A

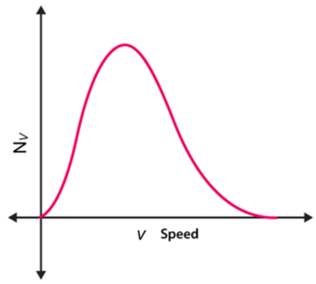
114 學年第一學期 普通物理 A 第期末考試題

[Benson Ch. 14 –20] 2020/12/17, ***10:10AM – 12:30 pM***

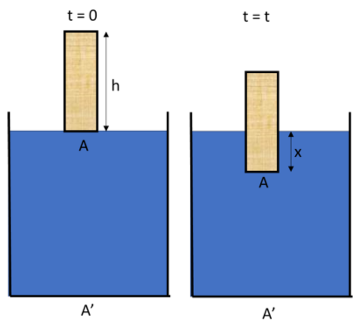
$G = 6.67\times10^{-11}$ N·m²/kg²; 1 atm = 1.013×10^{5} Pa= 1.013×10^{5} N/m², the reference intensity for thershold of hearing = 10^{-12} W/m², g = 9.80 m/s²; Sound speed (air) = 344 m/s 1 cal = 4.186 J; Gas constant R = 8.31 J/mol·K; Boltzmann constant $k_B = 1.38\times10^{-23}$ J/molecule·K; Avogadro's number = 6.02×10^{23} molecules/mol; 1 atm = 1.013×10^{5} Pa

(Detailed and elaborate process is necessary for each problem)

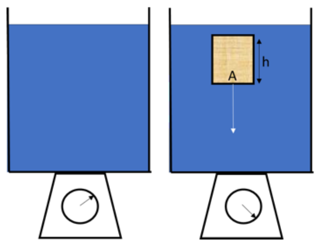
1. 1. The distribution curve of molecule velocity in a system is shown in the figure. The y axis, Nv, is the number of molecules per unit speed. The x axis is the molecule speed. (a) Please derive the most probable speed, v_{mp}, of the molecules. If the temperature increases, please prove (b) v_{mp} increases, (c) the number of molecules corresponding to v_{mp} decreases, and (d) the distribution curve become wider. (4, 2, 4, 4 points) $Nv = 4\pi N\left(\dfrac{m}{2\pi k_B T}\right)^{\frac{3}{2}} v^2 e^{\frac{-mv^2}{2k_B T}}$



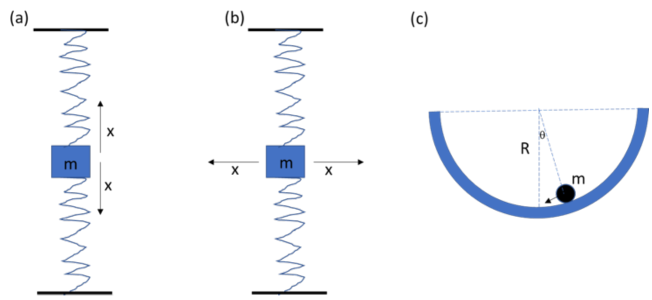
2. In the right figure, the object is right above the liquid at $t = 0$. Then the object is released. (a) Please derive x as a function of time t before the object is completely immersed into the liquid. x is the depth of immersion. (b) Please obtain the instantaneous speed of the object upon complete immersion. The densities of the object and the liquid are ρ_1 and ρ_2, $\rho_1 > \rho_2$. The height and the cross-sectional area of the object are h and A. The cross-sectional area of the bucket is A'. (8, 6 points)



3. In the right figure, when there is no object in the liquid, the scale shows 5 Kg. Then an object is completely immersed into the liquid. Before the object hits the bottom of the bucket, what does the scale read? The densities of the object and liquid are 2 and 1 g/cm³. The height and the cross-sectional area of the object are h = 20 cm and A = *10 cm²*. (5 points)

