

# JEE (Main) PHYSICS SOLVED PAPER

**2023**  
15<sup>th</sup> April Shift 1

## Section A

**Q. 1.** Match List I with List II of Electromagnetic waves with corresponding wavelength range:

List I	List II
(A) Microwave	(I) 400 nm to 1 nm
(B) Ultraviolet	(II) 1 nm to $10^{-3}$ nm
(C) X-Ray	(III) 1 mm to 700 nm
(D) Infra-red	(IV) 0.1 m to 1 mm

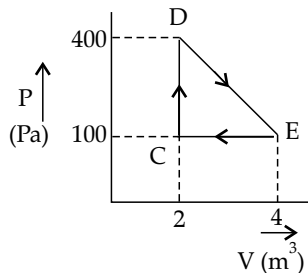
Choose the correct answer from the options given below:

- (1) (A)-(IV), (B)-(I), (C)-(III), (D)-(II)  
 (2) (A)-(IV), (B)-(I), (C)-(II), (D)-(III)  
 (3) (A)-(I), (B)-(IV), (C)-(II), (D)-(III)  
 (4) (A)-(IV), (B)-(II), (C)-(I), (D)-(III)

**Q. 2.** The electric field due to a short electric dipole at a large distance ( $r$ ) from center of dipole on the equatorial plane varies with distance as:

- (1)  $r$       (2)  $\frac{1}{r}$       (3)  $\frac{1}{r^2}$       (4)  $\frac{1}{r^3}$

**Q. 3.** A thermodynamic system is taken through cyclic process. The total work done in the process is:



- (1) 100 J    (2) 300 J    (3) 200 J    (4) Zero

**Q. 4.** The half-life of a radioactive nucleus is 5 years. The fraction of the original sample that would decay in 15 years is:

- (1)  $\frac{3}{4}$       (2)  $\frac{1}{8}$       (3)  $\frac{7}{8}$       (4)  $\frac{1}{4}$

**Q. 5.** The position vector of a particle related to time  $t$  is given by,  $\vec{r} = (10t\hat{i} + 15t^2\hat{j} + 7t\hat{k})$  m

The direction of net force experienced by the particle is:

- (1) Positive  $z$ -axis      (2) In  $x$ - $y$  plane  
 (3) Positive  $y$ -axis      (4) Positive  $x$ -axis

**Q. 6.** The height of transmitting antenna is 180 m and the height of the receiving antenna is 245 m. The maximum distance between them for satisfactory communication in line of sight will be:

(given  $R = 6400$  km)

- (1) 48 km    (2) 104 km    (3) 96 km    (4) 56 km

**Q. 7.** A single slit of width  $a$  is illuminated by a monochromatic light of wavelength 600 nm. The value of 'a' for which first minimum appears at  $\theta = 30^\circ$  on the screen will be:

- (1)  $0.6 \mu\text{m}$     (2)  $3 \mu\text{m}$     (3)  $1.8 \mu\text{m}$     (4)  $1.2 \mu\text{m}$

**Q. 8.** A 12 V battery connected to a coil of resistance  $6 \Omega$  through a switch, drives a constant current in the circuit. The switch is opened in 1 ms. The emf induced across the coil is 20 V. The inductance of the coil is:

- (1) 8 mH    (2) 10 mH    (3) 12 mH    (4) 5 mH

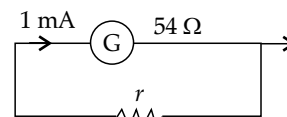
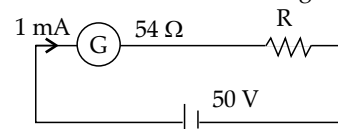
**Q. 9.** Two identical particles each of mass ' $m$ ' go round a circle of radius  $a$  under the action of their mutual gravitational attraction. The angular speed of each particle will be:

- (1)  $\sqrt{\frac{Gm}{a^3}}$     (2)  $\sqrt{\frac{Gm}{4a^3}}$     (3)  $\sqrt{\frac{Gm}{2a^3}}$     (4)  $\sqrt{\frac{Gm}{8a^3}}$

**Q. 10.** A body is released from a height equal to the radius ( $r$ ) of the earth. The velocity of the body when it strikes the surface of the earth will be: (Given  $g =$  acceleration due to gravity on the earth.)

