29/06/2022
Morning

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Answers & Solutions

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

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

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

(1) The test is of **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 **4 marks** for correct answer and **–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. Two balls *A* and *B* are placed at the top of 180 m tall tower. Ball *A* is released from the top at $t = 0$ s. Ball *B* is thrown vertically down with an initial velocity *u* at $t = 2$ s. After a certain time, both balls meet 100 m above the ground. Find the value of *u* in ms^{-1} [use $g = 10\ ms^{-2}$]

(A) 10

(B) 15

(C) 20

(D) 30

Answer (D)

Sol. Let us assume that they meet at $t = t_0$

$A:\ 80 = \frac{1}{2}gt_0^2$ ...(i)

$B:\ 80 = u(t_0 - 2) + \frac{1}{2}g(t_0 - 2)^2$ ...(ii)

From (i), $t_0 = 4$

$\Rightarrow\ 80 = 2u + 5(2)^2$

$\Rightarrow\ u = 30$ m/s

2. A body of mass *M* at rest explodes into three pieces, in the ratio of masses 1 : 1 : 2. Two smaller pieces fly off perpendicular to each other with velocities of 30 ms^{-1} and 40 ms^{-1} respectively. The velocity of the third piece will be

(A) 15 ms^{-1}

(B) 25 ms^{-1}

(C) 35 ms^{-1}

(D) 50 ms^{-1}

Answer (B)

Sol. Conserving momentum:

$m(30\hat{i}) + m(40\hat{j}) + 2m(\vec{v}) = \vec{0}$

$\Rightarrow\ \vec{v} = -15\hat{i} - 20\hat{j}$

$\Rightarrow\ |\vec{v}| = 25$ m/s

3. The activity of a radioactive material is 2.56×10^{-3} Ci. If the half life of the material is 5 days, after how many days the activity will become 2×10^{-5} Ci?

(A) 30 days

(B) 35 days

(C) 40 days

(D) 25 days

Answer (B)

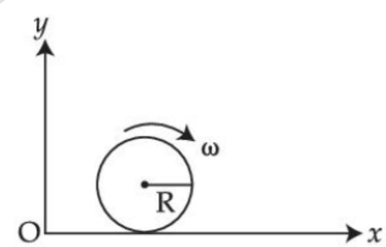
Sol. $A = A_0 e^{-\lambda t}$

$\Rightarrow\ 2 \times 10^{-5} = 2.56 \times 10^{-3}\, e^{-\lambda t}$

$\Rightarrow\ e^{-\lambda t} = \frac{1}{128} = \left[\frac{1}{2}\right]^7$

$\Rightarrow\ t = 7t_{\frac{1}{2}} = 35$ days

4. A spherical shell of 1 kg mass and radius *R* is rolling with angular speed ω on horizontal plane (as shown in figure). The magnitude of angular momentum of the shell about the origin *O* is $\frac{a}{3}R^2\omega$. The value of a will be



(A) 2

(B) 3

(C) 5

(D) 4

Answer (C)

Sol. $\vec{L}_0 = \vec{L}_{\text{of cm}} + \vec{L}_{\text{about cm}}$

$\Rightarrow\ \frac{a}{3}R^2\omega = mvR + \frac{2}{3}mR^2\omega = \frac{5}{3}mR^2\omega$

$\Rightarrow\ a = 5$

5. A cylinder of fixed capacity of 44.8 litres contains helium gas at standard temperature and pressure. The amount of heat needed to raise the temperature of gas in the cylinder by 20.0°C will be

(Given gas constant R = 8.3 JK^{-1}-mol^{-1})

(A) 249 J

(B) 415 J

(C) 498 J

(D) 830 J

Answer (C)

Sol. $\Delta Q = nC_V\Delta T$ (Isochoric process)

$$= 2 \times \frac{3R}{2} \times 20$$

= 498 J

6. A wire of length L is hanging from a fixed support. The length changes to L_1 and L_2 when masses 1 kg and 2 kg are suspended respectively from its free end. Then the value of L is equal to

(A) $\sqrt{L_1L_2}$

(B) $\frac{L_1 + L_2}{2}$

(C) $2L_1 - L_2$

(D) $3L_1 - 2L_2$

Answer (C)

Sol. $y = \frac{FL}{A\Delta L}$

$\Rightarrow \quad \Delta L = \frac{FL}{Ay}$

$\Rightarrow \quad L_1 = L + \frac{(1g)L}{Ay}$ ...(i)

and $L_2 = L + \frac{(2g)L}{Ay}$ ...(ii)

$\Rightarrow \quad L = 2L_1 - L_2$

7. Given below are two statements : one is labelled as **Assertion A** and the other is labelled as **Reason R.**

Assertion A : The photoelectric effect does not takes place, if the energy of the incident radiation is less than the work function of a metal.

