JEE MAIN 2024
Paper with Solution

PHYSICS | 27th January 2024 _ Shift-2

SECTION – A

31. The equation of state of a real gas is given by $\left(P+\frac{a}{V^2}\right)(V-b)=RT,$ where P, V and T are pressure, volume and temperature respectively and R is the universal gas constant. The dimensions of $\frac{a}{b^2}$ is similar to that of:

(1) PV (2) P (3) RT (4) R

Sol. **2**

$\left(P+\frac{a}{v^2}\right)(v-b)=RT$

dimension $[P]=\frac{[a]}{[v^2]} \Rightarrow [a]=[P]\quad[v^2]$

also, $[v]=[b]$

So, dimension of $\frac{a}{b^2}=\frac{[a]}{[b^2]}=\frac{[P][v^2]}{[v^2]}=[P]$

32. Wheatstone bridge principle is used to measure the specific resistance (S_1) of given wire, having length L, radius r. If X is the resistance of wire, then specific resistance is; $S_1=X\left(\frac{\pi r^2}{L}\right)$. If the length of the wire gets doubled then the value of specific resistance will be:

(1) $\frac{S_1}{4}$ (2) $2S_1$ (3) $\frac{S_1}{2}$ (4) S_1

Sol. **4**

As specific resistance only depends on material so it remain same

33. Given below are two statements; one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): The angular speed of the moon in its orbit about the earth is more than the angular speed of the earth in its orbit about the sun.

Reasons (R): The moon takes less time to move around the earth than the time taken by the earth to move around the sun.

In the light of the above statements, choose the most appropriate answer from the options given below:

(1) (A) is correct but (R) is not correct

(2) Both (A) and (R) are correct and (R) is the correct explanation of (A)

(3) Both (A) and (R) are correct but (R) is not the correct explanation of (A)

(4) (A) is not correct but (R) is correct

Sol. **2**

Angular speed $\omega=\frac{2\pi}{T}$

The period of moon is smaller than time period of earth

So, $\omega_{moon}>\omega_{earth}$

34. Given below are two statements:

Statement (I): The limiting force of static friction depends on the area of contact and independent of materials.

Statement (II): The limiting force of kinetic friction is independent of the area of contact and depends on materials.

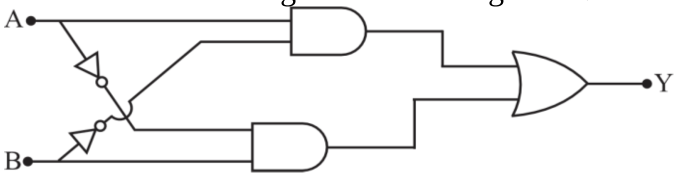
In the light of the above statements, choose the most appropriate answer from the options given below:

(1) Statement I is correct but Statement II is incorrect
(2) Statement I is incorrect but Statement II is correct
(3) Both Statement I and Statement II are incorrect
(4) Both Statement I and Statement II are correct

Sol. 2

Static friction and kinetic friction depend on material and are independent of area of contact.

35. The truth table of the given circuit diagram is:



(1)

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

(2)

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

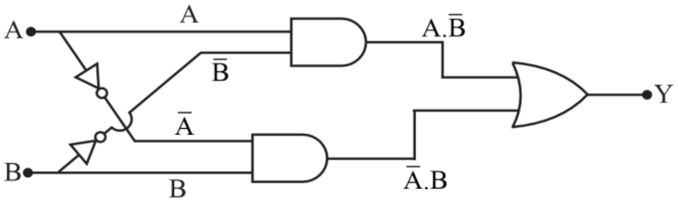
(3)

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

(4)

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Sol. 2



$Y = A.\bar{B} + \bar{A}.B$

So, the truth table is of XOR gate

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

36. A current of 200 μA deflects the coil of a moving coil galvanometer through 60°. The current to cause deflection through $\frac{\pi}{10}$ radian is:

(1) 30 μA (2) 120 μA (3) 60 μA (4) 180 μA

Sol. 3

As deflection $\phi \propto$ current I

$$\Rightarrow \frac{i_2}{i_1} = \frac{\phi_2}{\phi_1}$$

$$i_2 = \left(\frac{180°/10°}{60°}\right) 200\mu A = 60\mu A$$

37. The atomic mass of ${}_6C^{12}$ is 12.000000 u and that of ${}_6C^{13}$ is 13.003354 μ. The required energy to remove a neutron of ${}_6C^{13}$, if mass of neutron is 1.008665 u, will be:

(1) 62.5 MeV (2) 6.25 MeV (3) 4.95 MeV (4) 49.5 MeV

Sol. **3**

${}^{13}_{6}C \longrightarrow {}^{12}_{6}C + D + \theta$

$Q = \left[\text{ mass of } {}^{13}_{6}C - \text{ mass of } {}^{12}_{6}C - \text{ mass of neutron } \right]c^2$

$Q = [13.003354 - 12 - 1.008665][931.5\text{Mev}]$

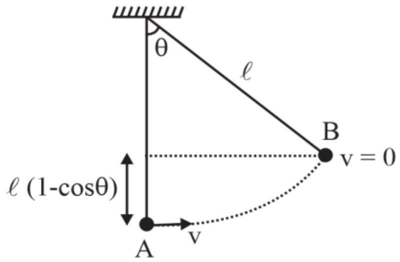
Q = –4.95 MeV

⇒ Energy required is 4.95 MeV

38. A ball suspended by a thread swings in a vertical plane so that its magnitude of acceleration in the extreme position and lowest position are equal. The angle (θ) of thread deflection in the extreme position will be:

(1) $\tan^{-1}(\sqrt{2})$ (2) $2\tan^{-1}\left(\frac{1}{2}\right)$ (3) $\tan^{-1}\left(\frac{1}{2}\right)$ (4) $2\tan^{-1}\left(\frac{1}{\sqrt{5}}\right)$

Sol. **2**



By energy conservation

$\frac{1}{2}mv^2 + 0 = 0 + mg\ell(1 - \cos\theta)$

$\Rightarrow v^2 = 2g\ell(1 - \cos\theta)$

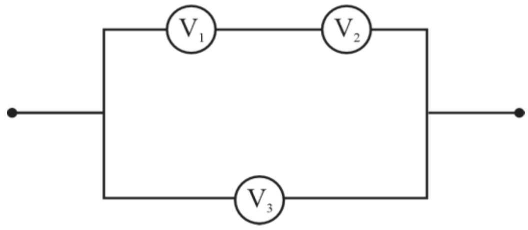
Given, $a_A = a_B$

$\frac{v^2}{\ell} = g\sin\theta$

$2g(1-\cos\theta) = g\sin\theta \Rightarrow 2\left(2\sin^2\frac{\theta}{2}\right) = 2\sin\frac{\theta}{2}\cos\frac{\theta}{2}$

$\tan\frac{\theta}{2} = \frac{1}{2} \Rightarrow \theta = 2\tan^{-1}\frac{1}{2}$

39. Three voltmeters, all having different internal resistances are joined as shown in figure. When some potential difference is applied across A and B, their readings are V_1, V_2 and V_3. Choose the correct option.



(1) $V_1 = V_2$ (2) $V_1 \neq V_3 - V_2$ (3) $V_1 + V_2 > V_3$ (4) $V_1 + V_2 = V_3$

Sol. **4**

as $v_1 + v_2$ is parallel with v_3

So, $v_1 + v_2 = v_3$

40. The total kinetic energy of 1 mole of oxygen at 27°C is:

[Use universal gas constant (R) = 8.31 J/mole K]

(1) 6845.5 J (2) 5942.0 J (3) 6232.5 J (4) 5670.5 J

Sol. **3**

Totat K.E. = $\frac{nfRT}{2} = \frac{1\times 5\times 8.314\times 300}{2} \approx 6235.5\,J$

41. Given below are two statements; one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): In Vernier Calliper if positive zero error exists, then while taking measurements, the reading taken will be more than the actual reading.

