31/01/2023
Morning

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Answers & Solutions

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

JEE (Main)-2023 (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:

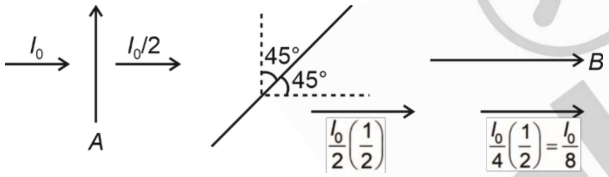
1. Two polaroids *A* and *B* are placed in such a way that the pass-axis of polaroids are perpendicular to each other. Now, another polaroid *C* is placed between *A* and *B* bisecting angle between them. If intensity of unpolarized light is I_0 then intensity of transmitted light after passing through polaroid *B* will be

(1) $\frac{I_0}{8}$ (2) Zero

(3) $\frac{I_0}{4}$ (4) $\frac{I_0}{2}$

Answer (1)

Sol.



2. A bar magnet with a magnetic moment 5.0 Am^2 is placed in parallel position relative to a magnetic field of 0.4 T. The amount of required work done in turning the magnet from parallel to antiparallel position relative to the field direction is

(1) Zero (2) 1 J

(3) 4 J (4) 2 J

Answer (3)

Sol. $W = -MB(\cos\theta_2 - \cos\theta_1)$

$= -0.4 \times 5[\cos 180° - \cos 0]$

$= 4$ J

3. The maximum potential energy of a block executing simple harmonic motion is 25 J. *A* is amplitude of oscillation. At $\frac{A}{2}$, the kinetic energy of the block is

(1) 18.75 J (2) 12.5 J

(3) 37.5 J (4) 9.75 J

Answer (1)

Sol. $E_{Total} = U_{max} = 25$ J

$K.E_{A/2} + U_{A/2} = 25$

$$K.E_{A/2} + \left(\frac{1}{2}KA^2\right)\frac{1}{4} = 25$$

$$K.E_{A/2} = 25\left[1 - \frac{1}{4}\right]$$

$$= \frac{3}{4} \times 25 = \frac{75}{4} \text{ J}$$

$= 18.75$ J

4. A rod with circular cross-section area 2 cm^2 and length 40 cm is wound uniformly with 400 turns of an insulated wire. If a current of 0.4 A flows in the wire windings, the total magnetic flux produced inside windings is $4\pi \times 10^{-6}$ Wb. The relative permeability of the rod is

(Given: Permeability of vacuum $\mu_0 = 4\pi \times 10^{-7}$ N A^{-2})

(1) 125 (2) $\frac{32}{5}$

(3) 12.5 (4) $\frac{5}{16}$

Answer (4)

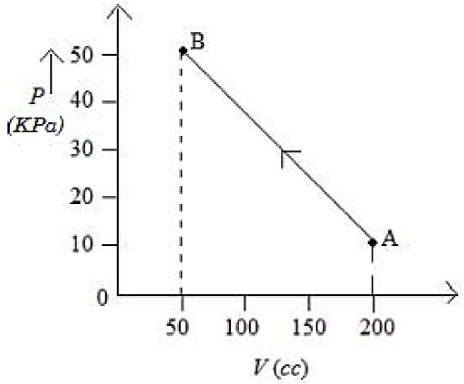
Sol. $\phi = NBA$

$(4\pi \times 10^{-6}) = 400[\mu_r\mu_0 ni](2 \times 10^{-4})$

$$(4\pi \times 10^{-6}) = 400\left[\mu_r \times 4\pi \times 10^{-7} \times \frac{400}{0.4} \times 0.4\right] \times 2 \times 10^{-4}$$

$$\mu_r = \frac{5}{16}$$

5. The pressure of a gas changes linearly with volume from *A* to *B* as shown in figure. If no heat is supplied to or extracted from the gas then change in the internal energy of the gas will be



