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JEE (MAIN) 2024

MEMORY BASED QUESTIONS & SOLUTIONS

SHIFT-2

DATE & DAY: 30th January 2024 & Tuesday

PAPER-1

Duration: 3 Hrs.
Time: 03:00 PM - 06:00 PM

SUBJECT: PHYSICS

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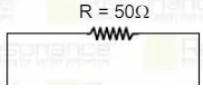
PART : PHYSICS

1. For a given electric circuit shown, find the time taken to change current from highest peak value to half of peak value

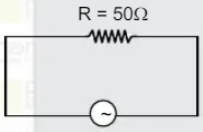


V = 220 sin (100 t)

(1) $\frac{\pi}{300}$ sec (2) $\frac{\pi}{200}$ sec (3) $\frac{\pi}{400}$ sec (4) $\frac{\pi}{100}$ sec

Ans. **(1)**

Sol.

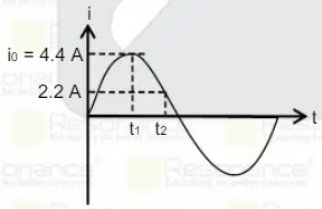


V = 220 sin (100 t)

$i = \frac{V}{R} \sin(100t)$

$= \frac{220}{50} \sin(100t)$

$i = 4.4 \sin(100t)$



For finding time t_1, taking i = 4.4 A

$4.4 = 4.4 \sin(100t_1)$

$\sin(100t_1) = 1$

$100\, t_1 = \frac{\pi}{2}$

$t_1 = \frac{\pi}{200}$ sec

For Finding time t_2, taking i = 2.2 A

$2.2 = 4.4\sin(100t_2)$

$\frac{1}{2} = \sin(100\, t_2)$

$\Rightarrow 100t_2 = \frac{5\pi}{6}$

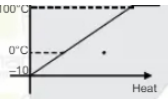
$t_2 = \frac{5\pi}{600}$ sec

Time taken from peak value to half of peak value of current

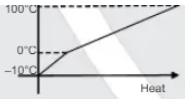
$\Delta t = t_2 = t_1 = \frac{5\pi}{600} - \frac{\pi}{200} \Rightarrow \frac{5\pi}{600} - \frac{3\pi}{600}$

$= \frac{2\pi}{600} = \frac{\pi}{300}$ Ans

2. Draw true phase diagram for true temperature versus heat supplied when ice at (–10°C) converts into stream at 100°C.

(1) 

(2) 

(3) 

(4) 

Ans. **(4)**

3. A simple pendulum of length ℓ = 4 m is taken to height 'R' from earth surface. Calculate the time period of oscillation of simple pendulum at given height. Given : acceleration due to gravity at earth' surface $g = \pi^2$

(1) 4 sec (2) 8 sec (3) 6 sec (4) 10 sec

Ans. **(2)**

Sol. $T = 2\pi\sqrt{\frac{\ell}{g_{eff}}}$ where $g_{eff} = g\left[\frac{R}{R+h}\right]^2 = g\left[\frac{R}{R+R}\right]^2 = \frac{g}{4}$

$\therefore\ T = 2\pi\sqrt{\frac{4}{\frac{g}{4}}} = 2\pi\sqrt{\frac{16}{\pi^2}} = 8\,\text{sec}.$

4. If $m = K.c^x G^{\frac{-1}{2}} h^{\frac{1}{2}}$ then find x if symbols have general meaning and k is dimensionless (m = mass, c = speed of light, G = universal gravitation constant f h = plank's constant)

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

Ans. **(3)**

Sol. $[M^1] = [L^x T^{-x}][L^3 M^{-1} T^{-2}]^{\frac{-1}{2}} [M^1 L^2 T^{-1}]^{\frac{1}{2}}$

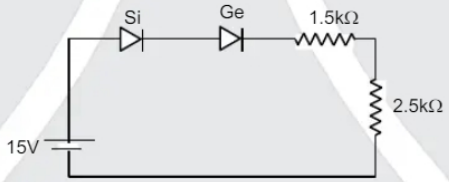
$\Rightarrow \quad [M^1] = \left[M^1 L^{\left(x-\frac{1}{2}\right)} T^{\left(\frac{1}{2}-x\right)}\right]$

