac{1}{2}mv^2 = mgh\left(\frac{R}{h+R}\right)$$

CASE I.

$$\Rightarrow \frac{1}{2}m\left(\frac{2gR}{3}\right) = mgh_1\left(\frac{R}{h_1+R}\right)$$

$$\Rightarrow \frac{1}{2}m\left(\frac{4gR}{3}\right) = mgh_2\left(\frac{R}{h_2+R}\right)$$

Solving (i)

$$\Rightarrow \frac{1}{3} = \frac{h_1}{h_1 + R}$$

$$\Rightarrow h_1 = \frac{R}{2}$$

Solving (ii)

$$\Rightarrow \frac{2}{3} = \frac{h_2}{h_2 + R}$$

$$\Rightarrow h_2 = 2R$$

From (iii) and (iv)

$$\Rightarrow \frac{h_1}{h_2} = \frac{R/2}{2R}$$

$$\therefore \frac{h_1}{h_2} = \frac{1}{4} = 0.25$$

Q23. The amplitude of a wave disturbance propagating in positive direction of x-axis is given by $y = \frac{1}{1+x^2}$ at t = 0 and by $y = \frac{1}{1+(x-1)^2}$ at t = 2s, where x and y are in meters. The shape of the wave disturbance does not change during propagation. The velocity of the wave is (in cm/s) :-

23. 50

23. In a wave equation, x and t must be related in the form (x-v t). Therefore, we rewrite the given equation as

$$y = \frac{1}{1+(x-vt)^2}$$

For t = 0, it becomes $y = \frac{1}{1+x^2}$

And for t = 2, it becomes

$$y = \frac{1}{\left[1+(x-2v)^2\right]} = \frac{1}{1+(x-1)^2}$$

$$\therefore 2v = 1 \text{ or } v = 0.5\,ms^{-1}$$

Q24. Emulsification of oil in water produces 2.4×10^{18} droplets. If the surface tension at the oil water interface is $0.03 Jm^{-2}$ and the surface area of each droplet is $12.5 \times 10^{-16}\,m^2$, the energy (in J) spent in the formation of oil droplets is

Ans. 90

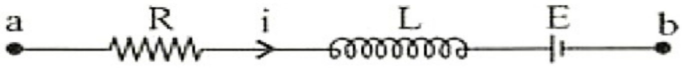
Sol.

$$W = NT\Delta A$$

$$= 2.4 \times 10^{18} \times 0.03 \times 12.5 \times 10^{-16}$$

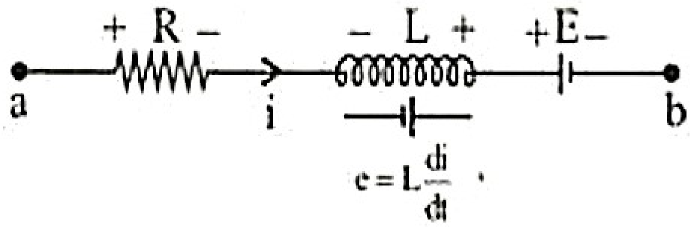
$$= 90\,J$$

Q25. In the circuit diagram shown in figure, $R = 10\Omega$, L = 5H, E = 20V and i = 2A. This current is decreasing at a rate of 1 A/s. Find the potential difference (in volt) between points A and $B(V_A - V_B)$ at this instant.



Ans. 35

Sol.



$$V_A - iR + L\frac{di}{dt} - E = V_B$$

$$V_A - V_B = E + iR - L\frac{di}{dt}$$

$$= 20 + (2)(10) - (5)(1)$$
$$= 35V$$

CHEMISTRY

Section-I(SC)

Q1. In the series carbon, nitrogen, oxygen and fluorine, electronegativity :

(A) Decreases from carbon to fluorine

(B) Remains constant

(C) Decreases from carbon to oxygen and then increases

(D) Increases from carbon to fluorine

Ans. [D]

Q2. The correct order of hybridization of the central atom in the following species NH_3, H_2O, PCl_5 and BCl_3 is -

(A) dsp^2, dsp^3, sp^2 and sp^3
(B) sp^3, sp^3, sp^3d, sp^2
(C) dsp^2, sp^2, sp^3, dsp^3
(D) dsp^2, sp^3, sp^2, dsp^3

Ans. [B]

Q3. Melting point of calcium halides decreases in the order -

(A) $CaF_2 > CaCl_2 > CaBr_2 > CaI_2$
(B) $CaI_2 > CaBr_2 > CaCl_2 > CaF_2$
(C) $CaBr_2 > CaI_2 > CaF_2 > CaCl_2$
(D) $CaCl_2 > CaBr_2 > CaI_2 > CaF_2$

Ans. **[A]**

Sol. Due to high lattice energy

Q4. Which one of the following statements is incorrect –

(A) Greater the stability constant of a complex ion, greater is its stability

(B) Greater the charge on the central metal ion, greater is the stability of the complex.

