

**TEST PAPER OF JEE(MAIN) EXAMINATION – 2019****(Held On Thursday 10th JANUARY, 2019) TIME : 02 : 30 PM To 05 : 30 PM****PHYSICS**

1. Two forces P and Q of magnitude $2F$ and $3F$, respectively, are at an angle θ with each other. If the force Q is doubled, then their resultant also gets doubled. Then, the angle is :

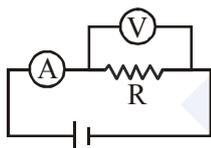
(1) 30° (2) 60° (3) 90° (4) 120° **Ans. (4)**

Sol. $4F^2 + 9F^2 + 12F^2 \cos \theta = R^2$
 $4F^2 + 36F^2 + 24F^2 \cos \theta = 4R^2$
 $4F^2 + 36F^2 + 24F^2 \cos \theta = 4(13F^2 + 12F^2 \cos \theta)$
 $= 52F^2 + 48F^2 \cos \theta$

$$\cos \theta = -\frac{12F^2}{24F^2} = -\frac{1}{2}$$

2. The actual value of resistance R, shown in the figure is 30Ω . This is measured in an experiment as shown using the standard

formula $R = \frac{V}{I}$, where V and I are the readings of the voltmeter and ammeter, respectively. If the measured value of R is 5% less, then the internal resistance of the voltmeter is :

(1) 350Ω (2) 570Ω (3) 35Ω (4) 600Ω **Ans. (2)**

Sol. $0.95R = \frac{R R_v}{R + R_v}$

$$0.95 \times 30 = 0.05 R_v$$

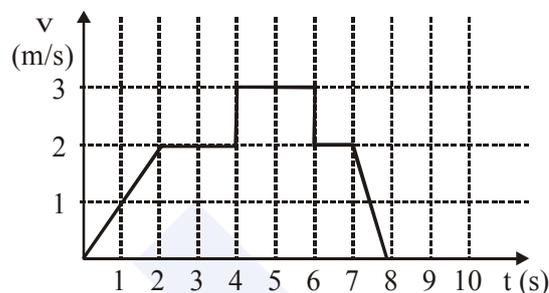
$$R_v = 19 \times 30 = 570\Omega$$

3. An unknown metal of mass 192 g heated to a temperature of 100°C was immersed into a brass calorimeter of mass 128 g containing 240 g of water a temperature of 8.4°C . Calculate the specific heat of the unknown metal if water temperature stabilizes at 21.5°C (Specific heat of brass is $394\text{ J kg}^{-1}\text{ K}^{-1}$)

(1) $1232\text{ J kg}^{-1}\text{ K}^{-1}$ (2) $458\text{ J kg}^{-1}\text{ K}^{-1}$
(3) $654\text{ J kg}^{-1}\text{ K}^{-1}$ (4) $916\text{ J kg}^{-1}\text{ K}^{-1}$ **Ans. (4)**

Sol. $192 \times S \times (100 - 21.5)$
 $= 128 \times 394 \times (21.5 - 8.4)$
 $+ 240 \times 4200 \times (21.5 - 8.4)$
 $\Rightarrow S = 916$

4. A particle starts from the origin at time $t = 0$ and moves along the positive x-axis. The graph of velocity with respect to time is shown in figure. What is the position of the particle at time $t = 5\text{ s}$?

(1) 6 m (2) 9 m (3) 3 m (4) 10 m **Ans. (2)**

$$S = \text{Area under graph}$$

$$\frac{1}{2} \times 2 \times 2 + 2 \times 2 + 3 \times 1 = 9\text{ m}$$

5. The self induced emf of a coil is 25 volts . When the current in it is changed at uniform rate from 10 A to 25 A in 1 s , the change in the energy of the inductance is :

(1) 437.5 J (2) 637.5 J
(3) 740 J (4) 540 J **Ans. (1)**

$$L \frac{di}{dt} = 25$$

$$L \times \frac{15}{1} = 25$$

$$L = \frac{5}{3}\text{ H}$$

$$\Delta E = \frac{1}{2} \times \frac{5}{3} \times (25^2 - 10^2) = \frac{5}{6} \times 525 = 437.5\text{ J}$$

