JEE (Main) PHYSICS SOLVED PAPER

2023

08th April Shift 1

General Instructions :

(i) There are 30 questions in this section.

(ii) Section A consists of 20 Multiple choice questions and Section B consists of 10 Numerical value type questions. In Section B, candidates have to attempt any five questions out of 10.

(iii) There will be only one correct choice in the given four choices in Section A. For each question for Section A, 4 marks will be awarded for correct choice, 1 mark will be deducted for incorrect choice questions and zero mark will be awarded for not attempted questions.

(iv) For Section B questions, 4 marks will be awarded for correct answer and zero for unattempted and incorrect answer.

(v) Any textual, printed or written material, mobile phones, calculator etc. is not allowed for the students appearing for the test.

(vi) All calculations/ written work should be done in the rough sheet which is provided with Question Paper.

Section A

Q. 1. A cylindrical wire of mass (0.4 ± 0.01)g has length (8 ± 0.04) cm and radius (6 ± 0.03) mm. The maximum error in its density will be:

(A) 4% **(B)** 1%
(C) 3.5% **(D)** 5%

Q. 2. The engine of a train moving with speed 10 ms^{-1} towards a platform sounds a whistle at frequency 400 Hz. The frequency heard by a passenger inside the train is : (neglect air speed. Speed of sound in air = 330 ms^{-1})

(A) 400 Hz **(B)** 388 Hz
(C) 200 Hz **(D)** 412 Hz

Q. 3. The weight of a body on the earth is 400 N. Then weight of the body when taken to a depth half of the radius of the earth will be:

(A) 300 N **(B)** Zero
(C) 100 N **(D)** 200 N

Q. 4. A TV transmitting antenna is 98 m high and the receiving antenna is at the ground level. If the radius of the earth is 6400 km, the surface area covered by the transmitting antenna is approximately:

(A) 120 km^2 **(B)** 1549 km^2
(C) 4868 km^2 **(D)** 3942 km^2

Q. 5. Certain galvanometers have a fixed core made of non magnetic metallic material. The function of this metallic material is

(A) To produce large deflecting torque on the coil
(B) To bring the coil to rest quickly
(C) To oscillate the coil in magnetic field for longer period of time
(D) To make the magnetic field radial

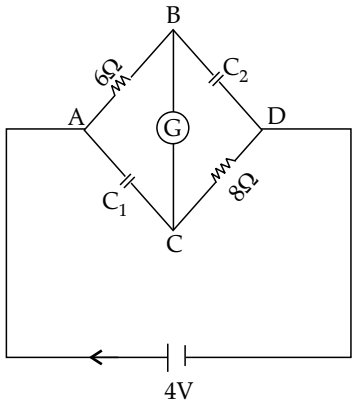
Q. 6. Dimension of $\frac{1}{\mu_0 \varepsilon_0}$ should be equal to

(A) $\frac{T}{L}$ **(B)** $\frac{T^2}{L^2}$
(C) $\frac{L}{T}$ **(D)** $\frac{L^2}{T^2}$

Q. 7. Two projectiles A and B are thrown with initial velocities of 40 m/s and 60 m/s at angles 30° and 60° with the horizontal respectively. The ratio of their ranges respectively is (g = 10 m/s^2)

(A) $2:\sqrt{3}$ **(B)** $\sqrt{3}:2$
(C) 4 : 9 **(D)** 1 : 1

Q. 8. In this figure the resistance of the coil of galvanometer G is 2 Ω. The emf of the cell is 4 V. The ratio of potential difference across C_1 and C_2 is:



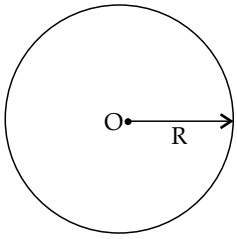
(A) $\frac{5}{4}$ **(B)** 1
(C) $\frac{4}{5}$ **(D)** $\frac{3}{4}$

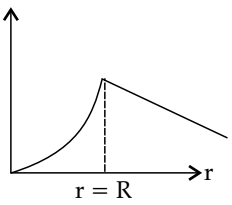
Q. 9. A charge particle moving in magnetic field B, has the components of velocity along B as well as perpendicular to B. The path of the charge

particle will be
(A) Helical path with the axis along magnetic field B
(B) Straight along the direction of magnetic field B
(C) Helical path with the axis perpendicular to the direction of magnetic field B
(D) Circular path

