29/01/2024
Evening

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Memory Based
Answers & Solutions

Time : 3 hrs. *for* M.M. : 300

JEE (Main)-2024 (Online) Phase-1

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

(1) The test is of **3 hours** duration.

(2) This test paper consists of 90 questions. Each subject (PCM) has 30 questions. The maximum marks are 300.

(3) This question paper contains **Three Parts**. **Part-A** is Physics, **Part-B** is Chemistry and **Part-C** is **Mathematics**. Each part has only two sections: **Section-A** and **Section-B**.

(4) **Section - A :** Attempt all questions.

(5) **Section - B :** Attempt any 05 questions out of 10 Questions.

(6) **Section - A (01 – 20)** contains 20 multiple choice questions which have **only one correct answer**. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.

(7) **Section - B (21 – 30) contains** 10 **Numerical value** based questions. The answer to each question should be rounded off to the **nearest integer**. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.

PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. In a simple pendulum of length 10 m, string is initially kept horizontal and the bob is released. 10% of energy is lost till the bob reaches lowermost position. Then find speed of bob at lowermost position.

(1) 6 m/s

(2) $6\sqrt{5}$ m/s

(3) $7\sqrt{5}$ m/s

(4) $4\sqrt{2}$ m/s

Answer (2)

Sol. $W_{total} = \Delta K$

$\Rightarrow \quad 0.9mgl = \frac{1}{2}mv^2$

$\Rightarrow \quad v = \sqrt{1.8\times10\times10}$

$= 6\sqrt{5}$ m/s

2. The intensity at each slit are equal for a YDSE and it is maximum (I_{max}) at central maxima. If I is intensity for phase difference $\frac{7\pi}{2}$ between two waves (at screen).

Then $\frac{I}{I_{max}}$ is

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

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

Answer (1)

Sol. $I = I_{max}\cos^2\left(\frac{\Delta\phi}{2}\right)$

$\frac{I}{I_{max}} = \cos^2\frac{7\pi}{4} \qquad \because \ \Delta\phi = \frac{7\pi}{2}$

$\frac{I}{I_{max}} = \cos^2\left(\frac{\pi}{4}\right) = \frac{1}{2}$

3. An electromagnetic wave has electric field given by $\vec{E} = (9.6\hat{j})\sin\left[2\pi\left\{30\times10^6 t - \frac{1}{10}x\right\}\right]$, x and t are in SI units. The maximum magnetic field is

(1) 3.2×10^{-8}

(2) 9.6×10^{-8}

(3) 1.7×10^{-8}

(4) 10^{-7}

Answer (1)

Sol. $\frac{E}{B} = C$

$\Rightarrow \quad B = \frac{E}{C} = 3.2\times10^{-8}$

4. A planet at distance r from sun takes 200 days to complete one revolution around sun. What will be time period for a planet at distance $\frac{r}{4}$ from the sun?

(1) 50 days

(2) 25 days

(3) 100 days

(4) 12.5 days

Answer (2)

Sol. $T^2 \propto R^3$

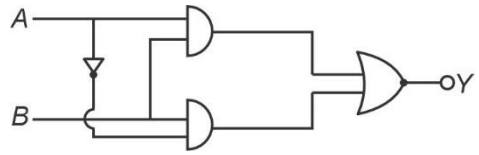
$\frac{200^2}{T^2} = \frac{r^3}{\left(\frac{r}{4}\right)^3}$

$\frac{200}{T} = (4)^{\frac{3}{2}}$

$\frac{200}{8} = T$

$\Rightarrow \quad T = 25$ days

5. The truth table for the combination of logical gates



(1)

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

(2)

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

(3)

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

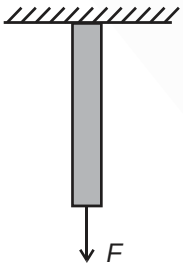
(4)

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

Answer (3)

