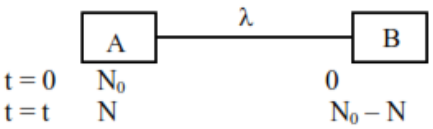
Physics (Paper 1)
JEE MAIN 2017

***Questions*: 1:-** A radioactive nucleus A with a half-life T, decays into a nucleus B. At t = 0, there is no nucleus B. At some time t, the ratio of the number of B to that of A is 0.3. Then, t is given by:

(A) $t = \frac{T}{\log(1.3)}$ (B) $t = \frac{T}{2}\frac{\log 2}{\log 1.3}$

(C) $t = T\frac{\log 1.3}{\log 2}$ (D) $t = T\log(1.3)$

***Ans*:- (C)**



$$\frac{N_0 - N}{N} = 0.3$$

$$\Rightarrow N = \frac{N_0}{1.3}$$

$$N = N_0\, e^{-\lambda t}$$

$$\Rightarrow \frac{1}{1.3} = e^{-\lambda t}$$

$$\Rightarrow t = \frac{\ell n(1.3)}{\lambda} = T\frac{\ell n(1.3)}{\ell n(2)}$$

$$\because \lambda = \frac{\ell n\, 2}{T}.$$

***Questions*: 2:-** The following observations were taken for determining surface tension T of water by capillary method:

Diameter of capillary, D = 1.25×10^{-2} m

Rise of water, h = 1.45×10^{-2} m

Using g = 9.80 m/s^2 and the simplified relation $T = \frac{rhg}{2} \times 10^3$ N/m, the possible error in surface tension is closest to:

(A) 10 % (B) 0.15 %

(C) 1.5 % (D) 2.4 %

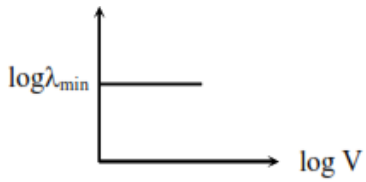
***Ans*:- (C)**

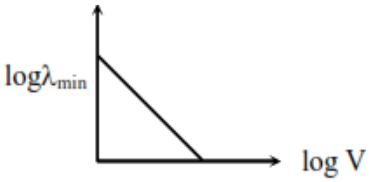
$$T = \frac{rhg}{2} \times 10^3\, N/m$$

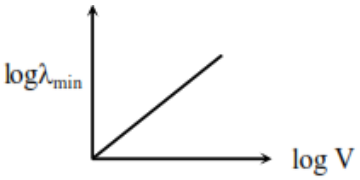
$$\frac{\Delta T}{T} = \left|\frac{\Delta r}{r}\right| + \left|\frac{\Delta h}{h}\right| = \frac{0.01}{1.25} + \frac{0.01}{1.45}$$

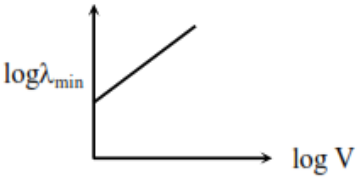
$$\%\ \text{error} = \frac{\Delta T}{T} \times 100 = \frac{1}{1.25} + \frac{1}{1.45} = 0.8 + 0.69 \simeq 1.5\%$$

***Questions*: 3:-** An electron beam is accelerated by a potential difference V to hit a metallic target to produce X –rays. It produces continuous as well as characteristic X-rays. If λ_{min} is the smallest possible wavelength of X-ray in the spectrum, the variation of log λ_{min} with log V is correctly represented in:

(A) 

(B) 

(C) 

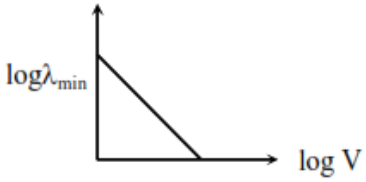
(D) 

***Ans*:- (B)**

$$\frac{hc}{\lambda_{min}} = eV$$

$$\log\frac{hc}{e} - \log\lambda_{min} = \log V$$

$$\Rightarrow \log\lambda_{min} = k - \log V$$



***Questions*: 4:-** The moment of inertia of a uniform cylinder of length ℓ and radius R about its perpendicular bisector is I. What is the ratio ℓ/R such that the moment of inertia is minimum?

