JEE (Main) PHYSICS SOLVED PAPER

2023
13^{th} April Shift 2

Section A

Q. 1. Given below are two statements:

Statement I: An AC circuit undergoes electrical resonance if it contains either a capacitor or an inductor.

Statement II: An AC circuit containing a pure capacitor or a pure inductor consumes high power due to its non-zero power factor.

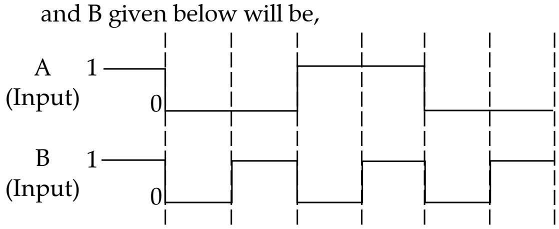
In the light of above statements, choose the correct answer form the options given below:

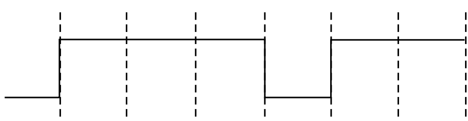
(1) Statement I is false but Statement II is true
(2) Statement I is true but Statement II is false
(3) Both Statement I and Statement II are false
(4) Both Statement I and Statement II are true

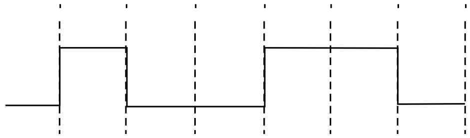
Q. 2. A passenger sitting in a train A moving at 90 km h^{-1} observes another train B moving in the opposite direction for 8 s. If the velocity of the train B is 54 km h^{-1}, then length of train B is:

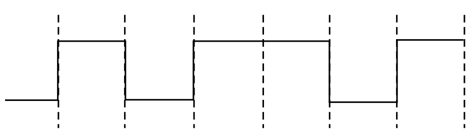
(1) 120 m **(2)** 200 m **(3)** 320 m **(4)** 80 m

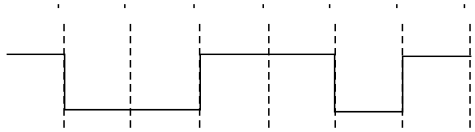
Q. 3. The output from a NAND gate having inputs A and B given below will be,



(1)


(2)


(3)


(4)


Q. 4. The distance travelled by an object in time t is given by $s = (2.5)t^2$. The instantaneous speed of the object at $t = 5$ s will be:

(1) 25 m s^{-1} **(2)** 12.5 m s^{-1}
(3) 5 m s^{-1} **(4)** 62.5 m s^{-1}

Q. 5. In a Young's double slits experiment, the ratio of amplitude of light coming from slits is 2 : 1. The ratio of the maximum to minimum intensity in the interference pattern is:

(1) 9 : 1 **(2)** 9 : 4
(3) 2 : 1 **(4)** 25 : 9

Q. 6. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: The binding energy per nucleon is practically independent of the atomic number for nuclei of mass number in the range 30 to 170.

Reason R: Nuclear force is short ranged.

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

(1) Both A and R are true but R is NOT the correct explanation of A
(2) Both A and R are true and R is the correct explanation of A
(3) A is true but R is false
(4) A is false but R is true

Q. 7. Two planets A and B of radii R and 1.5R have densities ρ and $\frac{\rho}{2}$ respectively. The ratio of acceleration due to gravity at the surface of B to A is:

(1) 2 : 3 **(2)** 2 : 1 **(3)** 4 : 3 **(4)** 3 : 4

Q. 8. The mean free path of molecules of a certain gas at STP is 1500d, where, d is the diameter of the gas molecules.

While maintaining the standard pressure, the mean free path of the molecules at 373 K is approximately :

