Solution

PHYSICS

Class 12 - Physics

Section A

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

(i) **(c)** $1.326 \times 10^{-27}\ kg - m/s$

Explanation: {

Momentum: $p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{5000 \times 10^{-10}}$

$= 1.326 \times 10^{-27}\ kg - m/s$

(ii) **(c)** $W = Q$

Explanation: {

For a cyclic process, the total change in the internal energy of a system is zero.

$\therefore \Delta U = 0$

According to the first law of thermodynamics,

$Q = \Delta U + W$

$\therefore Q = W$

(iii) **(d)** intrinsic semiconductor

Explanation: {

intrinsic semiconductor

(iv) **(c)** $2\cos^{-1}\left(\frac{\mu}{2}\right)$

Explanation: {

$\mu = \frac{\sin i}{\sin r}$

Given that, $i = 2r$

$\therefore \mu = \frac{\sin 2r}{\sin r} = \frac{2\sin r\cos r}{\sin r} = 2\cos r$

$\therefore \cos r = \frac{\mu}{2} \Rightarrow r = \cos^{-1}\left(\frac{\mu}{2}\right)$

$\therefore \frac{i}{2} = \cos^{-1}\left(\frac{\mu}{2}\right) \Rightarrow i = 2\cos^{-1}\left(\frac{\mu}{2}\right)$

(v) **(b)** $\frac{\pi}{2} rad$

Explanation: {

Nodes and antinodes are formed alternately. Therefore, the distance between a node and an adjacent antinode is $\frac{\lambda}{4}$.

From, $\Delta\phi = \frac{2\pi}{\lambda} \times \Delta x$

$\Delta\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{4} = \frac{\pi}{2} rad$

(vi) **(a)** Molten copper

Explanation: {

Molten copper

(vii) **(b)** $\frac{1}{n^2}$

Explanation: {

$\frac{1}{n^2}$

(viii) **(a)** shows a depression in the middle.

Explanation: {

shows a depression in the middle.

(ix) **(d)** $9R$

Explanation: {

$9R$

(x) **(a)** accelerated minority charge carrier

Explanation: {

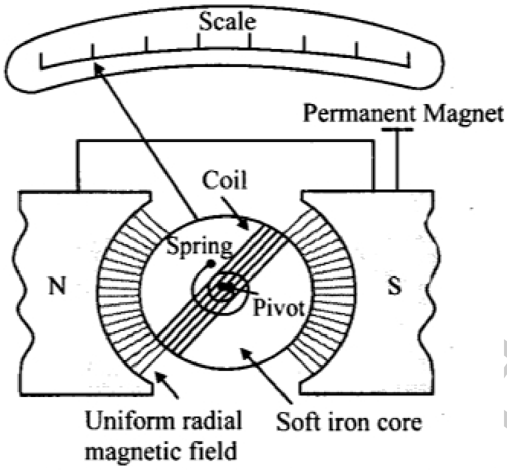
accelerated minority charge carrier

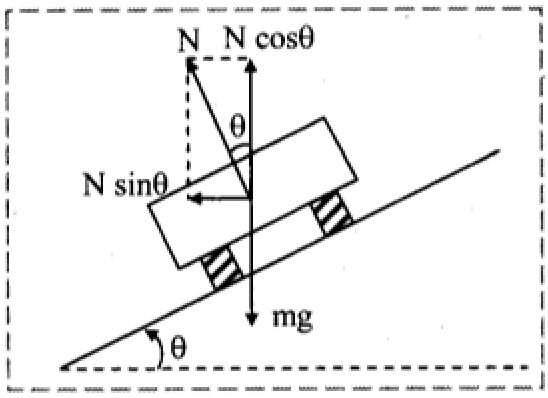
2. Answer the following questions:

(i) No. Any light possessing sufficient energy to initiate the photoemission can be used to get photoelectric effect.
(ii) Periodic oscillations of gradually decreasing amplitude are called damped harmonic oscillations.
(iii) Average value of alternating current over a complete cycle is zero.
(iv) Potential gradient is defined as potential difference per unit length of wire.
(v) **Definition:** During circular motion, if the speed of the particle remains constant, it is called Uniform Circular Motion (UCM).
Forces acting on the body executing nonuniform circular motion: Centripetal force provided partly by the weight of the body performing circular motion and partly by the normal reaction.
(vi) H_2O- polar dielectric
CO_2- non-polar dielectric
(vii) Force on a closed circuit in a magnetic field is zero.
(viii) Formula for Bohr Magneton $= \frac{ch}{4\pi\, m_q}$

Section B

3. i. Surface tension is defined as the tangential force acting per unit length on both sides of an imaginary line drawn on the free surface of liquid.
ii. Surface energy:
The extra energy of the molecules on the surface layer of a liquid is called surface energy of the liquid.

