Toughest Questions for JEE Advanced 2015 with Solutions

Maths>

Q1. IIT JEE 2012 Paper - 2

Four fair dice D_1, D_2, D_3 and D_4, each having six faces numbered 1, 2,3,4,5 and 6, are rolled simultaneously. The probability that D_4 shows a number appearing on one of D_1, D_2 and D_3 is

(a) $\frac{91}{216}$

(b) $\frac{108}{216}$

(c) $\frac{125}{216}$

(d) $\frac{127}{216}$

Correct Answer: Option A

Case I: When D_1, D_2, D_3 all shows different number and one of the number is shown by D_4 $P(E_1) = \frac{{}^6C_3 \times 3!}{216} \times \frac{3}{6} = \frac{60}{216}$

Case II: When D_1, D_2, D_3 all show same number and that number is shown by D_4

$P(E_2) = 6 \times (1/6)^4 = 1/216$

Case III: When two numbers shown by D_1, D_2, D_3 are same and one is different and one of the numbers is shown by D_4

$$P(E_3) = \frac{{}^6C_1 \times {}^5C_1}{216} \times \frac{3!}{2!} \times \frac{2}{6} = \frac{30}{216}$$

$\therefore$ Required probability $= P(E_1) + P(E_2) + P(E_3) = \frac{91}{216}$.

Q2. IIT JEE 2012 Paper - 1

The value of $6 + \log_{\frac{3}{2}}\left(\frac{1}{3\sqrt{2}}\sqrt{4 - \frac{1}{3\sqrt{2}}\sqrt{4 - \frac{1}{3\sqrt{2}}\sqrt{4 - \frac{1}{3\sqrt{2}}\ldots}}}\right)$ is

Correct Answer: 4

Solution:

Let $S = \sqrt{4 - \frac{1}{3\sqrt{2}}\sqrt{4 - \frac{1}{3\sqrt{2}}\sqrt{4 - \frac{1}{3\sqrt{3}}\ldots\ldots}}}$.

$$\Rightarrow S = \sqrt{4 - \frac{1}{3\sqrt{2}}S} \quad \Rightarrow 3\sqrt{2}S^2 + S - 12\sqrt{2} = 0$$

Solving the equation for S we get,

$$\Rightarrow S = \frac{4\sqrt{2}}{3}, S = \frac{-3}{\sqrt{2}}(\text{neglected})$$

As, the log of the negative values is not defined.

Now putting the value of S we get

$$6+\log_{\frac{3}{2}}\left(\frac{1}{3\sqrt{2}}\sqrt{4-\frac{1}{3\sqrt{2}}\sqrt{4-\frac{1}{3\sqrt{2}}\sqrt{4-\frac{1}{3\sqrt{2}}\ldots}}}\right) =$$

$$6+\log_{3/2}\left(\frac{1}{3\sqrt{2}}\times\frac{4\sqrt{2}}{3}\right)=4$$

Hence, the value of the given expression is 4.

Q3. JEE Advanced 2013 paper - 2

Consider the lines $L_1:\frac{x-1}{2}=\frac{y}{-1}=\frac{z+3}{1}, L_2:\frac{x-4}{1}=\frac{y+3}{1}=\frac{z+3}{1}$ and the planes $P_1:7x+y+2z=3,\ P_2:3x+5y-6z=4.$ Let $ax + by + cz = d$ be the equation of the plane passing through the point of intersection of lines L_1 and L_2, and perpendicular to planes P_1 and P_2.

Match List − I with List − II and select the correct answer using the code given below the lists:

	List I		List II
P.	a =	**1.**	13
Q.	b =	**2.**	–3
R.	c =	**3.**	1
S.	d =	**4.**	–2

(a)

P	Q	R	S
3	2	4	1

(b)

P	Q	R	S
1	3	4	2

(c)

P	Q	R	S
3	2	1	4

(d)

P	Q	R	S
2	4	1	3

Correct Answer: Option A

The given lines and planes are:

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

$$L_2 : \frac{x-4}{1} = \frac{y+3}{1} = \frac{z+3}{2}$$

$$P_1 : 7x + y + 2z = 3$$

$$P_2 : 3x + 5y - 6z = 4$$

$$P : ax + by + cz = d$$

Normal to the plane P is

$$\vec{n} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 7 & 1 & 2 \\ 3 & 5 & -6 \end{vmatrix}$$

$$= \hat{i}(-16) - \hat{j}(-42-6) + \hat{k}(32)$$

$$= -16\hat{i} + 48\hat{j} + 32\hat{k}$$

$$= -16\left(\hat{i} - 3\hat{j} - 2\hat{k}\right)$$

$$\Rightarrow \vec{n} = \hat{i} - 3\hat{j} - 2\hat{k}$$

Let $\frac{x-1}{2}=\frac{y}{-1}=\frac{z+3}{1}=k_1$ and $\frac{x-4}{1}=\frac{y+3}{1}=\frac{z+3}{2}=k_2$

Since, L_1 and L_2 intersect, therefore,

$2k_1 + 1 = k_2 + 4$ ... (1)

$-k_1 = k_2 - 3$ … (2)

$k_1 - 3 = 2k_2 - 3$ … (3)

Solving equation (1) and (2), we get $k_1 = 2$, $k_2 = 1$

Thus, the point of intersection of the lines L_1 and L_2 is

$$(k_2+4,\ k_2-3, 2k_2-3)=(5,-2,-1)$$

Therefore, equation of the plane P is

$$1(x-5)-3(y+2)-2(z+1)=0$$
$$x-3y-2z=13$$

$\Rightarrow a = 1, b = -3, c = -2, d = 13$

Hence, the correct code is A.