- (1)  $\sqrt{gR}$     (2)  $\sqrt{\frac{gR}{2}}$     (3)  $\sqrt{4gR}$     (4)  $\sqrt{2gR}$

**Q. 11.** For designing a voltmeter of range 50 V and an ammeter of range 10 mA using a galvanometer which has a coil of resistance  $54 \Omega$  showing a full scale deflection for 1 mA as in figure.



(A) for voltmeter  $R \approx 50\text{k}\Omega$

(B) for ammeter  $r \approx 0.2 \Omega$

(C) for ammeter  $r \approx 6 \Omega$

(D) for voltmeter  $R \approx 5\text{k}\Omega$

(E) for voltmeter  $R \approx 500 \Omega$

Choose the correct answer from the options given below:

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

**Q. 12.** Given below are two statements:

**Statement I:** The equivalent resistance of resistors in a series combination is smaller than least resistance used in the combination.

**Statement II:** The resistivity of the material is independent of temperature.

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

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

**Q. 13.** The de-Broglie wavelength of an electron having kinetic energy  $E$  is  $\lambda$ . If the kinetic energy of electron becomes  $\frac{E}{4}$  then its de-Broglie wavelength will be:

- (1)  $\frac{\lambda}{\sqrt{2}}$
- (2)  $2\lambda$
- (3)  $\frac{\lambda}{2}$
- (4)  $\sqrt{2}\lambda$

**Q. 14.** A vector in  $x$ - $y$  plane makes an angle of  $30^\circ$  with  $y$ -axis. The magnitude of  $y$ -component of vector is  $2\sqrt{3}$ .

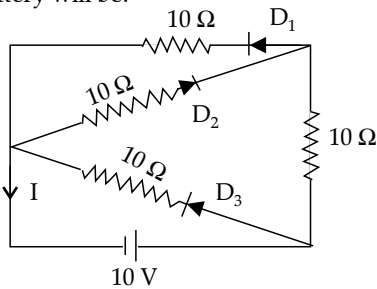
The magnitude of  $x$ -component of the vector will be:

- (1) 2
- (2)  $\sqrt{3}$
- (3)  $\frac{1}{\sqrt{3}}$
- (4) 6

**Q. 15.** The speed of a wave produced in water is given by  $v = \lambda^a g^b \rho^c$ . Where  $\lambda$ ,  $g$  and  $\rho$  are wavelength of wave, acceleration due to gravity and density of water respectively. The values of  $a$ ,  $b$  and  $c$  respectively, are:

- (1)  $\frac{1}{2}, 0, \frac{1}{2}$
- (2) 1, -1, 0
- (3)  $\frac{1}{2}, \frac{1}{2}, 0$
- (4) 1, 1, 0

**Q. 16.** In the given circuit, the current (I) through the battery will be:



- (1) 1 A
- (2) 1.5 A
- (3) 2 A
- (4) 2.5 A

**Q. 17.** In a linear Simple Harmonic Motion (SHM)

- (A) Restoring force is directly proportional to the displacement.
- (B) The acceleration and displacement are opposite in direction.
- (C) The velocity is maximum at mean position.
- (D) The acceleration is minimum at extreme points.