Q. 10. Proton (P) and electron (e) will have same de-Broglie wavelength when the ratio of their momentum is (assume, $m_p = 1849\ m_e$):
(A) 1 : 43 **(B)** 43 : 1
(C) 1 : 1849 **(D)** 1 : 1

Q. 11. Graphical variation of electric field due to a uniformly charged insulating solid sphere of radius R, with distance r from the centre O is represented by:



(A)


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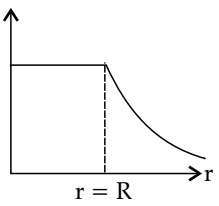
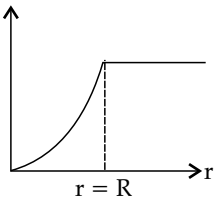
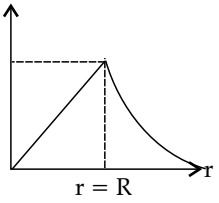


(C)


(D)


Q. 12. For a nucleus ${}^{A}_{Z}X$ having mass number A and atomic number Z

A. The surface energy per nucleon $(b_s) = -a_1 A^{2/3}$.
B. The Coulomb contribution to the binding energy $b_c = -a_2 \dfrac{Z(Z-1)}{A^{4/3}}$
C. The volume energy $bv = a_3 A$
D. Decrease in the binding energy is proportional to surface area.
E. While estimating the surface energy, it is assumed that each nucleon interacts with 12 nucleons. (a_1, a_2 and a_3 are constants)
Choose the most appropriate answer from the options given below:
(A) B, C only **(B)** A, B, C, D only
(C) B, C, E only **(D)** C, D only

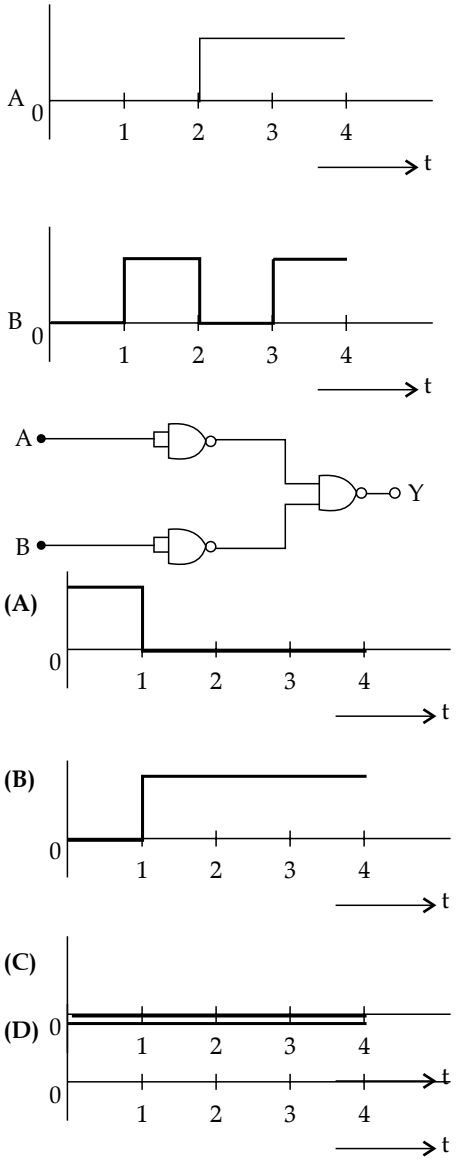
Q. 13. At any instant the velocity of a particle of mass 500 g is $(2t\hat{i} + 3t^2\hat{j})$ ms^{-1}. If the force acting on the particle at $t = 1$s is $(\hat{i} + x\hat{j})$ N . Then the value of x will be:
(A) 2 **(B)** 6
(C) 3 **(D)** 4

Q. 14. Given below are two statements:
Statement I: If E be the total energy of a satellite moving around the earth, then its potential energy will be $\dfrac{E}{2}$.

