JEE (Main) PHYSICS SOLVED PAPER

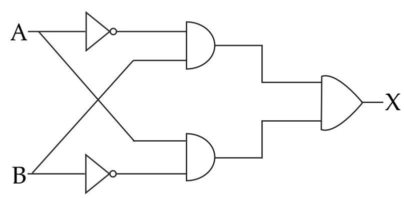
2023
29th Jan Shift 2

Section A

Q. 1. Substance A has atomic mass number 16 and half-life of 1 day. Another substance B has atomic mass number 32 and half-life of $\frac{1}{2}$ day. If both A and B simultaneously start undergo radio activity at the same time with initial mass 320 g each, how many total atoms of A and B combined would be left after 2 days?

(1) 3.38×10^{24} **(2)** 1.69×10^{24}
(3) 6.76×10^{24} **(4)** 6.76×10^{23}

Q. 2. For the given logic gates combination, the correct truth table will be



(1)

A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

(2)

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

(3)

A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

(4)

A	B	X
0	0	1
0	1	0
1	0	1
1	1	0

Q. 3. The time taken by an object to slide down 45° rough inclined plane is n times as it takes to slide down a perfectly smooth 45° incline plane. The coefficient of kinetic friction between the object and the incline plane is:

(1) $\sqrt{1-\frac{1}{n^2}}$ **(2)** $1+\frac{1}{n^2}$ **(3)** $1-\frac{1}{n^2}$ **(4)** $\sqrt{\frac{1}{1-n^2}}$

Q. 4. Heat energy of 184 kJ is given to ice of mass 600 g at -12°C. Specific heat of ice is 2222.3 J kg^{-1} C^{-1} and latent heat of ice is 336 kJ kg^{-1}

A. Final temperature of system will be 0°C.
B. Final temperature of the system will be greater than 0°C.
C. The final system will have a mixture of ice and water in the ratio of 5 : 1.
D. The final system will have a mixture of ice and water in the ratio of 1 : 5.
E. The final system will have water only.

Choose the correct answer from the options given below:

(1) A and D Only **(2)** A and E Only
(3) A and C Only **(4)** B and D Only

Q. 5. Identify the correct statements from the following:

A. Work done by a man in lifting a bucket out of a well by means of a rope tied to the bucket is negative.
B. Work done by gravitational force in lifting a bucket out of a well by a rope tied to the bucket is negative.
C. Work done by friction on a body sliding down an inclined plane is positive.
D. Work done by an applied force on a body moving on a rough horizontal plane with uniform velocity is zero.
E. Work done by the air resistance on an oscillating pendulum is negative.

Choose the correct answer from the options given below:

(1) B, D and E only **(2)** A and C Only
(3) B and D only **(4)** B and E only

Q. 6. A scientist is observing a bacteria through a compound microscope. For better analysis and to improve its resolving power should. (Select the best option)

(1) Increase the refractive index of the medium between the object and objective lens
(2) Decrease the diameter of the objective lens
(3) Increase the wave length of the light
(4) Decrease the focal length of the eyepiece.

Q. 7. With the help of potentiometer, we can determine the value of emf of a given cell. The sensitivity of the potentiometer is

(A) directly proportional to the length of the potentiometer wire
(B) directly proportional to the potential gradient of the wire
(C) inversely proportional to the potential gradient of the wire
(D) inversely proportional to the length of the potentiometer wire

Choose the correct option for the above statements:

(1) A only **(2)** C only
(3) A and C only **(4)** B and D only

Q. 8. A force acts for 20 s on a body of mass 20 kg, starting from rest, after which the force ceases and then body describes 50 m in the next 10 s. The value of force will be:

(1) 40 N **(2)** 5 N **(3)** 20 N **(4)** 10 N

Q. 9. The modulation index for an A.M. wave having maximum and minimum peak to peak voltages of 14 m V and 6 m V respectively is:

(1) 0.4 **(2)** 0.6 **(3)** 0.2 **(4)** 1.4

Q. 10. Given below are two statements:

Statement I: Electromagnetic waves are not deflected by electric and magnetic field.

