Thermo Principles by Process: \( W = \text{work ON gas; } Q = \text{heat INTO gas} \)

**ALWAYS TRUE**

\[ pV = NkT \quad \text{(Ideal Gas Law)} \]
\[ W + Q = \Delta E_{th} \quad \text{(1st Law = Conservation of Energy)} \]
\[ \Delta E_{th} = Nc_v \Delta T \quad \text{(because } W = 0 \text{ for constant-volume process)} \]

- monatomic gas: \( c_v = \frac{3}{2} k \)
- diatomic gas: \( c_v = \frac{5}{2} k \)  
  (Equipartition Theorem)
- any ideal gas: \( c_p = c_v + k \)

**ISOBARIC PROCESS**

\[ p = \text{constant; } T \div V = \text{constant} \]
\[ W = -p \Delta V \]
\[ Q = N c_p \Delta T \]
\[ \Delta E_{th} = N c_v \Delta T \]

**ISOThERMAL PROCESS**

\[ T = \text{constant; } pV = \text{constant} \]
\[ \Delta E_{th} = 0 \]
\[ Q = -W = NkT \ln \frac{V_f}{V_i} = pV \ln \frac{V_f}{V_i} \]

**ISOCHORIC (constant-volume) PROCESS**

\[ V = \text{constant; } T \div P = \text{constant} \]
\[ W = 0 \]
\[ Q = \Delta E_{th} = N c_v \Delta T \]

**ADIABATIC PROCESS**

\[ Q = 0 \]
\[ W = \Delta E_{th} = N c_v \Delta T \]
\[ pV^\gamma = \text{constant} \quad ( \gamma = \frac{c_p}{c_v} ) \]

ENGINES: reverse sign of \( W \) since we talk about work done BY gas. Sorry.