$\Rightarrow$ After comparing powers

$x - \frac{1}{2} = 0, \qquad \frac{1}{2} - x = 0$

$x = \frac{1}{2}, \qquad x = \frac{1}{2}$

5. In the given circuit find the potential difference 2.5 k Ω. Given : knew voltages for silicon and germanium P-N junction is 0.7 volt and 0.3 Volt respectively



(1) 3.25 V (2) 4.75 (3) 9.50 (4) 8.75 V

Ans. **(4)**

Sol. $V_{Si} = 0.7$ V

$V_{Ge} = 0.3$ V

$i = \frac{15 - 0.3 - 0.7}{(2.5+1.5)\times 10^3} = \frac{14}{4}\,\text{mA} = \frac{7}{2}\,\text{mA}$

therefor potential difference across resistor

$V = iR$

$= \frac{7}{2} \times 10^3 \times 2.5 \times 10^3$

$= \frac{35}{4} \times 1$

$= 8.75$ V.

6. A Charge '–q' and mass 'm' is revolving in circular orbit of radius 'r' around infinite length wire with linear charge density 'λ'. Find the time period of revolution

(1) $(2\pi)^{1/2} r\sqrt{\frac{m\varepsilon_0}{\lambda q}}$ (2) $(2\pi)^{3/2}\sqrt{\frac{rm\varepsilon_0}{\lambda q}}$ (3) $(2\pi)^{3/2} r\sqrt{\frac{m\varepsilon_0}{\lambda q}}$ (4) $(2\pi)^{1/2}\sqrt{\frac{rm\varepsilon_0}{\lambda q}}$

Ans. **(3)**

Sol. $E = \frac{\lambda}{2\pi r \in_o}$

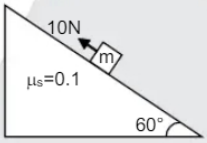
$\left|\vec{F}_{\in}\right|$ = centripetal force required

$\left|\vec{F}_{\in}\right| = \frac{\lambda q}{2\pi r \in_o} \quad \Rightarrow \frac{\lambda q}{2\pi r \in_o} = m\omega^2 r$

$\Rightarrow \quad \omega = \sqrt{\frac{\lambda q}{2\pi m r^2 \in_o}}$

$T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{\lambda q}{2\pi m r^2 \in_o}}} = (2\pi)^{3/2} r\sqrt{\frac{m \in_o}{\lambda q}}$

7. A 10 N Force is applied on mass 1 kg in upward direction as shown. Find the work done against friction force in taking it up by 10 m along inclined

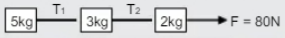


(1) 10 J (2) 5 J (3) 20 J (4) 25 J

Ans. **(2)**

Sol. $w = (\mu mg\cos 60°)10 = 5$ J

8. Find the value of tension T_1 and T_2 respectively in the given figure?

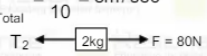


(1) 60N, 72 N (2) 72 N, 60N (3) 40 N, 64N (4) 64N, 40 N

Ans. **(3)**

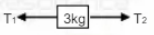
Sol. $M_{Total} = 5 + 3 + 2 = 10$ kg

$a = \frac{F}{M_{Total}} = \frac{80}{10} = 8 m/sec^2$

$\Rightarrow$ 

$80 - T_2 = 2 \times 8$

$T_2 = 80 - 16 = 64$ N

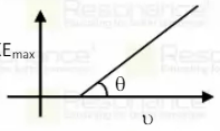
$\Rightarrow$ 

$T_2 - T_1 = 3 \times 8$

$T_1 = 64 - 3 \times 8$

$T_1 = 64 - 24 = 40$ N

9. Graph of maximum possible K.E. of photo-electron and frequency of incident photons is as shown in figure. Find slope of graph.



(1) h/e (2) h (3) e/h (4) 1/h

Ans. **(2)**

Sol. $k_{max} = h\upsilon - h\upsilon_{th}$

Slope = h.

