Temperature and Pressure

2nd meeting

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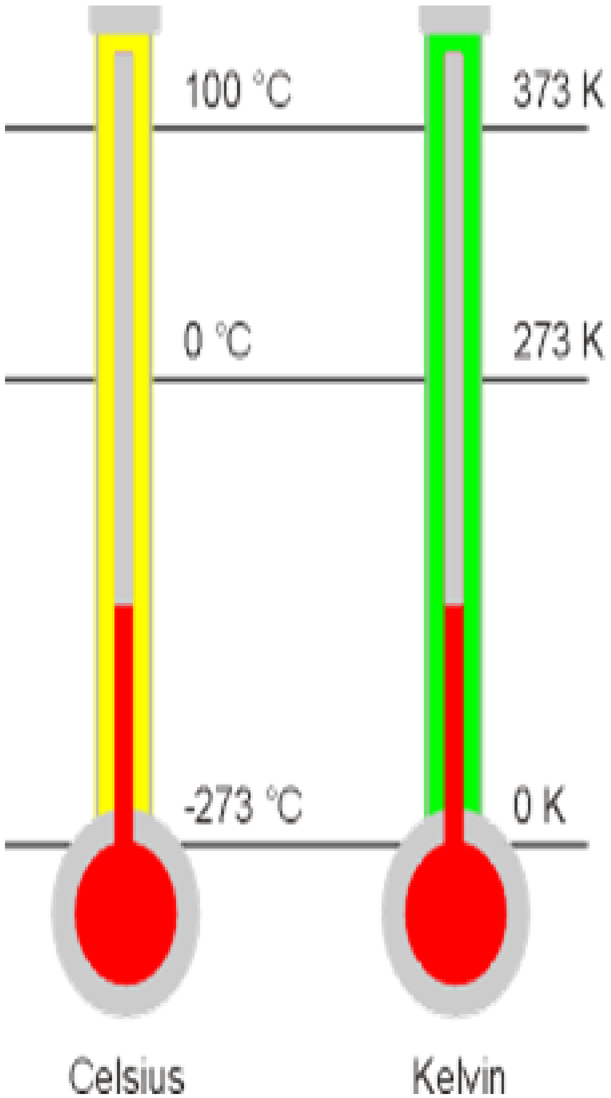
Kelvin temperature conversion formulae

	from Kelvin	to Kelvin
Celsius	[°C] = [K] − 273.15	[K] = [°C] + 273.15
Fahrenheit	[°F] = [K] × 9/5 − 459.67	[K] = ([°F] + 459.67) × 5/9
Rankine	[°R] = [K] × 9/5	[K] = [°R] × 5/9



For temperature *intervals* rather than specific temperatures,

1 K = 1 °C

and

1 K = 1.8 °R

Temperature relathionships

$$(°F) = 9/5*(°C) + 32$$

$$(°C) = 5/9*[(°F) - 32]$$

$$(°F) = (°R) - 459.67$$

$$(°C) = (K) - 273.15$$

Thermodynamics Processes

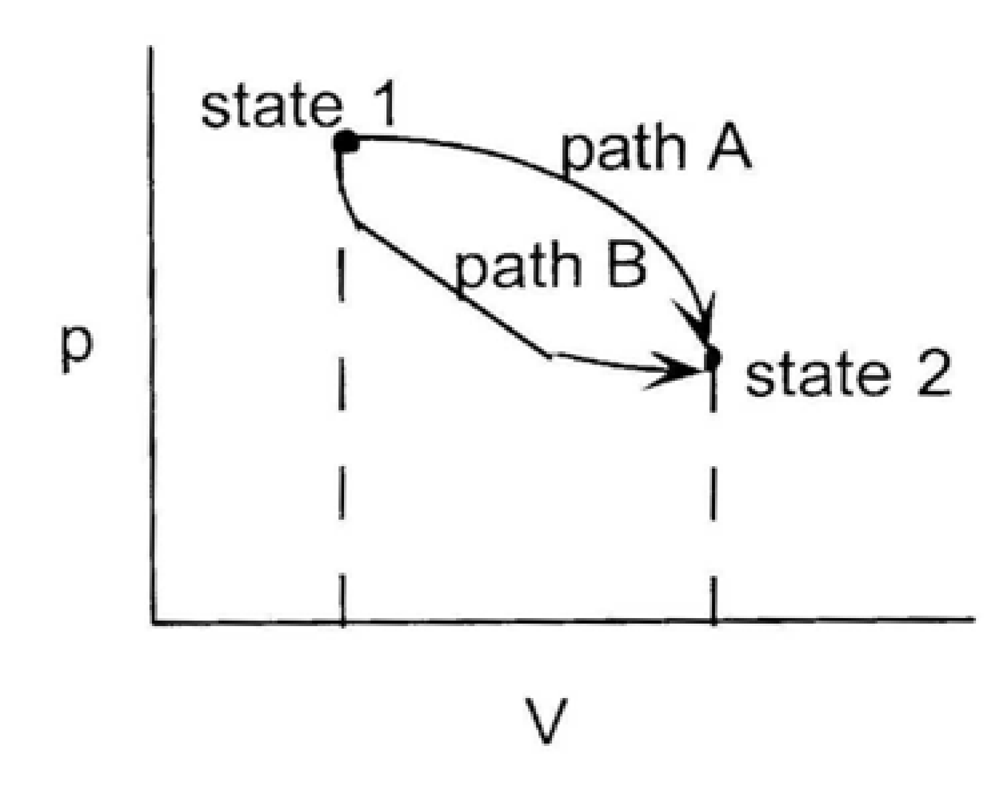
When any properties of a system change, the state of the system changes and the system is said to undergo a *process*.

Process : change in p-V-T state of system due to exchange of heat and/or work with the surroundings.

