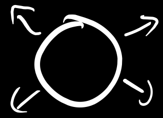
THERMODYNAMIC SYSTEM

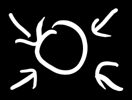
A system is a closed environment where heat transfer takes place, for example, the gas/walls/cylinder of an automobile engine

The first law of thermodynamics (law of energy conservation)
says that energy can neither be created or destroyed

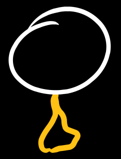
When examined more closely, it actually gives us the relation ship between
Internal energy (U) – work (W) – heat (Q)



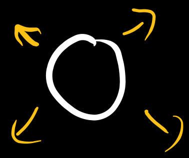
= system does work on sorrounding (lose energy) = $+W$



= work done on system = $-W$ (gain energy)



= heat transferred to system (gain energy) = $+Q$



= heat transferred from system (lose energy) = $-Q$

It can be expressed as an equation

$$\Delta U = Q - W$$

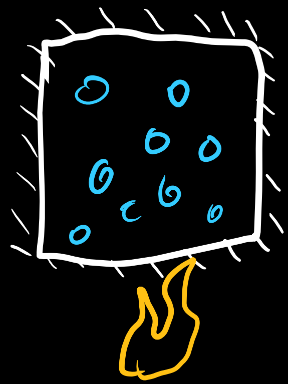
Where
- **ΔU** = change in internal energy of a system
- **Q** = amount of energy transferred to/from a system as heat
- **W** = amount of energy transferred to/from a system as work

With everything measured in joules, using this law, we can show the types of processes that can occur in a system

- **Constant volume**

$$W = 0 \rightarrow \Delta U = Q$$

$T\uparrow \quad W = 0$



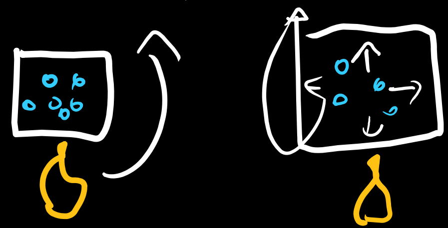
  - This tells us that there is no work being done on the system to "compress/stretch" it so W is 0
  - So any change In the internal energy, is the result of **heat transfer**
    or in other words
    0% of the heat transferred to a system is used to do work
  - This process is called an **isovolumetric (isochoric) process**, meaning no change in volume
  - EX. A bomb calorimeter
    - Were a combustion reaction happens resulting in heat, but the rigid wall cause the volume to not change, the change in the internal energy of that system is always because of heat transfer

- **Constant temperature**

$$\Delta U = 0 \rightarrow Q = W$$

  - If there is no change in the temperature of a system, this tells us that there is **no change in energy** as these 2 are positively correlated
  - So that means that the amount of heat transferred is countered by the amount of work done
    or in other words
    100% of the heat added transferred to the system is used to do work
  - This process is called an **isothermal process,** meaning no change in temperature
  - EX. Perfect car engine
    - A car engine that uses all the energy generated from the combustion reaction to do work

$Q = W$



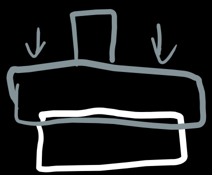
- **No Heat Transfer**

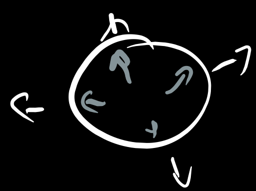
$$Q = 0 \rightarrow \Delta U = -W$$

  - If there is no heat transfer, then means that the internal energy of a system changes as a result of work done by/done on the system
  - This process is called an **adiabatic process**, meaning that there is no heat transferred

$-W$

$+\Delta U$





$+W$

$-\Delta U$

WORK

$W = P\Delta V$

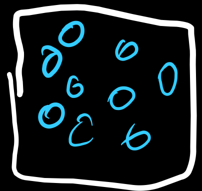
W = work
P = pressure acting on the system
ΔV = change in volume **or** (V2-V1)