6. A current of 2 mA was passed through an unknown resistor which dissipated a power of 4.4 W . Dissipated power when an ideal power supply of 11 V is connected across it is :

(1) $11 \times 10^{-5}\text{ W}$ (2) $11 \times 10^{-4}\text{ W}$
(3) $11 \times 10^5\text{ W}$ (4) $11 \times 10^{-3}\text{ W}$


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Ans. (1)

$$P = I^2 R$$

$$4.4 = 4 \times 10^{-6} R$$

$$R = 1.1 \times 10^6 \Omega$$

$$P' = \frac{11^2}{R} = \frac{11^2}{1.1} \times 10^{-6} = 11 \times 10^{-5} W$$

7. The diameter and height of a cylinder are measured by a meter scale to be 12.6 ± 0.1 cm and 34.2 ± 0.1 cm, respectively. What will be the value of its volume in appropriate significant figures ?

(1) 4260 ± 80 cm³ (2) 4300 ± 80 cm³

(3) 4264.4 ± 81.0 cm³ (4) 4264 ± 81 cm³

Ans. (1)

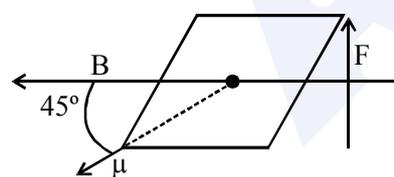
$$\frac{\Delta V}{V} = 2 \frac{\Delta d}{d} + \frac{\Delta h}{h} = 2 \left(\frac{0.1}{12.6} \right) + \frac{0.1}{34.2}$$

$$V = 12.6 \times \frac{\pi}{4} \times 314.2$$

8. At some location on earth the horizontal component of earth's magnetic field is 18×10^{-6} T. At this location, magnetic needle of length 0.12 m and pole strength 1.8 Am is suspended from its mid-point using a thread, it makes 45° angle with horizontal in equilibrium. To keep this needle horizontal, the vertical force that should be applied at one of its ends is :

(1) 3.6×10^{-5} N (2) 6.5×10^{-5} N

(3) 1.3×10^{-5} N (4) 1.8×10^{-5} N

Ans. (2)


$$\mu B \sin 45^\circ = F \frac{l}{2} \sin 45^\circ$$

$$F = 2\mu B$$

9. The modulation frequency of an AM radio station is 250 kHz, which is 10% of the carrier wave. If another AM station approaches you for license what broadcast frequency will you allot ?

(1) 2750 kHz (2) 2000 kHz

(3) 2250 kHz (4) 2900 kHz

Ans. (2)

$$f_{\text{carrier}} = \frac{250}{0.1} = 2500 \text{ KHZ}$$

$$\therefore \text{Range of signal} = 2250 \text{ Hz to } 2750 \text{ Hz}$$

Now check all options : for 2000 KHZ

$$f_{\text{mod}} = 200 \text{ Hz}$$

$$\therefore \text{Range} = 1800 \text{ KHZ to } 2200 \text{ KHZ}$$

10. A hoop and a solid cylinder of same mass and radius are made of a permanent magnetic material with their magnetic moment parallel to their respective axes. But the magnetic moment of hoop is twice of solid cylinder. They are placed in a uniform magnetic field in such a manner that their magnetic moments make a small angle with the field. If the oscillation periods of hoop and cylinder are T_h and T_c respectively, then :

(1) $T_h = 0.5 T_c$ (2) $T_h = 2 T_c$

(3) $T_h = 1.5 T_c$ (4) $T_h = T_c$

Ans. (4)

$$T = 2\pi \sqrt{\frac{I}{\mu B}}$$

$$T_h = 2\pi \sqrt{\frac{mR^2}{(2\mu)B}}$$

$$T_c = 2\pi \sqrt{\frac{1/2 mR^2}{\mu B}}$$

11. The electric field of a plane polarized electromagnetic wave in free space at time $t=0$ is given by an expression

$$\vec{E}(x,y) = 10\hat{j} \cos [(6x + 8z)]$$

The magnetic field \vec{B} (x, z, t) is given by : (c is the velocity of light)