(1) 750d **(2)** 1500d **(3)** 1098d **(4)** 2049d

Q. 9. To radiate EM signal of wavelength λ with high efficiency, the antennas should have a minimum size equal to:

(1) λ **(2)** $\frac{\lambda}{2}$ **(3)** 2λ **(4)** $\frac{\lambda}{4}$

Q. 10. A particle executes SHM of amplitude A. The distance from the mean position when its kinetic energy becomes equal to its potential energy is:

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

Q. 11. In an electromagnetic wave, at an instant and at a particular position, the electric field is along the negative z-axis and magnetic field is along the positive x-axis. Then the direction of propagation of electromagnetic wave is:

(1) negative y-axis
(2) at 45° angle from positive y-axis
(3) positive y-axis
(4) positive z-axis

Q. 12. Given below are two statements:
Statement I: Out of microwaves, infrared rays and ultraviolet rays, ultraviolet rays are the most effective for the emission of electrons from a metallic surface.
Statement II: Above the threshold frequency, the maximum kinetic energy of photoelectrons is inversely proportional to the frequency of the incident light.
In the light of above statements, choose the correct answer from the options given below:
(1) Statement I is false but statement II is true
(2) Both Statement I and Statement II are true
(3) Statement I is true but statement II is false
(4) Both Statement I and Statement II are false

Q. 13. Given below are two statements:
Statement I: For a planet, if the ratio of mass of the planet to its radius increases, the escape velocity from the planet also increases.
Statement II: Escape velocity is independent of the radius of the planet.
In the light of above statements, choose the most appropriate answer form the options given below:
(1) Both Statement I and Statement II are correct
(2) Statement I is correct but statement II is incorrect
(3) Statement I is incorrect but statement II is correct
(4) Both Statement I and Statement II are incorrect

Q. 14. A vehicle of mass 200 kg is moving along a levelled curved road of radius 70 m with angular velocity of 0.2 rad s^{-1}. The centripetal force acting on the vehicle is:
(1) 2800 N **(2)** 560 N **(3)** 2240 N **(4)** 14 N

Q. 15. A 10 μC charge is divided into two parts and placed at 1 cm distance so that the repulsive force between them is maximum. The charges of the two parts are:
(1) 7 μ C, 3 μ C **(2)** 8 μ C, 2 μ C
(3) 9 μ C, 1 μ C **(4)** 5 μ C, 5 μ C

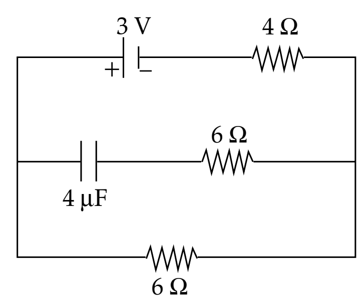
Q. 16. In the equation $\left[x+\frac{a}{y^2}\right][Y-b]=RT$, X is pressure, Y is volume, R is universal gas constant and T is temperature. The physical quantity equivalent to the ratio $\frac{a}{b}$ is:
(1) Coefficient of viscosity
(2) Energy
(3) Impulse
(4) Pressure gradient

Q. 17. An electron is moving along the positive *x*-axis. If the uniform magnetic field is applied parallel to the negative *z*-axis, then
A. The electron will experience magnetic force along positive *y*-axis
B. The electron will experience magnetic force along negative *y*-axis
C. The electron will not experience any force in magnetic field
D. The electron will continue to move along the positive *x*-axis
E. The electron will move along circular path in magnetic field
Choose the correct answer from the options given below:
(1) B and E only **(2)** A and E only
(3) B and D only **(4)** C and D only

Q. 18. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R.
Assertion A : A spherical body of radius (5 ± 0.1) mm having a particular density is falling through a liquid of constant density. The percentage error in the calculation of its terminal velocity is 4%.
Reason R : The terminal velocity of the spherical body falling through the liquid is inversely proportional to its radius.
In the light of the above statements, choose the correct answer from the options given below:
(1) Both A and R are true but R is NOT the correct explanation of A
(2) Both A and R are true and R is the correct explanation of A
(3) A is false but R is true
(4) A is true but R is false

