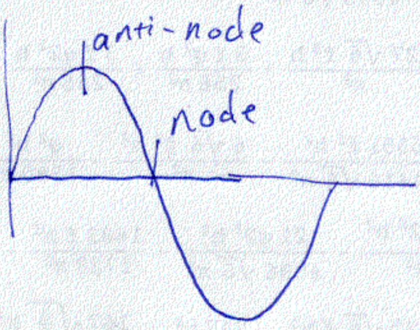
1.] a. Add $y_2 = (2\times10^{-2}\,m)\cos\left[(18\,\frac{rad}{m})x + (24.0\,\frac{rad}{s})t\right]$.

(5 pts) $y_1 + y_2 = 2 \times (2\times10^{-2}\,m)\cos\left[(18\,\frac{rad}{m})x\right]\cos(24.0\,\frac{rad}{s}t)$.



b. distance between nodes
c.
d. $=$ distance between anti-nodes

$= 2 \times$ (distance between a node and anti-node)

$= \left(\frac{\text{Wavelength}}{2}\right)$

wavelength $= \dfrac{2\pi}{(18\,\frac{rad}{m})} = \boxed{.175\ m.}$

(5 pts each). $\boxed{(d) = .0873\ m}$

2.]

a.) The air in the bell will compress in accord with the ideal gas law, $\frac{PV}{T} = (nR)$.

(15 pts)

Hence, $V_{Final} = V_i\left(\frac{P_i}{P_F}\right)\left(\frac{T_F}{T_i}\right)$.

· The Temperatures : $T_i = 20°C = 293\ K$, $\frac{T_F}{T_i} = .945$

$T_F = 4°C = 277\ K$.

· The Pressures : $P_i = P_{atmos} = 1\ atm = 1.013\times10^5\ \frac{N}{m^2}$.

$P_F = P_i + (\rho^{sea}_{H_2O})(g)\big((\text{depth of bottom of jar}) - (\text{height of water in bell})\big)$.

Assume height of H_2O in jar is small compared to depth of jar, so

$P_F \simeq P_i + \rho g(\text{depth}) = 1\ atm + 8.16\ atm = 9.16\ atm$

Hence, $\frac{P_i}{P_F} = 1/9.16 = .109$

- Volume of air in jar = (Height of air in jar)(cross-sectional area of jar)

$$V_i = A h_i$$

$$V_f = A(h_i - \underbrace{x}_{\text{height of water}})$$

- Thus, $x = h_i \left[1 - \frac{P_i}{P_F}\frac{T_F}{T_i}\right]$

$$= (\cancel{82.3}\ (2.5\,m))[1 - (.109)(.945)]$$

$$= (\cancel{82.3\,m}\ (2.5))[.897]$$

$$\boxed{= 2.24\ m}$$

b.) (5 pts) If the water is fully expelled, then the air pressure must equal that of the water at the bottom of the jar:

$$P = P_{atm} + \rho g\,(\text{depth})$$

$$= \boxed{9.16\ atm}$$

$$= 928\ kPa$$

3]

a) Isobaric Process : $P_f = P_i$

$$W = -P_i(V_f - V_i) \quad , \quad V_f = \frac{1}{2}V_i$$

$$= \frac{1}{2}P_iV_i$$

b) Isothermal Process : $T_f = T_i \Rightarrow P_iV_i = P_fV_f$

$\therefore V_f = \frac{1}{4}V_i$

$$W = -\int_{V_i}^{V_f} P\,dV$$

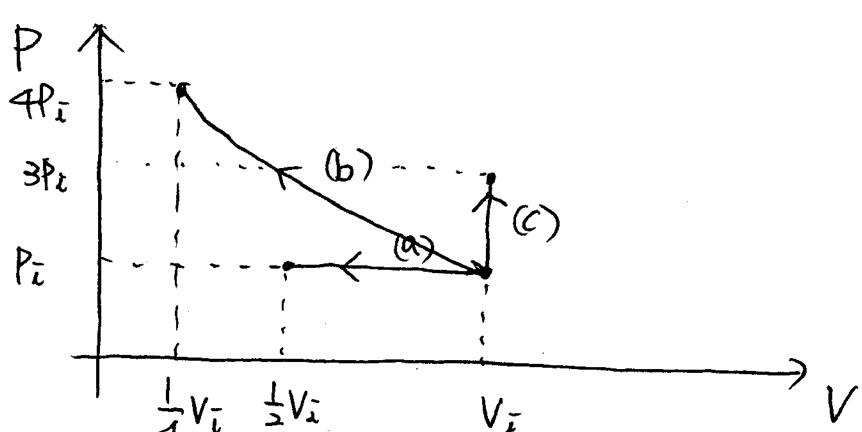
$$= -\int_{V_i}^{V_f} nRT\frac{dV}{V}$$

$$= \underset{1}{n}RT_i \ln\left(\frac{V_i}{V_f}\right)$$

$$= RT_i \ln 4$$

c) Isovolumetric Process : $\Delta V = 0$

$\therefore W = 0$



4] a) $m_{N_2} = \dfrac{28g}{N_A} = 4.65 \times 10^{-23}\ g = 4.65 \times 10^{-26}\ kg$

b) $\frac{1}{2} m_{N_2} \overline{V^2} = \frac{5}{2} k_B T$ (← This is diatomic molecule.)

$\therefore V_{rms} = \sqrt{\dfrac{5 \times (1.38 \times 10^{-23}) \times 250}{(4.65 \times 10^{-26})}}$

$= 609\ m/s$

c) Temperature is same.

$\therefore T = 250\ K$ or $-23\ °C$

d)

$$\begin{cases} \frac{1}{2} m_{N_2} \overline{V_{N_2}^2} = \frac{5}{2} k_B T \\ \frac{1}{2} m_{H_2} \overline{V_{H_2}^2} = \frac{5}{2} k_B T \end{cases}$$

$\therefore V_{H_2} = \sqrt{\dfrac{m_{N_2}}{m_{H_2}}} \cdot V_{N_2}$ ---- (1)

$= \sqrt{14} \times 609$

$= 2279\ m/s$

e) $V_{rms}^2 \propto T$

$\therefore$ T should be 4 times greater.

$\Rightarrow T = 1000\ K$

f) No. ($\because$) according to relation (1).

5] (a) $W = mgh = 73.5\text{ J}$

$\uparrow$ lifting up

$\Rightarrow$ positive work is done.

(b) $\Delta E = 0$ $(\because \text{ cyclic })$

(c) $\Delta E = \underbrace{W_{\text{done on the engine}}}_{= -W_{\text{done by the engine}}} + Q_h = 0$

$= -73.5\text{J} + Q_h$

$\therefore Q_h = 73.5\text{ J}$

(d) $\Delta E = -73.5\text{ J} + \underbrace{90\text{ J}}_{= Q_c} + Q_h = 0$

$\therefore Q_h = 163.5\text{ J}$

(e) $e = \dfrac{W}{Q_h} = \dfrac{73.5}{163.5} = 0.45$

(f) For Carnot's engine,

$$\frac{T_c}{T_h} = \frac{Q_c}{Q_h} = \frac{90}{163.5} = 0.55$$