PHYSICS

BOOKS - KVPY PREVIOUS YEAR

SOLVED PAPER 2019

Example

1. In a muonic atom, a muon of mass of 200 times of that of electron and same charge is

bound to the proton. The wavelengths of its Balmer series are in the range of

A. X-rays

B. infrared

C. γ-rays

D. microwave

Answer:

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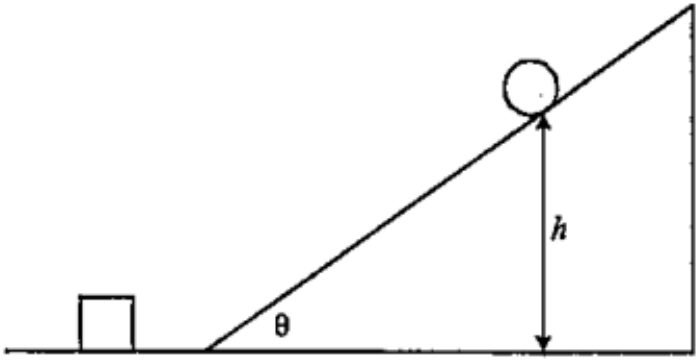
2. A spherical rigid ball is realeased from rest and starts rolling down an inclined plane from height h=7m, as shown in the figure. It hits a block at rest on the horizontal plane (assme elastic collision). If the mass of both the ball and the block is m and the ball is rolling without sliding, then the speed of the block after collision is close to



A. 6m/s

B. 8m/s

C. 10 m/s

D. 12 m/s

Answer:

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3. A girl drops an apple from the window of a train which is moving on a straight track with speed increasing with a constant rate. Te

trajectory of the falling apple as seen by the girl is

A. parabolic and in the direction of the moving train

B. parabolic and opposite to the direction of the moving train

C. an inclined straight line pointing in the direction of the moving train.

D. an inclined straight line pointing opposite to the direction of the moving

train

Answer:

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4. A train is moving slowly at 2 m/s next to a railway platform. A man, 15 m tall, alights from the train such that his feet are fixed on the ground. Taking him to be a rigid body, the instantaneous angular velocity (in rad/sec)is

A. 1.5

B. 2

C. 2.5

D. 3

Answer:

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5. A point mass M moving with a certain velocity collides with a stationary point mass M/2. The collision is elastic and in one

dimension. Let the ratio of the final velocities of M and M/2 be x. The value of x is

A. 2

B. 3

C. $\frac{1}{2}$

D. $\frac{1}{4}$

Answer:

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6. A particle of mass 2/3 kg with velocity v=-15m/s at t=-2 s is acted upon by a force $f = k - \beta t^2$. Here k=8 N and $\beta = 2N/s^2$. The motion is one dimensional. Then the speed at which the particle acceleration is zero again, is

A. 1 m/s

B. 16 m/s

C. 17 m/s

D. 32 m/s

Answer:

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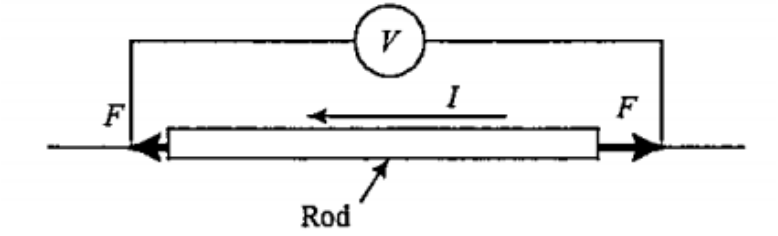
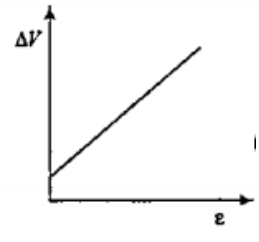
7. As shown in the schematic below, a rod of uniform cross-sectional area A and length l is carrying a constant current I through it and voltage across the rod is measured using an ideal voltmeter. The rod is stretched by the appliction of a force F. Which of the following graphs would show tha variation in the voltage across the rod as Junction of the strain,ε, when the strain is small. Neglect Joule

heating.



A.



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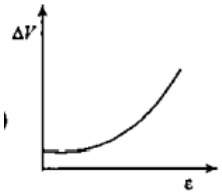
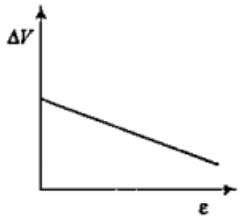
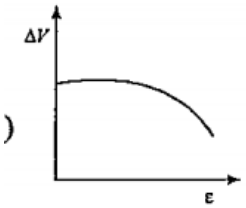


C.