Statement II: The kinetic energy of a satellite revolving in an orbit is equal to the half the magnitude of total energy E.
In the light of the above statements, choose the most appropriate answer from the options given below
(A) Both Statement I and Statement II are incorrect
(B) Statement I is incorrect but Statement II is correct
(C) Statement I is correct but Statement II is incorrect
(D) Both Statement I and Statement II are correct

Q. 15. Two forces having magnitude A and $\dfrac{A}{2}$ are perpendicular to each other. The magnitude of their resultant is:
(A) $\dfrac{5A}{2}$ **(B)** $\dfrac{\sqrt{5}A^2}{2}$
(C) $\dfrac{\sqrt{5}A}{4}$ **(D)** $\dfrac{\sqrt{5}A}{2}$

Q. 16. For the logic circuit shown, the output waveform at Y is:



Q. 17. An aluminium rod with Young's modulus $Y = 7.0 \times 10^{10}$ N/m^2 undergoes elastic strain of 0.04%. The energy per unit volume stored in the rod in SI unit is:

(A) 5600 **(B)** 2800
(C) 11200 **(D)** 8400

Q. 18. Given below are two statements:
Statement I: If heat is added to a system, its temperature must increase.
Statement II: If positive work is done by a system in a thermodynamic process, its volume must increase.
In the light of the above statements, choose the correct answer from the options given below
(A) Both Statement I and Statement II are true
(B) Both Statement I and Statement II are false
(C) Statement I is true but Statement II is false
(D) Statement I is false but Statement II is true

Q. 19. An air bubble of volume 1 cm^3 rises from the bottom of a lake 40 m deep to the surface at a temperature of 12°C. The atmospheric pressure is 1×10^5 Pa, the density of water is 1000 kg/m^3 and $g = 10$ m/s^2. There is no difference of the temperature of water at the depth of 40 m and on the surface. The volume of air bubble when it reaches the surface will be:

(A) 3 cm^3 **(B)** 4 cm^3
(C) 2 cm^3 **(D)** 5 cm^3

Q. 20. In a reflecting telescope, a secondary mirror is used to:
(A) Make chromatic aberration zero
(B) Reduce the problem of mechanical support
(C) Move the eyepiece outside the telescopic tube
(D) Remove spherical aberration

Section B

Q. 21. The momentum of a body is increased by 50%. The percentage increase in the kinetic energy of the body is _____ %

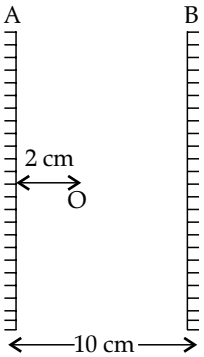
Q. 22. A nucleus with mass number 242 and binding energy per nucleon as 7.6 MeV breaks into two fragment each with mass number 121. If each fragment nucleus has binding energy per nucleon as 8.1 MeV, the total gain in binding energy is _____ MeV.

Q. 23. An electric dipole of dipole moment 6.0×10^{-6} Cm placed in a uniform electric field of 1.5×10^3 NC^{-1} in such a way that dipole moment is along electric field. The work done in rotating dipole by 180° in this field will be _____ mJ.

Q. 24. An organ pipe 40 cm long is open at both ends. The speed of sound in air is 360 ms^{-1}. The frequency of the second harmonic is _____ Hz.

Q. 25. The moment of inertia of a semicircular ring about an axis, passing through the center and perpendicular to the plane of ring, is $\frac{1}{x}$ MR^2, where R is the radius and M is the mass of the semicircular ring. The value of x will be _____.

Q. 26. Two vertical parallel mirrors A and B are separated by 10 cm. A point object O is placed at a distance of 2 cm from mirror A. The distance of the second nearest image behind mirror A from the mirror A is _____ cm



Q. 27. The magnetic intensity at the center of a long current carrying solenoid is found to be 1.6×10^3 Am^{-1}. If the number of turns is 8 per cm, then the current flowing through the solenoid is _____ A.

Q. 28. A current of 2 A through a wire of cross-sectional area 25.0 mm^2. The number of free electrons in a cubic meter are 2.0×10^{28}. The drift velocity of the electrons is _____ $\times 10^{-6}$ ms^{-1}

(given, charge on electron = 1.6×10^{-19} C).

Q. 29. An oscillating LC circuit consists of a 75 mH inductor and a 1.2 μF capacitor. If the maximum charge to the capacitor is 2.7 μC. The maximum current in the circuit will be _____ mA.