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

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

***Ans*:- (B)**

$$I = \frac{m}{12}\left[3R^2 + \ell^2\right] \qquad \left(R^2 = \frac{m}{\pi\ell\rho}\right)$$

$$= \frac{m}{12}\left[\frac{3m}{\pi\rho}\ell^{-1} + \ell^2\right]$$

$$\frac{dI}{d\ell} = \frac{m}{12}\left[-\frac{3m}{\pi\rho\ell^2} + 2\ell\right]$$

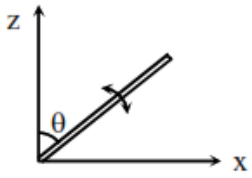
For minima

$$0 = \frac{-3m}{\pi\rho\ell^2} + 2\ell$$

$$\Rightarrow \frac{3\pi R^2\ell\rho}{\pi\rho\ell^2} = 2\ell$$

$$\Rightarrow \frac{\ell}{R} = \sqrt{\frac{3}{2}}$$

***Questions*: 5:-** A slender uniform rod of mass M and length ℓ is pivoted at one end so that it can rotate in a vertical plane (see figure). There is negligible friction at the pivot. The free end is held vertically above the pivot and then released. The angular acceleration of the rod when it makes an angle θ with the vertical is:



(A) $\frac{2g}{3\ell}\cos\theta$ (B) $\frac{3g}{2\ell}\sin\theta$

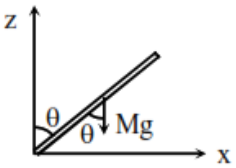
(C) $\frac{2g}{3\ell}\sin\theta$ (D) $\frac{3g}{2\ell}\cos\theta$

Ans:- **(B)**

$\tau = I\alpha$

$\Rightarrow Mg\ \frac{\ell}{2}\sin\theta = \frac{M\ell^2}{3}\alpha$

$\Rightarrow\ \alpha = \frac{3}{2}\frac{g}{\ell}\sin\theta$



***Questions*: 6:-** C_P and C_v are specific heats at constant pressure and constant volume respectively. It is observed that

$C_P - C_v$ = a for hydrogen gas

$C_P - C_v$ = b for nitrogen gas.

The correct relation between a and b is

(A) a = 28 b (B) $a = \frac{1}{14}b$

(C) a = b (D) a = 14 b

Ans:- **(D)** For ideal gas

$C_P - C_v = R/M$

If C_P and C_v are specific heats (J/kg –^{0}C)

M = molar mass of gas

$\Rightarrow$ a = R/2 and b = R/28

$\Rightarrow$ a = 14b

***Questions*: 7:-** A copper ball of mass 100 gm is at a temperature T. It is dropped in a copper calorimeter of mass 100 gm, filled with 170 gm of water at room temperature. Subsequently, the temperature of the system is found to be 75^{0}C. T is given by: (Given: room temperature = 30^{0}C, specific heat of copper = 0.1 cal/gm^{0}C)

(A) 825^{0}C (B) 800^{0}C

(C) 885^{0}C (D) 1250^{0}C

Ans:- **(C)** Final temperature of calorimeter and its contents is given, T^0 = 75^{0}C

$\Rightarrow 100 \times 0.1 \times (75 - T) + 100 \times 0.1\ (75 - 30) + 170 \times 1 \times (75 - 30) = 0$

$\Rightarrow 75 - T + 45 + 765 = 0$

$\Rightarrow$ T = 885^{0}C

***Questions*: 8:-** In amplitude modulation, sinusoidal carrier frequency used is denoted by ω_c and the signal frequency is denoted by ω_m. The bandwidth ($\Delta\omega_m$) of the signal is such that $\Delta\omega_m << \omega_c$. Which of the following frequencies is **not** contained in the modulated wave?