Plot process ***path*** on a pressure-volume graph state of system at 2 is :

- independent of path (A or B)

- but, Q and W are different for each path



- Cannot infer Q from this diagram
- Path depends on how T varies with V.

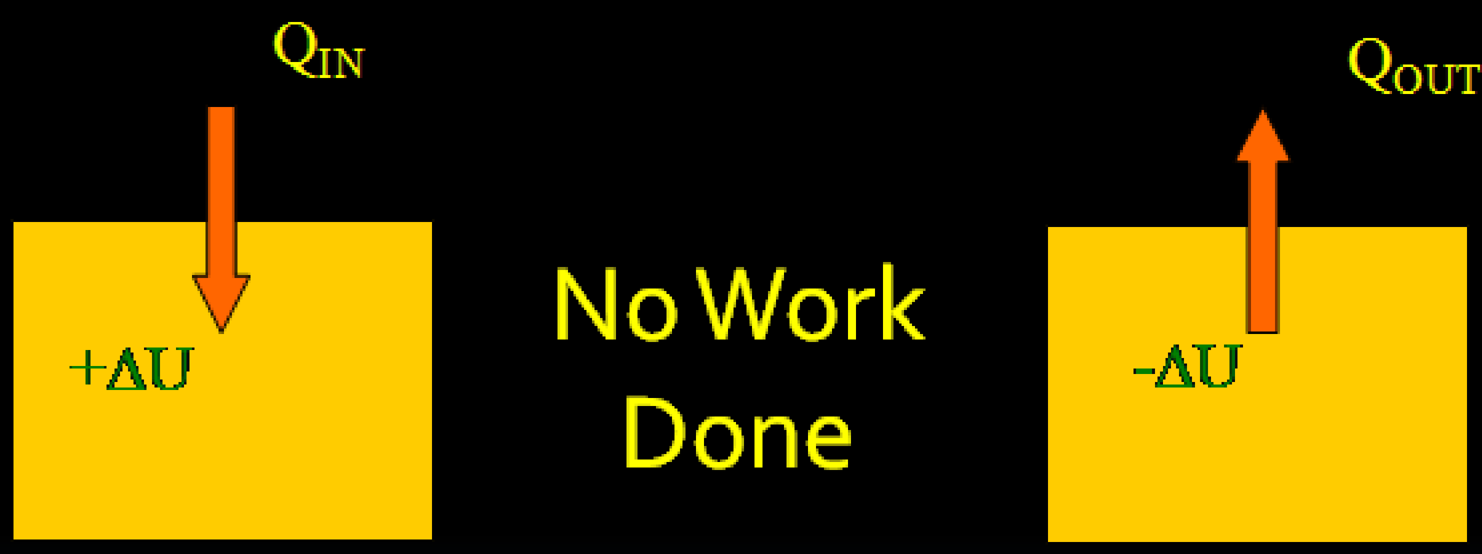
FOUR THERMODYNAMIC PROCESSES:

- Isovolumetric Process: $\Delta V = 0$, $\Delta W = 0$
- Isobaric Process: $\Delta P = 0$
- Isothermal Process: $\Delta T = 0$, $\Delta U = 0$
- Adiabatic Process: $\Delta Q = 0$

$$\Delta Q = \Delta U + \Delta W$$

IsovolumetricPROCESS:
CONSTANT VOLUME, $\Delta V = 0$, $\Delta W = 0$

$$\Delta Q = \Delta U + \Delta W^{\,0} \quad \text{so that} \quad \Delta Q = \Delta U$$