Sol. $Y = A \cdot B + \overline{A} \cdot B = B(A + \overline{A}) = B$

6. A uniform wire has length L and radius r. It is acted on by a force F as shown. The elongation is Δl. If F and r are both halved, the new elongation will be :



(1) $\frac{\Delta l}{2}$

(2) Δl

(3) $4\Delta l$

(4) $2\Delta l$

Answer (4)

Sol. $\Delta l = \frac{FL}{Ay} \propto \frac{F}{r^2}$

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

7. Two forces F_1 and F_2 are applied on two rods P and Q of same materials such that elongation in rods are same. If ratio of their radii is $x : y$ and ratio of length is $m : n$, then ratio of $F_1 : F_2$ is

(1) $\left(\frac{y}{x}\right)^2 \frac{n}{m}$

(2) $\left(\frac{x}{y}\right)^2 \cdot \frac{n}{m}$

(3) $\left(\frac{x}{y}\right)^2 \cdot \frac{m}{n}$

(4) $\left(\frac{y}{x}\right)^2 \cdot \left(\frac{m}{n}\right)$

Answer (2)

Sol. $\Delta l_1 = \frac{F_1 l_1}{YA_1}, \Delta l_2 = \frac{F_2 l_2}{YA_2}$

$\frac{F_1}{F_2} = \frac{A_1}{A_2} \times \frac{l_2}{l_1} = \left(\frac{r_1}{r_2}\right)^2 \left(\frac{l_2}{l_1}\right) = \frac{x^2}{y^2} \cdot \frac{n}{m}$

8. Two charged particles A and B have charge q each while masses are m_1 & m_2. Both have same velocity v and enter into a transverse magnetic field B such that their radii are r_1 & r_2. Then the ratio $m_1 : m_2$ is

(1) $\frac{r_2}{r_1}$

(2) $\left(\frac{r_1}{r_2}\right)^2$

(3) $\frac{r_1}{r_2}$

(4) $\left(\frac{r_2}{r_1}\right)^2$

Answer (3)

Sol. $r = \frac{mv}{Bq}$

$r \propto m \Rightarrow \frac{r_1}{r_2} = \frac{m_1}{m_2}$

9. A liquid drop of radius R is divided into 27 identical drops. If surface tension of the drops is T, then find work done in this process.

(1) $4\pi R^2T$

(2) $3\pi R^2T$

(3) $8\pi R^2T$

(4) $\frac{1}{8}\pi R^2T$

Answer (3)

Sol. $W = T \times$ change in area (ΔS)

From volume conservation

$$\frac{4}{3}\pi R^3 = 27\pi r^3 \times \frac{4}{3}$$

$R = 3r$

$$r = \frac{R}{3}$$

$$\therefore \quad \Delta S = 4\pi r^2 \times 27 - 4\pi R^2$$

$$= 4\pi \times \frac{R^2}{9} \times 27 - 4\pi R^2 = 2\left(4\pi R^2\right)$$

$$W = 8\pi R^2T$$

10. Alternating voltage and current in circuit is given as

$V = (100 \sin\omega t)$ volt

$$I = 100\sin\left(\omega t + \frac{\pi}{3}\right)\text{mA}$$

Find average power dissipated in circuit.

(1) 2.5 w

(2) 5 w

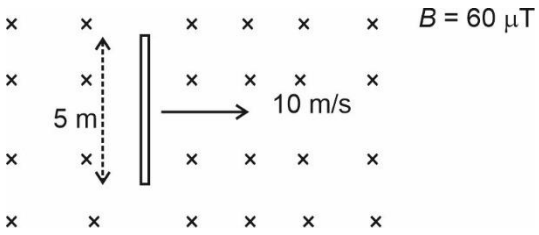
(3) 10 w

(4) 20 w

Answer (1)

Sol. $$P_{avg} = IV\cos\phi = \frac{100}{\sqrt{2}} \times \frac{100\times10^{-3}}{\sqrt{2}}\cos 60° = 2.5 \text{ w}$$

