

04/04/2025

Morning



Corporate Office : AESL, 3rd Floor, Incuspaze Campus-2, Plot-13,
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Time : 3 hrs.

for

M.M. : 300

JEE (Main)-2025 (Online) Phase-2

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

- (1) The test is of **3 hours** duration.
- (2) This test paper consists of 75 questions. Each subject (PCM) has 25 questions. The maximum marks are 300.
- (3) This question paper contains **Three Parts**. **Part-A** is Physics, **Part-B** is Chemistry and **Part-C** is **Mathematics**. Each part has only two sections: **Section-A** and **Section-B**.
- (4) **Section - A** : Attempt all questions.
- (5) **Section - B** : Attempt all questions.
- (6) **Section - A (01 – 20)** contains 20 multiple choice questions which have **only one correct answer**. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.
- (7) **Section - B (21 – 25)** contains 5 **Numerical value** based questions. The answer to each question should be rounded off to the **nearest integer**. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.

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PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. Find the dimension of $\frac{E}{B}$, where E represents electric field and B represents magnetic field.

- (1) ML^2T^{-1}
- (2) LT^{-1}
- (3) L^2T^{-1}
- (4) LT^{-2}

Answer (2)

Sol. $\frac{E}{B} = C$
 $= LT^{-1}$

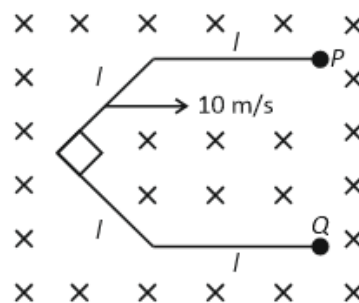
2. Mean free path for an ideal gas is to be observed $20 \mu m$ while average speed of molecules of gas is observed to be 600 m/s . Then frequency of collision is nearly

- (1) 4×10^7
- (2) 1.2×10^7
- (3) 3×10^7
- (4) 2×10^{-7}

Answer (3)

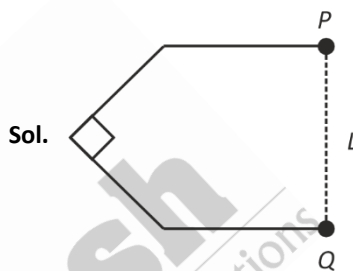
Sol. Mean free time $\tau = \frac{\lambda}{v} \Rightarrow f = \frac{v}{\lambda} = \frac{600}{20 \times 10^{-6}} = 3 \times 10^7$

3. 4 rods of equal length are joined as shown in the figure. Combined system is moving with speed 10 m/s in a perpendicular magnetic field of $\frac{1}{\sqrt{2}}$ tesla. Find emf induced between point P and Q ($l = 10 \text{ cm}$).



- (1) 1 volt
- (2) 0.1 volt
- (3) 2 volts
- (4) $\sqrt{2}$ volt

Answer (1)

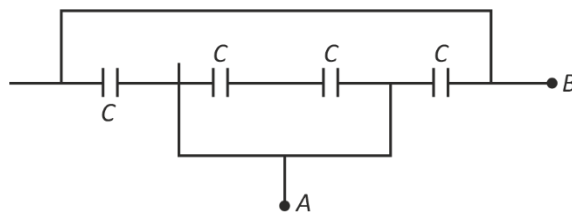


$$L = \frac{l}{\sqrt{2}} + \frac{l}{\sqrt{2}} = \sqrt{2}l$$

$$\text{emf} = \frac{1}{\sqrt{2}} \times 10 \times \sqrt{2} \times 0.1$$

$$= 1 \text{ v}$$

4. Find equivalent capacitance between A and B , where $C = 16 \mu F$



- (1) $48 \mu F$
- (2) $8 \mu F$
- (3) $32 \mu F$
- (4) $16 \mu F$

Answer (3)

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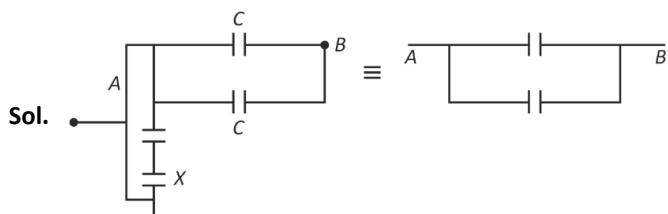
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$$C_{eq} = 2C = 32 \mu F$$

5. A real object placed in front of a spherical mirror forms an image whose magnification is $-\frac{1}{3}$. If the distance between the image and object is 30 cm. The focal length of the mirror is _____ cm.

- (1) -11.25 cm (2) -22.5 cm
 (3) -45 cm (4) -60 cm

Answer (1)

Sol. Magnification is negative implies mirror is converging.

$$m = -\frac{v}{u} = -\frac{1}{3}$$

Or $v = \frac{u}{3}$

Also, $v - u = 30$ cm

$u = -45$ cm

$v = -15$ cm

$$f = \frac{uv}{u+v} = -11.25 \text{ cm}$$

6. The current in a AC circuit is given as

$$i = 100\sqrt{2} \sin\left(\frac{100\pi}{t}\right) \text{ A.}$$

Find rms current and frequency in Hertz.

- (1) 100 A, 100 Hz (2) 50 A, 100 Hz
 (3) 200 A, 50 Hz (4) 100A, 50 Hz

Answer (4)

Sol. $i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{100\sqrt{2}}{\sqrt{2}} = 100$

$$\omega t = 100 \pi t \Rightarrow \omega = 2\pi f = 100 \pi$$

$$f = 50 \text{ Hz}$$

7. An electric dipole with charges $2 \mu\text{C}$ and a separation 20 cm is placed close to an infinitely charge non-conducting sheet with surface charge density 100 C/m^2 . Find the torque acting on the dipole if the dipole makes an angle 30° with the normal to the sheet.

- (1) $\frac{12}{\epsilon_0} \times 10^{-5} \text{ N-m}$ (2) $\frac{2}{\epsilon_0} \times 10^{-5} \text{ N-m}$
 (3) $\frac{4}{\epsilon_0} \times 10^{-5} \text{ N-m}$ (4) $\frac{1}{\epsilon_0} \times 10^{-5} \text{ N-m}$

Answer (4)

Sol. $\tau = pE \sin\theta$

$$p = qd$$

$$E = \frac{\sigma}{2\epsilon_0}$$

$$\tau = qdE \sin\theta$$

$$= \frac{(2 \times 10^{-6} \text{ C})(0.2 \text{ m}) \times 100}{2\epsilon_0} \text{ C/m}^2 \sin 30^\circ = \frac{2}{\epsilon_0} \times 10^{-5} \text{ N-m}$$

8. **Assertion (A):** The minimum kinetic energy required to take a body of mass m from surface of earth to infinity is mgR .

Reason (R): Potential energy at surface of earth is zero.

- (1) (A) and (R) both are correct and (R) is correct explanation of (A)
 (2) (A) and (R) both are correct and (R) is not correct explanation of (A)
 (3) (A) is correct but (R) is incorrect
 (4) (A) is incorrect but (R) is correct

Answer (3)

Sol. Conceptual.

