Solution

PHYSICS

Class 12 - Physics

Section A

1. Select and write the correct answers for the following multiple choice type of questions:

(i) **(b)** both p and E decrease.
Explanation: {
both p and E decrease.

(ii) **(d)** isobaric process
Explanation: {
isobaric process

(iii) **(a)** photovoltaic action
Explanation: {
photovoltaic action

(iv) **(c)** $n\bar{u}$
Explanation: {
$n\bar{u}$

(v) **(d)** $\sqrt{T}$
Explanation: {
$\sqrt{T}$

(vi) **(d)** $\left[L^0 M^1 T^{-2}\right]$
Explanation: {
$\left[L^0 M^1 T^{-2}\right]$

(vii) **(c)** isotopes
Explanation: {
isotopes

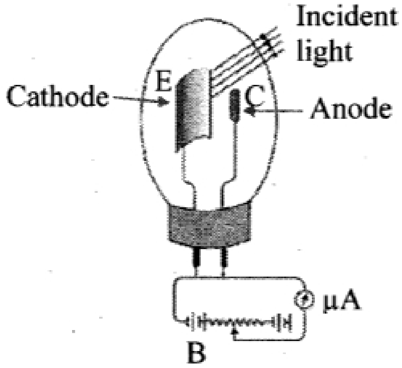
(viii) **(a)** shows a depression in the middle.
Explanation: {
shows a depression in the middle.

(ix) **(d)** dry air
Explanation: {
dry air

(x) **(d)** NOR
Explanation: {
NOR

2. Answer the following questions:

(i)



Schematic of a photocell

(ii) At the extreme position, the total energy of a particle executing linear S.H.M. is purely potential.

(iii) Average value of alternating current over a complete cycle is zero.

(iv) Moving coil galvanometer is converted into an ammeter by connecting a low resistance in parallel with the galvanometer, which effectively reduces the resistance of the galvanometer. This low resistance connected in parallel is called as shunt (S).

(v) **Definition:** During circular motion, if the speed of the particle remains constant, it is called Uniform Circular Motion (UCM).

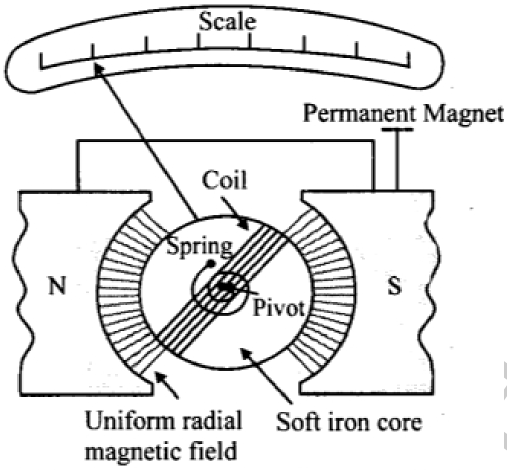
(vi) Expression for electric field intensity at a point outside an infinitely long charged conducing cylinder:
$E = \frac{\lambda}{2\pi k\varepsilon_0 r}$

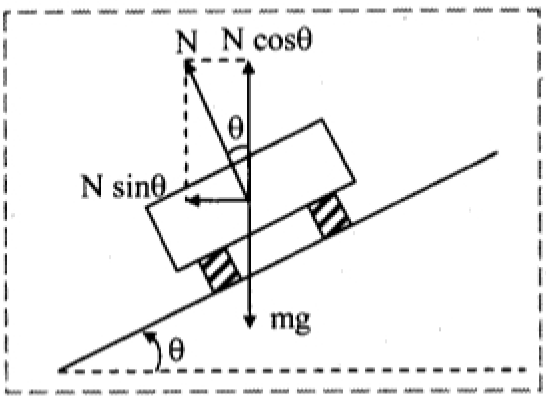
(vii) $\vec{\tau} = \vec{m} \times \vec{B}$
where $\vec{m}$ is the magnetic dipole moment of rotating current coil and $\vec{B}$ is the magnetic field.

(viii) When the rod of diamagnetic material is placed in a non-uniform magnetic field, it tends to move from stronger part to the weaker part of the magnetic field.

Section B

3. i. Coefficient of viscosity: The coefficient of viscosity is defined as the viscous force per unit area per unit velocity gradient.
   ii. Formula: $\eta = \frac{F}{\frac{dv}{dx}}$
   iii. Unit of η is Ns/m^2 or decapoise in S.I. system

4. 