$W = atm \times -1$

$\Delta U \uparrow \leftarrow -W$

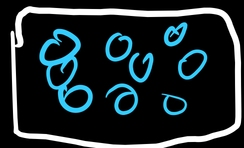
$\leftarrow W = -atm$ Joules

$P = atm$



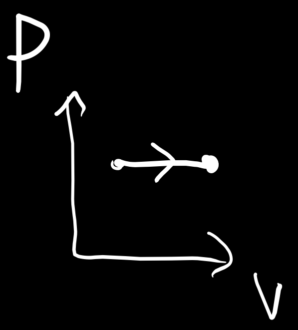
$\rightarrow V_i = 2$

$P = atm$

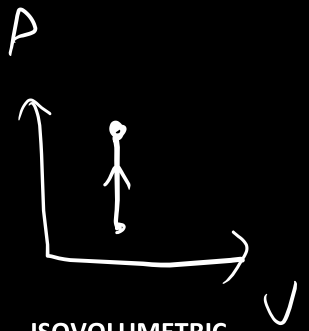


$V_F = 1$

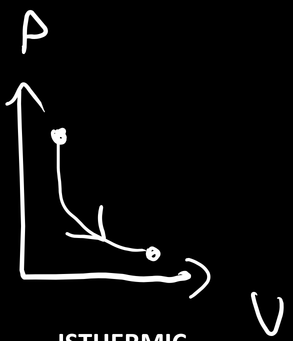
PV graph



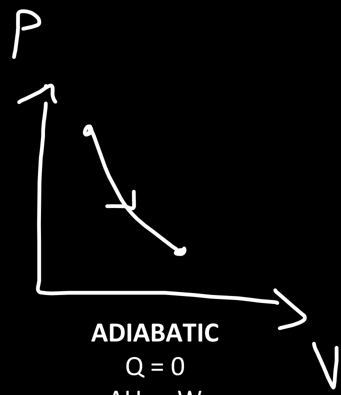
ISOBARIC
P = constant
W = PΔV (but now it's linear)
ΔU = Q - W