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9. Longitudinal sound waves travel in three different gases namely helium, methane and carbon dioxide. Mean temperature of three gases are equal then ratio of speeds of wave in three gases respectively is

$$(1) \sqrt{5} : \sqrt{7} : \frac{1}{\sqrt{11}} \quad (2) \sqrt{3} : \sqrt{5} : \frac{1}{\sqrt{11}}$$

$$(3) \sqrt{5} : 1 : \sqrt{\frac{21}{55}} \quad (4) \frac{1}{\sqrt{3}} : \frac{1}{\sqrt{5}} : \frac{1}{2}$$

Answer (3)

Sol. $v = \sqrt{\frac{\gamma RT}{M_0}}$

$$\text{Ratio} \equiv \sqrt{\frac{\gamma_1}{M_1}} : \sqrt{\frac{\gamma_2}{M_2}} : \sqrt{\frac{\gamma_3}{M_3}}$$

$$= \sqrt{\frac{5}{3 \times 4}} : \sqrt{\frac{4}{3 \times 16}} : \sqrt{\frac{7}{5 \times 44}} \equiv \sqrt{\frac{5}{3}} : \sqrt{\frac{1}{3}} : \sqrt{\frac{7}{55}}$$

10. Ratio of radii of 5th orbit of He⁺ and Li²⁺ atom will be

$$(1) \frac{5}{3} \quad (2) \frac{25}{3}$$

$$(3) \frac{3}{2} \quad (4) \frac{2}{3}$$

Answer (3)

Sol. $r = \frac{\eta^2}{Z} a_0$ $\frac{r_{\text{He}^+}}{r_{\text{Li}^{2+}}} = \frac{\eta^2}{Z} \frac{Z_{\text{Li}^{2+}}}{\eta^2} = \frac{3}{2}$

11. **Assertion** : In photoelectric effect, if intensity of monochromatic light is increased then stopping potential increases.

Reason : Increased intensity results in increment of photocurrent.

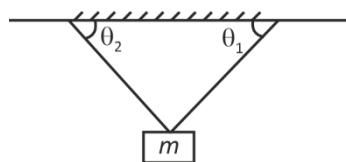
- (1) A is correct, R is correct and R is explanation of A
(2) A is correct, R is correct and R is not explanation of A
(3) A is incorrect and R is correct
(4) A is correct and R is incorrect

Answer (3)

Sol. (1) Frequency changes the stopping potential not intensity.

(2) Higher in density means higher number of electrons.

12. A block of mass m kg is connected to two strings as shown. If $T_1 = \sqrt{3}T_2$, then choose correct option



$$(1) \theta_1 = 60^\circ, \theta_2 = 30^\circ, T_1 = \frac{mg}{2}$$

$$(2) \theta_1 = 60^\circ, \theta_2 = 30^\circ, T_2 = \frac{mg}{2}$$

$$(3) \theta_1 = 30^\circ, \theta_2 = 60^\circ, T_1 = \frac{3mg}{4}$$

$$(4) \theta_1 = 30^\circ, \theta_2 = 60^\circ, T_2 = \frac{3mg}{4}$$

Answer (2)

Sol. $T_2 \cos \theta_2 = T_2 \cos \theta_1$

$$T_2 \cos \theta_2 = \sqrt{3} T_2 \cos \theta_1$$

$$\cos \theta_2 = \sqrt{3} \cos \theta_1$$

$$\theta_1 = 60^\circ, \theta_2 = 30^\circ$$

$$T_1 \sin \theta_1 + T_2 \sin \theta_2 = mg$$

$$\sqrt{3} T_2 \cdot \frac{\sqrt{3}}{2} + T_2 \cdot \frac{1}{2} = mg$$

$$2T_2 = mg$$

$$T_2 = \frac{mg}{2}$$

$$T_1 = \frac{\sqrt{3}}{2} mg$$

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13. A Closed organ pipe having fundamental frequency f_0 . Now $\frac{1}{5}$ of volume its filled with water then % change in the fundamental frequency.

- (1) +10%
(2) +25%
(3) -20%
(4) -10%

Answer (2)

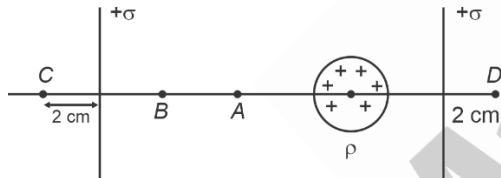
Sol. $f_0 = \frac{v}{4L}$

$$f'_0 = \frac{v}{4\left(\frac{4L}{5}\right)} = \frac{5}{4} \left(\frac{v}{4L}\right) = \frac{5}{4} f_0$$

$$= 1.25 f_0$$

$$\Rightarrow +25\%$$

14. In arrangement shown, has two non-conducting plane sheets with charge density σ , and a non-conducting sphere with volume charge density ρ .



Choose the correct relation between the magnitude of electric fields at A, B, C and D. Point A is at the middle of two sheets.

- (1) $E_A = E_B, E_C \neq E_D$
(2) $E_A > E_B, E_C \neq E_D$
(3) $E_A > E_B, E_C = E_D$
(4) $E_A \neq E_B, E_C = E_D$

Answer (2)

Sol. $\Rightarrow |E_A| = \left| +\frac{\sigma}{2\epsilon_0} - \frac{\sigma}{2\epsilon_0} - \frac{1}{4\pi\epsilon_0} \frac{Q}{r_A^2} \right| = \frac{Q}{4\pi\epsilon_0 r_A^2}$

$$\Rightarrow |E_B| = \left| +\frac{\sigma}{2\epsilon_0} - \frac{\sigma}{2\epsilon_0} - \frac{1}{4\pi\epsilon_0} \frac{Q}{r_B^2} \right| = \frac{Q}{4\pi\epsilon_0 r_B^2}$$

$$\Rightarrow |E_A| > |E_B| \text{ since } r_A < r_B$$

$$\Rightarrow |E_C| = \left| -\frac{\sigma}{2\epsilon_0} - \frac{\sigma}{2\epsilon_0} - \frac{1}{4\pi\epsilon_0} \frac{Q}{r_C^2} \right| = \frac{\sigma}{\epsilon_0} + \frac{Q}{4\pi\epsilon_0 r_C^2}$$

$$\Rightarrow |E_D| = \left| \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0} + \frac{Q}{4\pi\epsilon_0 r_D^2} \right| = \frac{\sigma}{\epsilon_0} + \frac{Q}{4\pi\epsilon_0 r_D^2}$$

$$\Rightarrow |E_C| \neq |E_D| \text{ as } r_C \neq r_D$$

15. Two simple pendulums with amplitudes θ_1 and θ_2 have length of strings as l_1 and l_2 respectively. Choose the correct options if the maximum angular accelerations are same.

- (1) $\theta_1 l_1 = \theta_2 l_2$
(2) $\theta_1 l_2 = \theta_2 l_1$
(3) $\theta_1 l_1^2 = \theta_2 l_2^2$
(4) $\theta_1 l_2^2 = \theta_2 l_1^2$

Answer (2)

Sol. $\theta = \theta_0 \sin\left(\sqrt{\frac{g}{l}} t + \phi\right)$

$$\text{or } \alpha = -\frac{g}{l} \theta$$

$$\alpha_{\max} = \frac{g}{l} \theta_0$$

$$(\alpha_{\max})_1 = (\alpha_{\max})_2$$

$$\frac{\theta_1}{l_1} = \frac{\theta_2}{l_2}$$

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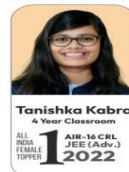


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16. In YDSE setup, distance between slits $d = 0.2$ mm. If d is changed to 0.4 mm, then % change in fringe width

- (1) 25%
(2) 50%
(3) 100%
(4) 75%

Answer (2)

Sol. $B = \frac{\lambda D}{d}$ $B' = \frac{\lambda D}{2d} = \frac{B}{2}$

$$100 \times \frac{DB}{B} = 50\%$$

17. Regarding the rotational motion of rigid bodies, following two statements are given where symbols are having usual meaning.