Statement II: The amplitude of electric field and the magnetic field in electromagnetic waves are related to each other as $E_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} B_0$

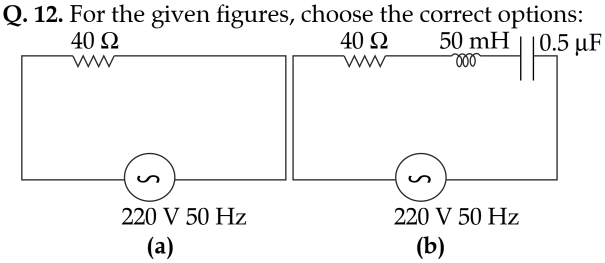
In the light of the above statements, choose the correct answer from the options given below:

(1) Statement I is true but statement II is false
(2) Both Statement I and Statement II are false
(3) Statement I is false but statement II is true
(4) Both Statement I and Statement II are true

Q. 11. A square loop of area 25 cm^2 has a resistance of 10 Ω. The loop is placed in uniform magnetic field of magnitude 40.0 T. The plane of loop is perpendicular to the magnetic field. The work done in pulling the loop out of the magnetic field slowly and uniformly in 1.0 s, will be

(1) 1.0×10^{-3} J **(2)** 2.5×10^{-3} J
(3) 5×10^{-3} J **(4)** 1.0×10^{-4} J

Q. 12. For the given figures, choose the correct options:



(1) At resonance, current in (b) is less than that in (a)
(2) The rms current in circuit (b) can never be larger than that in (a)
(3) The rms current in figure(a) is always equal to that in figure (b)
(4) The rms current in circuit (b) can be larger than that in (a)

Q. 13. A fully loaded boeing aircraft has a mass of 5.4×10^5 kg. Its total wing area is 500 m^2. It is in level flight with a speed of 1080 km h^{-1}. If the density of air ρ is 1.2 kg m^{-3}, the fractional increase in the speed of the air on the upper surface of the wing relative to the lower surface in percentage will be. (g = 10 m s^{-2}):

(1) 16 **(2)** 10 **(3)** 8 **(4)** 6

Q. 14. The ratio of de-Broglie wavelength of an α-particle and a proton accelerated from rest by the same potential is $\frac{1}{\sqrt{m}}$, the value of m is:

(1) 16 **(2)** 4 **(3)** 2 **(4)** 8

Q. 15. The time period of a satellite of earth is 24 hours. If the separation between the earth and the satellite is decreased to one fourth of the previous value, then its new time period will become.

(1) 4 hours **(2)** 6 hours
(3) 3 hours **(4)** 12 hours

Q. 16. The electric current in a circular coil of four turns produces a magnetic induction of 32 T at its centre. The coil is unwounded and is rewounded into a circular coil of single turn, the magnetic induction at the centre of the coil by the same current will be:

(1) 16 T **(2)** 2 T **(3)** 8 T **(4)** 4 T

Q. 17. A point charge 2×10^{-2} C is moved from P to S in a uniform electric field of 30 NC^{-1} directed along positive x-axis. If co-ordinates of P and S are (1, 2, 0) m and (0, 0, 0) m respectively, the work done by electric field will be:

(1) 1200 m J **(2)** −1200 m J
(3) −600 m J **(4)** 600 m J

Q. 18. An object moves at a constant speed along a circular path in a horizontal plane with centre at the origin. When the object is at = + 2 m, its velocity is $-4j$ m/s. The object's velocity (v) and acceleration (a) at $x = -2$ m will be:

(1) $v = -4\hat{i}\frac{m}{s}, a = -8\hat{j}\, m/s^2$

(2) $v = -4\hat{i}\frac{m}{s}, a = 8\hat{j}\, m/s^2$

(3) $v = 4\hat{j}\frac{m}{s}, a = 8\hat{i}\, m/s^2$

(4) $v = -4\hat{j}\frac{m}{s}, a = 8\hat{i}\, m/s^2$

Q. 19. At 300 K the rms speed of oxygen molecules is $\sqrt{\frac{\alpha + 5\alpha}{\alpha}}$ times to that of its average speed in the gas. Then, the value of α will be (use $\pi = \frac{22}{7}$)

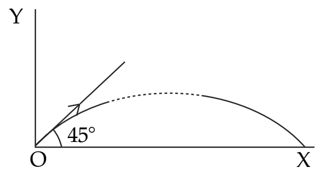
(1) 28 **(2)** 24 **(3)** 32 **(4)** 27

Q. 20. The equation of a circle is given by $x^2 + y^2 = a^2$, where a is the radius. If the equation is modified to change the origin other than (0, 0), then find out the correct dimensions of A and B in a new equation: $(x - At)^2 + \left(y - \frac{t}{B}\right)^2 = a^2$. The dimensions of t is given as $[T^{-1}]$.