(A) $\omega_c - \omega_m$ (B) ω_m

(C) ω_c (D) $\omega_m + \omega_c$

***Ans*:- (B)**

Modulated signal can be written as

$C_m(t) = (A_c + A_m \sin \omega_m t) \sin \omega_c t$

$$\Rightarrow C_m(t) = A_c \sin\omega_c t + \frac{\mu A_c}{2}\cos(\omega_c - \omega_m)t - \frac{\mu A_c}{2}\cos(\omega_c + \omega_m)t$$

where $\mu = \frac{A_m}{A_c}$

***Questions*: 9:-** The temperature of an open room of volume 30 m^3 increases from 17^0C to 27^0C due to the sunshine. The atmospheric pressure in the room remains 1×10^5 Pa. If n_i and n_f are the number of molecules in the room before and after heating, then $n_f - n_i$ will be:

(A) -2.5×10^{25} (B) -1.61×10^{23}

(C) 1.38×10^{23} (D) 2.5×10^{25}

***Ans*:- (A)**

Using, $n = \left(\frac{PV}{RT}\right)$

$$n_f - n_i = \frac{PV}{R}\left(\frac{1}{T_f} - \frac{1}{T_i}\right) \text{moles}$$

$$= \frac{1\times10^5 \times 30}{8.32}\left(\frac{1}{300} - \frac{1}{290}\right) \times 6.023\times10^{23} \text{ molecules}$$

$$= -2.5 \times 10^{25} \text{ molecules}$$

***Questions*: 10:-** In a Young's double slit experiment, slits are separated by 0.5 mm, and the screen is placed 150 cm away. A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes on the screen. The least distance from the common central maximum to the point where the bright fringes due to both the wavelengths coincide is

(A) 15.6 mm (B) 1.56 mm

(C) 7.8 mm (D) 9.75 mm

***Ans*:- (C)**

$$y = \frac{m\times650\times10^{-9}\times D}{d} = \frac{n\times520\times10^{-9}\times D}{d}$$

$$\Rightarrow \frac{m}{n} = \frac{4}{5} \Rightarrow \text{minimum values of m and n will be 4 and 5 respectively.}$$

$$y = \frac{4\times650\times10^{-9}\times1.5}{5\times10^{-4}} \text{ meter}$$

$$= 7.8 \text{ mm}$$

***Questions*: 11:-** A particle A of mass m and initial velocity v collides with a particle B of mass $\frac{m}{2}$ which is at rest. The collision is head on, and elastic. The ratio of the de-Broglie wavelengths λ_A to λ_B after the collision is:

(A) $\frac{\lambda_A}{\lambda_B} = \frac{1}{2}$ (B) $\frac{\lambda_A}{\lambda_B} = \frac{1}{3}$

(C) $\frac{\lambda_A}{\lambda_B} = 2$ (D) $\frac{\lambda_A}{\lambda_B} = \frac{2}{3}$

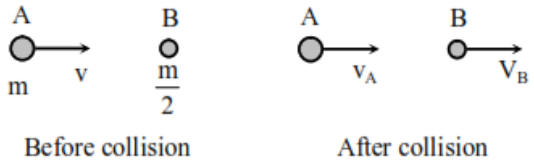
***Ans*:- (C)**

$mv = mv_A + \frac{m}{2}v_B$ (conservation of linear momentum)

$\therefore\ v = v_A + \frac{v_B}{2} = v_B - v_A$ (elastic collision)

$\therefore\ \frac{v_B}{v_A} = 4$

$\therefore\ \frac{\lambda_A}{\lambda_B} = \frac{m_B v_B}{m_A v_A} = 2$



Before collision After collision

***Questions*: 12:-** A magnetic needle of magnetic moment 6.7×10^{-2} Am^2 and moment of inertia 7.5×10^{-6} kg m^2 is performing simple harmonic oscillations in a magnetic field of 0.01 T. Time taken for 10 complete oscillations is:

