

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,

$$W_{EC} = -\int_{V_1}^{V_2} PdV = -\int_{V_1}^{V_2} (RT/V)dV = -RT \int_{V_1}^{V_2} (1/V)dV = -RT \ln(V_2/V_1) \quad (ig)$$

Isochoric – constant volume.

$$W_{EC} = -\int_{V_1}^{V_2} PdV = 0$$

Isobaric – constant pressure

$$W_{EC} = -\int_{V_1}^{V_2} PdV = -P(V_2 - V_1)$$

Adiabatic – $Q = 0$

$$W_{EC} = -\int_{V_1}^{V_2} PdV, \text{ but easier to use energy balance, } \Delta U = W.$$

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

$$\text{For an ideal gas, } \Delta U = \int C_v dT = W \quad (ig)$$

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 ΔU and ΔH 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.

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

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.