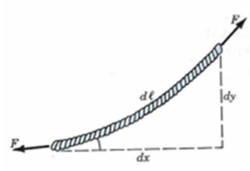


4. Please derive the equation and the period of of SHM for the cases of (a), (b), and (c). For (a), the spring constants of the two springs are is k1 and k2. For (b), the spring constant is k for both. x is with respect to the equilibrium point. For all three cases, the moving amplitude is small. (4, 4 ,4 points)



5. Drive (a) relation $P_1V_1^{\gamma}=P_2V_2^{\gamma}$ for adiabatic process of an ideal gas and the work done between state *1* and state *2* by two different methods: (b) using molar specific heat at constant volume, C_v, and (c) using integration. (4, 3, 3 points)

6. Please derive the energy density and the average transmitted power of a string wave with the amplitude A and propagation speed v. The density of the string is μ. (8 points)



7. Prove that $\beta = 2\alpha$. β is the coefficient of surface expansion, $\Delta A = \beta A_0 \Delta T$. α is the coefficient of linear expansion $\Delta L = \alpha L_0 \Delta T$. (3 points)

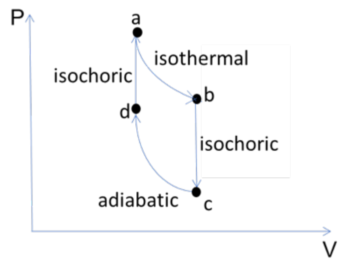
8. The displacement of a 4-kg block attached to a spring was given by $x = 0.02 \cos(20t + \pi/4)$.(a) Find the kinetic energy K and (b) the acceleration of the block at the instant $t = \pi/40$ s. (c) Find the average value of potential energy over the period T. (d) If a 1 kg mud is suddenly dropped to the block and sticks to it, the period T changes to be ? (3, 3, 4, 4 points)

9. At 1 kHz, the minimum audible intensity is 10^{-12} W/m^2, whereas the maximum tolerable without pain is 1 W/m^2. Calculate the pressure and the displacement amplitudes for (a) the threshold of hearing and (b) the threshold of pain. The density of air is 1.29 kg/m^3. (4, 4 points)

10. (a) Write down the displacement form and pressure form of the wave functions of a sound wave. (b) Derive the intensity of a sound wave (c) Show that the displacement wave function of the sound spreading from a point source is in the form of y = (A'/r)sin(kr-wt). r is the distance from the point source (d) Consider an idealized model with a bird (treated as a point source) emitting constant sound power. By how many decibels does the sound intensity level drop when you move three times as far away from the bird? (2, 4, 3, 3 points)

11. . Drive the rate of energy dissipation for a damped oscillation system. ($F= -kx -bv = m\,(d^2x/dt^2)$) (4 points)

12. Five moles of an ideal diatomic gas ($\gamma = 1.4$) operate in the cycle (a→ b→ c→d) of the right Figure, where Ta = 600 K, Tc = 100 K , Vc = 100 m^3 and Td = 400 K. Find the work done and the heat transferred during the process of (a) a→ b (b) b→ c (c) c→d (d) d→a. (e) How much is the internal energy difference between b and d. (6,6, 6,6,6 points).

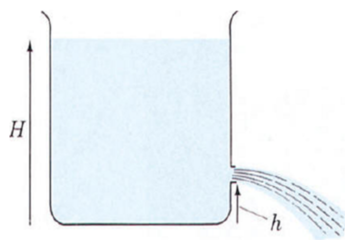


13. How much are the heat transfer needed and work done to make 2 moles of hydrogen gas expand from 20 cm^3 to 50 cm^3 at T = 20 K (a) at constant temperature and (b) at constant pressure? (4, 4 points)

14. The frequencies of two consecutive harmonics of a pipe 0.45 m long are 929 Hz and 1300 Hz. (a) Is it open or closed? (b) What is the wave speed? (Note: you will get points only when both answers are right.). (3, 3 points)

