Single Choice Type

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.

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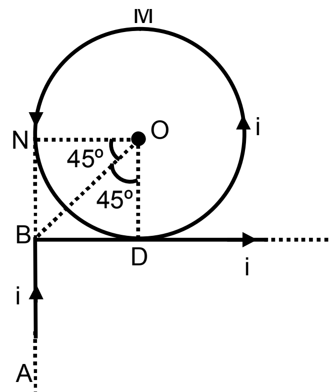
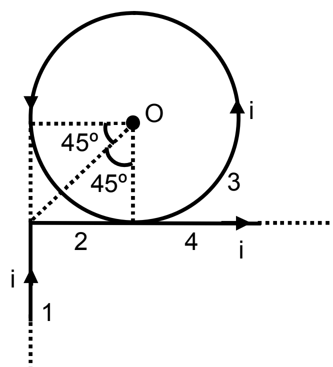
1. Find magnetic field at O.



(1) $\frac{\mu_0 i}{2\pi R}\left[\frac{-1}{\sqrt{2}}+\pi\right]$ (2) $\frac{\mu_0 i}{2\pi R}[\pi-1]$ (3) $\frac{\mu_0 i}{2R}$ (4) $\frac{\mu_0 i}{2\pi R}\left[\frac{1}{\sqrt{2}}+\pi\right]$

Ans. **(4)**

Sol.



$$\vec{B}_0 = \left(\vec{B}_0\right)_1 + \left(\vec{B}_0\right)_2 + \left(\vec{B}_0\right)_3 + \left(\vec{B}_0\right)_4$$

$$\frac{\mu_0 i}{4\pi R}[\sin 90^\circ - \sin 45^\circ]\otimes + \frac{\mu_0 i}{2R}\odot + \frac{\mu_0 i}{4\pi R}(\sin 45^\circ + \sin 90^\circ)\odot$$

$$= \frac{-\mu_0 i}{4\pi R}\left[1-\frac{1}{\sqrt{2}}\right] + \frac{\mu_0 i}{2R} + \frac{\mu_0 i}{4\pi R}\left[\frac{1}{\sqrt{2}}+1\right]\odot$$

$$= \frac{\mu_0 i}{4\pi R}\left[-1+\frac{1}{\sqrt{2}}+2\pi+\frac{1}{\sqrt{2}}+1\right]\odot \qquad = \frac{\mu_0 i}{4\pi R}\left[\sqrt{2}+2\pi\right]\odot \qquad = \frac{\mu_0 i}{2\pi R}\left[\frac{1}{\sqrt{2}}+\pi\right]\odot$$

2. Position of particle as a function of time is given as $\vec{r} = \cos\omega t\hat{i} + \sin\omega t\hat{j}$. Choose correct statement about $\vec{r}, \vec{v}$ and $\vec{a}$ where $\vec{v}$ and $\vec{a}$ are velocity and acceleration of particle at time t.

(1) $\vec{v}$ is perpendicular to $\vec{r}$ and $\vec{a}$ is towards origin

(2) $\vec{v}$ and $\vec{a}$ are perpendicular to $\vec{r}$

(3) $\vec{v}$ is parallel to $\vec{r}$ and $\vec{a}$ parallel to $\vec{r}$.

(4) $\vec{v}$ is perpendicular to $\vec{r}$ and $\vec{a}$ is away from origin.

Ans. **(1)**

Sol. $\vec{r} = \cos\omega t\hat{i} + \sin\omega t\hat{j}$

$$\vec{v} = \frac{d\vec{r}}{dt} = \omega(-\sin\omega t\hat{i} + \cos\omega t\hat{j})$$

$$\vec{a} = \frac{d\vec{v}}{dt} = -\omega^2(\cos\omega t\hat{i} + \sin\omega t\hat{j})$$

$\vec{a} = -\omega^2\vec{r}$ $\quad\therefore$ $\vec{a}$ is antiparallel to $\vec{r}$

$\vec{v} \cdot \vec{r} = \omega\,(-\sin\omega t\cos\omega t + \cos\omega t\sin\omega t) = 0$

so अतः $\vec{v} \perp \vec{r}$

3. A Carnot engine, having an efficiency of $\eta = 1/10$ as heat engine, is used as a refrigerator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is