S1 : Torque τ is given as $\vec{\tau} = \frac{d\vec{L}}{dt}$ and angular momentum about inertial point is given as $\vec{L} = \sum(\vec{r}_i \times \vec{p}_i)$.

S2 : Torque τ is given as $\vec{\tau} = I\vec{\alpha}$ and angular momentum about inertial point is given as $\vec{L} = I\vec{\omega}$.

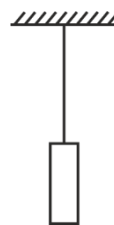
- (1) S1 is correct and S2 is incorrect
(2) S1 is incorrect and S2 is correct
(3) Both are incorrect
(4) Both are correct

Answer (1)

Sol. $\vec{L} = I_{\text{ang}}\vec{\omega} + \vec{r} \times M\vec{V}_{CM}$

Results in S2 is specific cases derived from results in S1.

18. A small mirror of mass m is suspended to a fix point with an ideal string of length l . A photon of energy E incident normally on the mirror. Find maximum angular deviation (θ) of the mirror.



- (1) $\frac{3E}{mc\sqrt{gl}}$ (2) $\frac{E}{2mc\sqrt{gl}}$
(3) $\frac{E}{mc\sqrt{2gl}}$ (4) $\frac{2E}{mc\sqrt{gl}}$

Answer (4)

Sol.



Moment imparted to the mirror = $\frac{2E}{c}$

$$\Delta KE = -\Delta PE$$

$$\frac{\left(\frac{2E}{c}\right)^2}{2m} = mg(l - l\cos\theta)$$

$$\frac{2E^2}{mc^2} = mgl \cdot 2\sin^2\left(\frac{\theta}{2}\right)$$

$$\frac{2E^2}{mc^2} = mgl \cdot \frac{\theta^2}{2}$$

$$\theta = \frac{2E}{mc\sqrt{gl}}$$

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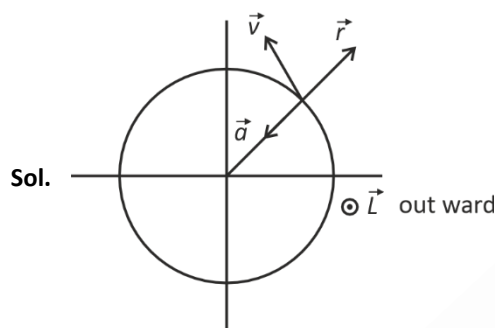


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19. $\vec{L}$ and $\vec{p}$ are angular momentum about origin and linear momentum of a particle. If position vector of particle is given as $\vec{r} = a(\sin\omega t\hat{i} + \cos\omega t\hat{j})$ then direction of force is

- (1) Opposite to $\vec{L} \times \vec{r}$
- (2) Opposite to $\vec{p} \times \vec{r}$
- (3) Opposite to $\vec{L} \cdot \vec{r}$
- (4) Opposite to $\vec{p} \times \vec{L}$

Answer (4)



20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. A ring and a solid sphere released from rest from same height on enough rough inclined surface. Ratio of their speed when they reach at bottom is $\sqrt{\frac{7}{x}}$ m/s, then x is

Answer (10)

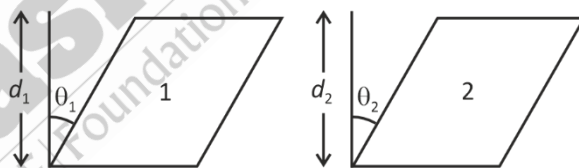
Sol. $mgh = \frac{1}{2} 2mR^2 \frac{(v_r^2)}{R^2} = \frac{1}{2} \cdot \frac{7}{5} mR^2 \frac{(v_s^2)}{R^2}$

$$\Rightarrow \frac{2(v_r^2)}{R^2} = \frac{7(v_s^2)}{5 R^2}$$

$$\Rightarrow \left(\frac{v_r}{v_s} \right)^2 = \frac{7}{10}$$

$$\Rightarrow \frac{v_r}{v_s} = \sqrt{\frac{7}{10}}$$

22. The figure shows two boxes with identical square cross-sections and heights h_1 and h_2 ($h_1 = 2h_2$) are made of different materials. An equal force is applied on the square cross-sections such that the deformations θ_1 and θ_2 are realized ($\theta_1 = 2\theta_2$). If shear modulus of box 1 is $4 \times 10^9 \text{ N/m}^2$ and that of box 2 is $x \times 10^9 \text{ N/m}^2$, then x is _____.



Answer (8)

Sol. $G = \frac{F}{A\theta}$ Since $F_1 = F_2$ and $A_1 = A_2$ x = 8

$$\Rightarrow G\theta = \frac{F}{A} \quad \left| \begin{array}{l} G_1\theta_1 = G_2\theta_2 \\ (4 \times 10^9 \text{ N/m}^2)\theta_1 = (x \times 10^9 \text{ N/m}^2)\theta_2 \end{array} \right|$$

23.

24.

25.

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CHEMISTRY

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer :

1. Which of the following is the ratio of 5th Bohr orbit (r_5) of He^+ & Li^{2+} ions?

- (1) $\frac{2}{3}$ (2) $\frac{3}{2}$
(3) $\frac{9}{4}$ (4) $\frac{4}{9}$

Answer (2)

Sol. $r \propto \frac{n^2}{Z}$

$$\frac{(r_5)_{\text{He}^+}}{(r_5)_{\text{Li}^{2+}}} = \frac{5^2}{\frac{5^2}{2}} = \frac{3}{2}$$

2. Which of the following pair of ions have equal number of unpaired electrons

- (1) V^{2+} and Ni^{2+}
(2) Cr^{2+} and Mn^{2+}
(3) Fe^{2+} and Sc^{2+}
(4) Mn^{3+} and Fe^{2+}

Answer (4)

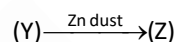
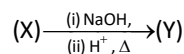
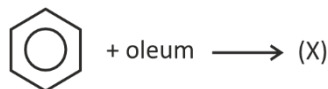
Sol. unequal $\begin{cases} \text{V}^{2+} \Rightarrow s^0 d^3 \Rightarrow 3 \text{ unpaired } e^- \\ \text{Ni}^{2+} \Rightarrow s^0 d^8 \Rightarrow \text{unpaired } e^- \end{cases}$

unequal $\begin{cases} \text{Cr}^{2+} \Rightarrow s^0 d^4 \Rightarrow 4 \text{ unpaired } e^- \\ \text{Mn}^{2+} \Rightarrow s^0 d^5 \Rightarrow 5 \text{ unpaired } e^- \end{cases}$

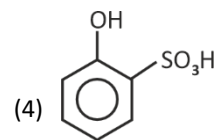
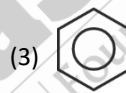
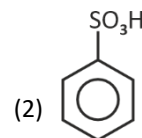
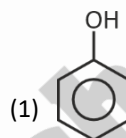
unequal $\begin{cases} \text{Fe}^{2+} \Rightarrow s^0 d^6 \Rightarrow 4 \text{ unpaired } e^- \\ \text{Sc}^{2+} \Rightarrow s^0 d^1 \Rightarrow 1 \text{ unpaired } e^- \end{cases}$

unequal $\begin{cases} \text{Fe}^{2+} \Rightarrow s^0 d^6 \Rightarrow 4 \text{ unpaired } e^- \\ \text{Mn}^{3+} \Rightarrow s^0 d^4 \Rightarrow 4 \text{ unpaired } e^- \end{cases}$

3. In the reaction sequence :

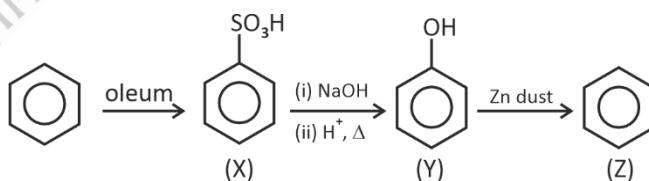


The compound (Z) is



Answer (3)

Sol.