(1) $A = [LT], B = [L^{-1}T^{-1}]$
(2) $A = [L^{-1}T^{-1}], B = [LT]$
(3) $A = [L^{-1}T], B = [LT^{-1}]$
(4) $A = [L^{-1}T^{-1}], B = [LT^{-1}]$

Section B

Q. 21. A particle of mass 100 g is projected at time $t = 0$ with a speed 20 m s^{-1} at an angle 45° to the horizontal as given in the figure. The magnitude of the angular momentum of the particle about the starting point at time t = 2 s is found to be $\sqrt{K}$ kg m^2 s^{-1}. The value of K is ________. (Take g = 10 m s^{-2})



Q. 22. Unpolarised light is incident on the boundary between two dielectric media, whose dielectric constants are 2.8 (medium-1) and 6.8 (medium-2), respectively. To satisfy the condition, so that the reflected and refracted rays are perpendicular to each other, the angle of incidence should be $\tan^{-1}\left(1+\frac{10}{\theta}\right)^{1/2}$ the value of θ is _______.

(Given: for dielectric media, $\mu_r = 1$)

Q. 23. A particle of mass 250 g executes a simple harmonic motion under a periodic force F = $(-25x)$ N. The particle attains a maximum speed of 4 m s^{-1} during its oscillation. The amplitude of the motion is ______ cm.

Q. 24. A car is moving on a circular path of radius 600 m such that the magnitudes of the tangential acceleration and centripetal acceleration are equal. The time taken by the car to complete first quarter of revolution, if it is moving with an initial speed of 54 km/h is $(1 - e^{-\pi/2})$ *s*. The value of *t* is _______.

Q. 25. When two resistances R_1 and R_2 connected in series and introduced into the left gap of a metre bridge and a resistance of 10 Ω is introduced into the right gap, a null point is found at 60 cm from left side. When R_1 and R_2 are connected in parallel and introduced into the left gap, a resistance of 3 Ω is introduced into the right gap to get null point at 40 cm from left end. The product of R_1R_2 is _______ Ω^2.

Q. 26. In an experiment of measuring the refractive index of a glass slab using travelling microscope in physics lab, a student measures real thickness of the glass slab as 5.25 mm and apparent thickness of the glass slab as 5.00 mm. Travelling microscope has 20 divisions in one cm on main scale and 50 divisions on Vernier scale is equal to 49 divisions on main scale. The estimated uncertainty in the measurement of refractive index of the slab is $\frac{x}{10} \times 10^{-3}$, where x is _______.

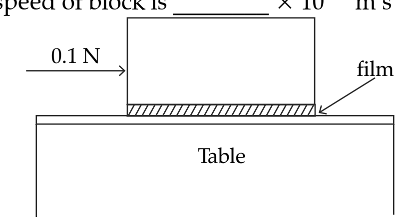
Q. 27. An inductor of inductance 2 μH is connected in series with a resistance, a variable capacitor and an AC source of frequency 7 kHz. The value of capacitance for which maximum current is drawn into the circuit is $\frac{1}{x}$F, where the value of x is ______. (Take $\pi = \frac{22}{7}$)

Q. 28. A null point is found at 200 cm in potentiometer when cell in secondary circuit is shunted by 5 Ω. When a resistance of 15 Ω is used for shunting, null point moves to 300 cm. The internal resistance of the cell is _______ Ω.

Q. 29. For a charged spherical ball, electrostatic potential inside the ball varies with r as $V = 2ar^2 + b$. Here, a and b are constant and r is the distance from the center. The volume charge density inside the ball is $-\lambda a\varepsilon$. The value of λ is ________.

(where, ε = permittivity of the medium)

Q. 30. A metal block of base area 0.20 m^2 is placed on a table, as shown in figure. A liquid film of thickness 0.25 mm is inserted between the block and the table. The block is pushed by a horizontal force of 0.1 N and moves with a constant speed. If the viscosity of the liquid is 5.0×10^{-3} poise, the speed of block is ________ $\times 10^{-3}$ m s^{-1}.



Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	(1)	Radioactive Decay	Nuclear physics
2	(3)	Logic Gate	Semi conductor & electronics
3	(3)	Kinetic friction	Friction
4	(1)	Calorimetry	Calorimetry
5	(4)	Work done by force	Work, Power & energy
6	(1)	Resolving power	Optical instruments/diffraction
7	(3)	Potentiometer	Current
8	(2)	Impulse	NLM
9	(1)	Modulation	Principle of communication
10	(1)	Nature of EM waves	EM waves
11	(1)	Motional emf	EMI
12	(2)	L-C-R Series circuit	AC

13	**(2)**	Pressure difference	Fluid statics
14	**(4)**	de-Broglie waves	Photoelectric Effect / Matter Waves
15	**(3)**	Motion of satellites	Gravitation
16	**(2)**	Magnetic field of circular loop	Magnetic effect of current
17	**(3)**	Potential difference	Electrostatics
18	**(3)**	Centripetal acceleration	Circular motion
19	**(1)**	r.m.s. speed	KTG
20	**(1)**	Dimensional operations	Unit & dimensions
21	**[800]**	Angular momentum	Rotational motion
22	**[7]**	Polarisation	Wave optics
23	**[40]**	Max speed of body in SHM	SHM
24	**[40]**	Centripetal and tangential acceleration	Circular motion
25	**[30]**	Metre Bridge	Current electricity
26	**[41]**	Vernier Callipers	Errors in measurement
27	**[3872]**	Resonance	AC
28	**[5]**	Potentiometer	Current electricity
29	**[12]**	Electrostatic Potential	Electrostatics
30	**[25]**	Viscous force	Viscocity

SOLUTIONS

Section A

1. Option (1) is correct.

Initial number of atoms of substance

$$A = \frac{m_A}{M_A} \times N_A = \frac{320}{16} \times N_A$$

$= 20 \times N_A$ (N_A = Avogadro number)

Initial number of atoms of substance

$$B = \frac{m_B}{M_B} \times N_A$$

$$= \frac{320}{32} \times N_A = 10N_A$$

As half life of A is 1 day, Number of atoms of A left after 2 days $= \dfrac{\text{initial number}}{4} = \dfrac{20N_A}{4}$

Similarly number of atoms of B, left after 2 days (after 4 half lives)

$$= \frac{10N_A}{2^4} = \frac{10N_A}{16}$$

Total number of atoms left after 2 days

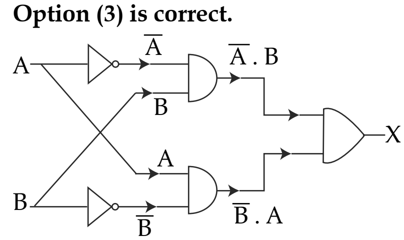
$$= \frac{20N_A}{4} + \frac{10N_A}{16}$$

$$= \frac{90}{16} N_A$$

$= 5.625 \times 6.023 \times 10^{23}$

$= 3.38 \times 10^{24}$ atoms

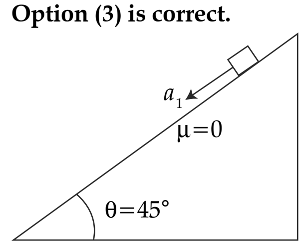
2. Option (3) is correct.

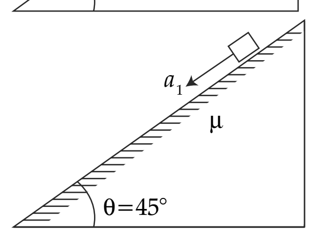


Output $X = \overline{A}\,.\,B + \overline{B}\,.\,A$

This expression is of XOR gate and its truth table is option (3).

3. Option (3) is correct.





Acceleration of object on smooth inclined plane

$= g\sin 45^o = g/\sqrt{2}$

Acceleration of object on rough inclined plane

$= g(\sin\theta - \mu\cos\theta)$

$$= \frac{g}{\sqrt{2}}(1-\mu)$$

If it takes t_1 second to slide down on smooth plane and t_2 second to slide down on rough inclined plane, it is given that

$$t_2 = nt_1$$

by $$t = \sqrt{\frac{2s}{a}}$$

$$\sqrt{\frac{2s}{a_2}} = n\sqrt{\frac{2s}{a_1}} \Rightarrow \frac{1}{a_2} = \frac{n^2}{a_1}$$

$$a_1 = n^2 a_2$$

$$\frac{g}{\sqrt{2}} = n^2 \frac{g}{\sqrt{2}}(1-\mu)$$

$$1-\mu = \frac{1}{n^2} \Rightarrow \mu = 1-\frac{1}{n^2}$$

4. **Option (1) is correct.**

Here first temp. of ice increases to 0^{o}C from -12^{o}C

Energy required to raise the temp. of ice from -12^{o}C to 0°C

$$\Delta Q_1 = ms(\Delta\theta)$$
$$= \frac{600}{1000} \times 2222.3 \times (12)$$
$$= 7.2 \times 2222.3 = 16000.56 \text{ J}$$

Energy given = 184000 J

Remaining energy = (184000 – 16000.56) J = 167999.44

This remaning energy is used by ice in melting.