(1) $\frac{1}{c}(6\hat{k} + 8\hat{i})\cos[(6x - 8z + 10ct)]$

(2) $\frac{1}{c}(6\hat{k} - 8\hat{i})\cos[(6x + 8z - 10ct)]$

(3) $\frac{1}{c}(6\hat{k} + 8\hat{i})\cos[(6x + 8z - 10ct)]$

(4) $\frac{1}{c}(6\hat{k} - 8\hat{i})\cos[(6x + 8z + 10ct)]$



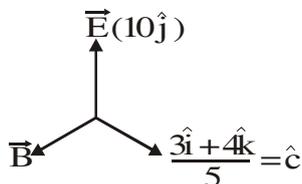
Ans. (2)

$$\vec{E} = 10\hat{j} \cos \left[(6\hat{i} + 8\hat{k}) \cdot (x\hat{i} + z\hat{k}) \right]$$

$$= 10\hat{j} \cos[\vec{K} \cdot \vec{r}]$$

$\therefore \vec{K} = 6\hat{i} + 8\hat{k}$; direction of waves travel.

i.e. direction of 'c'.



\therefore Direction of \hat{B} will be along

$$\hat{C} \times \hat{E} = \frac{-4\hat{i} + 3\hat{k}}{5}$$

Mag. of \vec{B} will be along $\hat{C} \times \hat{E} = \frac{-4\hat{i} + 3\hat{k}}{5}$

$$\text{Mag. of } \vec{B} = \frac{E}{C} = \frac{10}{C}$$

$$\therefore \vec{B} = \frac{10}{C} \left(\frac{-4\hat{i} + 3\hat{k}}{5} \right) = \frac{(-8\hat{i} + 6\hat{k})}{C}$$

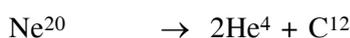
12. Consider the nuclear fission



Given that the binding energy/nucleon of Ne^{20} , He^4 and C^{12} are, respectively, 8.03 MeV, 7.07 MeV and 7.86 MeV, identify the correct statement :

- (1) 8.3 MeV energy will be released
- (2) energy of 12.4 MeV will be supplied
- (3) energy of 11.9 MeV has to be supplied
- (4) energy of 3.6 MeV will be released

Ans. (3)



$$8.03 \times 20 \quad 2 \times 7.07 \times 4 + 7.86 \times 12$$

$$\therefore E_B = (\text{BE})_{\text{react}} - (\text{BE})_{\text{product}} = 9.72 \text{ MeV}$$

13. Two vectors \vec{A} and \vec{B} have equal magnitudes.

The magnitude of $(\vec{A} + \vec{B})$ is 'n' times the

magnitude of $(\vec{A} - \vec{B})$. The angle between \vec{A}

and \vec{B} is :

$$(1) \sin^{-1} \left[\frac{n^2 - 1}{n^2 + 1} \right] \quad (2) \cos^{-1} \left[\frac{n - 1}{n + 1} \right]$$

$$(3) \cos^{-1} \left[\frac{n^2 - 1}{n^2 + 1} \right] \quad (4) \sin^{-1} \left[\frac{n - 1}{n + 1} \right]$$

Ans. (3)

$$|\vec{A} + \vec{B}| = 2a \cos \theta / 2 \quad \text{---(1)}$$

$$|\vec{A} - \vec{B}| = 2a \cos \frac{(\pi - \theta)}{2} = 2a \sin \theta / 2 \quad \text{---(2)}$$

$$\Rightarrow n \left(2a \cos \frac{\theta}{2} \right) = 2a \frac{\sin \theta}{2}$$

$$\Rightarrow \tan \frac{\theta}{2} = n$$

14. A particle executes simple harmonic motion with an amplitude of 5 cm. When the particle is at 4 cm from the mean position, the magnitude of its velocity in SI units is equal to that of its acceleration.

