26/06/2022
Morning

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## Answers \& Solutions

Time : 3 hrs.

## JEE (Main)-2022 (Online) Phase-1

## (Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:
(1) The test is of $\mathbf{3}$ hours duration.
(2) The Test Booklet consists of 90 questions. The maximum marks are 300 .
(3) There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 30 questions in each part of equal weightage. Each part (subject) has two sections.
(i) Section-A: This section contains 20 multiple choice questions which have only one correct answer. Each question carries $\mathbf{4}$ marks for correct answer and $\mathbf{- 1}$ mark for wrong answer.
(ii) Section-B: This section contains 10 questions. In Section-B, attempt any five questions out of 10. The answer to each of the questions is a numerical value. Each question carries 4 marks for correct answer and -1 mark for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

## 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. An expression for a dimensionless quantity $P$ is given by $P=\frac{\alpha}{\beta} \log _{e}\left(\frac{k t}{\beta x}\right)$; where $\alpha$ and $\beta$ are constants, $x$ is distance; $k$ is Boltzmann constant and $t$ is the temperature. Then the dimensions of $\alpha$ will be
(A) $\left[\mathrm{M}^{0} \mathrm{~L}^{-1} \mathrm{~T}^{0}\right]$
(B) $\left[\mathrm{ML}^{0} \mathrm{~T}^{-2}\right]$
(C) $\left[\mathrm{MLT}^{-2}\right]$
(D) $\left[\mathrm{ML}^{2} \mathrm{~T}^{-2}\right]$

## Answer (C)

Sol. $[\alpha]=[\beta]=\left[\frac{k t}{x}\right]$

$$
\begin{aligned}
& =\left[\frac{\mathrm{ML}^{2} \mathrm{~T}^{-2}}{\mathrm{~L}}\right] \\
& =\left[\mathrm{MLT}^{-2}\right]
\end{aligned}
$$

2. A person is standing in an elevator. In which situation, he experiences weight loss?
(A) When the elevator moves upward with constant acceleration
(B) When the elevator moves downward with constant acceleration
(C) When the elevator moves upward with uniform velocity
(D) When the elevator moves downward with uniform velocity

## Answer (B)

Sol. Apparent weight $=m(g-a)$
$\Rightarrow$ Weight loss in downward accelerated elevator
3. An object is thrown vertically upwards. At its maximum height, which of the following quantity becomes zero?
(A) Momentum
(B) Potential Energy
(C) Acceleration
(D) Force

## Answer (A)

Sol. At topmost position,
$v=0$
$\Rightarrow$ momentum $=0$
4. A ball is released from rest from point $P$ of a smooth semi-spherical vessel as shown in figure. The ratio of the centripetal force and normal reaction on the ball at point $Q$ is $A$ while angular position of point $Q$ is $\alpha$ with respect to point $P$. Which of the following graphs represent the correct relation between $A$ and $\alpha$ when ball goes from $Q$ to $R$ ?

(A)

(B)

(C)

(D)


## Answer (C)

Sol. $N=m g \sin \alpha+\frac{m v^{2}}{R}$

$$
\text { and, } v^{2}=2 g \times R \sin \alpha
$$

$\therefore \quad N=m g \sin \alpha+m \times(2 g \sin \alpha)$

$$
=3 m g \sin \alpha
$$

$\therefore \quad$ ratio, $A=\frac{\frac{m v^{2}}{R}}{N}$

$$
\begin{aligned}
& =\frac{2 m g \sin \alpha}{3 m g \sin \alpha} \\
& =\frac{2}{3}
\end{aligned}
$$


5. A thin circular ring of mass $M$ and radius $R$ is rotating with a constant angular velocity $2 \mathrm{rad} \mathrm{s}^{-1}$ in a horizontal plane about an axis vertical to its plane and passing through the center of the ring. If two objects each of mass $m$ be attached gently to the opposite ends of a diameter of ring, the ring will then rotate with an angular velocity (in rad s-1).
(A) $\frac{M}{(M+m)}$
(B) $\frac{(M+2 m)}{2 M}$
(C) $\frac{2 M}{(M+2 m)}$
(D) $\frac{2(M+2 m)}{M}$