5. 

6. i. The ability of a conductor to store the electric charge is called capacitance of conductor.
   ii. SI unit of capacity of conductor is farad (F).
   $\therefore 1\ F = \frac{1C}{1\ V}$
   Thus, the capacity of a conductor is said to be 1 farad if the potential difference across it rises by 1 volt, when 1C charge is given to it.

7. i. A simple pendulum whose period is two seconds is called second's pendulum.
   ii. Time period of simple pendulum, $T = 2\pi\sqrt{\frac{L}{g}}$
   For a second's pendulum, $2 = 2\pi\sqrt{\frac{L_s}{g}}$
   Where, L_s is the length of second's pendulum, having period $T = 2\ s$.
   $\therefore L_s = \frac{g}{\pi^2}$

8. i. A process in which change in pressure and volume takes place at a constant temperature is called an isothermal process or isothermal change.
   ii. Adiabatic process is a process during which there is no transfer of heat from or to the system.
9. Given: $L = 0.1H, C = 25 \times 10^{-6}\ F, R = 15\Omega$
   $e_{rms} = 120\ V$
   To find: Resonant frequency (f_r)
   Formula: $f_r = \frac{1}{2\pi\sqrt{LC}}$
   Calculation: From formula,
   $f_r = \frac{1}{2\times3.142\times\sqrt{0.1\times25\times10^{-6}}}$
   $= \frac{1}{9.9356\times10^{-3}}$
   $f_r = 100.6\ Hz$
   The value of resonant frequency is $100.6 Hz$.
10. Given: m = 1 kg,
   $k = 25 \times 10^3$ dyne $/cm = 25\ N/m$
   To find: Angular velocity (ω), Frequency (n)
   Calculation: From formula (i),
   $\omega = \sqrt{\frac{25}{1}}$ = 5 rad/s
   From formula (ii),
   $n = \frac{\omega}{2\pi} = \frac{5}{2\pi} = \frac{2.5}{3.14}$ = 0.7962 Hz
   The angular velocity of the body is 5 rad/s and the frequency of vibration is 0.7962 Hz.
11. i. **Law of length:** The fundamental frequency of vibrations of a string is inversely proportional to the length of the vibrating string, if tension and mass per unit length are constant.
   $n \propto \frac{1}{l}$ (if T and m are constant.)
   ii. **Law of linear density:** The fundamental frequency of vibrations of a string is inversely proportional to the square root of mass per unit length (linear density), if the tension and vibrating length of the string are constant.
   $\therefore n \propto \frac{1}{\sqrt{\rho}} \ldots$ (if T and l are constant.)
12. Given: $A = 200\ cm^2 = 200 \times 10^{-4} m^2$,
   $T = 127^\circ C = (127 + 273)K = 400\ K$
   $t = 0.5\ min = 30\ s$;
   Also, $\sigma = 5.7 \times 10^{-8} Jm^{-2}s^{-1}K^{-4}$
   To find: Energy radiated (Q)
   Formula: $Q = \sigma AtT^4$
   Calculation: From formula,
   $Q = \sigma AtT^4$
   $= 5.7 \times 10^{-8} \times 200 \times 10^{-4} \times 30 \times (400)^4$
   $= 5.7 \times 10^{-8} \times 0.6 \times 10^4 \times 10^{-4} \times 4^4 \times 10^8$
   $= 5.7 \times 0.6 \times 256 = 875.5\ J$
   Energy radiated in one minute is $875.5\ J$.
13. Given: $R = 50\Omega, l_X = 40\ cm = 0.4\ m$
   $l_R = 60\ cm = 0.6\ m$
   To find: Unknown resistance (X)
   Formula: $X = R\frac{l_x}{l_R}$
   Calculation: From formula,
   $X = \frac{50\times40}{60}$
   $= \frac{100}{3}\Omega$
   $= 33.33\Omega$
   The value of unknown resistance is 33.33Ω.
14. For hydrogen: $\frac{1}{\lambda} = R_H\left(\frac{1}{n^2} - \frac{1}{m^2}\right)$.
   For longest wavelength of Lyman series, $n = 1$ and $m = 2$

$\therefore \frac{1}{\lambda_L} = R_H\left(\frac{1}{1^2} - \frac{1}{2^2}\right) \Rightarrow \lambda_L = \frac{3}{4}R_H$