(C) Greater is the basic character of the ligand, the greater is the stability of the complex

(D) Chelate complexes have low stability constant

Ans. **[D]**

Sol. Chelation provide stability to complex.

Q5. The pair in which both species have same magnetic moment is -

(A) $[Cr(H_2O)_6]^{2+}$, $[CoCl_4]^{2-}$ (B) $[Cr(H_2O)_6]^{2+}$, $[Fe(H_2O)_6]^{2+}$

(C) $[Mn(H_2O)_6]^{2+}$, $[Cr(H_2O)_6]^{2+}$ (D) $[CoCl_4]^{2-}$, $[Fe(H_2O)_6]^{2+}$

Ans. **[B]**

Sol. $[Cr(H_2O)_6]^{2+}$ have Cr^{2+}

$Cr^{2+} = 3d^4\ 4s^{\circ}$ (four unpaired electrons)

$Fe^{2+} = 3d^6\ 4s^{\circ}$ (in presence of weak ligand also have four unpaired electrons)

Q6. During compression of a spring the work done is 10kJ and 2kJ heat escaped to the surrounding. The change in internal energy (in kJ) is-

(A) –12 (B) –8 (C) 8 (D) 12

Ans. (C)

Sol. FLOT

$\Delta U = q + w$

$= 10 - 2$

$= 8kJ$

Q7. The amount of electricity that can deposit 108 gm of silver from $AgNO_3$ solution is:

(A) 1 ampere (B) 1 coulomb

(C) 1 Faraday (D) 2 ampere

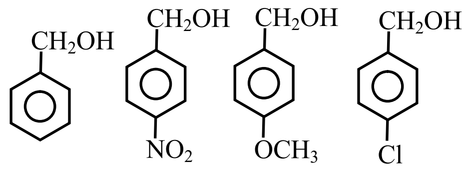
Ans. (C)

Sol. $Ag^{+} + e^{-} \rightarrow Ag(s)$

1F 1 mol

1 Farad charge will deposit 1 mol (=108 gm) of silver.

Q8. Consider following benzyl alcohol



I II III IV

Correct order of their K_b value is

(A) III > IV > II > I (B) I > III > IV > II

(C) I < II < III < IV (D) IV > II > I > III

Ans. **[B]**

Sol. Acidic strength $\propto K_a \propto \dfrac{1}{K_b}$

Q9. Which of the following has neither secondary nor tertiary hydrogen ?

(A) Isobutane (B) Isopentane (C) Pentane (D) Neopentane

Ans. **[D]**

Sol. $CH_3-C(CH_3)_2-CH_3$ (Neopentane)

Q10. Select the alkane which forms four isomeric dihalo derivatives (excluding stereo isomers)-

(A) Isobutane (B) Propane (C) Neopentane (D) Ethane

Ans. **[B]**

Sol. $CH_3-CH_2-CH(Cl)(Cl)$, $CH_3-CH(Cl)-CH_2(Cl)$

$CH_2(Cl)-CH_2-CH_2(Cl)$ $CH_3-C(Cl)(Cl)-CH_3$

Q11. $n-\text{Heptane} \xrightarrow{[X]} \xrightarrow{[Y]} \xrightarrow[(ii)H^+]{(i)Z} Ph-COOH + Ph-CH_2-OH$ reagent x, y and z are respectively:-

(A) $CrO_3 / \Delta, Al_2O_3 / \Delta, NaOH$ (B) $Al_2O_3 / \Delta, CrO_2Cl_2$ & $H_3O^+, NaOH$

(C) $V_2O_5 / \Delta, KMnO_4, KOH$ (D) $MO_2O_3 / \Delta, CrO_3, KOH$

Ans. **[B]**

Q12. The reaction

$C_2H_5ONa + BrC_2H_5 \rightarrow C_2H_5–O–C_2H_5 + NaBr$ is called -

(A) Frankland reaction (B) Wurtz reaction

(C) Williamson's synthesis (D) Cannizzaro reaction

Ans. **[C]**

Q13. In phenols –

(A) – OH group is attached in side chain

(B) – OH group is directly attached to benzene nucleus

(C) Both (A) & (B)

(D) None

Ans. **[B]**

Q14. Which of the following will give yellow precipitate with $I_2/NaOH$?

