1- a) $pV = nRT \Leftrightarrow n = \frac{PV}{RT} = 4.9$ moles

$V = 100L$

$p = 1$ atm

$T = -23°C$

b) $C_V = \frac{\#}{2}R = \frac{5}{2}R = 20.785$ $\quad \gamma = \frac{C_p}{C_V} = 1.4$

$C_p = C_V + R = \frac{7}{2}R = 29.094$

c) $\Delta U = Q$

$\Delta U = mC_V\Delta T \Rightarrow Q = mC_V\Delta T = -509$ J

d) $V = 100 \times 10^{-3}$

$T = -28°C$ $\Rightarrow P_f = \frac{mRT}{V} = 0.985$ atm

$F = (P_a - P_f)A = 745$ N

e) $P_iV_i^\gamma = P_fV_f^\gamma \Rightarrow P_f = 0.862$ atm

$T_iV_i^{\gamma-1} = T_fV_f^{\gamma-1} \Rightarrow T_f = 235.8$ K $= 37°C$

4) $m = 1$ g

$T_g = 0°C$

$T_{am} = 10°C$

$P = 1$ atm

a) $C_V = \frac{5}{2}R$ $\quad C_p = C_V + R = \frac{7}{2}R$

b) $\Delta U = Q = m\lambda = 1 \cdot 80$ cal $= 334.88$ J

$\Delta U = mC_V\Delta T \Rightarrow \Delta T = \frac{\Delta U}{mC_V} \simeq 8 \Rightarrow T_{cal} = 1.94°C$

c) $Q_{água} + Q_{cal} = 0 \Leftrightarrow m_{ag}c_{m,ag}\Delta T_{ag} + m_{cal}c_{V,cal}\Delta T_{cal} = 0$

$T_{eq} = \frac{m_{ag}c_{m,ag}T_{fusão} + m_{cal}c_{V,cal}T_{fcal}}{m_{ag}c_{m,ag} + m_{cal}c_{V,cal}} = 1.79°C$

d) $dS_g = \frac{dq_g}{T} \Rightarrow \Delta S = \int \frac{dq_g}{T_f} = \frac{m_g\lambda_{fus}}{T_f} = 1.23$ J/K

2 - $\Delta S = \frac{\Delta Q_{rr}}{T} = \frac{m\lambda}{T} = \frac{1 \times 10^{-3} \times 10^3 \times 540}{373} = 1.447$ cal/K

$T = 100°C \rightarrow 373$ K

3- $m = 100$ g

$\Delta S = \frac{\Delta Q}{T}$

a) $\Delta S_{gelo} = \frac{m\lambda}{T} = \frac{100g \cdot 80\,cal/g \cdot 4.186\,J/cal}{273 + 0} = 122,7$ J/K

$\Delta S_{amb} = \frac{-m\lambda}{T_{amb}} = -\frac{100 \cdot 80 \cdot 4.186\,J}{273 + 30\,K} = -110.5$ J/K

$\Delta S_U = \Delta S_{gelo} + \Delta S_{amb} = 12,2$ J/K

b) Se $T_{amb} = 0°C \Rightarrow \Delta S_{gelo} = -\Delta S_{amb} \Rightarrow \Delta S_U = 0$

5. $V_{cu} = 1L = 1dm^3$

$T_f = 1083°C = 1356$ K

$T_{água} = 20°C = 293$ K

a) 6 graus de liberdade $\Rightarrow C_V = \frac{6}{2}R = 3R$

$C_{m,V} = \frac{C_V}{M_{cu}} = 0.39$ J K^{-1} g^{-1}

b) $Q_A = m_{cu} \cdot C_{mV}(T_A - T_f) \Rightarrow 3.412$ MJ

$m_{cu} = \rho V_{cu}$

c) $Q_A = m_{ag} \cdot C_{m,Pag}(T_{fag} - T_{ag}) + m_{ag}\lambda_{fag}$ $\Rightarrow V_A = \frac{Q_A}{\rho_{ag}} \frac{1}{C_{m,Pag}(T_{fag} - T_{ag}) + \lambda_{fag}} = 1.31L$

$m_{ag} = \rho_{ag}V_A$

d) $dS = \frac{dQ}{T} \Rightarrow dS = \frac{PV}{M}C_V\frac{dT}{T} \Rightarrow \Delta S = \int_{T_{cu}}^{T_A} \frac{PV}{M}C_V\frac{1}{T}dT = \frac{PV}{M}C_V\ln\left(\frac{T_A}{T_{cu}}\right) = -4.5$ J/K

e) $\Delta U = 0 \Rightarrow Q_{Bag} + Q_{Bcu} = 0 \Leftrightarrow \frac{\overbrace{PV}^{ag}}{M}C_V(T_{eq} - T_A) + \frac{\overbrace{PV}^{cu}}{M}C_{mV}(T_{eq} - T_{ag}) \Rightarrow T_{eq} = 307,8K = 34,8°C$