Reasons (R): The zero error in Vernier Calliper might have happened due to manufacturing defect or due to rough handling.

In the light of the above statements, choose the most appropriate answer from the options given below:

(1) Both (A) and (R) are correct and (R) is the correct explanation of (A)

(2) Both (A) and (R) are correct but (R) is not the correct explanation of (A)

(3) (A) is true but (R) is false

(4) (A) is false but (R) is true

Sol. **2**

Actual reading = observed reading – zero error

$\Rightarrow$ observed reading > actual reading

42. Primary side of a transformer is connected to 230 V, 50 Hz supply. Turns ratio of primary to secondary winding is 10:1. Load resistance connected to secondary side is 46Ω. The power consumed in it is :

(1) 12.5 W (2) 10.0 W (3) 11.5 W (4) 12.0 W

Sol. **3**

As $\frac{V_2}{V_1} = \frac{N_2}{N_1} \Rightarrow \frac{V_2}{230} = \frac{1}{10} \Rightarrow V_2 = 23$ Volt

Power $= \frac{V^2}{R} = \frac{(23)^2}{46} = \frac{23}{2} = 11.5W$

43. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio of $\frac{C_p}{C_v}$ for the gas is:

(1) $\frac{5}{3}$ (2) $\frac{3}{2}$ (3) $\frac{7}{5}$ (4) $\frac{9}{7}$

Sol. **2**

Given $P \propto T^3 \Rightarrow P \propto \left(\frac{PV}{nR}\right)^3$

$\Rightarrow P^2V^3$ = constant

$\Rightarrow PV^{3/2}$ = constant

for adiabatic PV^γ = constant

$\Rightarrow \gamma = \frac{C_p}{C_v} = \frac{3}{2}$

44. The threshold frequency of a metal with work function 6.63 eV is:
(1) 16×10^{15} Hz (2) 16×10^{12} Hz (3) 1.6×10^{12} Hz (4) 1.6×10^{15} Hz

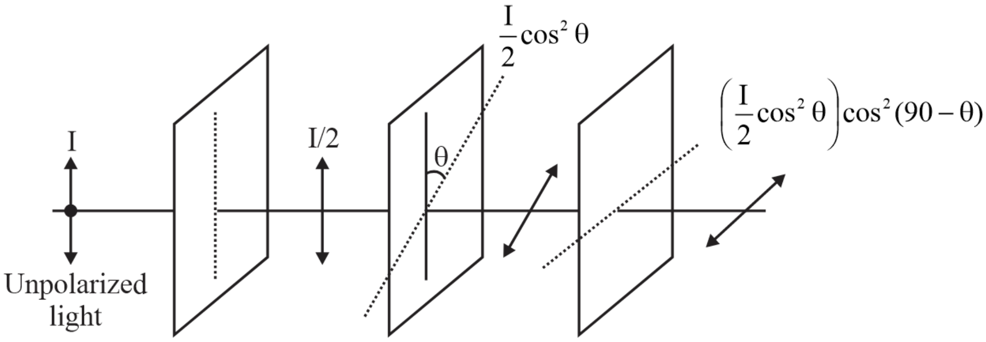
Sol. **4**
work function $\phi = h\nu_{th}$
$$\nu_{th} = \frac{\phi}{h} = \frac{6.63 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-34}} = 1.6 \times 10^{15} \text{ Hz}$$

45. Given below are two statements; one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The property of body, by virtue of which it tends to regain its original shape when the external force is removed, is Elasticity.
Reasons (R): The restoring force depends upon the bonded inter atomic and inter molecular force of solid.
In the light of the above statements, choose the most appropriate answer from the options given below:
(1) (A) is false but (R) is true
(2) (A) is true but (R) is false
(3) Both (A) and (R) are true and (R) is the correct explanation of (A)
(4) Both (A) and (R) are true but (R) is not the correct explanation of (A)

Sol. **3**
by definition of elasticity

46. When a polaroid sheet is rotated between two crossed polaroids then the transmitted light intensity will be maximum for a rotation of:
(1) 60° (2) 30° (3) 90° (4) 45°