Then, its periodic time in seconds is :

$$(1) \frac{7}{3} \pi \quad (2) \frac{3}{8} \pi$$

$$(3) \frac{4\pi}{3} \quad (4) \frac{8\pi}{3}$$

Ans. (4)

$$v = \omega \sqrt{A^2 - x^2} \quad \text{---(1)}$$

$$a = -\omega^2 x \quad \text{---(2)}$$

$$|v| = |a| \quad \text{---(3)}$$

$$\omega \sqrt{A^2 - x^2} = \omega^2 x$$

$$A^2 - x^2 = \omega^2 x^2$$

$$5^2 - 4^2 = \omega^2 (4^2)$$

$$\Rightarrow 3 = \omega \times 4$$

$$T = 2\pi/\omega$$

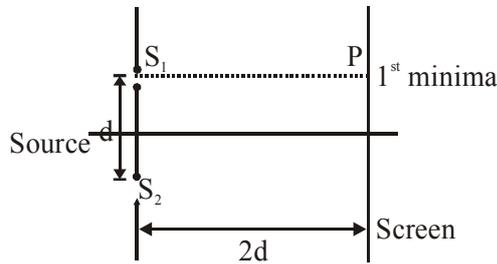
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15. Consider a Young's double slit experiment as shown in figure. What should be the slit separation d in terms of wavelength λ such that the first minima occurs directly in front of the slit (S_1) ?



- (1) $\frac{\lambda}{2(5-\sqrt{2})}$ (2) $\frac{\lambda}{(5-\sqrt{2})}$
 (3) $\frac{\lambda}{(\sqrt{5}-2)}$ (4) $\frac{\lambda}{2(\sqrt{5}-2)}$

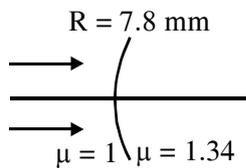
Ans. (4)

$$\sqrt{5}d - 2d = \frac{\lambda}{2}$$

16. The eye can be regarded as a single refracting surface. The radius of curvature of this surface is equal to that of cornea (7.8 mm). This surface separates two media of refractive indices 1 and 1.34. Calculate the distance from the refracting surface at which a parallel beam of light will come to focus.

- (1) 2 cm (2) 1 cm
 (3) 3.1 cm (4) 4.0 cm

Ans. (3)



$$\frac{1.34}{V} - \frac{1}{\infty} = \frac{1.34-1}{7.8}$$

$$\therefore V = 30.7 \text{ mm}$$

17. Half mole of an ideal monoatomic gas is heated at constant pressure of 1atm from 20 °C to 90°C. Work done by gas is close to : (Gas constant $R = 8.31 \text{ J /mol.K}$)

- (1) 73 J (2) 291 J (3) 581 J (4) 146 J

Ans. (2)

$$WD = P\Delta V = nR\Delta T = \frac{1}{2} \times 8.31 \times 70$$

18. A metal plate of area $1 \times 10^{-4} \text{ m}^2$ is illuminated by a radiation of intensity 16 mW/m^2 . The work function of the metal is 5eV. The energy of the incident photons is 10 eV and only 10% of it produces photo electrons. The number of emitted photo electrons per second and their maximum energy, respectively, will be : [1 eV = $1.6 \times 10^{-19} \text{ J}$]

- (1) 10^{10} and 5 eV (2) 10^{14} and 10 eV
 (3) 10^{12} and 5 eV (4) 10^{11} and 5 eV

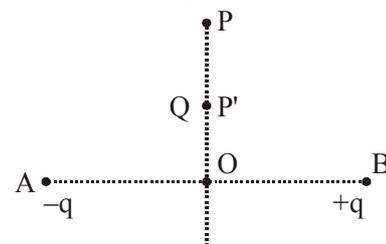
Ans. (4)

$$I = \frac{nE}{At}$$

$$16 \times 10^{-3} = \left(\frac{n}{t}\right)_{\text{Photon}} \frac{10 \times 1.6 \times 10^{-19}}{10^{-4}} = 10^{12}$$

19. Charges $-q$ and $+q$ located at A and B, respectively, constitute an electric dipole. Distance $AB = 2a$, O is the mid point of the dipole and OP is perpendicular to AB. A charge Q is placed at P where $OP = y$ and $y \gg 2a$. The charge Q experiences an electrostatic force F. If Q is now moved along the equatorial line

to P' such that $OP' = \left(\frac{y}{3}\right)$, the force on Q will be close to : $\left(\frac{y}{3} \gg 2a\right)$