(1) 99 J (2*) 90 J (3) 1 J (4) 100 J

Ans. 2

Sol. For Carnot engine using as refrigerator

$$W = Q_2\left(\frac{T_1}{T_2} - 1\right)$$

It is given $\eta = \frac{1}{10}$ $\Rightarrow$ $\eta = 1 - \frac{T_2}{T_1}$ $\Rightarrow$ $\frac{T_2}{T_1} = \frac{9}{10}$

So, $Q_2 = 90$ J (as W = 10 J)

4. Two uniformly charged solid spheres are such that E_1 is electric field at surface of 1^{st} sphere due to itself. E_2 is electric field at surface of 2^{nd} sphere due to itself. r_1, r_2 are radius of 1^{st} and 2^{nd} sphere respectively. If $\frac{E_1}{E_2} = \frac{r_1}{r_2}$ then ratio of potential at the surface of spheres 1^{st} and 2^{nd} due to their self charges is :

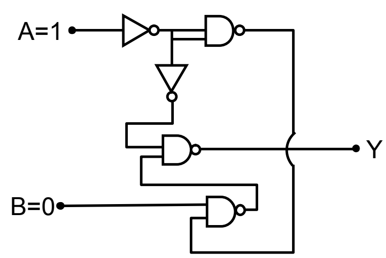
(1) $\frac{r_1}{r_2}$ (2) $\left(\frac{r_1}{r_2}\right)^2$ (3) $\frac{r_2}{r_1}$ (4) $\left(\frac{r_2}{r_1}\right)^2$

Ans. **(2)**

Sol. $\frac{E_1}{E_2} = \frac{r_1}{r_2}$

$$\frac{V_1}{V_2} = \frac{E_1 r_1}{E_2 r_2} = \frac{r_1}{r_2} \times \frac{r_1}{r_2} = \left(\frac{r_1}{r_2}\right)^2$$

5. Output at terminal Y of given logic circuit.



(1) 1
(2) 0
(3) Not determine

(4) Oscillating between 0 and 1

Ans. **(2)**

Sol. $Y = \overline{\overline{AB} \bullet A}$

$= \overline{\overline{AB}} + \overline{A}$

$= AB + \overline{A}$

$= 0 + 0$

$= 0$

6. Velocity of a wave in a wire is v when tension in it is 2.06×10^4 N. Find value of tension in wire when velocity of wave become $\frac{v}{2}$.

(1) 5.15×10^3 N (2) 8.24×10^4 N (3) 6×10^4 (4) 5.15×10^4 N

Ans. (1)

Sol. $v \propto \sqrt{T}$

$\Rightarrow \quad \frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}} \quad \Rightarrow \quad \frac{v}{(v/2)} = \sqrt{\frac{2.06 \times 10^4}{T}}$

$\Rightarrow \quad T = \frac{2.06 \times 10^4}{4} N = 0.515 \times 10^4$ N

7. n mole of He and 2n mole of O_2 is mixed in a container. Then $\left(\frac{C_P}{C_V}\right)_{mix}$ will be

(1) $\frac{19}{13}$ (2) $\frac{40}{27}$ (3) $\frac{1}{3}$ (4) $\frac{1}{4}$

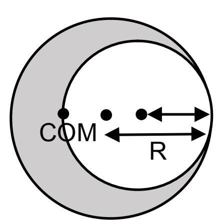
Ans. **(1)**

Sol. $\gamma_{mix} = \frac{n_1 c_{p_1} + n_2 c_{p_2}}{n_1 c_{v_1} + n_2 c_{v_2}}$

$= \frac{n\left(\frac{5}{2}R\right) + 2n\left(\frac{7}{2}R\right)}{n\left(\frac{3}{2}R\right) + 2n\left(\frac{5}{2}R\right)}$

$= \frac{5+14}{3+10} = \frac{19}{13}$

8. A uniform solid sphere of radius R has a cavity of radius 1m cut from it if centre of mass of the system lies at the periphery of the cavity then



(1) $(R^2 + R + 1)(2–R) = 1$ (2) $(R^2 – R – 1)(2–R) = 1$
(3) $(R^2 – R + 1)(2–R) = 1$ (4) $(R^2 + R – 1)(2–R) = 1$

Ans.

