PART : PHYSICS

Single Choice Type (एकल विकल्पीय प्रकार)

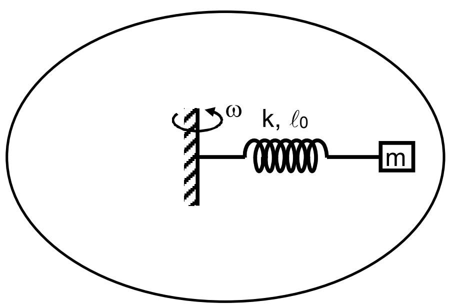
This section contains **20 Single choice questions.** Each question has 4 choices (1), (2), (3) and (4) for its answer, out of which **Only One** is correct.

1. A mass m attached to spring of natural length ℓ_0 and spring constant k. One end of string is attached to centre of disc in horizontal plane which is being rotated by constant angular speed ω. Find extension per unit length in spring (given k >> $m\omega^2$) :

(1) $\frac{m\omega^2}{k}$ (2) $\frac{\sqrt{2}}{3}\frac{m\omega^2}{k}$ (3) $\frac{m\omega^2}{2k}$ (4) $\frac{3m\omega^2}{k}$

Ans. **(1)**

Sol.



$m\omega^2(\ell_0 + x) = kx$

$\left(\frac{\ell_0}{x}+1\right)=\frac{k}{m\omega^2}$

$x = \frac{\ell_0 m\omega^2}{k - m\omega^2}$

$k >> m\omega^2$

So, $\frac{x}{\ell_0}$ is equal to $\frac{m\omega^2}{k}$.

$\frac{x}{\ell_0}, \frac{m\omega^2}{k}$

2. A loop of radius R and mass m is placed in a uniform magnetic field B with its plane perpendicular to the field. Current I is flowing in it. Now loop is slightly rotated about its diameter and released. Find time period of oscillation.

(1) $2\sqrt{\frac{\pi m}{IB}}$ (2) $\sqrt{\frac{2\pi m}{IB}}$ (3) $2\sqrt{\frac{m}{\pi IB}}$ (4) $\sqrt{\frac{m}{\pi IB}}$

Ans. **(2)**

Sol. $\tau = MB\sin\theta = I\alpha$

$\pi R^2 I B\theta = \frac{mR^2}{2}\alpha$

$\omega = \sqrt{\frac{2\pi IB}{m}} = \frac{2\pi}{T}$

$T = \sqrt{\frac{2\pi m}{IB}}$

3. A string of mass per unit length $\mu = 6 \times 10^{-3}$ kg/m is fixed at both ends under the tension 540 N. If the string is in resonance with consecutive frequencies 420 Hz and 490 Hz. Then find the length of the string?

(1) 2.1 m (2) 1.1 m (3) 4.8 m (4) 4.2 m

Ans. **(1)**

Sol. Fundamental frequency मूल आवृत्ति = 490 – 420 = 70 Hz

$70 = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}}$

$\Rightarrow 70 = \frac{1}{2\ell}\sqrt{\frac{540}{6\times10^{-3}}}$

$\Rightarrow \ell = \frac{1}{2\times70}\sqrt{90\times10^{3}} = \frac{300}{140}$

$\Rightarrow \ell \approx 2.14$ m

4. Ratio of energy density of two steel rods is 1 : 4 when same mass is suspended from the rods. If length of both rods is same then ratio of diameter of rods will be.

