

**JEE–MAIN EXAMINATION – JUNE, 2022**

**24 June S - 01 Paper Solution**

**SECTION-A**

1. The bulk modulus of a liquid is  $3 \times 10^{10} \text{ Nm}^{-2}$ . The pressure required to reduce the volume of liquid by 2% is :

- (A)  $3 \times 10^8 \text{ Nm}^{-2}$                       (B)  $9 \times 10^8 \text{ Nm}^{-2}$   
 (C)  $6 \times 10^8 \text{ Nm}^{-2}$                       (D)  $12 \times 10^8 \text{ Nm}^{-2}$

**Ans. (C)**

**Sol.**  $B = 3 \times 10^{10}$

$$-\frac{\Delta V}{V} = 0.02$$

$$B = \frac{\Delta P}{-\frac{\Delta V}{V}} \Rightarrow \Delta P = -B \left( \frac{\Delta V}{V} \right)$$

$$= (3 \times 10^{10})(0.02)$$

$$= 6 \times 10^8 \text{ N/m}^2$$

2. Given below are two statements : One is labelled as Assertion (A) and the other is labelled as Reason (R).

**Assertion (A) :** In an uniform magnetic field, speed and energy remains the same for a moving charged particle.

**Reason (R) :** Moving charged particle experiences magnetic force perpendicular to its direction of motion.

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A)  
 (B) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)  
 (C) (A) is true but (R) is false  
 (D) (A) is false but (R) is true.

**Ans. (A)**

**Sol.**  $\vec{F} = q(\vec{v} \times \vec{B})$

$$\boxed{\vec{F} \perp \vec{v}}$$

$$\text{Work done} = \vec{F} \cdot \vec{S}$$

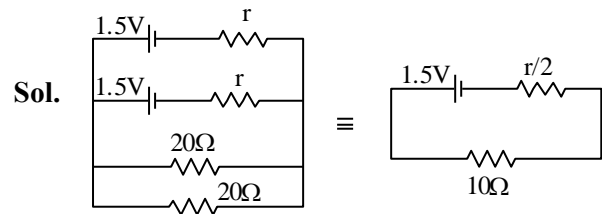
$$\text{Work done} = 0$$

3. Two identical cells each of emf 1.5 V are connected in parallel across a parallel combination of two resistors each of resistance  $20\Omega$ . A voltmeter connected in the circuit measures 1.2 V.

The internal resistance of each cell is

- (A)  $2.5\Omega$                                       (B)  $4\Omega$   
 (C)  $5\Omega$                                       (D)  $10\Omega$

**Ans. (C)**



$$V = E - ir/2$$

$$1.2 = 1.5 - i \left( \frac{r}{2} \right)$$

$$i \frac{r}{2} = 0.3$$

$$i = \frac{1.5}{10 + \frac{r}{2}} \Rightarrow 10i + \frac{ir}{2} = 1.5$$

$$10i = 1.5 - 0.3$$

$$i = 0.12 \text{ A}$$

$$\Rightarrow r = \frac{0.6}{0.12} = 5\Omega$$

4. Identify the pair of physical quantities which have different dimensions :

- (A) Wave number and Rydberg's constant
- (B) Stress and Coefficient of elasticity
- (C) Coercivity and Magnetisation
- (D) Specific heat capacity and Latent heat

**Ans. (D)**

**Sol.**  $S = \frac{Q}{m\Delta T} = \frac{J}{Kg^{\circ}C}$

$$L = \frac{Q}{m} = \frac{J}{Kg}$$

5. A projectile is projected with velocity of 25 m/s at an angle  $\theta$  with the horizontal. After  $t$  seconds its inclination with horizontal becomes zero. If  $R$  represents horizontal range of the projectile, the value of  $\theta$  will be : [use  $g = 10 \text{ m/s}^2$ ]

- (A)  $\frac{1}{2} \sin^{-1} \left( \frac{5t^2}{4R} \right)$
- (B)  $\frac{1}{2} \sin^{-1} \left( \frac{4R}{5t^2} \right)$
- (C)  $\tan^{-1} \left( \frac{4t^2}{5R} \right)$
- (D)  $\cot^{-1} \left( \frac{R}{20t^2} \right)$