Sol. $M_1 = \frac{4}{3}\pi R^3 \rho$

$M_2 = \frac{4}{3}\pi (1)^3 (-\rho)$

$X_{com} = \frac{M_1X_1 + M_2X_2}{M_1 + M_2}$

$$\Rightarrow \frac{\left[\frac{4}{3}\pi R^3 \rho\right]0 + \left[\frac{4}{3}\pi (1)^3 (-\rho)\right][R-1]}{\frac{4}{3}\pi R^3 \rho + \frac{4}{3}\pi (1)^3 (-\rho)} = -(2-R)$$

$$\Rightarrow \frac{(R-1)}{(R^3-1)} = (2-R) \qquad (R \neq 1)$$

$$\frac{(R-1)}{(R-1)(R^2+R+1)} = 2-R$$

$(R^2 + R + 1)(2 - R) = 1$

Alternative:

$M_{remaining}(2 - R) = M_{cavity}(1 - R)$

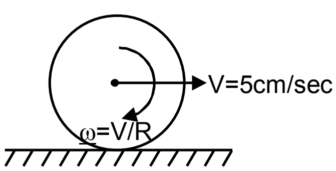
$\Rightarrow (R^3 - 1^3)(2 - R) = 1^3[R - 1]$

$\Rightarrow (R^2 + R + 1)(2 - R) = 1$

9. A solid sphere of mass m= 500gm is rolling without slipping on a horizontal surface. Find kinetic energy of a sphere if velocity of centre of mass is 5 cm/sec.

(1) $\frac{35}{2} \times 10^{-4}$ J (2) $\frac{35}{4} \times 10^{-4}$ J (3) 35×10^{-4}J (4) 35×10^{-3}J

Ans. (2)



Sol.

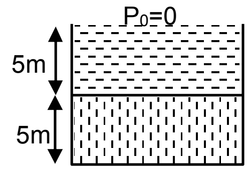
K.E. of the sphere = Translational K.E + Rotational K.E.

$= \frac{1}{2}mv^2\left(1 + \frac{K^2}{R^2}\right)$ K = Radius of gyration

$\frac{1}{2} \times \frac{1}{2} \times \left(\frac{5}{100}\right)^2 \left(1 + \frac{2}{5}\right)$

$\frac{35}{4} \times 10^{-4}$ J

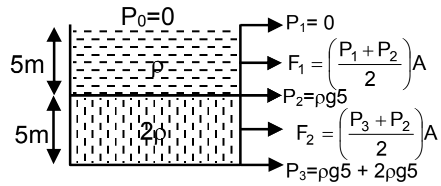
10. Two liquid columns of same height 5m and densities ρ and 2ρ are filled in a container of uniform cross sectional area. Then ratio of force exerted by the liquid on upper half of the wall to lower half of the wall is.



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

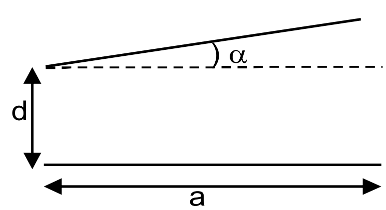
Ans. **(1)**

Sol.



$$\frac{F_1}{F_2} = \frac{1}{4}$$

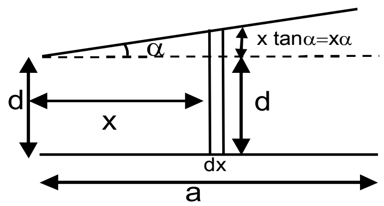
11. Two square plates of side 'a' are arranged as shown in the figure. The minimum separation between plates is 'd' and one of the plate is inclined at small angle α with plane parallel to another plate. The capacitance of capacitor is (given α is very small)



(1) $\frac{\varepsilon_0 a^2}{d}\left(1 - \frac{\alpha a}{2d}\right)$ (2) $\frac{\varepsilon_0 a^2}{d}\left(1 - \frac{\alpha a}{d}\right)$ (3) $\frac{\varepsilon_0 a^2}{d}\left(1 + \frac{\alpha a}{2d}\right)$ (4) $\frac{\varepsilon_0 a^2}{d}\left(1 - \frac{\alpha a}{4d}\right)$

Ans. 1

Sol.



