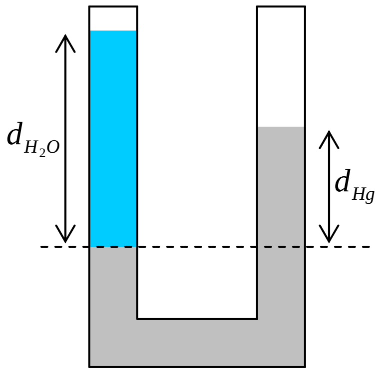
Physics 213 / Spring 2007 **Name: ________Answer Key______________________**
Dr. Zimmerman
Quiz 1, Ch. 15

I expect you to show *all* your work (if you want full credit, that is).

A U-shaped tube, opened to air on both ends, contains mercury ($\rho_{Hg} = 13,600\ kg/m^3$). Water is poured in the left arm until the water column is $10.0\ cm$ deep. How far upward *from its initial position* does the mercury in the right arm rise?



$$P_{H_2O} = \rho_{H_2O}\, g\, d_{H_2O} = \rho_{Hg}\, g\, d_{Hg} = P_{Hg}$$

$$d_{Hg} = \frac{\rho_{H_2O}}{\rho_{Hg}} d_{H_2O} = 7.35\ mm \quad \text{\{final height\}}$$

Initial height is $3.68\ mm$, so the difference is $\boxed{3.68\ mm}$

Physics 213 / Spring 2007 **Name: ________Answer Key_______________________**
Dr. Zimmerman
Quiz 2, Ch. 16

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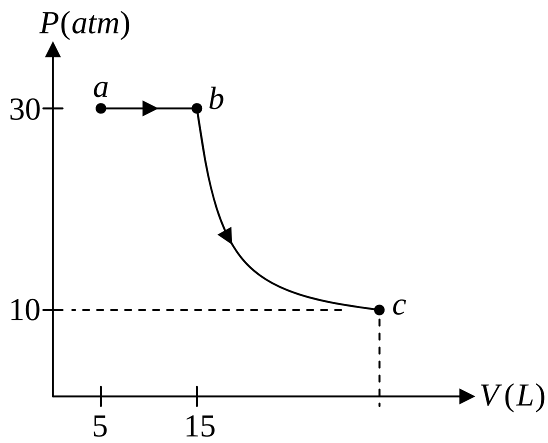
3 moles of ideal gas, occupying $5\,L$, is taken along the isobar from $a \to b$ and then along the isotherm from $b \to c$. Determine the temperature at point b and the volume at point c.



(a) $\frac{V_a}{T_a} = \frac{V_b}{T_b} \quad \to \quad T_b = \left(\frac{V_b}{V_a}\right) T_a$

$$T_a = \frac{P_a V_a}{nR} = \frac{(30\ atm)(5\ L)}{3(0.0821\ atm \cdot L / mol \cdot K)} = 609\ K$$

$$T_b = \left(\frac{15}{5}\right) 609\ K = \boxed{1827\ K}$$

(b) $P_b V_b = P_c V_c$

$$(30\ atm)(15\ L) = (10\ atm) V_c$$

$$V_c = \boxed{45\ L}$$

Physics 213 / Spring 2007 **Name: ANSWER KEY**
Dr. Zimmerman
Quiz 3, Ch. 18

I expect you to show *all* your work (if you want full credit, that is).

In some physical systems, single particles (such as electrons) are confined to move on a 2-dimensional surface. (a) If such particles are treated as an ideal gas, determine the translational energy per particle from the equipartition theorem. (b) What is the *rms* speed of these electrons ($m = 9.1 \times 10^{-31}\ kg$) at $300\ K$? (c) If there are $N = 3.0 \times 10^{22}$ such electrons, what is the change in the internal energy of the system if the temperature is decreased from room temperature to the boiling point of liquid helium ($300\ K \rightarrow 4.2\ K$)?