Reason R : Kinetic energy of the photoelectrons is zero, if the energy of the incident radiation is equal to the work function of a metal.

In the light of the 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 but **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 (B)

Sol. When energy of incident radiation is equal to the work function of the metal, then the KE of photoelectrons would be zero. But this statement does not comment on the situation when energy is less than the work function.

8. A particle of mass 500 gm is moving in a straight line with velocity $v = bx^{5/2}$. The work done by the net force during its displacement from x = 0 to x = 4 m is : (Take b = 0.25 $m^{-3/2}s^{-1}$).

(A) 2 J (B) 4 J

(C) 8 J (D) 16 J

Answer (D)

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

$$= \frac{1}{2}\left(\frac{1}{2}\right)\left[\{b(4)^{5/2}\}^2 - 0\right]$$

$$= \frac{b^2}{4} \times 4^5$$

$\Rightarrow \quad W_{total}$ = 16 J

9. A charge particle moves along circular path in a uniform magnetic field in a cyclotron. The kinetic energy of the charge particle increases to 4 times its initial value. What will be the ratio of new radius to the original radius of circular path of the charge particle

(A) 1 : 1

(B) 1 : 2

(C) 2 : 1

(D) 1 : 4

Answer (C)

Sol. $R = \frac{mv}{Bq} = \frac{\sqrt{2mK}}{Bq}$

$\Rightarrow \quad R \propto \sqrt{K}$

$\Rightarrow$ ratio = 2 : 1

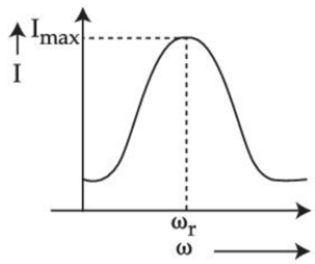
10. For a series LCR circuit, I vs ω curve is shown :

(a) To the left of ω_r, the circuit is mainly capacitive.

(b) To the left of ω_r, the circuit is mainly inductive.

(c) At ω_r, impedance of the circuit is equal to the resistance of the circuit.

(d) At ω_r, impedance of the circuit is 0.



Choose the **most appropriate** answer from the options given below

(A) (a) and (d) only (B) (b) and (d) only

(C) (a) and (c) only (D) (b) and (c) only

Answer (C)

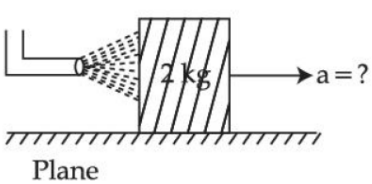
Sol. We know that $X_C = \frac{1}{\omega C}$ and $X_L = \omega L$

Also, at $\omega = \omega_r$: $X_L = X_C$

$\Rightarrow$ For $\omega < \omega_r$: capacitive

and At $\omega = \omega_r : z = \sqrt{R^2 + (X_L - X_C)^2} = R$

11. A block of metal weighing 2 kg is resting on a frictionless plane (as shown in figure). It is struck by a jet releasing water at a rate of 1 kgs^{-1} and at a speed of 10 ms^{-1}. Then, the initial acceleration of the block, in ms^{-2}, will be:



(A) 3

(B) 6

(C) 5

(D) 4

Answer (C)

Sol. $F = \rho v^2 a$

$\Rightarrow$ 10 × 1 = 2 × acceleration

$\Rightarrow$ Acc. = 5 m/s^2

12. In van der Wall equation $\left[P + \frac{a}{V^2}\right][V - b] = RT; P$ is pressure, V is volume, R is universal gas constant and T is temperature. The ratio of constants $\frac{a}{b}$ is dimensionally equal to:

(A) $\frac{P}{V}$

(B) $\frac{V}{P}$

(C) PV

(D) PV^3

Answer (C)

Sol. From the equation

$[a] \equiv [PV^2]$

$[b] \equiv [V]$

$\Rightarrow \left[\frac{a}{b}\right] \equiv [PV]$

13. Two vectors $\vec{A}$ and $\vec{B}$ have equal magnitudes. If magnitude of $\vec{A} + \vec{B}$ is equal to two times the magnitude of $\vec{A} - \vec{B}$, then the angle between $\vec{A}$ and $\vec{B}$ will be:

(A) $\sin^{-1}\left(\frac{3}{5}\right)$

(B) $\sin^{-1}\left(\frac{1}{3}\right)$

(C) $\cos^{-1}\left(\frac{3}{5}\right)$

(D) $\cos^{-1}\left(\frac{1}{3}\right)$

Answer (C)

Sol. $\sqrt{A^2 + A^2 + 2A^2\cos\theta} = 2\sqrt{A^2 + A^2 + 2A^2(-\cos\theta)}$

$\Rightarrow 2A^2 + 2A^2\cos\theta = 8A^2 + 8A^2(-\cos\theta)$

$\Rightarrow 5\cos\theta = 3$

$\Rightarrow \theta = \cos^{-1}\left(\frac{3}{5}\right)$

14. The escape velocity of a body on a planet '*A*' is 12 kms^{-1}. The escape velocity of the body on another planet '*B*', whose density is four times and radius is half of the planet '*A*', is:

(A) 12 kms^{-1}

(B) 24 kms^{-1}

(C) 36 kms^{-1}

(D) 6 kms^{-1}

Answer (A)

Sol. $v_{esc} = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2G}{R} \times \rho \times \frac{4}{3}\pi R^3}$

$\Rightarrow \quad v_{esc} \propto R\sqrt{\rho}$

$\Rightarrow \quad \frac{(v_{esc})_B}{(v_{esc})_A} = 1$

$\Rightarrow \quad (v_{esc})_B$ = 12 km/s

15. At a certain place the angle of dip is 30° and the horizontal component of earth's magnetic field is 0.5 G. The earth's total magnetic field (in G), at that certain place, is :

(A) $\frac{1}{\sqrt{3}}$

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

(C) $\sqrt{3}$

(D) 1

Answer (A)

Sol. $B_H = B\cos 30°$

$\Rightarrow \quad B = \frac{1}{\sqrt{3}} G$

16. A longitudinal wave is represented by $x = 10\sin 2\pi\left(nt - \frac{x}{\lambda}\right)$ cm. The maximum particle velocity will be four times the wave velocity if the determined value of wavelength is equal to :

(A) 2π

(B) 5π

(C) π

(D) $\frac{5\pi}{2}$

Answer (B)

Sol. Particle velocity $= \frac{\partial x}{\partial t}$

$\Rightarrow$ Maximum particle velocity = $(2\pi n)$ (10)

$\Rightarrow$ $(2\pi n)$ (10) = $(n\lambda)$ (4)

$\Rightarrow$ $\lambda = 5\pi$

17. A parallel plate capacitor filled with a medium of dielectric constant 10, is connected across a battery and is charged. The dielectric slab is replaced by another slab of dielectric constant 15. Then the energy of capacitor will :

(A) increased by 50%

(B) decrease by 15%

(C) increase by 25%

(D) increase by 33%

Answer (A)

Sol. $U = \frac{1}{2}(kC_0)V^2$

$\Rightarrow \quad \frac{U'}{U} = 1.5$

$\Rightarrow$ Energy increases by 50%

18. A positive charge particle of 100 mg is thrown in opposite direction to a uniform electric field of strength 1×10^5 NC^{-1}. If the charge on the particle is 40 μC and the initial velocity is 200 ms^{-1}, how much distance it will travel before coming to the rest momentarily?

(A) 1 m

(B) 5 m

(C) 10 m

(D) 0.5 m

Answer (D)

Sol. $v^2 - u^2 = 2aS$

$\Rightarrow \quad 0^2 - 200^2 = 2\left(\frac{-qE}{m}\right)(S)$

$\Rightarrow \quad -200^2 = 2\left[\frac{-40 \times 10^{-6} \times 10^5}{100 \times 10^{-6}}\right][S]$

$\Rightarrow \quad S = \frac{4}{2 \times 4}$ m = 0.5 m

19. Using Young's double slit experiment, a monochromatic light of wavelength 5000 Å produces fringes of fringe width 0.5 mm. If another monochromatic light of wavelength 6000 Å is used and the separation between the slits is doubled, then the new fringe width will be :

(A) 0.5 mm (B) 1.0 mm

(C) 0.6 mm (D) 0.3 mm

Answer (D)

Sol. Fringe width $= \frac{\lambda D}{d}$

$\Rightarrow$ Fringe width $\propto \frac{\lambda}{d}$

$\Rightarrow$ New fringe width = $0.5\text{ mm} \times \frac{1.2}{2} = 0.3\text{ mm}$

20. Only 2% of the optical source frequency is the available channel bandwidth for an optical communicating system operating at 1000 nm. If an audio signal requires a bandwidth of 8 kHz, how many channels can be accommodated for transmission?