4. Incorrect order of atomic radius is

- (1) $\text{B} < \text{Al}$ (2) $\text{In} < \text{Tl}$
(3) $\text{Al} < \text{Ga}$ (4) $\text{Ga} < \text{In}$

Answer (3)

Sol.

B	Al	Ga	In	Tl
88	143	135	167	170 (pm)

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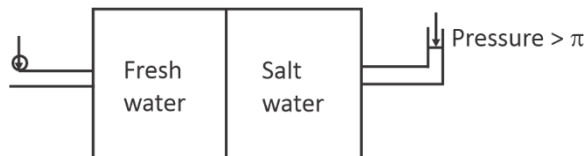


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5. Observe the following diagram.



For reverse osmosis, which of the following can be used for porous membrane?

- (1) Cellulose acetate (2) Porous silicate
(3) Silicone (4) Glass membrane

Answer (1)

Sol. Cellulose acetate is used as semipermeable membrane for reverse osmosis.

6. One mole of an ideal gas expands from 10 dm^3 to 20 dm^3 through isothermal reversible process. Find ΔU , q & w

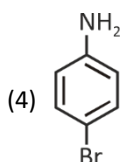
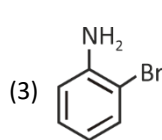
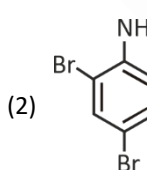
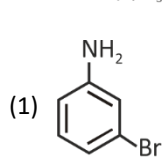
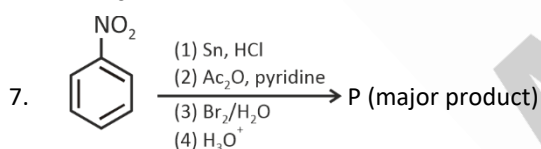
- (1) $\Delta U = 0$, $q = 0$, $w = 0$ (2) $\Delta U = 0$, $q \neq 0$, $w \neq 0$
(3) $\Delta U \neq 0$, $q = 0$, $w \neq 0$ (4) $\Delta U \neq 0$, $q \neq 0$, $w = 0$

Answer (2)

Sol. For an ideal gas undergoing isothermal reversible process $\Delta U = 0$ (As $\Delta T = 0$)

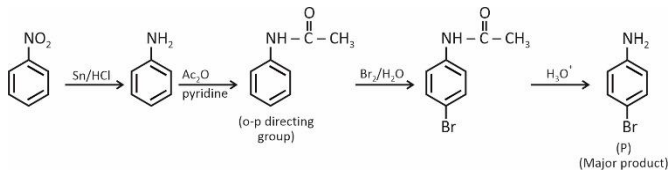
But $q \neq 0$

$w \neq 0$



Answer (4)

Sol.

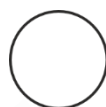


8. Which of the following is correct option regarding 1s orbital

- (1) It is symmetrical (2) It is non-symmetrical
(3) It is directional (4) It has two radial nodes

Answer (1)

Sol.



1s Orbital $\Rightarrow$ Symmetrical, non-directional, zero radial node.

9. Total number of stereoisomers possible for complexes $[\text{Cr}(\text{Cl}_3)(\text{Py})_3]$ and $[\text{CrCl}_2(\text{C}_2\text{O}_4)_2]$ respectively are

- (1) 2, 3 (2) 3, 2
(3) 3, 3 (4) 2, 2

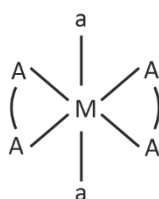
Answer (1)

Sol. $[\text{CrCl}_3(\text{Py})_3]$, this complex is type of $[\text{Ma}_3\text{b}_3]$, where a and b are monodentate ligands.

There are two possible geometrical isomer facial isomers and meridional and both are optically inactive.

Total number of stereoisomers = 2

$[\text{CrCl}_2(\text{C}_2\text{O}_4)_2]^{3-}$, this complex is of type $[\text{Ma}_2(\text{AA})_2]$



(1)



Optically active

(2)

Total stereoisomers = 3

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10. In lead storage battery during charging oxidation state of lead show changes

at anode from x_1 to y_1

at cathode from x_2 to y_2

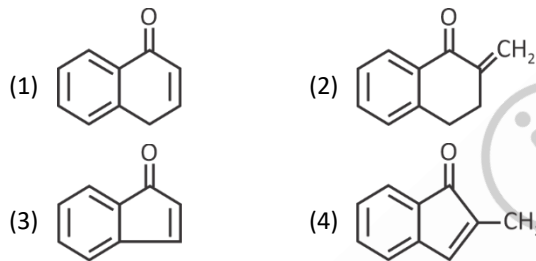
Find value of x_1, y_1, x_2, y_2

- (1) $x_1 = +2, y_1 = 0$
 $x_2 = +2, y_2 = +4$
- (2) $x_1 = +4, y_1 = 0$
 $x_2 = +2, y_2 = +4$
- (3) $x_1 = 0, y_1 = +2$
 $x_2 = +4, y_2 = +2$
- (4) $x_1 = +2, y_1 = 0$
 $x_2 = +4, y_2 = 0$

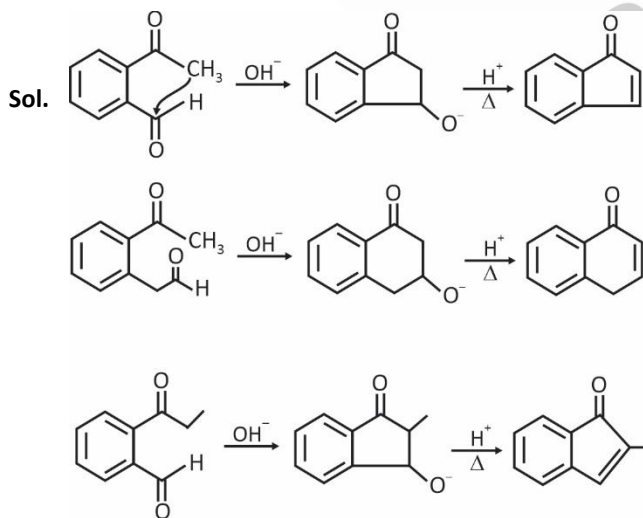
Answer (1)

Sol. On changing the lead storage battery $\text{PbSO}_4(\text{s})$ at anode is converted into Pb and $\text{PbSO}_4(\text{s})$ at cathode is converted into PbO_2 .

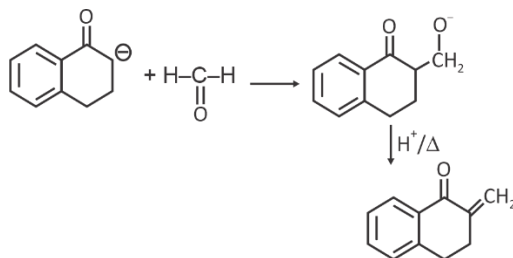
11. Which of the following compound is not a product of intramolecular aldol condensation reaction?



