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BEWARE OF NEGATIVE MARKING

PART-1 : PHYSICS

SECTION-I (i) : (Maximum Marks: 24)

- This section contains **SIX (06)** questions.
- Each question has **FOUR** options. **ONE OR MORE THAN ONE** of these four option(s) is (are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s)
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks	:	+4	If only (all) the correct option(s) is (are) chosen.
Zero Marks	:	0	If none of the options is chosen (i.e. the question is unanswered).
Negative Marks	:	–1	In all other cases.

1. Two particle A and B executing SHM along same straight line with same amplitude and same mean position. A starts its motion form mean position and moves towards positive extreme while B starts from negative extreme position. Angular frequency of A is ω_A and that of B is ω_B choose the correct statement.

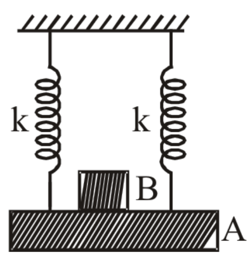
(A) If $\omega_B = 2\omega_A$, then when they first meet their velocity is zero.

(B) If $\omega_B > 2\omega_A$, then when they first meet their velocities are in same direction.

(C) If $\omega_B < 2\omega_A$, then when they first meet their velocities are in opposite direction.

(D) When they first meet their velocity direction doesn't depend on ω.

2. In the figure shown a block A of mass m is rigidly attached with two light springs each of stiffness k and suspended from a fixed support. Another block B of same mass is just placed on it and blocks are in equilibrium. Suddenly the block B is removed. Choose the **CORRECT** option(s) afterward.



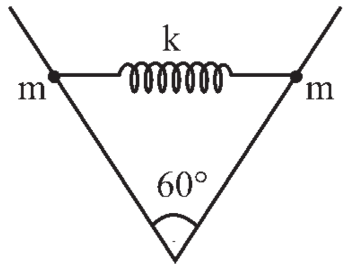
(A) Block A will perform simple harmonic motion

(B) Amplitude of oscillation of the block A is $\frac{mg}{2k}$

(C) Maximum speed acquired by the block A is $\sqrt{\frac{mg^2}{2k}}$

(D) Period of oscillation is $2\pi\sqrt{\frac{m}{k}}$

3. Figure shows two beads, each of mass M, constrained to move along two fixed rods, placed horizontally, making an angle 60° with each other. The spring constant is k. Now beads are disturbed slightly and symmetrically so that spring maintains equal angle with the two rods. (ignore gravity and friction any where). :-



(A) Time spend under compressed state of spring is less than time spent under elongated state of spring.

(B) Time spend under compresses state of spring is same as time spent under elongated state of spring.

(C) Angular frequency of motion = $\sqrt{\frac{k}{2m}}$

(D) Angular frequency of motion = $\sqrt{\frac{2k}{m}}$

4. A nucleus has a radius of 7.2×10^{-15} m. When an α-decay takes place from this nucleus, ratio of number of neutrons and number of protons in the daughter nucleus becomes $\frac{65}{41}$:-

(A) Parent nucleus is $_{84}Po$.

(B) Daughter nucleus is $_{82}Pb$.

(C) Mass number of daughter nucleus is 216.

(D) Mass number of parent nucleus is 216.

5. Three radioactive elements A, B and C respectively show α-decay, β–decay and k–capture. Their half half lives are T_A, T_B and T_C respectively. If their temperatures are increased simultaneously (from room temperature upto 10^{12}K) :-

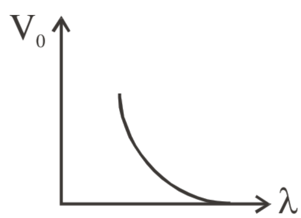
(A) T_A, T_B or T_C (anyone or more) may change during heating.

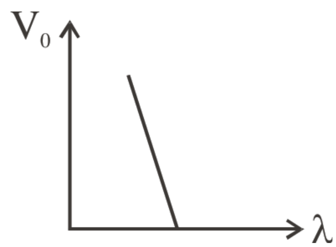
(B) T_A will be the first one to change

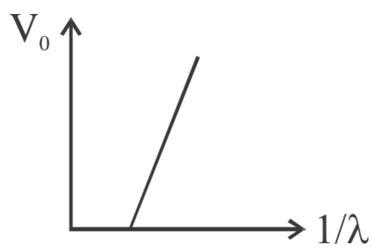
(C) T_B will be the first one to change

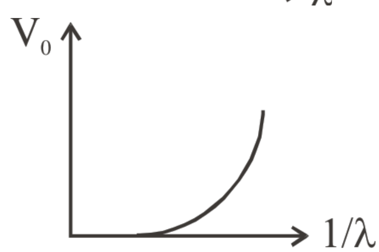
(D) T_C will be the first one to change

6. For photoelectric effect with incident photon wavelength λ, the stopping potential is V_0. Identify the correct variation (s) of V_0 with λ and $\frac{1}{\lambda}$.

