Summary Of Expansion/Contraction Work For An Ideal Gas In A Closed System By Various Pathways

The work on a mass or molar basis is always calculated by $W_{EC} = -\int_{V_1}^{V_2} PdV$. Using the ideal gas law in the integral permits the work to be calculated.

**Isothermal** – constant temperature, $P = RT/V$, plug into integral,

$$W_{EC} = -\int_{V_i}^{V_f} PdV = -\int_{V_i}^{V_f} (RT/V)dV = -RT\int_{V_i}^{V_f} (1/V)dV = -RT \ln(V_f/V_i)$$

**(ig)**

**Isochoric** – constant volume.

$$W_{EC} = -\int_{V_i}^{V_f} PdV = 0$$

**Isobaric** – constant pressure

$$W_{EC} = -\int_{V_i}^{V_f} PdV = -P(V_f-V_i)$$

**Adiabatic** – $Q = 0$

$$W_{EC} = -\int_{V_i}^{V_f} PdV$$, but easier to use energy balance, $\Delta U = W$.  

For ideal gas, use example 2.9 to find state properties like temperature and pressure changes, relate these to $\Delta U$. However, recognize that the result is limited to ideal gases.

For an ideal gas, $\Delta U = \int C_v dT = W$  

**(ig)**

The constraint of an ideal gas is necessary for the above equation because $U$ depends on $P$ and density for real fluids in addition to temperature, so the change in $U$ cannot be calculated by only $T$. More complex relations will be introduced in Chapter 5, 6, and 7 for calculation of $U$ for real fluids as a function of $P$ and density.

**Summary of $\Delta U$ and $\Delta H$ for ideal gases**

Ideal gas $U$ and $H$ depend on only temperature. Changing the intermolecular separation (density or pressure) does not have an energetic effect because there is no potential energy between particles.

$$\Delta U = \int C_v dT, \quad \Delta H = \int C_p dT$$

**(ig)**

For real fluids, consult section 2.10. More complex relations will be introduced in Chapter 5, 6, and 7 for calculation of $U$ and $H$ for real fluids as a function of $P$ and density.