## Answer (C)

Sol. $I_{1} \omega_{1}=I_{2} \omega_{2}$

$$
\begin{aligned}
& \Rightarrow \quad M R^{2} \times 2=\left(M R^{2}+2 m R^{2}\right) \omega_{2} \\
& \Rightarrow \quad \omega_{2}=\frac{2 M}{M+2 m}
\end{aligned}
$$

6. The variation of acceleration due to gravity ( $g$ ) with distance ( $r$ ) from the center of the earth is correctly represented by
(Given $R=$ radius of earth)
(A)

(B)

(C)

(D)


Answer (A)

Sol. For $r<R g=\frac{G m r}{R^{3}}=\operatorname{Cr}(C=$ Constant $)$
For $r>R g=\frac{G m}{r^{2}}=\frac{C^{\prime}}{r^{2}}\left(C^{\prime}=\right.$ Constant $)$
For the above equations the best suited graph is as given in option (A)
7. The efficiency of a Carnot's engine, working between steam point and ice point, will be
(A) $26.81 \%$
(B) $37.81 \%$
(C) $47.81 \%$
(D) $57.81 \%$

## Answer (A)

Sol. $\eta=1-\frac{T_{C}}{T_{H}}=\frac{T_{H}-T_{C}}{T_{H}}$
$=\frac{100}{373} \times 100 \%$
$=26.81 \%$
$\Rightarrow$ option (A)
8. Time period of a simple pendulum in a stationary lift is ' $T$. If the lift accelerates with $\frac{g}{6}$ vertically upwards then the time period will be
(Where $g=$ acceleration due to gravity)
(A) $\sqrt{\frac{6}{5}} T$
(B) $\sqrt{\frac{5}{6}} T$
(C) $\sqrt{\frac{6}{7}} T$
(D) $\sqrt{\frac{7}{6}} T$

## Answer (C)

Sol. $T^{\prime}=2 \pi \sqrt{\frac{l}{g_{\text {eff }}}}$

$$
\begin{aligned}
& T^{\prime}=2 \pi \sqrt{\frac{l}{g+\frac{g}{6}}}=2 \pi \sqrt{\frac{6 l}{7 g}} \\
& \Rightarrow T^{\prime}=\sqrt{\frac{6}{7}} T \\
& \Rightarrow \text { Option (C) }
\end{aligned}
$$

9. A thermally insulated vessel contains an ideal gas of molecular mass $M$ and ratio of specific heats 1.4. Vessel is moving with speed $v$ and is suddenly brought to rest. Assuming no heat is lost to the surrounding and vessel temperature of the gas increases by
( $R=$ universal gas constant)
(A) $\frac{M v^{2}}{7 R}$
(B) $\frac{M v^{2}}{5 R}$
(C) $2 \frac{M v^{2}}{7 R}$
(D) $7 \frac{M v^{2}}{5 R}$

## Answer (B)

Sol. $\frac{1}{2} m v^{2}=n \frac{5}{2} R \Delta T$

$$
\begin{aligned}
\Rightarrow \Delta T & =\frac{m v^{2}}{5 n R} \\
& =\frac{M v^{2}}{5 R}
\end{aligned}
$$

Option (B)
10. Two capacitors having capacitance $C_{1}$ and $C_{2}$ respectively are connected as shown in figure. Initially, capacitor $C_{1}$ is charged to a potential difference $V$ volt by a battery. The battery is then removed and the charged capacitor $C_{1}$ is now connected to uncharged capacitor $C_{2}$ by closing the switch $S$. The amount of charge on the capacitor $C_{2}$, after equilibrium, is

(A) $\frac{C_{1} C_{2}}{\left(C_{1}+C_{2}\right)} V$
(B) $\frac{\left(C_{1}+C_{2}\right)}{C_{1} C_{2}} V$
(C) $\left(C_{1}+C_{2}\right) V$
(D) $\left(C_{1}-C_{2}\right) V$