Q. 19. The initial pressure and volume of an ideal gas are P_0 and V_0. The final pressure of the gas when the gas is suddenly compressed to volume $\frac{V_0}{4}$ will be:
(Given γ = ratio of specific heats at constant pressure and at constant volume)
(1) $P_0(4)^{1/\gamma}$ **(2)** $4P_0$ **(3)** P_0 **(4)** $P_0(4)^{\gamma}$

Q. 20. In the network shown below, the charge accumulated in the capacitor in steady state will be:



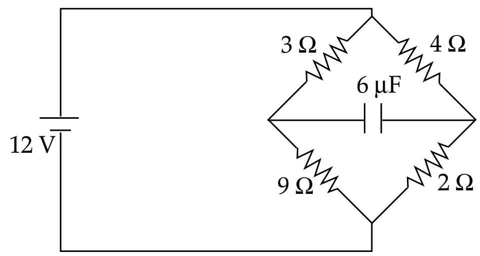
(1) 4.8 μC **(2)** 12 μC **(3)** 7.2 μC **(4)** 10.3 μC

Section B

Q. 21. In an experiment with sonometer when a mass of 180 g is attached to the string. It vibrates with fundamental frequency of 30 Hz. When a mass m is attached, the string vibrates with fundamental frequency of 50 Hz. The value of *m* is _______ *g*.

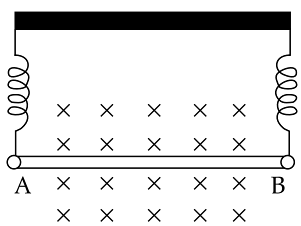
Q. 22. Two plates A and B have thermal conductivities 84 W m^{-1} K^{-1} and 126 W $m^{-1}K^{-1}$ respectively. They have same surface area and same thickness. They are placed in contact along their surfaces. If the temperatures of the outer surfaces of A and B are kept at 100°C and 0°C respectively, then the temperature of the surface of contact in steady state is ______ °C.

Q. 23. In the circuit shown, the energy stored in the capacitor is n μJ. The value of n is:



Q. 24. A light rope is wound around a hollow cylinder of mass 5 kg and radius 70 cm. The rope is pulled with a force of 52.5 N. The angular acceleration of the cylinder will be ________ rad s^{-2}.

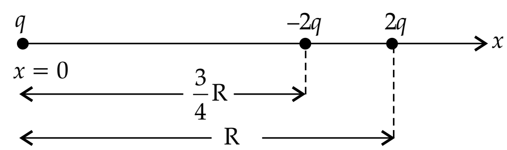
Q. 25. A straight wire AB of mass 40 g and length 50 cm is suspended by a pair of flexible leads in uniform magnetic field of magnitude 0.40 T as shown in the figure. The magnitude of the current required in the wire to remove the tension in the supporting leads is _______A. (Take g = 10 m s^{-2})



Q. 26. An insulated copper wire of 100 turns is wrapped around a wooden cylindrical core of the cross-sectional area 24 cm^2. The two ends of the wire are connected to a resistor. The total resistance in the circuit is 12 Ω. If an externally applied uniform magnetic field in the core along its axis changes from 1.5 T in one direction to 1.5 T in the opposite direction, the charge flowing through a point in the circuit during the change of magnetic field will be ______ mC.

Q. 27. A biconvex lens of focal length 10 cm is cut in two identical parts along a plane perpendicular to the principal axis. The power of each lens after cut is _______ D.

Q. 28. Three point charges q, $-2q$ and $2q$ are placed on x-axis at a distance $x = 0$, $x = \frac{3}{4}R$ and $x = R$ respectively from origin as shown. If $q = 2 \times 10^{-6}$ C and R = 2 cm, the magnitude of net force experienced by the charge $-2q$ is _________ N.