(A) $CH_3CH_2COCH_2CH_3$ (B) $CH_3COOCOCH_3$

(C) CH_3CONH_2 (D) $CH_3CH(OH)CH_2CH_3$

Ans. **[D]**

Q15. The products (A) and (B) formed in the given reaction is

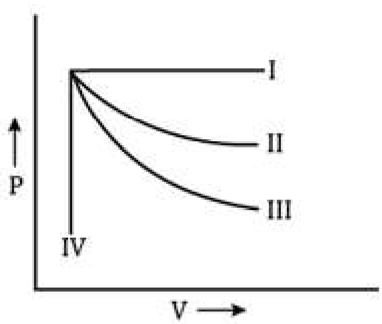
$$RCOCl \xrightarrow{NH_3} A \xrightarrow{KOH+Br_2} B$$

(A) $RCONH_2$ and RCN (B) $RCONH_2$ and RNC

(C) $RCONH_2$ and RNH_2 (D) RNCO and RNH_2

Ans. **[C]**

Q16. The plots between p and v which represents isochoric and isobaric process respectively :



(A) I,II (B) IV,I (C) I,IV (D) II,III

Ans. (B)

Sol. For IV volume is constant (isochoric)

For I pressure is constant (isobaric)

Q17. The equilibrium constant. K_c for the reaction $P_4(g) \rightleftharpoons 2P_2(g)$ is 1.4 at 400°C. Suppose that 3 moles of $P_4(g)$ and 2 moles of $P_2(g)$ are mixed in a 2 litre container at 400°C. What is the value of reaction quotient (Q)?

(A) 3/2 (B) 2/3 (C) 1 (D) 2/5

Ans. **[B]**

Sol. $Q_c = \dfrac{[P_2(g)]^2}{[P_4(g)]} = \dfrac{(1)^2}{(3/2)} = 2/3$

Q18. The basic buffer is?

(A) NaOH + NaCl (B) CH_3COOH + HCl

(C) $NH_4OH + NH_4\,Cl$ (D) NH_4OH + NaOH

Ans. **(C)**

Sol. $NH_4OH + NH_4Cl$ mixture acts as basic buffer.

Q19. A solution containing 62 gm of ethylene glycol in 250 gm of water is cooled to $-10^{\circ}C$. If K_f for water is $1.86\dfrac{k \times kg}{mol}$, find amount of water (in gm) seperated as ice ?

(Mol. wt of ethylene glycol = 62).

(A) 64 (B) 186 (C) 50 (D) 28

Ans. (A)

Sol. $10 = 1.86 \times \dfrac{(62/62)}{x/1000}$

x = 186

ice = 250 - 186 = 64

Q20. When initial amount of reactant is doubled, the half life of reaction does not change. The order of reaction is

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

Ans. (D)

Sol. $t_{1/2}$ = constant for 1st order reaction.

Section-II(NV)

Q21. Out of : $Na_2O, MgO, Al_2O_3, CO, N_2O, CO_2, SO_3$, number of acidic oxide is:

Ans. (2)

Sol. CO, N_2O

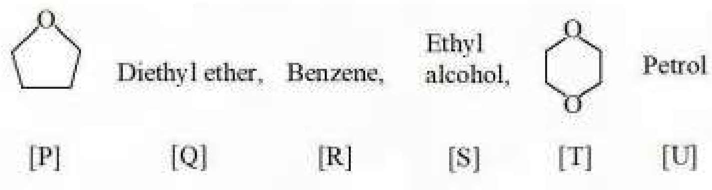
Q22. The number of resonating structures exist for the azide ion, N_3^- are............

Ans. (3)

Sol. Resonating structures of N_3^- are

$[:\ddot{N} = N = \ddot{N}:]^- \leftrightarrow [:\ddot{\underset{..}{N}} - N \equiv N:]^- \leftrightarrow [:N \equiv N - \ddot{\underset{..}{N}}:]^-$

Q23. How many of the following are polar aprotic solvents ?



Ans. (3)

Sol. Polar aprotic solvents are

Q24. Heat absorbed in the reaction $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ is 182 KJ. Bond energies of H-H = 430 KJ/mol and Cl-Cl = 242 KJ/mol. the H-Cl bond energy is ___________ KJ/mol?

Ans. 245

Sol. $182 = 430 + 242 - 2\times B.E_{H-Cl}$

$B.E_{HCl} = 245$ KJ/mol.