**Ans. (D)**

**Sol.**  $R = \frac{V^2(2 \sin \theta \cos \theta)}{g}$

$$t = \frac{V \sin \theta}{g} \Rightarrow V = \frac{gt}{\sin \theta}$$

$$\Rightarrow R = \frac{g^2 t^2}{\sin^2 \theta} \cdot \frac{2 \sin \theta \cos \theta}{g}$$

$$\tan \theta = \frac{2gt^2}{R} = \frac{20t^2}{R}$$

$$\cot \theta = \frac{R}{20t^2}$$

6. A block of mass 10 kg starts sliding on a surface with an initial velocity of  $9.8 \text{ ms}^{-1}$ . The coefficient of friction between the surface and block is 0.5. The distance covered by the block before coming to rest is : [use  $g = 9.8 \text{ ms}^{-2}$ ]

- (A) 4.9 m
- (B) 9.8 m
- (C) 12.5 m
- (D) 19.6 m

**Ans. (B)**

**Sol.**  $a = -\mu g = -0.5 \times 9.8 = -4.9 \text{ m/s}^2$

$$d = \frac{v^2}{2a} = \frac{9.8 \times 9.8}{2(4.9)}$$

$$= 9.8 \text{ m}$$

7. A boy ties a stone of mass 100 g to the end of a 2 m long string and whirls it around in a horizontal plane. The string can withstand the maximum tension of 80 N. If the maximum speed with which the stone can revolve is  $\frac{K}{\pi} \text{ rev./min}$ . The value of  $K$  is :

(Assume the string is massless and unstretchable)

- (A) 400
- (B) 300
- (C) 600
- (D) 800

**Ans. (C)**

**Sol.**  $T = M\omega^2 R$

$$T = 80 \text{ N} \quad M = 0.1 \quad \omega = ? \quad R = 2 \text{ m}$$

$$80 = 0.1 \omega^2 (2)$$

$$\omega^2 = 400$$

$$\omega = 20$$

$$2\pi f = 20$$

$$f = \frac{10 \text{ rev}}{\pi \text{ s}}$$

$$= \frac{600 \text{ rev}}{\pi \text{ min}}$$





**Sol.**  $f_c = 3.5\text{GHz}$   $f_m = 3.5\text{MHz}$

Side band frequencies are  $f_c - f_m$  &  $f_c + f_m$ . which are almost  $f_c$

$$\lambda = \frac{c}{f_c}$$

Minimum length of antenna =

$$\frac{c}{f_c \cdot 4} = \frac{\lambda}{4} = \frac{3 \times 10^8}{3.5 \times 10^9 \times 4}$$

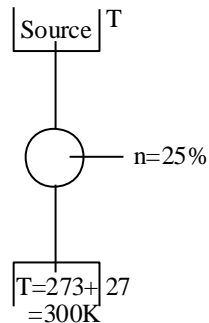
$$= 21.4 \text{ mm}$$

**17.** A Carnot engine whose heat sinks at  $27^\circ\text{C}$ , has an efficiency of 25%. By how many degrees should the temperature of the source be changed to increase the efficiency by 100% of the original efficiency ?

- (A) Increases by  $18^\circ\text{C}$     (B) Increase by  $200^\circ\text{C}$   
 (C) Increase by  $120^\circ\text{C}$     (D) Increase by  $73^\circ$

**Ans. (B)**

**Sol.**



$$1 - \frac{300}{T} = 0.25$$

$$\frac{300}{T} = 0.75$$

$$T = 400\text{K}$$

If efficiency increased by 100% then new efficiency  $\Rightarrow n' = 50\%$

$$1 - \frac{300}{T'} = 0.5$$

$$T' = 600\text{K}$$

$$\begin{aligned} \text{Increase in temp} &= 600 - 400 \\ &= 200 \text{ K or } 200^\circ\text{C} \end{aligned}$$

**18.** A parallel plate capacitor is formed by two plates each of area  $30\pi \text{ cm}^2$  separated by 1 mm. A material of dielectric strength  $3.6 \times 10^7 \text{ Vm}^{-1}$  is filled between the plates. If the maximum charge that can be stored on the capacitor without causing any dielectric breakdown is  $7 \times 10^{-6} \text{ C}$ , the value of dielectric constant of the material is :

$$\left\{ \text{Use : } \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2\text{C}^{-2} \right\}$$

