Temperature Unit Conversion

$$T_k = T_c + 273$$

$$T_F = \frac{9}{5} T_c + 32$$

T_k = Temp. in kelvin
T_c = " " celsius
T_F = " " Fahrenheit

Q. What is absolute zero in Fahrenheit?

$$T_c = -273 \quad (T_k = 0)$$

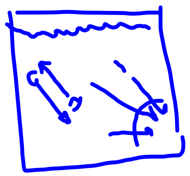
$$T_F = \frac{9}{5}(-273) + 32$$

$$= -459.4$$

Thermal Contact – heat is able to flow between bodies

Thermal Equilibrium (of two bodies in thermal contact) — heat has ceased to flow between bodies (temps no longer change)

Thermal Equilibrium (of a composite system) – the absence of net heat flows and temperature changes



Zeroeth Law of Thermo

$$\left.\begin{array}{l} A \sim C \\ B \sim C \end{array}\right. \Rightarrow A \sim B$$

"$\sim$" $\equiv$ "in equilibrium with"

Specific Heat Capacity

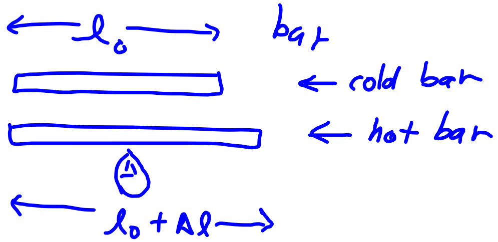
$$c = \frac{\Delta Q}{m \, \Delta T}$$

- c — specific heat
- ΔQ — heat added
- m — mass of sample
- ΔT — temp change

Thermal Expansion

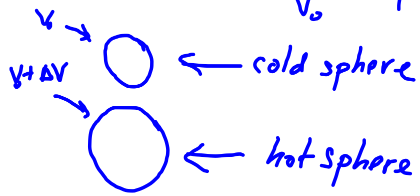
Linear: $$\frac{\Delta l}{l_0} = \alpha \, \Delta T$$

- $\frac{\Delta l}{l_0}$ — fractional expansion of heated bar
- α — coef. of linear expansion
- ΔT — temp change of bar



Volume: $$\frac{\Delta V}{V_0} = \beta \, \Delta T$$

- β — coef. of volume expansion



Q. Does an increase in temperature always result in an increase in volume?

A. No! Water decreases its volume as its temperature increases between 0°C and 4°C.

$\Rightarrow$ Water at the bottom of a frozen lake is always 4°C.

Modes of Heat Transfer

1. Conduction — transfer of heat through direct contact.
2. Convection — transfer of heat through the motion of a mass of fluid.
3. Radiation — transfer of heat through electromagnetic waves

First Law of Thermo

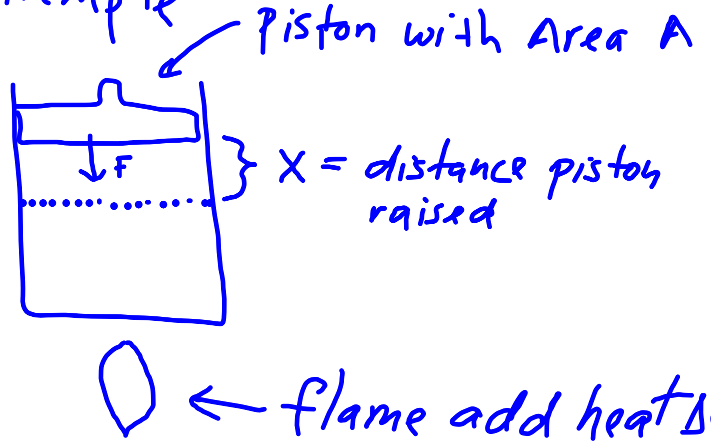
$$\Delta U = \Delta Q - \Delta W$$

ΔU = change in intenal energy

ΔQ = heat added

ΔW = work done

Example



$$\Delta W = Fx = \frac{F}{A} Ax = pV$$

Ideal Gas

Internal Energy depends only on temperature.

