1 –

$\not{m} g h = \not{m} c_m \Delta T \iff h = \frac{c\,\Delta T}{g}$

$g = 9{,}8\ m/s$

$\Delta T = 1°C$

$c = 1\ cal\, g^{-1}\, °C^{-1}$

$h = \frac{1}{9{,}8} = \frac{4186}{9{,}8} \times 10^3 = 427\ m$

2 –

$-20°C \rightarrow 0 \rightarrow 100°C$

– De $-20°C$ a 0

$Q_1 = m c_m \Delta T = 200 \times 20 \times 0{,}5 = 2000$

– Em 0

$Q_2 = m\lambda = 200 \times 80 = 16\,000$

– De 0 a 100°C

$Q_3 = m c_m \Delta T = 200 \times 1 \times 100 = 20\,000$

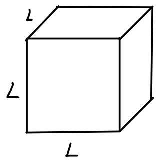
– Em 100°C

$Q_4 = m\lambda = 200 \times 540 = 108\,000$

$\sum Q = Q_1 + Q_2 + Q_3 + Q_4 = 146\,000\ cal = 6.11 \times 10^5\ J$

3 – a) $Q = m c_m \Delta T = 1000 \times 0.384 \times 30 = 11,52 \times 10^3\ J$

b) Bloco



$dL = \alpha_c L\, dT$

$dV = \beta_c V\, dT$

$V = L^3$

$\rightarrow V + \Delta V = (L + \Delta L)^3 = L^3 + 3L^2 \Delta L + 3L\, \Delta L^2 + \Delta L^3$

Considerando dilatações pequenas ($L \gg \Delta L$)

$V + \Delta V = L^3 + 3L^2 \Delta L \iff V + \Delta V = V + 3\frac{\Delta L}{L} V$

Logo $\Delta V \approx 3 \cdot \frac{\alpha_c L\, dT}{L} V = 3\alpha_c\, dT\, V \Rightarrow \beta_c = 3\alpha_c$ //

c) $W = -\int P\, dV = P\Delta V = 171.525 \times 10^{-3}\ atm\ cm^3 = 17.4 \times 10^{-2}\ J$

$\Delta V = V_f - V_i = V_i(1 + \alpha\Delta T) - V_i = \beta V_i \Delta T = 3\alpha V_i \Delta T$

$\alpha = 1{,}7 \times 10^{-5}\ K^{-1}$ $\qquad V_i = \frac{m}{\rho} = 112.108\ cm^3$

$\Delta T = 30\ K$

d) $\Delta U = Q + W = 1.152 \times 10^4\ J$

4 – a) Monoatômico $\Rightarrow$ 3 graus de translação $\Rightarrow U = \frac{3N}{2} K_B T$

$C_V = \frac{1}{m}\frac{dU}{dT} = \frac{3}{2}\frac{N}{m} K_B = \frac{3}{2} R$

b) Diatomico $\Rightarrow$ 3 translação + 2 rotação $\Rightarrow U = \frac{5N}{2} K_B T$

$C_V = \frac{5}{2} R$

c) Diatomico + altas temps $\Rightarrow$ 3 translação + 2 rotação + 2x1 vibração $\Rightarrow U = \frac{7N}{2} K_B T$

$C_V = \frac{7}{2} R$

d) Triatomico + altas Temp.

Linear: 3 translação

2 rotação

2x4 vibração

$C_V = \frac{13}{2} R$

Não linear: 3 translação

3 rotação

2x3 vibração

$C_V = \frac{12}{2} R = 6R$

e) Sólido: 0 translação

0 rotação

2x3 vibração

$C_V = \frac{6R}{2} = 3R$

5) a) N_2 e O_2 são diatomicos

$U = \frac{5}{2} k_B N T$ $\quad c_V = \frac{1}{n}\frac{dU}{dT} = \frac{5}{2}R = 20.785 \ J K^{-1} mol^{-1}$

