1a) $P(2) = \binom{5}{2}\left(\frac{2}{3}\right)^2\left(\frac{1}{3}\right)^3 = 10\ \frac{4}{9}\ \frac{1}{27} = \frac{40}{243}$

b) $V_{rms} = \sqrt{\frac{3k_BT}{m}} \Rightarrow \frac{T_{He}}{m_{He}} = \frac{T_{Ar}}{m_{Ar}}$

$$\frac{T_{Ar}}{T_{He}} = \frac{m_{Ar}}{m_{He}} = 10$$

c) $\lambda = \frac{1}{\sqrt{2}\sigma n}$ independent of T

d) $V = \frac{Nk_BT}{p}$ $\quad K_T = -\frac{1}{V}\left(\frac{\partial V}{\partial p}\right)_T = +\frac{1}{V}\frac{Nk_BT}{p^2}$

$$K_T = \frac{1}{p}$$

2) $P(\vec{v})\,d^2v = \frac{m}{2\pi k_BT}\,e^{-\frac{m}{2}\vec{v}^2/k_BT}\,dv_x\,dv_y$

$$= \frac{m}{2\pi k_BT}\,e^{-\frac{m}{2}v^2/k_BT}\,2\pi v\,dv$$

$$f(v) = \frac{m}{k_BT}\,v\,e^{-\frac{m}{2}v^2/k_BT}$$

<u>normalization</u> $\quad u = \frac{m}{2}v^2/k_BT$

$$du = \frac{m}{k_BT}v\,dv$$

$$\int_0^\infty f(v)\,dv = \int_0^\infty e^{-u} = 1$$

3) a) $p_e = \frac{1}{1+e^{-\beta\varepsilon}}$

b) $p_s = \frac{e^{-\beta\varepsilon}}{1+e^{-\beta\varepsilon}}$

c) $\langle L \rangle = N\left(p_e 2a + p_s a\right)$

$= Na \frac{2 + e^{-\beta\varepsilon}}{1+e^{-\beta\varepsilon}}$

d) $T \to 0,\ \beta \to \infty$ $\qquad \langle L \rangle = 2Na$

e) $T \to \infty,\ \beta \to 0$ $\qquad \langle L \rangle = \frac{3}{2} Na$

4) $pV = Nk_BT$

a) $T_A = \frac{p_0 V_0}{Nk_B}$, $\quad T_B = \frac{2p_0V_0}{Nk_B}$, $\quad T_C = \frac{2p_0V_0}{Nk_B}$

b) $\delta W_{A\to B} = 0 \qquad (V = \text{const})$

c) $\Delta U = \cancel{\Delta W} + \Delta Q \qquad \Delta Q = \Delta U = \frac{3}{2}Nk_B(T_B - T_A)$

$= \frac{3}{2} p_0 V_0$

d) $\delta W = -p\,dV = -\frac{Nk_BT}{V}dV$

$\Delta W = -\int_{V_0}^{2V_0} \frac{Nk_BT}{V}dV = -Nk_BT \ln\frac{2V_0}{V_0} = -2p_0V_0 \ln(2)$

$\Delta U = 0 = \Delta W + \Delta Q \Rightarrow \Delta Q = 2p_0V_0\ln(2)$