- (1) $\frac{F}{3}$ (2) 3F (3) 9F (4) 27F

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Ans. (4)

Sol. Electric field of equatorial plane of dipole

$$= -\frac{K\vec{P}}{r^3}$$

$$\therefore \text{At P, } F = -\frac{K\vec{P}}{r^3} Q.$$

$$\text{At P}^1, F^1 = -\frac{K\vec{P}Q}{(r/3)^3} = 27F.$$

20. Two stars of masses 3×10^{31} kg each, and at distance 2×10^{11} m rotate in a plane about their common centre of mass O. A meteorite passes through O moving perpendicular to the star's rotation plane. In order to escape from the gravitational field of this double star, the minimum speed that meteorite should have at O is : (Take Gravitational constant $G = 6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$)

- (1) 1.4×10^5 m/s (2) 24×10^4 m/s
(3) 3.8×10^4 m/s (4) 2.8×10^5 m/s

Ans. (4)

By energy conservation between 0 & ∞ .

$$-\frac{GMm}{r} + \frac{-GMm}{r} + \frac{1}{2}mV^2 = 0 + 0$$

[M is mass of star m is mass of meteorite)

$$\Rightarrow v = \sqrt{\frac{4GM}{r}} = 2.8 \times 10^5 \text{ m/s}$$

21. A closed organ pipe has a fundamental frequency of 1.5 kHz. The number of overtones that can be distinctly heard by a person with this organ pipe will be : (Assume that the highest frequency a person can hear is 20,000 Hz)

- (1) 7 (2) 5 (3) 6 (4) 4

Ans. (1)

Sol. For closed organ pipe, resonant frequency is odd multiple of fundamental frequency.

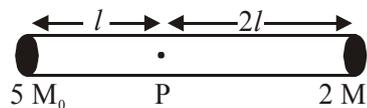
$$\therefore (2n + 1) f_0 \leq 20,000$$

(f_0 is fundamental frequency = 1.5 KHz)

$$\therefore n = 6$$

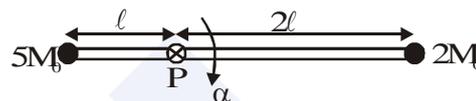
\therefore Total number of overtone that can be heard is 7. (0 to 6).

22. A rigid massless rod of length $3l$ has two masses attached at each end as shown in the figure. The rod is pivoted at point P on the horizontal axis (see figure). When released from initial horizontal position, its instantaneous angular acceleration will be :



- (1) $\frac{g}{2l}$ (2) $\frac{7g}{3l}$ (3) $\frac{g}{13l}$ (4) $\frac{g}{3l}$

Ans. (3)



Applying torque equation about point P.

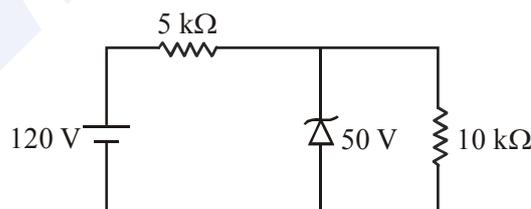
$$2M_0(2l) - 5M_0gl = I\alpha$$

$$I = 2M_0(2l)^2 + 5M_0l^2 = 13M_0l^2$$

$$\therefore \alpha = -\frac{M_0gl}{13M_0l^2} \Rightarrow \alpha = -\frac{g}{13l}$$

$$\therefore \alpha = \frac{g}{13l} \text{ anticlockwise}$$

23. For the circuit shown below, the current through the Zener diode is :



- (1) 5 mA (2) Zero (3) 14 mA (4) 9 mA

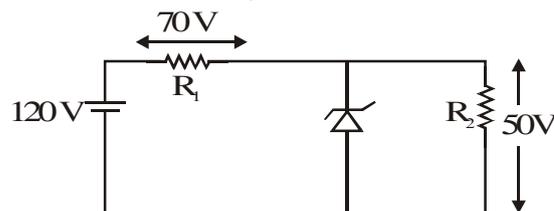
Ans. (4)

Assuming zener diode does not undergo

$$\text{breakdown, current in circuit} = \frac{120}{15000} = 8 \text{ mA}$$

$$\therefore \text{Voltage drop across diode} = 80 \text{ V} > 50 \text{ V.}$$

The diode undergoes breakdown.