$dc = \frac{\varepsilon_0 a dx}{d + \alpha x}$

$\Rightarrow \quad c = \frac{\varepsilon_0 a}{\alpha}\left[\ln(d + \alpha x)\right]_0^a$

$= \frac{\varepsilon_0 a}{\alpha}\ln\left(1 + \frac{\alpha a}{d}\right) \approx \frac{\varepsilon_0 a^2}{d}\left(1 - \frac{\alpha a}{2d}\right)$

12. In YDSE path difference at a point on screen is $\frac{\lambda}{8}$. Find ratio of intensity at this point with maximum intensity.

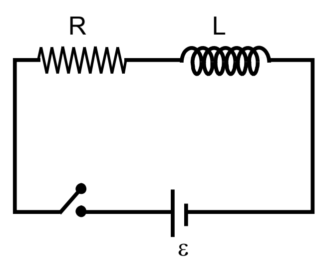
(1) 0.853 (2) 0. 533 (3) 0.234 (4) 0.123

Ans. **(1)**

Sol. $I = I_0 \cos^2\left(\frac{\Delta\phi}{2}\right)$

$\frac{I}{I_0} = \cos^2\left[\frac{\frac{2\pi}{\lambda}\times\Delta x}{2}\right] = \cos^2\left(\frac{\pi}{8}\right)$; $\quad \frac{I}{I_0} = 0.853$

13. In the given circuit switch is closed at t = 0. The charge flown in time t = T_C (where T_C is time constant).



(1) $\frac{\varepsilon L}{R^2 e}$ (2) $\frac{\varepsilon L}{R^2}$ (3) $\frac{\varepsilon L\left(1 - \frac{1}{e}\right)}{R}$ (4) $\frac{\varepsilon L}{R}$

Ans. **(1)**

Sol. $q = \int_0^{T_C} i\,dt$

$= \frac{\varepsilon}{R}\left[t - \frac{e^{-t/T_C}}{\frac{-1}{T_C}}\right]_0^{T_C}$; $= \frac{\varepsilon}{R}\left[T_C + T_C e^{-1} - T_C\right]$

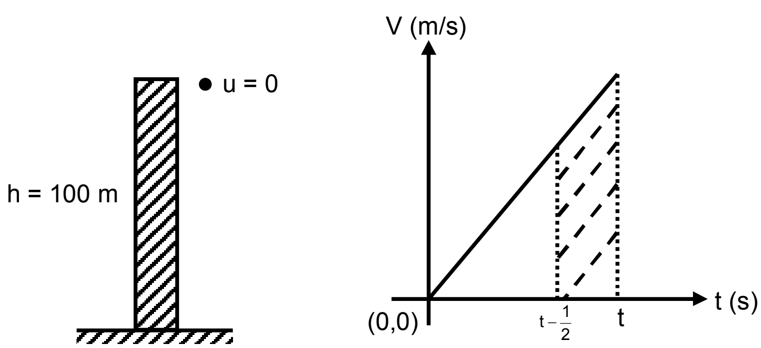
$= \frac{\varepsilon}{R} \times \frac{1}{e} \times \frac{L}{R}$; $= \frac{\varepsilon L}{R^2 e}$

14. A particle is dropped from height h = 100 m, from surface of a planet. If in last $\frac{1}{2}$ sec of its journey it covers 19 m. Then value of acceleration due to gravity that planet is :

(1) 8 m/s^2 (2) $\frac{1}{8}$ m/s^2 (3) $\frac{1}{4}$ m/s^2 (4) 2 m/s^2

Ans. **(1)**

Sol.