15. What are the *rms* speeds of (a) Argon atoms (M = 18 g/mole) at 1000°C and (b) Oxygen molecules (M = 32 g/mole) (ideal rigid-rotator diatomic gas) at 400 K? (c) To heat 4 moles of Oxygen gas with a constant volume from 300 K to 400 K, how much heat is needed? (2, 2, 2 points)

16. Water emerges from a small opening at a height h from the bottom of a large container, as shown in the figure, which filled to a constant depth H. (a) Find the distance R from the base at which water hits the ground. (b) At what other height would a similar opening lead to the same point of impact? (3, 4 points)



17. A 2-kg block is attached to a spring for which k = 400 N/m. It is held at an extension of 50

cm and then release at t=0. Find: (a) the displacement as a function of time; (b) the velocity when x = 10 cm (c) the acceleration when x = 20cm. (2, 2, 2 points)

1. (a)有微分 1 分 全部 4

   (b)全對 2

5.) a.) $N(v) = 4\pi N\left(\frac{m}{2\pi k_B T}\right)^{\frac{3}{2}} v^2 e^{\frac{-mv^2}{2k_BT}}$

$$\frac{dN}{dV} = 0 = 4\pi N\left(\frac{m}{2\pi k_B T}\right)^{\frac{3}{2}}\left(2V - \frac{mV}{k_BT}V^2\right) e^{-\frac{mv^2}{2k_BT}}$$

$$\therefore 2v - \frac{mv}{k_BT}v^2 = 0$$

$$2 - \frac{m}{k_BT}v^2 = 0$$

$$\boxed{V_{mp} = \sqrt{\frac{2k_BT}{m}}}$$

(b) $\frac{dV_{mp}}{dT} = \frac{1}{2}\left(\frac{2k_BT}{m}\right)^{-\frac{1}{2}}\frac{2k_B}{m} > 0$

$\therefore$ T increase and V_{mp} increase

(c) 有寫 N(v) 1 分 全部 4

$$Nv = 4\pi N\left(\frac{m}{2\pi k_B T}\right)^{\frac{3}{2}} v^2 e^{\frac{-mv^2}{2k_BT}}$$

The height of the peak is $Nv(v_{mp})$

$$Nv(v_{mp}) = 4\pi N\left(\frac{m}{2\pi k_B T}\right)^{\frac{3}{2}} v_{mp}^2 e^{\frac{-mv_{mp}^2}{2k_BT}} = 4\pi N\left(\frac{m}{2\pi k_B T}\right)^{\frac{3}{2}}\left(\frac{2k_BT}{m}\right)e^{-1} = 4N\left(\frac{2k_B\pi}{m}\right)^{-\frac{1}{2}}e^{-1}T^{-\frac{1}{2}}$$

So when T increases, the height of peak $Nv(v_{mp})$ decreases #

4 分

(d) Since the area of the N-V graph is the number of molecules it is conservative quantity, the most propable point decrease as temperature increase, therefore the width of the distribution curve become wider.

2.

(a) 第二行的 x=y+(A/A')改成 x=y+(A/A')x

$\rho_1 hAg - \rho_2 Axg = \rho_1 hA\dfrac{d^2y}{dt^2}$, y is the distance between the center of mass of the object at $t = 0$ and that at $t = t$.

$x = y + y\dfrac{A}{A'} = y\,(1+\dfrac{A}{A'}),\ y = \dfrac{A'}{A'+A}x$

$\rho_1 hAg - \rho_2 Agx = \rho_1 h(\dfrac{A'A}{A'+A})\dfrac{d^2x}{dt^2}$

$\dfrac{d^2x}{dt^2} + \dfrac{\rho_2 g}{\rho_1 h}(\dfrac{A'+A}{A'})x - (\dfrac{A'+A}{A'})g = 0$

$\dfrac{d^2x}{dt^2} + Bx - C = 0$

$x(t) = \dfrac{C}{B} + C_1\cos\left(\sqrt{B}t\right) + C_2\sin\left(\sqrt{B}t\right)$