Q4. JEE Advanced 2013 Paper - 1

The area enclosed by the curves $y = \sin x + \cos x$ and $y = |\cos x - \sin x|$ over the interval $\left[0, \frac{\pi}{2}\right]$ is

(a) $4\left(\sqrt{2}-1\right)$

(b) $2\sqrt{2}\left(\sqrt{2}-1\right)$

(c) $2\left(\sqrt{2}+1\right)$

(d) $2\sqrt{2}\left(\sqrt{2}+1\right)$

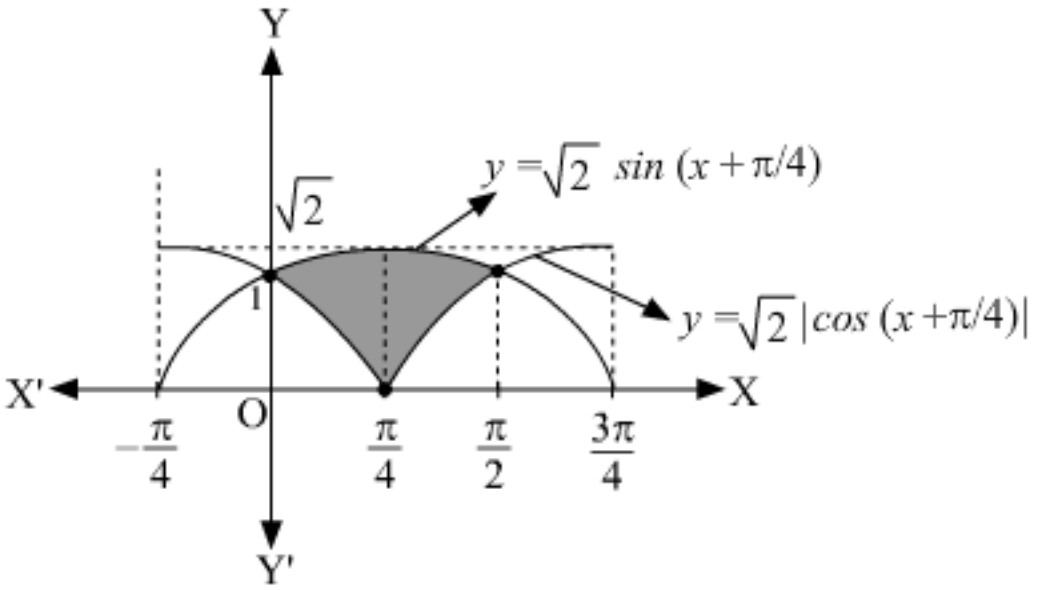
Correct Answer: Option B

The given curves over the interval $\left[0, \frac{\pi}{2}\right]$ are

$$y = \sin x + \cos x = \sqrt{2}\sin\left(x + \frac{\pi}{4}\right) \quad \ldots (1)$$

$$y = |\cos x - \sin x| = \sqrt{2}\left|\cos\left(x + \frac{\pi}{4}\right)\right| \quad \ldots (2)$$

With the help of shifting of origin the graphs of $y = \sqrt{2}\sin\left(x + \frac{\pi}{4}\right)$ and $y = \sqrt{2}\left|\cos\left(x + \frac{\pi}{4}\right)\right|$ is



Now,

$$y = |\cos x - \sin x| = \begin{cases} \cos x - \sin x\ ; & x \in \left[0, \frac{\pi}{4}\right] \\ \sin x - \cos x\ ; & x \in \left[\frac{\pi}{4}, \frac{\pi}{2}\right] \end{cases}$$

∴ Area enclosed by the given curves, A is

$$A = \int_0^{\frac{\pi}{4}} \left|(\sin x + \cos x) - (\cos x - \sin x)\right| dx + \int_{\frac{\pi}{4}}^{\frac{\pi}{2}} \left|(\sin x + \cos x) - (\sin x - \cos x)\right| dx$$

$$= 2\left[\int_0^{\frac{\pi}{4}} |\sin x|\, dx + \int_{\frac{\pi}{4}}^{\frac{\pi}{2}} |\cos x|\, dx\right]$$

$$= 2\left[(-\cos x)_0^{\frac{\pi}{4}} + (\sin x)_{\frac{\pi}{4}}^{\frac{\pi}{2}}\right]$$

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

$$= 2\sqrt{2}\left(\sqrt{2} - 1\right)$$

Hence, the correct option is B.