## Answer (A)

Sol. $V_{\text {common }}=\frac{C_{1} V}{C_{1}+C_{2}}$
$\Rightarrow$ Charge on capacitor $C_{2}$

$$
\begin{aligned}
& =C_{2} V_{\text {common }} \\
& =\frac{C_{1} C_{2} V}{C_{1}+C_{2}}
\end{aligned}
$$

$$
\Rightarrow \text { Option }(\mathrm{A})
$$

11. Given below two statements: One is labelled as Assertion (A) and other is labelled as Reason (R).
Assertion (A) : Non-polar materials do not have any permanent dipole moment.
Reason (R) : When a non-polar material is placed in an electric field, the centre of the positive charge distribution of it's individual atom or molecule coincides with the centre of the negative charge distribution.
In the light of above statements, choose the most appropriate answer from the options given below.
$(A)$ Both (A) and (R) are correct and (R) is the correct explanation of (A).
$(B)$ Both $(A)$ and (R) are correct and (R) is not the correct explanation of (A).
$(C)(A)$ is correct but $(R)$ is not correct.
(D) (A) is not correct but (R) is correct.

## Answer (C)

Sol. Non polar material does not have any permanent dipole moment and when placed in an electric field the positive and negative charges displace in opposite directions and result into an induced dipole moment as long as the field is applied.
12. The magnetic flux through a coil perpendicular to its plane is varying according to the relation $\phi=\left(5 t^{3}+4 t^{2}+2 t-5\right)$ Weber. If the resistance of the coil is 5 ohm, then the induced current through the coil at $t=2 \mathrm{~s}$ will be,
(A) 15.6 A
(B) 16.6 A
(C) 17.6 A
(D) 18.6 A

Answer (A)
Sol. Emf $=-\frac{d \phi}{d t}=-\left(15 t^{2}+8 t+2\right)$
So, $i=\frac{|E \mathrm{Ef}|}{R}=\frac{\left(15 t^{2}+8 t+2\right)}{5}$
at $t=2$
$i=15.6 \mathrm{~A}$
13. An aluminium wire is stretched to make its length, $0.4 \%$ larger. The percentage change in resistance is :
(A) $0.4 \%$
(B) $0.2 \%$
(C) $0.8 \%$
(D) $0.6 \%$

## Answer (C)

Sol. When the wire is stretched, volume remains constant. If length is increased by $0.4 \%$ area will decrease by $0.4 \%$ so

From $R=\rho \frac{I}{A}$
$\frac{d R}{R} \times 100=\frac{d l}{l} \times 100+\frac{d A}{A} \times 100$
$\% R=0.4+0.4=0.8 \%$
14. A proton and an alpha particle of the same velocity enter in a uniform magnetic field which is acting perpendicular to their direction of motion. The ratio of the radii of the circular paths described by the alpha particle and proton is :
(A) $1: 4$
(B) $4: 1$
(C) $2: 1$
(D) $1: 2$

## Answer (C)

Sol. $R=\frac{m v}{q B}$
$\frac{R_{\alpha}}{R_{p}}=\frac{m_{\alpha} / q_{\alpha}}{m_{p} / q_{p}}=2$
15. If electric field intensity of a uniform plane electro magnetic wave is given as
$E=-301.6 \sin (k z-\omega t) \hat{a}_{x}+452.4 \sin (k z-\omega t) \hat{a}_{y} \frac{V}{m}$.
Then, magnetic intensity ' H ' of this wave in $\mathrm{Am}^{-1}$ will be :
[Given : Speed of light in vacuum $c=3 \times 10^{8} \mathrm{~ms}^{-1}$, Permeability of vacuum $\mu_{0}=4 \pi \times 10^{-7} \mathrm{NA}^{-2}$ ]
(A) $+0.8 \sin (k z-\omega t) \hat{a}_{y}+0.8 \sin (k z-\omega t) \hat{a}_{x}$.
(B) $+1.0 \times 10^{-6} \sin (k z-\omega t) \hat{a}_{y}+1.5 \times 10^{-6}$