$v(t) = \dfrac{dy}{dt} = \dfrac{A'}{A'+A}\left(-C_1\sqrt{B}\sin\left(\sqrt{B}t\right) + C_2\sqrt{B}\cos\left(\sqrt{B}t\right)\right)$

Initial conditions: When $t = 0, x = 0 \Rightarrow C_1 = -\dfrac{C}{B}$, When $t = 0, v = 0 \Rightarrow C_2 = 0$

$x(t) = \dfrac{C}{B} - \dfrac{C}{B}\cos\left(\sqrt{B}t\right) = \dfrac{C}{B}(1-\cos\left(\sqrt{B}t\right)) = \dfrac{\rho_1 h}{\rho_2}(1-\cos\left(\sqrt{\dfrac{\rho_2 g}{\rho_1 h}(\dfrac{A'+A}{A'})}t\right))$ #

(b)

$$x(\mathrm{t}) = \frac{C}{B} - \frac{C}{B}\cos\left(\sqrt{\mathrm{B}}\mathrm{t}\right) = \frac{C}{B}(1-\cos\left(\sqrt{\mathrm{B}}\mathrm{t}\right)) = \frac{\rho_1 h}{\rho_2}(1-\cos\left(\sqrt{\frac{\rho_2 g}{\rho_1 h}(\frac{A'+A}{A'})}\mathrm{t}\right))$$

$$v(\mathrm{t}) = \frac{dx}{dt} = \sqrt{\frac{\rho_1 hg}{\rho_2}(\frac{A'+A}{A'})}\sin\left(\sqrt{\frac{\rho_2 g}{\rho_1 h}(\frac{A'+A}{A'})}\mathrm{t}\right)$$

When $x = h$ and $t = t'$ $\Rightarrow$ $(1-\cos\left(\sqrt{\frac{\rho_2 g}{\rho_1 h}(\frac{A'+A}{A'})}\mathrm{t}'\right)) = \frac{\rho_2}{\rho_1}$, $(1-\frac{\rho_2}{\rho_1}) = \cos\left(\sqrt{\frac{\rho_2 g}{\rho_1 h}(\frac{A'+A}{A'})}\mathrm{t}'\right)$

$$\sin\left(\sqrt{\frac{\rho_2 g}{\rho_1 h}(\frac{A'+A}{A'})}\mathrm{t}'\right) = \sqrt{1-(1-\frac{\rho_2}{\rho_1})^2}$$

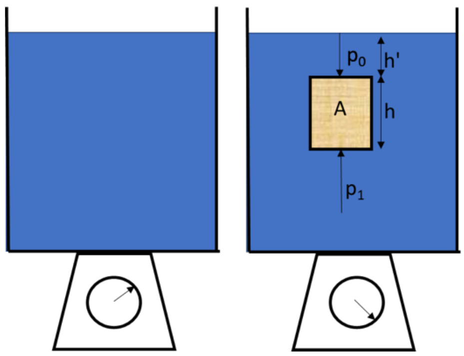
So $v(\mathrm{t}') = \sqrt{\frac{\rho_1 hg}{\rho_2}(\frac{A'+A}{A'})}\sqrt{1-(1-\frac{\rho_2}{\rho_1})^2} = \sqrt{\frac{\rho_1 hg}{\rho_2}(\frac{A'+A}{A'})}\sqrt{2\frac{\rho_2}{\rho_1}-(\frac{\rho_2}{\rho_1})^2} = \sqrt{\frac{\rho_1 hg}{\rho_2}(\frac{A'+A}{A'})}\sqrt{\frac{\rho_2}{\rho_1}(2-(\frac{\rho_2}{\rho_1}))}$

$= \sqrt{hg(\frac{A'+A}{A'})}\sqrt{(2-(\frac{\rho_2}{\rho_1}))}$ #

3.