Q25. The Van't Hoff factor (i) for a dilute solution of $K_3[Fe(CN)_6]$ is ?
(aasuming 100% ionisation)

Ans. (4)

Sol. $K_3[Fe(CN)_6] \rightarrow 3K^+ + [Fe(CN)_6]^{3-}$

- -

1 mol 3 mol 1 mol

$i = \frac{4}{1} = 4$

MATH

Section-I(SC)

Q1. The coefficient of x^4 in the expansion of $\left(1 + x + x^2\right)^6$ is

(A) 72 (B) 90 (C) 96 (D) 112

1. (B)

1. $(1+x(1+x))^6 = 1 + {}^6C_1x(1+x) + {}^6C_2x^2(1+x)^2 + {}^6C_3x^3(1+x)^3 + {}^6C_4x^4(1+x)^4 + \dots$

Coefficient of x^4 is

${}^6C_2 + {}^6C_3 \cdot 3 + {}^6C_4$

$= \frac{6\times 5}{2} + \frac{6\times 5\times 4}{3\times 2}\times 3 + \frac{6\times 5}{2}$

= 15 + 60 + 15

= 90

Q2. Consider the family of lines $5x + 3y - 2 + \lambda(3x - y - 4) = 0$ and $x - y + 1 + \mu(2x - y - 2) = 0$. The equation of a straight line that belongs to both the families is

(A) $5x - 2y - 7 = 0$ (B) $3x + y - 2 = 0$

(C) $5x + 2y - 3 = 0$ (D) $2x + y - 1 = 0$

2. (A)

2. All lines of the family $5x + 3y - 2 = 0$ and $(3x - y - 4) = 0$ are concurrent.

The point of concurrency is (1, –1)

Similarly, the point of concurrency of lines of the other family is (3, 4)

$\Rightarrow$ The line of both families is the line passing through (1, –1) & (3, 4)

$\Rightarrow$ Equation of the required line is $5x - 2y - 7 = 0$

Q3. If the differential equation $3x^{\frac{1}{3}}dy + x^{-\frac{2}{3}}\ ydx = 3xdx$ is satisfied by $kx^{\frac{1}{3}}y = x^2 + c$ (where c is an arbitrary constant), then the value of k is

(A) 2 (B) 4 (C) 6 (D) 8

Ans. (A)

Sol. The given equation is $x^{\frac{1}{3}} \cdot dy + \frac{1}{3}x^{-\frac{2}{3}}dx$

$y = x\ dx$

or $d\left(x^{\frac{1}{3}} \cdot y\right) = xdx$

Integrating, we get

$x^{\frac{1}{3}} \cdot y = \frac{x^2}{2} + \lambda$

or $2x^{\frac{1}{3}}y = x^2 + C$

$\Rightarrow k = 2$

Q4. The perpendicular bisector of a line segment with end points (1, 2, 6) and (–3, 6, 2) passes through

(–6, 2, 4) and has the equation of the form $\frac{x+6}{l}=\frac{y-2}{m}=\frac{z-4}{n}$ (Where l, m, n are integers, l is a prime number and $l > 0$), then the value of $l$mn – (l + m + n) equals to

(A) –3 (B) –5 (C) –7 (D) –9

4. (C)

4. Midpoint of the line segment is $\left(\frac{1-3}{2},\frac{2+6}{2},\frac{6+2}{2}\right)\equiv(-1,4,4)$

Parallel vector to the required line $=(-1+6)\hat{i}+(4-2)\hat{j}+(4-4)\hat{k}$

$=5\hat{i}+2\hat{j}+0\hat{k}$

Hence, equation of the line is

$\frac{x+6}{5}=\frac{y-2}{2}=\frac{z-4}{0}$

$\Rightarrow l=5, m=2, n=0$

Q5. Two vertices of a triangle are (0, 2) and (4, 3). If its orthocentre is at the origin, then its third vertex lies in which quadrant ?

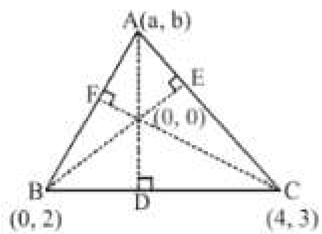
(A) Third (B) First (C) Second (D) Fourth

5. (C)

5. $m_{BD}\times m_{AD}=-1\Rightarrow\left(\frac{3-2}{4-0}\right)\times\left(\frac{b-0}{a-0}\right)=-1$

$\Rightarrow b+4a=0$ ....(I)

$m_{AB}\times m_{CF}=-1$



$\Rightarrow\left(\frac{(b-2)}{a-0}\right)\times\left(\frac{3}{4}\right)=-1$

$\Rightarrow 3b-6=-4a$

$\Rightarrow 4a+3b=6$ ......(ii)

from (i) and (ii)

$a=\frac{-3}{4}, b=3$

$\therefore$ II^{nd} *quadrant*

Q6. If $f : A \to B$ defined by $f(x) = \sin x - \cos x + 3\sqrt{2}$ is an invertible function, then the correct statement can be