$$
(k z-\omega t) \hat{a}_{x}
$$

(C) $-0.8 \sin (k z-\omega t) \hat{a}_{y}-1.2 \sin (k z-\omega t) \hat{a}_{x}$
(D) $-1.0 \times 10^{-6} \sin (k z-\omega t) \hat{a}_{y}-1.5 \times 10^{-6}$

$$
\sin (k z-\omega t) \hat{a}_{x}
$$

## Answer (C)

Sol. We know
$\vec{B} \times \vec{C}=\vec{E}$
Taking cross product of $\vec{C}$ both the sides
$\vec{C} \times(\vec{B} \times \vec{C})=\vec{C} \times \vec{E}$
So $\vec{B}=\frac{\vec{C} \times \vec{E}}{C^{2}}$
$\vec{C}=C \hat{k}$
$\vec{E}=-301.6 \sin (k z-\omega t) \hat{a}_{x}+452.4 \sin (k z-\omega t) \hat{a}_{y}$
and $\vec{H}=\frac{\vec{B}}{\mu_{0}}$
On solving
$\vec{H}=-0.8 \sin (k z-\omega t) \vec{a}_{y}-1.2 \sin (k z-\omega t) \vec{a}_{x}$
16. In free space, an electromagnetic wave of 3 GHz frequency strikes over the edge of an object of size $\frac{\lambda}{100}$, where $\lambda$ is the wavelength of the wave in free space. The phenomenon, which happens there will be:
(A) Reflection
(B) Refraction
(C) Diffraction
(D) Scattering

Answer (D)
Sol. Since size is of the order of $\frac{\lambda}{100}$, hence scattering will take place.
17. An electron with speed $v$ and a photon with speed $c$ have the same de-Broglie wavelength. If the kinetic energy and momentum of electron are $E_{e}$ and $p_{\mathrm{e}}$ and that of photon are $E_{p h}$ and $p_{p h}$ respectively. Which of the following is correct?
(A) $\frac{E_{e}}{E_{p h}}=\frac{2 c}{v}$
(B) $\frac{E_{e}}{E_{p h}}=\frac{v}{2 c}$
(C) $\frac{p_{e}}{p_{p h}}=\frac{2 c}{v}$
(D) $\frac{p_{e}}{p_{p h}}=\frac{v}{2 c}$

## Answer (B)

Sol. $\lambda_{e}=\lambda_{p h} \Rightarrow \frac{h}{p_{e}}=\frac{h c}{E_{p h}}$

$$
\Rightarrow \quad E_{p h}=p_{e} \times c=2 E_{e} \frac{c}{v}
$$

$\Rightarrow \frac{E_{e}}{E_{p h}}=\frac{v}{2 c}$
18. How many alpha and beta particles are emitted when Uranium ${ }_{92} \mathrm{U}^{238}$ decays to lead ${ }_{82} \mathrm{~Pb}^{206}$ ?
(A) 3 alpha particles and 5 beta particles
(B) 6 alpha particles and 4 beta particles
(C) 4 alpha particles and 5 beta particles
(D) 8 alpha particles and 6 beta particles

## Answer (D)

Sol. ${ }_{92}^{238} \mathrm{U} \longrightarrow{ }_{82}^{206} \mathrm{~Pb}+x{ }_{2}^{4} \mathrm{He}+y\left({ }_{-1}^{0} e\right)$
$\Rightarrow 206+4 x=238$
and $82+2 x-y=92$.
$\Rightarrow x=8$ and $y=6$
19. The $I-V$ characteristics of a p-n junction diode in forward bias is shown in the figure. The ratio of dynamic resistance, corresponding to forward bias voltage of 2 V and 4 V respectively, is :