Area of shaded trapezium

$= \frac{g\left[t - \frac{1}{2} + t\right]}{2} \times \frac{1}{2} = 19$ ....(1)

$\frac{1}{2} g t^2 = 100$ ....(2)

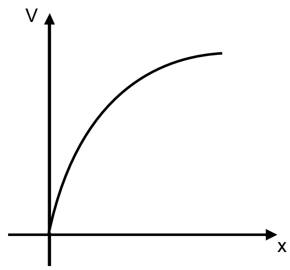
$\Rightarrow t = \sqrt{\frac{200}{g}}$

$g\left[2t - \frac{1}{2}\right] = 76$ $\Rightarrow \frac{76}{g} = \frac{\left[4\sqrt{\frac{200}{g}} - 1\right]}{2}$

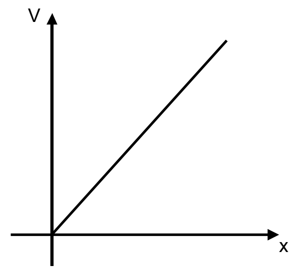
g = 8 m/s^2

15. A charge particle of mass m and charge q is released from rest in uniform electric field. Its graph between velocity (v) and distance travelled (x) will be :

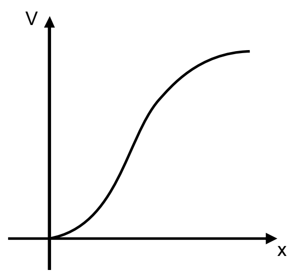
(1)



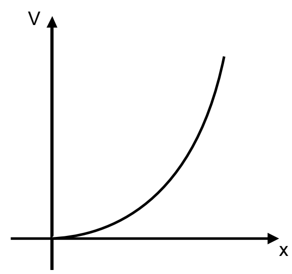
(2)



(3)

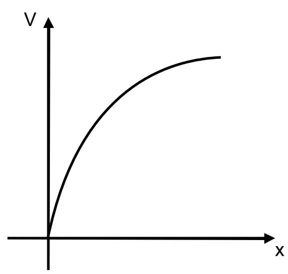


(4)

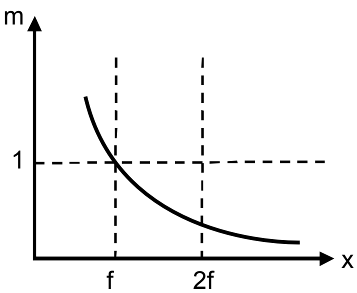


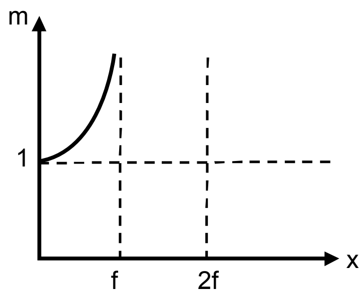
Ans. **(1)**

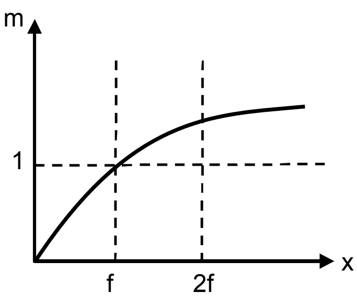
Sol. $V^2 = \frac{2qE}{m}x$

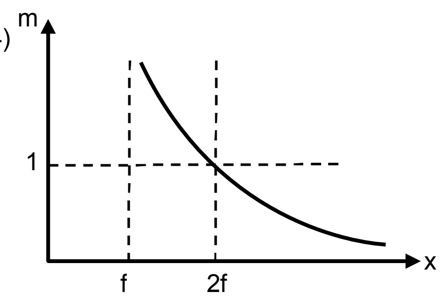


16. An object is moving away from concave mirror of focal length f starting from focus. The distance of an object from pole of mirror is x. The correct graph of magnitude of magnification(m) verses distance x is:

(1)


(2)


(3)


(4)


Ans. **(4)**

Sol. At focus, magnification is ∞.

17. In full scale deflection current in galvanometer of 100 Ω resistance is 1 mA. Resistance required in series to convert it into voltmeter of range 10 V.