(A) $A = \left[\frac{\pi}{4}, \frac{5\pi}{4}\right], B = [3\sqrt{2}, 4\sqrt{2}]$

(B) $A = \left[\frac{-\pi}{4}, \frac{5\pi}{4}\right], B = [2\sqrt{2}, 4\sqrt{2}]$

(C) $A = \left[\frac{-\pi}{4}, \frac{3\pi}{4}\right], B = [\sqrt{2}, 4\sqrt{2}]$

(D) $A = \left[\frac{-\pi}{4}, \frac{3\pi}{4}\right], B = [2\sqrt{2}, 4\sqrt{2}]$

6. (D)

6. $f(x) = \sqrt{2}\left(\frac{1}{\sqrt{2}}\sin x - \frac{1}{\sqrt{2}}\cos x\right) + 3\sqrt{2} = \sqrt{2}\sin\left(x - \frac{\pi}{4}\right) + 3\sqrt{2}$

Clearly, for options A and B f(x) is not injective and for the option C f(x) is not surjective
Hence, f(x) is bijective only for option D

Q7. The relation R given by $\{(x, y) : x^2 - 3xy + 2y^2 = 0, \forall x, y \in R\}$ is

(A) reflexive but not symmetric
(B) symmetric but not transitive
(C) symmetric and transitive
(D) an equivalence relation

7. (A)

7. $\because x^2 - 3xy + 2y^2 = 0$

$\Rightarrow x^2 - xy - 2xy + 2y^2 = 0$

$\Rightarrow x(x - y) - 2y(x - y) = 0$

$\Rightarrow (x - 2y)(x - y) = 0$

$\Rightarrow x = y$ or $x = 2y$

Now, $\because$ in R all ordered pairs (x, x) are present

$\therefore$ It is reflexive

Now, $(4, 2) \in R$ as $4 = 2(2)$

but $(2, 4) \notin R$ as $2 \neq 2(4)$

$\therefore$ It is not symmetric

Also $(4, 2)$ & $(2, 1) \in R$ but $(4, 1) \notin R$

$\therefore$ It is not transitive

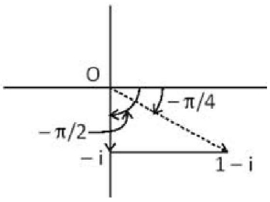
Q8. If Z is a variable complex number such that $|Z - 1 + i| + |Z + i| = 1$, then the locus of Z is-

(A) an ellipse
(B) a pair of rays
(C) a line segment
(D) a hyperbola

8. (C)

8. $|Z - 1 + i| + |Z + i| = |(1 - i) - (-i)|$

$\Rightarrow$ locus of Z is the line segment joining $-i$ with $1 - i$



$\Rightarrow$ minimum arg (Z) = $-\frac{\pi}{2}$ & maximum arg (Z)

$= -\frac{\pi}{4}$

$\Rightarrow$ principal $(Z) \in \left[-\frac{\pi}{2}, -\frac{\pi}{4}\right]$

Q9. The number of distinct real roots of the equation $x^7 - 7x - 2 = 0$ is

(A) 5 (B) 7 (C) 1 (D) 3

9. (D)

Sol. $f(x) = x^7 - 7x - 2$

$f'(x) = 7 \times x^6 - 7 = 0 \Rightarrow x = \pm 1$

$f(-1)f(1) < 0$

Q10. The radius of the circle touching the line $x + y = 4$ at $(1,3)$ and intersecting $x^2 + y^2 = 4$ orthogonally is

(A) $\frac{3\sqrt{2}}{4}$ units (B) $\frac{3}{4}$ units (C) $\frac{3}{\sqrt{2}}$ units (D) $\frac{4\sqrt{2}}{3}$ units

10. (A)

10. Let the equation of the circle is $(x-1)^2 + (y-3)^2 + \lambda(x+y-4) = 0$

$\Rightarrow x^2 + y^2 + (\lambda-2)x + (\lambda-6)y + (10-4\lambda) = 0$

which is orthogonal to $x^2 + y^2 = 4$

Now, $2g_1g_2 + 2f_1f_2 = c_1 + c_2$ implies $0 + 0 = 10 - 4\lambda - 4 \Rightarrow \lambda = \frac{3}{2}$

Hence, the equation of the circle is

$x^2 + y^2 - \frac{x}{2} - \frac{9y}{2} + 4 = 0$

Radius $= \sqrt{\frac{1}{16} + \frac{81}{16} - 4} = \sqrt{\frac{18}{16}}$

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

Q11. Let α be a root of the equation $1+x^2+x^4=0$. Then, the value of $\alpha^{1011}+\alpha^{2022}-\alpha^{3033}$ is equal to