Q5. IIT 2010 Solved Paper - 2

Let f be a function defined on R (the set of all real numbers) such that $f'(x) = 2010(x-2009)(x-2010)^2(x-2011)^3(x-2012)^4$ for all $x \in R$. If g is a function defined on R with values in the interval $(0,\infty)$ such that $f(x) = \ln(g(x))$ for all $x \in R$, then the number of points in R at which g has a local maximum is

Correct Answer: 0

Solution:

$f(x) = \ln\{g(x)\}$

$g(x) = e^{f(x)}$

$g'(x) = e^{f(x)}.f'(x)$

$$g'(x)=0 \Rightarrow f'(x)=0 \text{ as } e^{f(x)} \neq 0$$

$$\Rightarrow 2010(x-2009((x-2010)^2(x-2011)^3(x-2012)^4=0$$

So there is only one point of local maxima.

Q6. IIT JEE 2011 Paper - 1

Let α and β be the roots of $x^2-6x-2=0$, with $\alpha>\beta$. If $a_n=\alpha^n-\beta^n$ for n ≥ 1, then the value of $\frac{a_{10}-2a_8}{2a_9}$ is

(a) 1

(b) 2

(c) 3

(d) 4

Correct Answer: Option C

It is given that, α and β are the roots of $x^2-6x-2=0$. Therefore,

$$\alpha^2-6\alpha-2=0 \Rightarrow \alpha^2-2=6\alpha$$

$$\beta^2-6\beta-2=0 \Rightarrow \beta^2-2=6\beta$$

We shall use the above equations to simplify the expression given in the problem.

Thus,

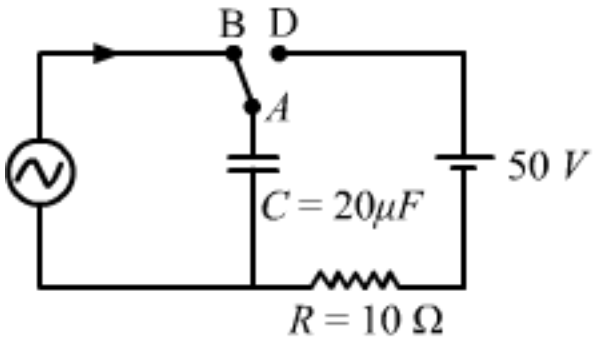
$$\frac{a_{10}-2a_8}{2a_9}=\frac{\left(\alpha^{10}-\beta^{10}\right)-2\left(\alpha^8-\beta^8\right)}{2\left(\alpha^9-\beta^9\right)}$$
$$=\frac{\alpha^8\left(\alpha^2-2\right)-\beta^8\left(\beta^2-2\right)}{2\left(\alpha^9-\beta^9\right)}$$
$$=\frac{\alpha^8\cdot 6\alpha-\beta^8\cdot 6\beta}{2\left(\alpha^9-\beta^9\right)}$$
$$=3$$

Hence, the correct option is C.

Physics>

Q1. JEE Advanced 2014 paper - 1

At time t = 0, terminal A in the circuit shown in the figure is connected to B by a key and an alternating current $I(t) = I_0 \cos(\omega t)$, with I_0 = 1 A and ω = 500 rad s^{-1} starts flowing in it with the initial direction shown in the figure. At $t = \frac{7\pi}{6\omega}$, the key is switched from B to D. Now onwards only A and D are connected. A total charge Q flows from the battery to charge the capacitor fully. If C = 20 μF, R = 10 Ω and the battery is ideal with *emf* of 50 V, identify the correct statement (s).



(A) Magnitude of the maximum charge on the capacitor before $t = \frac{7\pi}{6\omega}$ is 1×10^{-3} C.

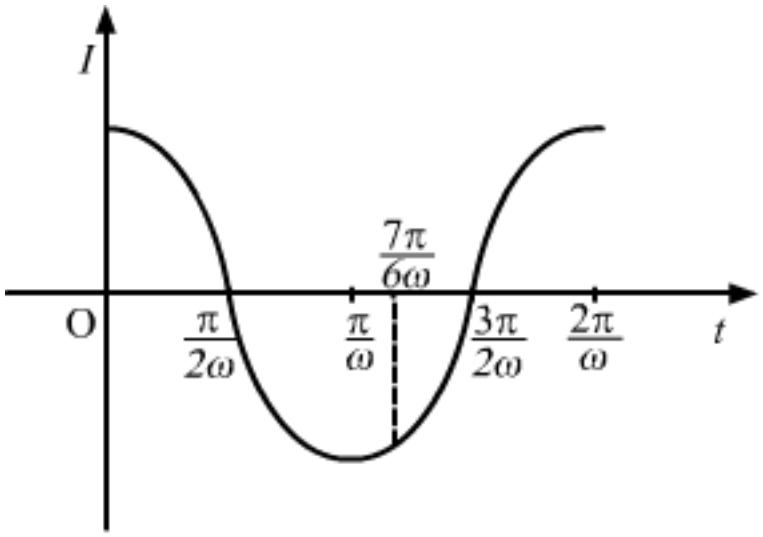
(B) The current in the left part of the circuit just before $t = \frac{7\pi}{6\omega}$ is clockwise.