4. 

5. 

6. i. **Gauss' law:** The flux of the net electric field through a closed surface equals the net charge enclosed by the surface divided by ε_0.
$\int \overrightarrow{E} \cdot \overrightarrow{ds} = \frac{q}{\varepsilon_0}$
where q is the total charge within the surface.
ii. Expression for electric field intensity at a point outside an infinitely long charged conducting cylinder:
$E = \frac{\lambda}{2\pi k \varepsilon_0 r}$

7. **Definition:** Phase in S.H.M. (or for any motion) is the state of oscillation.
Particle performing S.H.M., starting from the positive extreme position:
Equations: As the particle starts from the positive extreme position, $\phi = \frac{\pi}{2}$
$\therefore$ Phase, $\theta = \omega t + \phi = \omega t + \frac{\pi}{2}$
$\therefore$ Displacement, $x = A\sin(\omega t + \frac{\pi}{2}) = A\cos\omega t$

Velocity, $v=\frac{dx}{dt}=\frac{d(A\cos\omega t)}{dt}=-A\omega\cdot\sin(\omega t)$

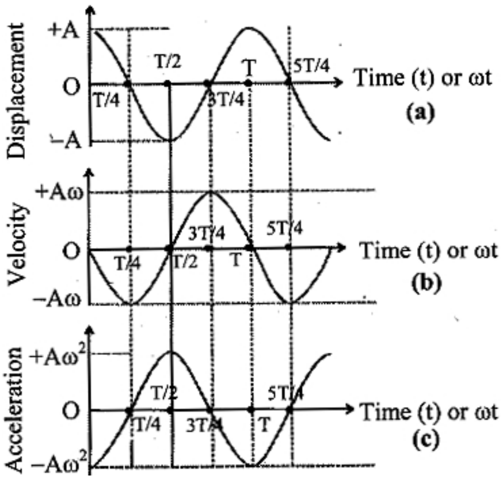
Acceleration, $a=\frac{dv}{dt}=\frac{d[-A\omega\sin(\omega t)]}{dt}$

$=-A\omega^2\cos(\omega t)$

Table:

(t)	0	$T/4$	$T/2$	$3\,T/4$	T	$5\,T/4$
(θ)	$\frac{\pi}{2}$	π	$\frac{3\pi}{2}$	2π	$\frac{5\pi}{2}$	3π
(x)	A	0	-A	0	A	0
(v)	0	$-A\omega$	0	$A\omega$	0	$-A\omega$
(a)	$-A\omega^2$	0	$A\omega^2$	0	$-A\omega^2$	0

Graph:



a. Variation of displacement with time
b. Variation of velocity with time
c. Variation of acceleration with time

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. i. **Inductive reactance:** The opposing nature of an inductor to the flow of alternating current is called inductive reactance.
   Formula : $X_L=\omega L=2\pi fL$.
   Where $f=$ frequency of AC supply
   ii. **Capacitive reactance:** The capacitive reactance of a capacitor is defined as the ratio of r.m.s voltage (e.m.f) across the capacitor to the corresponding r.m.s current.
   Formula : $X_C=\frac{1}{\omega C}=\frac{1}{2\pi fC}$
10. $v_{\max}=\omega A$ and $a_{\max}=\omega^2 A$
   $\therefore\frac{a_{\max}}{v_{\max}}=\frac{\omega^2 A}{\omega A}=\omega$
   $\therefore\frac{0.32}{0.08}=\frac{2\pi}{T}$
   $\therefore T=\frac{\pi}{2}=\frac{3.142}{2}=1.571\ s$
11. 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),

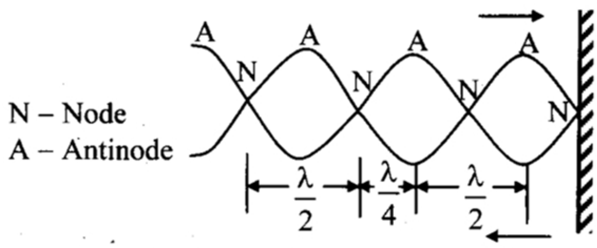
$y = A\sin(2\pi nt)$

$\therefore y = A\sin\omega t \ \ldots(\because \omega = 2\pi n)$

This is the equation of a stationary wave which gives resultant displacement due to two simple harmonic progressive waves.

ii.

