JEE(ADVANCED)-2013 PAPER 2

PHYSICS

1. **Sol:** (B)

$$\frac{2GMm}{L}+\frac{1}{2}mv^2=0$$

$$\Rightarrow v=2\sqrt{\frac{GM}{L}}$$

Note: *The energy of mass 'in' means its kinetic energy (KE) only and not the potential energy of interaction between m and the two bodies (of mass M each) - which is the potential energy of the system.*

2. **Sol:** (A, D)

$v=u_0\sin\omega t_1$ (suppose t_1 is the time of collision) $\frac{u_0}{2}=u_0\cos\omega t_1\Rightarrow t_1=\frac{\pi}{3\omega}$

Now the particle returns to equilibrium position at time $t_2=2t_1$ i.e. $\frac{2\pi}{3\omega}$ with the same mechanical energy

i.e. its speed will u_0

Let t_3 is the time at which the particle passes through the equilibrium position for the second time.

$$\therefore t_3=\frac{t}{2}+2t_1$$

$$=\frac{\pi}{\omega}+\frac{2\pi}{3\omega}=\frac{5\pi}{3\omega}$$

$$=\frac{5\pi}{3}\sqrt{\frac{m}{k}}$$

Energy of particle and spring remains conserved.

3. **Sol:** (A, D)

Due to field of solenoid is non-zero in region $0<r<R$ and non-zero in region $r>2R$ due to conductor.

4. **Sol:** (A, B)

If wind blows from source to observer

$$f_2=f_1\left(\frac{V+w+u}{V+w-u}\right)$$

When wind blows from observer towards source

$$f_2=f_1\left(\frac{V-w+u}{V-w-u}\right)$$

In both cases, $f_2>f_1$

5. **Sol:** (D)

$$d=\frac{\lambda}{2\sin\theta}$$

$$\ln d=\ln\left(\frac{\lambda}{n}\right)-\ln\ \sin\theta$$

$$\frac{\Delta d}{d}=0\frac{\cos\theta d\theta}{\sin\theta}$$

$$\left(\frac{\Delta d}{d}\right)_{\max}=\pm\cot\theta\Delta\theta$$

Also $(\Delta d)_{\max}=\text{d}\cot\theta\Delta\theta$

$$\frac{\lambda}{2\sin\theta}\cot\theta\Delta\theta$$

$$=\frac{\lambda\cos\theta}{2\sin^2\theta}\Delta\theta$$

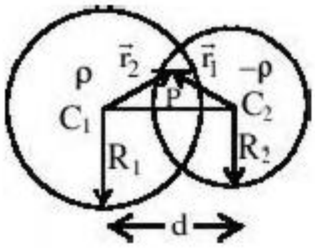
As θ increases $\cot\theta$ decreases and $\frac{\cos\theta}{\sin^2\theta}$ also decreases

6. **Sol:** (C, D)

In triangle PC_1C_2

$$\vec{r}_2=\vec{d}+\vec{r}_1$$

The electrostatic field at point P is



$$\vec{E}=\frac{K\left(\rho\frac{4}{3}\pi R_1^3\right)\vec{r}_2}{R_1^3}+\frac{K\left(\rho\frac{4}{3}\pi R_2^3\right)(-\vec{r}_1)}{R_2^3}$$

$$\vec{E}=K\rho\frac{4}{3}\pi(\vec{r}_2-\vec{r}_1)$$

$$\vec{E}=\frac{\rho}{3\varepsilon_0}\vec{d}$$

7. **Sol: .** (A, B, C, D)

Option (A) is correct because the graph between $(0\text{ -}100\,\text{K})$ appears to be a straight line up to a reasonable approximation.

Option (B) is correct because area under the curve in the temperature range $(0\text{ -}100\,\text{K})$ is less than in range $(400\text{ -}500\,\text{K})$

Option (C) is correct because the graph of C versus T is constant in the temperature range $(400\text{ -}500\,\text{K})$

Option (D) is correct because in the temperature range $(200\text{ -}300\,\mathrm{K})$ specific heat capacity increases with temperature.