(A) 8.76 s (B) 6.65 s

(C) 8.89 s (D) 6.98 s

***Ans*:- (B)**

$T = 2\pi\sqrt{\frac{I}{MB}}$

$= 2\pi\sqrt{\frac{7.5\times10^{-6}}{6.7\times10^{-2}\times0.01}} = 0.665$ sec

So, time of 10 oscillations = 6.65 sec

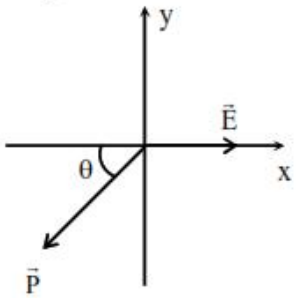
***Questions*: 13:-** An electric dipole has a fixed dipole moment $\vec{p}$, which makes angle θ with respect to x-axis. When subjected to an electric field $\vec{E}_1 = E\hat{i}$, it experiences a torque $\vec{T}_1 = \tau\hat{k}$. When subjected to another electric field $\vec{E}_2 = \sqrt{3}E_1\hat{j}$ it experiences a torque $\vec{T}_2 = -\vec{T}_1$. The angle θ is:

(A) 90^0 (B) 30^0

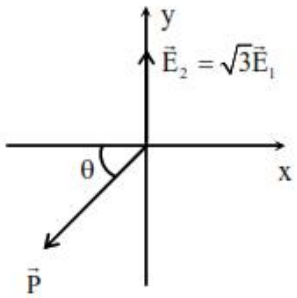
(C) 45^0 (D) 60^0

***Ans*:- (D)**

From the given information



Case - I

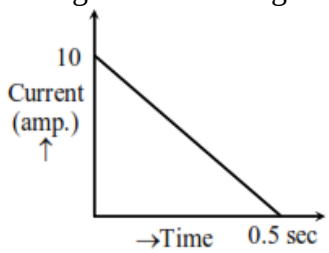


Case - II

$\therefore\ PE_1 \sin\theta = \sqrt{3}PE_1 \sin\left(\frac{\pi}{2} + \theta\right)$

$\therefore\ \theta = 60°$

***Questions*: 14:-** In a coil of resistance 100 Ω, a current is induced by changing the magnetic flux through it as shown in the figure. The magnitude of change in flux through the coil is:



(A) 275 Wb (B) 200 Wb
(C) 225 Wb (D) 250 Wb

***Ans*:- (D)** Change in flux = $R\int idt = 250$ Wb

***Questions*: 15:-** A time dependent force F = 6t acts on a particle of mass 1 kg. If the particle starts from rest, the work done by the force during the first 1 sec. will be:

(A) 18 J (B) 4.5 J
(C) 22 J (D) 9 J

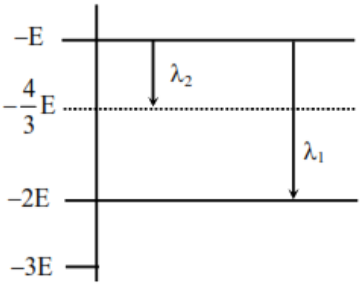
***Ans*:- (B)** From impulse momentum theorem

$$\int_0^1 6t\,dt = mv$$

$\therefore v = 3$ m/s

So, work done by the force = $\Delta K.E. = \frac{1}{2}(1)(3)^2 = 4.5J$

***Questions*: 16:-** Some energy levels of a molecule are shown in the figure. The ratio of the wavelengths $r = \lambda_1/\lambda_2$, is given by:



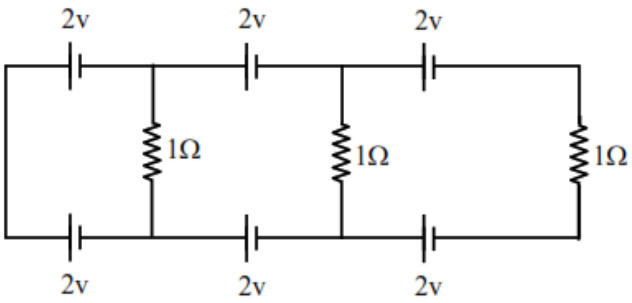
(A) $r = \frac{1}{3}$ (B) $r = \frac{4}{3}$
(C) $r = \frac{2}{3}$ (D) $r = \frac{3}{4}$

***Ans*:- (A)**

$$\Delta E \propto \frac{1}{\lambda}$$

$$\Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{\Delta E_2}{\Delta E_1} = \frac{1}{3}$$

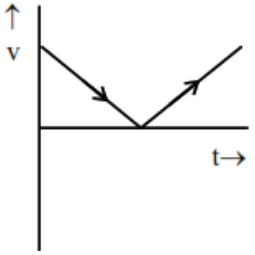
***Questions*: 17:-** In the given circuit, the current in each resistance is:

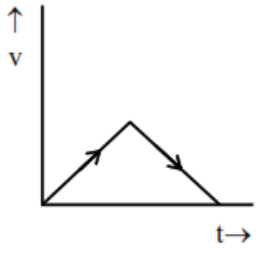


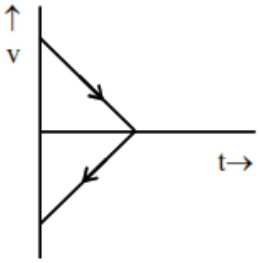
(A) 0 A (B) 1 A
(C) 0.25 A (D) 0.5 A

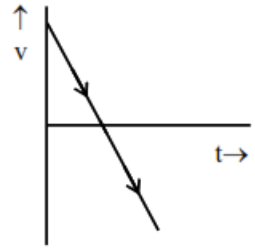
Ans:- **(A)** Potential difference across each resistor is zero.

***Questions*: 18:-** A body is thrown vertically upwards. Which one of the following graphs correctly represent the velocity vs time?

(A)


(B)


(C)


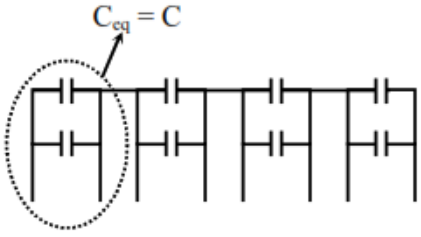
(D)


Ans:- **(D)** v = u – gt

***Questions*: 19:-** A capacitance of 2 μF is required in an electrical circuit across a potential difference of 1.0 kV. A large number of 1 μF capacitors are available which can withstand a potential difference of not more than 300 V. The minimum number of capacitors required to achieve this is:

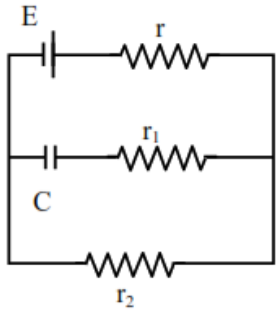
(A) 32 (B) 2
(C) 16 (D) 24

Ans:- **(A)** $\frac{C}{4} = 2 \Rightarrow C = 8\ \mu F$



Which requires eight 1 μF capacitors in parallel.
⇒ Minimum number of capacitors required is 32.

***Questions*: 20:-** In the given circuit diagram when the current reaches steady state in the circuit, the charge on the capacitor of capacitance C will be:



(A) $CE = \frac{r_1}{(r_1+r)}$ (B) CE

(C) $CE = \frac{r_1}{(r_2+r)}$ (D) $CE = \frac{r_2}{(r+r_2)}$

***Ans*:- (D)** q = CV

$= \frac{CEr_2}{r+r_2}$