Equation of state [gives $P = P(V, T, \text{mass})$]

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

R = ideal gas const
$= 8.31 \ J/\text{mol}\ {}^\circ K$

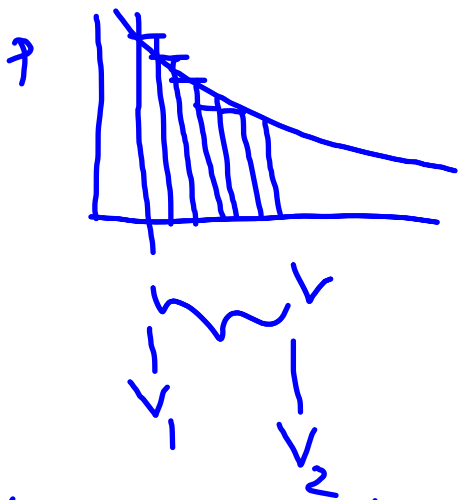
$$\frac{PV}{T} = nR = \text{const}$$

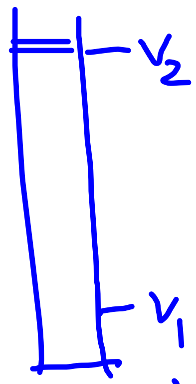
n = # of moles

↑ for fixed quantity of gas

Work done by a gas (again)

$W = p\,\Delta V$ ← true only if pressure remains constant.





$$\left(\text{Work done by gas as it expands from } V_1 \text{ to } V_2\right) = \int_{V_1}^{V_2} p(V)\,dV = \left(\text{area under p-V curve}\right)$$

Two important processes

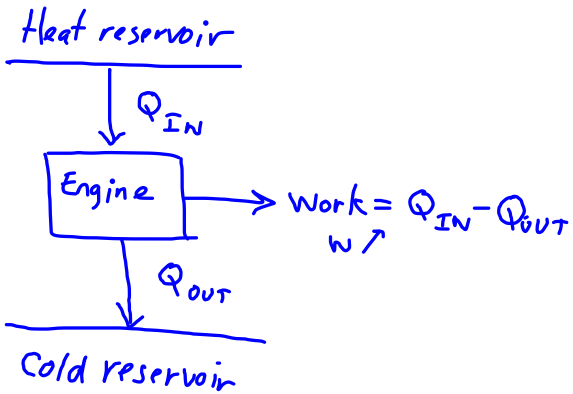
① adiabatic — no heat transfer into or out of system

② isothermal — temperature remains the same

adiabatic eq. of state $pV^{\gamma} = \text{constant}$

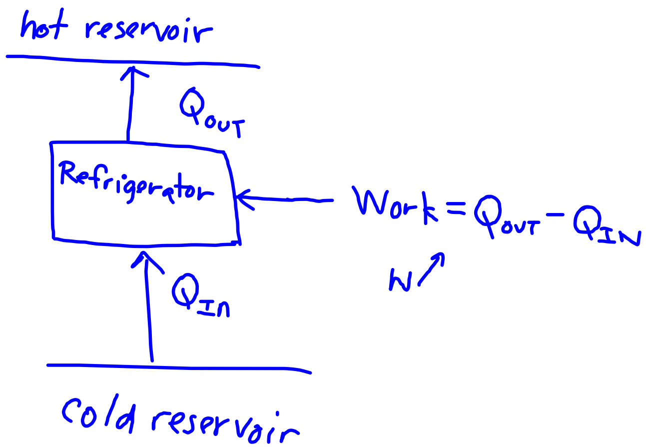
isothermal eq. of state $pV = \text{constant}$

Heat Engines



$$\text{Efficiency} = \frac{W}{Q_{IN}} = 1 - \frac{Q_{OUT}}{Q_{IN}}$$

Refrigerator



$$\text{Performance} = \frac{Q_{IN}}{W} = \frac{Q_{IN}}{Q_{OUT} - Q_{IN}}$$

Entropy

A measure of the disorder of a state.

$$S = k \ln N$$

- S: entropy of state of interest
- k: constant (Boltzmann's)
- N: number of way that the system can be in the state of interest.

2nd Law of Thermodynamics

1. Entropy* cannot decrease
2. Heat will not spontaneosly flow from a cold object to a hot object
3. Impossible for an engine to be 100% efficient

* of a closed system

1, 2, & 3 are equivalent statements of 2nd Law