Thus Energy req. to melt complete ice = mL

$$= \frac{600}{1000} \times 336 \times 1000$$
$$= 201600 \text{ J}$$

Thus the energy required to melt ice is more that than the available energy, hence all the ice will not melt. So amount of ice melted

$$m = \frac{Q}{L}$$
$$m = \frac{167999.44}{336000} \text{ kg}$$
$$= 0.4999 \text{ kg} \simeq 500 \text{ gm}$$

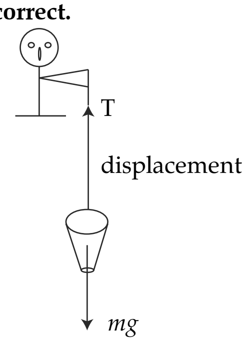
Remaining ice = (600 – 500) gm = 100 gm

Final amount of water = 500 gm

Final temp = 0°C

Hence, Statements A & D are correct.

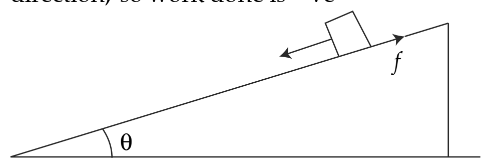
5. **Option (4) is correct.**



Clearly force applied by man in lifting bucket and displacement of bucket are in same direction that's why work done will be positive.

So option A is wrong.

Gravitational force and displacement are in opposite direction, so work done is – ve



Friction and displacement are in opposite direction, hence work done will be – ve.

Air resistance always act opposite to direction of motion w.r.t. air so work done will be – ve

Statements B & E are correct.

6. **Option (1) is correct.**

Resolving power of Compound Microscope,

$$\text{R.P.} = \frac{2\mu\sin\theta}{1.22\lambda}$$

On decreasing diameter of objective lens, θ ↓ so sin θ ↓ and R.P. ↓

As R.P. $\propto \frac{1}{\lambda}$, on ↑ λ, R.P. ↓

R.P. of microscope is independent of f_e

R.P. $\propto \mu$

so option 1 is correct.

7. **Option (3) is correct.**

A potentiometer is called more sensitive when it gives sufficient balance length, for low emf also.

By $E = \rho l$

For an emf balance length l will be more when ρ (potential gradient) is low.

and $$\rho = \frac{V}{L}$$

where, V = total potential difference across potentiometer were and L = length of wire

So for low ρ, L should be high.

So A & C are correct.

8. **Option (2) is correct.**

After force is removed a=0 so object will move with constant velocity, hence

$$v \times 10 = 50$$
$$v = 5 \text{ m s}^{-1}$$

Now by $F \times (\Delta t) = \Delta P$

$$F(20) = 20\,(5-0)$$
$$F = 5 \text{ N}$$

9. **Option (1) is correct.**

$$\text{Modulatory index} = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$$
$$= \frac{14-6}{14+6} = \frac{8}{20} = \frac{4}{10}$$
$$= 0.4$$

10. **Option (1) is correct.**

EM waves have no charge so no deflection will take place by electric field or magnetic field.

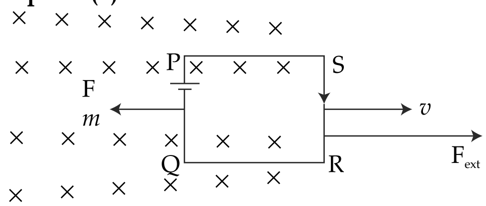
Relation between E & B in EM waves is

$$\frac{E}{B} = C$$

$$\frac{E}{B} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

So statement 1 is correct statement 2 is wrong.

11. Option (1) is correct.



Loop moves with constant velocity

Current in loop = $\frac{e}{R} = \frac{Blv}{R}$

Manetic force on PQ = $Bil\sin\theta$

$$= \frac{B^2l^2v}{R}$$

This magnetic force acts opposite to motion, that's why to keep velocity constant force of same magnitude must be applied in the direction of motion.

So, external force applied on loop $= \frac{B^2l^2v}{R}$

Work done by this force $W = Fd$

$$= \frac{B^2l^2v}{R} \times l$$

And $v = \frac{l}{t}$

$$\therefore W = \frac{B^2l^2}{R} \times \frac{l}{t} \times l$$

$$W = \frac{B^2l^4}{Rt}$$

$$W = \frac{1600 \times 5^4 \times 10^{-8}}{10 \times 1}$$

$$= 160 \times 625 \times 10^{-8} = 10^5 \times 10^{-8}$$
$$= 1 \times 10^{-3} \text{ J}$$

12. Option (2) is correct.

Here we check that circuit (b) is in resonance or not.