Q. 29. An atom absorbs a photon of wavelength 500 n m and emits another photon of wavelength 600 n m. The net energy absorbed by the atom in this process is $n \times 10^{-4}$ e V. The value of n is ______. (Assume the atom to be stationary during the absorption and emission process.) (Take $h = 6.6 \times 10^{-34}$ J s and $c = 3 \times 10^{8}$ m s^{-1})

Q. 30. A car accelerates from rest to u m s^{-1}. The energy spent in this process is E J. The energy required to accelerate the car from u m s^{-1} to 2 u m s^{-1} is nE J. The value of n is ______.

Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	(3)	RLC circuit	Alternating current
2	(3)	Relative velocity	Motion in a straight line
3	(1)	Logic gates	Semiconductors
4	(1)	Instantaneous speed	Motion in a straight line
5	(1)	YDSE	Wave optics
6	(2)	Binding energy	Nuclei
7	(4)	Acceleration due to gravity	Gravitation
8	(4)	Mean free path	Kinetic theory of gases
9	(4)	Size of antenna	Communication system
10	(3)	Energies in SHM	Waves
11	(1)	Transverse nature of EM wave	EM waves
12	(3)	Photoelectric effect	Dual nature of matter and radiation
13	(2)	Escape velocity	Gravitation
14	(2)	Circular motion	Kinematics
15	(4)	Coulomb's law	Electrostatics

16	**(2)**	Dimensional equation	Unit & Dimension
17	**(1)**	Force on moving charge in magnetic field	Magnetic effect of current & Magnetism
18	**(4)**	Percentage error	Unit & Dimension
19	**(4)**	Adiabatic process	Thermodynamics
20	**(3)**	Circuit containing resistance and capacitor	Electric current
21	**[500]**	Fundamental mode	Oscillation and wave
22	**[40]**	Heat transfer	Properties of solid and liquid
23	**[75]**	Circuit containing resistor and capacitor	Electric current
24	**[15]**	Torque	Rotational Motion
25	**[2]**	Force acting on current carrying while in magnetic field	Magnetic effect of current and Magnetism
26	**[60]**	Induced EMF	Electromagnetic induction
27	**[5]**	Power of lens	Ray optics
28	**[5440]**	Coulomb's law	Electrostatics
29	**[4125]**	Energy absorption	Atoms
30	**[3]**	Kinetic energy	Work, Energy and Power

SOLUTIONS

Section A

1. Option (3) is correct.
For resonance, both inductor and capacitor are needed such that $X_L = X_C$. Statement I is false. Inductor and capactior never consume power instead these store energy. It is the resistance of the circuit, which consumes power. Statement II is false.

2. Option (3) is correct.

$v_A = 90 \text{ km h}^{-1} = 90 \times \dfrac{5}{18} = 25 \text{ m s}^{-1}$

$v_B = 54 \text{ km h}^{-1} = 54 \times \dfrac{5}{18} = 15 \text{ m s}^{-1}$

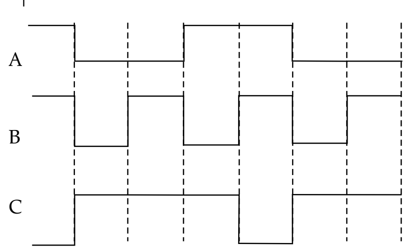
$v_{BA} = 25 - (-15) = 40 \text{ m s}^{-1}$ = velocity of B w.r.t. A.