ISOVOLUMETRIC (isochoric)
V = constant
W = 0
ΔU = Q



ISTHERMIC
Temp = constant
ΔU = 0
W = Q

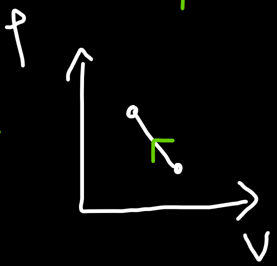


ADIABATIC
Q = 0
ΔU = -W

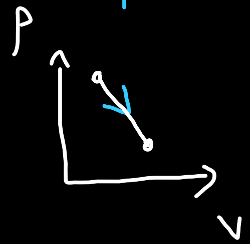
$-W \leftarrow$ compression

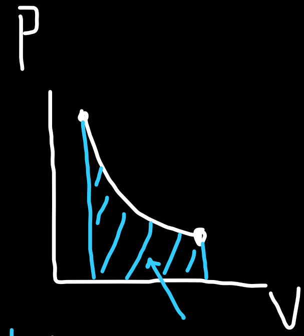
$\downarrow$

$\Delta U \uparrow$

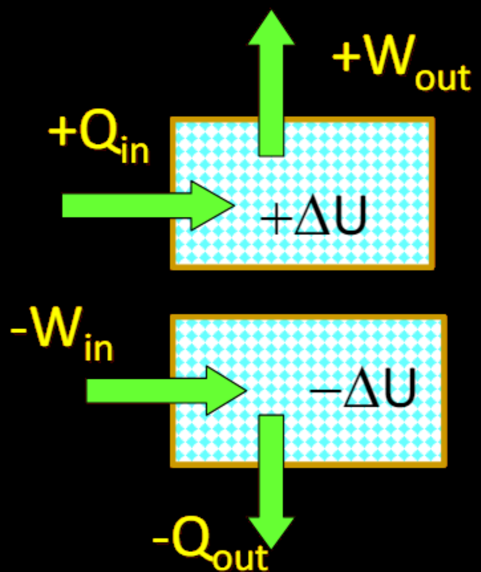


expansion $\rightarrow +W \rightarrow \Delta U \downarrow$





W = area

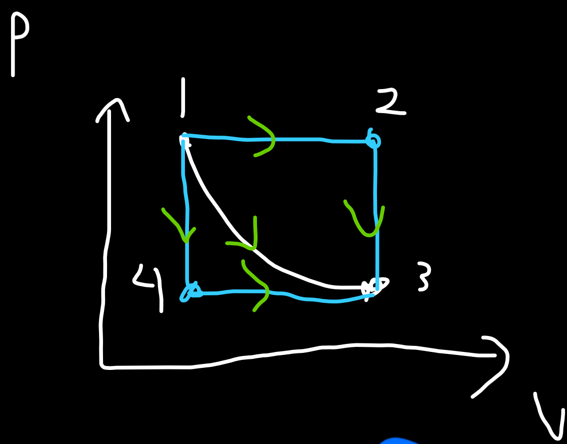


IN ANY THERMODYNAMIC PROCESS
The change in internal energy during the process is independent of the path

So if you go like 1->4->3
is like going 1->2->3
Is like going to 1->3

ΔU is always the same (constant) **if temperature in all paths is the same**

NOTE
Work (1->4) = PΔV
Same for any other point
Work from 1->4->3
= work(1->4) + work (4->3)



THE IDEAL GAS LAW

a fundamental equation in thermodynamics that relates the pressure (P), volume (V), temperature (T), and amount of gas (n) for an ideal gas

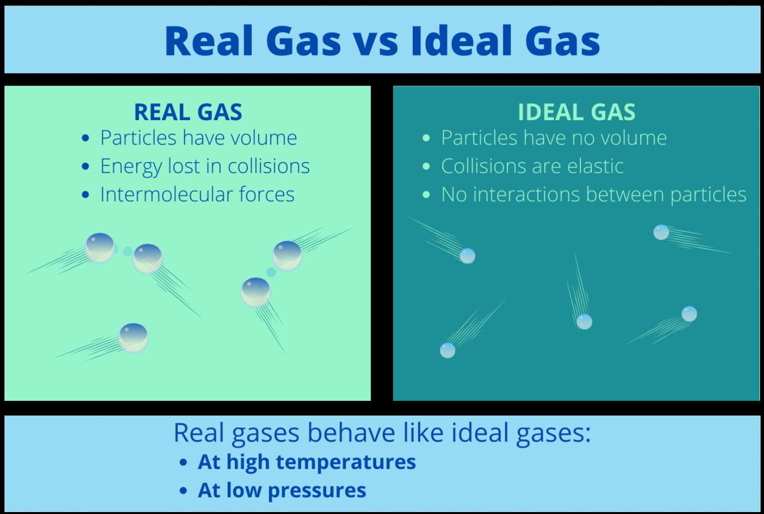
$$PV = nRT$$

WHERE

- n = amount of gas (in moles)
- R = ideal gas constant (8.31446261815324 joules/kelvin . mole)
- T = temperature

Units to use for $PV = nRT$

$R = 8.31 \dfrac{J}{K \cdot mol}$	$R = 0.082 \dfrac{L \cdot atm}{K \cdot mol}$
Pressure in pascals Pa	Pressure in atmospheres atm
Volume in m^3	volume in liters L
Temperature in kelvin K	Temperature in kelvin K



THE IDEAL GAS

It's a theoretical gas that unlike real gasses

- Do not have interactions/intermolecular forces between each other
- The molecules of it have no volume, so the volume is the body of the gas
- Any collisions between the particles are elastic, no energy / speed is lost
- Particles move in random directions
- Predictable behavior using the ideal gas law

GETTING THE WORK IN AN ISOTHERMAL PROCESS

$$W = nRT \ln \frac{V_B}{V_A}$$