Q. 30. An air bubble of diameter 6 mm rises steadily through a solution of density 1750 kg/m^3 at the rate of 0.35 cm/s. TGe co-efficient of viscosity of the solution (neglect density of air) is _____ poise (given, $g = 10$ ms^{-2}).

Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	A	Error	Unit and dimension
2	A	Doppler's effect	Sound wave
3	D	Variation of g	Gravitation
4	D	Range	Communication system
5	B	Galvanometer	Magnetism
6	D	Dimensional equation	Units & Dimension
7	C	Range of projectile	Motion in 2D
8	C	RC circuit	Electric current
9	A	Force on moving charge in magnetic field	Moving charge and magnetism
10	D	Debroglie wavelength	Dual nature of matter
11	D	electric field due to charged sphere	Electrostatics
12	D	Binding energy	Nuclear physics
13	C	Momentum	Newton's second law
14	A	Energy of satellite	Gravitation
15	D	Resultant vector	Vectors
16	B	Logic gates	Semiconductors
17	A	Energy stored in stretched rod	Elasticity
18	D	Thermodynamic process	Thermodynamics
19	D	Isothermal process	Thermodynamics
20	C	Telescope	Ray optics
21	[125]	Kinetic energy	Work, Energy and Power
22	[121]	Binding energy	Nuclear physics
23	[18]	Dipole in uniform electric field	Electric dipole
24	[900]	Organ pipe	Sound wave
25	[1]	MI of semicircular ring	Rotational motion
26	[18]	Plane mirror	Ray optics
27	[2]	Solenoid	Electromagnetism
28	[25]	Drift velocity	Electric current
29	[9]	LC circuit	Electromagnetic induction
30	[10]	Terminal velocity	Fluid mechanics

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ANSWERS WITH EXPLANATIONS

Section A

1. Option (A) is correct.

$$\rho = \frac{m}{V} = \frac{m}{\pi r^2 l}$$

Now the relative error is given by

$$\left(\frac{\Delta\rho}{\rho}\right)_{max} = \left(\frac{\Delta m}{m}\right) + 2\left(\frac{\Delta r}{r}\right) + \left(\frac{\Delta l}{l}\right)$$

$$\Rightarrow \left(\frac{\Delta\rho}{\rho}\right)_{max} = \left(\frac{0.01}{0.4}\right) + 2\left(\frac{0.03}{6}\right) + \left(\frac{0.04}{8}\right)$$

$$\Rightarrow \left(\frac{\Delta\rho}{\rho}\right)_{max} = 0.04$$

Now % error in density $= \left(\frac{\Delta\rho}{\rho}\right) \times 100\%$

$= 0.04 \times 100\% = 4\%$

2. Option (A) is correct.

The relative velocity between the train and passanger is zero. Therefore there would not be Doppler's effect. And hence frequency heard by the passanger would be same 400 Hz.

3. Option (D) is correct.

Given $w = mg = 400$ N

$$d = \frac{R}{2}$$

At depth d,

$$g' = g\left(1 - \frac{d}{R}\right)$$

$$\Rightarrow g' = g\left(1 - \frac{R}{2R}\right) \Rightarrow g' = g\left(\frac{1}{2}\right) = \frac{g}{2}$$

So,

$$w' = mg' = \frac{mg}{2}$$

$$w' = \frac{400}{2} = 200 \text{ N}$$

4. Option (D) is correct.

Given values

$h_T = 98$ m

$h_R = 0$

R = 6400 km

Now

$$d = \sqrt{2Rh_T} + \sqrt{2Rh_r}$$

$$= \sqrt{2 \times 6400 \times 10^3 \times 98} + 0$$

$$d = \frac{112}{\sqrt{2}} \text{km}$$

Now area $= \pi d^2$

$$= \frac{22}{7} \times \left(\frac{112}{\sqrt{2}}\right)^2 = 3942 \text{ km}^2$$

5. Option (B) is correct.

By making fixed core with non magnetic material, the coil is brought quickly at rest because due to motion of the coil eddy current develops.