10. Match the following :

A.	$\oint \vec{B}.d\vec{A} = 0$	P.	Faraday & Lens's law
B.	$\oint \vec{E}.d\vec{A} = \frac{Q_{in}}{\epsilon_o}$	Q.	Gauss law of on magnetism
C.	$\oint \vec{B}.d\vec{l} = \mu_o i_{enc}$	R.	Ampere's law
D.	$\oint \vec{E}.d\vec{l} = \frac{-d\phi_B}{dt}$	S.	gauss law of electrostatics

(1) (A – Q), (B – S), (C – R), (D – P)

(2) (A – S), (B – Q), (C – R), (D – P)

(3) (A – Q), (B – R), (C – S), (D – P)

(4) (A – Q), (B – S), (C – P), (D – R)

Ans. **(1)**

Sol. (A – Q), (B – S), (C – R), (D – P)

11. For a given planet $R_P = \frac{R_e}{3}$ & $M_P = \frac{M_e}{6}$, Then find the escape velocity for this planet if the escape velocity for earth is 11.2 km/sec. (R_e = radius of earth and Me = mass of earth)

(1) 7.92 km/sec (2) 11. 2 km/sec (3) 10.3 km/sec (4) 6.9 km/sec

Ans. **(1)**

Sol. $V_{es} = \sqrt{\frac{2GM}{R}}$

$$\frac{(V_{es})_p}{(V_{es})_e} = \sqrt{\frac{M_P}{M_e} \times \frac{R_e}{R_P}}$$

$$\frac{(V_{es})_p}{11.2} = \sqrt{\frac{3}{6}}$$

$(V_{es})_P$ = 7.92 km/sec.

12. 5A current is passing through a square of side 1m then find the magnetic field at the centre of this square.

(1) $8\sqrt{2} \times 10^{-6}$ T (2) $4\sqrt{2} \times 10^{-6}$ T (3) $2\sqrt{2} \times 10^{-6}$ T (4) $6\sqrt{2} \times 10^{-6}$ T

Ans. **(2)**

Sol. $B_C = 4 \times \frac{\mu_o I}{4\pi d}(\sin 45^\circ + \sin 45^\circ)$

$$= 20 \times \frac{\mu_o}{4\pi \times \frac{1}{\ }} \times \sqrt{2}$$

$= 4\sqrt{2} \times 10^{-6}\,T$

13. A vector which have magnitude same as of $3\hat{i}+4\hat{j}$ & direction along $4\hat{i}+3\hat{j}$, is $x\hat{i}+3\hat{j}$ then value x will be?

(1) 3 (2) 2 (3) 4 (4)10

Ans. **(3)**

Sol. $\hat{d} = \frac{4\hat{i}+3\hat{j}}{\sqrt{4^2+3^2}} = \frac{4}{5}\hat{i}+\frac{3}{5}\hat{j}$

$\left|\vec{d}\right| = \sqrt{3^2+4^2} = \sqrt{25} = 5$

$\vec{d} = \left|\vec{d}\right| \hat{d}$

$\vec{d} = 5\left(\frac{4}{5}\hat{i}+\frac{3}{5}\hat{j}\right)$

$\vec{d} = \left(4\hat{i}+3\hat{j}\right)$

14. An electron is revolving in n^{th} orbit of He^+ ion. Its magnetic moment depends on the radius of orbit as :

(1) r (2) $r^{1/2}$ (3) $r^{3/2}$ (4) r^2

Ans. **(2)**

Sol. M = iA

$= \frac{e}{T}A$

$= \frac{ev}{2\pi r}\pi r^2$

$= \frac{evr}{2}$

$= \frac{er}{2}\left[\frac{nh}{2\pi rmr}\right] = \frac{neh}{4\pi m}$

$\therefore \quad M \propto n$

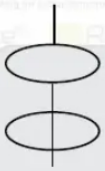
$M \propto \sqrt{r}$

15. A disc of moment of inertia 4 kg/m^2 is spinning freely with ω = 10 rad/s. A second disc of moment of inertia 2 kg/m^2 and spinning with ω = 4 rad/s in same direction, slides down on the spindle and combined slowly and start spinning together. What is the loss in kinetic energy?

