

Heat Capacities of Ideal Gases

$$dE = dQ + dW \quad \text{anything}$$

$$\text{but } dW = -P dV \quad \text{all gases [} dW = \text{Work on gas]}$$

$$dQ = dE + P dV \quad \text{all gases}$$

At constant volume,

$$dQ = C_v dT \quad \text{and } dV = 0$$

$$dE = C_v dT \quad \text{all gases}$$

This leads immediately to

$$C_v = \frac{3}{2}nR \quad \text{for ideal monatomic gases, } \frac{5}{2}nR \quad \text{for ideal diatomic gases with rotation only, etc.}$$

At constant pressure,

$$dQ = dE + P dV = C_p dT \quad \text{all gases}$$

$$\text{and we also have } PV = nRT \quad \text{ideal gases}$$

$$P dV + V dP = nR dT$$

$$C_p dT = C_v dT + P dV$$

$$C_p dT = C_v dT + nR dT$$

$$C_p = C_v + nR = C_v + Nk \quad \text{ideal gases}$$

$$\gamma \quad C_p/C_v = 1 + nR/C_v = 5/3 \quad \text{for ideal monatomic gases, } 7/5$$

for diatomic gases with rotation only, etc.