Choose the correct answer from the options given below:

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

**Q. 18.** A wire of length 'L' and radius 'r' is clamped rigidly at one end. When the other end of the wire is pulled by a force  $f$ , its length increases by 'l'. Another wire of same material of length '2L' and radius '2r' is pulled by a force '2f'. Then the increase in its length will be:

- (1)  $\frac{l}{2}$
- (2)  $4l$
- (3)  $l$
- (4)  $2l$

**Q. 19.** A flask contains Hydrogen and Argon in the ratio 2 : 1 by mass. The temperature of the mixture is  $30^\circ\text{C}$ . The ratio of average kinetic energy per molecule of the two gases ( $K_{\text{argon}}/K_{\text{hydrogen}}$ ) is :

- (Given : Atomic Weight of Ar = 39.9)
- (1) 2
  - (2) 39.9
  - (3) 1
  - (4)  $\frac{39.9}{2}$

**Q. 20.** The position of a particle related to time is given by  $x = (5t^2 - 4t + 5)$  m. The magnitude of velocity of the particle at  $t = 2$  s will be:

- (1)  $10 \text{ m s}^{-1}$
- (2)  $06 \text{ m s}^{-1}$
- (3)  $16 \text{ m s}^{-1}$
- (4)  $14 \text{ m s}^{-1}$

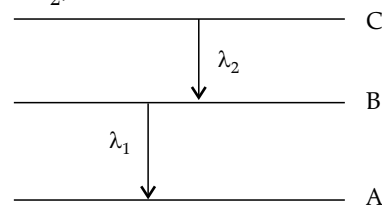
### Section B

**Q. 21.** An electron in a hydrogen atom revolves around its nucleus with a speed of  $6.76 \times 10^6 \text{ m s}^{-1}$  in an orbit of radius  $0.52 \text{ \AA}$ . The magnetic field produced at the nucleus of the hydrogen atom is \_\_\_\_\_ T.

**Q. 22.** A 20 cm long metallic rod is rotated with 210 rpm about an axis normal to the rod passing through its one end. The other end of the rod is in contact with a circular metallic ring. A constant and uniform magnetic field  $0.2 \text{ T}$  parallel to the axis exists everywhere. The emf developed between the centre and the ring is \_\_\_\_\_ mV.

(Take  $\pi = \frac{22}{7}$ )

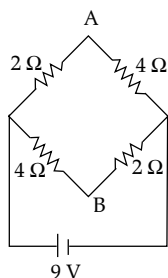
**Q. 23.** As per given figure A, B and C are the first, second and third excited energy levels of hydrogen atom respectively. If the ratio of the two wavelengths (i.e.  $\frac{\lambda_1}{\lambda_2}$ ) is  $\frac{7}{4n}$ , then the value of  $n$  will be \_\_\_\_\_.



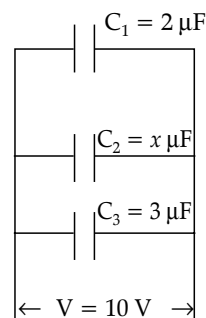
**Q. 24.** The refractive index of a transparent liquid filled in an equilateral hollow prism is  $\sqrt{2}$ . The angle of minimum deviation for the liquid will be \_\_\_\_\_.

**Q. 25.** A block of mass 10 kg is moving along  $x$ -axis under the action of force  $F = 5x \text{ N}$ . The work done by the force in moving the block from  $x = 2 \text{ m}$  to  $4 \text{ m}$  will be \_\_\_\_\_ J.

- Q. 26. The fundamental frequency of vibration of a string stretched between two rigid support is 50 Hz. The mass of the string is 18 g and its linear mass density is  $20 \text{ g m}^{-1}$ . The speed of the transverse waves so produced in the string is \_\_\_\_\_  $\text{m s}^{-1}$ .
- Q. 27. A solid sphere and a solid cylinder of same mass and radius are rolling on a horizontal surface without slipping. The ratio of their radius of gyration respectively ( $k_{sph} : k_{cyl}$ ) is  $2 : \sqrt{x}$ . The value of  $x$  is \_\_\_\_\_.
- Q. 28. A network of four resistances is connected to 9 V battery, as shown in figure. The magnitude of voltage difference between the points A and B is \_\_\_\_\_ V.



- Q. 29. In the given figure the total charge stored in the combination of capacitors is  $100 \mu\text{C}$ . The value of 'x' is \_\_\_\_\_.