(1) $\sqrt{2}:1$ (2) $1:\sqrt{2}$ (3) 1 : 2 (4) 2 : 1

Ans. **(1)**

Sol. $\frac{du}{dv} = \frac{1}{2}$ stress $\times \frac{stress}{y}$

$= \frac{1}{2}\frac{F^2}{A^2 y}$

$\frac{du}{dv} \propto \frac{1}{d^4}$

$\frac{\left(\frac{du}{dv}\right)_1}{\left(\frac{du}{dv}\right)_2} = \frac{d_2^4}{d_1^4} = \frac{1}{4}$

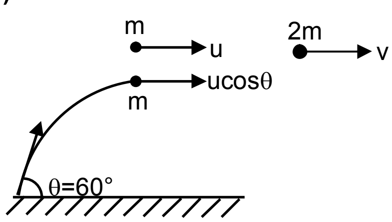
$\frac{d_1}{d_2} = (4)^{1/4}$

$\frac{d_1}{d_2} = \sqrt{2} : 1$

5. A particle is projected from the ground with speed u at angle 60° from horizontal. It collides with a second particle of same mass moving with horizontal speed u in same direction at highest point of its trajectory. If collision is perfectly inelastic then find horizontal distance travelled by them after collision when they reached at ground

(1) $\frac{3\sqrt{6}u^2}{8g}$ (2) $\frac{3\sqrt{3}u^2}{8g}$ (3) $\frac{u^2}{8g}$ (4) $\frac{\sqrt{3}u^2}{g}$

Ans. **(2)**



Sol.

$p_i = p_f$

$mu + mu\cos\theta = 2mv$

$\Rightarrow v = \frac{u(1+\cos 60°)}{2} = \frac{3}{4}u$

so horizontal range after collision

$$= v\sqrt{\frac{2H_{max}}{g}}$$

$$= \frac{3}{4}u\sqrt{\frac{2u^2\sin^2(60°)}{2g^2}}$$

$$= \frac{3}{4}u^2\frac{\sqrt{\frac{3}{4}}}{g} = \frac{3\sqrt{3}u^2}{8g}$$

6. H-like atom with ionization energy of 9R. Find the wavelength of light emitted (in nm) when electron jumps from second excited state to ground state. (R is Rydberg constant)

(1) 11.39 (2) 12.86 (3) 8.02 (4) 2.19

Ans. **(1)**

Sol. $\frac{hc}{\lambda} = (13.6eV)z^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$n_1 = 1$

$n_2 = 3$

$\frac{hc}{\lambda} = (13.6eV)(3^2)\left[\frac{1}{1^2} - \frac{1}{3^2}\right]$

$\Rightarrow \frac{hc}{\lambda} = (13.6eV)(9)\left(\frac{8}{9}\right)$

wavelength $= \frac{1240}{8 \times 13.6}$nm

λ = 11.39nm

7. Two planets of masses M and $\frac{M}{2}$ have radii R and $\frac{R}{2}$ respectively. If ratio of escape velocities from their surfaces $\frac{v_1}{v_2}$ is $\frac{n}{4}$, then find n :

v_2 4

(1) 3 (2) 1 (3) 2 (4) 4

Ans. **(4)**

Sol. $v_e = \sqrt{\frac{2GM}{R}}$

$\therefore \quad \frac{v_1}{v_2} = \frac{\sqrt{\frac{2GM}{R}}}{\sqrt{\frac{2GM/2}{R/2}}} = 1 = \frac{n}{4}$

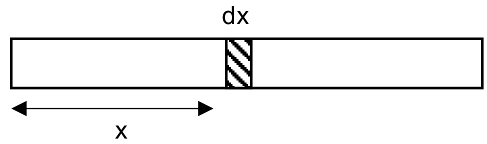
$\Rightarrow \quad n = 4$

8. Find centre of mass of given rod of linear mass density $\lambda = \left(a + b\left(\frac{x}{\ell}\right)^2\right)$, x is distance from one of its end. Length of the rod is ℓ.