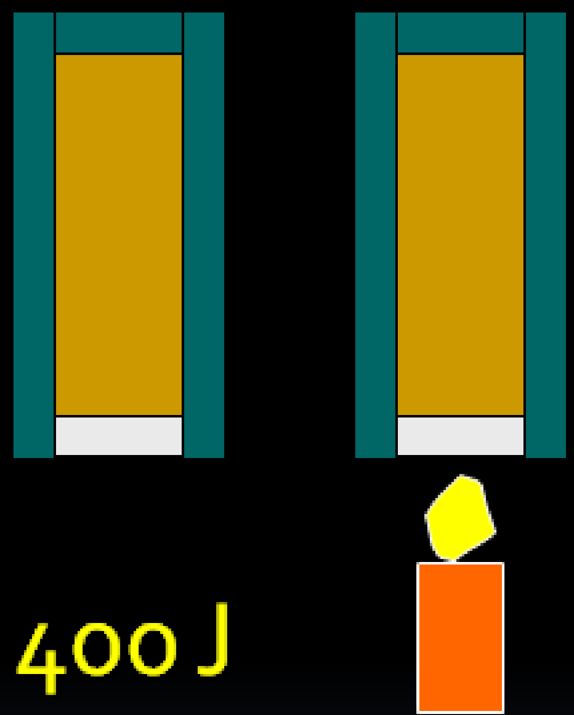


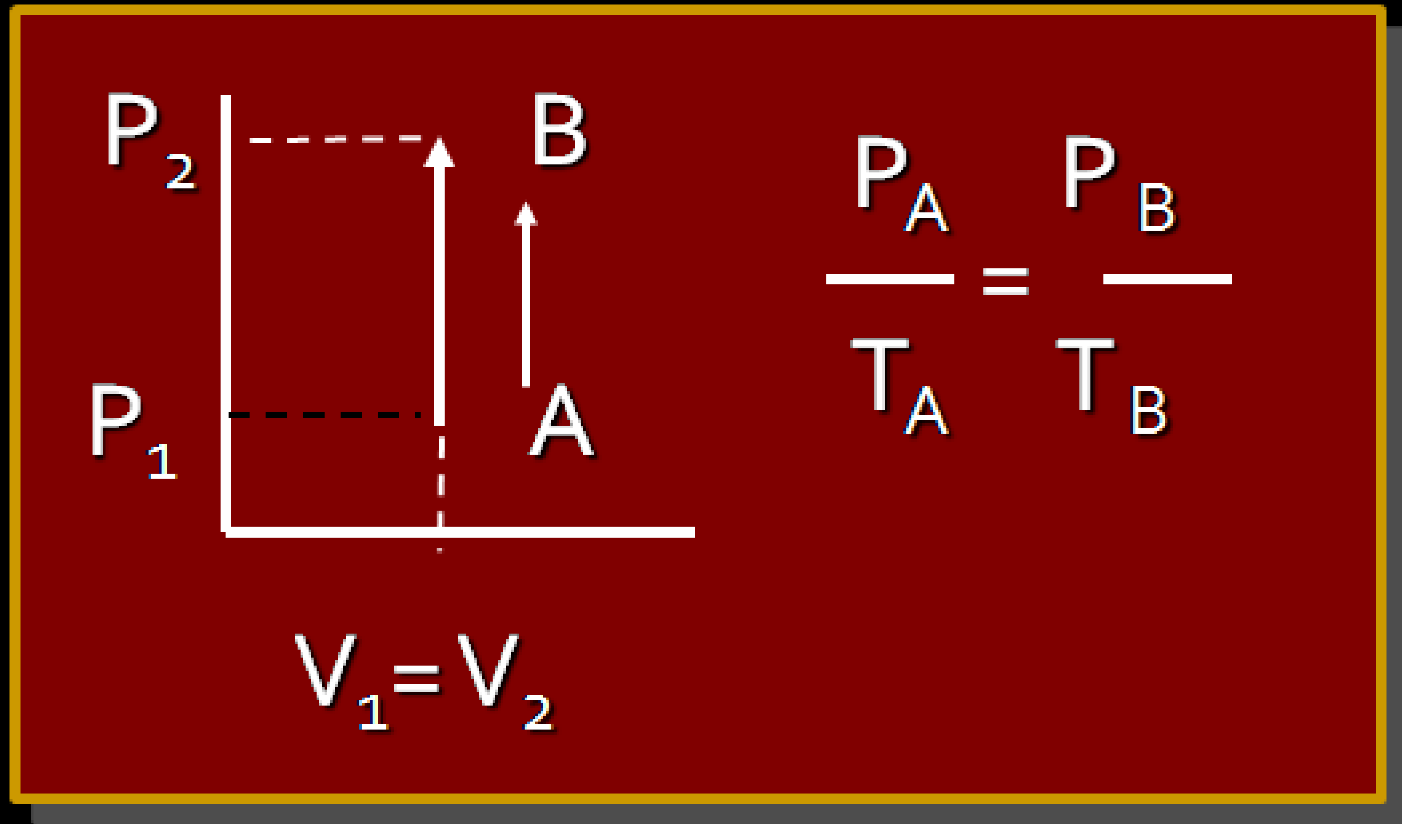
HEAT IN = INCREASE IN INTERNAL ENERGY

HEAT OUT = DECREASE IN INTERNAL ENERGY

Isovolumetric EXAMPLE:

No Change in volume:





Heat input increases P with const. V

400 J heat input increases internal energy by 400 J and zero work is done.

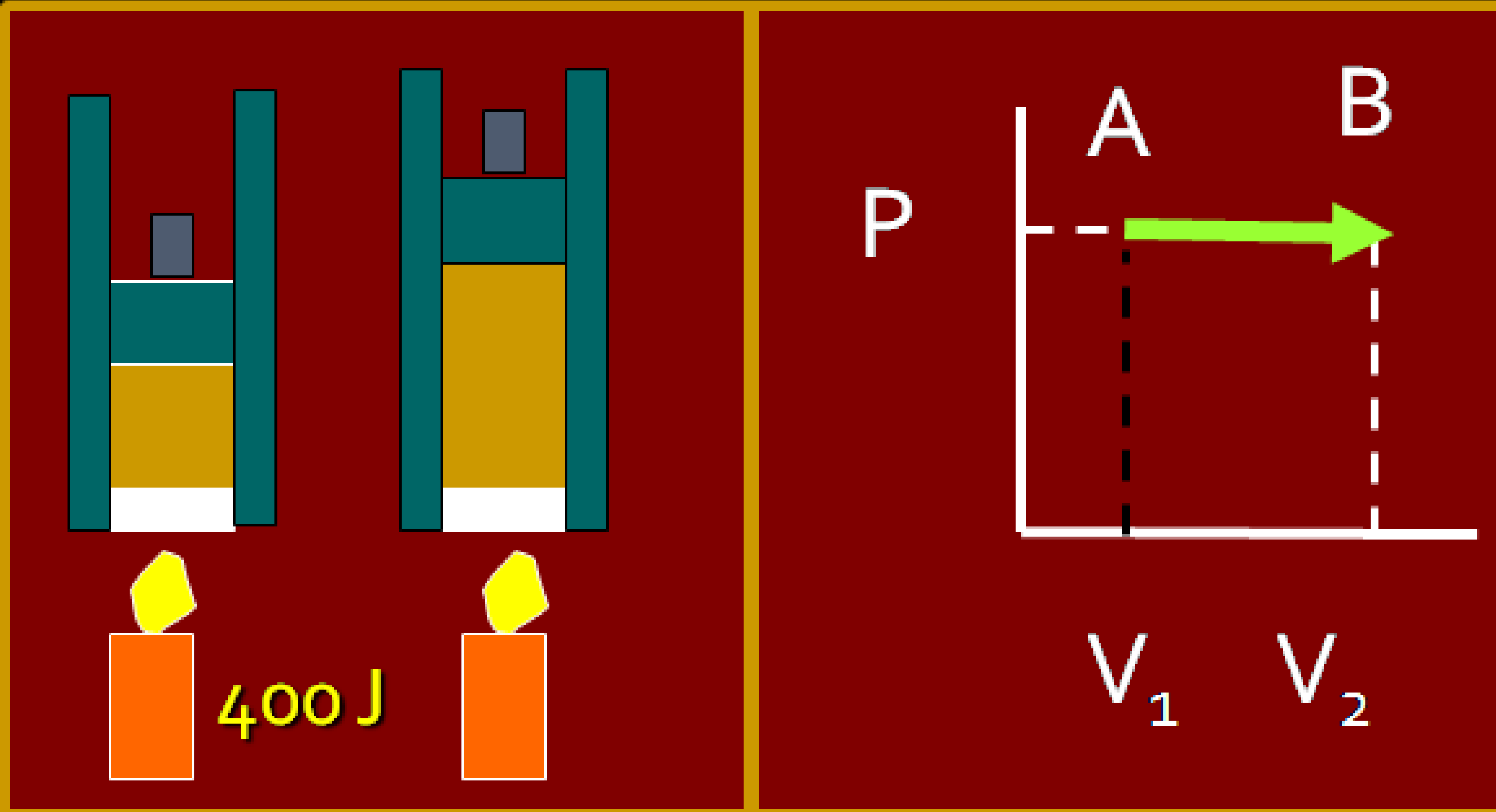
ISOBARIC PROCESS: CONSTANT PRESSURE, $\Delta P = 0$