Sol. **4**



find output = $\frac{I}{2}\cos^2\theta \sin^2\theta = \frac{I}{8}(\sin 2\theta)^2$
Clearly output is maximum for θ = 45°

47. An object is placed in a medium of refractive index 3. An electromagnetic wave of intensity 6×10^8 W/m^2 falls normally on the object and it is absorbed completely. The radiation pressure on the object would be (speed of light in free space = 3×10^8 m/s)
(1) 36 Nm^{-2} (2) 18 Nm^{-2} (3) 6 Nm^{-2} (4) 2 Nm^{-2}

Sol. **3**

radiation pressure is given as

$$P = \frac{I}{v}(1+r)$$

here $r = 0 \Rightarrow P = \frac{I}{v} = \frac{6\times10^8}{\frac{3\times10^8}{3}}$ $\left(v = \frac{c}{n}\right)$

$\Rightarrow P = 6\ N/m^2$

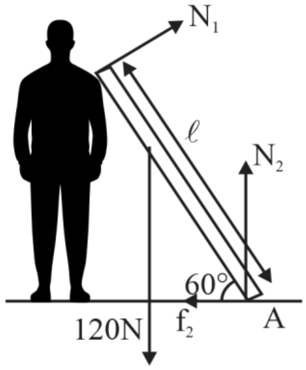
48. Given below are two statements; one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Work done by electric field on moving a positive charge on an equipotential surface is always zero.
Reasons (R): Electric lines of forces are always perpendicular to equipotential surfaces.
In the light of the above statements, choose the most appropriate answer fro the options given below:
(1) Both (A) and (R) are correct and (R) is the correct explanation of (A)
(2) (A) is correct but (R) is not correct
(3) (A) is not correct but (R) is correct
(4) Both (A) and (R) are correct but (R) is not the correct explanation of (A)

Sol. **4**

As electric field and electric force on charge is perpendicular to the equipotential surface. So work done by electric force is zero on moving a charge on equipotential surface.

49. A heavy iron bar of weight 12 kg is having its one end on the ground and the other on the shoulder of a man. The rod makes an angle 60° with the horizontal, the weight experienced by the man is:
(1) 6 kg (2) 12 kg (3) 3 kg (4) $6\sqrt{3}$ kg

Sol. **3**

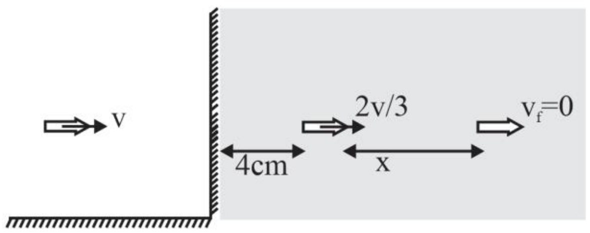


As rod is in equilibrium, net torque on it about point A is zero

$$\tau_A = 0 = (120)\ \frac{\ell}{2}\cos 60° - N_1\ \ell \Rightarrow N_1 = 30N = 3\ kg.f$$

50. A bullet is fired into a fixed target looses one third of its velocity after travelling 4cm. It penetrates further $D \times 10^{-3}$ m before coming to rest. The value of D is:
(1) 2 (2) 5 (3) 3 (4) 4

Sol. **Bonus**



Let resistive force acting on bullet remain same

$\Rightarrow$ retardation is uniform

by $v^2 = u^2 + 2as \rightarrow \left(\frac{2v}{3}\right)^2 = v^2 - 2a(4\,cm) \Rightarrow 2a(4\,cm) = \frac{5v^2}{9}$

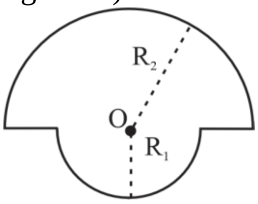
also, $O^2 = \left(\frac{2v}{3}\right)^2 - 2ax$