(1) 4.5 J (2) Zero

(3) 6 J (4) –4.5 J

Answer (1)

Sol. $\because \quad \Delta Q = 0$

$\Delta U = -W$

$$= -\left[-\frac{1}{2}\times(50+10)\times10^{3}\times150\times10^{-6}\right]$$

$= 4.5$ J

6. 100 balls each of mass m moving with speed v simultaneously strike a wall normally and reflected back with same speed, in time t s. The total force exerted by the balls on the wall is

(1) $\frac{200mv}{t}$ (2) $200mvt$

(3) $\frac{mv}{100\ t}$ (4) $\frac{100\ mv}{t}$

Answer (1)

Sol. Total force exerted = $\frac{\Delta P}{\Delta t}$

$$= \frac{100(m)(2v)}{t}$$

$$= \frac{200\ mv}{t}$$

7. The effect of increase in temperature on the number of electrons in conduction band (n_e) and resistance of a semiconductor will be as

(1) Both n_e and resistance decrease

(2) n_e increases, resistance decreases

(3) n_e decreases, resistance increases

(4) Both n_e and resistance increase

Answer (2)

Sol. As temperature increases n_e increases, this results in increase in conductance

$\therefore$ T increases, n_e increases and R decreases

8. A free neutron decays into a proton but a free proton does not decay into neutron. This is because

(1) neutron has larger rest mass than proton

(2) neutron is a composite particle made of a proton and an electron

(3) proton is a charged particle

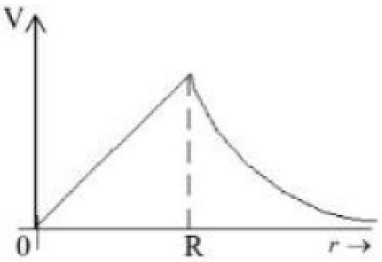
(4) neutron is an uncharged particle

Answer (1)

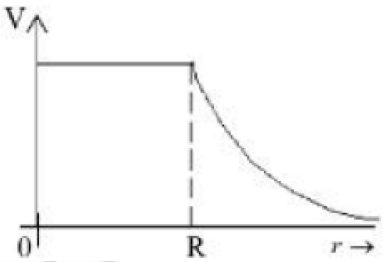
Sol. Rest mass of proton > Rest mass of neutron.

9. Which of the following correctly represents the variation of electric potential(V) of a charged spherical conductor of radius (R) with radial distance (r) from the center?

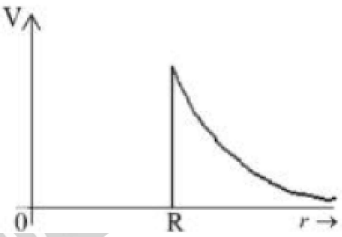
(1)



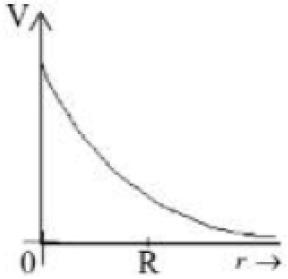
(2)



(3)

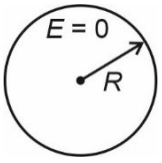


(4)



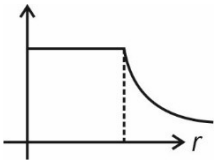
Answer (2)

Sol.



Electric field inside a conductor = 0

Hence V = constant



10. The amplitude of 15 sin (1000π t) is modulated by 10 sin (4π t) signal. The amplitude modulated signal contains frequency(ies) of

A. 500 Hz

B. 2 Hz

C. 250 Hz

D. 498 Hz

E. 502 Hz

Choose the correct answer from the options given below

(1) B only (2) A and B only

(3) A, D and E only (4) A only

Answer (3)

Sol. Frequencies in AM are

$f_c, f_c + f_m, f_c - f_m$

$f_c = 500, f_m = 2$

500, 498 and 502 are present

11. If a source of electromagnetic radiation having power 15kW produces 10^{16} photons per second, the radiation belongs to a part of spectrum is.