6. Option (D) is correct.

Since,

$$c^2 = \frac{1}{\mu_0 \varepsilon_0} \quad \text{(where } c \text{ = speed of light)}$$

$$\Rightarrow \left[\frac{1}{\mu_0 \varepsilon_0}\right] = [c^2]$$

$$\Rightarrow \left[\frac{1}{\mu_0 \varepsilon_0}\right] = [L^2T^{-2}] = \left[\frac{L^2}{T^2}\right]$$

7. Option (C) is correct.

Range of a projectile is given by

$$R = \frac{u^2 \sin 2\theta}{g}$$

Now $R_A = \frac{(40)^2 \sin(2 \times 30)}{g}$ ...(i)

$$R_B = \frac{(60)^2 \sin(2 \times 60)}{g}$$ ...(ii)

From (i) & (ii)

$$\frac{R_A}{R_B} = \frac{(40)^2 \sin(2 \times 30)}{(60)^2 \sin(2 \times 60)} = \frac{4}{9}$$

8. Option (C) is correct.

At a steady state, no current would be flowing in capacitor circuit.

Required $= 6 + 2 + 8 = 16\ \Omega$

From Ohm's law

$$i = \frac{V}{R} = \frac{4}{16} = \frac{1}{4} \text{A}$$

Voltage across AC

$$V_{AC} = i(6 + 2) = \frac{1}{4} \times 8 = 2 \text{ V}$$

Voltage across BD

$$V_{BD} = i(2 + 8) = \frac{1}{4} \times 10 = 2.5 \text{ V}$$

Now $\frac{V_{AC}}{V_{BD}} = \frac{2}{2.5} = \frac{4}{5}$

9. Option (A) is correct.

As the velocity vector has two components. One is along magnetic field and other is perpendicular to it. Due to perpendicular component of velocity, the charge particle moves in circular path.

And the component of velocity is along the magnetic field remains unchanged.
Therefore the particle will move in helical path along magnetic field.

10. Option (D) is correct.
Debroglie wavelength (λ) is given by :

$$\lambda = \frac{h}{mv}$$ (h = plank's const.)

According to the question,

$$\lambda_e = \lambda p$$

$$\Rightarrow \frac{h}{m_e v_e} = \frac{h}{m_p v_p}$$

$$\Rightarrow \frac{h}{p_e} = \frac{h}{p_p} \qquad (\because P = mv)$$

$$\Rightarrow P_e = P_p \Rightarrow \frac{P_P}{P_e} = \frac{1}{1}$$

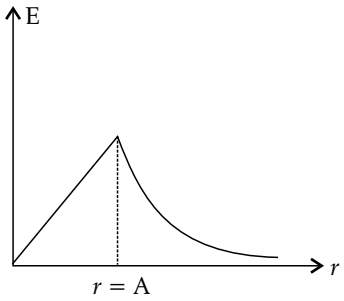
11. Option (D) is correct.
Electric field due to uniformly charged solid sphere is given by

$$E = \frac{Q}{4\pi\varepsilon_0 r^2} \qquad r \geq R$$

&

$$E = \frac{Qr}{4\pi\varepsilon_0 R^3} \qquad r \leq R$$

Therefore
$E \propto r$ when $r \leq R$
and $E \propto \frac{1}{r^2}$ when $r \geq R$
So



12. Option (D) is correct.

Mass number $A \propto r^3 \Rightarrow r \propto A^{\frac{1}{3}}$

Now, surface energy per nucleon $\propto \frac{r^2}{A} \propto \frac{A^{\frac{2}{3}}}{A} \propto \frac{1}{A^{\frac{1}{3}}}$
is

$$= -\frac{a_2 Z(Z-1)}{(A)^{\frac{1}{3}}}$$

And volume energy $\propto A$
Based on above statement, the correct option is (D).

13. Option (C) is correct.
Given value,
$m = 500\ g = 0.5\ kg$

$$\vec{v} = (2t\hat{i} + 3t^2\hat{j})$$

$$\vec{a} = \frac{d\vec{v}}{dt} = 2\hat{i} + 6t\hat{j}$$

acceleration at $t = 1$ sec.