(A) 

(B) 

(C) 

(D) 

SECTION-I (ii) : (Maximum Marks: 16)

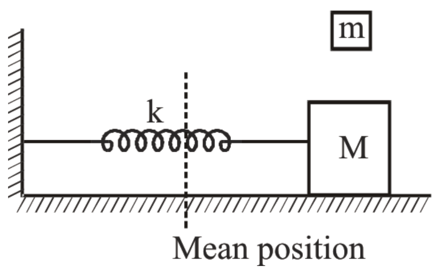
- This section contains **FOUR (04)** questions.
- This section contains **TWO** paragraphs.
- Based on each paragraph, there are **TWO** questions
- Each question has Four options (A), (B), (C) and (D) **ONE OR MORE THAN ONE** of these four option(s) is(are) correct.
- For each question, choose the option(s) corresponding to (all) the correct answer(s)
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 If only (all) the correct option(s) is (are) chosen.
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered).
Negative Marks : –1 In all other cases.

Paragraph for Questions 7 and 8

A horizontal spring block system executes SHM ($x = A \sin(\omega t + \phi)$) with amplitude $A = 10$ cm initial phase $\phi = 0$ and angular frequency ω. The mass of block is $M = 25$ kg and there is no friction between the block and the horizontal surface. The spring constant is 2500 N/m.

At $t = t_1$ sec [for which $\omega t_1 = \phi_1 = 30°$], a mass $m = 75$ kg is gently put on the block. [Assume that collision between the block and the mass is perfectly inelastic and mass m remains stationary w.r.t. the block M always].



Read above passage carefully and answer the following questions.

7. The total energy of system after collision at any moment of time is

(A) $\frac{175}{32}$ Joule (B) $\frac{88}{15}$ Joule

(C) $\frac{96}{25}$ Joule (D) None of these

8. The new amplitude of the system will be

(A) $\frac{\sqrt{7}}{40}$ m (B) $\frac{\sqrt{3}}{40}$ m

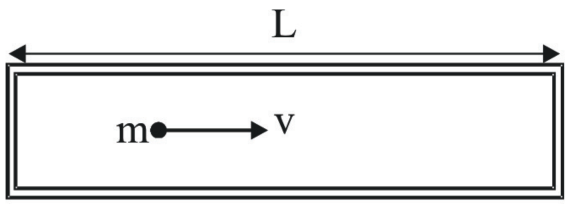
(C) $\frac{\sqrt{5}}{40}$ m (D) None of these

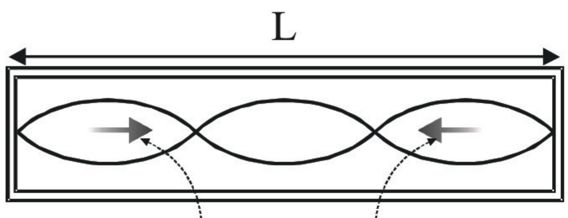
Paragraph for Questions 9 and 10

While conducting his doctoral research in theoretical physics and with no experimental evidence to go on, de Broglie reasoned by analogy with Einstein's equation E = hf and with some of the ideas of his theory of relativity. The details need not concern us, but they led de Broglie to postulate that if a material particle of momentum p = mv has a wave-like nature, then its wavelength must be given by

$\lambda = \frac{h}{p} = \frac{h}{mv}$ where h is Planck's constant. This is called the de-Broglie wavelength.

de-Broglie considered a matter wave to be a traveling wave. But suppose that a "particle" of matter is confined to a small region of space and cannot travel. How do the wave-like properties manifest themselves? This is the problem of "a particle in a box." Figure shows a particle of mass m moving in one dimension as it bounces back and forth with speed v between the ends of a box of length L. We'll call this a one-dimensional box; its width isn't relevant. A particle in a box creates a standing de Broglie wave as it reflects back and forth.





Matter waves travel in both directions.

9. What should be de-Broglie wavelength of confined particle in the box [here $n \in N$]

(A) $\frac{L}{2n}$

(B) $\frac{2L}{n}$

(C) $\frac{L}{n}$

(D) nL

10. Confined particle's energy is given by

(A) $\frac{n^2h^2}{2mL^2}$

(B) $\frac{2n^2h^2}{mL^2}$

(C) $\frac{n^2h^2}{8mL^2}$

(D) $\frac{n^2h^2}{4mL^2}$

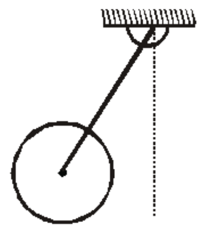
NOTE : NO QUESTION WILL BE ASKED IN SECTION II

SECTION-III : (Maximum Marks: 40)

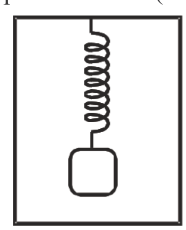
- This section contains **TEN (10)** questions.
- The answer to each question is a **SINGLE DIGIT INTEGER** ranging from 0 to 9, both inclusive.
- For each question, enter the correct integer value of the answer in the place designated to enter the answer.
- For each question, marks will be awarded in one of the following categories :

Full Marks	:	+4	If only the correct answer is given.
Zero Marks	:	0	In all other cases

1. A metal rod of length 1.25 m and mass 'm' is pivoted at one end. A solid sphere of same mass and radius 0.25 m is attached at its center to the free end of the rod and the sphere is free to rotate about its center. The rod-sphere system performs SHM in vertical plane after being released from the same displaced position. Angular frequency of small oscillations is n rad/s. Find the value of n^2.