8. **Sol**: (A, C)

Given Data

$$4.5a_0 = a_0\frac{n^2}{Z} \quad \ldots(i)$$

$$\frac{nh}{2\pi}\ \frac{3h}{2\pi} \quad \ldots(ii)$$

So $n = 3 \text{and}\, z = 3$

So possible wavelength are

$$\frac{1}{\lambda_1} = RZ^2\left[\frac{1}{1^2} - \frac{1}{3^2}\right] \Rightarrow \lambda_1 = \frac{9}{32R}$$

$$\frac{1}{\lambda_2} = RZ^2\left[\frac{1}{1^2} - \frac{1}{3^2}\right] \Rightarrow \lambda_2 = \frac{1}{3R}$$

$$\frac{1}{\lambda_3} = RZ^2\left[\frac{1}{1^2} - \frac{1}{3^2}\right] \Rightarrow \lambda_3 = \frac{9}{5R}$$

9. **Sol**: (B)

Using work energy theorem

$$mg\,R\sin 30^\circ + w_f = \frac{1}{2}mv^2$$

$$200 - 150 = \frac{v^2}{2}$$

$$v = 10\,m/s$$

10. **Sol**: (A)

$$N - mg\ \cos 60^\circ = \frac{mv^2}{R}$$

$$N = 5 + \frac{5}{2} = 7.5\,Newton.$$

11. **Sol**: (B)

For direct transmission

$$P = i^2R = (150)^2\,(0.4\times 20) = 1.8\times 10^5\,w$$

$$fraction\,(in\,\%) = \frac{1.8\times 10^5}{6\times 10^3}\times 100 = 30\%$$

12. **Sol**: (A)

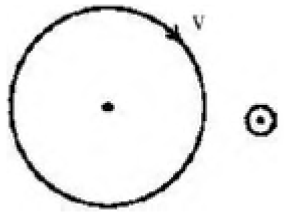
$$\frac{40000}{200} = 200$$

13. **Sol:** (B)

$$E(2\pi R) = \pi R^2 \frac{dB}{dt}$$

$$E = \frac{RB}{2}$$

14. **Sol:** (B)



$$\Delta L = \int \tau dt$$

$$= Q\left(\frac{R}{2}B\right)R(1)$$

$$= \frac{QR^2B}{2}, \text{ in magnitude}$$

$$\Delta\mu = \gamma\Delta L$$

$$= \gamma\frac{BQR^2}{2}\ (\text{taking into account the direction})$$

15. **Sol:** (C)

$${}^{6}_{3}Li \rightarrow {}^{4}_{2}He + {}^{2}_{1}H$$

$$\frac{Q}{C^2} = 6.015123 - 4.002603 - 2.014102$$

$$0 = -0.001582 < 0$$

So no α-decay is possible

$${}^{210}_{84}P_0 \rightarrow {}^{1}_{1}H + {}^{209}_{83}Bi$$

$$\frac{Q}{C^2} = 209.9828766 - 1.007825 - 208.980388 = -0.005337 < 0$$

So, this reaction is not possible

$${}^{2}_{1}H \rightarrow {}^{4}_{2}He + {}^{6}_{3}Li$$

$$\frac{Q}{C^2} = 2.014102 + 4.002603 - 6.015123 = -0.001582 > 0$$

So, this reaction is possible

$${}^{70}_{30}Zn \rightarrow {}^{82}_{34}Se + {}^{152}_{64}Gd$$

$$\frac{Q}{C^2} = 69.925325 + 81.916709 - 151.919803 = -0.077769 < 0$$

So, this reaction is not possible

16. **Sol:** (C)

$^{210}_{84}Po \to {}^{4}_{2}H + {}^{206}_{82}Pb$

$Q = (209.982876 - 4.002603 - 205.97455)C^2$

$= 5.422\, MeV$

form conservation of momentum

$\sqrt{2K_1(4)} = \sqrt{2K_2(206)}$

$4K_1 = 206K_2$

$\therefore K_1 = \frac{103}{2}K_2$

$K_1 + K_2 = 5.422$

$\Rightarrow \frac{105}{103}K_1 = 5.422$

$\therefore K_1 = 5.319\, MeV = 5319\, MeV$

17. **Sol:** (D)