Position of Nodes and Antinodes:



Position and displacement of nodes and antinodes in a stationary wave

12. Given: $m_1 = 1\ kg,\ T_1 = 300\ K,\ K_1 = 2.5 \times 10^6\ J$,

$m_2 = 4\ kg,\ T_2 = 600\ K, M_1 = 28, M_2 = 32$

To find: Kinetic energy (K_2)

Formula: $K = \frac{3}{2}\frac{mRT}{M}$

Calculation: From formula,

$K_1 = \frac{3}{2}\left(\frac{1\times R\times 300}{28}\right)$

$K_2 = \frac{3}{2}\left(\frac{4\times R\times 600}{32}\right)$

$\therefore \frac{K_1}{K_2} = \frac{4\times 600}{32} \times \frac{28}{300}$

$K_2 = \frac{224}{32} \times 2.5 \times 10^6$

$K_2 = 7 \times 2.5 \times 10^6$

$K_2 = 17.5 \times 10^6 J$

The kinetic energy of 4 kg oxygen at 600 K is $17.5 \times 10^6\ J$.

13. Given: $G = 500\Omega, R_{eq.} = 21\Omega$

To find: Shunt resistance (S)

Formula: $\frac{1}{R_{eq}} = \frac{1}{G} + \frac{1}{S}$

Calculation: From formula,

$\frac{1}{S} = \frac{1}{R_{eq}} - \frac{1}{G}$

$= \frac{G - R_{eq}}{R_{eq}\times G}$

$\therefore\ S = \frac{R_{eq}\times G}{G - R_{eq}}$

$= \frac{21\times 500}{500-21}$

$= \frac{10500}{479}$

$= \text{antilog}\{\log(10500) - \log(479)\}$

$= \text{antilog}\{4.0212 - 2.6803\}$

$= \text{antilog}\{1.3409\}$

$\therefore S = 21.93\Omega$

The value of shunt resistance is 21.93Ω.

14. Given:

$r = 0.5\overset{\circ}{A} = 0.5 \times 10^{-10}\ m = 5 \times 10^{-11}\ m$

To find: Period of revolution (T)

Formula: $T = \frac{2\pi r}{v}$

Calculation: Using formula (i) we get,

$T = \frac{2\times 3.14\times 5\times 10^{-11}}{2.24\times 10^{6}}$

$= \frac{31.4}{2.24} \times 10^{-17}$

$= 14.02 \times 10^{-17}$

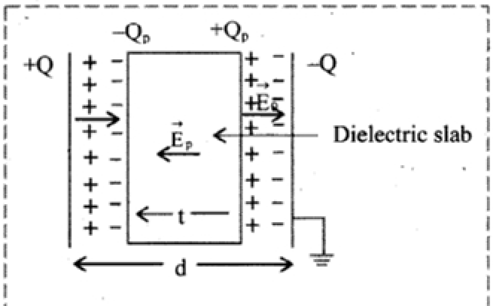
$\therefore T = 1.402 \times 10^{-16}\ s$

Period of revolution of electron in the first Bohr orbit is $1.402 \times 10^{-16} s$.

Section C

15. Conditions for obtaining sharp and steady interference pattern are:

   i. The two sources of light must be coherent.
   ii. The two sources of light must be monochromatic.
   iii. The two interfering waves must have the same amplitude.
   iv. The separation between the two slits (d) must be small in comparison to the distance between the plane containing the slits and the observing screen (D).
   v. The two slits should be narrow.
   vi. The two waves should be in the same state of polarization if polarized light is used for the experiment.

16. 

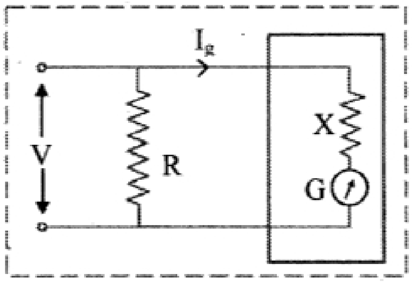
Parallel plate capacitor with a dielectric slab between the

17. i. The ratio of magnetic dipole moment with angular momentum of revolving electron is called the gyromagnetic ratio.
   ii. Gyromagnetic ratio is given by, $\frac{m_{\text{otb}}}{L} = \frac{e}{2m_e}$

18. The phenomenon of emission of electrons from a metal surface, when radiation of appropriate frequency is incident on it, is known as photoelectric effect.

   i. If increasingly negative potentials were applied to the collector in experiment of photoelectric effect, the photocurrent decreases and for some typical value $(-V_0)$, photocurrent becomes zero. This value of V_0 is termed as cut-off or stopping potential.
   ii. The minimum amount of energy required to be provided to an electron to pull it out of the metal from the surface is called the work function of the metal.