Answer (2)



$\therefore$ option (2) cannot be formed by intramolecular aldol condensation



12. Consider the reaction $A + B \rightarrow \text{Product}$

$$R = k[A]^m[B]^n$$

When conc. of A & B taken are A_1 & B_1 respectively, then rate of reaction is R_1 . When conc. of A & B taken are $2A_1$ & $\frac{B_1}{2}$, then rate of reaction is R_2 . Find $\frac{R_2}{R_1}$?

- (1) 2^{m+n} (2) 2^{n-m}
- (3) 2^{m-n} (4) 1

Answer (3)

Sol. $R_1 = k[A_1]^m[B_1]^n$

$$R_2 = k[2A_1]^m\left[\frac{B_1}{2}\right]^n$$

$$\frac{R_2}{R_1} = \frac{[2A_1]^m\left[\frac{B_1}{2}\right]^n}{[A_1]^m[B_1]^n} = \frac{2^m}{2^n} = 2^{m-n}$$

13. The complex ion having crystal field stabilization energy is zero and value of spin only magnetic moment is 5.92 BM.

- (1) $[\text{FeF}_6]^{4-}$
- (2) $[\text{Mn}(\text{SCN})_6]^{4-}$
- (3) $[\text{Co}(\text{NH}_3)_6]^{3+}$
- (4) $[\text{Fe}(\text{CN})_6]^{3-}$

Answer (2)

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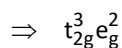
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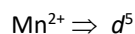
Sol. Complex having d^5 configuration with weak field ligand has CFSE = 0

with Mn^{2+} , SCN^- is weak field ligand



$$CFSE = [3 \times (-0.4) + 2 \times (0.6)] \Delta_0$$

$$= 0$$



$n = 5$ (unpaired electron)

$$\mu = \sqrt{n(n+2)} \text{ BM}$$

$$= \sqrt{5 \times 7} \text{ BM}$$

$$= \sqrt{35} \text{ BM}$$

$$= 5.92 \text{ BM}$$

14. Statement-I: (A) $C_2H_5 - CH = \overset{2}{CH} - \overset{1}{CHO}$ has higher dipole moment than (B) $C_2H_5 - \overset{2}{CH_2} - \overset{1}{CHO}$.

Statement-II : C1 – C2 bond length in (A) is longer than (B)

In the light of above statements, choose the correct option:

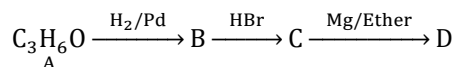
- (1) Both Statement-I and Statement-II are correct
- (2) Both Statement-I and Statement-II are incorrect
- (3) Statement-I is correct but Statement-II is incorrect
- (4) Statement-I is incorrect but Statement-II is correct

Answer (3)

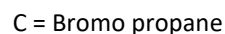
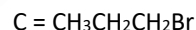
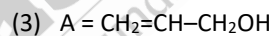
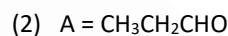
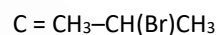
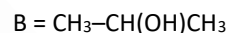
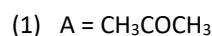
Sol. Due to resonance in (A) C1-C2 has partial π -bond character, hence shorter bond length than that in (B).

Due to resonance $C_2H_5 - CH = \overset{O}{\parallel} C - H$ electron flow is in one direction hence higher dipole moment.

15. In following sequence of reaction. A is converted to D

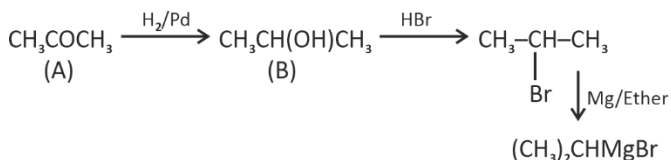


D is treated with A followed by hydrolysis to give 2,3-dimethyl-butan-2-ol. Then identify A, B, C.



Answer (1)

Sol.



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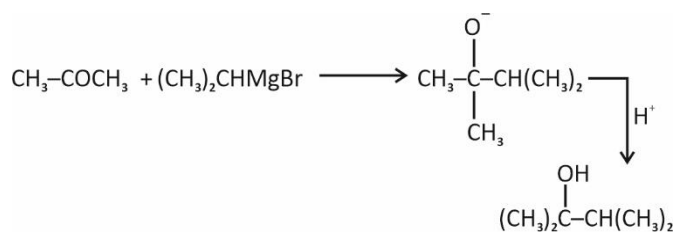
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16. The activation energy of forward reaction and backward reaction is 100 kJ/mole and 180 kJ/mole respectively. Find the correct statement if catalyst is added under same condition of temperature.

- (1) Catalyst does not change ΔG of reaction
- (2) Catalyst can make non-spontaneous reaction spontaneous
- (3) Catalyst changes ΔH of reaction
- (4) Enthalpy of reaction (ΔH) is 280 kJ/mole

Answer (1)

Sol. Catalyst does not change ΔH of reaction. It only alters activation energy.

Catalyst cannot make non-spontaneous reaction spontaneous

$$\begin{aligned}\Delta H &= (E_a)_f - (E_a)_b \\ &= (100 - 180) \text{ kJ/mol} \\ &= -80 \text{ kJ/mol}\end{aligned}$$

17. KMnO_4 oxidises others in acidic medium, Difference between two oxidation states of Mn is x. Neutral FeCl_3 reacts with oxalate ion to form a complex compound having y number of d-electrons. Find x + y.

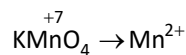
- (1) 5
- (2) 10

(3) 6

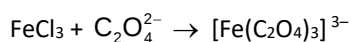
(4) 8

Answer (2)

Sol. When KMnO_4 oxidises others in acidic medium difference between the two oxidation states of Mn is 5.



$$\therefore x = 5$$



Fe is in +3 oxidation state.



$$\therefore y = 5$$

18.

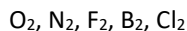
19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. In the following, the number of molecules which are paramagnetic are :



Answer (2)

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O ₂ - Paramagnetic	} According to Molecular orbital theory
N ₂ - Diamagnetic	
F ₂ - Diamagnetic	
B ₂ - Paramagnetic	
Cl ₂ - Diamagnetic	

Species having unpaired electrons are paramagnetic.

22. 0.01 M HX ($K_a = 4 \times 10^{-10}$) is diluted till the solution has pH = 6. If the new concentration is $x \times 10^{-4}$ M then find x.

Answer (25)

Sol. $H^+ = \sqrt{K_a \times C}$

$$10^{-6} = \sqrt{4 \times 10^{-10} \times C}$$

$$10^{-12} = 4 \times 10^{-10} \times C$$

$$C = \frac{1}{4} \times 10^{-2} = 0.25 \times 10^{-2} = 25 \times 10^{-4}$$

23. In Dumas method for estimation of N, 0.5 g of an organic compound gave 150 mL of N₂ collected at 300 K and 900 mmHg pressure (Aq tension is 15 mm Hg).

Find % of N

Answer (40)

Sol. Pressure of N₂ = 875 mm

$$V_{N_2} \text{ at STP} = \frac{273 \times 885 \times 150}{300 \times 760}$$

$$= 158.95 \text{ ML}$$

$$\text{Mass of N}_2 = \frac{158.95}{22400} \times 28$$

$$\approx 0.2 \text{ g}$$

$$\% \text{ of N} = \frac{0.2}{0.5} \times 100 = 40\%$$

24. Given below is a sample of DNA strand

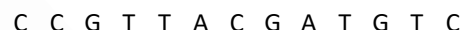
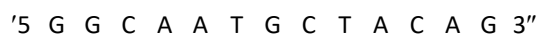


Find the number of hydrogen bonds present in this DNA strand.