3. consider the case that there are no drag force in liquid, then by Newton's 3rd law, the scale will provide a force equal to the bouyant force, hence the new reading:

$$W' = 5 + F_B = 5.2 \text{ (kgw)}$$



4. (a)

$$-(k_1+k_2)x = m\frac{d^2x}{dt^2}$$

$$\frac{d^2x}{dt^2} + \frac{(k_1+k_2)}{m}x = 0 \ \#$$

$$\mathrm{T} = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{k_1+k_2}{m}}} = 2\pi\sqrt{\frac{m}{k_1+k_2}} \ \#$$

(b)

Because the displacement is small so we can approximate $x \approx \Delta l \cos\theta$.

Δl is the small length increase of the spring and θ is the small angle between the spring and the vertical line.

$$-2k\Delta l\cos\theta = m\frac{d^2x}{dt^2} \Rightarrow -2kx = m\frac{d^2x}{dt^2}$$

$$\frac{d^2x}{dt^2} + \frac{2k}{m}x = 0 \ \#$$

$$\mathrm{T} = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{2k}{m}}} = \pi\sqrt{\frac{2m}{k}} \ \#$$

(c)

$-mg\sin\theta = m\dfrac{Rd^2\theta}{dt^2}$, θ is small so $\sin\theta \approx \theta$.

$$\frac{d^2\theta}{dt^2} + \frac{g}{R}\theta = 0 \ \#$$

$$\mathrm{T} = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{g}{R}}} = 2\pi\sqrt{\frac{R}{g}} \ \#$$

5.

(a)寫出 Q=0 或 U=-pdv（或是絕熱）1 分 全對全拿 4 分

The work done by the gas for an infinitesimal change in volume dV is $dW =$ dV. The temperature of the ideal gas will change by dT, which means that there ill be a change in its internal energy given by Eq. 19.12, $dU = nC_v\, dT$. The first w, $dU = dQ - dW = 0 - dW$, takes the form

$$nC_v\, dT = -P\, dV \qquad (19.16)$$

om the equation of state for an ideal gas, $PV = nRT$, we have

$$P\, dV + V\, dP = nR\, dT$$

to this equation we substitute $n\, dT = -P\, dV/C_v$ from Eq. 19.16 and rearrange to d

$$P(C_v + R)dV + C_vV\, dP = 0$$

om Eq. 19.15 we know that $C_v + R = C_p$ for an ideal gas. With the definition

$$\gamma = \frac{C_p}{C_v}$$

the last equation becomes

$$\gamma \frac{dV}{V} + \frac{dP}{P} = 0$$

which, after integration, yields

$$\gamma \ln V + \ln P = \text{constant}$$

The constant depends on the initial conditions. From this equation we
$\ln(PV^{\gamma})$ = constant, or equivalently

(Quasistatic, adiabatic) $$PV^{\gamma} = \text{constant} \quad (1\text{S}$$

Or you just check the lecture note which reveals more details.

(b) 寫出 U=-W 一分，全對滿分 3 分

$$\Delta U_{1\to 2} = -W_{1\to 2} = nC_V \int_{T_1}^{T_2} dT = nC_V \Delta T = nC_V (T_2 - T_1)$$

$$W_{1\to 2} = nC_V \left(\frac{P_1V_1}{nR} - \frac{P_2V_2}{nR}\right) = \frac{C_V}{R}(P_1V_1 - P_2V_2) = \frac{1}{\gamma - 1}(P_1V_2 - P_1V_2)$$ (1、2 標錯了)

(c) 全給全不給(3 分)

$$W = \int_{V_1}^{V_2} P\,dV = \int_{V_1}^{V_2} \frac{K}{V^{\gamma}}\,dV = \frac{K}{\gamma - 1}\left(\frac{1}{V_1^{\gamma-1}} - \frac{1}{V_2^{\gamma-1}}\right)$$

If we use $K = P_1V_1^{\gamma}$, we find

(Adiabatic) $$W = \frac{1}{\gamma - 1}(P_1V_1 - P_2V_2)$$

6. 課本及筆記有.