- Q. 30. There is an air bubble of radius 1.0 mm in a liquid of surface tension  $0.075 \text{ N m}^{-1}$  and density  $1000 \text{ kg m}^{-3}$  at a depth of 10 cm below the free surface. The amount by which the pressure inside the bubble is greater than the atmospheric pressure is \_\_\_\_\_ Pa ( $g = 10 \text{ m s}^{-2}$ )

## Answer Key

Q. No.	Answer	Topic name	Chapter name
1	(2)	Electromagnetic spectrum	Electromagnetic waves
2	(4)	Electric dipole	Electrostatics
3	(2)	Thermodynamic processes	Thermodynamics
4	(3)	Half life	Nuclear physics
5	(3)	Newton's second law	Newton's law of motion
6	(2)	Element of communication system	Communication system
7	(4)	Diffraction	Wave optics
8	(2)	LR circuit	Alternating current
9	(2)	Velocity	Gravitation
10	(1)	Potential energy	Gravitation
11	(4)	Electrical devices	Current electricity
12	(2)	Resistance & Resistivity	Current electricity
13	(2)	de-Broglie wave	Due nature of matter and radiation
14	(1)	Resolution of vectors	Vectors
15	(3)	Dimensions	Units & Dimensions
16	(2)	Diode	Semiconductors
17	(3)	Restoring forces	SHM
18	(3)	Hook's law	Properties of solid
19	(3)	Kinetic energy of molecule	Kinetic theory of gases
20	(3)	Velocity	Motion in 1 D
21	[40]	Biot-Savart's Law	Moving charge and magnetism
22	[88]	Induced EMF	Electromagnetic induction
23	[5]	Hydrogen spectrum	Atoms
24	[30]	Prism	Refraction
25	[30]	Work done by variable force	Work, Energy and Power
26	[90]	Stationary waves	Waves
27	[5]	Radius of gyration	Rotational Motion
28	[3]	KVL	Electric current
29	[5]	Capacitors in parallel	Electrostatics
30	[1150]	Surface tension	Fluid mechanics

# SOLUTIONS

## Section A

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

The spectrum in the order of increasing wavelength is as under.

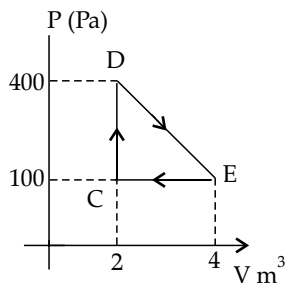
$\gamma$ -rays  $\rightarrow$  X-Rays  $\rightarrow$  Ultra violet  $\rightarrow$  VIBGYOR  $\rightarrow$   
Infra Red  $\rightarrow$  Micro waves  $\rightarrow$  Radiowaves

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

At an equatorial point,

$$E = \frac{kp}{r^3} \Rightarrow E \propto \frac{1}{r^3}$$

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



Work done in a cyclic process is given by area

enclosed by the cycle =  $\frac{1}{2} \times 2 \times 300 = 300$  J

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

No. of nuclei decayed in  $x$  half lives

$$= N_0 \left[ 1 - \left( \frac{1}{2} \right)^x \right]$$

Given  $x = \frac{t}{t_{1/2}} = \frac{15}{5} = 3$

$$N_d = N_0 \left[ 1 - \left( \frac{1}{2} \right)^3 \right] = N_0 \left( 1 - \frac{1}{8} \right) = \frac{7N_0}{8}$$