For longest wavelength of Balmer series, $n = 2$ and $m = 3$

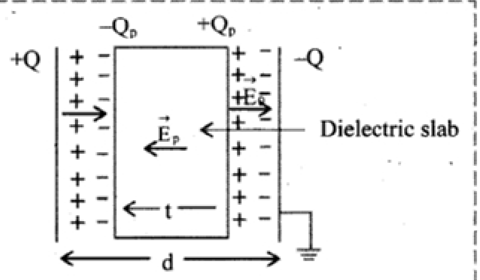
$\therefore \frac{1}{\lambda_B} = R_H\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \Rightarrow \lambda_B = \frac{5}{36}R_H$

$\therefore \frac{\lambda_L}{\lambda_B} = \frac{4}{3R_H} \times \frac{5R_H}{36} = \frac{5}{27}$

Section C

15. Conditions to get constructive interference:
   i. Two waves should be in same phase.
   ii. The phase difference between the interfering waves should be even multiple of π.
   $\Delta\phi = 0, 2\pi, 4\pi, 6\pi, \ldots$
   $\Delta\phi = 2n\pi$, where, $n = 0, \pm 1 \pm 2$
   iii. The path difference between the interfering waves should be an integral multiple of λ or even multiple of $\frac{\lambda}{2}$.
   i.e., $\Delta l = 2n\frac{\lambda}{2}$
   where, $n = 0, 1, 2, 3\ldots$

   Conditions to get destructive interference:
   i. Two waves should be in opposite phase.
   ii. The phase difference between the interfering waves should be odd multiple of π.
   $\Delta\phi = \pi, 3\pi, 5\pi, 7\pi, \ldots$
   $\therefore \Delta\phi = \left(n - \frac{1}{2}\right)2\pi$, where, $n = \pm 1, \pm 2$
   iii. The path difference between the interfering waves should be odd multiple of $\frac{\lambda}{2}$.
   i.e., $\Delta l = (2n - 1)\frac{\lambda}{2}$
   where,
   $n = 1, 2, 3$ .....
   Thus, constructive interference is obtained when path difference is an odd multiple of half wavelength.

16. 

Parallel plate capacitor with a dielectric slab between the

17. i. The temperature at which a ferromagnetic material transforms into a paramagnetic substance is called Curie temperature (T_c) of that material.
   ii. An increase in the temperature of a ferromagnetic material weakens the exchange coupling between neighbouring moments which results in the domain structure getting distorted.
   iii. Above Curie temperature the domain structure of a ferromagnetic material collapses totally and the material behaves like paramagnetic material.

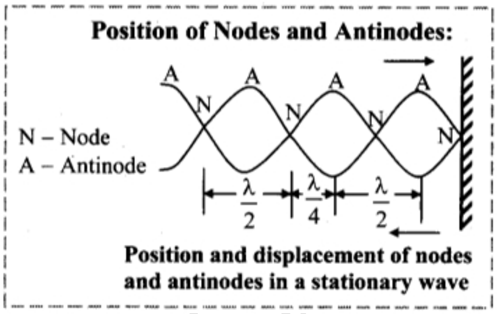
18. **Construction of photoelectric cell:**
   i. A photo cell consists of a semi-cylindrical photosensitive metal plate E acting as a cathode and a wire loop collector C acting as an anode supported in an evacuated glass or quartz bulb.
   ii. The electrodes are connected to an external circuit having a high tension battery B and a micro ammeter μA.
   iii. Instead of a photosensitive metal plate, the photosensitive material can be pasted in the form of a thin film on the inner walls of the glass bulb.

19.

	Ammeter	Voltmeter
a.	It measures current.	It measures potential difference
b.	It is connected in series.	It is connected in parallel.
c.	It is an MCG with low resistance. (Ideally zero)	It is an MCG with high resistance.