- (A) 1.66                                      (B) 1.75  
 (C) 2.25                                      (D) 2.33

**Ans. (D)**

**Sol.**  $K = \frac{q}{A \epsilon_0 E} = \frac{7 \times 10^{-6}}{30\pi \times 10^{-4} \times \frac{1}{4\pi \times 9 \times 10^9} \times 3.6 \times 10^7}$

$$K = \frac{36 \times 7}{30 \times 3.6} = 2.33$$

**19.** The magnetic field at the centre of a circular coil of radius  $r$ , due to current  $I$  flowing through it, is  $B$ . The magnetic field at a point along the axis at a distance  $\frac{r}{2}$  from the centre is :

- (A)  $B/2$                                       (B)  $2B$   
 (C)  $\left(\frac{2}{\sqrt{5}}\right)^3 B$                               (D)  $\left(\frac{2}{\sqrt{3}}\right)^3 B$

**Official Ans. by NTA (C)**

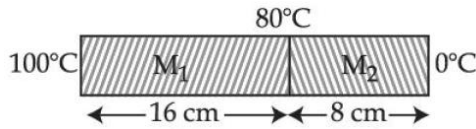
**Allen Ans. (C)**

**Sol.**  $B_c = \frac{\mu_0 I}{2r}, B_a = \frac{\mu_0 I r^2}{2(x^2 + r^2)^{3/2}}$

$$\text{At } x = \frac{r}{2}$$

$$\begin{aligned} B_a &= \frac{\mu_0 I r^2}{2\left(\frac{r^2}{4} + r^2\right)^{3/2}} \\ &= \frac{\mu_0 I r^2}{2\left(\frac{5}{4}r^2\right)^{3/2}} = \frac{\mu_0 I}{2r} \left(\frac{4}{5}\right)^{3/2} \\ &= \frac{\mu_0 I}{2r} \left(\frac{2}{\sqrt{5}}\right)^3 \end{aligned}$$

20. Two metallic blocks  $M_1$  and  $M_2$  of same area of cross-section are connected to each other (as shown in figure). If the thermal conductivity of  $M_2$  is  $K$  then the thermal conductivity of  $M_1$  will be : [Assume steady state heat conduction]



- (A) 10 K                      (B) 8 K  
(C) 12.5 K                    (D) 2 K

**Ans. (B)**

**Sol.**  $\Delta T \propto R \propto \frac{\ell}{k}$ ,

$$\frac{\Delta T_1}{\Delta T_2} = \frac{\ell_1}{k_1} \times \frac{k_2}{\ell_2} = \frac{16}{k_1} \times \frac{k}{8}$$

$$\frac{20}{80} = \frac{16}{k_1} \times \frac{k}{8} \rightarrow k_1 = 8k$$

**SECTION-B**

1. 0.056 kg of Nitrogen is enclosed in a vessel at a temperature of  $127^\circ\text{C}$ . The amount of heat required to double the speed of its molecules is \_\_\_\_\_ k cal. (Take  $R = 2 \text{ cal mole}^{-1}\text{K}^{-1}$ )

**Ans. (12)**

**Sol.**  $0.056 \text{ kg } N_2 = 56 \text{ gm of } N_2 = 2 \text{ mole of } N_2$

$$T_1 = 400 \text{ K, } v \propto \sqrt{T} \text{ so } T_2 = 4T_1 = 1600\text{K}$$

$$Q = \frac{f}{2} n R \Delta T$$

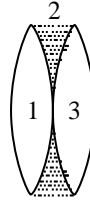
$$f = 5$$

$$Q = 12 \text{ k cal}$$

2. Two identical thin biconvex lenses of focal length 15 cm and refractive index 1.5 are in contact with each other. The space between the lenses is filled with a liquid of refractive index 1.25. The focal length of the combination is \_\_\_\_\_ cm.

**Ans. (10)**

**Sol.**



$$\frac{1}{f_1} = \frac{1}{15} = \left(\frac{3}{2} - 1\right) \left[\frac{2}{R}\right]$$

$$\frac{1}{R} = \frac{1}{15}$$

$$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$$

$$= \frac{1}{15} + \left(\frac{5}{4} - 1\right) \left[\frac{-2}{R}\right] + \frac{1}{15}$$

$$= \frac{1}{15} - \frac{1}{30} + \frac{1}{15}$$

$$= \frac{2 - 1 + 2}{30}$$

$$= \frac{3}{30} = \frac{1}{10}$$

$$= 10$$

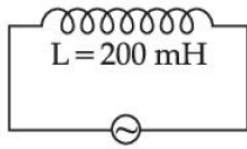
3. A transistor is used in common-emitter mode in an amplifier circuit. When a signal of 10 mV is added to the base-emitter voltage, the base current changes by  $10 \mu\text{A}$  and the collector current changes by 1.5 mA. The load resistance is 5 k $\Omega$ . The voltage gain of the transistor will be \_\_\_\_\_. **Ans. (750)**