Length of train $B = 40 \times 8 = 320$ m

3. Option (1) is correct.

Truth table of a NAND gate is:

A	B	C
0	0	1
0	1	1
1	0	1
1	1	0



4. Option (1) is correct.

$s = 2.5\, t^2$

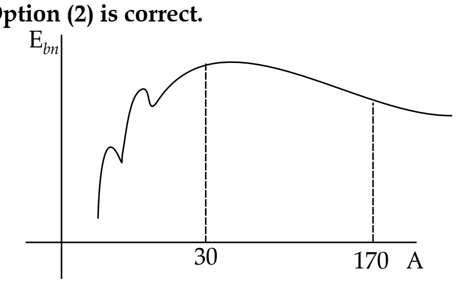
Instantaneous speed, $v = \dfrac{ds}{dt} = 5t$

v at $t = 5$ sec $= 5 \times 5 = 25 \text{ m s}^{-1}$

5. Option (1) is correct.

$$\frac{I_{Max}}{I_{Min}} = \frac{\left(\frac{a_1}{a_2}+1\right)^2}{\left(\frac{a_1}{a_2}-1\right)^2} = \left(\frac{2+1}{2-1}\right)^2 = 9:1$$

6. Option (2) is correct.



From theory, binding energy per nucleon is almost constant for mass numbers in the range 30 to 170. It is due to short range of the nuclear force.

7. Option (4) is correct.

$$g = \frac{GM}{R^2} = \frac{G}{R^2} \times \left(\frac{4}{3}\pi R^3 \rho\right)$$

$$g \propto R\rho$$

$$\frac{g_1}{g_2} = \frac{R_1}{R_2}\frac{\rho_1}{\rho_2} = \frac{R}{1.5R} \times \frac{\rho}{\frac{\rho}{2}} = \frac{4}{3}$$

$$\therefore \quad \frac{g_2}{g_1} = \frac{3}{4}$$

8. Option (4) is correct.
Mean free path,

$$\lambda = \frac{1}{\sqrt{2}\pi n d^2}$$

where, $\quad n = \dfrac{N}{V} = \dfrac{NP}{RT}$

$$\lambda = \frac{RT}{\sqrt{2}\pi NPd^2}$$

$$\lambda \propto T$$

$$\frac{\lambda_1}{\lambda_2} = \frac{T_1}{T_2}$$

$$\frac{1500d}{\lambda_2} = \frac{273}{373}$$

$$\lambda_2 = \frac{373}{273} \times 1500d = 2049d$$

9. Option (4) is correct.

For high efficiency, we take quarter wave antennas.

$\therefore$ size of the antenna $= \frac{\lambda}{4}$

10. Option (3) is correct.

KE = PE

$$\frac{1}{2}K(A^2 - x^2) = \frac{1}{2}Kx^2 \Rightarrow x = \pm\frac{A}{\sqrt{2}}$$

11. Option (1) is correct.

The directions of $\vec{E}, \vec{B}$ and $\vec{v}$ in an EM wave are related by $\vec{E} \times \vec{B} = \vec{v}$

$$-\hat{k} \times \hat{i} = -\hat{j}$$

12. Option (3) is correct.

Since ultra violet rays have maximum frequency from amongst the given rays, it has maximum photon energy which is enough to knock the electrons out of any metallic surface.

$\therefore$ Statement I is true

The maximum KE of the emitted photoelectrons is proportional to the frequency of the incident radiation.

$\therefore$ Statement II is false.

13. Option (2) is correct.

Escape velocity, $V_e = \sqrt{\frac{2GM}{R}} \Rightarrow V_e \propto \sqrt{\frac{M}{R}}$

$\therefore$ Statement I is true

and Statement II is false as $V_e \propto \frac{1}{\sqrt{R}}$

14. Option (2) is correct.

Centripetal force $F_C = mw^2r$

$= 200 \times 0.04 \times 70 = 560$ N

15. Option (4) is correct.

If Q is divided into q and Q – q and kept at a separation r, $F = \frac{kq(Q-q)}{r^2}$

for F_{max}, $\frac{dF}{dq} = 0 = Q - 2q$

$$q = \frac{10}{2} = 5\ \mu C$$

$$Q - q = 10\ \mu C - 5\ \mu C = 5\ \mu C$$

16. Option (2) is correct.

Putting the physical quantities respectively, we get

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT \Rightarrow [P] = \left[\frac{a}{V^2}\right]$$

$$\Rightarrow [a] = [PV^2] = [M^1L^5T^{-2}]$$

$$[V] = [b] = [L^3]$$

$$\left[\frac{a}{b}\right] = \left[\frac{M^1L^5T^{-2}}{L^3}\right] = [M^1L^2T^{-2}] = [\text{Energy}]$$