7. 作業類似.(7. 全給全不給(3 分))

線膨脹係數

對一條長度 L 的物體：

$$\alpha \equiv \frac{1}{L}\frac{dL}{dT}$$

面膨脹係數

對一個面積 A 的物體：

$$\beta \equiv \frac{1}{A}\frac{dA}{dT}$$

考慮一個各向同性固體的正方形薄片
邊長為 L，則面積為

$$A = L^2$$

對溫度微分

$$\frac{dA}{dT} = \frac{d}{dT}(L^2) = 2L\frac{dL}{dT}$$

兩邊同除以 $A = L^2$：

$$\frac{1}{A}\frac{dA}{dT} = \frac{2L}{L^2}\frac{dL}{dT} = 2\frac{1}{L}\frac{dL}{dT}$$

8.

a) $K = \frac{1}{2}m\left(\frac{dx}{dt}\right)^2 = \frac{1}{2}(4)(0.16)\sin^2(20t+\pi/4)$

At the instant $t = \pi/40$ *s*, $K = 0.16$ (J)

(b) $a = \frac{d^2x}{dt^2} = \frac{1}{2}(2)(8)\cos(20t+\pi/4)$

At the instant $t = \pi/40$ *s*, $a = 4\sqrt{2}$ (m/s^2) .

(c)

k=1600

$U_{av} = \frac{1}{2}(800)(0.02)^2 \frac{\int_0^T \cos^2(20t+\pi/4)\,dt}{T} = \frac{1}{2}(800)(0.02)^2(\frac{1}{2}) = 0.08(J)$ 左邊是錯的 正確答案是 0.16(J)

(d)

$T=\frac{2\pi}{\omega}=2\pi\sqrt{\frac{m}{k}}=2\pi\sqrt{\frac{4+1}{800}}\approx 0.497(s)$ 正確答案是 T=0.351(s)

9.

$$P_{\max}=\sqrt{2\rho v_c I},\qquad y_{max}=\sqrt{\frac{2I}{\rho v_c \omega^2}}$$

(a) At threshold of hearing, $I=10^{-12}\ \mathrm{W/m^2}$:

$$P_{\max}=\sqrt{2\times 1.29\times 344\times 10^{-12}}\approx \mathbf{2.96\times 10^{-5}\ (Pa)}$$

$$y_{max}=\sqrt{\frac{2\times 10^{-12}}{1.29\times 344\times (2\pi\times 10^{3})^2}}\approx \mathbf{1.07\times 10^{-11}\ (m)}$$

(b) At threshold of pain:

$$P_{\max}=\mathbf{29.6\ (Pa)},\qquad y_{max}=\mathbf{1.07\times 10^{-5}\ (m)}$$

10.

(a) y(x,t) = Asin(kx-ωt), p(x,t)= –ABkcos(kx-ωt)

(b) For the derivation, please check Beson book (Pgae 356) or my lecture note.

(c) The average power of the sound wave

$$P_{av}=sA^2Bk\omega$$

$$I_{av}=\frac{P_{av}}{s}=A^2Bk\omega$$

However, we know that the intensity

$$I_{av}\propto\frac{1}{r^2}$$

B, k, ω are all constants so A(r) = A’/r

Therefore, $y(x,t)=\frac{A'}{r}\sin(kx-\omega t)$ #

(d)

$$\beta_1 = (10\text{ dB})\log\frac{I_1}{I_0}, \beta_2 = (10\text{ dB})\log\frac{I_2}{I_0}$$

$$\beta_2 - \beta_1 = (10\text{ dB})\log\frac{I_2}{I_1},\ \frac{I_2}{I_1} = \frac{\frac{1}{r_2^2}}{\frac{1}{r_1^2}} = \frac{r_1^2}{r_2^2}$$

$$\beta_2 - \beta_1 = (10\text{ dB})\log\frac{r_1^2}{r_2^2}$$

When $r_2 = 3r_1,\ \beta_2 - \beta_1 = (10\text{ dB})\log\frac{1}{9} = -9.54\text{ (dB)}$ #