$\Delta Q = \Delta U + \Delta W$ But $\Delta W = P\,\Delta V$

HEAT IN = W_{out} + INCREASE IN INTERNAL ENERGY

HEAT OUT = W_{in} + DECREASE IN INTERNAL ENERGY

ISOBARIC EXAMPLE (P Constant):

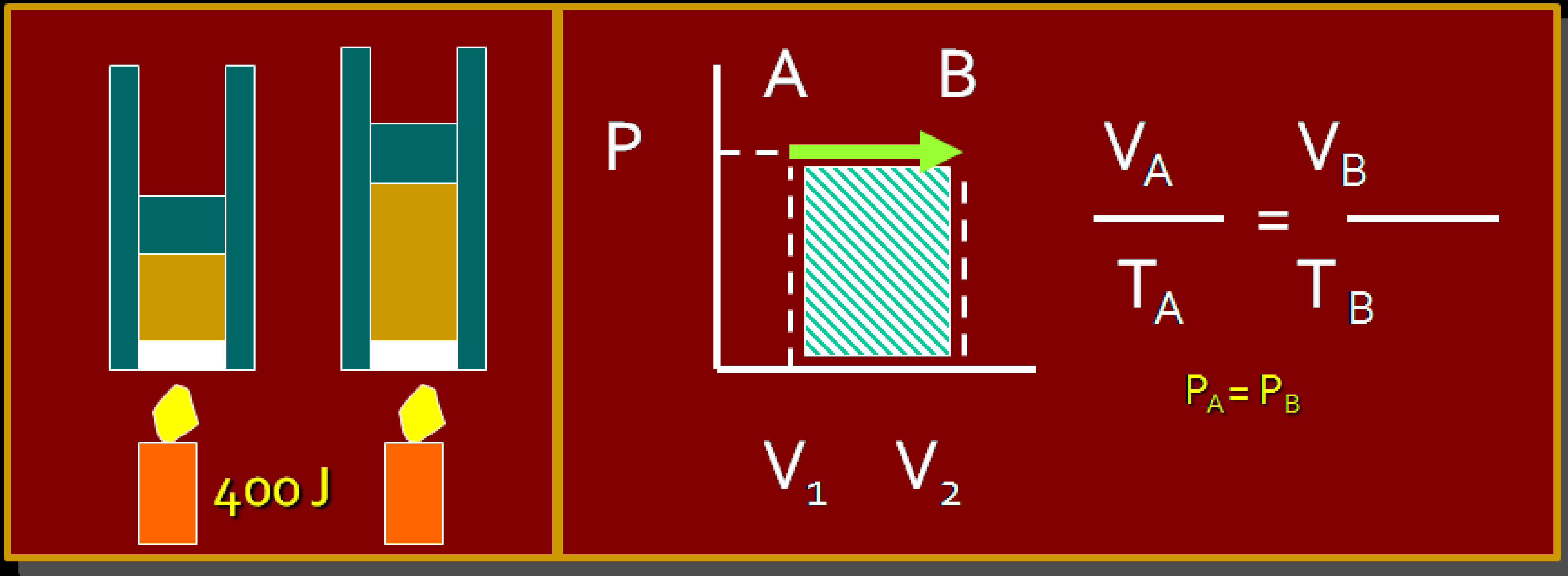


$$\frac{V_A}{T_A} = \frac{V_B}{T_B}$$

Heat input increases *V* with const. *P*

400 J heat does 120 J of work, increasing the internal energy by 280 J.

ISOBARIC WORK

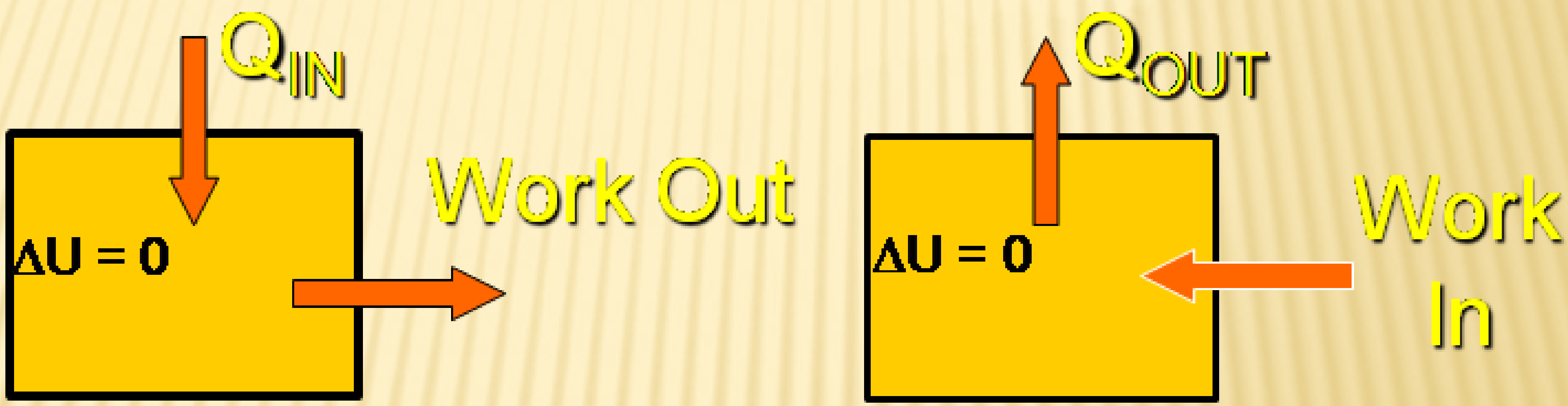


Work = Area under PV curve

$$Work = P\,\Delta V$$

ISOTHERMAL PROCESS:
CONST. TEMPERATURE, $\Delta T = 0$, $\Delta U = 0$

$\Delta Q = \Delta U + \Delta W$ and $\Delta Q = \Delta W$



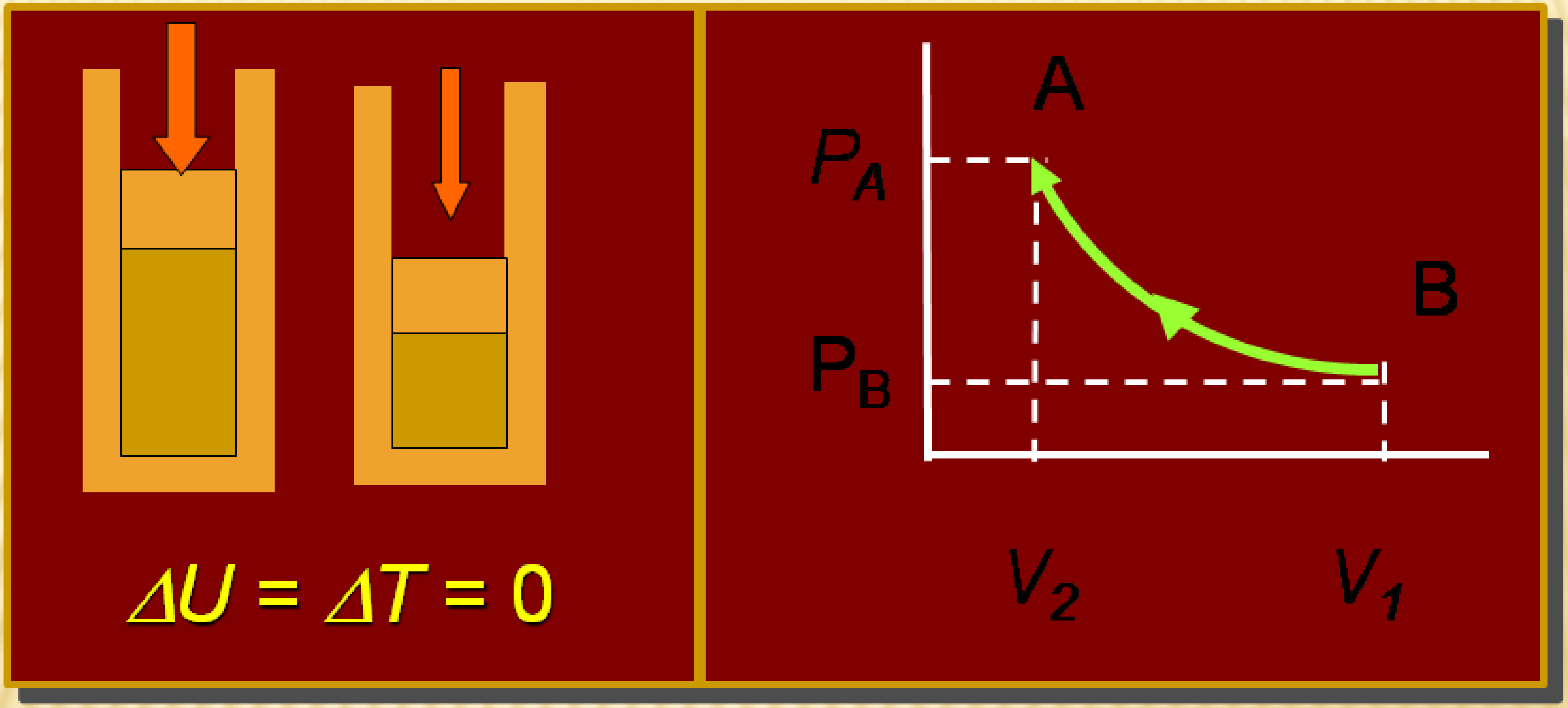
NET HEAT INPUT = WORK OUTPUT

WORK INPUT = NET HEAT OUT

Temperature

- The concept of temperature originated in man's sense perception → hotness or coldness.
- But it is unreliable and restricted in range.
- Relative hotness and coldness has developed an objective science of thermometry.
- The 1st step → set up a criterion of equality of temperature