Answer (33)

Sol. In DNA, pairing of complementary bases are A = T and C $\equiv$ G.

$\therefore$ Given strand :



Total number of hydrogen bonds = 33

25. A sample of 150 kg wheat contains Fe-metal. Find mass of FeSO₄·7H₂O in g. so that sample contains 12 ppm Fe-metal. (Atomic mass of Fe = 55.85 g/mol)

Answer (9)

Sol. $12 = \frac{x}{150} \times 10^6$

$$x = 12 \times 150 \times 10^{-6} = 1800 \times 10^{-6} = 1.8 \times 10^{-3} \text{ kg}$$

$$55.85 \text{ g Fe in } 278.02 \text{ g FeSO}_4 \cdot 7\text{H}_2\text{O}$$

$$1.8 \times 10^{-3} \text{ kg Fe} \rightarrow \frac{278.02}{55.85} \times 1.8 \times 10^{-3} \text{ kg of FeSO}_4 \cdot 7\text{H}_2\text{O}$$

$$= 8.96 \times 10^{-3} \text{ kg}$$

$$\approx 9 \text{ g}$$

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MATHEMATICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer :

1. Solve $\int_{-1}^1 \frac{1+2x}{e^x + e^{-x}} dx$

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

Answer (1)

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

$$I = \int_0^1 \frac{(1+2x) + (1-2x)}{e^x + e^{-x}} dx$$

$$= \int_0^1 \frac{2e^x}{e^{2x} + 1} dx$$

Let $e^x = t$

$$= \int_1^e \frac{2dt}{t^2 + 1}$$

$$= 2[\tan^{-1} t]_1^e$$

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

Prop. $\int_{-a}^a f(x) dx = \int_0^a (f(x) + f(-x)) dx$

2. The sum of the series $1 + 3 + 5^2 + 7 + 9^2 + \dots$ upto 80 terms is

- (1) 328160
(2) 338160
(3) 339400
(4) 326870

Answer (2)

Sol. $1 + 3 + 5^2 + 7 + 9^2 + \dots$

$$= (1^2 + 5^2 + 9^2 + \dots) + (3 + 7 + 11 + \dots)$$

$$= \left(\sum_{k=1}^{40} (4k-3)^2 \right) + \frac{40}{2} (6 + (40-1)4)$$

$$= 16 \sum_{k=1}^{40} k^2 + 9 \times 40 - 24 \sum_{k=1}^{40} k + 3240$$

$$= 16 \left(\frac{40 \times 41 \times 81}{6} \right) + 360 - 24 \left(\frac{40 \times 41}{2} \right) + 3240$$

$$= 354240 + 360 - 19680 + 3240 = 338160$$

3. Let there be two A.P.'s with each having 2025 terms. Find the number of distinct terms in union of these two A.P.'s, i.e., $A \cup B$ if first A.P. is 1, 6, 11, ... and second A.P. is 9, 16, 23, ...

- (1) 3761 (2) 4035
(3) 3022 (4) 2025

Answer (1)

Sol. 1st A.P. : 1, 6, 11... $\Rightarrow T_n = S_n - 4$

2nd A.P. : 9, 16, 23... $\Rightarrow T_m = 2 + 7m$

Let's find when they are equal for the first time:

$$5n - 4 = 2 + 7m$$

$$\Rightarrow 5n - 7m = 6$$

$$\Rightarrow n = 4, m = 2$$

$$\Rightarrow 16 \text{ is the first term, common difference will be}$$

$$\text{LCM}(d_1, d_2) = \text{LCM}(5, 7) = 35$$

$$\Rightarrow \text{Common terms will be } 16, 51, 86 \dots$$

The last term of 1st A.P.

$$= T_{2025} = 5 \times 2025 - 4 = 10121$$

$\Rightarrow$ Common term must be less than that

$$\Rightarrow 35n - 19$$

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$$\Rightarrow 35n - 19 \leq 10121 \Rightarrow 35n \leq 10140$$

$$\Rightarrow n \leq 289.7$$

$$\Rightarrow \boxed{n = 289}$$

$$\Rightarrow \text{in } n(A \cup B) = n(A) + n(B) - n(A \cap B)$$

$$= 2025 + 2025 - 289$$

$$= 3761$$

4. Consider a committee of 12 members is formed randomly out of 4 Engineers, 2 Doctors and 10 Professors. Find the probability that the committee has exactly 3 Engineers and 1 Doctor.

$$(1) \frac{17}{91}$$

$$(2) \frac{18}{91}$$

$$(3) \frac{15}{91}$$

$$(4) \frac{18}{71}$$

Answer (2)

$$\text{Sol. } P(3E, 1D) = \frac{{}^4C_3 \cdot {}^2C_1 \cdot {}^{10}C_8}{{}^{16}C_{12}}$$

$$= \frac{4 \times 2 \times \frac{10 \times 9}{2}}{16 \times 15 \times 14 \times 13} = \frac{360 \times 24}{13 \times 7 \times 30 \times 16}$$

$$= \frac{18}{91}$$

Explanation: 3 Engineers, 1 Doctors and remaining from Professors.

5. The number of integral values of $n \in N$ for which the equation $x^2 + 4x - n = 0, n \in [20, 100]$ have integral roots, is

$$(1) 4$$

$$(2) 5$$

$$(3) 6$$

$$(4) 7$$

Answer (3)

$$\text{Sol. } (x+2)^2 = n+4 \Rightarrow x = -2 \pm \sqrt{n+4}$$

$$\therefore 20 \leq n \leq 100 \Rightarrow 24 \leq n+4 \leq 104$$

$$\Rightarrow \sqrt{24} \leq \sqrt{n+4} \leq \sqrt{104}$$

$$\sqrt{n+4} \in \{5, 6, 7, 8, 9, 10\}$$

$\Rightarrow$ For integral values of x ,

$$\Rightarrow n = \{5^2 - 4, 6^2 - 4, 7^2 - 4, 8^2 - 4, 9^2 - 4, 10^2 - 4\}$$

$\Rightarrow$ There are six integral values of n .

6. If $10\sin^4\theta + 15\cos^4\theta = 6$, then find the value of

$$\frac{27\operatorname{cosec}^6\theta + 8\sec^6\theta}{8\sec^8\theta}$$

$$(1) \frac{3}{5}$$

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

$$(3) \frac{1}{5}$$

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

Answer (1)

$$\text{Sol. } 10(\sin^4\theta + \cos^4\theta) + 5\cos^4\theta = 6$$

$$\Rightarrow 10[1 - 2\sin^2\theta\cos^2\theta] + 5\cos^4\theta = 6$$

$$\Rightarrow 25\cos^4\theta - 20\cos^2\theta + 4 = 0$$

$$\Rightarrow (5\cos^2\theta - 2)^2 = 0$$

$$\therefore \cos^2\theta = \frac{2}{5}$$

$$\Rightarrow \sin^2\theta = \frac{3}{5} \text{ and } \sec^2\theta = \frac{5}{2}, \operatorname{cosec}^2\theta = \frac{5}{3}$$

$$\Rightarrow \frac{27\operatorname{cosec}^6\theta + 8\sec^6\theta}{8\sec^8\theta} = \frac{27 \cdot \left(\frac{5}{3}\right)^3 + 8 \cdot \left(\frac{5}{2}\right)^3}{8 \cdot \left(\frac{5}{2}\right)^4} = \frac{4}{5}$$

