Written assignment #1
Solution

Q1. The hole will increase. We can imagine a copper square that formed this hole: it clearly increases when heated. Before the square is cut it is clear that the sheet would increase uniformly, so the hole size will always match the square size

Q2

In the deep

$T_D = 5^\circ C = 278 K$

$V_0 = 0.5 cm^3 = 5 \cdot 10^{-7} m^3$

$P_D = P_S + \rho g h$

On the surface

$T_S = 20^\circ C = 293 K$

$V_S - ?$

P_S

$P_D V_0 = nRT_D$

$P_S V_S = nRT_S$

$$\frac{P_D V_0}{T_D} = \frac{P_S V_S}{T_S}$$

$$V_S = \frac{T_S}{T_D} \frac{P_D}{P_S} V_0$$

Q3

Since two sections are at two different temperature, as they come to thermal equilibrium the divider will slide to keep preasures equal.

In the equilibrium

P, $\frac{V}{2} + A\Delta x$	P, $\frac{V}{2} - A\Delta x$
T, N	T, $N/2$

$V = A \cdot L$

$$P\left(\frac{V}{2} + A\Delta x\right) = N k_B T$$

$$P\left(\frac{V}{2} - A\Delta x\right) = \frac{N}{2} k_B T$$

$$2\left(\frac{V}{2} + A\Delta x\right) = \left(\frac{V}{2} + A\Delta x\right)$$

$$3A\Delta x = \frac{V}{2} = \frac{1}{2} A \cdot L$$

$$\Delta x = L/6$$

Q4

a) Since the temperature of gas doesn't change

$P_0 \cdot V_0 = P_1 V_1$

no piston   w/piston $P_1 = P_0 + 4Mg/\pi d^2$

$$V_1 = V_0 \frac{1}{1 + 4Mg/\pi d^2 P_0}$$

With the dog on $\quad P_0 V_0 = P_2 V_2 \;;\; P_2 = P_0 + \frac{4(M+m)g}{\pi d^2}$

$$V_2 = V_0 \frac{1}{1 + \frac{4mg}{\pi d^2 P_0}}$$

$V_0 = \frac{\pi d^2}{4} \cdot H$

$V_1 = \frac{\pi d^2}{4} h_i$

$V_2 = \frac{\pi d^2}{4} (h_i + \Delta h)$

$$\cancel{\frac{\pi d^2}{4}} \cdot \Delta h = V_2 - V_1 = \cancel{\frac{\pi d^2}{4}} \cdot H \left[\frac{1}{1 + \frac{4Mg}{\pi d^2 P_0}} - \frac{1}{1 + \frac{4(m+M)g}{\pi d^2 P_0}} \right]$$

$$\Delta h = H \frac{4mg/\pi d^2 P_0}{\left(1 + \frac{4Mg}{\pi d^2 P_0}\right)\left(1 + \frac{4(m+M)g}{\pi d^2 P_0}\right)} \approx \frac{4mg H}{\pi d^2 P_0} = 2.6\,\text{mm}$$

since $\frac{Mg}{\pi d^2 P_0}, \frac{mg}{\pi d^2 P_0} << 1$

b) $P_2 V_2 = nRT$

$P_2 V_1 = nR(T + \Delta T)$ $P_2 V_2 = nRT \Rightarrow \frac{nR}{P_2} = \frac{T}{V_2}$

$nR\Delta T = P_2 (V_1 - V_2) \longrightarrow \frac{\Delta T}{T} = \frac{V_1 - V_2}{V_2} \approx \frac{\Delta h}{H}$

$\Delta T = T \frac{\Delta h}{H} = 0.38°$ (T here must be in K)!

$T_{final} = 20°C + 0.38°C = 20.38°C$