(C) Immediately after A is connected to D, the current in R is 10A.

(D) Q = 2×10^{-3} C.

Solution:

Variation of current in the circuit with time is given as follows:



As shown in the figure, from $t = 0$ to $\frac{7\pi}{6\omega}$ the charge will be maximum at $t = \frac{\pi}{2\omega}$, when current in the circuit is zero.

Charge at this point (Q) is given by

$$Q = \int_0^{\frac{\pi}{2\omega}} I_0 \cos\omega t\, dt$$

$$= \frac{I_0}{\omega}(\sin\omega t)_0^{\frac{\pi}{2\omega}}$$

$$= \frac{I_0}{\omega} = \frac{1}{500} = 2\times10^{-3}\ \text{C}$$

At $t = \frac{7\pi}{6\omega}$, the direction of current will be opposite to the initial direction. And, the charge on the upper plate is given by

$$Q = \int_0^{\frac{7\pi}{6\omega}} I_0 \cos\omega t dt$$

$$= \frac{I_0}{\omega}(\sin\omega t)_0^{\frac{7\pi}{6\omega}}$$

$$= \frac{I_0}{\omega} \times \sin\left(\frac{7\pi}{6}\right) = -\frac{1}{1000} = -10^{-3}\ \text{C}$$

Applying KVL, when the switch is shifted to D, we get:

$$50 + \frac{10^{-3}}{20\times10^{-6}} - i\times10 = 0$$

$$\Rightarrow 50 + \frac{1000}{20} - i\times10 = 0$$

$$\Rightarrow 100 - i\times10 = 0$$

$$\Rightarrow i = \frac{100}{10} = 10\ \text{A}$$

Final charge on *C* is given by

$$Q' = CV = 20\times10^{-6}\times50 = 10^{-3}\ \text{C}$$

Total charge flown from the battery will be $2\times10^{-3}\ \text{C}$.

Hence, the correct options are C and D.

Q2. JEE Advanced 2014 Paper – 1

A student is performing an experiment using a resonance column and a tuning fork of frequency 244 s^{-1}. He is told that the air in the tube has been replaced by another gas (assume that the column remains filled with the gas). If the minimum height at which resonance occurs is (0.350 ± 0.005) m, the gas in the tube is

(**Useful information :** $\sqrt{167RT} = 640\ \text{J}^{1/2}\ \text{mole}^{-1/2}$; $\sqrt{140RT} = 590\ \text{J}^{1/2}\ \text{mole}^{-1/2}$.

The molar masses *M* in grams are given in the options. Take the values of $\sqrt{\frac{10}{M}}$ for each gas as given there.)

(A) $\text{Neon}\left(M=20,\sqrt{\frac{10}{20}}=\frac{7}{10}\right)$

(B) $\text{Nitrogen}\left(M=28,\sqrt{\frac{10}{28}}=\frac{3}{5}\right)$

(C) $\text{Oxygen}\left(M=32,\sqrt{\frac{10}{32}}=\frac{9}{16}\right)$

(D) $\text{Argon}\left(M=36,\sqrt{\frac{10}{36}}=\frac{17}{32}\right)$

Correct Answer: Option D

We know:

Minimum length for the occurrence of resonance, $l = \lambda/4$

or $\lambda = 4l$

Now, fundamental frequency is given as follows:

$$f=\frac{1}{\lambda}\sqrt{\frac{\gamma RT}{M}}=\frac{1}{4l}\sqrt{\frac{\gamma RT}{M}}$$

$$\therefore \frac{\Delta f}{f}=\frac{\Delta l}{l}$$

(A) Neon:

$$f=\frac{1}{4\times 0.350}\sqrt{\frac{1.67RT}{20}}=320\ \text{Hz}$$

$$\Delta f=f\times\frac{\Delta l}{l}=320\times\frac{\pm 0.005}{0.350}=\pm 4.5\ \text{Hz}$$

(B) Nitrogen:

$$f = \frac{1}{4 \times 0.350}\sqrt{\frac{1.4RT}{28}} = 253 \text{ Hz}$$

$$\Delta f = f \times \frac{\Delta l}{l} = 253 \times \frac{\pm 0.005}{0.350} = \pm 3.6 \text{ Hz}$$

(C) Oxygen:

$$f = \frac{1}{4 \times 0.350}\sqrt{\frac{1.4RT}{32}} = 237 \text{ Hz}$$

$$\Delta f = f \times \frac{\Delta l}{l} = 237 \times \frac{\pm 0.005}{0.350} = \pm 3.4 \text{ Hz}$$

(D) Argon:

$$f = \frac{1}{4 \times 0.350}\sqrt{\frac{1.67RT}{36}} = 242.8 \text{ Hz}$$

$$\Delta f = f \times \frac{\Delta l}{l} = 242.8 \times \frac{\pm 0.005}{0.350} = \pm 3.5 \text{ Hz}$$

From the above calculations, the only possible gas is Argon because its frequency of vibration is comparable to the frequency of the tuning fork used.