(1) 12 J (2) 24 J (3) 36 J (4) 48 J

Ans. **(2)**

Sol. Angular momentum conservation



$I_1 = 4kg/\omega^2$
ω_1=10 rad/s

$I_2 = 2kg/\omega^2$
ω_2=4 rad/s

$L_i = L_f$

$I_1\omega_1 + I_2\omega_2 = (I_1 + I_2)\omega$

$4 \times 10 + 2 \times 4 = (4 + 2)\omega$

$40 + 8 = 6 \times \omega$

$\frac{48}{6} = \omega$

W = 8 rad/s

$E = \frac{1}{2}I_1\omega^2 + \frac{1}{2}I_2\omega^2$

$E_i = \frac{1}{2}I_1\omega_1 + \frac{1}{2}I_2\omega_2$

$= \frac{1}{2}\times 4\times(10)^2 + \frac{1}{2}\times 2\times(4)^2$

$E_i = 200 + 16 = 216$

$E_f = -\frac{1}{2}(I_1 + I_2)\omega^2$

$E_f = \frac{1}{2}(4+2)8^2$

$E_f = 3 \times 64$

$E_f = 192.$

Loss in K.E. = 216 – 192 = 24 J

16. Two polarizers are placed at 45° angle. The intensity of final light if unpolarised light of intensity I_0 is incident on one of polarizer.

(1) $\frac{I_0}{2}$ (2) $\frac{I_0}{8}$ (3) $\frac{I_0}{4}$ (4) $\frac{I_0}{16}$

Ans. **(3)**

Sol. $I = \frac{I_0}{2}\cos^2 45°$

$= \frac{I_0}{4}$

17. 3 moles of monoatomic gas is mixed with 2 moles of diatomic gas. find γ_{mix}

(1) 1.32 (2) 1.42 (3) 1.52 (4) 1.72

Ans. **(3)**

Sol. $\gamma_{mix} = \frac{C_{P_{mix}}}{Cv_{mix}} = \frac{n_1C_{P_1} + n_2C_{P_2}}{n_1C_{v_1} + n_2C_{v_2}}$

$= \frac{3\left(\frac{5}{2}R\right) + 2\left(\frac{7}{2}R\right)}{3\times\left(\frac{3}{2}R\right) + 2\left(\frac{5}{2}R\right)}$

$= \frac{15+14}{9+10}$

$= \frac{29}{19} = 1.52$

18. A step down transformer has primary voltage of V_p = 3.2 KV, number of turn in primary coil is 3000 with current 5 A. on secondary coil voltage is 320 V with number of turns Ns. If efficiency of transformer is 90% then find the current is secondary coil?

(1) 15 A (2) 30 A (3) 45 A (4) 60 A

Ans. **(3)**

Sol. Input power = $3.2 \times 5 \times 10^3$

= 16 kw

eff. = 90% = $\frac{\text{output power}}{\text{input power}} = \frac{P_{out}}{16KV} = \frac{9}{10}$

$P_{out} = \frac{9}{10} \times 16 \times 10^3$

$V_s I_s = \frac{9}{10} \times 16 \times 10^3$

$I_s = \frac{9 \times 16 \times 10^3}{10 \times 320} = 45A$

19. Heat developed in a wire of resistance R is W. If it is cut into two equal parts and connected into parallel with same source battery then heat produced in same time will be.

(1) W (2) 2 W (3) 3 W (4) 4W

Ans. **(4)**

Sol. Head $W = \frac{V^2}{R} t$

$\frac{W_2}{W_1} = \frac{R_1}{R_2} = \frac{R}{\left(\frac{R}{4}\right)} = 4$

$W_2 = 4W_1 \Rightarrow W_{new} = 4W$

20. Number of spectral line in the spectrum of He^+, for transition from n = 5 to 1.

(1) 10 (2) 6 (3) 8 (4) 5

Ans. (1)

Sol. Number of spectral lines = ${}^nC_2$

$= {}^5C_2 = 10$

21. A mass is to be kept on the surface of curve $y = x^2 / 4$ such that it does not slip. Find the maximum height at witch it should be kept if $\mu = 0.5$