19. i. To use a M.C.G as a voltmeter, a high resistance is connected in series with the M.C.G.
   ii. A very high resistance X is connected in series with the galvanometer for this purpose as shown in figure.



   iii. If V is the voltage to be measured, then

$V = I_g X + I_g G$

$\therefore I_g X = V - I_g G$

$\therefore X=\frac{V}{I_g}-G$ ...(1)

where I_g is the current flowing through the galvanometer.

iv. If voltage V is n_v times voltage V_g (voltage across galvanometer) then,

$V=n_v V_g=n_v\left(I_g G\right)$

Using this in equation (1),

$X=G\left(n_v-1\right)$.

20. i. Equation of simple harmonic progressive wave travelling along the positive X -direction is given by,

$y(x,t)=A\sin(kx-\omega t)$

where, $A=$ amplitude of the wave,

$\omega=$ angular frequency,

$t=$ instant time,

$k=$ wave number.

ii. Different forms of equation of simple harmonic progressive wave:

a. Wave number, $k=\frac{2\pi}{\lambda}$

$\therefore y(x,t)=A\sin\left(\frac{2\pi x}{\lambda}-\omega t\right)$

b. Angular velocity, $\omega=2\pi n$

$\therefore y(x,t)=A\sin\left(\frac{2\pi x}{\lambda}-2\pi nt\right)$

$y(x,t)=A\sin 2\pi\left(\frac{x}{\lambda}-nt\right)$

c. Frequency, $n=\frac{1}{T}$

$y(x,t)=A\sin 2\pi\left(\frac{x}{\lambda}-\frac{t}{T}\right)$

d. Wave frequency, $v=n\lambda=\frac{\lambda}{T}$

$y(x,t)=A\sin\frac{2\pi}{\lambda}(x-vt)$

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: $y=0.05\sin\pi\left(20t-\frac{x}{6}\right)$,

$x=5\ m, t=0.1\ s$

To find: Displacement (y)

Formula: $y=A\sin 2\pi\left(nt-\frac{x}{\lambda}\right)$

Calculation: Comparing with formula,

$y=0.05\sin 2\pi\left(10t-\frac{x}{12}\right)$

$=0.05\sin 2\pi\left(10\times 0.1-\frac{5}{12}\right)$

$=0.05\sin 2\pi\left(1-\frac{5}{12}\right)$

$=0.05\sin 2\pi\times\frac{7}{12}$

$=0.05\sin\frac{7\pi}{6}$

$=0.05\left(\frac{-1}{2}\right)$

$=-0.025\ m$

The displacement of the particle from origin is $-0.025m$.

23. Given: $\lambda=4800\overset{o}{A}=4.8\times 10^{-7}\ m,\ \ d=3\ mm=3\times 10^{-3}\ m,\ D=20+80=100\ cm=1\ m$

To find: Distance between 5$^{\text{th}}$ bright band on one side and 5$^{\text{th}}$ dark band on the other side of the central bright band, $\left(y_5+y_5'\right)$

Formulae:

i. For n^{th} bright band, $y_n=\frac{n\lambda D}{d}$

ii. For n^{th} dark band, $y_n' = (2n-1)\frac{\lambda D}{2d}$

Calculation: From formula (i),

$y_5 = \frac{5\lambda D}{d} = \frac{5\times4.8\times10^{-7}\times1}{3\times10^{-3}} = 8\times10^{-4}\ m$

From formula (ii),

$y_5' = (2\times5-1)\frac{\lambda D}{2\ d} = \frac{9}{2}\frac{\lambda D}{d} = \frac{9}{2}\times\frac{4.8\times10^{-7}\times1}{3\times10^{-3}} = 7.2\times10^{-4}\ m$

$\therefore y_5 + y_5' = 8\times10^{-4}\ m + 7.2\times10^{-4}\ m = 15.2\times10^{-4}\ m$

The distance between 5^{th} bright band on one side and 5^h dark band on the other side of the central bright band is $15.2\times10^{-4}\ m.$