Hence, the correct option is D.

Q3. JEE Advanced 2013 Paper - 2

Paragraph:

A point charge *Q* is moving in a circular orbit of radius *R* in the *x*-*y* plane with an angular velocity ω. This can be considered as equivalent to a loop carrying a steady current $\frac{Q\omega}{2\pi}$. A uniform magnetic field along the positive *z*-axis is now switched on, which increases at a constant rate from 0 to *B* in one second. Assume that the radius of the orbit remains constant. The application of the magnetic field induces an emf in the orbit. The induced emf is defined as the work done by an induced electric field in moving a unit positive charge around a closed loop. It is known that, for an orbiting charge, the magnetic dipole moment is proportional to the angular momentum with a proportionality constant γ.

The change in the magnetic dipole moment associated with the orbit, at the end of the time interval of the magnetic field change is

(a) $-\gamma BQR^2$

(b) $-\gamma \frac{BQR^2}{2}$

(c) $\gamma \frac{BQR^2}{2}$

(d) γBQR^2

Correct Answer: Option B

Given magnetic dipole moment, M=γL

And , L=Iω= $\frac{1}{2}mR^2(\frac{BQ}{m}) = \frac{1}{2}BQR^2$

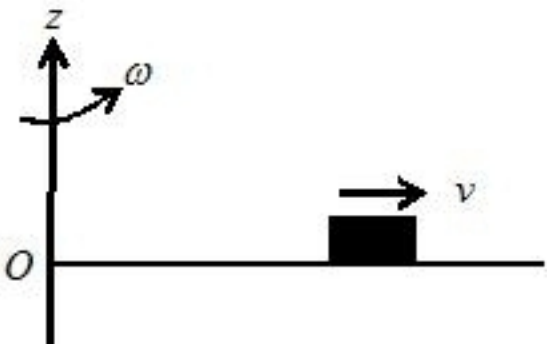
Now, change in magnetic dipole, M= $-\frac{\gamma BQR^2}{2}$

Negative sign shows that the change is in opposite direction of magnetic field.

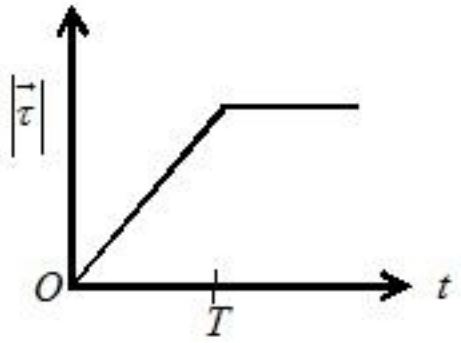
Q4. IITJEE 2012 Paper - 1

A thin uniform rod, pivoted at *O,* is rotating in the horizontal plane with constant angular speed ω , as shown in the figure, at time $t = 0$ a small insect from *O* and moves with constant speed *v* with respect to the rod towards the other end. It reaches the end of the rod at $t = T$

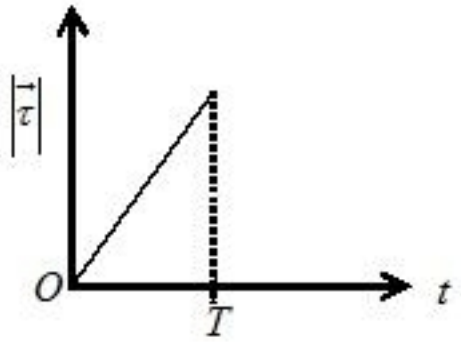
and stops. The angular speed of the system remains ω throughout. The magnitude of the torque $|\vec{\tau}|$ on the system about *O*, as a function of time is best represented by which plot?



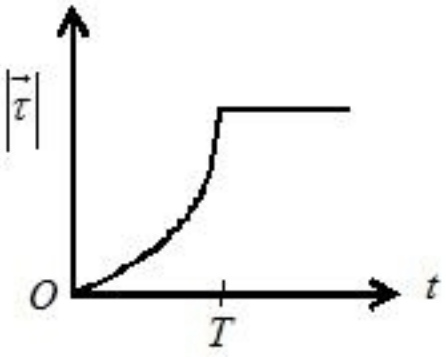
(a)