For resonance,

$$X_L = X_C$$

$$2\pi fL = \frac{1}{2\pi fC}$$

By using values,

$$f \neq \frac{1}{2\pi\sqrt{LC}}$$

Circuit is not in resonance, that's why impedence of circuit (b) is always greater than that of circuit (a)

So current in circuit (b) can never be larger than that in (a).

13. Option (2) is correct.

In aircraft, weight of aircraft is balanced by pressure difference

$$(P_2 - P_1)A = mg$$
$$(P_2 - P_1)\, 500 = 5.4 \times 10^5 \times 10$$
$$(P_2 - P_1) = \frac{5.4 \times 10^5}{50}$$
$$= \frac{54 \times 10^2 \times 10^2}{50}$$
$$= 10800$$

Now, according to Bernoulli's theorem,

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

$$P_2 - P_1 = \frac{1}{2}\rho(v_2^2 - v_1^2)$$

$$10800 = \frac{1}{2} \times 1.2\,(v_2 - v_1)(v_2 + v_1)$$

Here, $v_1 \approx v_2 = v$

& $v = 1080 \text{ km h}^{-1}$

$$= 1080 \times \frac{5}{18}$$
$$= 300 \text{ m s}^{-1}$$

$$\therefore \quad 10800 = \frac{1}{2}(1.2)(v_2 - v_1)(600)$$

$$v_2 - v_1 = \frac{18 \times 2}{1.2} = 30$$

$$\therefore \text{ \% increase} = \frac{30}{300} \times 100\% \simeq 10\%$$

14. Option (4) is correct.

de-Broglie wavelength is given by, $\lambda = \frac{h}{p}$

And when a charge particle is accelerated through potential difference V from rest, it's speed is given by

$$v = \sqrt{\frac{2qV}{m}}$$

$$\therefore \quad p = mv = \sqrt{2qVm}$$

$$\lambda = \frac{h}{\sqrt{2qVm}}$$

Now as V = same

$$\lambda \propto \frac{1}{\sqrt{qm}}$$

$$\frac{\lambda_\alpha}{\lambda_p} = \sqrt{\frac{q_p \times m_p}{q_\alpha \times m_\alpha}} = \sqrt{\frac{e \times m}{2\,e \times 4m}} = \frac{1}{\sqrt{8}}$$

$$m = 8$$

15. Option (3) is correct.

According to Kepler's law

$T \propto r^{3/2}$

$$\frac{T_2}{T_1} = \left(\frac{r_2}{r_1}\right)^{3/2}$$

$$\frac{T_2}{T_1} = \left(\frac{r_1}{4r_1}\right)^{3/2}$$

$$T_2 = \left(\frac{1}{2}\right)^3 T_1$$

$$T_2 = \frac{T_1}{8}$$

$$T_1 = 24 \text{ h}$$

$$T_2 = 3 \text{ hours}$$

16. Option (2) is correct.

Magnetic field at the centre of coil is given by

$$B = \frac{\mu_0 n i}{2r}$$

For single turn, $n' = \frac{1}{n}$

Radius will increase by n times, hence radius of single coil, $r' = nr$

Hence, $B' = \frac{\mu_0 i}{rn^2}$

$$\Rightarrow \quad B' = \frac{B}{n^2}$$

$$\Rightarrow \quad B' = \frac{B}{4^2} = \frac{B}{16} = 2 \text{ T}$$

17. Option (3) is correct.

Work done by electric field

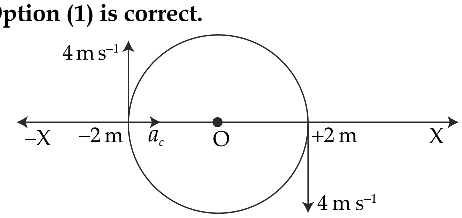
$$W = \vec{F}.\vec{S}$$

$$= q\vec{E}.\vec{S}$$

$$= 2 \times 10^{-2}(30\hat{i}).(-\hat{i} - 2\hat{j})$$

$$= -60 \times 10^{-2} = -600 \text{ mJ}$$

18. Option (1) is correct.



$$a = \frac{v^2}{r}$$

$$a = \frac{16}{2} = 8 \text{ m s}^{-2}$$

$$\vec{a} = 8\hat{i} \text{ m s}^{-2}$$

& $\quad v = 4\hat{j} \text{ m s}^{-1}$

19. Option (1) is correct.

r.m.s. speed of gas molecules is given by

$$= \sqrt{\frac{3RT}{M}}$$

Average speed of gas molecules is given by

$$= \sqrt{\frac{8RT}{\pi M}}$$

$$\sqrt{\frac{3RT}{M}} = \sqrt{\frac{\alpha+5}{\alpha}}\sqrt{\frac{8RT}{\pi M}}$$

