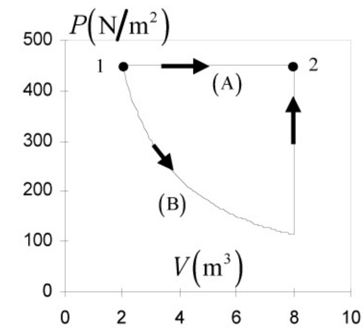
11. (*a,c*) See diagram.



(*b*) The work done is found from Eq. 15-3.

$$W = P\Delta V = \left(455\,\text{N/m}^2\right)\left(8.00\,\text{m}^3 - 2.00\,\text{m}^3\right) = \boxed{2.73\times10^3\,\text{J}}$$

The change in internal energy depends on the temperature change, which can be related to the ideal gas law, $PV = nRT$.

$$\Delta U = \tfrac{3}{2}nR\Delta T = \tfrac{3}{2}\left(nRT_2 - nRT_1\right) = \tfrac{3}{2}\left[\left(PV\right)_2 - \left(PV\right)_1\right]$$

$$= \tfrac{3}{2}P\Delta V = \tfrac{3}{2}W = \tfrac{3}{2}\left(2.73\times10^3\,\text{J}\right) = \boxed{4.10\times10^3\,\text{J}}$$

(*d*) The change in internal energy only depends on the initial and final temperatures. Since those temperatures are the same for process (B) as they are for process (A), the internal energy change is the same for process (B) as for process (A), $\boxed{4.10\times10^3\,\text{J}}$.

12. For the path ac, use the first law of thermodynamics to find the change in internal energy.

$$\Delta U_{ac} = Q_{ac} - W_{ac} = -63\text{ J} - \left(-35\text{ J}\right) = -28\text{ J}$$

Since internal energy only depends on the initial and final temperatures, this ΔU applies to any path that starts at a and ends at c. And for any path that starts at c and ends at a, $\Delta U_{ca} = -\Delta U_{ac} = 28\text{ J}$

(*a*) Use the first law of thermodynamics to find Q_{abc}.

$$\Delta U_{abc} = Q_{abc} - W_{abc} \;\rightarrow\; Q_{abc} = \Delta U_{abc} + W_{abc} = -28\,\text{J} + \left(-48\text{ J}\right) = \boxed{-76\text{ J}}$$

(*b*) Since the work along path bc is 0, $W_{abc} = W_{ab} = P_b\Delta V_{ab} = P_b\left(V_b - V_a\right)$. Also note that the work along path da is 0.

$$W_{cda} = W_{cd} = P_c\Delta V_{cd} = P_c\left(V_d - V_c\right) = \tfrac{1}{2}P_b\left(V_a - V_b\right) = -\tfrac{1}{2}W_{abc} = -\tfrac{1}{2}\left(-48\text{ J}\right) = \boxed{24\text{ J}}$$

(*c*) Use the first law of thermodynamics to find Q_{abc}.

$$\Delta U_{cda} = Q_{cda} - W_{cda} \;\rightarrow\; Q_{cda} = \Delta U_{cda} + W_{cda} = 28\,\text{J} + 24\text{ J} = \boxed{52\text{ J}}$$

(*d*) As found above, $U_c - U_a = \Delta U_{ca} = -\Delta U_{ac} = \boxed{28\text{ J}}$

(*e*) Since $U_d - U_c = 5\text{ J} \;\rightarrow\; U_d = U_c + 5\text{ J} \;\rightarrow\; \Delta U_{da} = U_a - U_d = U_a - U_c - 5\text{ J} = \Delta U_{ca} - 5\text{ J} = 23\text{ J}$.

Use the first law of thermodynamics to find Q_{da}.

$$\Delta U_{da} = Q_{da} - W_{da} \;\rightarrow\; Q_{da} = \Delta U_{da} + W_{da} = 23\text{ J} + 0 = \boxed{23\text{ J}}$$

13. We are given that $Q_{ac} = -80\text{ J}$ and $W_{ac} = -55\text{ J}$.

(*a*) Use the first law of thermodynamics to find $U_a - U_c = \Delta U_{ca}$

$$\Delta U_{ca} = -\Delta U_{ac} = -\left(Q_{ac} - W_{ac}\right) = -\left(-80\,\text{J} - -55\,\text{J}\right) = \boxed{25\text{ J}}$$

(*b*) Use the first law of thermodynamics to find Q_{cda}.

$$\Delta U_{cda} = Q_{cda} - W_{cda} \;\rightarrow\; Q_{cda} = \Delta U_{cda} + W_{cda} = \Delta U_{ca} + W_{cda} = 25\text{ J} + 38\text{ J} = \boxed{63\text{ J}}$$

(*c*) Since the work along path bc is 0, $W_{abc} = W_{ab} = P_a\Delta V_{ab} = P_a\left(V_b - V_a\right)$.

$$W_{abc} = W_{ab} = P_a\Delta V_{ab} = P_a\left(V_b - V_a\right) = 2.5P_d\left(V_c - V_d\right) = -2.5\,W_{cda} = -2.5\left(38\text{ J}\right) = \boxed{-95\text{ J}}$$

(*d*) Use the first law of thermodynamics to find Q_{abc}

$$\Delta U_{abc} = Q_{abc} - W_{abc} \;\rightarrow\; Q_{abc} = \Delta U_{abc} + W_{abc} = -25\text{ J} - 95\,\text{J} = \boxed{-120\text{ J}}$$