17. Option (1) is correct.

$$\vec{F} = q(\vec{v} \times \vec{B}) = -e(v\hat{i} \times B(-\hat{k})) = evB(-\hat{j})$$

Since $\vec{v} \perp \vec{B}$, electron moves along circular path.

18. Option (4) is correct.

Terminal velocity, $v_T \propto r^2$

$$\frac{\Delta v_T}{v_T} = 2\frac{\Delta r}{r} \Rightarrow 100 \times \frac{\Delta v_T}{v_T} = 2\left(\frac{\Delta r}{r} \times 100\right)$$

$$= 2\left(\frac{0.1}{5} \times 100\right) = 4\%$$

$\therefore$ Assertion is true, but Reason is false.

19. Option (4) is correct.

Sudden compression is adiabetic

$$P_1V_1^{\gamma} = P_2V_2^{\gamma}$$

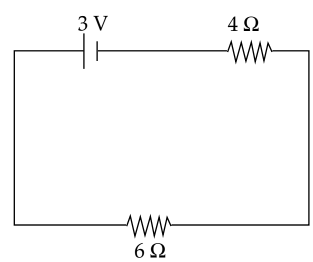
$$P_0V_0^{\gamma} = P_2\left(\frac{V_0}{4}\right)^{\gamma}$$

$$P_2 = P_0(4)^{\gamma}$$

20. Option (3) is correct.

In the steady state, capacitor acts as an open circuit.

The equivalent circuit becomes:



$$i = \frac{3}{10} = 0.3 \text{ A}$$

$$V_C = 6i = 1.8 \text{ V}$$

$$q = CV_C = 4 \times 1.8 = 7.2\ \mu C$$

Section B

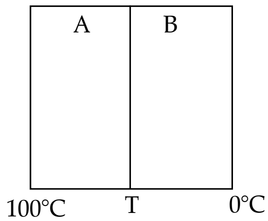
21. The correct answer is [500].

$f = \frac{1}{2l}\sqrt{\frac{Mg}{\mu}}$ where, μ = mass per unit length of string

$$\frac{f_1}{f_2} = \sqrt{\frac{M_1}{M_2}} \Rightarrow \frac{30}{50} = \sqrt{\frac{180}{M}}$$

$$M = \frac{25 \times 180}{9} = 500 \text{ gm}$$

22. The correct answer is [40].



At steady state, rate of flow of heat is same through both slabs

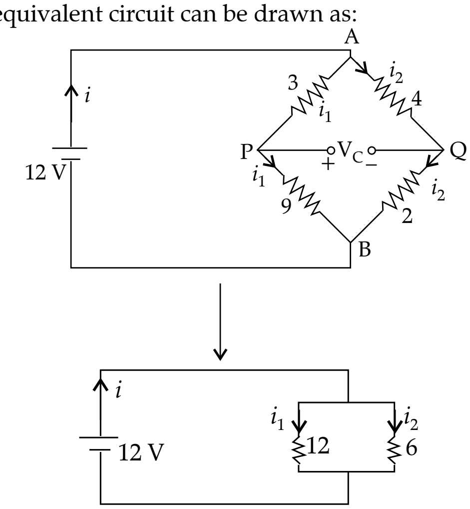
$$\therefore \ \frac{\Delta Q}{\Delta t} = \frac{k_A A(100^\circ - T)}{l} = \frac{k_B A(T - 0^\circ)}{l}$$

$k_A(100 - T) = k_B T$

$$T = \frac{100k_A}{k_A + k_B} = \frac{100 \times 84}{84 + 126} = \frac{100 \times 84}{210} = 40^\circ\text{C}$$