$$\frac{N_d}{N_0} = \frac{7}{8}$$

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

$$\vec{r} = (10t\hat{i} + 15t^2\hat{j} + 7t\hat{k})m$$

$$\vec{v} = \frac{d\vec{r}}{dt} = 0\hat{i} + 30\hat{j} + 0\hat{k}$$

$$\vec{a} = \frac{d\vec{v}}{dt} = 0\hat{i} + 30\hat{j} + 0\hat{k} = 30\hat{j}$$

$$\vec{F} = m\vec{a} = 30m\hat{j}$$

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

Line of sight distanc

$$d = \sqrt{2Rh_t} + \sqrt{2Rh_R}$$

$R$  = radius of earth

$$d = \sqrt{2 \times 6400 \times 10^3} [\sqrt{180} + \sqrt{245}] m$$

$$= 10^3 \sqrt{12.8} [13.42 + 15.65]$$

$$= 10^3 \times 3.58 \times 29.07 m$$

$$= 104 km$$

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

From condition of diffraction minima

$$a \sin \theta = n\lambda, \quad n = 1, 2, 3 \dots$$

$$a \sin 30^\circ = 6 \times 10^{-7}$$

(for  $n = 1$ )

$$a = 12 \times 10^{-7} m$$

$$= 1.2 \mu m$$

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

When a constant current flows in an R-L circuit, L acts as a short and the steady current is given by

$$i = \frac{E}{R} = \frac{12}{6} = 2 A$$

emf induced across the inductance

$$e_L = L \frac{\Delta i}{\Delta t}$$

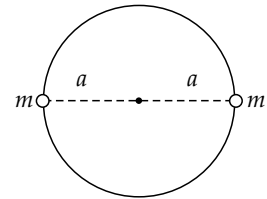
$$L = e_L \times \frac{\Delta t}{\Delta i} = 20 \times \frac{10^{-3}}{0 - (-2)}$$

$$= 10^{-2} H = 10 mH$$

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

$$\frac{Gm^2}{(2a)^2} = m\omega^2 a$$

$$\omega = \sqrt{\frac{Gm}{4a^3}}$$



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

Conservation of Energy gives

$$KE_i + PE_i = KE_f + PE_f$$

$$0 - \frac{GMm}{2R} = \frac{1}{2}mv^2 - \frac{GMm}{R}$$

$$\frac{GM}{R} - \frac{GM}{2R} = \frac{v^2}{2}$$

$$v = \sqrt{\frac{GM}{R}}$$

Since

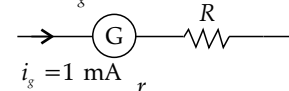
$$GM = gR^2$$

$$v = \sqrt{gR}$$

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

For voltmeter,

$$R_g = 54 \Omega$$



$$50 = i_g(R_g + R)$$

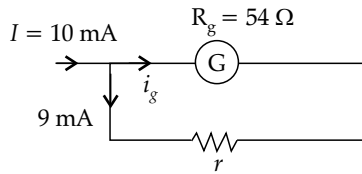
$$50 = i_g(R_g + R)$$

$$R = \frac{50}{i_g} - R_g$$

$$R = 50 \times 10^3 - 54$$

$$R \approx 50 \times 10^3 \Omega = 50 \text{ k}\Omega$$

For ammeter



$$R_g i_g = r(i - i_g)$$

$$54 \times 1 = r \times 9$$

$$r = 6 \Omega$$

12. Option (2) is correct.

For series combination,

$$R = R_1 + R_2$$

Hence  $R > R_1$

$$R > R_2$$

$\therefore$  Statement I is false.

Resistivity  $\rho = \rho_0(1 + \alpha \Delta T)$

$\therefore$  Statement II is false.

13. Option (2) is correct.

$$\lambda = \frac{h}{\sqrt{2m(\text{KE})}}$$

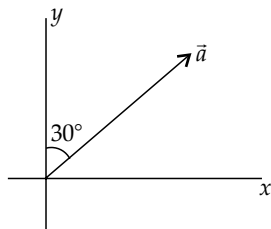
$$\lambda \propto \frac{1}{\sqrt{\text{KE}}}$$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{\text{KE}_2}{\text{KE}_1}}$$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{E}{4E}} = \frac{1}{2}$$