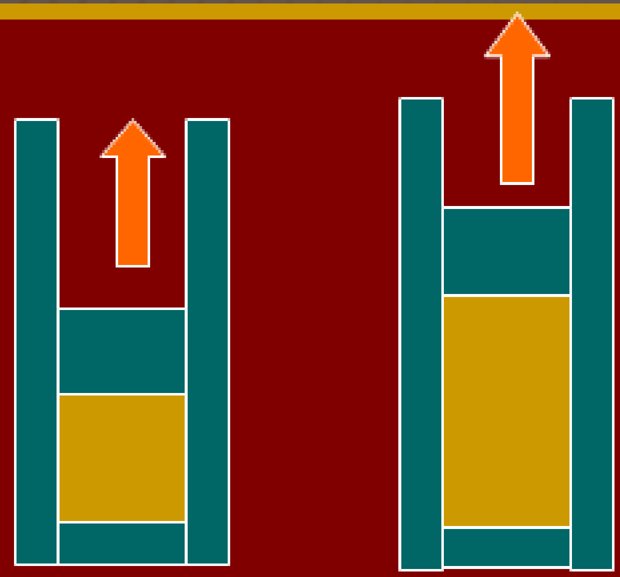
ISOTHERMAL EXAMPLE (CONSTANT T):



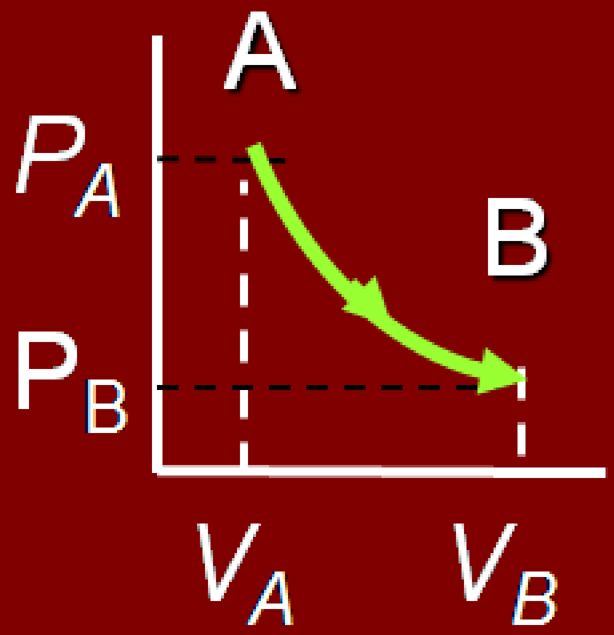
$$P_A V_A = P_B V_B$$

Slow compression at constant temperature: ----- No change in U.

ISOTHERMAL EXPANSION (CONSTANT T):



$\Delta U = \Delta T = 0$



$$P_A V_A = P_B V_B$$

$$T_A = T_B$$

400 J of energy is absorbed by gas as 400 J of work is done on gas.

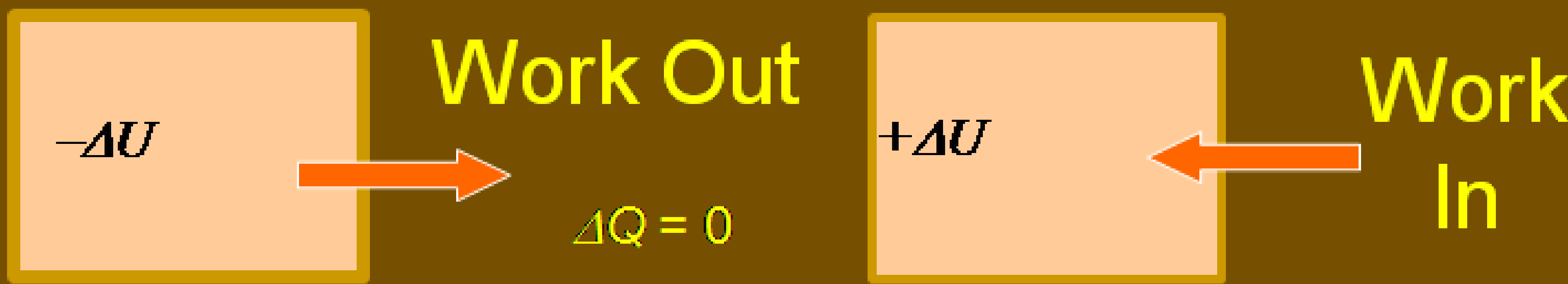
$$\Delta T = \Delta U = 0$$

ADIABATIC PROCESS:

NO HEAT EXCHANGE, $\Delta Q = 0$

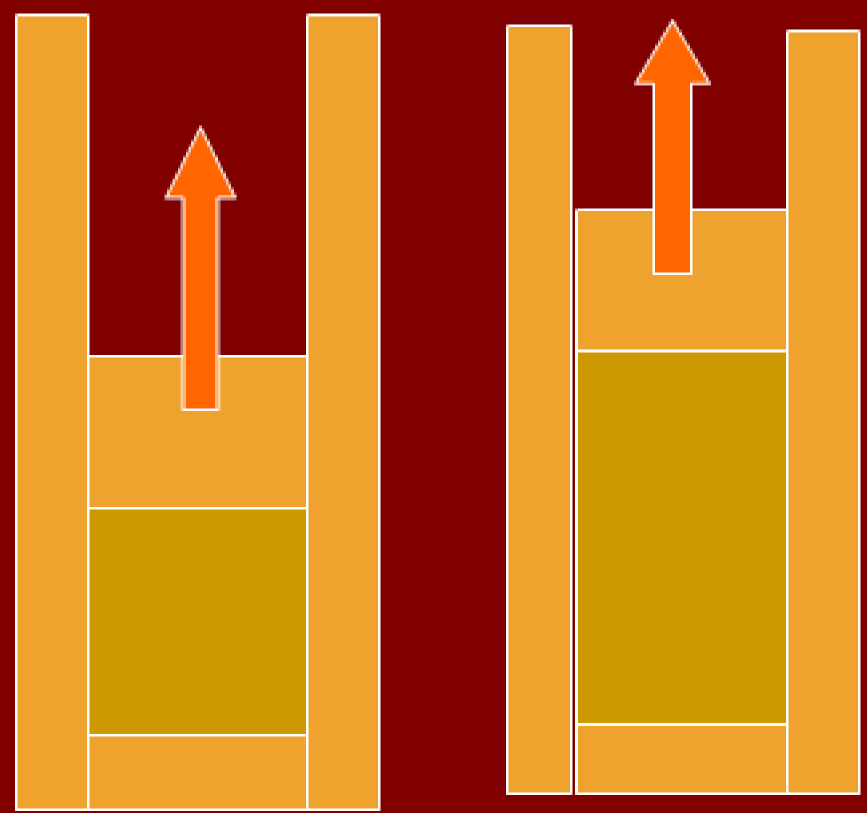
$$\Delta Q = \Delta U + \Delta W\;; \quad \Delta W = -\Delta U \quad or \quad \Delta U = -\Delta W$$