23. The correct answer is [75].

At steady state, C acts as an open circuit. The equivalent circuit can be drawn as:



$$i = \frac{12}{4} = 3 \text{ A}$$

$$i_1 = 3 \times \frac{6}{18} = 1 \text{ A}$$

$i_2 = i - i_1 = 2$ A

Applying KVL in the loop APQA, we get

$-3i_1 - V_C + 4i_2 = 0$

$V_C = -3(1) + 4(2) = 5$ V

$$U_C = \frac{1}{2}CV_C^2 = \frac{1}{2} \times 6 \times 25$$

$= 75\ (\mu\text{ J}) = n(\mu\text{ J})$

On comparing, $n = 75$

24. The correct answer is [15].

Torque, $\tau = FR = I_{CM}\alpha$

$$\alpha = \frac{FR}{I_{cm}} = \frac{FR}{MR^2} = \frac{F}{MR} = \frac{1 \times 52.5}{5 \times 0.7} = 15 \text{ rad s}^{-2}$$

25. The correct answer is [2].

For tension to be zero,

$Mg = Bil$

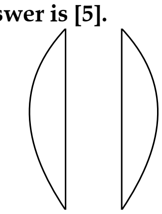
$$i = \frac{Mg}{Bl} = \frac{0.04 \times 10}{0.4 \times 0.5} = 2 \text{ A}$$

26. The correct answer is [60].

$$\Delta q = \frac{\Delta\phi_B}{R} = \frac{NA\Delta B}{R} = \frac{100 \times 24 \times 10^{-4}(1.5 - (-1.5))}{12}$$

$= 2 \times 10^{-2} \times 3 = 6 \times 10^{-2}$ C $= 60$ mC

27. The correct answer is [5].



$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{f}$$

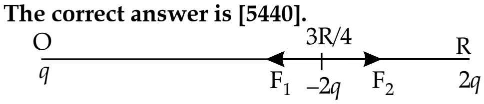
$f_1 = f_2 =$ as both halves are identical

$$\frac{2}{f_1} = \frac{1}{f}$$

$2P_1 = P$

$$P_1 = \frac{P}{2} = \frac{1}{2f} = \frac{1}{2 \times 0.1} = 5 \text{ D}$$

28. The correct answer is [5440].



$$F_{net} = F_2 - F_1 = \frac{k4q^2}{\left(\frac{R}{4}\right)^2} - \frac{k2q^2}{\left(\frac{3R}{4}\right)^2}$$

$$= \frac{16kq^2}{R^2}\left(4 - \frac{2}{9}\right) = \frac{16kq^2}{R^2} \times \frac{34}{9} = \frac{544kq^2}{9R^2}$$

Given, $q = 2 \times 10^{-6}$ C

$R = 2 \times 10^{-2}$ m

$$F_{net} = \frac{544}{9} \times \frac{9 \times 10^9 \times 4 \times 10^{-12}}{4 \times 10^{-4}}$$

$= 5440$ N

29. The correct answer is [4125].

Net energy absorbed by the atom,

$$E = hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$$

$$E = 6.6 \times 10^{-34} \times 3 \times 10^8 \left(\frac{1}{500 \times 10^{-9}} - \frac{1}{600 \times 10^{-9}}\right)$$

$$= 6.6 \times 10^{-20} \text{ J} = \frac{6.6 \times 10^{-20}}{1.6 \times 10^{-19}} \text{ e V}$$

$= 4125 \times 10^{-4}$ e V

On comparing, $n = 4125$

30. The correct answer is [3].

$$E = \frac{1}{2}m(u^2 - 0) = \frac{1}{2}mu^2$$

$$E' = \frac{1}{2}m(4u^2 - u^2) = \frac{3}{2}mu^2 = \frac{3}{2} \times 2E = 3E$$

● ● ●