$$\lambda_2 = 2\lambda_1$$

14. Option (1) is correct.



Given,  $a_y = a \cos 30^\circ = \frac{\sqrt{3}a}{2} = 2\sqrt{3}$

$$\Rightarrow a = 4$$

$$a_x = a \sin 30^\circ = 4 \times \frac{1}{2} = 2$$

15. Option (3) is correct.

$$v = \lambda^a g^b \rho^c$$

from dimensional consistency, we get

$$[v] = [\lambda]^a [g]^b [\rho]^c$$

$$[L^1 T^{-1}] = [L^1]^a [L^1 T^{-2}]^b [M^1 L^{-3}]^c$$

$$= [M]^c [L]^{a+b-3c} [T]^{-2b}$$

Comparing the like terms, we get

$$c = 0$$

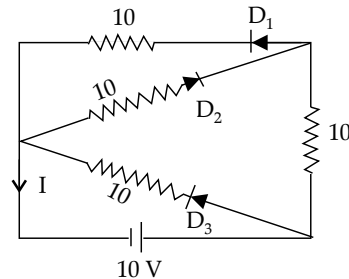
$$-2b = -1$$

$$b = \frac{1}{2}$$

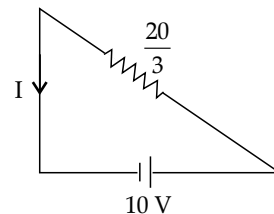
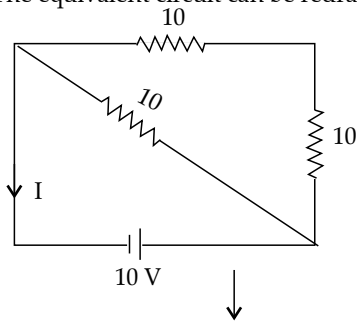
$$a + b - 3c = 1$$

$$\Rightarrow a = \frac{1}{2}$$

16. Option (2) is correct.



$D_2$  is reverse biased, hence it acts as an open circuit.  $D_1$  and  $D_3$  are forward biased, hence these act as short. The equivalent circuit can be redrawn as:



$$I = \frac{10}{\frac{20}{3}} = \frac{3}{2} = 1.5 \text{ A}$$

17. Option (3) is correct.

In a linear SHM

$$F = -kx \rightarrow F \propto -x$$

acc  $\propto -x$

Velocity is maximum at the mean position and minimum at the extremes while acceleration is maximum at the extremes and minimum at the mean position.

18. Option (3) is correct.

Increase in length,  $\Delta l = \frac{Fl}{\gamma A} = \frac{Fl}{\gamma(\pi r^2)}$

$$\frac{\Delta l_1}{\Delta l_2} = \frac{F_1 l_1}{F_2 l_2} \times \frac{r_2^2}{r_1^2}$$

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

$$\frac{l}{\Delta l_2} = 1 \Rightarrow \Delta l_2 = l$$

19. Option (3) is correct.

KE<sub>av</sub> per molecule =  $\frac{3}{2}k_bT$  where,  $k_b$  = Boltzmann's constant

Since both the gases are at the same temperature

$$\frac{KE_{(Ar)}}{KE_{(H_2)}} = \frac{1}{1}$$

20. Option (3) is correct.

$$x = 5t^2 - 4t + 5 \Rightarrow v = \frac{dx}{dt} = 10t - 4$$

At  $t = 2$  s,  $v = 16$  m s<sup>-1</sup>

### Section B

21. The correct answer is (40).

$B$  at the nucleus due to revolving electron is given by

$$B = \frac{\mu_0 ev}{4\pi r^2} = \frac{10^{-7} \times 1.6 \times 10^{-19} \times 6.76 \times 10^6}{0.52 \times 0.52 \times 10^{-20}} = 40 \text{ T}$$

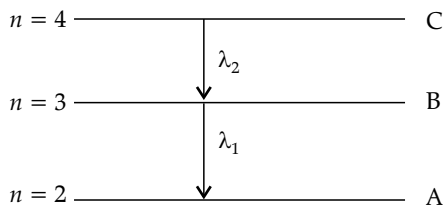
22. The correct answer is (88).