**Sol.**  $r_i = \frac{10\text{mV}}{10\mu\text{A}} = 10^3 \Omega$

$$\beta = \frac{1.5\text{mA}}{10\mu\text{A}} = 150$$

$$A_v = \left(\frac{R_o}{r_i}\right) \beta = \left(\frac{5000}{1000}\right) \times 150 = 750$$

4. As shown in the figure an inductor of inductance 200 mH is connected to an AC source of emf 220 V and frequency 50 Hz. The instantaneous voltage of the source is 0 V when the peak value of current is  $\frac{\sqrt{a}}{\pi}$  A. The value of a is \_\_\_\_\_.



**Ans. (242)**

**Sol.**  $f = 50\text{Hz}$   
 $X_L = 2\pi fL$   
 $= 2\pi(50)(200 \times 10^{-3})$   
 $= 20\pi\Omega$

$$i_0 = \frac{V_0}{X_L} \Rightarrow \frac{V_{\text{rms}}\sqrt{2}}{X_L}$$

$$= \frac{(220)\sqrt{2}}{20\pi} = \frac{11\sqrt{2}}{\pi}$$

$$i_0 = \frac{\sqrt{242}}{\pi}$$

5. Sodium light of wavelengths 650 nm and 655 nm is used to study diffraction at a single slit of aperture 0.5 mm. The distance between the slit and the screen is 2.0 m. The separation between the positions of the first maxima of diffraction pattern obtained in the two cases is \_\_\_\_\_  $\times 10^{-5}$  m.

**Official Ans. by NTA (3)**

**Allen Ans. (3)**

**Sol.**  $a \sin \theta = \frac{3\lambda}{2}$   
 $\frac{y}{L} = \theta = \frac{3\lambda}{2a}$   $L = 2\text{m}$   
 $y_1 = \frac{3\lambda_1 L}{2a}$   $\lambda_2 = 655\text{ nm}$   
 $y_2 = \frac{3\lambda_2 L}{2a}$   $\lambda_1 = 650\text{ nm}$   
 $a = 0.5\text{ mm}$

$$\Delta y = y_2 - y_1 = \frac{3(\lambda_2 - \lambda_1)L}{2a}$$

$$= \frac{3(655 - 650)}{2 \times 0.5 \times 10^{-3}} \times 2 \times 10^{-9}$$

$$= \frac{3 \times 5 \times 2}{1 \times 10^{-3}} \times 10^{-9}$$

$$= 3 \times 10^{-5}$$

6. When light of frequency twice the threshold frequency is incident on the metal plate, the maximum velocity of emitted electron is  $v_1$ . When the frequency of incident radiation is increased to five times the threshold value, the maximum velocity of emitted electron becomes  $v_2$ . If  $v_2 = x v_1$ , the value of x will be \_\_\_\_\_.

**Ans. (2)**

**Sol.**  $h\nu = h\nu_{\text{th}} + \frac{1}{2}mv^2$   
 $v = 2v_{\text{th}}$   
 $2h\nu_{\text{th}} = h\nu_{\text{th}} + \frac{1}{2}mv_1^2 \dots (1)$

$v = 5v_{\text{th}}$   
 $5h\nu_{\text{th}} = h\nu_{\text{th}} + \frac{1}{2}mv_2^2 \dots (2)$

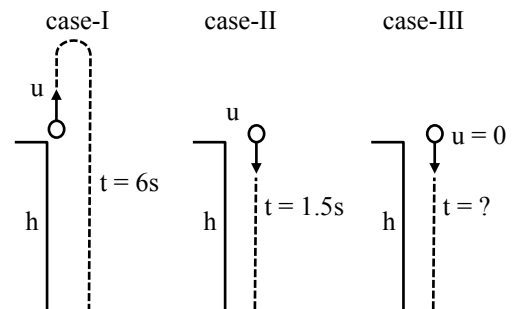
$$\frac{\frac{1}{2}mv_1^2}{\frac{1}{2}mv_2^2} = \frac{h\nu_{\text{th}}}{4h\nu_{\text{th}}}$$

$$\left(\frac{v_1}{v_2}\right)^2 = \frac{1}{4} \Rightarrow \boxed{v_2 = 2v_1}$$

7. From the top of a tower, a ball is thrown vertically upward which reaches the ground in 6 s. A second ball thrown vertically downward from the same position with the same speed reaches the ground in 1.5 s. A third ball released, from the rest from the same location, will reach the ground in \_\_\_\_\_ s.