11. Consider a rod moving in a magnetic field as shown:



The induced emf across the ends of the rod is

(1) 3 mV

(2) 6 mV

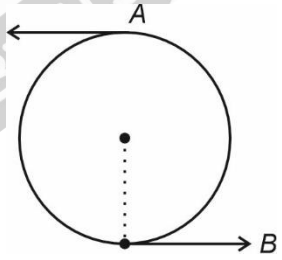
(3) 0 V

(4) 1 mV

Answer (1)

Sol. $\varepsilon = B\ell v = 3$ mV

12. A particle connected with light thread is performing vertical circular motion. Speed at point B (Lowermost point) is of just sufficient, so that it is able to complete its circular motion. Ignoring air friction, find the ratio of kinetic energy at A to that at B. (A being top-most point)



(1) 1 : 5

(2) 5 : 1

(3) $1:7\sqrt{2}$

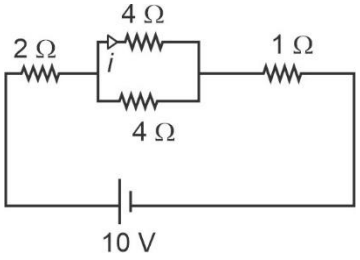
(4) $1:5\sqrt{2}$

Answer (1)

Sol. $v_A = \sqrt{gL}$

$$v_B = \sqrt{5gL}$$

$$\Rightarrow \quad \frac{k_A}{k_B} = \frac{1}{5}$$

13. 

In given circuit, an ideal battery is connected with four resistances as shown. Find current i as mentioned in diagram.

(1) 2 A (2) 1 A

(3) 4 A (4) 0.5 A

Answer (2)

Sol. req = 2 + 2 + 1 = 5 Ω

$$i_b = \frac{10}{5} = 2 \text{ A}$$

$$i = \frac{i_b}{2} = 1 \text{ A}$$

14.

15.

16.

17.

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. A physical quantity Q depends on other physical quantities a, b and c as

$$Q = \frac{a^4 b^3}{c^2}$$

If maximum percentage error in measurement of a, b and c are 3%, 4% and 5% respectively, then find maximum percentage error in measurement of Q.

Answer (34)

Sol. $Q = \frac{a^4 b^3}{c^2}$

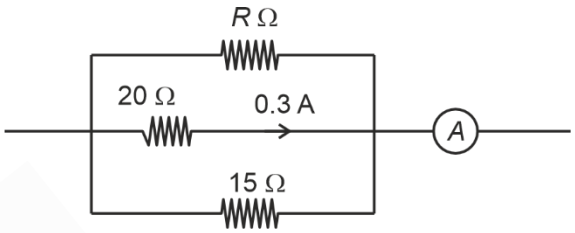
$$\frac{\Delta Q}{Q} = 4\frac{\Delta a}{a} + 3\frac{\Delta b}{b} + 2\frac{\Delta c}{c}$$

$$\frac{\Delta Q}{Q} \times 100 = 4(3) + 3(4) + 2(5)$$

$$= 12 + 12 + 10$$

% error $\frac{\Delta Q}{Q}\% = 34\%$

22. Consider the circuit shown :



The ammeter reads 0.9 A. Value of R is _____

Answer (30)

Sol. 20 Ω & 15 Ω in parallel

$\Rightarrow$ 20 × 0.3 = 15 × i

$\Rightarrow$ i = 0.4 A

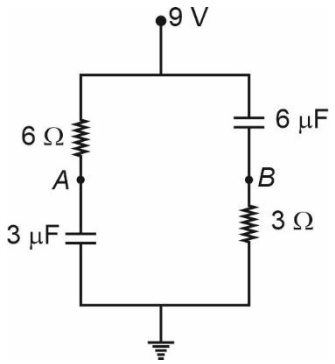
$\Rightarrow$ i_R = 0.9 – 0.3 – 0.4 A

= 0.2 A

$\Rightarrow$ R × 0.2 = 20 × 0.3

$\Rightarrow$ R = 30 Ω

23. Consider the circuit shown :



Charge on 6 μF when A and B are shorted is _____ μC.

