06/04/2023
Morning

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Memory Based
Answers & Solutions

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

JEE (Main)-2023 (Online) Phase-2

(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. Kinetic energy of electron, proton and α-particle is given as k, $2k$ and $4k$ respectively then which of the following gives the correct order of de-Broglie wavelength of electron, proton and α-particle?

(1) $\lambda_p > \lambda_\alpha > \lambda_e$ (2) $\lambda_\alpha > \lambda_p > \lambda_e$

(3) $\lambda_e > \lambda_p > \lambda_\alpha$ (4) $\lambda_e > \lambda_\alpha > \lambda_p$

Answer (3)

Sol. $\lambda = \dfrac{h}{\sqrt{2m\,K\cdot E\cdot}}$

$\Rightarrow \lambda_e : \lambda_p : \lambda_\alpha = \dfrac{1}{\sqrt{m_e}} : \dfrac{1}{\sqrt{2m_p}} : \dfrac{1}{\sqrt{16m_p}}$

$\Rightarrow \lambda_e > \lambda_p > \lambda_\alpha$

2. If the height of a tower used for LOS communication is increased by 21%. The percentage change in range is

(1) 5% (2) 10%

(3) 15% (4) 12%

Answer (2)

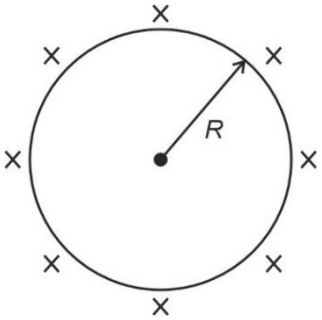
Sol. New range is $\sqrt{2R(h+0.21h)}$

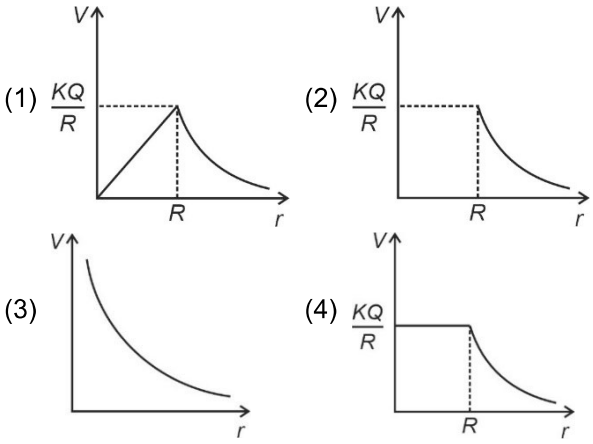
$= \sqrt{2R(1.21)h}$

$= 1.1\sqrt{2Rh}$

% increase in range = 10%

3. Pick the correct graph between potential V at distance r from centre for the uniformly charged spherical shell of radius R.



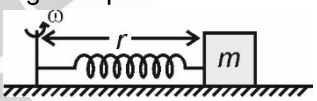


Answer (4)

Sol. $V = \dfrac{KQ}{R}$ for $r \le R$

$V = \dfrac{KQ}{r}$ for $r > R$

4. A block of mass m is connected to one end of a spring and kept on a smooth surface. The other end of the spring is connected to fixed shaft rotating with constant angular speed ω. Find tension in spring.

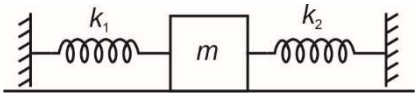


(1) $\dfrac{m\omega^2 r}{2}$ (2) $2m\omega^2 r$

(3) $m\omega^2 r$ (4) $\dfrac{3}{2} m\omega^2 r$

Answer (3)

Sol. $T = m\omega^2 r$

5. 

For the oscillations exhibited by the spring block system, on smooth surface, along the springs, the time period is equal to

(1) $2\pi\sqrt{\dfrac{m(k_1+k_2)}{k_1k_2}}$ (2) $2\pi\sqrt{\dfrac{m(k_1+k_2)}{2k_1k_2}}$

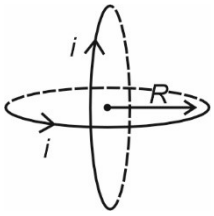
(3) $2\pi\sqrt{\dfrac{m}{k_1+k_2}}$ (4) $\pi\sqrt{\dfrac{m}{k_1+k_2}}$

Answer (3)

Sol. Both springs can be considered equivalent to a parallel combination of springs

$\Rightarrow k_{eq} = k_1 + k_2$

$\Rightarrow T = 2\pi\sqrt{\dfrac{m}{k_1+k_2}}$

6. 