$$\text{Current through } R_1 = \frac{70}{5000} = 14 \text{ mA}$$

$$\text{Current through } R_2 = \frac{50}{10000} = 5 \text{ mA}$$

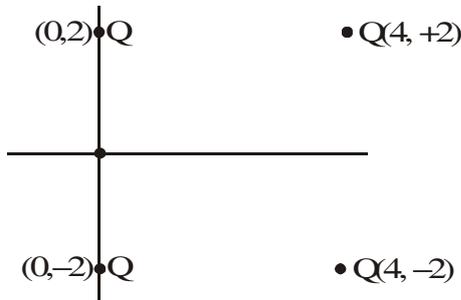
$$\therefore \text{Current through diode} = 9 \text{ mA}$$


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24. Four equal point charges Q each are placed in the xy plane at $(0, 2)$, $(4, 2)$, $(4, -2)$ and $(0, -2)$. The work required to put a fifth charge Q at the origin of the coordinate system will be :

(1) $\frac{Q^2}{2\sqrt{2}\pi\epsilon_0}$ (2) $\frac{Q^2}{4\pi\epsilon_0}\left(1+\frac{1}{\sqrt{5}}\right)$
 (3) $\frac{Q^2}{4\pi\epsilon_0}\left(1+\frac{1}{\sqrt{3}}\right)$ (4) $\frac{Q^2}{4\pi\epsilon_0}$

Ans. (2)



$$\text{Potential at origin} = \frac{KQ}{2} + \frac{KQ}{2} + \frac{KQ}{\sqrt{20}} + \frac{KQ}{\sqrt{20}}$$

(Potential at $\infty = 0$)

$$= KQ\left(1 + \frac{1}{\sqrt{5}}\right)$$

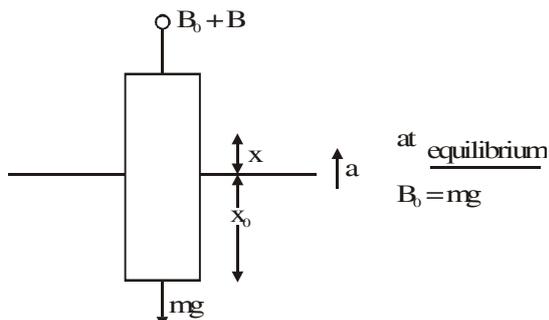
\therefore Work required to put a fifth charge Q at origin

$$\text{is equal to } \frac{Q^2}{4\pi\epsilon_0}\left(1 + \frac{1}{\sqrt{5}}\right)$$

25. A cylindrical plastic bottle of negligible mass is filled with 310 ml of water and left floating in a pond with still water. If pressed downward slightly and released, it starts performing simple harmonic motion at angular frequency ω . If the radius of the bottle is 2.5 cm then ω close to : (density of water = 10^3 kg / m^3)

(1) 5.00 rad s^{-1} (2) 1.25 rad s^{-1}
 (3) 3.75 rad s^{-1} (4) 2.50 rad s^{-1}

Ans. (Bonus)



$$\text{Extra Boyant force} = \delta A x g$$

$$B_0 + B - mg = ma$$

$$B = ma$$

$$a = \left(\frac{\delta A g}{m}\right)^x$$

$$w^2 = \frac{\delta A g}{m}$$

$$w = \sqrt{\frac{10^3 \times \pi (2.5)^2 \times 10^{-4} \times 10}{310 \times 10^{-6} \times 10^3}}$$

$$= \sqrt{63.30} = 7.95$$

26. A parallel plate capacitor having capacitance 12 pF is charged by a battery to a potential difference of 10 V between its plates. The charging battery is now disconnected and a porcelain slab of dielectric constant 6.5 is slipped between the plates the work done by the capacitor on the slab is :

(1) 692 pJ (2) 60 pJ
 (3) 508 pJ (4) 560 pJ

Ans. (3)

Initial energy of capacitor

$$U_i = \frac{1}{2} \frac{v^2}{c}$$

$$= \frac{1}{2} \times \frac{120 \times 120}{12} = 600 \text{ J}$$

Since battery is disconnected so charge remain same.