(Take Planck constant h = 6 × 10^{-34}Js)

(1) Gamma rays (2) Ultraviolet rays

(3) Micro waves (4) Radio waves

Answer (1)

Sol. huv = 15kW

$$huv = \frac{15\times10^3}{6\times10^{-34}\times10^{16}} = 2.5\times10^{21}\text{ Hz}$$

gamma rays

12. At a certain depth "d" below surface of earth, value of acceleration due to gravity becomes four times that of tis value at a height 3R above earth surface. Where R is Radius of earth (Take R = 6400 km). The depth d is equal to

(1) 4800 km (2) 5260 km

(3) 2560 km (4) 640 km

Answer (1)

Sol. $g_d = \frac{GM}{R^3}(R-d)$ (depth variation)

$g_h = \frac{GM}{(R+h)^2}$ (h above surface)

$g_d = 4\ g_h$

$$\frac{GM}{R^3}(R-d) = 4\frac{GM}{(R+3R)^2}$$

$$R-d = \frac{R}{4}$$

$$d = \frac{3R}{4}$$

d = 4800 km

13. Spherical insulating ball and a spherical metallic ball of same size and mass are dropped from the same height. Choose the correct statement out of the following {Assume negligible air friction}

(1) Time taken by them to reach the earth's surface will be independent of the properties of their materials

(2) Insulating ball will reach the earth's surface earlier than the metal ball

(3) Metal ball will reach the earth's surface earlier than the insulating ball

(4) Both will reach the earth's surface simultaneously.

Answer (2)

Sol. Consider magnetic force of earth, induced eddy current will develop inside the conducting sphere which retards the conducting sphere.

14. The initial speed of a projectile fired from ground is u. At the highest point during its motion, the speed of projectile is $\frac{\sqrt{3}}{2}u$ The time of filight of the projectile is

(1) $\frac{\sqrt{3u}}{g}$ (2) $\frac{u}{g}$

(3) $\frac{2u}{g}$ (4) $\frac{u}{2g}$

Answer (2)

Sol. $u\cos\theta = \frac{\sqrt{3}}{2}u$

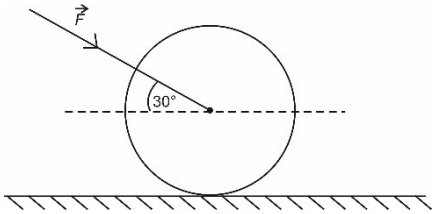
$$\cos\theta = \frac{\sqrt{3}}{2}$$

$$\boxed{\theta = 30^\circ}$$

Time of flight $= \frac{2u\sin\theta}{g} = \left(\frac{u}{g}\right)$

15. As shown in figure, a 70 kg garden roller is pushed with a force of $\vec{F} = 200$ N at an angle of 30° with horizontal. The normal reaction on the roller is

(Given g = 10 m s^{-2})



(1) 600 N

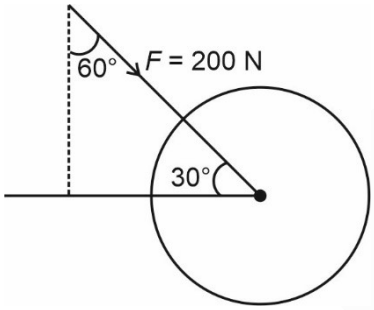
(2) 800 N

(3) $200\sqrt{3}$ N

(4) $800\sqrt{2}$ N

Answer (2)

Sol.