(1) $\frac{3\ell}{4}\left(\frac{3a+b}{2a+b}\right)$ (2) $\frac{3\ell}{4}\left(\frac{2a+b}{3a+b}\right)$ (3) $\frac{\ell}{4}\left(\frac{2a+b}{3a+b}\right)$ (4) $\ell\left(\frac{2a+b}{3a+b}\right)$

Ans. **(2)**

Sol.



$$x_{cm} = \frac{1}{M}\int_0^{\ell} x.dM$$

$$dM = \lambda .dx = \left(a + b\left(\frac{x}{\ell}\right)^2\right) . dx$$

$$x_{cm} = \frac{\int xdM}{\int dM} = \frac{\int x\lambda dx}{\int \lambda dx} = \frac{\int_0^{\ell} x\left(a + \frac{bx^2}{\ell^2}\right)dx}{\int_0^{\ell}\left(a + \frac{bx^2}{\ell^2}\right)dx}$$

$$= \frac{a\left(\frac{x^2}{2}\right)_0^{\ell} + \frac{b}{\ell^2}\left(\frac{x^4}{4}\right)_0^{\ell}}{a(x)_0^{\ell} + \frac{b}{\ell^2}\left(\frac{x^3}{3}\right)_0^{\ell}}$$

$$= \frac{a\frac{\ell^2}{2} + b\frac{\ell^2}{4}}{a\ell + \frac{b\ell}{3}} = \frac{(2a+b)}{(3a+b)}\frac{\ell}{4}\times 3$$

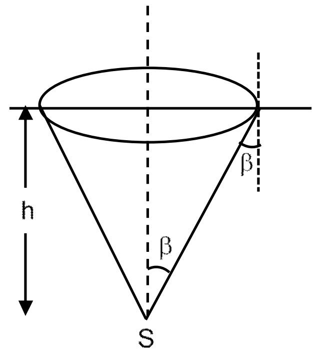
$$= \frac{3\ell}{4}\left(\frac{2a+b}{3a+b}\right)$$

9. If a point source is placed at a depth h in a liquid of refractive index $\frac{4}{3}$. Find percentage of energy of light that escapes from liquid. (assuming 100% transmission of emerging light)

(1) 15% (2) 17% (3) 21 % (4) 34%

Ans. **(2)**

Sol.



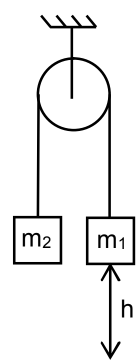
$\sin\beta = \frac{3}{4}$, $\cos\beta = \frac{\sqrt{7}}{4}$

Solid angle ठोस कोण $d\Omega = 2\pi R^2 (1 - \cos\beta)$

Percentage of light प्रकाश का प्रतिशत = $\frac{2\pi R^2(1-\cos\beta)}{4\pi R^2} \times 100$

$= \frac{1-\cos\beta}{2} \times 100 = \left(\frac{4-\sqrt{7}}{8}\right) \times 100 \approx 17\%$

10. System is released from rest. Moment of inertia of pulley 'I'. Find angular speed of pulley when m_1 block falls by 'h'. (Given $m_1 > m_2$ and assume no slipping between string and pulley).



(1) $\frac{1}{R}\sqrt{\frac{2(m_2 - m_1)gh}{\left(m_1 + m_2 + \frac{I}{R^2}\right)}}$

(2) $\frac{1}{R}\sqrt{\frac{2(m_2 + m_1)gh}{\left(m_1 + m_2 + \frac{I}{R^2}\right)}}$

(3) $\frac{1}{R}\sqrt{\frac{(m_2 - m_1)gh}{\left(m_1 + m_2 + \frac{I}{R^2}\right)}}$

(4) $\frac{1}{R}\sqrt{\frac{(m_2 + m_1)gh}{\left(m_1 + m_2 + \frac{I}{R^2}\right)}}$