		(Ideally infinite)
d.	Smaller the shunt, greater will be the current measured.	Larger its resistance greater will be the potential difference measured.
e.	Resistance of ammeter, $R_A = \frac{SG}{S+G} = \frac{G}{n}$	Resistance of voltmeter, $R_v = G + X = Gn_v$

20. i. 1. Consider two simple harmonic progressive waves of equal amplitudes (a) and wavelength (λ) propagating on a long uniform string in opposite directions.
2. The equation of wave travelling along the X -axis in the positive direction is given by,
$y_1 = a\sin\left[2\pi\left(nt - \frac{x}{\lambda}\right)\right]$
The equation of wave travelling along the X -axis in the negative direction is given by,
$y_2 = a\sin\left[2\pi\left(nt + \frac{x}{\lambda}\right)\right]$
3. When these waves interfere, the resultant displacement of particles of string is given by the principle of superposition of waves as
$y = y_1 + y_2$
$\therefore y = a\sin\left[2\pi\left(nt - \frac{x}{\lambda}\right)\right] + a\sin\left[2\pi\left(nt + \frac{x}{\lambda}\right)\right]$
4. By using trigonometry formula,
$\sin C + \sin D = 2\sin\left(\frac{C+D}{2}\right)\cos\left(\frac{C-D}{2}\right)$
$\therefore y = 2a\sin(2\pi nt)\cos\frac{2\pi x}{\lambda}$
$y = 2a\cos\frac{2\pi x}{\lambda}\sin(2\pi nt)$ ...(1)
5. Substituting $2a\cos\frac{2\pi x}{\lambda} = A$ in equation (1),
$y = A\sin(2\pi nt)$
$\therefore y = A\sin\omega t \ \ldots(\therefore \omega = 2\pi n)$
This is the equation of a stationary wave which gives resultant displacement due to two simple harmonic progressive waves.

ii. 

21. i. For parallel combination of two coils, the current through each parallel inductor is a fraction of the total current and the voltage across each parallel inductor is same.
ii. As a result, a change in total current will result in less voltage dropped across the parallel array than for any one of the individual inductors.
iii. There will be less voltage drop across parallel inductors for a given rate of change in current than for any of the individual inductors.
iv. Less voltage for the same rate of change in current results in less inductance.
v. Thus, the total inductance of two coils is less than the inductance of either coil.

22. Given:
$n_1 = 320\ Hz, n_2 = 340\ Hz$,
$v = 326.4\ ms^{-1}$
To find: Difference of wavelength of the waves.
Formula: $\lambda = \frac{v}{n}$
Calculation: From formula,
$\lambda_1 = \frac{v}{n_1}$
$\lambda_2 = \frac{v}{n_2}$
$\because n_1 < n_2$

$\therefore \lambda_1 > \lambda_2$

Difference in wavelength,

$\therefore \lambda_1 - \lambda_2 = \frac{v}{n_1} - \frac{v}{n_2}$

$\therefore \lambda_1 - \lambda_2 = v\left[\frac{1}{n_1} - \frac{1}{n_2}\right]$

$\therefore \lambda_1 - \lambda_2 = 326.4\left[\frac{1}{320} - \frac{1}{340}\right]$

$\therefore \lambda_1 - \lambda_2 = 326.4\left[\frac{340-320}{320\times340}\right]$

$= \frac{6528}{320\times340}$

$= \frac{192}{320\times10}$

$= \frac{6}{100} = 0.06\ m$

The difference in wavelength is $0.06\ m$.

23. Given: $\lambda = 6400$ A.U. $= 6400 \times 10^{-10}\ m = 6.4 \times 10^{-7}\ m,\ D = 60\ cm = 0.6\ m,\ d = 4\ mm = 4 \times 10^{-3}\ m$,
$d_1 = 4 + 1 = 5\ mm = 5 \times 10^{-3}\ m,\quad d_2 = 4 - 1 = 3\ mm = 3 \times 10^{-3}\ m$.
To find: Changes in fringe width (ΔW)
Formula: $W = \frac{\lambda D}{d}$
Calculation: From formula,
$W = \frac{6.4\times10^{-7}\times0.6}{4\times10^{-3}} = 96 \times 10^{-6}\ m$
$W_1 = \frac{6.4\times10^{-7}\times0.6}{5\times10^{-3}} = 76.8 \times 10^{-6}\ m$
$\therefore \Delta W_1 = W - W_1 = 96 \times 10^{-6}\ m - 76.8 \times 10^{-6}\ m = 19.2 \times 10^{-6}\ m = 19.2\mu\ m.$
Also, $W_2 = \frac{6.4\times10^{-7}\times0.6}{3\times10^{-3}} = 128 \times 10^{-6}\ m.$
$\therefore \Delta W_2 = W_2 - W = 128 \times 10^{-6} - 96 \times 10^{-6} = 32 \times 10^{-6}\ m = 32\mu\ m.$
Changes in fringe width respectively are $19.2\mu\ m$ and $32\mu m$.