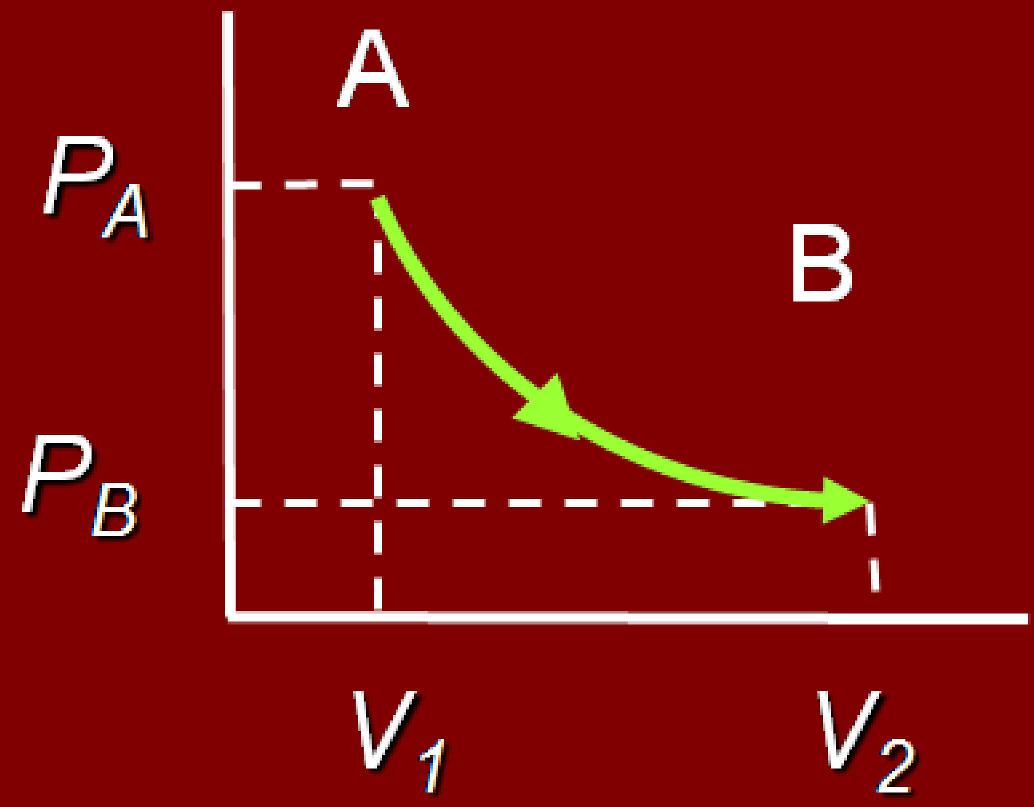
$\Delta W = -\Delta U$ $\quad\quad$ $\Delta U = -\Delta W$



Work done at EXPENSE of internal energy
INPUT Work INCREASES internal energy

ADIABATIC EXAMPLE:

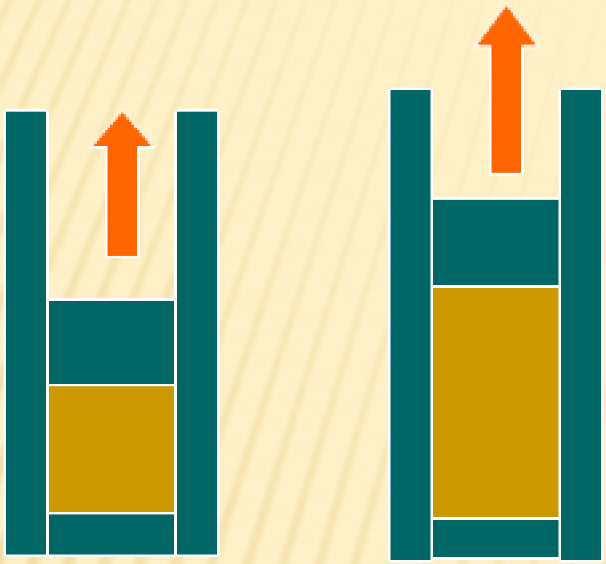




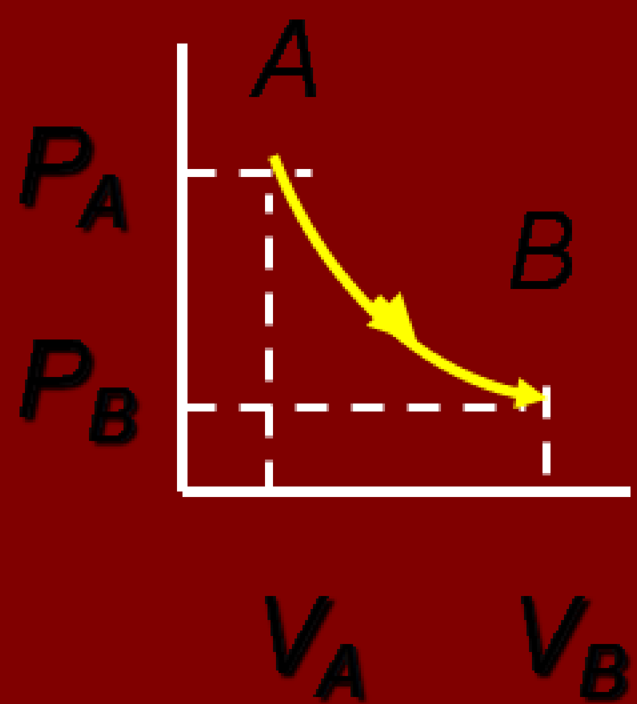
Insulated Walls: $\Delta Q = 0$

Expanding gas does work with zero heat loss. Work = $-\Delta U$

ADIABATIC EXPANSION:



$$\Delta Q = 0$$



$$\frac{P_A V_A}{T_A} = \frac{P_B V_B}{T_B}$$

400 J of WORK is done, DECREASING the internal energy by 400 J: Net heat exchange is ZERO. $\Delta Q = 0$

$$P_A V_A^{\gamma} = P_B V_B^{\gamma}$$

Problem

1. The thermodynamics temperature of the normal boiling of nitrogen is 77.35K. Calculate the corresponding value of : a) the Celsius, b) the Rankine, and c) the Fahrenheit temperature

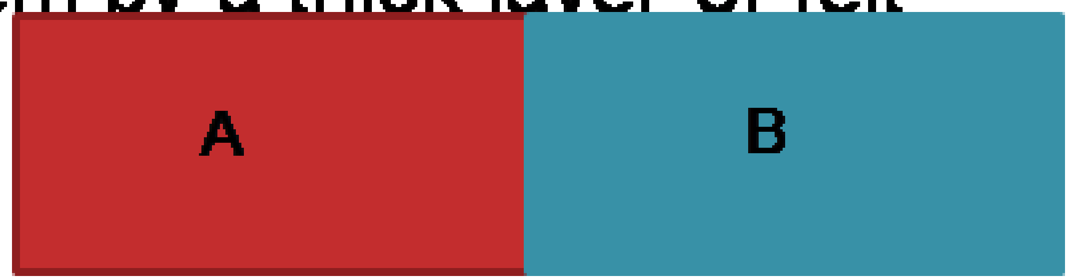
2. A mixture of hydrogen and oxygen is isolated and allowed to reach a state of constant temperature and pressure. The mixture is exploded with a spark of negligible energy and again allowed to come to a state of constant temperature and pressure.
   a) Is the initial state an equilibrium state? Explain
   b) Is the final state an equilibrium state? Explain

Two metal blocks A and B, of the same material

Suppose that our temperature sense :

A is warmer than B.

We bring A and B into contact, surround them by a thick layer of felt



We find that after a sufficiently long time has elapsed the two fell equally warm.

Volume, electrical resistivities, or elastic moduli changed when the bodies were first brought into contact, but eventually they become constant also.

Suppose that two bodies of different materials, Ex. a block of metal and a block of wood.

After a sufficiently long time the measurable properties of these bodies (such as their volumes) cease to change .

The bodies will not feel equally warm → difference in thermal conductivity

The bodies are of the same material or not, is that an end state is eventally reached in which no further observable changes in the measurable properties of the bodies.

→ defined as one of *thermal equilibirum*

→ all ordinary object have a physical property that determines whether or not they will be in thermal equilibrium when placed contact with other object.

This property called *temperature*.

(i). A and C is in thermal equilibrium → temperature of A and C are equal
B and C is in thermal equilibrium → temperature of B and C are equal
(ii) A and B is in thermal equilibrium → temperature of A and B are equal

" When any two bodies are each other separately in thermal equilibrium with a third, they are also in thermal equilibrium with each other"

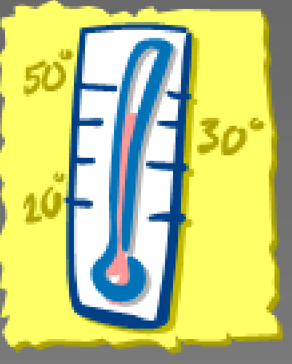
(The Zeroth Law of Thermodynamics)

Thermometer

Thermometer is a thermometric property which changes with temperature and is readily measured.

Comparison of temperature scales

- Relative Scales
  - Fahrenheit (°F)
  - Celsius (°C)
- Absolute Scales
  - Rankine (°R)
  - Kelvin (K)



Celcius

The **Celsius** temperature scale was previously known as the **centigrade scale.** The **degree Celsius** (symbol: ℃) can refer to a specific temperature on the **Celsius scale** as well as serve as a unit increment to indicate a temperature *interval* (a difference between two temperatures or an uncertainty).
The Celsius scale was defined 0 °C as the freezing point of water and 100 °C was defined as the boiling point of water under a pressure of one standard atmosphere

Fahrenheit

In Fahrenheit scale, the freezing point of water is 32 degrees Fahrenheit (°F) and the boiling point 212 °F, placing the boiling and freezing points of water exactly 180 degrees apart

Rankine

In Rankine scale, the freezing point of water is 492 R and the boiling point 672 R, placing the boiling and freezing points of water exactly 180 apart.

Kelvin

The **kelvin** (symbol: **K**) is a unit increment of temperature and is one of the seven SI base units.
The **Kelvin scale** is a thermodynamic (absolute) temperature scale where absolute zero, the theoretical absence of all thermal energy, is zero (0 K).
In Kelvin scale, the freezing point of water is 273 K and the boiling point 373 K, placing the boiling and freezing points of water exactly 100 apart
Absolute zero—the temperature at which nothing could be colder and no heat energy remains in a substance—is, by definition, exactly 0 K *and* −273.15 °C