Ans. **(1)**

Sol. $k_i + U_i = k_1 + k_2$

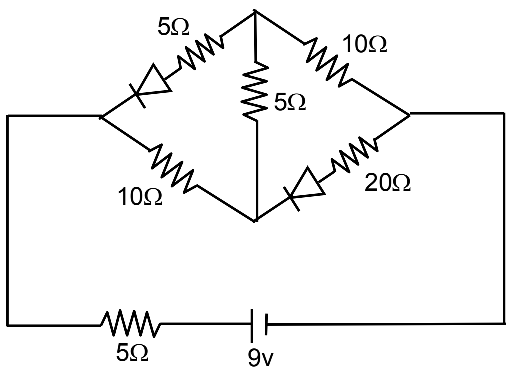
$$0 + 0 = \frac{1}{2}m_2v^2 + \frac{1}{2}m_1v^2 + \frac{1}{2}I\omega^2 - m_2gh + m_1gh$$

$$(m_2 - m_1)gh = \frac{1}{2}m_2(\omega R)^2 + \frac{1}{2}m_1\left(\omega R^2\right) + \frac{1}{2}I\omega^2$$

$$\sqrt{\frac{2(m_2 - m_1)gh}{\left(m_1 + m_2 + \frac{I}{R^2}\right)R^2}} = \omega$$

$$\frac{1}{R}\sqrt{\frac{2(m_2 - m_1)gh}{\left(m_1 + m_2 + \frac{I}{R^2}\right)}}$$

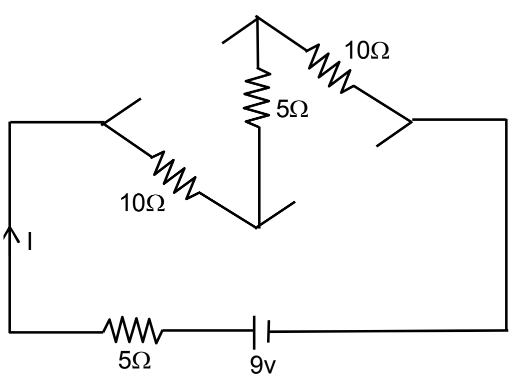
11. Find the current supplied by the battery?



(1) 0.1 A (2) 0.3 A (3) 0.4 A (4) 0.5 A

Ans. **(2)**

Sol. Both diodes are in reverse biased



$$I = \frac{9}{30} = \frac{3}{10}A = 0.3A$$

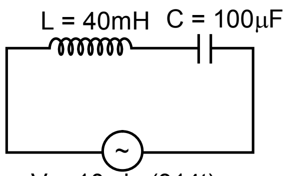
12. An AC source is connected to the LC series circuit with V = 10 sin (314t). Find the current in the circuit

? (L = 40 mH, C = 100 μF)

(1) 10 sin (314t) (2) 5.2 sin (314t) (3) 0.52 sin (314t) (4) 0.52 cos (314t)

Ans. **(4)**

Sol.



V = 10 sin (314t)

$z = \sqrt{R^2 + (X_C - X_L)^2}$

R = 0

$Z = X_C - X_L$

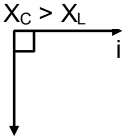
$= \frac{1}{\omega C} - \omega L$

$= \frac{1}{314 \times 100 \times 10^{-6}} - 314 \times 40 \times 10^{-3}$

= 31.84 – 12.56

= 19.28 Ω

$X_C > X_L$



$V_C - V_L$

$i = \frac{V_0}{Z} \sin\left(314t + \frac{\pi}{2}\right)$

$\therefore$ $i = \frac{V_0}{Z} \cos(314t)$ $\Rightarrow$ $i = \frac{10}{19.28} \cos(314t)$ $\Rightarrow$ i = 0.52 cos (314t)

13. There is a long solenoid of radius 'R' having 'n' turns per unit length with current i flowing in it. A particle having charge 'q' and mass 'm' is projected with speed 'v' in the perpendicular direction of axis from a Point on its axis Find maximum value of 'v' so that it will not collide with the solenoid.