$P. \to (2); Q. \to (3); R. \to (4); S. \to (1)$

$P.\quad \mu_2 > \mu_1 ....$ $(towards\ normal)$

$\mu_2 > \mu_3 ....$ $(away\ from\ normal)$

$Q.\quad \mu_1 = \mu_2 ....$ $(No\ change\ in\ path)$

$\angle i = 0 \Rightarrow \angle r = 0\ on\ the\ block.$

$R.\quad \mu_1 > \mu_2 ....$ $(Away\ from\ normal)$

$\mu_2 > \mu_3 ....$ $(Away\ from\ normal)$

$\mu_1 \times \frac{1}{\sqrt{2}} = \mu_2 \sin r \Rightarrow \sin r = \frac{\mu_1}{\sqrt{2}\mu_2}$ Since $\sin r < 1 \Rightarrow \mu_1 < \sqrt{2}\mu_2$

$S.\quad For\ TIR: 45° > \sin C \Rightarrow 45° > \sin C \Rightarrow \frac{1}{\sqrt{2}} > \frac{\mu_2}{\mu_1} \Rightarrow \mu_1 > \sqrt{2\mu_2}$

18. **Sol:** (C)

$P. \to (4); Q. \to (2); R. \to (1); S. \to (3)$

$P.\quad KE = \frac{3}{2}KT \Rightarrow [ML^2T^{-2}] = K'[K] \Rightarrow K' = [ML^2T^{-2}K^{-1}]$

$Q.\quad F = 6\pi\eta rv \Rightarrow [ML^2T^{-2}] = \eta[L][LT^{-1}] \Rightarrow \eta = [ML^{-1}T^{-1}]$

$R.\quad E = hf \Rightarrow [MLT^2T^2] = \frac{h}{[T]} \Rightarrow h = [ML^2T^{-1}]$

$S.\quad \frac{dQ}{dt} = \frac{K'A(\Delta T)}{\Delta x} \Rightarrow \frac{[ML^2T^{-2}]}{[T]} = \left[\frac{k[L^2][K']}{[L]}\right]$

$K' = [MLT^{-3}K^{-1}]$

19. (A)

$P.\to(4);Q.\to(3);R.\to(2);S.\to(1)$

Apply $PV^{1+2/3}=constant\ for\ F\ to\ H$.

$(32P_0)V_0^{5/3}=P_0V_H^{5/3}\Rightarrow V_H=8V_0$

For path FG $PV=constant$

$\Rightarrow(32P_0)V_0=P_0V_G\Rightarrow V_G=32V_0$

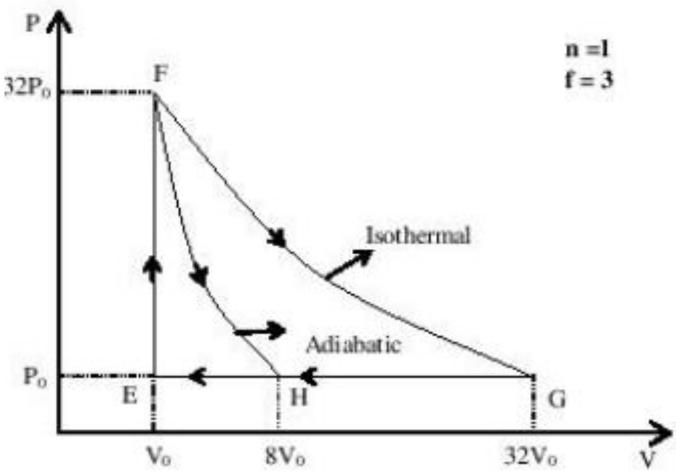
$Work\ done\ in\ GE\ =31P_0V_0$

$Work\ done\ in\ GH\ =24P_0V_0$

$Work\ done\ in\ FH\ =\dfrac{P_HV_H-P_FV_F}{(-2/f)}=36P_0V_0$

$Work\ done\ in\ FG\ =RT\ In\left(\dfrac{V_G}{V_F}\right)$

$=160P_0V_0In2.$



20. (C)

$P.\to(2);Q.\to(1);R.\to(4);S.\to(3)$

$^{15}_{8}O\to^{15}_{7}N+^{0}_{1}\beta$ (Beta decay)

$^{238}_{92}U\to^{234}_{90}Th+^{4}_{2}He$ (Alpha decay)

$^{185}_{83}Bi\to^{184}_{82}Pb+^{1}_{1}H$ (Proton emisson)

$^{239}_{94}Ph\to^{140}_{57}La+^{99}_{37}Rb$ (fission)