24. Given: $A = 1.6\ cm^2 = 1.6\times10^{-4}\ m^2,\quad B = 2\ N/Am, \tau = 0.02Nm, I = 1.25\ A$

Since the axis of the coil is kept inclined at 30° with the direction of uniform magnetic field, $\theta = 90^\circ - 30^\circ = 60^\circ$

To find: Number of turns (n)

Formula: $\tau = nIAB\sin\theta$

Calculation: From formula,

$n = \frac{\tau}{IAB\sin\theta} = \frac{0.02}{1.25\times1.6\times10^{-4}\times2\times\sin(60^\circ)} = \frac{0.02}{1.25\times1.6\times10^{-4}\times2\times\left(\frac{\sqrt{3}}{2}\right)}$

$= \frac{0.02\times10^4}{1.25\times1.6\times1.732} = \frac{200}{2\times1.732} = \frac{1}{1.732}\times100$

Using reciprocal table.

$\therefore n = 57.73 \approx 58$

Number of turns in coil are around **58**.

25. The alternating voltage is given by,

$e = 8\sin 628.4t$

i. On comparing with $e = e_0\sin\omega t$, we get $e_0 = 8\ V$

ii. $\omega = 628.4 rad/s$

$\therefore$ Frequency, $f = \frac{\omega}{2\pi} = \frac{628.4}{2\times3.142} = 100Hz$

iii. At $t = 10\ ms = 10^{-2}\ s$,

$e = 8\sin\left(628.4\times10^{-2}\right)$

$= 8\sin\left(\frac{200\times\pi}{100}\right)$

$= 8\sin(2\pi)$

$= 0\ V$

(i) The peak value of emf is 8 V.

(ii) The frequency of emf is 100 Hz.

(iii) The instantaneous value of emf at t = 10rns is 0 V.

26. Given: $R_H = 1.097\times10^7\ m^{-1}$, We know that, for Balmer series, $n = 2$

To find:

i. Wavelength of first line of Balmer series

ii. Wavelength of second line of Balmer series

Formula: For Balmer series, $\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{m^2}\right)$

Calculation:

i. For first line in Balmer series, $m = 3$

$\therefore$ From formula,

$\frac{1}{\lambda} = 1.097\times10^7\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = 1.097\times10^7\times\left(\frac{5}{4\times9}\right) = 1.524\times10^6\ m^{-1}$

Using reciprocal table,

$\lambda = 6.563\times10^{-7}\ m = 6563\mathring{A}$

ii. For second line in Balmer series, $m = 4$

$\therefore$ From formula,

$\frac{1}{\lambda} = 1.097\times10^7\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = 1.097\times10^7\times\left(\frac{12}{4\times16}\right) = 0.2057\times10^7\ m^{-1}$

Using reciprocal table,

$\lambda = 4.862\times10^{-7}\ m = 4862\mathring{A}$

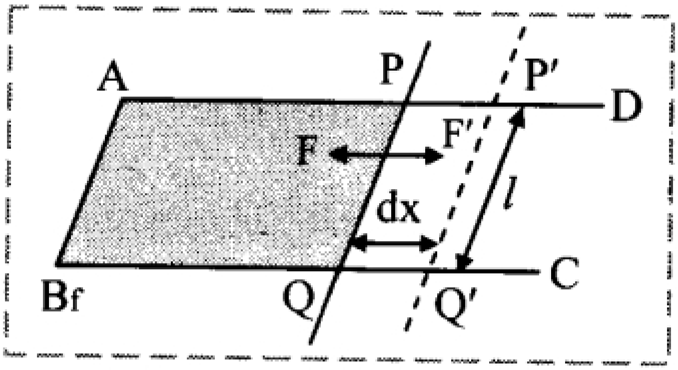
i. The wavelength of the first line of the Balmer series is $6563\overset{\circ}{A}$.

ii. The wavelength of the second line of the Balmer series is $4862\overset{\circ}{A}$.