**Ans. (3)**

- Sol.** Let height of tower be h and speed of projection in first two cases be u.



For case-I : 2<sup>nd</sup> equation  $s = ut + \frac{1}{2}at^2$

$$h = -u(6) + \frac{1}{2}g(6)^2$$

$$H = -6u + 18g \dots (i)$$

$$\text{For case-II : } h = u(1.5) + \frac{1}{2}g(1.5)^2$$

$$h = 1.5u + \frac{2.25g}{2} \dots (ii)$$

Multiplying equation (ii) by 4 we get

$$4h = 6u + 4.5g \dots (iii)$$

equation (i) + equation (iii) we get  $5h = 22.5g$

$$h = 4.5g \dots (iv)$$

For case-III :

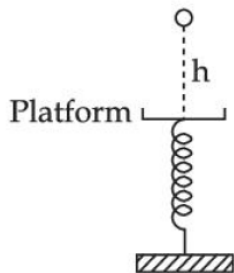
$$h = 0 + \frac{1}{2}gt^2 \dots (v)$$

Using equation (4) & equation (5)

$$4.5g = \frac{1}{2}gt^2$$

$$t^2 = 9 \Rightarrow t = 3s$$

8. A ball of mass 100 g is dropped from a height  $h = 10$  cm on a platform fixed at the top of vertical spring (as shown in figure). The ball stays on the platform and the platform is depressed by a distance  $\frac{h}{2}$ . The spring constant is \_\_\_\_\_  $\text{Nm}^{-1}$ . (Use  $g = 10 \text{ ms}^{-2}$ )



**Ans. (120)**

**Sol.** By energy conservation

$$PE = KE$$

$$mg\left(H + \frac{H}{2}\right) = \frac{1}{2}kx^2 \left(x = \frac{H}{2}\right)$$

$$0.100 \times 10 \times \frac{3}{2}(0.10) = \frac{1}{2}k(0.05 \times 0.05)$$

$$k = \frac{3 \times 0.10}{0.05 \times 0.05}$$

$$= \frac{3 \times 1000}{25} = 120 \text{ N/m}$$

9. In a potentiometer arrangement, a cell gives a balancing point at 75 cm length of wire. This cell is now replaced by another cell of unknown emf. If the ratio of the emfs of two cells respectively is 3 : 2, the difference in the balancing length of the potentiometer wire in above two cases will be \_\_\_\_\_ cm.

**Ans. (25)**

$$\text{Sol. } \frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$$

$$\frac{3}{2} = \frac{75 \text{ cm}}{l_2}$$

$$l_2 = 50 \text{ cm}$$

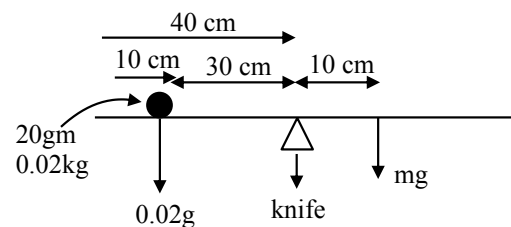
$$l_1 - l_2 = 75 - 50$$

$$= 25 \text{ cm}$$

10. A metre scale is balanced on a knife edge at its centre. When two coins, each of mass 10 g are put one on the top of the other at the 10.0 cm mark the scale is found to be balanced at 40.0 cm mark. The mass of the metre scale is found to be  $x \times 10^{-2}$  kg. The value of  $x$  is

**Ans. (6)**

**Sol.** Let mass of meter scale be  $m$ .



Balancing torque about knife edge

$$(0.02g) \times (30 \times 10^{-2}) = mg \times (10 \times 10^{-2})$$

$$m = 0.06 \text{ kg} = 6 \times 10^{-2} \text{ kg}$$