Normal reaction = 70 g + $F\cos 60$

= 700 + 100

= 800 N

16. If 1000 droplets of water of surface tension 0.07 N/m, having same radius 1 mm each, combine to from a single drop. In the process the released surface energy is-

$\left(\text{Take } \pi = \frac{22}{7}\right)$

(1) 7.92 × 10^{-6} J

(2) 7.92 × 10^{-4} J

(3) 9.68 × 10^{-4} J

(4) 8.8 × 10^{-5} J

Answer (2)

Sol. Radius of bigger drop = $10r = R$

(r = radius of smaller droplet)

$\Delta E = 1000 \times 4\pi r^2 \times T - 4\pi R^2 T$

$= 4\pi T\,[1000 \times r^2 - 100r^2]$

$= 3600\ \pi r^2 T$

$= 3600 \times \frac{22}{7} \times 1 \times 10^{-6} \times \frac{7}{100}$

$= 22 \times 36 \times 10^{-6}$

$= 792 \times 10^{-6}$ J

$= 7.92 \times 10^{-4}$ J

17. The drift velocity of electrons for a conductor connected in an electrical circuit is V_d. The conductor in now replaced by another conductor with same material and same length but double the area of cross section. The applied voltage remains same. The new drift velocity of electrons will be

(1) V_d

(2) $2V_d$

(3) $\frac{V_d}{4}$

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

Answer (1)

Sol. $i = nAV_d e$

$i_1 = \left(\frac{V}{R}\right)$

$i_2 = \left(\frac{2V}{R}\right)$

So, $\frac{i_1}{i_2} = \frac{1}{2} = \frac{(AV_d)_1}{(AV_d)_2} = \frac{V_d}{(V_d)_2} \times \left(\frac{1}{2}\right)$

$\frac{1}{2} \times \frac{V_d}{(V_d)_2} = \frac{1}{2}$

$\Rightarrow (V_d)_2 = V_d$

18. If R, X_L and X_C represent resistance, inductive reactance and capacitive reactance. Then which of the following is dimensionless

(1) $R\frac{X_L}{X_C}$ (2) $R\,X_L\,X_C$

(3) $\frac{R}{\sqrt{X_L X_C}}$ (4) $\frac{R}{X_L X_C}$

Answer (3)

Sol. R = Resistance

$[X_L] = [R]$

$[X_C] = [R]$

So, $\frac{R}{\sqrt{X_L X_C}}$ is dimensionless.

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

Assertion A : The beam of electrons show wave nature and exhibit interference and diffraction.

Reason R : Davisson Germer Experimentally verified the wave nature of electrons.

In the light of the above statements, choose the ***most appropriate*** answer from the options given below:

(1) A is not correct but R is correct

(2) Both A and R are correct and R is the correct explanation of A

(3) Both A and R are correct but R is not the correct explanation of A

(4) A is correct but R is not correct

Answer (2)

Sol. Beam of electrons show wave nature and exhibit interference and diffraction as shown by Davisson Germer experiment.

20. The correct relation between $\gamma = \frac{C_p}{C_v}$ and temperature T is

(1) $\gamma \alpha T^{\circ}$

(2) $\gamma \alpha \frac{1}{\sqrt{T}}$

(3) $\gamma \alpha \frac{1}{T}$

(4) $\gamma \alpha T$

Answer (1)

Sol. $\gamma = \frac{C_P}{C_V}$

At low temperature (T), γ is independent of T.

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.

21. In a medium the speed of light wave decreases to 0.2 times to its speed in free space. The ratio of relative permittivity to the refractive index of the medium is x : 1. The value of x is _____.