$$\text{emf, } e = \frac{1}{2}B\omega l^2$$

$$\omega = 210 \text{ rpm} = 210 \times \frac{2\pi}{60} = 7\pi = 22 \text{ rad s}^{-1}$$

$$e = \frac{1}{2} \times 0.2 \times 22 \times 0.04 = 88 \text{ mV}$$

23. The correct answer is (5).



$$\frac{1}{\lambda_2} = R \left( \frac{1}{9} - \frac{1}{16} \right) = \frac{7R}{144} \Rightarrow \frac{1}{\lambda_1} = R \left( \frac{1}{4} - \frac{1}{9} \right) = \frac{5R}{36}$$

Dividing, we get

$$\frac{\lambda_1}{\lambda_2} = \frac{7}{144} \times \frac{36}{5} = \frac{7}{20} = \frac{7}{4n}$$

On comparing,  $n = 5$

24. The correct answer is (30).

For equilateral prism,  $A = 60^\circ$

$$r = \frac{A}{2} = 30^\circ$$

Applying Snell's law,

$$\sin i = \mu \sin r = \sqrt{2} \times \sin 30^\circ$$

$$\Rightarrow \sin i = \frac{1}{\sqrt{2}}$$

$$i = 45^\circ$$

$$\Delta_{\min} = 2i - A = 90^\circ - 60^\circ = 30^\circ$$

25. The correct answer is (30).

$F = 5x$  (Variable force)

$$W = \int F dx = \int_2^4 5x dx = 5 \left[ \frac{x^2}{2} \right]_2^4 = \frac{5}{2} (16 - 4) = 30 \text{ J}$$

26. The correct answer is (90).

$$v = \sqrt{\frac{T}{\mu}} \text{ where, } \mu = \frac{m}{l} \Rightarrow l = \frac{m}{\mu} = \frac{18}{20} \text{ m}$$

$$\mu = 0.9 \text{ m}$$

$$f_0 = \frac{v}{2l}$$

$$\Rightarrow v = f_0(2l) = 50 \times 2 \times 0.9 = 90 \text{ m s}^{-1}$$

27. The correct answer is (5).

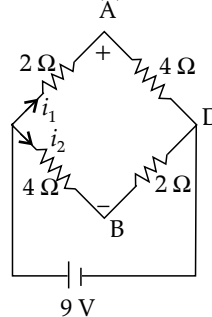
$$\text{For solid sphere, } K_{sph} = \sqrt{\frac{2}{5}}R$$

$$\text{For solid cylinder } K_{cyl} = \frac{R}{\sqrt{2}}$$

$$\frac{K_{sph}}{K_{cyl}} = \frac{2}{\sqrt{5}} = \frac{2}{\sqrt{x}}$$

$$\Rightarrow x = 5$$

28. The correct answer is (3).



$$i_1 = i_2 = \frac{9}{6} = 1.5 \text{ A}$$

Applying KVL along ABCA, we get

$$-V_{AB} + 4(1.5) - 2(1.5) = 0$$

$$V_{AB} = 3 \text{ V}$$

29. The correct answer is (5).

Since all three capacitors are connected in parallel,

$$q_1 = C_1V = 20 \mu\text{C}$$

$$q_2 = C_2V = 10x \mu\text{C}$$

$$q_3 = C_3V = 30 \mu\text{C}$$

$$q = q_1 + q_2 + q_3 = 50 + 10x = 100$$

$$x = 5 \mu\text{F}$$

30. The correct answer is (1150).

$$P_{\text{inside}} = P_0 + \rho gh + \frac{25}{r}$$

$$P_{\text{inside}} - P_0 = \rho gh + \frac{25}{r}$$

$$= (1000 \times 10 \times 0.1) + \frac{2 \times 0.075}{10^{-3}}$$

$$= 1000 + 150 = 1150 \text{ Pa}$$