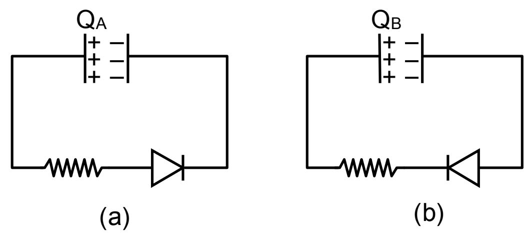
(1) $\frac{Rq\mu_0 in}{2m}$ (2) $\frac{2Rq\mu_0 in}{m}$ (3) $\frac{Rq\mu_0 in}{3m}$ (4) $\frac{Rq\mu_0 in}{4m}$

Ans. **(1)**

Sol. $R_{max} = \frac{R}{2} = \frac{mv_{max}}{q\mu_0 in}$

$V_{max} = \frac{Rq\mu_0 in}{2m}$

14. A Capacitor C and resister R are connected to a battery of 5V in series. Now battery is disconnected and a diode is connected as shown in figure (a) and (b) respectively. Then charge on the capacitor after time RC in (a) and (b) respectively is Q_A and Q_B. Their value are



(1) 5CV, 5CV (2) $\frac{5CV}{e}, \frac{5CV}{e}$ (3) $\frac{5CV}{e}$, 5CV (4) 5CV, $\frac{5CV}{e}$

Ans. **(3)**

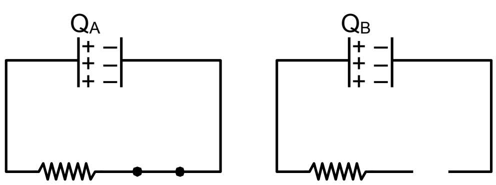
Sol. Maximum charge on capacitor = 5CV

(a) is forward biased and (b) is reverse biased

for case (a)

(a) (b)

(a)



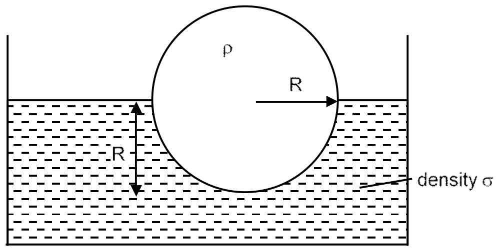
so $q = q_{max}\,[e^{-t/RC}]$ $Q_B = 5CV$
= 5 CV
$Q_A = 5CVe^{-1}$

15. A sphere of density ρ is half submerged in a liquid of density σ and surface tension T. The sphere remains in equilibrium. Find radius of the sphere (assume the force due to surface tension acts tangentially to surface of sphere)

(1) $\sqrt{\frac{T}{(\rho-\sigma)g}}$ (2) $\sqrt{\frac{T}{(\rho-2\sigma)g}}$ (3) $\sqrt{\frac{2T}{(2\rho-3\sigma)g}}$ (4) $\sqrt{\frac{3T}{(2\rho-\sigma)g}}$

Ans. **(4)**

Sol.



$$\rho V g = \sigma\left(\frac{V}{2}\right)g + T(2\pi R)$$

$$\Rightarrow \quad \rho \,.\, \frac{4}{3}\pi R^3 g = \sigma.\frac{2}{3}\pi R^3 g + 2\pi R T$$

$$\Rightarrow \quad \frac{2}{3}R^2 g(2\rho - \sigma) = 2T$$

$$\Rightarrow \quad R = \sqrt{\frac{3T}{(2\rho-\sigma)g}}$$

16. An EM wave is travelling in $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$ direction. Axis of polarization of EM wave is found to be $\hat{k}$. Then equation of magnetic field will be

(1) $\frac{\hat{i}+\hat{j}}{\sqrt{2}}\cos\left[\omega t + k\left(\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)\right]$

(2) $\frac{\hat{i}-\hat{j}}{\sqrt{2}}\cos\left[\omega t - k\left(\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)\right]$

(3) $\frac{\hat{i}-\hat{j}}{\sqrt{2}}\cos\left[\omega t + k\left(\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)\right]$

(4) $\hat{k}\cos\left[\omega t - k\left(\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)\right]$

