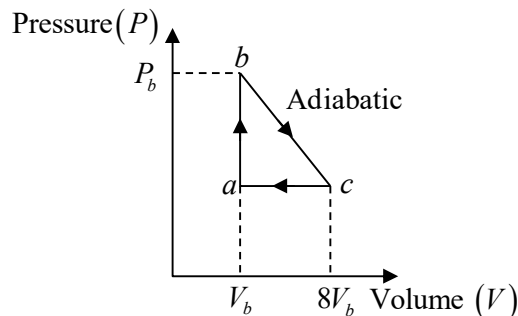


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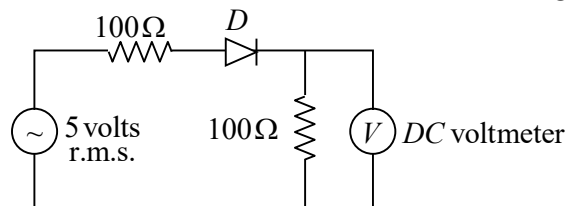
- Q1. One hydrogen atom collides with a second hydrogen atom which is initially at rest in the laboratory. Both the atoms are in the ground state before the collision. What should be the minimum kinetic energy (in the laboratory frame) of the incident hydrogen atom so that one of the two atoms can be in its first excited state after the collision?
- (a) $3.4 eV$ (b) $5.1 eV$ (c) $10.2 eV$ (d) $13.6 eV$
(e) $20.4 eV$
- Q2. A proton of kinetic energy $1880 MeV$ is moving in a circular orbit in a plane perpendicular to a uniform magnetic field of strength 5 Tesla. What is the radius of the orbit?
- (a) $75.6 m$ (b) $3.1 m$ (c) $5.3 m$ (d) $1.8 m$
(e) $24.3 m$
- Q3. Consider a planet, of radius $5000 km$, which is entirely in the liquid state and has a uniform density of $5 gm/cm^3$. The planet is in equilibrium under the action of gravitational forces and hydrostatic pressure. The pressure at the centre of the planet is
- (a) $90 \times 10^9 N/m^2$ (b) $360 \times 10^9 N/m^2$
(c) $180 \times 10^9 N/m^2$ (d) $270 \times 10^9 N/m^2$
(e) $540 \times 10^9 N/m^2$
- [Hint: (i) Consider the equilibrium of a small volume element at a distance r from the centre and (ii) pressure on the surface is zero.]
- Q4. Two events occur in the space time continuum. Event A has coordinates $(1 m, 2m, 3m, 0s)$ and event B occurs at $\left(2m, 3m, 4m, \frac{10^{-8}}{3} s\right)$, where the 4th coordinate gives the time in seconds. The proper distance between these two events is given by
- (a) $2m$ (b) $\sqrt{3} m$ (c) $\sqrt{2} m$ (d) $3m$
(e) $1 m$
- Q5. An idealized ping-pong ball of mass m is bouncing on a recoilless table in one dimension. The energy of the ball is given by
- (a) $-\frac{1}{3}$ (b) -1 (c) 3 (d) $\frac{2}{3}$
(e) 0

- Q6. Newton's rings are formed between two biconvex lenses of equal radii of curvature by reflected light of wavelength 5000 \AA . If the distance between the 5th and the 15th rings is 0.085 cm , what is the radius of either lens?
- (a) 109.7 cm (b) 71.29 cm (c) 107.9 cm (d) 75.6 cm
- (e) 105.4 cm
- Q7. The visible spectrum has wavelength in the range of 400 nm to 700 nm . The angular spread of the first-order visible spectrum produced by a plane diffraction grating having $6000 \text{ lines cm}^{-1}$, when the light is incident normal to the grating is
- (a) 8.9° (b) 9.9° (c) 10.9° (d) 11.9°
- (e) 12.9°
- Q8. One mole of a monatomic ideal gas is taken through the reversible cycle shown below. The path $b \rightarrow c$ is an adiabatic expansion process with $P_b = 10 \text{ atm}$ and $V_b = 1 \times 10^{-3} \text{ m}^3$:



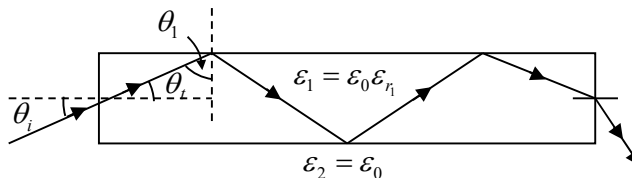
The efficiency of this cycle is closest to

- (a) 0.75 (b) 0.83 (c) 0.41 (d) 0.39
- (e) 0.62
- Q9. Two reversible engines are connected in series. The first one receives heat at $T^\circ \text{ K}$ and rejects heat at 1527° C . The second one receives the heat rejected by the first at 1527° C and then expels heat at 527° C . Find the temperature T for equal efficiencies of the two engines.
- (a) 3240° K (b) 2800° K (c) 2054° K (d) 1000° K
- (e) 3100° K
- Q10. In the following circuit, the diode D is ideal. What is the reading in the DC voltmeter?