(1) 0.99 KΩ (2) 9.9 KΩ (3) 9.8 KΩ (4) 10 KΩ

Ans. **(2)**

Sol. $V_g = i_g R_g = 0.1$ V

$V = 10$ V

$$R = R_g\left(\frac{V}{V_g} - 1\right)$$

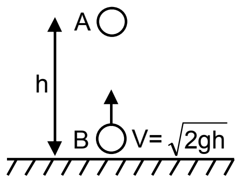
$$= 100 \times 99 = 9.9\ K\Omega$$

18. There are two identical particles A and B. One is projected vertically upward with speed $\sqrt{2gh}$ from ground and other is dropped from height h along the same vertical line. Collision between them is perfectly inelastic. Find time taken by them to reach the ground after collision in terms of $\sqrt{\frac{h}{g}}$.

(1) $\sqrt{\frac{3}{2}}$ (2) $\sqrt{\frac{1}{2}}$ (3) $\sqrt{3}$ (4) $\sqrt{\frac{1}{5}}$

Ans. **(1)**

Sol.



time for collision $t_1 = \frac{h}{\sqrt{2gh}}$

After t_1

$V_A = 0 - gt_1 = -\sqrt{\frac{gh}{2}}$

and $V_B = \sqrt{2gh} - gt_1 = \sqrt{gh}\left[\sqrt{2} - \frac{1}{\sqrt{2}}\right]$

at the time of collision

$\vec{P}_i = \vec{P}_f$

$\Rightarrow m\vec{V}_A + m\vec{V}_B = 2m\vec{V}_f$

$\Rightarrow -\sqrt{\frac{gh}{2}} + \sqrt{gh}\left[\sqrt{2} - \frac{1}{\sqrt{2}}\right] = 2\vec{V}_f$

$V_f = 0$

and height from ground $= h - \frac{1}{2}gt_1^2 = h - \frac{h}{4} = \frac{3h}{4}$

so time $= \sqrt{2 \times \frac{\left(\frac{3h}{4}\right)}{g}} = \sqrt{\frac{3h}{2g}}$

19. Length of a simple pendulum is 25.0 cm and time of 40 oscillation is 50 sec. If resolution of stop watch is 1 sec then accuracy is g is (in %)

(1) 2.4 (2) 3.4 (3) 4.4 (4) 5.4

Ans. (3)

Sol. $\frac{\Delta T}{T} = \frac{1}{2}\left(\frac{\Delta g}{g} + \frac{\Delta L}{L}\right)$

$\frac{\Delta g}{g} = \frac{2\Delta T}{T} + \frac{\Delta L}{L}$; $= 2\left(\frac{1}{50}\right) + \frac{0.1}{25.0}$

= 4.4 %

20. An electron is moving initially with velocity $v_0\hat{i} + v_0\hat{j}$ in uniform electric field $\vec{E} = -E_0\hat{k}$. If initial wavelength of electron is λ_0 and mass of electron is m. Find wavelength of electron as a function of time.

(1) $\frac{\lambda_0}{\sqrt{1 + \frac{e^2E_0^2}{m^2v_0^2}t^2}}$

(2) $\frac{\lambda_0}{\sqrt{2 + \frac{e^2E_0^2}{m^2v_0^2}t^2}}$

(3) $\frac{\lambda_0 mv_0}{eE_0t}$

(4) $\frac{2\lambda_0 mv_0}{eE_0t}$

Ans. **(1)**

Sol. Initially $m\left(\sqrt{2}v_0\right) = \frac{h}{\lambda_0}$

Velocity as a function of time = $v_0\hat{i} + v_0\hat{j} + \frac{eE_0}{m}t\hat{k}$

so wavelength $\lambda = \frac{h}{m\sqrt{2v_0^2 + \frac{e^2E_0^2}{m^2}t^2}}$

$$\lambda = \frac{\lambda_0}{\sqrt{1 + \frac{e^2E_0^2}{m^2v_0^2}t^2}}$$

Numerical Value Type

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

21. An asteroid of mass m (m << m_E) is approaching with a velocity 12 km/s when it is at distance of 10 R from the centre of earth (where R is radius of earth). When it reaches at the surface of Earth, its velocity is (Nearest Integer) in km/s.