(Given speed of light in free space =3 × 10^8 ms^{-1} and for the given medium $\mu_1 = 1$)

Answer (5)

Sol. We know that $v = \frac{c}{n} = \frac{c}{\sqrt{\varepsilon_r}}$

Putting the values:

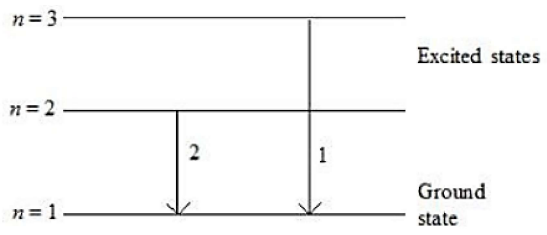
$0.2c = \frac{c}{\sqrt{\varepsilon_r}}$

$\Rightarrow \sqrt{\varepsilon_r} = 5$

$\Rightarrow$ Required ratio $= \frac{\varepsilon_r}{n} = \frac{\varepsilon_r}{\sqrt{\varepsilon_r}} = \sqrt{\varepsilon_r} = 5$

$\Rightarrow$ x = 5

22. For hydrogen atom, λ_1 and λ_2 are the wavelengths corresponding to the transitions 1 and 2 respectively as shown in figure. The ratio of λ_1 and λ_2 is $\frac{x}{32}$. The value of x is _____.



Answer (27)

Sol. $\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$\Rightarrow \frac{1}{\lambda_1} = R\left[1 - \frac{1}{9}\right]$

& $\frac{1}{\lambda_2} = R\left[1 - \frac{1}{4}\right]$

$\Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{R \cdot \frac{3}{4}}{R \cdot \frac{8}{9}} = \frac{27}{32}$

$\Rightarrow x = 27$

23. The speed of a swimmer is 4 km h^{-1} in still water. If the swimmer makes his strokes normal to the flow of river of width 1 km, he reaches a point 750 m down the stream on the opposite bank.

The speed of the river water is _____ km h^{-1}

Answer (3)

Sol. Let speed of river water = v_0

$\Rightarrow$ drift $= v_0 \times \Delta t$ ...(1)

& $\Delta t = \frac{1}{4}h$ ...(2)

$\Rightarrow 0.75 = v_0 \times \frac{1}{4}$

$\Rightarrow v_0 = 3$ km/hr

24. Two identical cells, when connected either in parallel or in series gives same current in an external resistance 5 Ω. The internal resistance of each cell will be _____ Ω.

Answer (5)

Sol. $\varepsilon_{series} = \varepsilon_1 + \varepsilon_2 = 2\varepsilon$

$r_{series} = r_1 + r_2 = 2r$

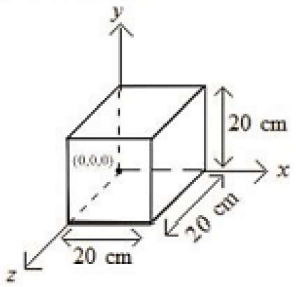
$\varepsilon_{parallel} = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \varepsilon$

& $r_{parallel} = \frac{r}{2}$

$\Rightarrow \frac{2\varepsilon}{2r + 5} = \frac{\varepsilon}{\frac{r}{2} + 5}$

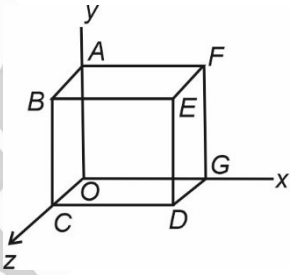
$\Rightarrow r + 10 = 2r + 5 \Rightarrow r = 5\ \Omega$

25. Expression for an electric field is given by $\vec{E} = 4000x^2\hat{i}\frac{V}{m}$. The electric flux through the cube of side 20 cm when placed in electric field (as shown in the figure) is _____ V cm.



Answer (640)

Sol. The flux will be only from *DEFG* surface as on the surface *OABC* field is 0 and for rest of the surface, area vector is perpendicular to field.



