

4125 HW 2

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3 February 2022

1.34a

For process A, the volume is constant, so there is no work done on the gas. Therefore, $\Delta U = -Q$. There are five degrees of freedom, all quadratic, for a diatomic molecule with frozen-out vibrational modes; the internal energy is therefore $\frac{5}{2}kT_i$ at the beginning of the process and $\frac{5}{2}kT_f$ at the end. The delta is then, applying the equation of state,

$$\Delta U = \frac{5}{2}k(T_f - T_i) = \frac{5}{2}(P_f V_f - P_i V_i) = \frac{5}{2}(P_2 V_1 - P_1 V_1)$$

The heat put into the gas is then $Q = \frac{5}{2}(P_1 V_1 - P_2 V_1)$.

For process B, the pressure is constant, so the work done by the gas is the integral $W = \int P dV$. Since the process is a horizontal line on the PV diagram, this is just the area of the rectangle, i.e. $W = P(V_f - V_i) = P_2(V_2 - V_1)$. The internal energy is the same as above, so the change in it is

$$\Delta U = \frac{5}{2}k(T_f - T_i) = \frac{5}{2}(P_2 V_2 - P_2 V_1)$$

The heat put in the gas is therefore

$$Q = P(V_f - V_i) - \frac{5P}{2}(V_f - V_i) = -\frac{3}{2}P_2(V_2 - V_1)$$

Processes C and D have the same formulas in terms of initial and final variables as processes A and B, just with different values for those variables. For process C,

$$W = 0, \Delta U = \frac{5}{2}(P_1 V_2 - P_2 V_2), Q = \frac{5}{2}(P_2 V_2 - P_1 V_2)$$

For process D,

$$W = P_1(V_1 - V_2), \Delta U = \frac{5}{2}(P_1 V_1 - P_1 V_2), Q = -\frac{3}{2}P_1(V_1 - V_2)$$

1.34b