$c_p = c_V + R = 29.099 \ J K^{-1} mol^{-1}$

b) $n_{N_2} = 0,785$ mol N_2 $\quad n_{O_2} = 0,215$ mol O_2

$m_{N_2} = 28 g/mol$ $\quad m_{O_2} = 32 g/mol$

$$0.785 + 0.215 = \frac{0.785 \cdot 28 + 0.215 \cdot 32}{M} \Leftrightarrow M = 28.86 \ g/mol$$

$$\rho = \frac{m}{V} = \frac{m \cdot P}{nRT} = \frac{MP}{RT}$$

$M = 28.86$ g/mol $\quad J = Pa/m^3$

$P = 1$ atm $\quad 1 atm = 1,013 \times 10^5 Pa$

$R = 8.314 \ J K^{-1} mol^{-1}$

$T = 273 K$

$$\rho = 1289 g/m^3 = 1.29 kg/m^3$$

c) $c_{mV} = \frac{c_V}{M} = 0.72 \ J K^{-1} g^{-1}$

6 $V = 120 L = 0.12 m^3$

$A_p = 0,8 \times 0,5 = 0.4 m^2$

$\Delta V = 0 \quad \Delta T \neq 0$

Porta aberta: $p_a = 1 atm$

$T_a = -8°C = 265 K$

Porta fechada: $p_f = ?$

$T_f = -10°C = 263 K$

Ar é perfeito: $PV = nRT$

$P_a V = n R T_a \Rightarrow n = \frac{P_a V}{R T_a}$

$P_f V = \frac{P_a V}{R T_a} R T_f \Rightarrow P_f = \frac{P_a}{T_a} T_f$

$$F = (P_{atm} - P_f) A_p = \left(P_a - \frac{P_a}{T_a} T_f\right) A_p = P_a A_p \left(1 - \frac{T_f}{T_a}\right) = 305.8 N$$

7. $p_i = 1,2$ atm $\quad m = 1 kg$

$T_i = 300 K \quad h = 50 cm$

$V_i = 1 L$

a) $P_i = P_{atm} + (m+M)\frac{g}{A_p} \Leftrightarrow (P_i - P_{atm})\frac{A_p}{g} - m = M \Leftrightarrow \frac{40.52}{9.8} - 1 = M = 3,13 kg$

$A_p = \frac{V_i}{h_i} = 2 \times 10^{-3} m^2$

b) $P_f = P_{atm} + m\frac{g}{A_p} = 1.05$ atm

c) $dU = \delta W + \delta Q$

Adiabática $\Rightarrow \delta Q = 0$

$\Delta U = W \quad U = \frac{3}{2} PV \rightarrow \Delta U = \frac{3}{2}(P_f V_f - P_i V_i)$

$$W = -\int_{V_i}^{V_f} P_f dV = -P_f (V_f - V_i)$$

$\frac{3}{2}(P_f V_f - P_i V_i) = P_f (V_i - V_f) \Leftrightarrow$

$\Leftrightarrow \frac{V_f}{V_i} = \frac{2P_f + 3P_i}{5P_f} = 1.09$

d) $W = - - P_f (V_f - V_i) = 4.54 J$

e) $\frac{P_f V_f}{P_i V_i} = \frac{T_f}{T_i} \rightarrow T_f = 285 K$

8 Reservatório (H_e)

$V = 5L = 5 \times 10^{-3}\ m^3$

Paredes rígidas $\Rightarrow \Delta V = 0$

Adiabática $\Rightarrow \delta Q = 0 \Rightarrow \Delta U = W$

$V_H = 4L$ $P_H = 1atm$ $T_H = 300\ K$

Balão (O_2)

$V_B = 1L$

$T_B = T_H$

$P_{bor} = \frac{K}{V_B}$

$K = 0.1\ atm\ L$

$C_{VO_2} = \frac{5}{2} R$

a) $m = ?$ $PV = mRT$

$P_B = P_{atm} + P_{bor} = 1 + \frac{K}{V_B}\ atm \rightarrow \left(1 + \frac{K}{V_B}\right) \cdot 1{,}013 \times 10^5\ Pa$

$P_B V_B = m R T_B \Rightarrow m = \frac{P_B V_B}{R T_B} = 0.045\ mol$

b) $p' = 0.1\ atm$ $\Delta T = 0$

Adiabática $\Rightarrow \Delta U = W$

$V'_B = 2L$

b1) Adiabática: $pV^{\gamma} = cnt. \rightarrow TV^{\gamma-1} = cnt.$

Estado inicial = Estado final $\Rightarrow T_{iO_2} V_{iO_2}^{\gamma-1} = T_{f,O_2} V_{f,O_2}^{\gamma-1}$

$\gamma = \frac{c_P}{c_V} = \frac{c_V + R}{c_V} = 1 + \frac{R}{c_V} = 1 + \frac{R}{\frac{5}{2}R} = \frac{7}{5}$

