普通物理期末考(1/12/2017)時間:10:00-13:00

每大題含1-3小題，每小題5分，總分100分。將計算或推導過程清楚寫在答案本中，計算題最後答案畫長方格圈示。

1. (a) Find the general solution for thewave equation $\frac{\partial^2 s(x,t)}{\partial x^2} - \frac{1}{v^2}\frac{\partial^2 s(x,t)}{\partial t^2} = 0$ using separation of variables. (b) Derive the beat frequency forthe two waves $s_1(x,t) = s_m \cos(k_1 x - \omega_1 t + \phi_1)$ and $s_2(x,t) = s_m \cos(k_2 x - \omega_2 t + \phi_2)$ at the point $x = x_0$, noting $\frac{\omega_1}{k_1} = \frac{\omega_2}{k_2} = v,\ f_1 = \frac{\omega_1}{2\pi}, f_2 = \frac{\omega_2}{2\pi}$

2. A light source emitting a wave of frequency f is traveling at speed v_S with respect to astationary detector. Derive the frequency seen by the detector if the source is (a) moving directly toward the detectorand (b) passing through the closest point to the detectoron its straight trajectoryat a distance from the detector.

3. (a) Derive the relativistic kinetic energy from the relativistic momentum $p = \gamma m v$. (b) Show that $E^2 = c^2 p^2 + m^2 c^4$.

$C_V = (\frac{3}{2}R)$

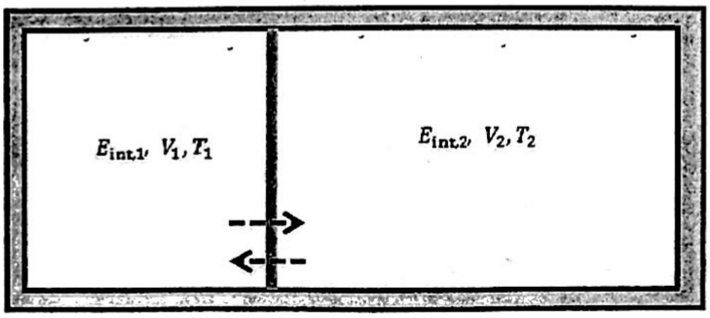
4. Derive (a) the molar specific heat at constant volume and (b) the molar specific heat at constant pressure for a monoatomic ideal gas. (c)Show that $TV^{\gamma-1}$ is a constant for an ideal gas in an adiabatic process, where $\gamma = \frac{c_P}{c_V}$.

5. Derive the mean free path λfor each of the N molecules of diameter d contained in a box of volume V.

$\frac{d}{2}$ = 半徑

6. Aclosed system is divided into two subsystems. The two subsystems have fixed volume and are in thermal contact with each other but both are isolated from the environment.Given $S = k \ln W$, show that the closed system has the maximum multiplicity when the two subsystems have the same temperature.

$T_1 = T_2$



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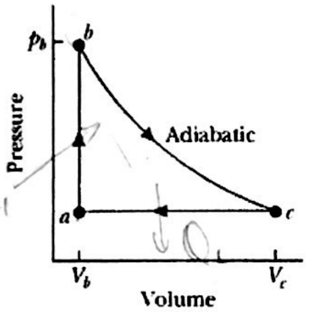
$dQ = nC_V dT = dE = \frac{3}{2} k dT \cdot N$ $\quad NkT = nRT$

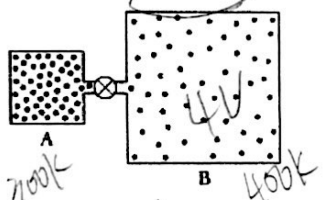
$C_V = \frac{3k \cdot N}{2n} = \frac{3nR}{2n} = \frac{3}{2}R$

7. A reversible cycle through which 1.00 mol of a monatomic ideal gas is taken. Volume $V_c = 8.00V_b$. Process bc is an adiabatic expansion, with $p_b = 1.013\times10^6$ Pa and $V_b = 1.00\times10^{-3}$ m^3. For the cycle, find (a) the energy added to the gas as heat, (b) the energy leaving the gas as heat, (c) the efficiency of the cycle.?

$\eta = 1 - \frac{|Q_L|}{|Q_H|}$ $\qquad$ $P_bV_b = |1013|$ (N.m)



8. Container A holds an ideal gas at a pressure of 5.0×10^5 Pa and a temperature of 300 K. It is connected by a thin tube (and a closed valve) to container B, with four times the volume of A. Container B holds the same ideal gas at a pressure of 1.0×10^5 Pa and a temperature of 400 K. The valve is opened to allow the pressures to equalize, but the temperature of each container is maintained. What then is the pressure?



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9. A 600 W Carnot engine operates between constant-temperature reservoirs at 100°C and 60.0°C. What is the rate at which energy is (a) taken in by the engine as heat and (b) exhausted by the engine as heat?

333K

$\Delta S = 0 = \frac{|Q_H|}{T_H} - \frac{|Q_L|}{T_L}$

10. A girl is sitting near the open window of a train that is moving at a velocity of 10.00 m/s to the east. The girl's uncle stands near the tracks and watches the train move away. The locomotive whistle emits sound at frequency 520.0 Hz. A wind begins to blow from the east at 10.00 m/s. What frequency does the uncle hear? [Note: The speed of sound in the air is 343m/s.]

11. (a) What potential difference would accelerate an electron to speed c according to classical physics? (b) With this potential difference, what speed would the electron actually attain? [Note: The mass of an electron is 0.511MeV/c^2.]

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