6 - $m = 1$ $\quad A = 10\,cm^2$

$P_i = 1$ bar $\quad M = 20$ kg

$T_i = 300$ K $\quad \Delta T = 0 \Rightarrow \Delta U = 0$

a) $F = P \cdot A \Leftrightarrow m \cdot a = P \cdot A \Leftrightarrow P = \frac{mg}{A} = 1.985$ atm

1 bar $= 10^5$ Pa $= 1.013$ atm

$P_f = 1.013 + 1.985 = 2.998 \simeq 3$ atm

b) $\Delta U = 0 \Rightarrow Q = -W =$

$W = -\int P_{ext}\,dV = -P_f\Delta V = -P_f\,nR\left(\frac{T}{P_f} - \frac{T}{P_i}\right) = -mRT\left(1 - \frac{P_f}{P_i}\right) = 488$ J

$Q = -W = -488$ J

c) $\Delta S_U = \Delta S_{gás} + \Delta S_{amb}$

$T\Delta S_{gás} = P_{ext}\Delta V \Leftrightarrow dS_{gás} = \frac{P_{ext}}{T}dV \Leftrightarrow \Delta S_{gás} = nR\ln\left(\frac{P_i}{P_f}\right) \simeq -9$ J/K

$\Delta S_{Amb} = -\frac{Q}{T} = \frac{488}{300} \simeq 16,3$ J/K

$\Delta S_{Uno} = 7,3$ J/K $> 0 \Rightarrow$ irreversível

7. $P_i = 6 \times 10^5$ Pa $\quad$ Adiabática

$T_i = 3000$ K $\quad T_f = 2000$ K

$V_i = 40L$

$\gamma = \frac{5}{3}$

a) $PV = mRT$

$m = \frac{P_iV_i}{RT_i} = 0.96$ mol

b) $\Delta U = mC_V\Delta T \Rightarrow -12$ kJ $\Rightarrow W_{gás} = 12$ kJ $\quad \Delta U = W$! $\quad Q = 0$

c1) $T_iV_i^{\gamma-1} = T_fV_f^{\gamma-1}$ $\quad$ c2) $P_iV_i^\gamma = P_fV_f^\gamma$

$V_f = \sqrt[\gamma-1]{\frac{T_iV_i^{\gamma-1}}{T_f}} = 73.5L$ $\quad P_f = \frac{P_iV_i^\gamma}{V_f^\gamma} = 2.2 \times 10^5$ Pa

d1) $W = P_{ext}(V_f - V_i) \Rightarrow \frac{W}{P_{ext}} + V_i = V_f = 158,5L$ $\quad (P_{ext} = 1$ atm$)$

d2) $\Delta S = \int dS = \int \frac{dQ_R}{T}$

$\Delta S_{ext} = \frac{1}{T_{ext}}\int dQ_R = 0$

$\Delta S_{s.} = \int \frac{dQ_R}{T} = \int \frac{dU}{T} - \int \frac{dW}{T} = mC_V\ln\left(\frac{T_f}{T_i}\right) + mR\ln\left(\frac{V_f}{V_i}\right) = 6,1$ J K^{-1}

8 a) $T_i = 200$ K $\Rightarrow T_f = 200$ K

$P_f = \frac{mRT}{V_f} = 831.4$ Pa

b) $P_i = \frac{mRT}{V_i}$ $\quad T' = \frac{P_iV_f}{mR} = \frac{mRTV_f}{V_imR} = \frac{TV_f}{V_i} = 2T \rightarrow 400$ K

$\Delta U = mC_V\Delta T \Leftrightarrow Q = mC_V\Delta T = 4157$ J

c) d/dão

d) $\Delta U = -mgh$

$C_V = \frac{1}{m}\frac{\Delta U}{\Delta T} \rightarrow \Delta U = C_V\,m\,\Delta T$

$\frac{-mgh}{C_Vm} = T_f - T_i \Leftrightarrow T_f = T_i - \frac{ghm}{C_Vm} \Rightarrow$