$2ax = \frac{4v^2}{9} = 4\left[\frac{2a(4cm)}{5}\right]$

$\Rightarrow x = \frac{16}{5}cm = 3.2\ cm = 32 \times 10^{-3}\ m$

SECTION – B

51. The magnetic field at the centre of a wire loop formed by two semicircular wires of radii $R_1 = 2\pi$ m and $R_2 = 4\pi$ m, carrying current I = 4 A as per figure given below is $\alpha \times 10^{-7}$ T. The value of α is _____. (Centre O is common for all segments)



Sol. **03.00**

$$B = \frac{\mu_0 i}{4R_1} + \frac{\mu_0 i}{4R_2} = \frac{\mu_0 \times 4}{4}\left[\frac{1}{2\pi} + \frac{1}{4\pi}\right] = 3\left(\frac{\mu_0}{4\pi}\right)$$

$= 3 \times 10^{-7}$ T

$\Rightarrow \alpha = 3$

52. Two charges of –4 μC and +4 μC are placed at the points A (1, 0, 4)m and B(2, –1, 5)m located in an electric field $\vec{E} = 0.20\hat{i}\ V/cm$. The magnitude of the torque acting on the dipole is $8\sqrt{\alpha} \times 10^{-5}\ Nm$, where α = _____.

Sol. **2**

dipole moment $\vec{p} = q\vec{a} = 4\mu C(\hat{i} - \hat{j} + \hat{k})$

Torque $= \vec{P} \times \vec{E} = 4\mu C(\hat{i} - \hat{j} + \hat{k}) \times (20\,V/m)\hat{i}$

$\vec{\tau} = 8 \times 10^{-5}\,Nm(\hat{k} + \hat{j}) \Rightarrow |\vec{\tau}| = 8\sqrt{2} \times 10^{-5}\,Nm$

$\Rightarrow \alpha = 2$

53. A closed organ pipe 150 cm long gives 7 beats per second with an open organ pipe of length 350 cm, both vibrating in fundamental mode. The velocity of sound is _____ m/s.

Sol. **294**

$f_1 = \frac{v}{4l_1} = \frac{v}{4(1.5)} = \frac{v}{6}$Hz

$f_2 = \frac{v}{2(3.5)} = \frac{v}{7}$

Clearly $f_1 > f_2$ So beats $7 = f_1 - f_2 = \frac{v}{6} - \frac{v}{7} = \frac{v}{42}$

$\Rightarrow v = 42 \times 7 = 294$ Hz

54. A body falling under gravity covers two points A and B separated by 80 m is 2s. The distance of upper point A from the starting point is _____ m (use $g = 10\ ms^{-2}$)

Sol. **45**

by $S = ut + \frac{1}{2}at^2$

$-x = -\frac{1}{2}gt_1^2$ ($t_1 \rightarrow$ time to travel from O to A)

$\Rightarrow x = 5t_1^2$ ....(i)

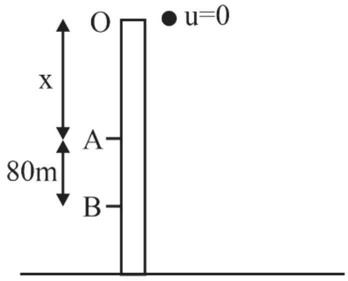
also $-(x + 80) = -\frac{1}{2}g(t_1 + 2)^2$

$\Rightarrow x + 80 = 5(t_1^2 + 4t_1 + 4)$ ....(II)

$\Rightarrow 5t_1^2 + 80 = 5t_1^2 + 20t_1 + 20 \Rightarrow 20t_1 = 60$

$\Rightarrow t_1 = 3$ sec

$\Rightarrow x = 5(3)^2 = 45$ m



55. The reading of pressure metre attached with a closed pipe is $4.5 \times 10^4\ N/m^2$. On opening the value, water starts flowing and the reading of pressure metre falls to $2.0 \times 10^4\ N/m^2$. The velocity of water is found to be $\sqrt{V}\ m/s$. The value of V is ______.