11.

$$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

$$\frac{dE}{dt} = mv\bullet\frac{dv}{dt} + kx\bullet\frac{dx}{dt} = v(ma + kx) = v(m\frac{d^2x}{dt^2} + kx)$$

From Netwon's second law, $F = -kx - bv = m\ (d^2x/dt^2)$

So $\frac{dE}{dt} = v(-kx - bv + kx) = -bv^2$ #

12. (a-d)都是 W 3 分 Q 3 分，一題 6 分，　(e) 總分 6 分 若沒寫單位一小題扣 1

$$p_aV_a = nRT_a = 600nR$$
$$p_bV_b = nRT_b = nRT_a = 600nR$$
$$p_cV_c = p_cV_b = nRT_c = 100nR,\ 100p_c = p_cV_b = nRT_c = 100nR,\ p_c = nR,\ p_c = 5R$$
$$p_dV_d = p_dV_a = nRT_d = 400nR.......(1)$$
$$C_V = \frac{R}{\gamma - 1} = \frac{5}{2}R$$

Adiabatic process

$$p_cV_c^\gamma = p_dV_d^\gamma \Rightarrow nRV_c^\gamma = p_dV_d^\gamma \Rightarrow p_dV_d^\gamma = nR(100)^\gamma......(2)$$

(2)/(1) $\quad V_d^{(\gamma-1)} = \frac{(100)^\gamma}{400} \Rightarrow 4^{\frac{1}{\gamma-1}} = \frac{100}{V_d} \Rightarrow 32 = \frac{100}{V_d} \Rightarrow V_d = 3.125\text{ m}^3$

$$p_d(3.125) = nRT_d = 400\times5\times R \Rightarrow p_d = \frac{2000R}{3.125} = 640R$$

$$p_aV_a = p_aV_d = nRT_a = 600nR \Rightarrow p_a = \frac{600\times5\times R}{3.125} = 960R$$

$$p_bV_b = p_bV_c = nRT_b = nRT_a = 600nR \Rightarrow p_b = 6nR = 30R$$

So now we make a summary:

$$p_a = 960R,\ V_a = 3.125\ \text{m}^3, T_a = 600\ \text{K}$$
$$p_b = 30R,\ V_b = 100\ \text{m}^3, T_b = 600\ \text{K}$$
$$p_c = 5R,\ V_c = 100\ \text{m}^3, T_c = 100\ \text{K}$$
$$p_d = 640R,\ V_d = 3.125\ \text{m}^3, T_d = 400\ \text{K}$$

OK, let's start getting W and Q for each process.

(a) a→b, $W = nRT_a \ln\frac{V_b}{V_a} = 3000R\ln\frac{100}{3.125} = 3000R\ln 32 = 86400.8\ \text{J}$ #, Q = 86400.8 J #

(b) b→c $W = 0$ #, $Q = \text{nC}_v(T_c - T_b) = 5\times\frac{5}{2}R(100-600) = -51937.5\ \text{J}$ #

(c) c→d $W = \frac{1}{\gamma - 1}(p_cV_c - p_dV_d) = \frac{1}{0.4}(5R\times100 - 640R\times3.125) = -31162.5\ \text{J}$ #, $Q = 0$ #

(d) d→e $W = 0$ #, $Q = \text{nC}_v(T_d - T_a) = 5\times\frac{5}{2}R(600-400) = 20775\ \text{J}$ #

(e) $W_{b\to c\to d} = 0 - 31162.5 = -31162.5\ \text{J},\ Q_{b\to c\to d} = -51937.5 + 0 = -51937.5\ \text{J}$
$\Delta U_{b\to c\to d} = Q_{b\to c\to d} - W_{b\to c\to d} = -51937.5 + 31162.5 = -20775\ \text{J}$ #