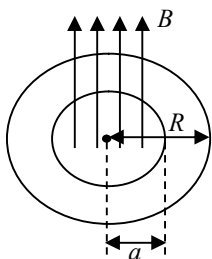


- (a) 3.18 volts (b) 2.25 volt (c) 4.50 volt (d) 1.59 volt
- (e) 1.85 volt

- Q14. A dielectric rod of a transparent material can be used to guide light under the condition of total internal reflection. What is the minimum dielectric constant of guiding medium so that a wave incident on one end at any angle will be confined within the rod until it emerges from the other end?

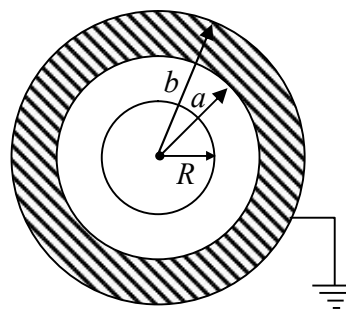


- (a) $\sqrt{2}$ (b) 1 (c) 2 (d) 1.5
 (e) 1.75
- Q15. A wire carrying line-charge density λ is converted into a circular loop of radius R . Then it is suspended horizontally (with non conducting spokes) so that it is free to rotate in the horizontal plane. A uniform magnetic field \vec{B} is applied in the central region (pointing up) out to radius a ($R > a$). The angular momentum imparted to the loop when the field is turned off is given by



- (a) $\pi B a^2$ (b) 0 (c) $\pi R^2 \lambda a$ (d) $\pi \lambda a^2 R B$
 (e) $\pi B \lambda^2$
- Q16. A metal sphere of radius R with charge q is surrounded by a thick concentric spherical shell of inner radius a and outer radius b . The shell is grounded. The potential at the centre of the sphere (with infinity as reference point) is given by

- (a) $\frac{1}{4\pi\epsilon_0} \left(\frac{q}{b} + \frac{q}{R} - \frac{q}{a} \right)$ (b) $\frac{1}{4\pi\epsilon_0} \left(\frac{q}{R} \right)$
 (c) $\frac{1}{4\pi\epsilon_0} \left(\frac{q}{b} - \frac{q}{a} \right)$ (d) $\frac{1}{4\pi\epsilon_0} \left(\frac{q}{R} - \frac{q}{a} \right)$
 (e) $\frac{1}{4\pi\epsilon_0} \left(\frac{q}{R} + \frac{q}{a} \right)$



- Q17. A dust particle of mass 10^{-8} kg is at room temperature (300 K). Its de Broglie wavelength is nearest to
- (a) 10^{-19} m (b) 10^{-15} m (c) 10^{-6} m (d) 10^{-9} m
 (e) 10^{-23} m

Q23. What is the residue of the complex function $f(z) = \exp\left(\frac{1}{z}\right)$ at $z = 0$?

- (a) 1 (b) 0 (c) undefined (d) e
 (e) ∞

Q24. Consider a monatomic ideal (Boltzmann) gas in which the atoms carry magnetic moment μ . The gas is placed in a magnetic field $B\hat{z}$ pointing up. At a given temperature T , what is the average energy per atom due to the interaction with the magnetic field?

(Hint: Take into account that a certain fraction of atoms will have magnetic moment pointing up and a certain fraction will have them pointing down)

- (a) $-\mu B \tanh\left(\frac{\mu B}{k_B T}\right)$ (b) $\mu B \tanh\left(\frac{\mu B}{k_B T}\right)$
 (c) $-\mu B \sinh\left(\frac{\mu B}{k_B T}\right)$ (d) $\mu B \sinh\left(\frac{\mu B}{k_B T}\right)$
 (e) $-\mu B \tan\left(\frac{\mu B}{k_B T}\right)$

Q25. Which of the following graphs gives the best schematic representation of the real-valued function $y = \sin(\sinh x)$ in an interval around $x = 0$?