(A) 1 (B) α (C) $1+\alpha$ (D) $1+2\alpha$

11. (A)

11. α is a root of the equation

$x^4+x^2+1=0$

$\therefore \alpha^2 = w$ or w^2

$\Rightarrow \alpha^{2022} = \left(\alpha^2\right)^{1011} = w^{1011} = 1$ and $\alpha^{3033} = \alpha^{1011}$

$\therefore \alpha^{1011}+\alpha^{2022}-\alpha^{3033}=1$

Q12. If the focus of a hyperbola is $(\pm 3, 0)$ and the equation of a tangent is $2x + y - 4 = 0$, then the equation of the hyperbola is

(A) $4x^2-5y^2=20$ (B) $5x^2-4y^2=20$ (C) $4x^2-5y^2=1$ (D) $5x^2-4y^2=1$

12. (A)

12. Given, $(\pm ae, 0) = (\pm 3, 0)$

$\Rightarrow \quad ae = 3$

$\Rightarrow a^2e^2 = 9$

$\Rightarrow b^2 + a^2 = 9 \ldots \text{(i)}$

$\because 2x + y - 4 = 0$

$\Rightarrow \quad y = -2x + 4$

is the tangent to the hyperbola

$\therefore \quad (4)^2 = a^2(-2)^2 - b^2 \left(\because c^2 = a^2m^2 - b^2\right)$

$\Rightarrow 4a^2 - b^2 = 16 \ldots \text{(ii)}$

On solving Eqs. (i) and (ii), we get,

$a^2 = 5, b^2 = 4$

$\therefore$ Equation of hyperbola is $\dfrac{x^2}{5} - \dfrac{y^2}{4} = 1$

$\Rightarrow 4x^2 - 5y^2 = 20$

Q13. In a group of data, there are n observations, $x_1, x_2, \ldots, x_n$. If $\sum_{i=1}^{n}\left(x_i+1\right)^2 = 9n$ and $\sum_{i=1}^{n}\left(x_i-1\right)^2 = 5n$, the standard deviation of the data is

(A) 2 (B) $\sqrt{7}$ (C) 5 (D) $\sqrt{5}$

13. (D)

13. $\sum x_i^2 + 2\sum x_i + \sum 1 = 9n$

$\Rightarrow \sum x_i^2 + 2\sum x_i = 8n$ ......(1)

Similarly $\sum x_i^2 - 2\sum x_i = 4n$ ......(2)

From equation 1 & 2

$\sum x_i^2 = 6n$ and $\sum x_i = n$

Now S.D. $\sqrt{\frac{\sum x_i^2}{n} - \left(\frac{\sum x_i}{n}\right)^2} = \sqrt{6-1}$

$= \sqrt{5}$

Q14. The solution of the differential equation $x\cos y\frac{dy}{dx} + \sin y = 1$ is (Here, $x > 0$ and λ is an arbitrary constant)

(A) $x - x\cos x = \lambda$ (B) $x + x\cos x = \lambda$ (C) $x - x\sin y = \lambda$ (D) $x + x\cos y = \lambda$

14. (C)

14. Let, $\sin y = t \Rightarrow \cos y\frac{dy}{dx} = \frac{dt}{dx}$

$\therefore$ the equation becomes

$x\frac{dt}{dx} + t = 1$ or $x\frac{dt}{dx} = 1 - t$

$\Rightarrow \frac{dt}{1-t} = \frac{dx}{x}$

On integrating, we get,

$-\ln|1-t| = \ln x + \ln C$

or $\frac{1}{1-t} = Cx$

i.e. $(1 - \sin y)x = \frac{1}{c} = \lambda(\text{say})$

Q15. The area (in sq. units) enclosed between the curve $x = \frac{1-t^2}{1+t^2}, y = \frac{2t}{1+t^2}, \forall t \in R$ and the line $y = x + 1$ above the line is

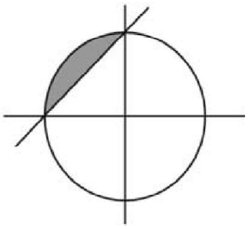
(A) $\frac{\pi}{4}$ (B) $\frac{1}{2}$ (C) $\frac{3\pi}{4} + \frac{1}{2}$ (D) $\frac{\pi}{4} - \frac{1}{2}$

15. (D)

15. Let, $t = \tan\theta$

$\Rightarrow x = \cos 2\theta,\ y = \sin 2\theta$

$\Rightarrow x^2 + y^2 = 1$



Area of the shaded region $=\frac{\pi}{4}-\frac{1}{2}\times 1\times 1=\frac{\pi}{4}-\frac{1}{2}$ sq. units