Answer (36)

Sol. In steady state, 6 Ω and 3 Ω are in series.

$\Rightarrow$ $\Delta V_{6\Omega} = 6\text{ V} = \Delta V_{6\mu F}$

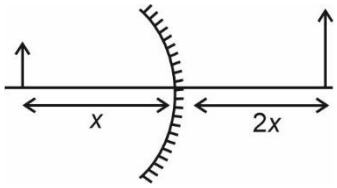
$\Rightarrow$ $\phi = CV = 36\ \mu C$

24. Distance between twice-magnified virtual image of an object placed in front of mirror is 15 cm. Find focal length of spherical mirror in cm.

Answer (10)

Sol. Magnified virtual image of real object

$\Rightarrow$ Concave mirror



$\left(\frac{v}{u}\right) = 2$

$\Rightarrow$ $2x + x = 15$

$x = 5$ cm

$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\Rightarrow$ $\frac{1}{10} - \frac{1}{5} = \frac{1}{f}$

$\frac{1-2}{10} = \frac{-1}{10} = \frac{1}{f}$

$\Rightarrow$ $f = -10$

25. The displacement of a particle changing with time as $x = 6t^3 - 12t^2 + 20t + 30$. Find velocity (in m/s) of particle when it's acceleration became zero. (t is time in s)

Answer (12)

Sol. $v = \frac{dx}{dt} = 20$

$= 18t^2 - 24t + 20$

$a = \frac{dv}{dt} = 36t - 24$

At $a = 0$

$t = \frac{24}{36} = \frac{2}{3}$ sec

Then,

$v = 18 \times \frac{4}{9} - 24 \times \frac{2}{3} + 20$

$= 8 - 16 + 20 = 12$ m/s

26. Electric field in a region is given by $\vec{E} = \left(6\hat{i} + 7\hat{j} + 8\hat{k}\right)$ units. An area of 30 units is considered in y-z plane. Calculate the electric flux through this area.

Answer (180)

Sol. $\phi = \vec{E} \cdot \vec{A} = \left(6\hat{i} + 7\hat{j} + 8\hat{k}\right) \cdot 30\hat{i} = 180$

27. N moles of non-linear polyatomic gas (degree of freedom 6) is mixed with 2 moles of monoatomic gas. The resultant mixture has molar specific heat equal to that of a diatomic gas, then N is

Answer (4)

Sol. $\frac{n_1 \frac{f_1}{2} R + n_2 \frac{f_2}{2} R}{n_1 + n_2} = \frac{5}{2} R$

$\frac{2 \times \frac{3}{2} R + N \times \frac{6}{2} R}{N + 2} = \frac{5}{2} R$

$\frac{6 + 6N}{N + 2} = 5$

$6 + 6N = 5N + 10$

$N = 4$

28. A particle starts oscillation from origin on x-axis with period of oscillation (6) sec and amplitude A. If time taken by particle to reach from $x = A$ to $x = \frac{\sqrt{3}}{2}A$ for the first time is τ then. Value of 6τ is _____ sec.

Answer (3)

Sol. $x = A\sin\left(\omega t + \frac{\pi}{2}\right)$

$x = A\cos\omega t$

$\frac{\sqrt{3}}{2}A = A\cos\left(\frac{2\pi}{\tau}t\right)$

$\frac{\sqrt{3}}{2} = \cos\left(\frac{\pi}{3}t\right)$

$\frac{\pi}{6} = \frac{t}{3}\pi$

$t = \frac{1}{2} = 0.5$

$6\tau = 3$

29.

30.