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

Ans. **(2)**

Sol. For no slipping

$\mu mg \cos\theta \geq mg \sin\theta$

$\mu \geq \tan\theta$

$\mu \geq dy/dx$

$0.5 \geq \frac{x}{2}$

$1 \geq x$

$y = \frac{x^2}{4} \Rightarrow x^2 = 4y$

$x^2 \leq 1$

$4y \leq 1$

$y \leq \frac{1}{4}$

22. 1000 drops , each have surface energy E_1 converted into 1 bigger drop of surface energy E_2 then $\frac{E_1}{E_2}$ will be

(1) $\frac{1}{110}$ (2) $\frac{1}{81}$ (3) $\frac{1}{100}$ (4) $\frac{1}{121}$

Ans. **(3)**

Sol. $E = S \times A$

$E_1 = S \times 4\pi r^2$ .... (i)

$E_2 = S \times 4\pi R^2$ .... (ii)

Vol. conservation

$$1000 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$$

$$10^3 \times r^3 = R^3$$

$$\frac{r}{R} = \frac{1}{10}$$

$$\frac{E_1}{E_2} = \frac{s \times 4\pi r^2}{s \times 4\pi R^2} = \left(\frac{r}{R}\right)^2$$

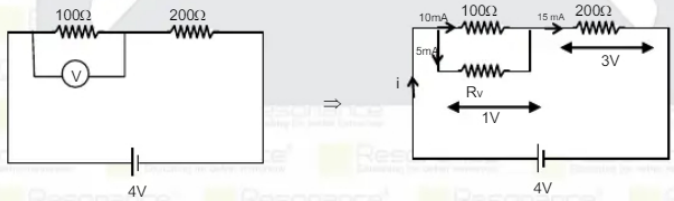
$$\frac{E_1}{E_2} = \frac{1}{100}$$

23. A 100Ω resistance and 200 Ω resistance is connected in a series with 4v battery. A voltmeter connected across 100 Ω reads 1V. Find internal resistance of voltmeter

(1) 150 (2) 200 (3) 190 (4) 220

Ans. **(2)**

Sol.



V = I Rv

$$1 = 5 \times 10^{-3} \times Rv \Rightarrow Rv = \frac{10^3}{5} = 200\Omega$$

24. 49 main scale divisions is equal to 50 vernier scale divisions. If one main scale divisions is 0.5 mm then find the value of vernier constant

(1) 0.01 mm (2) 0.1mm (3) 0.02 mm (4) 0.2 mm

Ans. **(1)**

Sol. vernier constant = L.C = 1MSD – 1VSD

$$= \left[1 - \frac{49}{50}\right] \text{MSD}$$

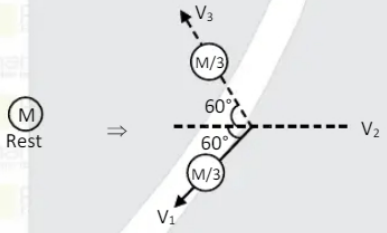
$= \frac{1}{50} \times 0.5\,\text{mm} = 0.01\text{mm}$

25. A parent nuclei of mass M is splits into three daughter nuclei of equal mass. Find speed of daughter nuclei if mass defect is Δm :

(1) $c\sqrt{\frac{2\Delta M}{M}}$ (2) $\sqrt{\frac{2\Delta MC}{M}}$ (3) $\sqrt{\frac{3\Delta M}{M}}$ (4) $\frac{2\Delta MC^2}{m}$

Ans. **(1)**

Sol.

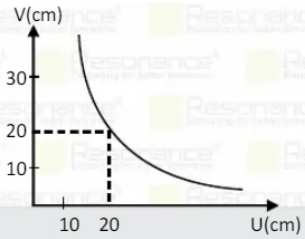


$V_1 = V_2 = V_3$ from symmetry or momentum conservation

Energy released $3\left(\frac{1}{2}\frac{M}{3}V^2\right) = \Delta mC^2$

$V = \sqrt{\frac{2\Delta m}{M}}.C$.

26. v-u graph is given for a concave mirror. Find focal length of concave mirror.



(1) 200 cm (2) 10 cm (3) 15 cm (4) 5 cm

Ans. **(2)**

Sol. $\frac{1}{V} + \frac{1}{u} = \frac{1}{f}$

$\frac{1}{-20} + \frac{1}{-20} = \frac{1}{f}$

F = 10 cm