7. Find the length of latus rectum of an ellipse if foci are $(2, 5)$ and $(2, -3)$ and the eccentricity of the ellipse is $\frac{4}{5}$

$$(1) \frac{32}{3}$$

$$(2) \frac{32}{5}$$

$$(3) \frac{18}{5}$$

$$(4) \frac{16}{5}$$

Answer (3)

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Sol. $F_1 : (2, 5)$ and $F_2 : (2, -3)$, notice major axis along y-axis

$$\Rightarrow F_1 F_2 = 8 = 2be \Rightarrow b = \frac{8}{2e} = \frac{4}{4/5} = 5$$

$$\Rightarrow e^2 = 1 - \frac{a^2}{b^2} = 1 - \frac{a^2}{25} = \frac{16}{25}$$

$$\Rightarrow a^2 = 9 \Rightarrow a = 3$$

$$\text{The length of latus rectum : } \frac{2a^2}{b} = \frac{2(9)}{5} = \frac{18}{5}$$

8. If $\lim_{x \rightarrow 1^+} \frac{(x-1)[6 + \lambda \cos(x-1)] + \mu \sin(x-1)}{(x-1)^3} = -1$.

Then the value of $\lambda + \mu$ is

(1) -6

(2) -4

(3) 4

(4) 2

Answer (1)

Sol. $\lim_{x \rightarrow 1^+} \frac{(x-1)[6 + \lambda \cos(x-1)] + \mu \sin(x-1)}{(x-1)^3} = -1$

$$\lim_{x \rightarrow 1^+} \frac{(x-1) \left[6 + \lambda \cos \left(1 - \frac{(x-1)^2}{2!} + \frac{(x-1)^4}{4!} \right) \right] + \mu \left((x-1) - \frac{(x-1)^3}{3!} + \dots \right)}{(x-1)^3}$$

$$\lim_{x \rightarrow 1^+} \frac{(x-1)(6 + \lambda) - \frac{\lambda(x-1)^3}{2!} + \dots + \mu(x-1) - \mu \frac{(x-1)^3}{3!} + \dots}{(x-1)^3}$$

For limit to exist

$$6 + \lambda + \mu = 0$$

$$\Rightarrow \boxed{\lambda + \mu = -6}$$

9. Let α and β be the number of points where the function. $f(x) = \max\{x, x^3, x^5, \dots, x^{21}\}$ is not continuous and not differentiable respectively, then $\alpha + \beta$ equals to

(1) 6

(2) 3

(3) 2

(4) 4

Answer (2)

Sol. For $x \geq 1$, $x^{21} \geq x^{19} \geq \dots \geq x$

$$\Rightarrow f(x) = \begin{cases} x & x < -1 \\ x^{21} & -1 \leq x \leq 0 \\ x & 0 < x < 1 \\ x^{21} & x \geq 1 \end{cases}$$

Closely, $f(x)$ is continuous everywhere $\Rightarrow \alpha = 0$

$$f'(x) = \begin{cases} 1 & , \quad x < -1 \\ 20x^{20} & , \quad -1 \leq x \leq 0 \\ 1 & , \quad 0 < x < 1 \\ 21x^{20} & , \quad x \geq 1 \end{cases}$$

$$\Rightarrow \beta = 3$$

$$\Rightarrow \alpha + \beta = 3$$

10. If $f(x) = 1 - 2x + \int_0^x e^{x-t} f(t) dt$, then the area bounded by the curve $y = f(x)$ and coordinate axes is (in square units)

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

(2) 1

(3) $\frac{3}{2}$

(4) 2

Answer (1)

Sol. $\because f(x) = 1 - 2x + \int_0^x e^{x-t} f(t) dt$

$$\text{or, } f(x) = 1 - 2x + e^x \int_0^x e^{-t} f(t) dt$$

on differentiating both sides w.r.t. x we get

$$f'(x) = -2 + e^x \int_0^x e^{-t} f(t) dt + e^x \cdot e^{-x} f(x)$$

$$f'(x) = -2 + f(x) + 2x - 1 + f(x) \quad \{\text{from eq. (1)}\}$$

$$\therefore f(x) - 2f(x) = 2x - 3$$

$$\text{I.F.} = e^{\int -2dx} = e^{-2x}$$

$$\therefore e^{-2x} \cdot f(x) = \int e^{-2x} (2x - 3) dx$$

$$e^{-2x} \cdot f(x) = (2x - 3) \cdot \frac{e^{-2x}}{-2} - \int 2 \cdot \frac{e^{-2x}}{-2} dx$$

$$e^{-2x} \cdot f(x) = \frac{(2x - 3)e^{-2x}}{-20} + \frac{e^{-2x}}{-2} + c$$

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$$f(x) = -x + 1 + c'e^{2x}$$

$$\therefore f(x) = 1 \text{ from eq. (1)}$$

$$\therefore 1 = 0 + 1 + c' \Rightarrow c' = 0$$

$$\therefore f(x) = -x + 1$$

$$\Rightarrow \text{Area} = \frac{1}{2}$$

11. The value of $\sin^{-1}\left(\frac{\sqrt{3}x}{2} + \frac{1}{2}\sqrt{1-x^2}\right), -\frac{1}{2} < x < \frac{1}{\sqrt{2}}$ is equivalent to

(1) $\frac{2\pi}{3} - \cos^{-1}x, -\frac{1}{2} < x < \frac{1}{\sqrt{2}}$

(2) $\pi - \cos^{-1}x, -\frac{1}{2} < x < \frac{1}{\sqrt{2}}$

(3) $\frac{\pi}{3} - \cos^{-1}x, -\frac{1}{2} < x < \frac{1}{\sqrt{2}}$

(4) $\frac{\pi}{2} - \sin^{-1}x, -\frac{1}{2} < x < \frac{1}{\sqrt{2}}$

Answer (1)

Sol. $\sin^{-1}\left(\frac{\sqrt{3}x}{2} + \frac{1}{2}\sqrt{1-x^2}\right), -\frac{1}{2} < x < \frac{1}{\sqrt{2}}$

Let $x = \cos\theta, \theta \in \left(-\frac{1}{2}, \frac{1}{\sqrt{2}}\right)$

$$\Rightarrow \sqrt{1-x^2} = \sin\theta, \text{ as } \sin\theta > 0$$

$$\begin{aligned} \sin^{-1}\left(\frac{\sqrt{3}}{2}\cos\theta + \frac{1}{2}\sin\theta\right) &= \sin^{-1}\left(\sin\frac{\pi}{3}\cos\theta + \cos\frac{\pi}{3}\sin\theta\right) \\ &= \sin^{-1}\left(\sin\left(\frac{\pi}{3} + \theta\right)\right) \end{aligned}$$

Since $\frac{\pi}{3} + \theta \in \left(\frac{7\pi}{12}, \pi\right)$

$$\Rightarrow \sin\left(\frac{\pi}{3} + \theta\right) = \sin\left(\pi - \left(\frac{\pi}{3} + \theta\right)\right) = \sin\left(\frac{2\pi}{3} - \theta\right)$$

$$\Rightarrow \sin^{-1}\left(\sin\left(\frac{\pi}{3} + \theta\right)\right) = \sin^{-1}\left(\sin\left(\frac{2\pi}{3} - \theta\right)\right)$$

$$\text{Since } \frac{2\pi}{3} - \theta \in \left(0, \frac{5\pi}{12}\right)$$

$$\Rightarrow = \frac{2\pi}{3} - \theta$$

$$= \frac{2\pi}{3} - \cos^{-1}x, x \in \left(-\frac{1}{2}, \frac{1}{\sqrt{2}}\right)$$

12. There are 10 pens such that 3 pens are defective. Let X represent the number of defective pen selected. If two pens are selected at random then variance of X is

(1) $\frac{38}{75}$ (2) $\frac{28}{75}$

(3) $\frac{14}{75}$ (4) $\frac{3}{75}$

Answer (2)

Sol.