(A) 375×10^7

(B) 75×10^7

(C) 375×10^8

(D) 75×10^9

Answer (B)

Sol. $v = f\lambda$

$$\Rightarrow f = \frac{v}{\lambda} = \frac{3\times 10^8}{1000\times 10^{-9}}\text{ Hz} = 3\times 10^{14}\text{ Hz}$$

$$\Rightarrow \text{Channels} = \frac{\frac{2}{100}\times 3\times 10^{14}}{8\times 10^3} = 75\times 10^7$$

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. Two coils require 20 minutes and 60 minutes respectively to produce same amount of heat energy when connected separately to the same source. If they are connected in parallel arrangement to the same source; the time required to produce same amount of heat by the combination of coils, will be ___ min.

Answer (15)

Sol. $H = \frac{V^2}{R}\cdot\Delta t$

$$\Rightarrow H = \frac{V^2}{R_1}\cdot 20 = \frac{V^2}{R_2}\cdot 60 \quad \ldots\text{(i)}$$

$$\text{Also, } H = \frac{V^2}{\left[\frac{R_1R_2}{R_1+R_2}\right]}\cdot\Delta t$$

$$= \frac{4}{3}\cdot\frac{V^2}{R_1}\cdot\Delta t \qquad [\because R_2 = 3R_1]$$

$\Rightarrow \Delta t = 15$

2. The intensity of the light from a bulb incident on a surface is 0.22 W/m². The amplitude of the magnetic field in this light-wave is ___ × 10^{-9} T.

(Given : Permittivity of vacuum ε_0 = 8.85 × 10^{-12} C^2N^{-1} –m^{-2}, speed of light in vacuum c = 3 × 10^8 ms^{-1})

Answer (43)

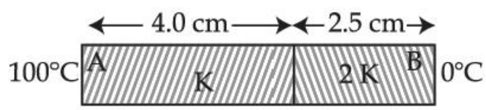
Sol. $I = \frac{1}{2}\varepsilon_0 E_0^2\cdot c = \frac{1}{2}\varepsilon_0 (cB_0)^2 c$

$$\Rightarrow I = \frac{1}{2}\varepsilon_0 c^3 B_0^2$$

$$\Rightarrow 0.22 = \frac{1}{2}\left(8.85\times 10^{-12}\right)\left(3\times 10^8\right)^3 B_0^2$$

$$\Rightarrow B_0 \simeq 43\times 10^{-9}T$$

3. As per the given figure, two plates *A* and *B* of thermal conductivity K and 2 K are joined together to form a compound plate. The thickness of plates are 4.0 cm and 2.5 cm respectively and the area of cross-section is 120 cm^2 for each plate. The equivalent thermal conductivity of the compound plate is $\left(1+\frac{5}{\alpha}\right)$ K, then the value of α will be ____.



Answer (21)

Sol. $\frac{L_1}{K_1A_1}+\frac{L_2}{K_2A_2}=\frac{L_1+L_2}{K_{eff}A_{eff}}$

$\Rightarrow \frac{4}{K}+\frac{2.5}{2K}=\frac{6.5}{K_{eff}}$

$\Rightarrow \frac{10.5}{2K}=\frac{6.5}{K_{eff}}$

$\Rightarrow K_{eff}=\frac{13K}{10.5}=\left(1+\frac{5}{21}\right)K$

$\Rightarrow \alpha = 21$

4. A body is performing simple harmonic with an amplitude of 10 cm. The velocity of the body was tripled by air Jet when it is at 5 cm from its mean position. The new amplitude of vibration is $\sqrt{x}$ cm. The value of x is ___.