Two identical current carrying coils with same centre are placed with their planes perpendicular to each other as shown.

If $i = \sqrt{2}A$ and radius of coils is R = 1 m then magnetic field at centre C is equal to

(1) μ_0 (2) $\frac{\mu_0}{2}$

(3) $2\mu_0$ (4) $\sqrt{2}\,\mu_0$

Answer (1)

Sol. $i = \sqrt{2}A$

$B_{net} = \sqrt{B_1^2 + B_2^2}$

$= \sqrt{\left(\frac{\mu_0 i}{2R}\right)^2 + \left(\frac{\mu_0 i}{2R}\right)^2}$

$= \mu_0$

7. A ball of mass m and radius r and density ρ is dropped in a liquid of density ρ_0. After moving for some time, the speed of the ball becomes constant, equal to v_0. The coefficient of viscosity of the liquid is

(1) $\frac{mg}{6\pi r v_0}\left(1-\frac{\rho_0}{\rho}\right)$ (2) $\frac{mg}{6\pi r v_0}\left(1+\frac{\rho_0}{\rho}\right)$

(3) $\frac{mg}{3\pi r v_0}\left(1+\frac{\rho_0}{\rho_0}\right)$ (4) $\frac{mg}{3\pi r v_0}\left(1-\frac{\rho_0}{\rho}\right)$

Answer (1)

Sol. $6\pi\eta r v_0 = v\rho g - v\rho_0 g$

$= vg(\rho - \rho_0)$

$= \frac{m}{\rho} g(\rho - \rho_0)$

$\therefore \quad \eta = \frac{mg}{6\pi r v_0}\left(1-\frac{\rho_0}{\rho}\right)$

8. **Assertion (A):** Earth has atmosphere and moon doesn't.

Reason (R): Escape speed on moon is less than that of earth.

(1) (A) and (R) are correct and (R) is the correct explanation of (A)

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

(3) (A) is true, but (R) is false

(4) (A) and (R), both are false

Answer (1)

Sol. Both (A) and (R), are true and escape speed on moon is less due to its small radius and acceleration due to gravity as compared to earth.

9. The amount of heat supplied to a gas in a system is equal to 1000 J, the system in return does 200 J of work on the surrounding. Find charge in internal energy of the gas.

(1) 800 J (2) 1200 J

(3) 1000 J (4) 1100 J

Answer (1)

Sol. Using first law of thermodynamics

$\Delta Q = \Delta U + W$

$\Delta U = 1000 - 200$

$= 800$ J

10. On a planet ρ (mass density) is same as that of earth while mass of planet is twice than that of earth. Ratio of weight of a body on surface of planet to that on earth is equal to

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

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

Answer (2)

Sol. $\frac{g_p}{g_e} = \frac{GM_p/R_p^2}{GM_e/R_e^2} = \frac{\left(M_p/\rho_p^2\right)^{1/3}}{\left(M_e/\rho_e^2\right)^{1/3}}$

$= \left(M_p/M_e\right)^{1/3}$

$= (2)^{1/3}$

11. **Assertion (A):** Range of a horizontal projectile is maximum when angle of projection is $\theta = 45°$.

Reason (R): Range is maximum when $\sin(2\theta) = 1$.

(1) (A) and (R) both are true and (R) is correct explanation of (A)

(2) (A) and (R) both are true but (R) is not correct explanation of (A)

(3) (A) is true and (R) is false

(4) Both (A) and (R) are false

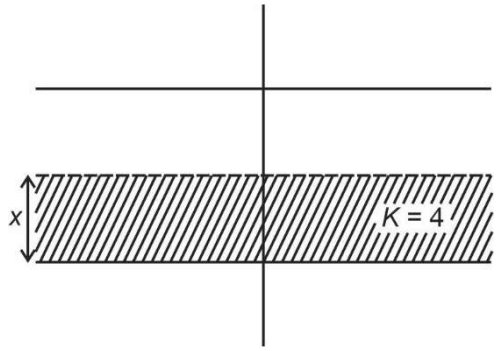
Answer (1)