24. Given: $N = 250,\ d = 18\ cm,\ r = 9\ cm = 9 \times 10^{-2}\ m, I = 12\ A$
To find: Magnetic moment of the coil (m)
Formula: m = NIA
Calculation: For the coil,
$A = \pi r^2$
Using formula,
$m = NI\pi r^2$
$= 250 \times 12 \times 3.142 \times \left(9 \times 10^{-2}\right)^2$
$= 250 \times 12 \times 3.142 \times 81 \times 10^{-4}$
$= \{\text{antilog}[\log(250) + \log(12) + \log(3.142) + \log(81)]\} \times 10^{-4}$
$= \{$ antilog $[2.3979 + 1.0792 + 0.4972 + 1.9085]\} \times 10^{-4}$
$= \{$ antilog[5.8828] $\} \times 10^{-4}$
$= 0.7635 \times 10^6 \times 10^{-4}$
$\therefore$ m = **76.35 Am^2**
Magnetic moment of the coil is **76.35 Am^2**.

25. Given: $e = 140 \sin 314.2t$
   i. On comparing it with standard equation,
   $e = e_0 \sin \omega t$
   We get
   $e_0 = 140\ V$
   $\omega = 314.2 rad/s = 100\pi rad/s$
   $\therefore f = \frac{\omega}{2\pi} = \frac{100\pi}{2\pi} = 50\ Hz$
   ii. Given: $R = 50\Omega$
   $i_{rms} = \frac{e_{ms}}{R} = \frac{e_0}{\sqrt{2}\times R}$
   $= \frac{140}{\sqrt{2}\times50}$
   $= \frac{14}{1.414\times5}$
   $= \frac{14}{7.07} \approx 1.98\ A$

i. The frequency of the source is 50 Hz.

ii. The rms current through the resistor is 1.98 A.

26. Given:

$m_e = 9.1 \times 10^{-31}\ kg, e, = 1.6 \times 10^{-19} C, h = 6.63 \times 10^{-34}\ J - s$

$\varepsilon_0 = 8.85 \times 10^{-12} C^2/Nm^2, n = 2$

To find: Radius of 2^{nd} Bohr orbit (r_2).

Formula: $r_n = \frac{\varepsilon_0 n^2 h^2}{\pi m e^2}$

Calculation: From formula,

$r_2 = \frac{8.85 \times 10^{-12} \times 2^2 \times (6.63 \times 10^{-34})^2}{3.14 \times 9.1 \times 10^{-31} \times (1.6 \times 10^{-19})^2} = \frac{8.85 \times 4 \times (6.63)^2 \times 10^{-12} \times 10^{-68}}{3.14 \times 9.1 \times (1.6)^2 \times 10^{-31} \times 10^{-38}} = \frac{8.85 \times 4 \times (6.63)^2}{3.14 \times 9.1 \times (1.6)^2} \times 10^{-11}$

$= \{\text{ antilog } [\log(8.85) + \log(4) + 2\log(6.63) - \log(3.14) - \log(9.1) - 2\log(1.6)]\} \times 10^{-11}$

$= \{\text{ antilog } [0.9469 + 0.6021 + 2 \times 0.8215\ - 0.4969 - 0.9590 - 2 \times 0.2041\} \times 10^{-11}$

$= \{\text{ antilog } [1.3279]\} \times 10^{-11}$

$= 21.27 \times 10^{-11} = 2.127 \times 10^{-10}\ \text{m}$

$\text{r}_2 = \mathbf{2.127\mathring{A}}$

Radius of second Bohr orbit is $2.127\mathring{A}$.

Section D

27. Expression for capillary rise:

i. When glass capillary tube is dipped into a liquid, then the liquid rises in the capillary against gravity. Hence, the weight of the liquid column must be equal and opposite to the component of force due to surface tension at the point of contact.

ii. The length of liquid in contact inside the capillary is the circumference 2π r.