Final energy of capacitor

$$U_f = \frac{1}{2} \frac{v^2}{c}$$

$$= \frac{1}{2} \times \frac{120 \times 120}{12 \times 6.5} = 92$$

$$W + U_f = U_i$$

$$W = 508 \text{ J}$$

27. Two kg of a monoatomic gas is at a pressure of $4 \times 10^4 \text{ N/m}^2$. The density of the gas is 8 kg / m^3 . What is the order of energy of the gas due to its thermal motion ?

(1) 10^3 J (2) 10^5 J
 (3) 10^6 J (4) 10^4 J

Ans. (4)

Thermal energy of N molecule

$$= N \left(\frac{3}{2} kT\right)$$



$$= \frac{N}{N_A} \frac{3}{2} RT$$

$$= \frac{3}{2} (nRT)$$

$$= \frac{3}{2} PV$$

$$= \frac{3}{2} P \left(\frac{m}{8} \right)$$

$$= \frac{3}{2} \times 4 \times 10^4 \times \frac{2}{8}$$

$$= 1.5 \times 10^4$$

order will 10^4

28. A particle which is experiencing a force, given by $\vec{F} = 3\vec{i} - 12\vec{j}$, undergoes a displacement of $\vec{d} = 4\vec{i}$. If the particle had a kinetic energy of 3 J at the beginning of the displacement, what is its kinetic energy at the end of the displacement?

(1) 15 J (2) 10 J (3) 12 J (4) 9 J

Ans. (1)

$$\begin{aligned} \text{Work done} &= \vec{F} \cdot \vec{d} \\ &= 12J \end{aligned}$$

work energy theorem

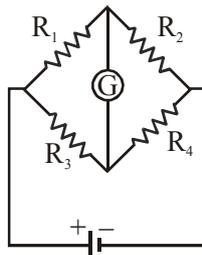
$$W_{\text{net}} = \Delta K.E.$$

$$12 = K_f - 3$$

$$K_f = 15J$$

29. The Wheatstone bridge shown in Fig. here, gets balanced when the carbon resistor used as R_1 has the colour code (Orange, Red, Brown). The resistors R_2 and R_4 are 80Ω and 40Ω , respectively.

Assuming that the colour code for the carbon resistors gives their accurate values, the colour code for the carbon resistor, used as R_3 , would be :



- (1) Red, Green, Brown
 (2) Brown, Blue, Brown
 (3) Grey, Black, Brown
 (4) Brown, Blue, Black

Ans. (2)

$R_1 = 32 \times 10 = 320$
 for wheat stone bridge

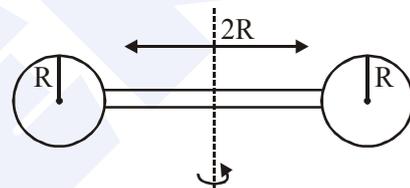
$$\Rightarrow \frac{R_1}{R_3} = \frac{R_2}{R_4}$$

$$\frac{320}{R_3} = \frac{80}{40}$$

$$R_3 = 160$$

Brown Blue Brown

30. Two identical spherical balls of mass M and radius R each are stuck on two ends of a rod of length $2R$ and mass M (see figure). The moment of inertia of the system about the axis passing perpendicularly through the centre of the rod is :



- (1) $\frac{152}{15} MR^2$ (2) $\frac{17}{15} MR^2$
 (3) $\frac{137}{15} MR^2$ (4) $\frac{209}{15} MR^2$

Ans. (3)

For Ball
 using parallel axis theorem.

$$I_{\text{ball}} = \frac{2}{5} MR^2 + M(2R)^2$$

$$= \frac{22}{5} MR^2$$

$$2 \text{ Balls so } \frac{44}{5} MR^2$$

$$I_{\text{rod}} = \text{for rod } \frac{M(2R)^2}{12} = \frac{MR^2}{3}$$

$$I_{\text{system}} = I_{\text{Ball}} + I_{\text{rod}}$$

$$= \frac{44}{5} MR^2 + \frac{MR^2}{3}$$

$$= \frac{137}{15} MR^2$$