Sol. $R = \frac{u^2 \sin 2\theta}{g}$

$\Rightarrow$ For R_{max}, $\sin(2\theta) = 1$

$\Rightarrow \quad \theta = 45°$

12. The capacitance of capacitor can be varied by filling dielectric constant $K = 4$ as shown in figure. As x varies, the capacitance changes. For $x = \frac{d}{3}$, the equivalent capacitance is G and for $x = \frac{2d}{3}$, the equivalent capacitance is 2 μF. Find the value of C_1 in μF



(1) 4 (2) 3

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

Answer (3)

Sol. $C_2 = \frac{\frac{3\varepsilon_0 A}{d} \times \frac{4\varepsilon_0 A \times 3}{2d}}{\frac{3\varepsilon_0 A}{d} + \frac{6\varepsilon_0 A}{d}}$

$= \frac{\varepsilon_0 A}{d}\left(\frac{3 \times 6}{9}\right)$

$= \left(\frac{2\varepsilon_0 A}{d}\right) = 2\ \mu F$

$C_1 = \frac{\frac{3\varepsilon_0 A}{2d} \times \frac{3 \times 4\varepsilon_0 A}{d}}{\frac{3\varepsilon_0 A}{2d} + \frac{12\varepsilon_0 A}{d}}$

$= \frac{\varepsilon_0 A}{d}\frac{\left(\frac{3}{2} \times 12\right)}{\left(\frac{3}{2} + 12\right)}$

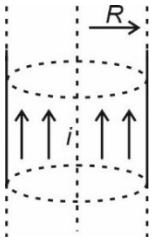
$= \frac{\varepsilon_0 A}{d} \times \frac{18 \times 2}{27}$

$= \frac{12}{9}\left(\frac{\varepsilon_0 A}{d}\right)$

$= \left(\frac{12}{9}\right)\mu F$

$= \left(\frac{4}{3}\right)\mu F$

13. The given figure shows a long cylindrical shell having current I flowing uniformly along the wall. The graph showing the variation of magnetic field (B) with the perpendicular distance(r) from the axis of the shell is



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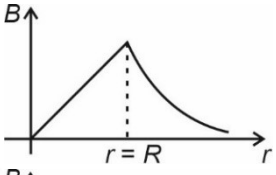

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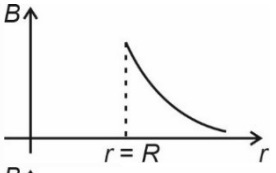

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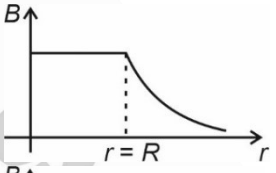

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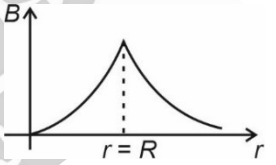


Answer (2)

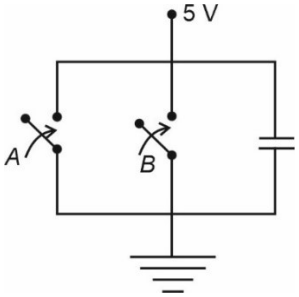
Sol. Using Ampere's circuital law

$B_{inside} = 0$

$B_{outside} = \frac{\mu \cdot i}{2\pi r}$

$\therefore \quad B_{outside} \propto \frac{1}{r}$

14. Which of the following logic gate is correct according to given circuit?



(1) OR gate (2) NAND gate

(3) AND gate (4) NOR gate

Answer (1)

Sol. Output = $A + B \Rightarrow OR$ gate

15. Find the radius of the orbit corresponding to the 4th excited state in Li^{++}. (a_0 is the radius of first orbit in H-atom)

(1) $\frac{25}{3}a_0$

(2) $\frac{16}{3}a_0$

(3) $25a_0$

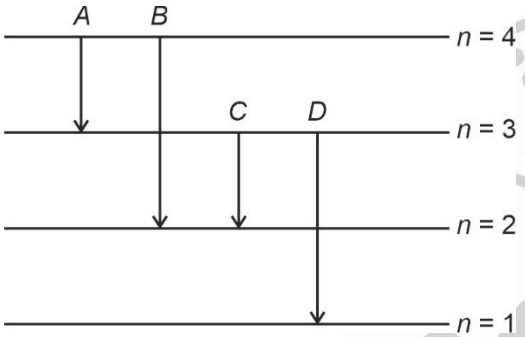
(4) $12a_0$

Answer (1)

Sol. $r_n = \frac{a_0 n^2}{z}$

$= a_0\left(\frac{25}{3}\right)$

16. In the given diagram, different type of transition of is named as *A*, *B*, *C* and *D*, then which transition emits shortest wavelength.