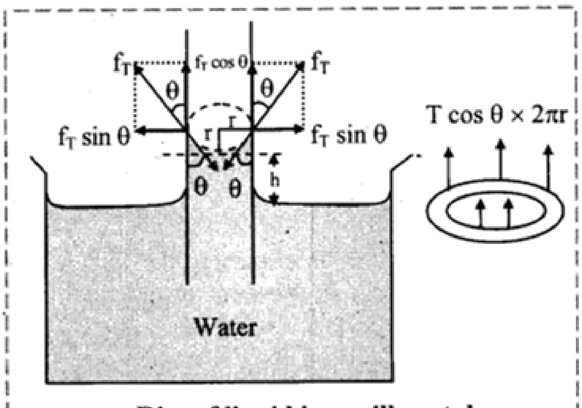
Let, $r =$ radius of capillary tube

$h =$ height of liquid level in the tube

$T =$ surface tension of liquid

$\rho =$ density of liquid

$g =$ acceleration due to gravity



Rise of liquid in capillary tube

iii. The force of magnitude f_T acts tangentially on unit length of liquid surface which is in contact with wall of capillary tube and is given as, $f_T = T \times 2\pi r$

This force can be resolved into two components:

a. $f_T \cos\theta$ - vertically upward and

b. $f_T \sin\theta$ - along horizontal

iv. Vertical component is effective. Horizontal component is not responsible for capillary rise

v. Vertical component of force acting on liquid column $(f_T)_v =$ force per unit length $\times$ circumference

$= T\cos\theta \times 2\pi r$

vi. Upward force balances weight of liquid in the capillary.

W = mg = Vρg = $\pi r^2 h\rho g$

where, $V =$ volume of liquid rise in the tube (ignoring the liquid in the concave meniscus.)

$m =$ mass of the liquid in the capillary rise.

This must be equal and opposite to the vertical component of the force due to surface tension.

vii. If liquid in meniscus is neglected, then for equilibrium,

$2\pi rT\cos\theta = \pi r^2\ h\rho\ g$

$\therefore h = \frac{2\,T\cos\theta}{rgg}$ ...(1)

This is the required expression for rise of liquid in capillary tube.

28. Answer the following questions:

(i)

Step-up transformer	Step-down transformer
(1) The number of turns in its secondary is more than that in its primary $(\mathrm{N_S} > \mathrm{N_P})$.	The number of turns in primary is greater than secondary $(\mathrm{N_P} > \mathrm{N_S})$.
(2) Alternating voltage across the ends of its secondary is more than that across its primary i.e., $e_S > e_P$	Alternating voltage across the ends of the primary is more than that across its secondary i.e., $e_P > e_S$
(3) Transformer ratio K > 1.	Transformer ratio K < 1.
(4) Primary coil made of thick wire.	Secondary coil made of thick wire.
(5) Secondary coil is made of thin wire.	Primary coil is made of thin wire.
(6) Current through secondary is less than primary.	Current through primary is less than secondary.

(ii) Induced e.m.f. is given by formula,

$e = (\vec{v}\times\vec{B}), l = vbl\sin\theta$

In given condition, the wire initially supported in east-west direction, when falls towards the ground travels in north-south direction. Hence, velocity $\vec{v}$ is acting in the north - south direction. Earth's magnetism $\vec{B}$ also acts from the north pole to the south pole. This makes $\vec{v}\|\vec{B}$.

$\therefore \sin\theta = 0 \Rightarrow e = 0$

The average induced e.m.f. in the wire will be **zero**.

29. Answer the following questions:

(i) **Thermodynamic process:** A process by which two or more of state variables of a system can be changed is called a thermodynamic process or a thermodynamic change.

Types of thermodynamic processes:

i. Quasi-static process
ii. isothermal process
iii. adiabatic process
iv. isochoric process
v. isobaric process
vi. reversible process
vii. irreversible process
viii. cyclic process

(Any two types)

(ii) Given: As the gas is monatomic, $\gamma = \frac{5}{3}$

$T_2 = 2T_1 \Rightarrow \frac{T_2}{T_1} = 2$

To find: Ratio of final pressure to its initial pressure $\left(\frac{p_2}{p_1}\right)$

Formula: $p_1^{1-\gamma}T_1^{\gamma} = p_2^{1-\gamma}T_2^{\gamma}$

Calculation: From formula,

$\therefore \left(\frac{p_1}{p_2}\right)^{1-r} = \left(\frac{T_2}{T_1}\right)^{\gamma}$

$\therefore \left(\frac{p_1}{p_2}\right)^{\frac{-2}{3}} = \left(\frac{T_2}{T_1}\right)^{\frac{5}{3}} \Rightarrow \left(\frac{p_2}{p_1}\right)^{\frac{2}{3}} = \left(\frac{T_2}{T_1}\right)^{\frac{5}{3}}$