Sol. **50.00**

By bernoullie's equation

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

$$4.5 \times 10^4 + 0 + 0 = 2 \times 10^4 + \frac{1}{2}(1000)v_2^2 + 0$$

$v_2 = \sqrt{50}$ m/s

$\Rightarrow v = 50$

56. A ring and a solid sphere roll down the same inclined plane without slipping. They start from rest. The radii of both bodies are identical and the ratio of their kinetic energies is $\frac{7}{x}$, where x is _____.

Sol. **7 or 10.00**

We assume masses of both objects are same

If we consider total kinetic energy then both objects have same K.E. and equal to mgh

$\Rightarrow \frac{7}{x} = 1 \Rightarrow x = 7$

If we consider only translation K.E. then both have different kinetic energy

$$\text{Translational K.E.} = \frac{1}{\left(1+\frac{K^2}{R^2}\right)} mgh$$

$$\frac{\text{K.E. of Ring}}{\text{K.E. of Solid Sphere}} = \frac{\left(\frac{1}{1+1}\right)mgh}{\left(\frac{1}{1+\frac{2}{5}}\right)mgh} = \frac{7}{10}$$

$\Rightarrow x = 10$

57. A parallel beam of monochromatic light of wavelength 5000 Å is incident normally on a single narrow slit of width 0.001 mm. The light is focused by convex lens on screen, placed on its focal plane. The first minima will be formed for the angle of diffraction of ____ (degree).

Sol. **30.00**

for 1st minima $\sin\theta = \frac{d}{\lambda}$

$$\sin\theta = \frac{0.001\text{mm}}{5000\text{Å}} = \frac{10^{-6}\text{ m}}{5\times10^{-7}\text{ m}} = \frac{1}{2}$$

$\theta = 30°$

58. The electric potential at the surface of an atomic nucleus (z = 50) of radius 9×10^{-13} cm is ____ $\times 10^6$ V.

Sol. **8.00**

We assume positive charge is uniformly distributed in nucleus

charge $q = ze = 50 \times 1.6 \times 10^{-19} = 8 \times 10^{-18}$ C

So, potential $V = \frac{kq}{R} = \frac{9\times10^9\times8\times10^{-18}}{9\times10^{-15}} = 8\times10^6\text{ Volt}$

59. If Rydberg's constant is R, the longest wavelength of radiation in Paschen series will be $\frac{\alpha}{7R}$, where α = _____.

Sol. **144**

Longest wavelength ⇒ smallest energy gap of paschen

⇒ n = 4 to n = 3

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = R\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$$

$$\frac{1}{\lambda} = R\left(\frac{1}{9} - \frac{1}{16}\right) = \frac{7R}{144}$$

$$\lambda = \frac{144}{7R} \Rightarrow \alpha = 144$$

60. A series LCR circuit with $L = \frac{100}{\pi}\text{mH}$, $C = \frac{10^{-3}}{\pi}\text{F}$ and R = 10Ω, is connected across an ac source of 220 V, 50 Hz supply. The power factor of the circuit would be ______.

Sol. **01.00**

$\omega = 2\pi f = 2\pi(50) = 100\pi$ rad/sec.

$$X_L = \omega L = (100\pi)\left(\frac{100}{\pi}\text{mH}\right) = 10\Omega$$

$$X_c = \frac{1}{\omega C} = \frac{1}{(100\pi)\left(\frac{10^{-3}}{\pi}\right)} = 10\Omega$$

net reactance of circuit $X = X_L - X_C = 10 - 10 = 0$

⇒ Circuit become purely resistive

⇒ Power factor = $\cos\phi = 1$


JEE Main + Advanced 2024
की तैयारी में रह रही है कमी?
Join
उत्थान
Crash Course
STARTING FROM
7th Feb'24
OFFLINE
Rs. 9999
ONLINE
Rs. 4999


JEE Main 2024 Session 1
की तैयारी में रह रही है कमी?
Join
उन्नति
Crash Course
STARTING FROM
7th Feb'24
OFFLINE
Rs. 6999
ONLINE
Rs. 3499