So $\phi = EA$

$= 4000 \times (\cdot 2)^2 \times \cdot 2 \times \cdot 2$

$= \frac{32}{5}$ Vm

$= \frac{32}{5} \times 100$ V cm

= 640 V cm

26. An inductor of 0.5 mH, a capacitor of 20 μF and resistance of 20 Ω are connected in series with a 220 V ac source. If the current is in phase with the emf, the amplitude of current of the circuit is $\sqrt{x}$ A. The value of x is

Answer (242)

Sol. As the current is in lase with emf the circuit is in resonance so

$i_{rms} = \frac{V_{rms}}{R} = \frac{220}{20} = 11$ A

as $i_0 = \sqrt{2}i_{rms} = \sqrt{2} \times 11 = \sqrt{242}$

27. A lift of mass M = 500 kg is descending with speed of 2 ms^{-1}. Its supporting cable begins to slip thus allowing it to fall with a constant acceleration of 2 ms^{-2}. The kinetic energy of the lift at the end of fall through to a distance of 6 m will be _____ kJ.

Answer (7)

Sol. u = 2m/s

a = 2m/s^2

s = 6m

v = ?

$v^2 = u^2 + 2as$

$v^2 = 4 + 2 \times 2 \times 6$

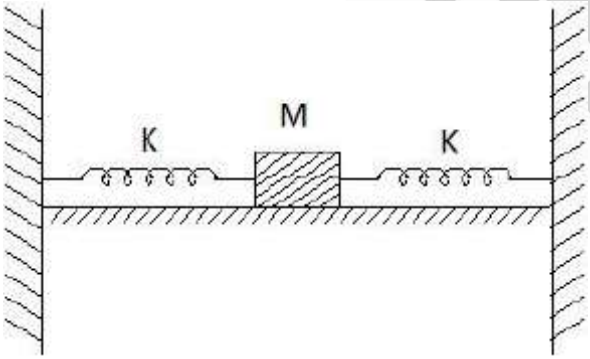
$= 28$

So $KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 500 \times 28\,J$

= 7000 J

= 7 kJ

28. In the figure given below, a block of mass M = 490 g placed on a frictionless table is connected with two springs having same spring constant (K = 2 N m^{-1}). If the block is horizontally displaced through 'X' m then the number of complete oscillations it will make in 14π seconds will be _____.



Answer (20)

Sol. $k_{net} = k_1 + k_2 = 4$ N/m

$T = 2\pi\sqrt{\frac{m}{k_{net}}} = 2\pi\sqrt{\frac{0.49}{4}}$

$= \frac{2\pi \times .7}{2}$

$= \frac{7\pi}{10}$

So number of oscillation completed.

$n = \frac{t}{T} = \frac{14\pi}{7\pi/10} = 20$

29. A solid sphere of mass 1 kg rolls without slipping on a plane surface. Its kinetic energy is 7×10^{-3} J. The speed of the centre of mass of the sphere is _____ cm s^{-1}.

Answer (10)

Sol. $K = \frac{1}{2}mv_{cm}^2 + \frac{1}{2}\frac{2}{5}mR^2\frac{v_{cm}^2}{R^2}$

$7 \times 10^{-3} = \frac{7}{10} \times 1 \times v_{cm}^2$

v_{cm} = 0.1 m/sec

= 10 cm/sec

30. A thin rod having a length of 1 m and area of cross-section 3×10^{-6} m^2 is suspended vertically from one end. The rod is cooled from 210°C to 160°C. After cooling, a mass M is attached at the lower end of the rod such that the length of rod again becomes 1 m. Young's modulus and coefficient of linear expansion of the rod are 2×10^{11} N m^{-2} and 2×10^{-5} K^{-1}, respectively. The value of M is _____ kg. (Take g = 10 m s^{-2})

Answer (60)

Sol. Stress $= \frac{T}{AY} = \frac{\Delta l}{l}$

and $\Delta l = l\alpha\Delta T$

or $\frac{\Delta l}{l} = \alpha\Delta T$

so $\frac{T}{AY} = \alpha\Delta T$

$\frac{M \times 10}{2 \times 10^{11} \times 3 \times 10^{-6}} = 2 \times 10^{-5} \times 50$

$M = \frac{2 \times 10^{-5} \times 50 \times 3 \times 10^{-6} \times 2 \times 10^{11}}{10}$

= 60 kg