$$\vec{a} = 2\hat{i} + 6\hat{j}$$

Now,

$$\vec{F} = m\vec{a} = 0.5(2\hat{i} + 6\hat{j}) \quad = \hat{i} + 3\hat{j}$$

$$\vec{F} = \hat{i} + x\hat{j}$$

Therefore, $x = 3$

14. Option (A) is correct.

Kinetic energy of satellite $= \frac{1}{2}mv^2 = \frac{GMm}{2r}$

Now, potential energy of the satellite

$$U = -\frac{GMm}{2r}$$

Total energy = K.E + U

$$= \frac{GMm}{2r} - \frac{GMm}{r} = -\frac{6Mm}{2r}$$

Therefore, potential energy = 2 × total energy
and, kinetic energy = |Total energy|

15. Option (D) is correct.

$$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

$$\Rightarrow |\vec{F}_{net}| = \sqrt{A^2 + \left(\frac{A}{2}\right)^2 + 2A + \frac{A}{2} \times \cos 90°} \quad (\because \theta = 90°)$$

$$\Rightarrow |\vec{F}_{net}| = \sqrt{A^2 + \frac{A^2}{4}}$$

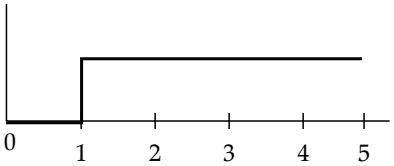
$$\Rightarrow |\vec{F}_{net}| = \sqrt{\frac{5A^2}{4}}$$

$$\Rightarrow |\vec{F}_{net}| = \sqrt{5}\frac{A}{2}$$

16. Option (B) is correct.
For the given circuit the truth table would be :

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

The truth table shows that the output graph is given by :



17. Option (A) is correct.
Given values,
$y = 7 \times 10^{10}\ N/m^2$

strain (E) = 0.04% = $\frac{0.04}{100}$

Now

$\text{Energy} = \frac{1}{2}\left(\frac{YA}{l}\right)(\Delta l)^2$

$\Rightarrow \text{Energy} = \frac{1}{2}\left(\frac{\Delta l}{l}\right)^2 YAl$

$\Rightarrow \frac{\text{Energy}}{Al} = \frac{1}{2}Y(E)^2$

$\Rightarrow \frac{E}{V} = \frac{1}{2}\times 7\times 10^{10}\times\frac{0.04\times 0.04}{100\times 100} = 56\times 10^2$

(where volume = A × l)

18. Option (D) is correct.

Statement-I: From Ist law of thermodynamics

$\Delta Q = \Delta u + w$

If heat is supplied ot the system and converted into work done.

Then, $\Delta u < 0$. Hence, $\Delta T < 0$

Statement I is false

Statement-II: Work done in thermodynamics system is given by

$w = \int PdV$

Therefore, to get the positive work done volume of the system must increase

Statement-II is true

19. Option (D) is correct.

$P = P_0 + \rho gh$

$= 10^5\,\text{Pa} + 10^3 \times 10 \times 40 = 5 \times 10^5\,\text{Pa}$

In isothermal process

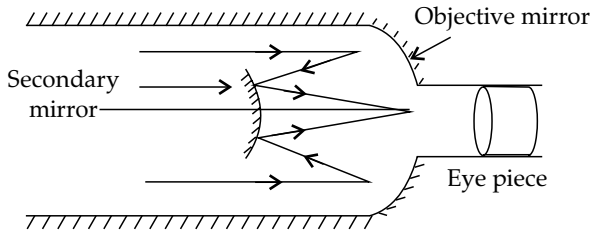
$PV = P_0V_0$

$\Rightarrow 5 \times 10^5\,\text{Pa} \times 1\,\text{cm}^3 = 10^5\,\text{Pa} \times V_0$

$\Rightarrow V_0 = \frac{5\times 10^5\,\text{Pa}\times 1\text{cm}^3}{5\times 10^5\,\text{Pa}}$

$\Rightarrow V_0 = 5\,\text{cm}^3$

20. Option (C) is correct.



Here the secondary mirror is used to move the eyepiece outside the telescope & it has advantage of a large focal length in a short telescope.

Section B

21. The correct answer is (125).

K.E. = $\frac{P^2}{2m}$

K.E.$_{\text{initial}} = \frac{P^2}{2m}$

K.E.$_{\text{final}} = \frac{(1.5P)^2}{2m} = 2.25\frac{P^2}{2m}$

% increase in K.E. = $\frac{2.25\frac{P^2}{2m} - \frac{P^2}{2m}}{\frac{P^2}{2m}} \times 100$

% increase in K.E. = 1.25 × 100 = 125%

22. The correct answer is (121).

Binding energy (Initial) = 242 × 7.6 MeV

Binding energy (final)

= 121 × 8.1 MeV + 121 × 8.1 MeV

= 242 × 8.1 MeV

Gain in binding energy.