13. Q 跟 W 各 2 a.b 一題 4 分 沒單位一小題扣 1

At T = 20 K, $C_V = \frac{3}{2}R$

(a) At constant temperature,

$$W = nRT_a\ln\frac{V_b}{V_a} = 2R(20)\ln\frac{50}{20} = 305.575\ \text{J}\ \#$$
$$Q = W = 305.575\ \text{J}\ \#$$

(b) At constant pressure,

$$PV_i = nRT_i,\ P(20\times10^{-3}) = 2R(20), P = \frac{40R}{20\times10^{-3}} = 2000R$$
$$W = P(V_f - V_i) = 2000R\ (30\times10^{-3}) = 60\ R = \ 498.6\ \text{J}\ \#$$

解答 Cp 要是 7/2（氫氣是雙原子）

$$PV_f = nRT_f \Rightarrow 50\times10^{-3}(2000R) = 2RT_f, T_f = 50\ \text{K}$$
$$Q = nC_p(T_f - T_i) = 2\ (\frac{3}{2}\text{R+R})(50-20) = 90\text{R} = 747.9\ \text{J}\ \#$$

Q=1746

14. For open pipe,

$$f_n = \frac{nv}{2L},\ (n = 1,2,3.....)$$

For closed pipe

$$f_n = \frac{(2n-1)v}{4L},\ (n = 1,2,3.....)$$

(a) Take these two frequency into the above equation can obtain that n is closed to integer for closed pipe. So the closed pipe is the correct answer.

(b) it is closed pipe, $f_{n+1} - f_n = \frac{v}{2L} = 371, \frac{v}{2\times 0.45} = 371, v =$ 333.9 m/sec

15.每題 2 分

(a)

$$M = 18 \text{ g/mol} = 0.018 \text{ kg/mol}$$

$$v_{\text{rms}} = \sqrt{\frac{3(8.314)(1273)}{0.018}} \approx \boxed{1.33 \times 10^3 \text{ m/s}}$$

(b)

rms speeds only has to do with the translation motion so for diatomic molecule, the form of *rms* speeds is still the same as that for monatomic molecule.

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3(8.314)(400)}{0.032}} \approx \boxed{5.58 \times 10^2 \text{ m/s}}$$

(c) $Q = 4C_v(400-300) = 4(\frac{5}{2})R(400-300) = 831$ J (少 10 被，正確解答為 8310 J)

16.

(a)

$$p_1 + 1/2\ \rho v_0^2 + \rho g y_1 = p_2 + 1/2\ \rho v^2 + \rho g y_2$$

$p_1 = p_2$, $v_0 \sim 0$, $y_1 = H$, $y_2 = h$ so $v = (2g(H-h))^{1/2}$

$h = (1/2)gt^2$, $t = (2h/g)^{1/2}$, $R = vt = 2(h(H-h))^{1/2}$ #

(b) H-h (*h* and *H-h* swich the roles

17.

(a) 17. $x(t) = A \sin(\omega t + \phi)$

$v(t) = dx/dt = A\omega \cos(\omega t + \phi)$

$x(0) = A \sin(\phi) = 0.5$ (m)

$v(0) = A\omega \cos(\phi) = 0$, $\phi = \pi/2$

$x(0) = A \sin(\pi/2) = A = 0.5$ (m)

$x(t) = 0.5 \sin(\omega t + \pi/2)$ #

(b) $v(t) = dx/dt = A\omega \cos(\omega t + \pi/2)$

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{400}{2}} = 10\sqrt{2}$$

$v(t) = 5\sqrt{2} \cos(10\sqrt{2}\, t + \pi/2)$

When $x = 0.1$ m , $\sin(\omega t + \pi/2) = 0.2$, $\cos(\omega t + \pi/2) = 0.98$, $v = 6.93$ (m/s) #

(c)

$v(t) = dx/dt = A\omega \cos(\omega t + \pi/2)$

$a(t) = dv/dt = -A\omega^2 \sin(\omega t + \pi/2)$

When $x = 0.2$ m, $\sin(\omega t + \pi/2) = 0.4$, $a(t) = -40$ (m/s^2) #