Q16. The value of $\int_0^{\frac{\pi}{3}}\log(1+\sqrt{3}\tan x)dx$ is equal to

(A) $\pi\log 2$ (B) $\frac{\pi}{2}\log 2$ (C) $\frac{\pi}{3}\log 2$ (D) $\frac{\pi}{4}\log 2$

16. (C)

16. Let, $I=\int_0^{\frac{\pi}{3}}\log(1+\sqrt{3}\tan x)dx$

$$I=\int_0^{\frac{\pi}{3}}\log\left[1+\sqrt{3}\tan\left(\frac{\pi}{3}-x\right)\right]dx$$

$$=\int_0^{\frac{\pi}{3}}\left[\log\left(1+\sqrt{3}\left(\frac{\sqrt{3}-\tan x}{1+\sqrt{3}\tan x}\right)\right)\right]dx$$

$$=\int_0^{\frac{\pi}{3}}\log\left(\frac{1+\sqrt{3}\tan x+3-\sqrt{3}\tan x}{1+\sqrt{3}\tan x}\right)dx$$

$$I=\int_0^{\frac{\pi}{3}}(\log 4-\log(1+\sqrt{3}\tan x))dx$$

$$I=(\log 4)\left(\frac{\pi}{3}\right)-I$$

$$I=\frac{\pi}{6}\log 4=\frac{\pi}{3}\log 2$$

Q17. The acute angles between the curves $y=2x^2-x$ and $y^2=x$ at (0,0) and (1,1) are α and β respectively, then

(A) $\alpha-\beta=0$ (B) $\alpha+\beta=0$ (C) $\alpha>\beta$ (D) $\alpha<\beta$

17. (A)

17. $y=2x^2-x$

$$\Rightarrow\frac{dy}{dx}=4x-1$$

Let ,$m_1=4x-1$

$y^2 = x$

$\Rightarrow 2y\frac{dy}{dx} = 1$

Let, $m_2 = \frac{dy}{dx} = \frac{1}{2y}$

At $P(0,0)$, $m_1 = -1$, $m_2 \rightarrow$ not defined

Angle $\alpha = \frac{\pi}{4}$

At $Q(1,1), m_1 = 3, m_2 = \frac{1}{2}$

$$\beta = \tan^{-1}\left(\frac{3-\frac{1}{2}}{1+\frac{3}{2}}\right) = \frac{\pi}{4}$$

Q18. The function $f(x) = \max\{(1-x),(1+x),2\}\forall x \in R$ is

(A) discontinuous at exactly two points

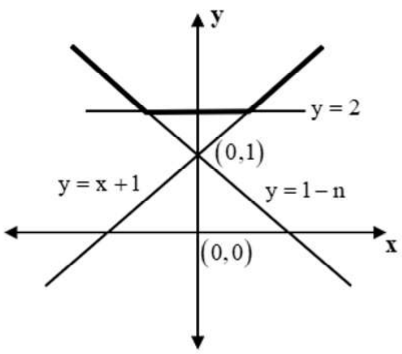
(B) differentiable $\forall x \in R$

(C) differentiable $\forall x \in R - \{-1,1\}$

(D) continuous $\forall x \in R - \{0,1,-1\}$

18. (C)

18.



Q19. A nine-digit number is formed using the digits 1, 2, 3, 5 and 7. The probability that the product of all digits is always 1920 is

(A) $\frac{1}{5^9}$

(B) $\frac{7}{5^8}$

(C) $\frac{72}{5^9}$

(D) $\frac{1}{7!}$

19. (C)

19. Total cases = 5^9

$1920 = 5 \times 3 \times 2^7$

Favourable cases = no. of ways of arrangement of 5,3,2,2,2,2,2,2,2 in a row $= \frac{9!}{7!}$ hence, required probability $= \frac{72}{5^9}$

Q20. If 100 times the 100^{th} term of an A.P. with non-zero common difference equals the 50 times its 50^{th} term, then the 150^{th} term of this A.P. is :

(A) zero (B) –150 (C) 150 times its 50^{th} term (D) 150

20. (A)

20. $100T_{100} = 50T_{50}$

$100(a + 99d) = 50(a + 49d)$

$a + 149d = 0$

$T_{150} = a + 149d = 0$

Section-II(NV)

Q21. If $P = \begin{bmatrix} 1 & \alpha & 3 \\ 1 & 3 & 3 \\ 2 & 4 & 4 \end{bmatrix}$ is the adjoint of a 3×3 matrix A and $|A| = 4$, then α is equal to