$$3 = \left(\frac{\alpha+5}{\alpha}\right)\frac{8}{22}(7)$$

$$33 = \left(\frac{\alpha+5}{\alpha}\right)28$$

$$33\alpha = 28\alpha + 28 \times 5$$

$$\alpha = 28$$

20. Option (1) is correct.

Dimensions of x = dimensions of At

$$L = [A]\, T^{-1}$$

$$[A] = [L\,T]$$

Dimensions of y = dimensions of $\frac{t}{B}$

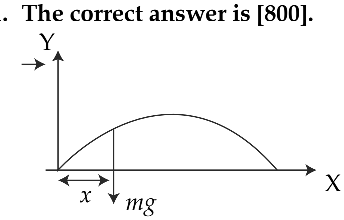
$$[y] = \left[\frac{t}{B}\right]$$

$$[L] = \frac{T^{-1}}{[B]}$$

$$[B] = L^{-1}\, T^{-1}$$

Section B

21. The correct answer is [800].



Angular impulse = change in angular momentum

$$\int_0^2 \tau\, dt = L_2 - L_1$$

$$\int_0^2 mgx dt = L - 0$$

$$\frac{1}{10} \times 10 \int_0^2 10\sqrt{2}\, t\, dt = L$$

$$10\sqrt{2}\left[\frac{t^2}{2}\right]_0^2 = L$$

$$10\sqrt{2}\left(\frac{4}{2}\right) = L$$

$$L = \sqrt{800}$$

22. The correct answer is [7].

Refractive Index of a medium is given by

$$n = \sqrt{\mu_r\, \varepsilon_r}$$

where, $\mu_r = 1$ (given)

And ε_r = dielectric constant of medium.

$$\therefore \quad \frac{n_1}{n_2} = \sqrt{\frac{\varepsilon r_1}{\varepsilon r_2}}$$

$$\frac{n_1}{n_2} = \sqrt{\frac{2.8}{6.8}}$$

$$\frac{n_1}{n_2} = \sqrt{\frac{14}{34}} = \sqrt{\frac{7}{17}}$$

According to Brewsters Law reflected & refracted rays are perpendicular to each other when angle of incidence, $i = \tan^{-1}(n)$