$\Rightarrow T_f = 190$ K

$P = \frac{mRT}{V} = 784$ Pa

e) $Q = \frac{5}{2}Rm(T_i - T_f) = 4361$ J

f) $\Delta S_{U_{tot}} = \Delta S_{s.s} + \Delta S_{amb}$

$dU = \delta Q + \delta W \Leftrightarrow mC_VdT = TdS - pdV \Leftrightarrow dS = mC_V\frac{dT}{T} + mR\frac{dV}{V}$

$\Delta S_{s.s} = mC_V\ln\left(\frac{T_f}{T_i}\right) + mR\ln\left(\frac{V_f}{V_i}\right)$

$\Delta S_U = \Delta S_{s.s}$ Logo 1- Processo $\quad \Delta S_U = mR\ln(2) = 5,76$ J/K

2- Processo $\quad \Delta S_U = mR\left(\frac{5}{2}\ln\left(\frac{T_f}{T_i}\right) + \ln(2)\right) = 4,72$ J/K

9) $C_V = \frac{3}{2}R$ $A = 20\,cm^2$

$T_0 = 300\,K$ $P_0 = 1\,atm$ $V_0 = 1\,L$

a) $M = 10\,kg$ a1) $P_i = P_0 + P = 1.48\,atm$ a2) $P_i V_i = nRT \Rightarrow V_i = \frac{nRT}{P_i}$ a3) $\Delta T = 0 \Rightarrow \Delta U = 0$

$P = \frac{F}{A} = \frac{Mxg}{A} = 0.48\,atm$ $P_0 V_0 = nRT$ $\hookrightarrow V_i = \frac{P_0 V_0}{P_i} = 0.67\,L$ $W = -Q = -\int P dV = -(P_0 + \frac{Mg}{A})(V_f - V_i) = 49\,J$

b) b1) $P_f = 1\,atm$ b2) $W = -Q = P_{ext}(V_i - V_f) = -33.4\,J$

$V_f = 1\,L$

c) $\Delta S = \Delta S_{Sis} + \Delta S_{Ext} \Rightarrow \Delta S_{iso} = 0$ e $\Delta S_{Ext} = \frac{1}{T_{ext}} Q_{tr} = 0.054\,JK^{-1}$

10 - $C_V = \frac{3}{2}R$ $T_1 = 400\,K \rightarrow \Delta P = 0 \rightarrow V_1$ c) Cdo $\Rightarrow \Delta S = 0$

$\Delta U = 0$

$W = 0$

$Q = 0$

$T_0 = 300\,K$ $T_0 = 300\,K \rightarrow \Delta P = 0 \rightarrow V_0$

$P_0 = 1\,atm$

$V_0 = 1\,dm^3 = 1 \times 10^{-3}\,m^3$ a) $\Delta U = nC_V \Delta T = \frac{P_0 V_0}{RT_0} C_V (T_1 - T_0) = 50.65\,J$ d) É irreversível

b) $W = -\int P dV = -P(V_f - V_i) = -P(V_1 - V_0) = -33.77\,J$

$V_0 P_0 = nRT_0$ $V_1 = V_0 \frac{T_1}{T_0}$

Realizado pelo gás $W = 33.77\,J$

11 - $P_i = 3,5\,atm$ a) $p = \frac{N}{V}$

$T_i = 300\,K$

$\left.\begin{array}{l} P_i V = nRT \\ n = \frac{N}{N_A} \end{array}\right\} \Rightarrow \frac{N}{V} = \frac{P_i}{RT} N_A = 8.6 \times 10^{25}\ Partículas/m^3$

b) b_1) $Q = 0 \Rightarrow \Delta S = 0$ e $\Delta U = W$ $\Delta U = -P_{ext}(V_f - V_i)$ $\Delta U = \frac{5}{2} nR \Delta T$ $\Big| \rightarrow \frac{5}{2} R n (T_f - T_i) = -P_{ext}(V_f - V_i)$

$P_f = \frac{nRT_f}{V_f} \Rightarrow T_f = \frac{P_f V_f}{nR}$ $\frac{V_f}{n} = \frac{(\frac{5}{2}P_i + P_f)RT_i}{\frac{7}{2}P_i P_f}$

$\frac{V_f}{n} = ?$

$T_f = \frac{(\frac{5}{2}P_i + P_f)}{\frac{7}{2}P_i} T_i = 238\,K \Rightarrow -34^\circ C$

b_2) $P^{1-\gamma} T^\gamma = cnst \rightarrow P_i^{1-\gamma} T_i^\gamma = P_f^{1-\gamma} T_f^\gamma$ $\Rightarrow T_f = 209\,K \Rightarrow -68^\circ C$

$\gamma = \frac{7}{5}$