Logo $T_{fO_2} = T_{iO_2} \left(\frac{V_B}{V'_B}\right)^{\gamma-1} \Rightarrow T_{fO_2} = 300 \cdot \left(\frac{1}{2}\right)^{\frac{7}{5}-1} \approx 227{,}36\ K$

b2) $p' = \frac{mRT'}{V'} = 0.42\ atm$

$p'_{eq} = P_{He} + \frac{K}{V_B} = 0.15\ atm$

b3) $P_{vap} > P'_{O_2}$

$T_{vap} << T'_{O_2}$

$\Rightarrow$ Estado gasoso

b4) Adiabática $\rightarrow \Delta U = W$

$dU = m c_V dt$

$W = m c_V (T'_{O_2} - T_{O_2}) = -67{,}9\ J$

Trabalho fornecido $W = 67{,}9\ J$

b5) $m_{HE} = \frac{P_{HE} V_{HE}}{R\ T_{HE}} = 0\ 012\ mol$

$\Delta U = 0 \Leftrightarrow m_{O_2} c_{V_{O_2}} (T_{eq} - T_{O_2}) = m_{HE} c_{V_{HE}} (T_{eq} - T_{HE}) = 0 \Leftrightarrow$

$\Leftrightarrow T_{eq} = \frac{5 m_{O_2} T_{O_2} + 3 m_{HE} T_{HE}}{5 m_{O_2} + 3 m_{HE}} = 237{,}4K$ //

9) a) A: $m_{N_2} = 28\,g\,mol^{-1}$ B: $m_{HE} = 4\,g\,mol^{-1}$

$P_A = 6\,atm$ $P_B = 1.5\,atm$

$T_A = 290K$ $T_B = T_A = 290K$

$V_A = 2L$ $V_B = 4L$

$n_A = \frac{P_A V_A}{R T_A} = 0.5\,mol$ $n_B = \frac{P_B V_B}{R T_B} = 0.25\,mol$

b) A: $U_A = \frac{5}{2} N k_B T_A = \frac{5}{2} n_A R T_A = 3\,kJ$

$C_{V_A} = \frac{5}{2} R = 20.785\,J\,K^{-1}\,mol^{-1}$

$C_{P_A} = C_{V_A} + R = 29.099\,J\,K^{-1}\,mol^{-1}$

B: $U_B = \frac{3}{2} n_B R T_B = 904\,J$

$C_{V_B} = \frac{3}{2} R = 12.471\,J\,K^{-1}\,mol^{-1}$

$C_{P_B} = C_{V_B} + R = 20.785\,J\,K^{-1}\,mol^{-1}$

c) $\rho_A = \frac{m_A}{V_A} = \frac{m_{N_2} \cdot n_A}{V_A} = 7\,Kg/m^3$

$\rho_B = \frac{m_B}{V_B} = \frac{m_{HE} \cdot n_B}{V_B} = 0.25\,Kg/m^3$

d) $\sqrt{\overline{v^2}} = \sqrt{\frac{3 K_B T}{m_0}}$

$V_q(N_2) = \sqrt{\frac{3 k_B T_A}{m_0 N_2}}$

$V_q(H_E) = \sqrt{\frac{3 k_B T_B}{m_0 H_E}}$

$\frac{V_q(N_2)}{V_q(H_E)} = \sqrt{\frac{m_{0HE}}{m_{0N_2}}} = \sqrt{\frac{N_A m_{0HE}}{N_A m_{0N_2}}} = \sqrt{\frac{4}{28}} = 0.38$

e) e1) $\Delta U = Q + W$ | $Q = 0$, $W = 0$ $\Rightarrow \Delta U = 0$

Como $U = U(T)$ e $\Delta U = 0 \Rightarrow \Delta T = 0 \Rightarrow T_{eq} = 290K$

e2) $U = U(T)$ Mas $\Delta T = 0$ $U = U_A + U_B = 3.9\,kJ$

e3) $P = \frac{n}{V} R T_{eq} \Leftrightarrow P_{eq} = \frac{n_{N_2} + n_{HE}}{V_A + V_B} R T_{eq} = 3\,atm$

$P_{eq} = P_{N_2} + P_{HE} = \frac{n_{N_2}}{V_A + V_B} R T_{eq} + \frac{n_{HE}}{V_A + V_B} R T_{eq} = 3\,atm \rightarrow$ Verifica-se!!

f) $\Delta T = 0$

$P'_{eq} = \frac{n_T}{V'} R T_{eq} = \frac{P_{eq}}{0.98} = 3.06\,atm$

$U = U(T)$ Mas $\Delta T = 0$ $U = U_A + U_B = 3.9\,kJ$