Answer (700)

Sol. $v=\omega\sqrt{A^2-y^2}$

$\Rightarrow 3\omega\sqrt{10^2-5^2}=\omega\sqrt{(A')^2-5^2}$

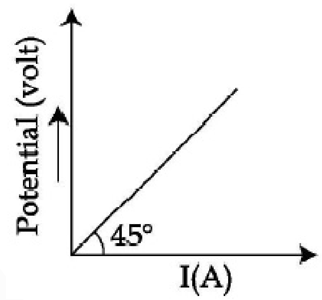
$\Rightarrow 9 \times 75 = (A')^2 - 25$

$\Rightarrow A'=\sqrt{28\times 25}$ cm

$\Rightarrow x = 700$

5. The variation of applied potential and current flowing through a given wire is shown in figure. The length of wire is 31.4 cm. The diameter of wire is measured as 2.4 cm. The resistivity of the given wire is measured as $x \times 10^{-3}\ \Omega$ cm. The value of *x* is____.

[Take π = 3.14]



Answer (144)

Sol. Resistance = tan45° = 1 Ω

$\Rightarrow 1=\frac{\rho l}{A}$

$\Rightarrow \rho=\frac{\pi(1.2\text{ cm})^2}{31.4\text{ cm}}=1.44\times 10^{-1}\ \Omega\text{cm}$

$\Rightarrow x = 144$

6. 300 cal. of heat is given to a heat engine and it rejects 225 cal. of heat. If source temperature is 227°C, then the temperature of sink will be _______°C.

Answer (102)

Sol. $\eta=\frac{W}{Q}=\frac{300-225}{300}$

$\Rightarrow \frac{75}{300}=1-\frac{T_L}{T_H}$

$\Rightarrow T_L=\frac{3}{4}T_H=\frac{3}{4}(500)$ = 375 K

$\Rightarrow T_L = 102°C$

7. $\sqrt{d_1}$ and $\sqrt{d_2}$ are the impact parameters corresponding to scattering angles 60° and 90° respectively, when an α particle is approaching a gold nucleus. For $d_1 = x\, d_2$, the value of x will be ________.

Answer (3)

Sol. Impact parameter $\propto \cot\frac{\theta}{2}$

$$\Rightarrow \sqrt{\frac{d_1}{d_2}} = \frac{\sqrt{3}}{1}$$

$$\Rightarrow d_1 = 3d_2$$

$$\Rightarrow x = 3$$

8. A transistor is used in an amplifier circuit in common emitter mode. If the base current changes by 100 μA, it brings a change of 10 mA in collector current. If the load resistance is 2 kΩ and input resistance is 1 kΩ, the value of power gain is $x \times 10^4$. The value of x is ________.

Answer (2)

Sol. Power gain = $\left[\frac{\Delta i_C}{\Delta i_B}\right]^2 \times \frac{R_o}{R_i}$

$$= \left[\frac{10^{-2}}{10^{-4}}\right]^2 \times \frac{2}{1}$$

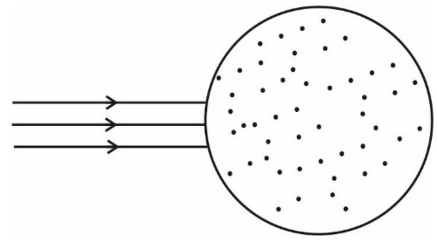
$$= 2 \times 10^4$$

$$\Rightarrow x = 2$$

9. A parallel beam of light is allowed to fall on a transparent spherical globe of diameter 30 cm and refractive index 1.5. The distance from the centre of the globe at which the beam of light can converge is________ mm.

Answer (225)

Sol.



1st refraction: $\frac{1.5}{v_1} - 0 = \frac{0.5}{15}$

$$\Rightarrow v_1 = 45 \text{ cm}$$

2nd refraction: $\frac{1}{v_2} - \frac{1.5}{15} = \frac{-0.5}{-15}$

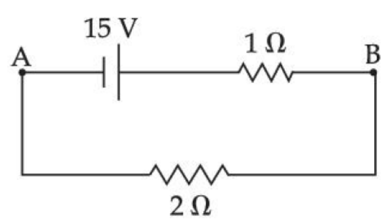
$$\Rightarrow \frac{1}{v_2} = \frac{1}{30} + \frac{1}{10}$$

$$= \frac{4}{30}$$

$$\Rightarrow v_2 = +7.5 \text{ cm}$$

$\Rightarrow$ Distance from centre = 22.5 cm

10. For the network shown below, the value of $V_B - V_A$ is ________ V.



Answer (10)

Sol. $V_B - V_A = i \times 2$

$$= \frac{15}{1+2} \times 2$$

$$\Rightarrow V_B - V_A = 10 \text{ volts}$$