Ans. **16**

Sol. $KE_i + PE_i = KE_f + PE_f$

$$\frac{1}{2}mu_0^2 + \left(-\frac{GMm}{10R}\right) = \frac{1}{2}mv^2 + \left(-\frac{GMm}{R}\right)$$

$$v^2 = u_0^2 + \frac{2GM}{R}\left[1-\frac{1}{10}\right]$$

$$v = \sqrt{u_0^2 + \frac{9}{5}\frac{GM}{R}}$$

$$= \sqrt{12^2 + \left(\frac{9}{5}\right)\frac{(11.2)^2}{2}}$$

$$= \sqrt{144 + 0.9(11.2)^2} = \sqrt{256.896}$$

= 16.028 km/s

$\simeq$ 16

22. In H–spectrum wavelength of 1st line of Balmer series is λ = 6561Å. Find out wavelength of 2nd line of same series in nm.

Sol. $$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{1}{\lambda_1} = R(1)^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$$

$$\frac{1}{\lambda_2} = R(1)^2\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3R}{16}$$

$$\frac{\lambda_2}{\lambda_1} = \frac{20}{27}$$

$$\lambda_2 = \frac{20}{27} \times 6561Å = 4860\ Å$$

= 486 nm

23. There are three containers C_1, C_2 and C_3 filled with same material at different constant temperature. When we mix then for different volume then we get some final temperature as shown in the below table. So find value of final temperature θ as shown in the table.

C_1	C_2	C_3	t(°C)
1ℓ	2ℓ	0	60
0	1ℓ	2ℓ	30
2ℓ	0	1ℓ	60
1ℓ	1ℓ	1ℓ	θ

Ans. **50º C**

Sol. $1\theta_1 + 2\theta_2 = (1 + 2)\ 60$

$\theta_1 + 2\theta_2 = 180$ ....(1)

$0 \times \theta_1 + 1 \times \theta_2 + 2 \times \theta_3 = (1 + 2)\ 30$

$\theta_2 + 2\theta_3 = 90$ ....(2)

$2 \times \theta_1 + 0 \times \theta_2 + 1 \times \theta_3 = (2 + 1)\ 60$

$2\theta_1 + \theta_3 = 180$ ....(3)

and $\theta_1 + \theta_2 + \theta_3 = (1 + 1 + 1)\ \theta$ ....(4)

from (1) + (2) + (3)

$3\theta_1 + 3\theta_2 + 3\theta_3 = 450 \Rightarrow \theta_1 + \theta_2 + \theta_3 = 150$

from (4) equation $150 = 3\theta \Rightarrow \theta = 50$ºC

24. Two batteries (connected in series) of same emf 10 V of internal resistances 20Ω and 5Ω are connected to a load resistance of 30Ω. Now an unknown resistance x is connected in parallel to the load resistance. Find value of x so that potential drop of battery having internal resistance 20Ω becomes zero.

Ans. 30

Sol. $V_1 = \varepsilon_1 - i.\ r_1$

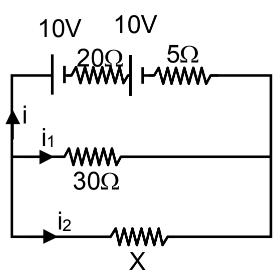
$0 = 10 - i \times 20$

$i = 0.5A$

$V_2 = \varepsilon_2 - ir_2$

$= 10 - 0.5 \times 5$

$V_2 = 7.5V$



0.5 =

x

$\frac{7.5}{30} + \frac{7.5}{}$

$0.5 = 0.25 + \frac{7.5}{x}$

$\frac{7.5}{x} = 0.25$

$x = \frac{7.5}{0.25} = 30$

25. An EMW is travelling along z-axis.

$\vec{B} = 5 \times 10^{-8}\,\hat{j}\,T$

C = 3 × 10^{8} m/s

& Frequency of wave is 25 Hz, then electric field in volt/m.

Ans. **15**

Sol. $\frac{E}{B} = c$

E = B × c

= 15 N/c