21. 11

21. $P = \text{adj}(A)$

taking determinant

$|P| = |\text{adj}(A)| \quad \left\{|\text{adj}(A)| = |A|^{n-1}\right\}$

$|P| = |A|^{n-1}$

$|P| = 4^2 = 16$

$2\alpha - 6 = 16 \Rightarrow \alpha = 11$

Q22. If $f : R \to R$ is a function defined as $f\left(x^3\right) = x^5, \forall x \in R - \{0\}$ and f(x) is differentiable $\forall x \in R$, then the value of $\frac{1}{4} f'(27)$ is equal to (here f' represents the derivative of f)

22. 3.75

22. $f\left(x^3\right) = x^5$

On differentiating with respect to x

$f'\left(x^3\right) \cdot 3x^2 = 5 \cdot x^4$

$f'\left(x^3\right) = \frac{5}{3} x^2$

Putting x = 3 , we get,

$$f'(27)=\frac{5}{3}(9)=15$$

Q23. The value of $\lim_{x\to 0}\frac{1}{x^{18}}\left(1-\cos\left(\frac{x^3}{3}\right)-\cos\left(\frac{x^6}{6}\right)+\cos\left(\frac{x^3}{3}\right)\cdot\cos\left(\frac{x^6}{6}\right)\right)$ is λ^2, then the value of 900λ is equal to (here, $\lambda > 0$)

23. 25

23. $$\lim_{x\to 0}\left\{1-\cos\left(\frac{x^3}{3}\right)-\cos\left(\frac{x^6}{6}\right)\left(1-\cos\left(\frac{x^3}{3}\right)\right)\right\}\cdot\frac{1}{x^{18}}$$

$$\lim_{x\to 0}\frac{\left(1-\cos\left(\frac{x^3}{3}\right)\right)\left(1-\cos\left(\frac{x^6}{6}\right)\right)}{x^{18}}$$

$$\lim_{x\to 0}\frac{1-\cos\left(\frac{x^3}{3}\right)}{\left(\frac{x^3}{3}\right)^2}\left(\frac{x^6}{9}\right)\cdot\frac{1-\cos\left(\frac{x^6}{6}\right)}{\left(\frac{x^6}{6}\right)^2}\cdot\left(\frac{x^6}{6}\right)^2\cdot\frac{1}{x^{18}}$$

$$\lim_{x\to 0}\frac{1}{2}\times\frac{x^6}{9}\cdot\frac{1}{2}\cdot\frac{x^{12}}{36}\cdot\frac{1}{x^{18}}=\frac{1}{(36)^2}$$

$$\therefore \lambda=\frac{1}{36}$$

Q24. The shortest distance between the lines $\frac{x-2}{2}=\frac{y-3}{2}=\frac{z-0}{1}$ and $\frac{x+4}{-1}=\frac{y-7}{8}=\frac{z-5}{4}$ is $\frac{A}{\sqrt{A-1}}$ then A is equal to -

Ans. (6)

24. Let, $\vec{a}=2i+3j$

$$\vec{b}=-4\hat{i}+7\hat{j}+5\hat{k}\Rightarrow\vec{b}-\vec{a}=-6\hat{i}+4\hat{j}+5\hat{k}$$

$$\vec{c}=2\hat{i}+2\hat{j}+\hat{k}$$

$$\vec{d}=-\hat{i}+8\hat{j}+4\hat{k}$$

$$\Rightarrow\vec{c}\times\vec{d}=-9\hat{j}+18\hat{k}$$

Hence, shortest distance $=\left|\frac{(\vec{b}-\vec{a})\cdot(\vec{c}\times\vec{d})}{|\vec{c}\times\vec{d}|}\right|$

$$=\left|\frac{-36+90}{9\sqrt{5}}\right|=\frac{6}{\sqrt{5}}\in(2,3]$$

Q25. If α and β are the solutions of $\cot x = -\sqrt{3}$ in $[0, 2\pi]$ and α and γ are the solutions of $\operatorname{cosec} x = -2$ in $[0, 2\pi]$, then the value of $\frac{|\alpha - \beta|}{\beta + \gamma}$ is equal to

25. 0.5

Sol. $\cot x = -\sqrt{3}$

$\Rightarrow x = \frac{5\pi}{6}, \frac{11\pi}{6}$ and

$\operatorname{cosec} x = -2$

$\Rightarrow x = \frac{7\pi}{6}, \frac{11\pi}{6}$

So, $\alpha = \frac{11\pi}{6}, \beta = \frac{5\pi}{6}, \gamma = \frac{7\pi}{6}$

$\Rightarrow \alpha - \beta = \pi$ and $\beta + \gamma = 2\pi$

$\Rightarrow \frac{|\alpha - \beta|}{\beta + \gamma} = \frac{\pi}{2\pi} = \frac{1}{2} = 0.5$