(A) $1: 2$
(B) $5: 1$
(C) $1: 40$
(D) $20: 1$

Answer (B)
Sol. Dynamic resistance $=\frac{d V}{d l}$

$$
\begin{aligned}
\Rightarrow & r_{1}=\frac{2.1-2}{10-5} \mathrm{k} \Omega \\
& \& r_{2}=\frac{4.2-4}{250-200} \mathrm{k} \Omega \\
\Rightarrow & r_{1}: r_{2}=5: 1
\end{aligned}
$$

20. Choose the correct statement for amplitude modulation :
(A) Amplitude of modulating signal is varied in accordance with the information signal.
(B) Amplitude of modulated signal is varied in accordance with the information signal.
(C) Amplitude of carrier signal is varied in accordance with the information signal.
(D) Amplitude of modulated signal is varied in accordance with the modulating signal.

## Answer (C)

Sol. In amplitude modulation, amplitude of carrier signal is varied according to the message signal.

## SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10 . The answer to each question is a NUMERICAL VALUE. For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. $06.25,07.00,-00.33,-00.30,30.27,-27.30$ ) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

1. A fighter jet is flying horizontally at a certain altitude with a speed of $200 \mathrm{~ms}^{-1}$. When it passes directly overhead an anti-aircraft gun, a bullet is fired from the gun, at an angle $\theta$ with the horizontal, to hit the jet. If the bullet speed is $400 \mathrm{~m} / \mathrm{s}$, the value of $\theta$ will be $\qquad$ $\stackrel{\circ}{\circ}$.
Answer (60)


To hit the jet
$400 \cos \theta=200$
$\Rightarrow \quad \cos \theta=\frac{1}{2}$
$\Rightarrow \theta=60^{\circ}$
2. A ball of mass 0.5 kg is dropped from the height of 10 m . The height, at which the magnitude of velocity becomes equal to the magnitude of acceleration due to gravity, is $\qquad$ m .
[Use $g=10 \mathrm{~m} / \mathrm{s}^{2}$ ]
Answer (5)

Sol. $g t=g$
$\Rightarrow t=1 \mathrm{sec}$
$\Delta h=\frac{1}{2} g t^{2}=\frac{1}{2} \times 5 \times 1^{2}=5 \mathrm{~m}$
$\therefore \quad h=H-\Delta h$

$$
=10-5
$$

$$
=5 \mathrm{~m}
$$

3. The elastic behaviour of material for linear stress and linear strain, is shown in the figure. The energy density for a linear strain of $5 \times 10^{-4}$ is $\qquad$ $\mathrm{kJ} / \mathrm{m}^{3}$. Assume that material is elastic upto the linear strain of $5 \times 10^{-4}$.


## Answer (25)

Sol. $u_{d}=\frac{1}{2} \times Y \times(\text { strain })^{2}$
$=\frac{1}{2} \times\left(\frac{20}{10^{-10}}\right) \times\left(5 \times 10^{-4}\right)^{2}$
$=10^{11} \times 25 \times 10^{-8}$
$=25 \times 10^{3} \mathrm{~J} / \mathrm{m}^{3}$
$=25 \mathrm{~kJ} / \mathrm{m}^{3}$
4. The elongation of a wire on the surface of the earth is $10^{-4} \mathrm{~m}$. The same wire of same dimensions is elongated by $6 \times 10^{-5} \mathrm{~m}$ on another planet. The acceleration due to gravity on the planet will be $\qquad$ $\mathrm{ms}^{-2}$. (Take acceleration due to gravity on the surface of earth $=10 \mathrm{~ms}^{-2}$ )

## Answer (6)

Sol. $\Delta I=\frac{M^{\prime} g l}{2 \mathrm{~A} \mathrm{y}}$
$\Rightarrow \quad \Delta l \propto g$
$\Rightarrow \frac{g_{p}}{g_{e}}=\frac{\Delta I_{p}}{\Delta I_{e}}=\frac{6 \times 10^{-5}}{10 \times 10^{-5}}$
$\Rightarrow g_{p}=6 \mathrm{~m} / \mathrm{s}^{2}$ as $g_{e}=10 \mathrm{~m} / \mathrm{s}^{2}$
5. A $10 \Omega, 20 \mathrm{mH}$ coil carrying constant current is connected to a battery of 20 V through a switch. Now after switch is opened current becomes zero in $100 \mu \mathrm{~s}$. The average e.m.f. induced in the coil is
$\qquad$ V.

