Solving for $T$ on web:
- Ideal gas law
- $U = \text{const}$.

1. A 1 L container, of volume $V = 0.1 \text{ m}^3$, contains 1 kg of water. Initially the system is at a temperature of $T_1 = 30^\circ\text{C}$.

(a) What is the initial pressure and quality (if applicable) of the water?
(b) Heat is now added to the container and the temperature increases. The process stops when the water exists as a single phase. What is the final pressure?

$$P = n \frac{R_u T}{V}$$

$$T = 30^\circ\text{C}, \ \rho = 0.1 \frac{g}{\text{cm}^3} \Rightarrow \text{sat} \text{ urate}, \ molal \ soln$$

$$\text{molal soln}$$

$$P = (\text{sat} \text{ vapor}) (\text{g}) \times \chi \Rightarrow U(T) = U = 0.1 \frac{g}{\text{cm}^3}$$

$\Rightarrow$ Ideal gas law

- Water is not an ideal gas.
- Do not apply the same conditions.
- Use IGL for water.

Assumptions:
1. Gas is dilute: molecules occupy negligible volume.
2. Molecules exert no forces on each other.

$P = n \frac{R_u T}{V}$

- Ideal gas law
- $T > T_c$
- $P < P_c$

$P = n \frac{R_u T}{V}$

- $n$: number of moles
- $R_u$: universal gas constant

$R_u = 8.314 \ \frac{\text{kJ}}{\text{mol} \cdot \text{K}}$

$M$: mass of substance

Air: $M \approx 29 \ \frac{\text{kJ}}{\text{mol}}$

$P = \frac{MRT}{V}$

$R = \frac{R_u \cdot M}{C_p}$

Air: $R = 0.287 \ \frac{\text{kJ}}{\text{K} \cdot \text{mol}}$

$W$: work

- Mechanical
- Electrical
- Magnetic
- Chemical

$W = \int F \, dx$

$F$: force

$W = F \cdot \Delta x$

$\Rightarrow$ Thermodynamics
Work done on system by environment:

- Application to simple processes:
  1. \( V = \text{const}; \) \( W = \) always zero.
  2. \( P = \text{constant} \) \( \Rightarrow P_1 = P_2 = P \)

\[
W = \int_1^2 P \, dV
= \int_1^2 \left( F \, dR \right)
\]

\[
W = \int_1^2 P \, dV
= P \cdot (V_2 - V_1)
\]

3. Arbitrary process: to evaluate work, need to know how \( P \) changes with \( V \).

- Polytropic process: process where \( P \) and \( V \) are related via

\[
P \cdot V^n = \text{constant} \quad \Rightarrow \quad n = \text{same power}, \quad \text{positive or negative}
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\[
P \cdot V^n = \text{constant} \quad \Rightarrow \quad P_1 \cdot V_1^n = P_2 \cdot V_2^n
\]

\[
\log P \quad \rightarrow \text{slope} = \frac{1}{n}
\]

- Specific work: \( \omega = \frac{W}{m} \quad m = \text{constant} \)

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\omega = \int_1^2 P \, dV \quad \Rightarrow \quad P \cdot V^n = C
\]

\[
C = \frac{1}{n+1} (U_2^{n+1} - U_1^{n+1})
\]

\[
\omega = \frac{1}{n+1} (P_2 V_2 - P_1 V_1) \quad \Rightarrow \quad \text{Polytropic process}
\]

\[
n = 1 \quad \Rightarrow \quad P_0 = \text{constant} \quad P = \frac{C}{V}
\]

\[
\omega = C \left( \int_1^2 \frac{1}{U} \, dU \right) = C \cdot \ln \frac{U_2}{U_1} = P_0 \cdot \ln \frac{U_2}{U_1}
\]

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IG: \quad P_0 = RT \quad \Rightarrow \quad n = 1
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