1st Law of Thermodynamics - 1

Monatomic Gas Isobar (1): 1. The number of moles follows from $P\,V_i = n\,R\,T_i$, where P and the initial values V_i, T_i are given, and $R = 8.31\,J/(K \cdot mol)$ is the gas constant.
2. Final temperature from $P\,V_f = n\,R\,T_f$, where P and V_f are given.
3. Work $W = P\,(V_f - V_i)$.

$P\,V$ **Diagram Work (2):** 1. Work on path A: $W = P_1\,(V_2 - V_1)$.
2. Work on path B: $W = \int_{V_1}^{V_2} P(V)\,dV$, where we have to determine $P(V)$ first, which is a straight line. From the figure the slope a of $P(V)$ is seen to be

$$a = \frac{P_2 - P_1}{V_2 - V_1} \quad \Rightarrow \quad P(V) = P_1 + a\,(V - V_1)$$

and the integration can be performed:
$W = \int_{V_1}^{V_2} P(V)\,dV = (V_2 - V_1)\,P_1 + a\,(V_2^2 - V_1^2)/2 - (P_2 - P_1)\,V_1$.
3. Work on path C: $W = P_2\,(V_2 - V_1)$.

1st Law of Thermodynamics - 2

Isothermal Expansion Work (4): $P\,V = n\,R\,T$ with T constant implies

$$W = \int_{V_1}^{V_2} P(V)\,dV = n\,R\,T \int_{V_1}^{V_2} \frac{dV}{V} = n\,R\,T\,\ln\left(\frac{V_2}{V_1}\right).$$

Note: $n\,R\,T = P_1\,V_1$ and one liter$= (0.1)^3\,m^3$.

Thermodynamic system (5): U, W, Q. Find the sign of $\triangle U$ from $U = c_V\,T$ and $P\,V = n\,R\,T$, from $\triangle W = \int_{V_1}^{V_2} P(V)\,dV$ the sign of $\triangle W$. Then, if the sum of $\triangle U$ and $\triangle W$ is positive (negative) $\triangle Q$ is positive (negative) because of energy conservation.