## Answer (400)

Sol. Initial flux through inductor $=\mathrm{LI}$

$$
\begin{aligned}
& \Rightarrow \quad \phi_{\mathrm{i}}=20 \times 10^{-3} \times \frac{20}{10} \\
& =4 \times 10^{-2} \text { weber }
\end{aligned}
$$

Final flux $=0$
$\Rightarrow$ average emf
$=\frac{\left|\phi_{i}-\phi_{f}\right|}{100 \mu \mathrm{~S}}$
$=\frac{4 \times 10^{-2}}{10^{-4}}=400 \mathrm{~V}$
6. A light ray is incident, at an incident angle $\theta_{1}$, on the system of two plane mirrors $M_{1}$ and $M_{2}$ having an inclination angle $75^{\circ}$ between them (as shown in figure). After reflecting from mirror $M_{1}$ it gets reflected back by the mirror $M_{2}$ with an angle of reflection $30^{\circ}$. The total deviation of the ray will be - degree.


## Answer (210)

Sol.


On first reflection angel of deviation is $90^{\circ}$ and on second reflection angle of deviation is $120^{\circ}$
so total deviation is $\delta=90^{\circ}+120^{\circ}=210^{\circ}$
7. In a vernier callipers, each cm on the main scale is divided into 20 equal parts. If tenth vernier scale division coincides with nineth main scale division. Then the value of vernier constant will be
$\qquad$ $\times 10^{-2} \mathrm{~mm}$.

## Answer (5)

Sol. $\mathrm{LC}=\frac{1 \mathrm{MSD}}{\mathrm{VSD}}=\frac{\frac{1}{20} \mathrm{~cm}}{10}$

$$
\begin{aligned}
& =\frac{1}{200} \mathrm{~cm} \\
& =5 \times 10^{-2} \mathrm{~mm}
\end{aligned}
$$

8. As per the given circuit, the value of current through the battery will be $\qquad$ A.


## Answer (1)

Sol. Because of diode $D_{2}$ current will not flow through it so new circuit diagram is

so $R_{\text {net }}=10 \Omega$
and $i=\frac{V}{R_{\text {net }}}=1 \mathrm{~A}$
9. A $110 \mathrm{~V}, 50 \mathrm{~Hz}, \mathrm{AC}$ source is connected in the circuit (as shown in figure). The current through the resistance $55 \Omega$, at resonance in the circuit, will be
$\qquad$ A.


## Answer (0)

Sol. At resonance $\left(\omega=\frac{1}{\sqrt{L C}}\right)$, impedance of the circuit is infinite.
$\Rightarrow$ Current through resistance $=0$.
10. An ideal fluid of density $800 \mathrm{k} \mathrm{gm}^{-3}$, flows smoothly through a bent pipe (as shown in figure) that tapers in cross-sectional area from a to $\frac{a}{2}$. The pressure difference between the wide and narrow sections of pipe is 4100 Pa . At wider section, the velocity of fluid is $\frac{\sqrt{x}}{6} \mathrm{~ms}^{-1}$ for $x=\longrightarrow$. (Given $g=10 \mathrm{~ms}^{-2}$ )


## Answer (363)

Sol. Applying Bernoulli's theorem:

$$
P_{1}+\rho g h+\frac{1}{2} \rho v^{2}=P_{2}+0+\frac{1}{2} \rho(2 v)^{2}
$$

Putting the values,
$4100=800\left\{\frac{3}{2} v^{2}-10\right\}$
$\Rightarrow v=\frac{\sqrt{363}}{6} \mathrm{~m} / \mathrm{s}$