Ans. **(2)**

Sol. EM wave is in direction $\rightarrow \frac{\hat{i}+\hat{j}}{\sqrt{2}}$

Electric field is in direction

$\vec{E}\times\vec{B} \rightarrow$ direction of propagation of EM wave

17. Different value of a, b and c are given and their sum is d. Arrange the value of d in increasing order

	a	b	c
1	220.1	20.4567	40.118
2	218.2	22.3625	40.372
3	221.2	20.2435	39.432
4	221.4	18.3625	40.281

(1) $d_1 < d_2 < d_3 < d_4$ (2) $d_1 = d_2 = d_3 = d_4$ (3) $d_4 < d_1 < d_2 = d_3$ (4) $d_4 < d_3 < d_2 < d_1$

Ans. **(3)**

Sol.

	a	b	c	a+b+c = d	Round off
1	220.1	20.4567	40.118	d_1 = 280.6747	280.7
2	218.2	22.3625	40.372	d_2 = 280.9345	280.9
3	221.2	20.2435	39.432	d_3 = 280.8755	280.9
4	221.4	18.3625	40.281	d_4 = 280.0435	280.0

18. Two gases Ar (40) and Xe (131) at same temperature have same number density. Their diameters are

(1) 1.03 (2) 2.04 (3) 3.04 (4) 2.40

Ans. **(2)**

Sol. Mean free time = $\dfrac{1}{\sqrt{2}n\pi d^2 v_{rms}}$

$$\frac{t_{Ar}}{t_{Xe}} = \frac{d_{Xe}^2}{d_{Ar}^2}$$

$$= \left(\frac{0.1}{0.07}\right)^2$$

$$= \left(\frac{10}{7}\right)^2 = 2.04$$

19. A particle starts moving from origin with velocity $\vec{u} = 3\hat{i}$ from origin and acceleration $\vec{a} = 6\hat{i} + 4\hat{j}$. Find x-coordinate at the instant when y-coordinate of the particle is 32 m.

Ans. **(2)**

Sol. $S_y = u_y t + \frac{1}{2} a_y t^2$

$32 = 0 + \frac{1}{2} \times 4t^2 \quad \Rightarrow \quad t = 4 \text{ sec}$

$S_x = u_x t + \frac{1}{2} a_x t^2$

$= 3 \times 4 + \frac{1}{2} \times 6 \times 16$

$= 60$ m.

20. An electron $(-|e|, m)$ is released in Electric field E from rest. Rate of change of de-Broglie wavelength with time will be.

(1) $-\dfrac{h}{2|e|}$ (2) $-\dfrac{h}{2|e|t}$ (3) $-\dfrac{h}{|e|Et^2}$ (4) $-\dfrac{2ht^2}{|e|E}$

Ans.

Sol. $\lambda_D = \frac{h}{mv}$

$\therefore$ v = at

$v = \frac{eE}{m}t \qquad (a = \frac{eE}{m})$

$\lambda_D = \frac{h}{m\left(\frac{eE}{m}\right)t}$

$\lambda_D = \frac{h}{eEt}$

$\frac{d\lambda_d}{dt} = -\frac{h}{|e|Et^2}$

This section contains **5 Numerical value type questions.**

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21. In YDSE pattern with light of wavelength λ_1 = 500nm, 15 fringes are obtained on a certain segment of screen. If number of fringes for light of wavelength λ_2 on same segment of screen is 10, then the value of λ_2 (in nm) is–

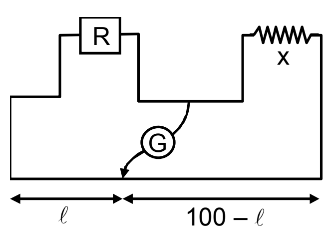
Ans. 750 nm

Sol. $15 \times 500 \times \frac{D}{d} = 10 \times \lambda_2 \times \frac{D}{d}$

$\lambda_2 = 15 \times 50$ nm

$\lambda_2 = 750$ nm

22. If in a meter bridge experiment, the balancing length ℓ was 25 cm for the situation shown in the figure. If the length and diameter of the of wire of resistance R is made half, then find the new balancing length in centimetre is