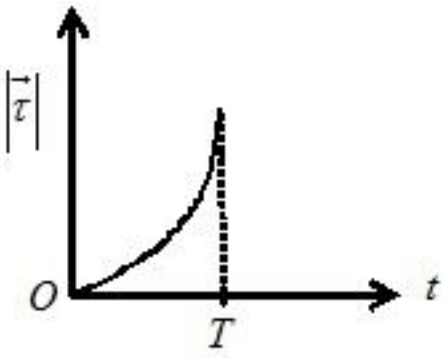
(b)



(c)

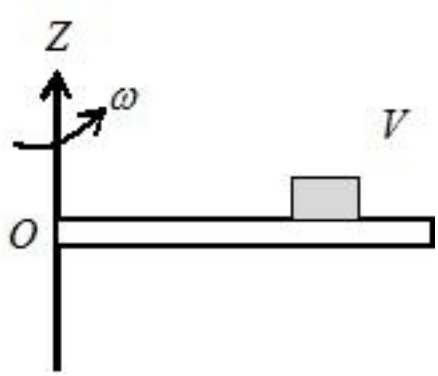


(d)



Solution:

$\omega =$ constant throughout



As we know that

$$\frac{\vec{dL}}{dt} = \vec{\tau}$$

Where L = Angular momentum

τ= Torque

Now

$$L = I\omega$$
$$= \left[(1/3)ML^2 + m(vt)^2\right]\omega$$

Differentiating the equation with respect to time

$$(dL/dt) = 2m\omega v^2 t$$

$$\Rightarrow \left|\vec{\tau}\right| \propto t$$

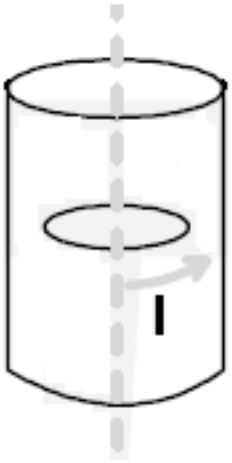
Hence the graph would be a straight line with a constant slope till the insect moves.

When insect stops *I* becomes constant $\Rightarrow \left(\left|dL/dt\right|\right) = 0 \Rightarrow \left|\vec{\tau}\right| = 0$

Hence the graph would be the x-axis.

Q5. IIT JEE 2011 Paper - 1

A long circular tube of length 10m and radius 0.3 m carries a current/along its curved surface as shown. A wire-loop of resistance 0.005 ohm and of radius 0.1m is placed inside the tube with its axis coinciding with the axis of the tube. The current varies as $I = I_0\cos(300t)$ where I_0 is constant. If the magnetic moment of the loop is $N\mu_0 I_0 \sin(300t)$, then 'N' is



Solution:

$$I = iN \Rightarrow i = (I/M)$$

[N: No. of turns per unit length assuming the tube as solenoid]

$$B = \mu_0 ni = \mu(N/L)i = (\mu_0 I/L)$$

$$\therefore \quad \phi = Ba = [(\mu_0 I/L).A]$$

$$\Rightarrow \quad e = -(d\phi/dt) = [-(\mu_0 A/L).(dI/dt)]$$

$$\therefore \quad \mu = i_1 A \quad = [(\mu_0 A^2/LR)(dI/dt), \text{where } A = \pi r_1^2]$$

$$\Rightarrow \mu = [(A^2/LR) \times 300]\mu_0 I_0 \sin(300t)$$

$$\Rightarrow N = 0.6\pi^2 = 6$$

Chemistry>

Q1. JEE Advanced 2014 Paper - 1

The pair(s) of reagents that yield paramagnetic species is/are

(A) Na and excess of NH_3

(B) K and excess of O_2

(C) Cu and dilute HNO_3

(D) O_2 and 2-ethylanthraquinol

Solution:

Na, on reaction with excess of NH_3, gives a solution of alkali metals containing free ammoniated electrons that are paramagnetic in nature.

$$Na + (x+y)NH_3 \rightarrow \underbrace{\left[Na(NH_3)_x\right]^+}_{\text{Ammoniated cation}} + \underbrace{\left[e(NH_3)_y\right]^-}_{\text{Ammoniated electron}}$$

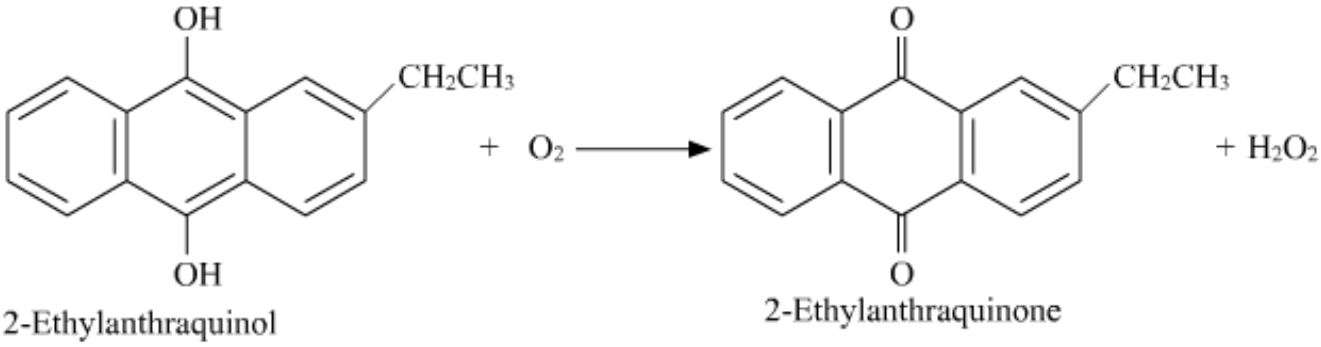
K, on reaction with excess of O_2, gives superoxide, which is paramagnetic in nature due to the presence of a single unpaired electron.