On taking cube of both sides, we get

$\therefore \left(\frac{p_2}{p_1}\right)^2 = \left(\frac{T_2}{T_1}\right)^5 = (2)^5 = 32$

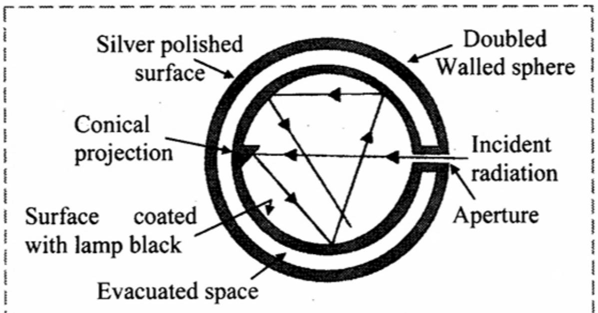
Taking square root of both sides, we get

$\therefore \frac{p_2}{p_1} = \sqrt{32} = 4\sqrt{2} = 4\times 1.414 = 5.656$

The ratio of final pressure to its initial pressure is 5.656.

30. Answer:

(i)



Ferry's blackbody

(ii) $\frac{C_p}{C_v} = 1.5$

$\therefore C_P = 1.5 C_V$

Given: $C_P - C_V = 9000\ J/kgK$

$\therefore 1.5 C_V - C_V = 9000$

$\therefore 0.5 C_V = 9000$

$\therefore C_V = \frac{9000}{0.5}$

$\therefore C_V = 1.8 \times 10^4\ J/kgK$

Now, $C_P = 9000 + C_V = 9000 + (1.8 \times 10^4)$

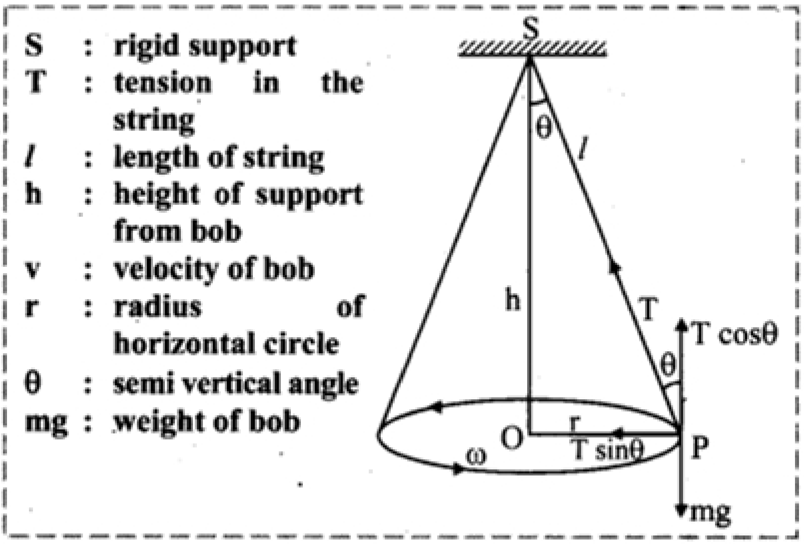
$= 2.7 \times 10^4\ J/kg\ K$

The value C_V is $1.8 \times 10^4\ J/kg\ K$ and C_P is $2.7 \times 10^4\ J/\ kg\ K$.

31. i. Consider a bob of mass m tied to one end of a string of length 'l' and other end is fixed to rigid support.

ii. Let the bob be displaced from its mean position and whirled around a horizontal circle of radius 'r' with constant angular velocity ω, then the bob performs U.C.M.

iii. During the motion, string is inclined to the vertical at an angle θ as shown in the figure.



iv. In the displaced position P, there are two forces acting on the bob.

a. The weight mg acting vertically downwards.

b. The tension T acting upward along the string.

v. The tension (T) acting in the string can be resolved into two components:

a. T $\cos\theta$ acting vertically upwards.

b. $T\sin\theta$ acting horizontally towards centre of the circle.

vi. Vertical component $T\cos\theta$ balances the weight and horizontal component $T\sin\theta$ provides the necessary centripetal force.

$\therefore T\cos\theta = mg$ ...(1)

$T\sin\theta = \frac{mv^2}{r} = mr\omega^2$ ...(2)

vii. Dividing equation (2) by (1), we get

$\tan\theta = \frac{v^2}{rg}$