where, $n = \frac{n_2}{n_1}$

$$i = \tan^{-1}\left(\sqrt{\frac{17}{7}}\right)$$

$$i = \tan^{-1}\left(\frac{7}{7} + \frac{10}{7}\right)^{1/2}$$

$$i = \tan^{-1}\left(1 + \frac{10}{7}\right)^{1/2}$$

So, $\theta = 7$

23. The correct answer is [40].

$$F = -25x$$
$$F = -kx$$

Force constant $k = 25$

By $\omega^2 = \frac{k}{m}$

$$\omega^2 = \frac{25}{\frac{1}{4}}$$

$$\omega^2 = 100$$

$\Rightarrow$ $\omega = 10$

By $v_{max} = A\omega$

$$4 = A \times 10$$
$$A = 0.4 \text{ m}$$
$$A = 40 \text{ cm}$$

24. The correct answer is [40].

$$a_t = u\frac{dv}{ds}$$

$$\& \ a_c = \frac{v^2}{R}$$

As per question

$$v\frac{dv}{ds} = \frac{v^2}{R}$$

$$\int_{v_0}^{v} \frac{dv}{u} = \int_0^s \frac{ds}{R}$$

$$\ln\frac{v}{v_0} = \frac{S}{R}$$

$$\frac{v}{v_0} = e^{S/R}$$

$$v = v_0 e^{S/R}$$

$$\frac{ds}{dt} = v_0 \ e^{S/R}$$

$$\int_0^S e^{-S/R} \ ds = \int_0^{t_1} v_0 dt$$

$$\left[-e^{S/R}\right]_0^S R = v_0 t_1$$

$$600(1 - e^{-\pi/2}) = 15t_1$$

Time taken to cover first quarter

$$t_1 = 40(1 - e^{-\pi/2})$$
$$t_1 = t(1 - e^{-\pi/2})$$

$\Rightarrow$ $t = 40$

25. The correct answer is [30].

$$\frac{R_1 + R_2}{10} = \frac{60}{40}$$

$$\frac{\frac{R_1R_2}{R_1 + R_2}}{3} = \frac{40}{60}$$

$\Rightarrow$ $R_1 + R_2 = 15$

$$\frac{R_1R_2}{3(R_1 + R_2)} = \frac{2}{3}$$

$$R_1R_2 = 2 \times 15$$
$$R_1R_2 = 30 \ \Omega^2$$

26. The correct answer is [41].

Apparent depth $(h') = \frac{\text{Real depth } (h)}{\mu}$

$$h' = \frac{h}{\mu}$$

$$\mu = \frac{h}{h'}$$

$$\frac{d\mu}{\mu} = \frac{dh}{h} + \frac{dh'}{h'}$$

Now for travelling microscope

50 VSD = 49 MSD

(VSD = Vernier scale devisions)

(MSD = Main scale devisions)

Least count of microscope,

= 1 MSD – 1 VSD

$= 1 \text{ MSD} - \frac{49}{50} \text{ MSD}$

$= \frac{1}{50} \text{ MSD}$

But on main scale 20 divisions are in 1 cm

So 1 division $= \frac{1}{20}$ cm

$\therefore$ L.C. $= \frac{1}{50} \times \frac{1}{20}$ cm

= 0.01 mm

Least count is equal to max Error.

So $\Delta h = 0.01$ mm, $\Delta h' = 0.01$ mm

$h = 5.25$ mm, $h' = 5.00$ mm

$$d\mu = \mu\left[\frac{dh}{h}+\frac{dh'}{h'}\right]$$

$$d\mu = \mu\left[\frac{0.01}{5.25}+\frac{0.01}{5.00}\right]$$

$$d\mu = \frac{5.25}{5.00}\left[\frac{1}{525}+\frac{1}{500}\right]$$

$$d\mu = \frac{525}{500}\left[\frac{500+525}{525\times500}\right]$$

$$d\mu = \frac{1025}{25}\times10^{-4}$$

$$= 41\times10^{-4}$$

$$= \frac{41}{10}\times10^{-3}$$

$$= 41\times10^{-4}$$

27. The correct answer is [3872].

Current in circuit is maximum when circuit is in resonance.

For resonance,

$$X_L = X_C$$

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

$$C = \frac{1}{\omega^2 L}$$

$$C = \frac{1}{4\pi^2\times f^2 L}$$

$$= \frac{1}{4\times\frac{22^2}{7^2}\times7^2\times10^6\times2\times10^{-6}}$$

$$= \frac{1}{8\times484}$$

$$= \frac{1}{3872}$$

$$x = 3872$$

28. The correct answer is [5].

When cell is shunted, terminal voltage of cell is balanced on potentiometer wire.

When cell of secondary circuit is shunted by 5 Ω.

$$V_1 = \frac{5E}{5+r}$$

By principle of potentiometer,

$$V_1 = \frac{5E}{5+r} = \rho\times200\text{ cm}$$

Similarly, when cell is shunted by 15 Ω,

$$V_2 = \frac{15E}{15+r} = \rho\times300\text{ cm}$$

$$\frac{V_1}{V_2} = \frac{\frac{5\,E}{5+r}}{\frac{15\,E}{15+r}} = \frac{\rho\times300}{\rho\times300}$$

$$\Rightarrow \quad \frac{15+r}{(5+r)3} = \frac{2}{3}$$

$$\Rightarrow \quad 15+r = 10+2r$$

$$r = 5\,\Omega$$

29. The correct answer is [12].

Given, $V = 2ar^2 + b$

By $E = \frac{-dV}{dr}$

$E = -4qr$

Also, inside a solid charged sphere

$$E = \frac{\rho r}{3\varepsilon_0}$$

where, ρ = volume charge density

$$\frac{\rho r}{3\varepsilon_0} = -4ar$$

$$\rho = -12a\varepsilon_0$$

$$\lambda = 12$$

30. The correct answer is [25].

As speed of block is constant, F_{net} on block must be zero so $F_{external} = F_{viscous}$

$$0.1 = \int A\left(\frac{\Delta v}{\Delta x}\right)$$

$$0.1 = 5\times10^{-3}\times0.20\left(\frac{v-D}{0.25\times10^{-3}}\right)$$

$$0.1 = 5\times\frac{0.20\,v}{0.25}$$

$$0.1 = 5\times\frac{4}{5}v$$

$$v = \frac{0.1}{4}$$

$$= 0.25\times0.1$$

$$= 25\times10^{-3}\text{ ms}^{-1}$$

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