(a) There are two translational degrees of freedom so, $\varepsilon_{avg} = 2(\tfrac{1}{2} k_B T) = \boxed{k_B T}$

(b) $\tfrac{1}{2} m v_{rms}^2 = k_B T$

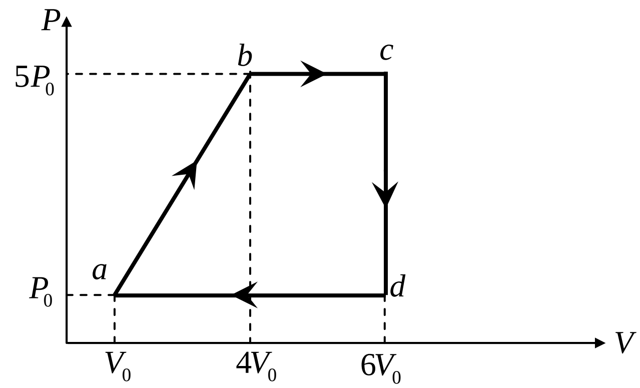
$$v_{rms} = \sqrt{\frac{2k_B T}{m}} = \boxed{95.3\ km/s}$$

(c) $\Delta E = N k_B \Delta T = \boxed{-122.5\ J}$

Physics 213 / Spring 2007 **Name: Answer Key**
Dr. Zimmerman
Quiz 4, Ch. 19

I expect you to show *all* your work (if you want full credit, that is).

Consider the heat engine cycle shown below. (a) Determine the efficiency of the engine. (b) How does the actual efficiency compare to the Carnot efficiency? (c) If the thermodynamic variables are assigned the values $P_0 = 1 atm$ and $V_0 = 3.8L$, how much work is extracted per cycle?



$$T_a = \frac{P_0V_0}{nR} \quad T_b = \frac{20P_0V_0}{nR}$$
$$T_c = \frac{30P_0V_0}{nR} \quad T_d = \frac{6P_0V_0}{nR}$$

$$W_{a\to b} = 9P_0V_0$$
$$\Delta E_{a\to b} = \tfrac{3}{2}nR\left(\frac{19P_0V_0}{nR}\right) = \frac{57P_0V_0}{2}$$
$$Q_{a\to b} = \Delta E + W = 28.5P_0V_0 + 9P_0V_0 = 37.5P_0V_0$$

$$W_{b\to c} = 10P_0V_0$$
$$\Delta E_{b\to c} = \tfrac{3}{2}nR\left(\frac{10P_0V_0}{nR}\right) = 15P_0V_0$$
$$Q_{b\to c} = 15P_0V_0 + 10P_0V_0 = 25P_0V_0$$

$$W_{c\to d} = 0$$
$$\Delta E_{c\to d} = \tfrac{3}{2}nR\left(\frac{-24P_0V_0}{nR}\right) = -36P_0V_0$$
$$Q_{b\to c} = \Delta E = -36P_0V_0$$

$$W_{d\to a} = -5P_0V_0$$
$$\Delta E_{d\to a} = \tfrac{3}{2}nR\left(\frac{-5P_0V_0}{nR}\right) = -7.5P_0V_0$$
$$Q_{d\to a} = -7.5P_0V_0 - 5P_0V_0 = -12.5P_0V_0$$

$$Q_H = 37.5P_0V_0 + 25P_0V_0 = 62.5P_0V_0$$
$$Q_C = -36P_0V_0 - 12.5P_0V_0 = -48.5P_0V_0$$

(a) $\eta = 1 - \frac{|Q_C|}{Q_H} = 1 - \frac{48.5}{62.5} = \boxed{0.224}$

(b) $\eta_C = 1 - \frac{T_C}{T_H} = 1 - \frac{1}{30} = \boxed{0.967}$

Quite a difference between the actual efficiency and the Carnot efficiency!

(c) $W_{cycle} = 9P_0V_0 + 10P_0V_0 + 0 - 5P_0V_0 = 14P_0V_0$

$$W_{cycle} = 14(1.013\times10^5\ Pa)(0.0038\ m^3) = \boxed{5860\ J}$$