2. A mass m is resting at equilibrium suspended from a vertical spring of natural length L and spring constant k inside a box as shown. The box begins accelerating upward with acceleration a. Find the maximum speed of the mass (in cm/s) relative to the box in subsequent motion. (Given : a = 1 m/s^2, m = 3kg, k = 1200 N/m)



3. A torsional pendulum is formed by attaching a wire to the center of a meter stick with a mass of 6 kg. If the resulting period is 2 second, what is the torsion constant (in SI unit) for the wire? [Take : $\pi^2 = 10$]

4. A particle of mass 5×10^{-5} kg is placed at the lowest point of a smooth parabola having the equation $20x^2 = y$ (x,y in m). Here y is the vertical height. If it is displaced slightly and it moves such that it is constrained to move along the parabola, the angular frequency of oscillation will be, (in rad/s). If your answer is N fill value N/4. (Consider acceleration due to gravity g = 10 m/s^2)

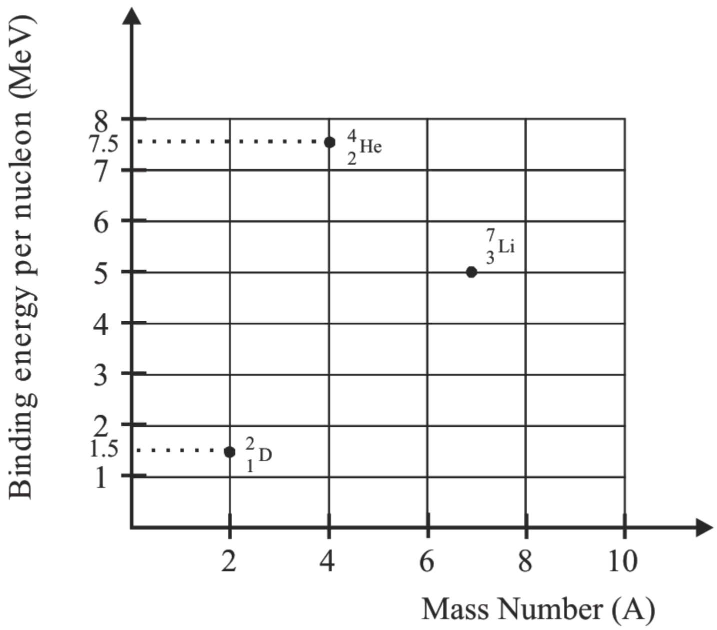
5. An element X of atomic number Z decays, first by positron emission and then two α-particles are emitted in successive radioactive decay. The product nuclei has a mass number 229 and atomic number 89. Find value of (Z – 88).

6. Consider a silver target in coolidge tube to produce x-rays. The accelerating potential is 31kV. E_k = 25.51 KeV, E_L = 3.51keV. What is $\lambda_{k\alpha} - \lambda_{min}$ (in pm). Round off to nearest integer. If your answer is X then fill the value of X/2. (Take : hc = 1240 eV nm)

7. Electromagnetic radiation whose electric component varies with time as $E = C_1(C_2 + C_3 \cos \omega t) \cos \omega_0 t$, here C_1, C_2 and C_3 are constants, is incident on lithium and liberates photoelectrons. If the kinetic energy of most energetic electrons be 2.6 eV, the work function of lithium is (in eV). [Take : $\omega_0 = 2.4\pi \times 10^{15}$ rad/sec and $\omega = 8\pi \times 10^{14}$ rad/sec, planks constant $h = 6.6 \times 10^{-34}$ MKS]

8. In an α-decay the kinetic energy of α particle is 48 MeV and Q value of the reaction is 50 MeV. The mass number of the parent nucleus is 20n then find n : (Assume that daughter nucleus is in ground state)

9. The positions of ${}_1^2D$, ${}_2^4He$ and ${}_3^7Li$ are shown on the binding energy per nucleon curve as shown in figure. Find the energy released in the fusion reaction, ${}_1^2D + {}_3^7Li \rightarrow 2\,{}_2^4He + {}_0^1n$ in multiple of 5.5 MeV.



10. In a slow reaction, heat is being evolved at a rate about 10mW in a liquid. If the heat were being generated by the decay of ^{32}P, a radioactive isotope of phosphorus that has half-life of 14 days and emits only beta-particles with a mean energy of 700KeV, estimate the number of ^{32}P atoms in the liquid. Express your answer in form of $A \times 10^{17}$ and fill 5A in

[Take : ln 2 = 0.675]