(1) A (2) B

(3) C (4) D

Answer (D)

Sol. For particular atom

$\lambda \propto \frac{1}{\Delta E}$

$\Delta E \propto \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For A $\Delta E \propto \left(\frac{1}{9} - \frac{1}{16}\right) = -K\left(\frac{7}{144}\right) \approx K \times 0.486$

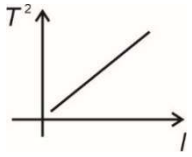
For B $\Delta E \propto \left(\frac{1}{4} - \frac{1}{16}\right) = K\left(\frac{3}{16}\right) \approx K \times 0.1875$

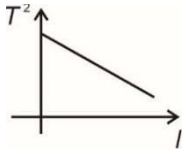
For C, $\Delta E \propto \left(\frac{1}{4} - \frac{1}{9}\right) = K\left(\frac{5}{36}\right) \approx K \times 0.1388$

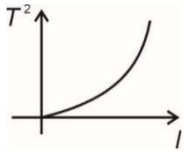
For D, $\Delta E \propto \left(1 - \frac{1}{4}\right) = K\frac{3}{4} \approx K \times 0.75$

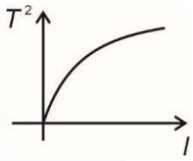
So, for D, ΔE is high, so λ_D is shortest.

17. During simple harmonic motion of a pendulum, the square of time period (T^2) can be plotted against length of pendulum (l) by

(1) 

(2) 

(3) 

(4) 

Answer (1)

Sol. $T = 2\pi\sqrt{\frac{l}{g}}$

$\boxed{T^2 \propto l}$

18. In an EM wave ratio of average electric field and magnetic field energy density in a region of wave is equal to

(1) $\frac{2\varepsilon_0}{\mu_0 C^2}$

(2) $\frac{C^2\varepsilon_0}{\mu_0}$

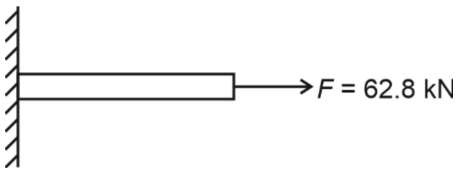
(3) 1 : 1

(4) $\frac{\varepsilon_0}{2\mu_0 C^2}$

Answer (3)

Sol. Average energy density contained with electric and magnetic field component of an EM wave remains same.

19. A rod is fixed at one end and other end is pulled with force F = 62.8 kN, Young's modulus of rod is 2×10^{11} N/m^2. If the radius of cross-section of rod is 20 mm the strain produced in rod is



(1) 2.5×10^{-3} (2) 2.5×10^{-4}

(3) 2×10^{-3} (4) 2×10^{-4}

Answer (2)

Sol. $\text{Strain} = \left(\frac{F}{AY}\right) = \frac{62.8 \times 10^3}{3.14 \times (0.02)^2 \times 2 \times 10^{11}} = 2.5 \times 10^{-4}$

20. A ray undergoes refraction at boundary of a medium such that incident angle is 45° while refraction angel is 30°. Wavelength and frequency of incident ray are λ_1 and ν_1 while for refracted ray are λ_2 and ν_2, then

(1) $\lambda_1 = \lambda_2,\ \nu_1 = \frac{\nu_2}{\sqrt{2}}$ (2) $\lambda_1 = \lambda_2,\ \nu_2 = 2\nu_1$

(3) $\lambda_1 = \sqrt{2}\lambda_2,\ \nu_1 = \nu_2$ (4) $\lambda_1 = \frac{\lambda_2}{\sqrt{2}},\ \nu_1 = \nu_2$

Answer (3)

Sol. $i = 45°,\ r = 30°$

$\mu = \sqrt{2}$

$\Rightarrow C_2 = \frac{C}{\sqrt{2}}$

$\Rightarrow \lambda_2 = \frac{\lambda_1}{\sqrt{2}}$

and $\nu_1 = \nu_2$

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. A block of mass 100 gm is placed on smooth surface, moves with acceleration of $a = 2x$, then the change is kinetic energy can be given as $\left(\frac{x^n}{10}\right)$.