= Binding energy final – Binding energy initial

= 242 × 8.1 – 242 × 7.6

= 242 (8.1 – 7.6)

= 242 × 0.5 = 121 MeV

23. The correct answer is (18).

Work done in rotating the dipole = $V_f - V_i$

Now, V_f = – PE cos (180°)

V_i = –PE cos 0°

Therefore, W = $V_f - V_i$

= (–PE cos 180°) – (–PE cos0°)

= 2PE

= 2 × 6 × 10^{-6} × 1.5 × 10^3 = 18 mJ

24. The correct answer is (900).

In an open organ pipe, the condition for second hormonies is :

The length of organ pipe = wavelength

$h = \lambda$

Now frequency = $f = \frac{v}{\lambda}$

$\Rightarrow f = \frac{360}{L} = \frac{360}{\frac{40}{100}} = \frac{360\times 100}{40}$

$\Rightarrow f$ = 900 Hz

25. The correct answer is (1).

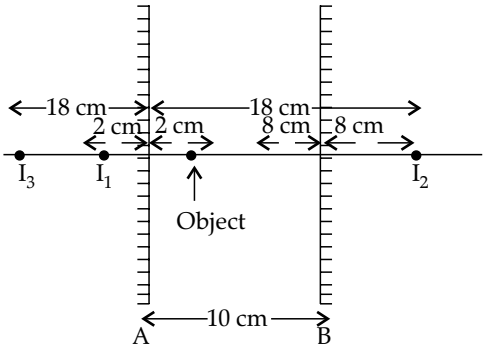
Moment of inertia of a semicircular ring about its centre and perpendicular to the plane of ring is given by MR^2

Therefore, $MR^2 = \frac{1}{x}MR^2$

$\therefore x = 1$

26. The correct answer is (18).

Therefore the second nearest image behind mirror A is at 18 cm



27. The correct answer is (2).

$B = \mu_0 ni$

and $H = \dfrac{B}{\mu_0}$

$\Rightarrow H = \dfrac{\mu_0 ni}{\mu_0} = ni$

Now, $i = \dfrac{H}{h} = \dfrac{1.6\times10^{3}\times10^{-2}}{8} = 2\,A$

28. The correct answer is (25).

$V_d = \dfrac{I}{neA}$

$\Rightarrow V_d = \dfrac{2}{2\times10^{28}\times1.6\times10^{-19}\times25\times10^{-6}}$

$\Rightarrow V_d = 25 \times 10^{-6}$ m/s

29. The correct answer is (9).

Maximum energy stored in capacitor

= Maximum energy stored in inductor which is given by :

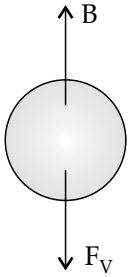
$\dfrac{1}{2}Li_{max}^2 = \dfrac{1}{2}\dfrac{Q_{max}^2}{C}$

$\Rightarrow i_{max}^2 = \dfrac{Q_{max}^2}{LC}$

$\Rightarrow i_{max} = \sqrt{\dfrac{Q_{max}^2}{LC}} = \dfrac{Q_{max}}{\sqrt{LC}}$

$= \dfrac{2.7\times10^{-6}}{\sqrt{75\times10^{-3}\times1.2\times10^{-6}}} = 9$ mA

30. The correct answer is (10).



From Newton's 1st law

$F_{net} = 0$

V = Constant

As the bubble moves with constant velocity, so net force must be zero.

$\therefore B = F_V$

$\Rightarrow \dfrac{4}{3}\pi R^3 \rho g = 6\pi\eta RV$

$\Rightarrow \eta = \dfrac{4\pi R^3 \rho g}{3\times6\pi RV}$

$\Rightarrow \eta = \dfrac{2R^2\rho g}{9V}$

$\Rightarrow \eta = \dfrac{2\times(3\times10^{-3})^2\times1750\times10}{9\times0.35\times10^{-2}}$

$\Rightarrow \eta = 10$ Poise