Ans. **40.00**

Sol. $\frac{X}{R} = \frac{75}{25} = 3$

$R = \frac{\rho\ell}{A} = \frac{4\rho\ell}{\pi d^2}$

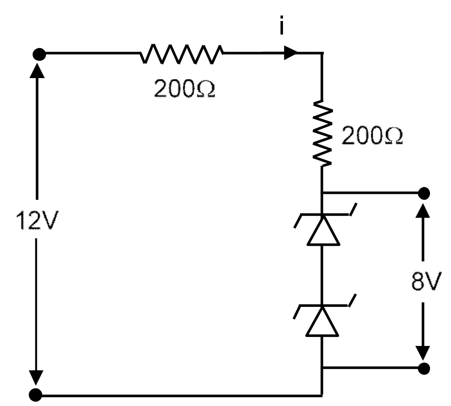
$R' = \frac{4\rho\left(\frac{\ell}{2}\right)}{\pi\left(\frac{d}{2}\right)^2} = 2R$

then $\frac{X}{R'} = \left(\frac{100-\ell}{\ell}\right)$

$\frac{100-\ell}{\ell} = \frac{X}{2R} = \frac{3}{2}$

$\ell = 40.00$ cm

23. Find the power loss in each diode (in mW), if potential drop across the zener diode is 8V.



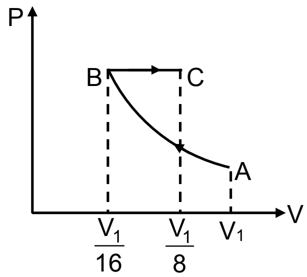
Ans. **40**

Sol. $i = \frac{(12-8)}{(200+200)}$ A $= \frac{4}{400} = 10^{-2}$ A

24. An ideal gas at initial temperature 300 K is compressed adiabatically ($\gamma = 1.4$) to $\left(\frac{1}{16}\right)^{th}$ of its initial volume. The gas is then expanded isobarically to double its volume. Then final temperature of gas round to nearest integer is:

Ans. **1819 K**

Sol.



PV^y = constant

TV^{y-1} = constant

$300\ (V_1)^{1.4-1} = T_B \left(\frac{V_1}{16}\right)^{2/5}$

$T_B = 300 \times 2^{8/5}$

Now for BC process

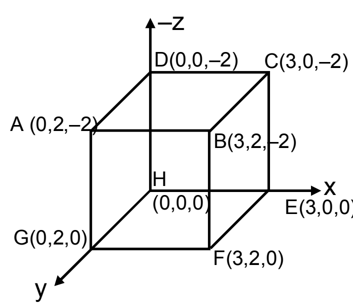
BC

$\frac{V_B}{T_B} = \frac{V_c}{T_c}$

$T_c = \frac{V_c T_B}{v_B} = 2 \times 300 \times 2^{8/5}$

$T_c = 1819$ K

25. If electric field in the space is given by $\vec{E} = 4x\hat{i} - (y^2+1)\hat{j}$, and electric flux through ABCD is ϕ_1 and electric flux through BCEF is ϕ_2, then find $(\phi_1 - \phi_2)$



Ans. **–48**

Sol. Flux via ABCD

$\phi_1 = \int \vec{E}.d\vec{A} = 0$

Flux via BCEF

$\phi_2 = \int \vec{E}.d\vec{A}$

$\phi_2 = \vec{E}.\vec{A}$ = $(4x\hat{i} - (y^2+1)\hat{j}) \cdot 4\hat{i}$ = 16x, x = 3

$\phi_2 = 48\frac{N-m^2}{C}$; $\phi_1 - \phi_2 = -48\frac{N-m^2}{C}$