Find the value of n

Answer (2)

Sol. $\frac{v\,dv}{dx} = 2x$

$\int v\,dv = \int 2x\,dx$

$\Rightarrow \frac{1}{2}\left(v_f^2 - v_i^2\right) = x^2$

$\Rightarrow \frac{1}{2}m\left(v_f^2 - v_i^2\right) = mx^2$

$\Delta k = \left(0.1x^2\right) = \left(\frac{x^2}{10}\right)$

22. A car is moving with speed of 15 m/s towards a stationary wall. A person in the car press the horn and experience the change in frequency of 40 Hz due to reflection from stationary wall. Find the frequency of horn.

(Use v_{sound} = 330 m/s)

Answer (420 Hz)

Sol.

$f' = \left(\frac{c+v}{c-v}\right) f_0$

$\frac{f'}{f_0} = \left(\frac{c+v}{c-v}\right) = \frac{1+\left(\frac{v}{c}\right)}{1-\left(\frac{v}{c}\right)} = \frac{345}{315}$

$\Rightarrow \frac{f'}{f_0} - 1 = \frac{345}{315} - 1 = \frac{30}{315}$

$\Rightarrow \frac{f' - f_0}{f_0} = \frac{30}{315}$

$\Rightarrow \frac{40 \times 315}{30} = f_0$

$f_0 = (4 \times 105)$

$= 420$ Hz

23. If the length of a conductor is increases by 20 percent and cross-sectional area is decreased by 4 percent, then calculate the percentage change in resistance of a conductor.

Answer (25.00)

Sol. $R = \left(\frac{\rho l}{A}\right)$

$R' = \frac{\rho l'}{A'} \Rightarrow l' = 1.2l$

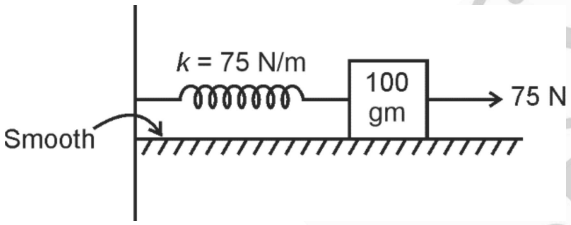
$A' = 0.96A$

$R' = \frac{\rho \times 1.2l}{0.96A} = \frac{10}{8}\left(\frac{\rho l}{A}\right)$

$\frac{R' - R}{R} = \left(\frac{1}{4}\right)$

$\Rightarrow$ 25 percent

24.



At equilibrium position a 75 N force starts acting on the block attach with the spring as shown. Maximum extension in spring in meter is

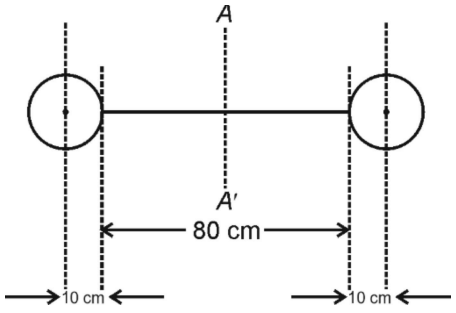
Answer (2)

Sol. $\Delta l_{max} = \frac{2F}{k}$

$= \frac{2 \times 75}{75}$

= 2 m

25.



Two solid spheres of mass $m = \frac{1}{2}$ kg each are connected at the ends of a light rod as shown in the figure. The assembly rotates about axis AA'. Then moment of inertia of the assembly is equal to $\frac{x}{5}$ kgm^2 value of x is equal to

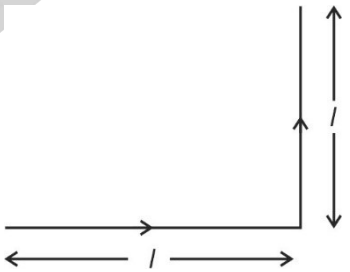
Answer (01.27)

Sol. $MI = \left[\left(\frac{2}{5}Mr^2\right) + \left(MR^2\right)\right] \times 2$

$= \left[\frac{2}{5} \times \frac{1}{2} \times (0.1)^2 + \frac{1}{2} \times (0.5)^2\right] \times 2$

$= \frac{0.02}{5} + \frac{1.25}{5}$

26. The path of an object moving with constant speed is shown in figure. The ratio of magnitude of average velocity to instantaneous speed is equal to $\sqrt{x}$ find x.



Answer (2)

Sol. |Average velocity| = $\sqrt{2}v$

Instantaneous speed = v

27.

28.

29.

30.