$$K + O_2 \rightarrow KO_2$$

Cu and dilute HNO_3 give NO, which is paramagnetic in nature.

$$3Cu + 8\,HNO_3 \rightarrow 3\,Cu(NO_3)_2 + 2\,NO + 4\,H_2O$$

O_2 and 2-ethylanthraquinol will give 2-ethylanthraquinone and hydrogen peroxide. Hydrogen peroxide is diamagnetic in nature.



2-Ethylanthraquinol 2-Ethylanthraquinone

Hence, the correct options are (A), (B) and (C).

Q2. JEE Advanced 2014 Paper - 1

The correct statement(s) for orthoboric acid is/are

(A) It behaves as a weak acid in water due to self ionisation.

(B) Acidity of its aqueous solution increases upon addition of ethylene glycol.

(C) It has a three dimensional structure due to hydrogen bonding.

(D) It is a weak electrolyte in water.

Solution:

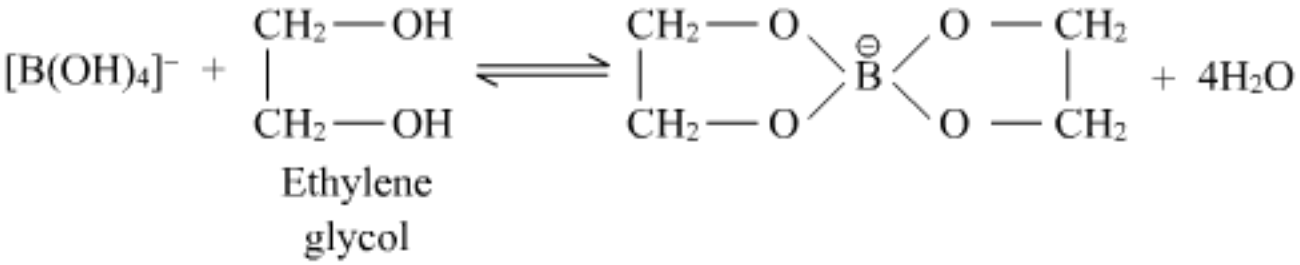
Orthoboric acid is H_3BO_3 or $B(OH)_3$.

It partially reacts with water and forms H_3O^+ and $[B(OH)_4]^-$. It is soluble in water and behaves as a weak monobasic acid. Orthoboric acid is a type of acid which does not donate proton; rather, it accepts hydroxyl ion and behaves as a Lewis acid.

$B(OH)_3 + 2\ H_2O \rightleftharpoons H_3O^+ + [B(OH)_4]^-$

Thus, orthoboric acid does not behave as a weak acid due to self ionisation.

In aqueous solution of orthoboric acid, if a certain organic polyhydroxy compound such as glycerol, mannitol or sugar is added, then it behaves as strong monobasic acid.



BO_3^{3-} units have a planar structure. In solid state, BO_3^{3-} units are hydrogen bonded, giving rise to a two-dimensional sheet with almost hexagonal symmetry.

Orthoboric acid is less soluble in cold water and furnishes BO_3^{3-} ions, so it is a weak electrolyte in water.

Hence, the correct options are (B) and (D).

Q3. JEE Advanced 2014 Paper - 2

For the process

H2O (l) →H2O (g)

at T = 100 °C and 1 atmosphere pressure, the correct choice is

(A) ΔSsystem >0 and ΔSsurroundings >0

(B) ΔSsystem >0 and ΔSsurroundings <0

(C) ΔSsystem<0 and ΔSsurroundings>0

(D) ΔSsystem <0 and ΔSsurroundings <0

Correct Answer: Option B

The total entropy change for a system and the surrounding for any reaction is given by

$$\Delta S_{total} = \Delta S_{system} + \Delta S_{surrounding} \quad ...(1)$$

At 100 °C and 1 atm pressure, H_2O changes from liquid to gaseous state. This temperature is termed as the boiling point of water. At this temperature, the liquid water and the gaseous water vapour exist in equilibrium.