X	$P(X)$	$XP(X)$	$(X_i - \mu)^2$	$P_i X(X_i - \mu)^2$
$X = 0$	$\frac{{}^7C_2}{{}^{10}C_2}$	0	$\left(0 - \frac{3}{5}\right)^2$	$\frac{7}{15} \left(\frac{9}{25}\right)$
$X = 1$	$\frac{{}^7C_1 {}^3C_1}{{}^{10}C_2}$	$\frac{7}{15}$	$\left(1 - \frac{3}{5}\right)^2$	$\frac{7}{15} \left(\frac{4}{25}\right)$
$X = 2$	$\frac{{}^7C_0 {}^3C_2}{{}^{10}C_2}$	$\frac{2}{15}$	$\left(2 - \frac{3}{5}\right)^2$	$\frac{1}{15} \left(\frac{49}{25}\right)$

$$\mu = \sum X_i P(X_i) = 0 + \frac{7}{15} + \frac{2}{15} = \frac{3}{5}$$

Variance (X) =

$$\sum P_i (X_i - \mu)^2 = \frac{7}{15} \left(\frac{9}{25}\right) + \frac{7}{15} \left(\frac{4}{25}\right) + \frac{1}{15} \left(\frac{49}{25}\right) = \frac{28}{75}$$

13.
14.
15.
16.
17.
18.
19.
20.

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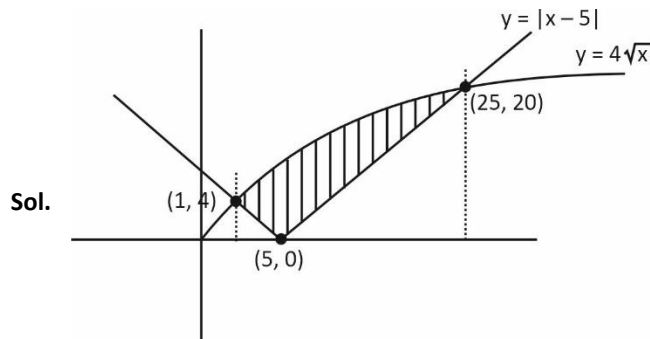


SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. Let $|x-5| \leq y \leq 4\sqrt{x}$. If the Area enclosed is A, then 3A equals to

Answer (368)



$$A = \int_1^{25} 4\sqrt{x} dx - \frac{1}{2} \times 4 \times 4 - \frac{1}{2} \times 20 \times 20$$

$$A = \left[\frac{4x^{3/2}}{3/2} \right]_1^{25} - 8 - 200$$

$$A = \frac{8}{3} [125 - 1] - 208$$

$$= \frac{368}{3} \Rightarrow 3A = 368$$

22. Given two lines

$$L_1: \frac{x-3}{3} = \frac{y-\alpha}{1} = \frac{z+2}{-2}$$

$$\text{and } L_2: \frac{x+1}{2} = \frac{y+2}{1} = \frac{z-\beta}{-1}$$

If shortest distance between L_1 and L_2 is $30\sqrt{3}$. Then the value of $|a+b|$ is

Answer (90)

Sol. $L_1: \frac{x-3}{3} = \frac{y-\alpha}{1} = \frac{z+2}{-2}$

$$L_2: \frac{x+1}{2} = \frac{y+2}{1} = \frac{z-\beta}{-1}$$

$$\text{Shortest distance, } d = \frac{|(\vec{a}_2 - \vec{a}_1) \cdot (\vec{b}_1 - \vec{b}_2)|}{|\vec{b}_1 \times \vec{b}_2|}$$

$$(\vec{a}_2 - \vec{a}_1) \cdot (\vec{b}_1 - \vec{b}_2) = \begin{vmatrix} 4 & \alpha+2 & -2-\beta \\ 3 & 1 & -2 \\ 2 & 1 & -1 \end{vmatrix}$$

$$= 4(-1+2) - (\alpha+2)(-3+4)$$

$$- (2+\beta)(3-2)$$

$$= 4 - \alpha - 2 - 2 - \beta$$

$$= -\alpha - \beta$$

$$\text{Also } |\vec{b}_1 \times \vec{b}_2| = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 1 & -2 \\ 2 & 1 & -1 \end{vmatrix}$$

$$= |\hat{i} - \hat{j} + \hat{k}|$$

$$= \sqrt{3}$$

$$30\sqrt{3} = \frac{|-\alpha - \beta|}{\sqrt{3}}$$

$$\Rightarrow |\alpha + \beta| = 90$$

23. If $\vec{v} = 2\hat{i} + \hat{j} - \lambda\hat{k}$, ($\lambda > 0$), $\vec{u} = 3\hat{i} - \hat{j}$ and $\vec{v}_1$ is parallel to $\vec{u}$, $\vec{v}_2$ is perpendicular to $\vec{u}$ and $\vec{v} = \vec{v}_1 + \vec{v}_2$. If angle between $\vec{v}$ and $\vec{v}_1$ is $\cos^{-1}\left(\frac{\sqrt{5}}{2\sqrt{7}}\right)$, then $|\vec{v}_1|^2 + |\vec{v}_2|^2$ equals to

Answer (14)

Sol. $\vec{v} = \vec{v}_1 + \vec{v}_2$

$$\vec{v} \cdot \vec{u} = \vec{v}_1 \cdot \vec{u} + \vec{v}_2 \cdot \vec{u} = (k\vec{u}) \cdot \vec{u} + 0$$

$$6 - 1 + 0 = k(0) \quad \begin{vmatrix} \vec{v}_1 \parallel \vec{u} \\ \vec{v}_2 \perp \vec{u} \end{vmatrix} \Rightarrow \vec{v}_1 = k\vec{u}$$

$$\Rightarrow k = \frac{1}{2}$$

$$\vec{v}_1 = \frac{1}{2}(3\hat{i} - \hat{j}) = \frac{3}{2}\hat{i} - \frac{1}{2}\hat{j}$$

Cosine of angle between $\vec{v}$ and $\vec{v}_1$

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$$= \frac{\vec{v} \cdot \vec{v}_1}{|\vec{v}| |\vec{v}_1|} = \frac{3 - \frac{1}{2} + 0}{\sqrt{\frac{9}{4} + \frac{1}{4}} \sqrt{4 + 1 + \lambda^2}}$$

$$\Rightarrow \frac{\sqrt{5}}{2\sqrt{7}} = \frac{\frac{5}{2}}{\sqrt{5} \sqrt{\lambda^2 + 5}}$$

$$\Rightarrow \frac{5}{4 \times 7} = \frac{5}{(\lambda^2 + 5)} \Rightarrow (\lambda^2 + 5) = 14$$

$$\lambda^2 = 9, \lambda = 3$$

$$\vec{v}_2 = \vec{v} - \vec{v}_1 = (2\hat{i} + \hat{j} - 3\hat{k}) - \left(\frac{3}{2}\hat{i} - \frac{\hat{j}}{2}\right)$$

$$= \frac{1}{2}\hat{i} + \frac{3}{2}\hat{j} - 3\hat{k}$$

$$|\vec{v}_1|^2 + |\vec{v}_2|^2 = \left(\frac{9}{4} + \frac{1}{4}\right) + \left(\frac{1}{4} + \frac{9}{4} + 9\right)$$

$$= \frac{10}{4} + \frac{10}{4} + 9 = 14$$

24.

25.




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