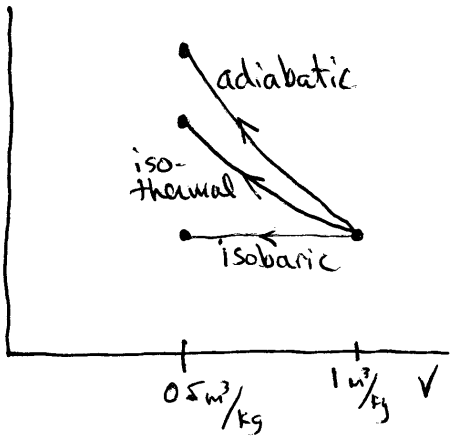
SOLUTIONS TO T4 BY WAITZ

a)



b) INITIAL CONDITIONS

$V_1 = 1\ m^3/kg$, $P_1 = 100\ kPa$ $\therefore$ $T_1 = 348.4\ K$ by ideal gas law

1) isobaric $P = \text{const.}$ $P_1 = P_2 = 100\ kPa$

$V_2 = 0.5\ m^3/kg$

$\therefore$ $\boxed{T_2 = 174.2\ K}$ by ideal gas law

2) isothermal $T = \text{const}$ $T_1 = T_2 = 348.4\ K$

$V_2 = 0.5\ m^3/kg$

$\therefore$ $\boxed{P_2 = 200\ kPa}$ by ideal gas law

3) q-s adiabatic $pV^\gamma = \text{const}$ $\gamma = 1.4$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = (2)^{0.4} = 1.32 \Rightarrow \boxed{T_2 = 459.7\ K}$$

$$\frac{P_2}{P_1} = \left(\frac{T_2}{T_1}\right)^{\gamma/\gamma-1} = 2.64 \quad \therefore \boxed{P_2 = 264\ kPa}$$

c) FOR EACH PROCESS CALCULATE WORK DONE BY SYSTEM & HEAT ADDED TO SYSTEM

1) ISOBARIC $\quad w = P\Delta v$

$w = 100\,kPa\,(0.5\,m^3/kg - 1.0\,m^3/kg) =$

$\boxed{w = -50\,kJ/kg}$ (compression)

1st Law: $\Delta u = q - w$

$\therefore \quad q = \Delta u + W = C_v(T_2 - T_1) + w$

$= 716.5(179.2 - 348.4) + (-50{,}000)$

$\boxed{= -175\,kJ/kg}$ (heat removal)

2) ISOTHERMAL

$w = RT\ln\left(\frac{V_2}{V_1}\right) = 287 \cdot 348.4 \ln(0.5)$

$\boxed{w = -69\,kJ/kg}$ (compression)

1st LAW $\quad \Delta u = q - w \quad \Delta u = C_v \Delta T = 0$

so $q = w$

$\boxed{q = -69\,kJ/kg}$ Heat removal

3) ADIABATIC $\quad \Delta u = \cancel{q}^{\,0} - w \quad \boxed{q = 0}$

$\therefore \quad w = -\Delta u = -C_v(T_2 - T_1) = -716.5(459.7 - 348)$

$\boxed{w = -80\,kJ/kg}$ (compression)

d) ENTHALPY CHANGE FOR EACH PROCESS

$$\Delta h = c_p \Delta T = \Delta[u + pv] = \Delta[c_v T + pv]$$

CAN CALC. EITHER WAY BUT $c_p \Delta T$ IS EASIER

1) ISOBARIC

$$\Delta h = 1003.5\,(174.2 - 348.4) = \boxed{-180\ \text{kJ/kg}}$$

2) ISOTHERMAL

$$\boxed{\Delta h = 0}$$

3) ADIABATIC

$$\Delta h = 1003.5\,(459.7 - 348.4) = \boxed{112\ \text{kJ/kg}}$$