For an equilibrium reaction, $\Delta S_{total} = 0$

On substituting the value of ΔS_{total} in equation (1), we get:

$$\Delta S_{system} + \Delta S_{surrounding} = 0$$
$$\Rightarrow \Delta S_{system} = - \Delta S_{surrounding}$$

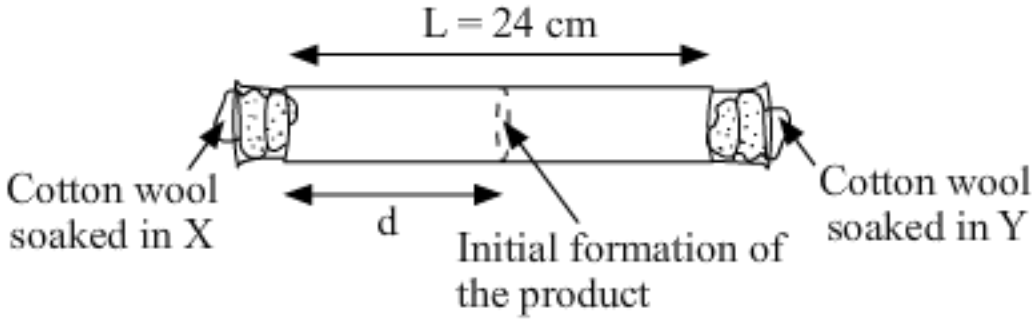
As the water is undergoing a change in phase (i.e., from liquid to gas), the degree of randomness increases. Hence, for this process, $\Delta S_{system} > 0$

As the change in entropy of the system is positive, the change in entropy of the surrounding will be negative ($\Delta S_{surrounding} < 0$).

Hence, the correct option is (B).

Q4. JEE Advanced 2014 Paper - 2

X and **Y** are two volatile liquids with molar weights 10 g mol^{-1} and 40 g mol^{-1}, respectively. Two cotton plugs, one soaked in **X** and the other soaked in **Y**, are simultaneously placed at the ends of a tube of length **L** = 24 cm, as shown in the figure. The tube is filled with an inert gas at 1 atmosphere pressure and a temperature of 300 K. Vapours of **X** and **Y** react to form a product, which is first observed at a distance **d** cm from the plug soaked in **X**. Take **X** and **Y** to have equal molecular diameters and assume ideal behaviour for the inert gas and the two vapours.



The value of **d** in cm (shown in the figure), as estimated from Graham's Law, is

(A) 8

(B) 12

(C) 16

(D) 20

Correct Answer: Option C

According to Graham's Law of Diffusion, "under similar conditions of temperature and pressure, the rate of diffusion of a gas is inversely proportional to the square root of its density."

$$r \propto \sqrt{\frac{1}{density}}$$

In other words, it can also be written as $r \propto \sqrt{\frac{1}{M}}$, where *M* is the molecular mass of the gas.

In the given reaction, vapours of gas X and gas Y diffuse in the tube to form a product at distance *d* from the plug soaked in X.

Thus, according to Graham's Law of Diffusion,

$$\frac{r_X}{r_Y} = \sqrt{\frac{M_Y}{M_X}}$$

$$\text{Time taken for diffusion by X} = \text{Time taken for diffusion by Y}$$

$$\Rightarrow \frac{d}{r_X} = \frac{24 - d}{r_Y}$$

$$\Rightarrow \frac{r_X}{r_Y} = \frac{d}{24 - d} = \sqrt{\frac{M_X}{M_Y}}$$

$$\Rightarrow \frac{d}{24 - d} = \sqrt{\frac{40}{10}} = 2$$

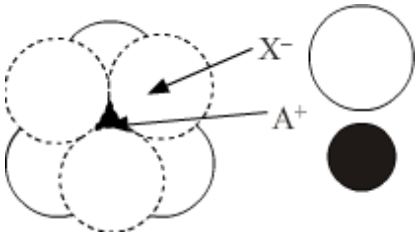
$$\Rightarrow d = 48 - 2d$$

$$\Rightarrow d = 16\ cm$$

Hence, the correct option is (C).

Q5. JEE Advanced 2013 Paper – 1

The arrangement of X^- ions around A^+ ion in solid AX is given in the figure (not drawn to scale). If the radius of X^- is 250 *pm*, the radius of A^+ is



(A) 104 *pm*

(B) 125 *pm*

(C) 183 *pm*

(D) 57 *pm*

Correct Answer: Option A

From the given figure, it can be said that cation A^+ occupies the octahedral void formed by the X^- anions. The radius ratio range is 0.414 - 0.732, Therefore,

$$\frac{r_c^+}{r_a^-} \geq 0.414$$

$$r_c^+ \geq 0.414 \times 250 = 103.5\,\text{pm}$$

$$r_c^+ \geq 103.5\,\text{pm}$$

$$\text{Now, } \frac{r_c^+}{r_a^-} < 0.732$$

$$r_c^+ < 0.732 \times 250 = 183\ \text{pm}$$

$$r_c^+ < 183\ \text{pm}$$

Since minimum value for a cation to accommodate an octahedral void without distortion is 0.414, therefore radius of cation is 103.5 ~ 104 pm.