Section D

27. The extra energy of the molecules on the surface layer of a liquid is called surface energy of the liquid.
Relation between surface tension and surface energy per unit area:

1. Let $ABCD$ be a rectangular frame of wire, fitted with a movable arm PQ.



2. The frame held in horizontal position is dipped into soap solution and taken out so that a soap film APQB is formed. Due to surface tension of soap solution, a force ' F ' will act on each arm of the frame. Under the action of this force, the movable arm PQ moves towards AB.
3. Magnitude of force due to surface tension is,
$F = 2\,Tl\ldots\ldots[\because T = F/l]$
(A factor of 2 appears because soap film has two surfaces which are in contact with wire.)
4. Let the wire PQ be pulled outwards through a small distance ' dx ' to the position $P'Q'$, by applying an external force F' isothermally, which is equal and opposite to F. Work done by this force, $dW = F'dx = 2T/dx$.
5. But, $2ldx = dA =$ increase in area of two surfaces of film.
$\therefore dW = TdA$
6. This work done in stretching the film is stored in the area dA in the form of potential energy (surface energy).
$\therefore$ Surface energy, $E = TdA$
$\therefore \frac{E}{dA} = T$
Hence, surface tension = surface energy per unit area.
7. Thus, surface tension is equal to the mechanical work done per unit surface area of the liquid, which is also called as surface energy.

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) Given: $l = 60\ m, B = 6 \times 10^{-5}\ T, v = 500\ m/s$
To find: Induced emf (e)
Formula: $e = B/v$
Calculation: From formula
$e = 6 \times 10^{-5} \times 60 \times 500$
$= 180000 \times 10^{-5} = 1.8\ V$
Induced emf between tips of wings is **1.8 V.**

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: $W = -104\ J, Q = -125\ kJ = -125000\ J$

To find: Change in internal energy $(\Delta \mathrm{U})$

Formula: $\Delta \mathrm{U} = |\mathrm{Q}| - |\mathrm{W}|$

Calculation: From formula,

$\Delta U = |Q| - |W|$

$\therefore \Delta U = (125000 - 104) J = 124896\ J$

= 124.896 kJ

Change in internal energy is 124.896 kJ.

30. Answer:

(i) **Definition:** A body, which absorbs the entire radiant energy incident on it, is called an ideal or perfect blackbody. Ferry's perfectly blackbody consists of a double walled hollow sphere having tiny hole or aperture, through which radiant heat can enter.

(ii) Given: $R = 8320\ J/k$ mole $K, M_0 = 40$,

$T = 127^{\circ} C = 127 + 273 = 400\ K$

To find: Kinetic energy (K.E)

Formula: $K \cdot E/kg = \frac{3}{2} \frac{RT}{M_0}$

Calculation: From formula,

$K.E/kg = \frac{3}{2} \times \frac{8320 \times 400}{40}$

$= 1.248 \times 10^5\ J$

$\therefore$ K.E for 10 gram $= 1248 J$ of Argon

The kinetic energy of 10 grams of Argon molecules at $127^{\circ} C$ is $1248\ J$.

31. Given:

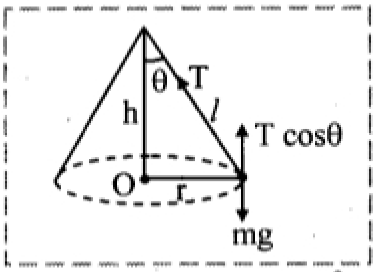
$l = 120\ cm = 1.2\ m, r = 0.2\ m$

$m = 150\ g = 0.15\ kg$

To find: Tension in the string (T).

Formula: Tension, $T = \frac{mg}{\cos\theta}$

Calculation:



By Pythagoras theorem, $l^2 = r^2 + h^2$

$\therefore h^2 = (1.2)^2 - (0.2)^2 = 1.4$

$\therefore h = 1.183\ m$

The weight of bob is balanced by vertical component of tension T.

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

From figure,

$\cos\theta = \frac{h}{l}$

$\therefore \cos^2\theta = \frac{h^2}{l^2} = \frac{h^2}{r^2+h^2}$

$\cos\theta = \frac{h}{\sqrt{r^2+h^2}}$

$\therefore$ Substituting in formula,

$T = \frac{mg\sqrt{r^2+h^2}}{h}$

$= mg\sqrt{\left(\frac{r}{h}\right)^2 + 1}$

$= 0.15 \times 9.8 \times \sqrt{1 + \left(\frac{0.04}{1.4}\right)}$

$= 0.15 \times 9.8 \times \sqrt{\frac{36}{35}} = 1.47 \times \frac{6}{\sqrt{35}}$

$= \text{antilog}\left[\log(1.47) + \log(6) - \frac{1}{2}\log(35)\right]$

$= \text{antilog}\left[0.1673 + 0.7781 - \frac{1}{2} \times 1.5440\right]$

$=$ antilog $[0.1734]$

$= 1.491\ N$

Tension in the string is **1.491 N.**