

CHEM2011 Chapter 1 problems

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Question 1a,b

One mole of an ideal **monoatomic** gas initially at 300K and pressure of 15.0atm expands to a final pressure of 1.00atm . The expansion can occur via any of five different paths. For each case, calculate the value of q , w , ΔU and ΔH .

a) Isothermal and reversible

Solution::

Assume $T_2 = T_1 \implies \Delta T = 0$ by isothermal. Because $\Delta T = 0$, we have that $\Delta H = 0$ and $\Delta U = 0$ as a consequence. So, $\Delta U = q + w = 0 \implies w = -q$.

We can now find the value of w by using the formula::

$$w = -nRT \ln\left(\frac{P_1}{P_2}\right) = -(1)(8.314)(300) \ln\left(\frac{15}{1}\right) = -6.75\text{E} - 3\text{J} \implies q = 6.75\text{E} - 3\text{J}$$

b) Isothermal and irreversible

Solution::

ΔU and ΔH are still 0 since $\Delta T = 0$. Because this process is irreversible, $P_2 = P_{\text{external}}$. So we have that

$$w = -P_2 \Delta V = -P_2(V_2 - V_1)$$

Apply ideal gas law to find V_1 and V_2 .

$$V_1 = \frac{nRT}{P_1} = \frac{(1)(0.08206)(300)}{15} = 1.641L, V_2 = \frac{nRT}{P_2} = 24.62L$$

We can now find our work for the irreversible process.

$$w = -1(24.62 - 1.641)\left(\frac{101.325J}{1Latm}\right) = -2.33E3J \implies q = 2.33E3J$$

c) Isothermal and irreversible in a 2 step process. **Step 1::** $P = 7atm$, **Step 2::** $P=1atm$.

Solution::

The process is still isothermal, so assume $\Delta T, \Delta U, \Delta H = 0$ and $q = -w$.

Let $P' = 7atm$ denote the intermediate pressure between the two steps. So we want to find the work between V_1 and V' along with V' and V_2 .

$$V_1 = 1.641L, V' = \frac{(1)(0.08206)(300)}{7} = 3.52L, V_2 = 24.62L$$

Now let us calculate the work done for both steps.

$$w = w_1 + w_2 = -P_2\Delta V = -((7)(3.52 - 1.641) + (1)(24.62 - 3.52)) \approx -34.251Latm\left(\frac{101.325}{Latm}\right) =$$