D.



Answer:

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8. A photon falls through a height of 1 km through the earth's gravitational field. To calculate the change in its frequency, take its mass to be hv/c^2. The fractional change in frequency v is close to

A. 10^{-20}

B. 10^{-17}

C. 10^{-13}

D. 10^{-10}

Answer:

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9. 0.02 moles of an ideal diatomic gas with initial temperature $20^{\circ}C$ is compressed from $1500cm^3$ to $500cm^3$ The thermodynamic process is such that $PV^2 = \beta$ where β is a constant. Then the value of β is close to :(The gas constant, R=8.31 J/K/mol)

A. $7.5 \times 10^{-2} Pa.\, m^6$

B. $1.5 \times 10^{2} Pa.\, m^6$

C. $5 \times 10^{-2} Pa.\, m^6$

D. $2.2 \times 10^1 Pa.\, m^6$

Answer:

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10. A heater supplying constant power P watts is switched on at time t=0 minutes to raise the temperature of a liquid kept in a calorimeter of negligible heat capacity. A student records the temperature of the liquid T(t) at equal time intervals. A graph is plotted with T(t) on

the y-axis versus t on the x-axis. Assume that there is no heat loss to the surroundings during heating. Then,

A. the graph is a straight line parallel to the time axis

B. the heat capacity of the liquid is inversely proportional to the slope of the graph.

C. If some heat were lost at a constant rate to the surroundings during heating, the

graph would be a straight line but with a larger slope

D. the internal energy of the liquid increases quadratically with time.

Answer:

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11. Unpolarized red light is incident on the surface of a lake at incident angle θ_R. An observer seeing the light reflected from the

water surface through a polarizer notices that on rotating the polarizer, the intensity of light drops to zero at a certain orientation. The red light is replaced by unpolarized blue light. The observer sees the same effect with reflected blue light at incident angle θ_B. Then

A. $\theta_B < \theta_R < 45^\circ$

B. $\theta_B = \theta_R$

C. $\theta_B > \theta_R > 45^\circ$

D. $\theta_R > \theta_B > 45^\circ$

Answer:

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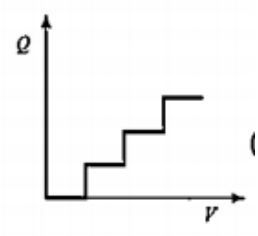
12. A neutral spherical copper particle has a radius of 10 nm ($1nm = 10^{-9}m$). It gets charged by applying the voltages slowly adding one electron at a time. Then the graph of the total charge on the particle vs the applied voltage would look like:

A.



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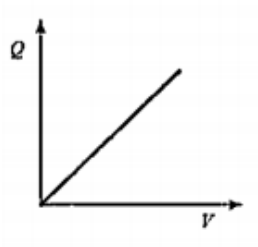
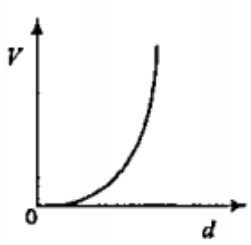
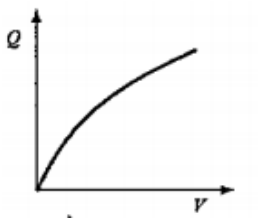


C.



D.



Answer:

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13. A charge +q is distributed over a thin ring of radius r with line charge density $\lambda = q\sin^2\theta/(\pi r)$. Note that the ring is in the x-y plane and θ is the angle made by $\vec{r}$ with the x axis. The work done by the electric force in displacing a point charge +Q from the center of the ring to infinity is

A. equal to $qQ/2\pi\varepsilon_0 r$

B. equal to $qQ/4\pi\varepsilon_0 r$

C. equal to zero only if the path is a straight line perpendicular to the plane of the ring

D. equal to $qQ / 8\pi\varepsilon_0 r$

Answer:

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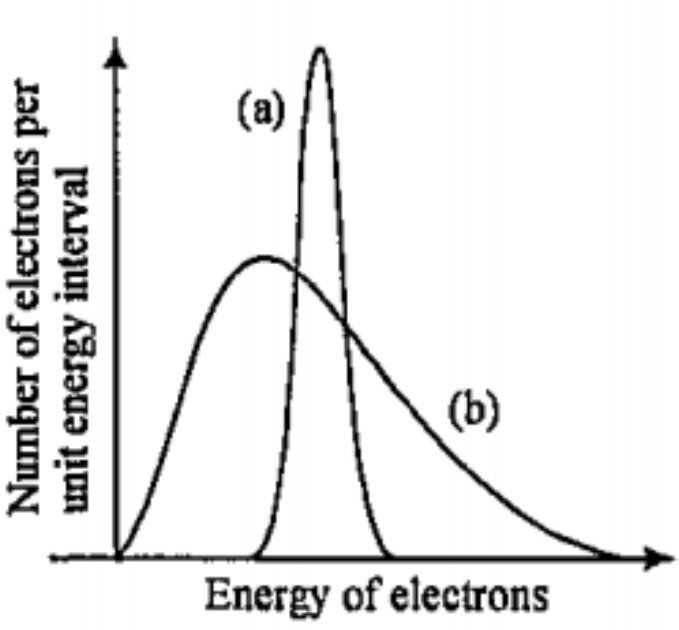
14. Originally the radioactive beta decay was thought as a decay of a nucleus with the emission of electrons only (Case I). However, in

addition to the electron, another (nearly) massless and electrically neutral particle is also emitted (Case II). Based on the figure below, which of the following is correct:



A. (a) in both cases I and II

B. (a) in case I and (b) in case II

C. (a) in case II and (b) in case I

D. (b) in both cases I and II

Answer:

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15. One gram-mole of an ideal gas A with the ratio of constant pressure and constant volume specific heats. $\gamma_A = 5/3$ is mixed with n gram-moles of another ideal gas B with

$\gamma_B = 7/5$. If the γ for the mixture is $19/13$ what will be the value of n?

A. 0.75

B. 2

C. 1

D. 3

Answer:

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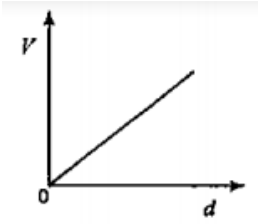
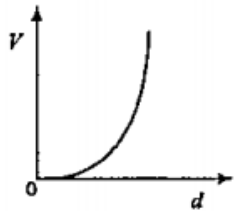
16. How will the voltage (V) between the two plates of a parallel plate capacitor depend on the distance (d) between the plates, if the charge on the capacitor remains the same?

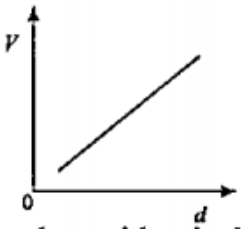
A.



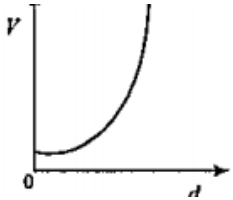
B.



C.



D.



Answer:

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17. Three large identical plates are kept close and parallel to each other. The outer two plates are maintained at temperatures T and 2T. respectively. The temperature of the middle plate in steady state will be close to

A. 1.1 T

B. 1.3 T

C. 1.7 T

D. 1.9 T

Answer:

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18. A metal rod of cross-sectional area $10^{-4}m^2$ is hanging in a chamber kept at $20^{\circ}C$ with a weight attached to its free end. The coefficient of thermal expansion of the rod is $2.5 \times 10^{-6}K^{-1}$ and its Young's modulus is $4 \times 10^{12}N/m^2$. When the temperarure of the chamber is lowered to T then a weight of 5000 N needs to be attached to the rod so that its length is unchanged. Then T is

A. $15^{\circ} C$

B. $12^{\circ} C$

C. $5^{\circ} C$

D. $0^{\circ} C$

Answer:

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19. A short solenoid (length l and radius r, with n turns per unit length) lies well inside and on the axis of a very long, coaxial solenoid

(lengthL, radius R and N turns per unit length, with R>r). Current I flows in the short solenoid. Choose the correct statement

A. There is uniform magnetic field $\mu_0 nI$ in the long solenoid

B. Mutual inductance of the solenoids is $\mu_0 r^2 nNl$

C. Flux through outer solenoid due to current I in the inner solenoid is proportional to the ratio R/r.

D. Mutual inductance of the solenoids is

$$\pi\mu_0 rRnNlL(rR)^{1/2}$$

Answer:

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20. Consider the wall of a dam to be straight with height H and length L. It holds a lake of water of height h(h < H) on one side. Let the density of water be ρ_w. Denote the torque about the axis along the bottom length of the

wall by T_1. Denote also a similar torque due to the water up to height h/2 and wall length L/2 by T_2. Then T_1/T_2 (ignore atmospheric pressure) is

A. 2

B. 4

C. 8

D. 16

Answer:

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21. Two containers C1 and C2 of volumes V and 4V respevtively hold the same ideal gas and are connected by a thin horizontal tube of negligible volume with a valve which is initially closed. The initial pressures of the gas in C1 and C2 are P and 5P, respectively. Heat baths are employed to maintain the temperatures in the containers at 300 K and 400 K respectively. The valve is now opened. Select the correct statement:

A. The gas will flow from the hot cointainer to the cold one and the process is irreversible

B. The gas will flow from one cointainer to the other till the number of moles in two containers are equal

C. A long time after the valve is opened, the pressure in both the containers will be 3P

D. A long time after the valve is opened, number of moles of gas in the hot container will be thrice that of the cold one

Answer:

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22. Four electrons, each of mass m_e are in a one dimensional box of size L. Assume that the elections are non-interacting, obey the Pauli

exclusion principle and are described by standing de Broglie waves confined within the box. Define $\alpha = h^2/8m_eL^2$ and U_0 to be the ground state energy. Then

A. the energy of the highest occupied state is 16α

B. $U_0 = 30\alpha$

C. the total energy of the first excited state is $U_0 + 9\alpha$

D. The total energy of the second excited state is $U_0 + 8\alpha$

Answer:

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23. A rope of length L and uniform linear density is hanging from the ceiling. A transverse wave pulse, generated close to the free end of the rope, travels upwards through the rope. Select the correct option:

A. The speed of the pulse decreases as it moves up

B. The time taken by the pulse to travel the length of the rope is proportional to $\sqrt{L}$

C. The tension will be constant along the length of the rope

D. The speed of the pulse will be constant along the length of the rope

Answer:

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24. A circuit consisits of a coil with inductance L and an uncharged capacitor of capacitance C. The coil is in a constant uniform magnetic field such that the flux through the coil is Φ. At time t=0, the magnetic filed is abruptly switched off Let $\omega_0 = 1/\sqrt{LC}$ and ignore the resistance of the circuit. Then,

A. current m the circuit is

$$I(t) = (\Phi/l)\cos\omega_0 t$$

B. magnitude of the charge on the capacitor is $|Q(t)| = 2C\omega_0|\sin\omega_0 t|$

C. initial current m the circuit is infinite

D. initial charge on the capacitor is $C\omega_0\Phi$

Answer:

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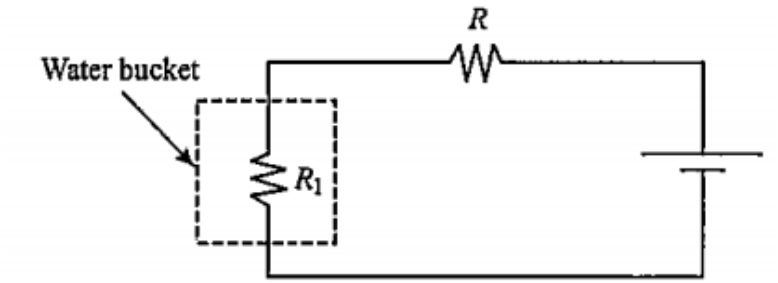
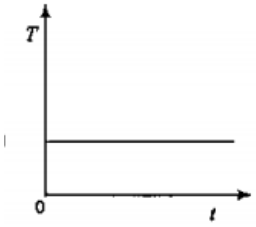
25. The circuit below is used to heat water kept in a bucket.



Assuming heat loss by Newton's law of cooling, the variationin the temperature of the water in the bucket as a function of time is depicted by:

A.



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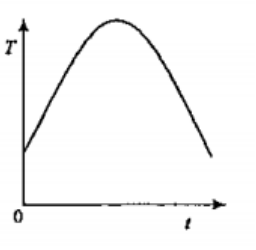
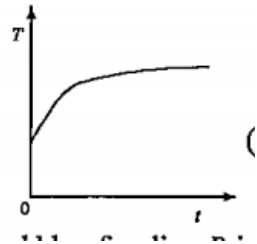
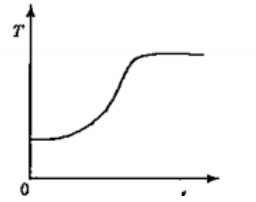


C.



D.



Answer:

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26. A bubble of radius R in water of density ρ is expanding uniformly at speed v. Given that water is incompressible, the kinetic energy of water being pushed is

A. Zero

B. $2\pi\rho R^3 v^2$

C. $2\pi\rho R^3 v^2 / 3$

D. $4\pi\rho R^3 v^2 / 3$

Answer:

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