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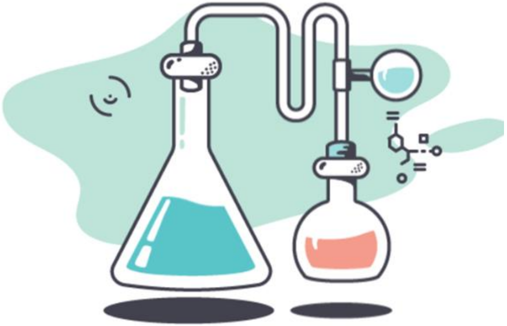
Thermodynamics

Lecture 2



Topics we will learn today

- Scope of Thermodynamics
- Limitations of Thermodynamics
- System, surrounding & Boundary
- Thermodynamic Equilibrium
- System Variables & Processes

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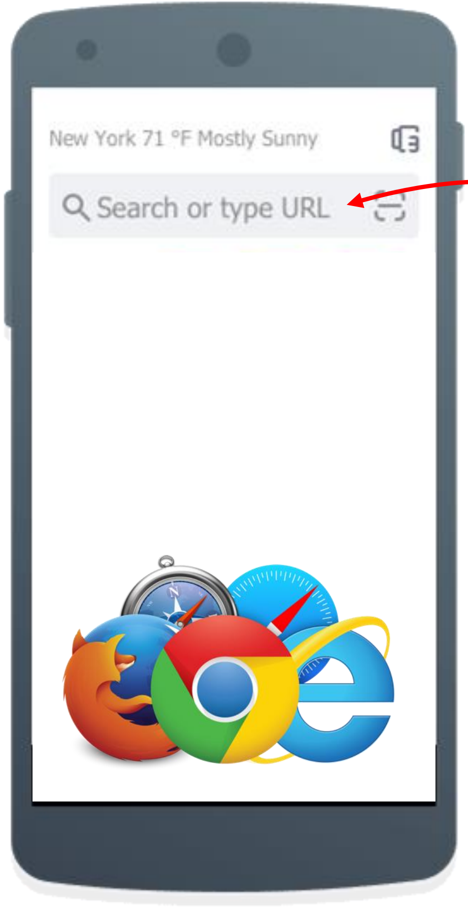

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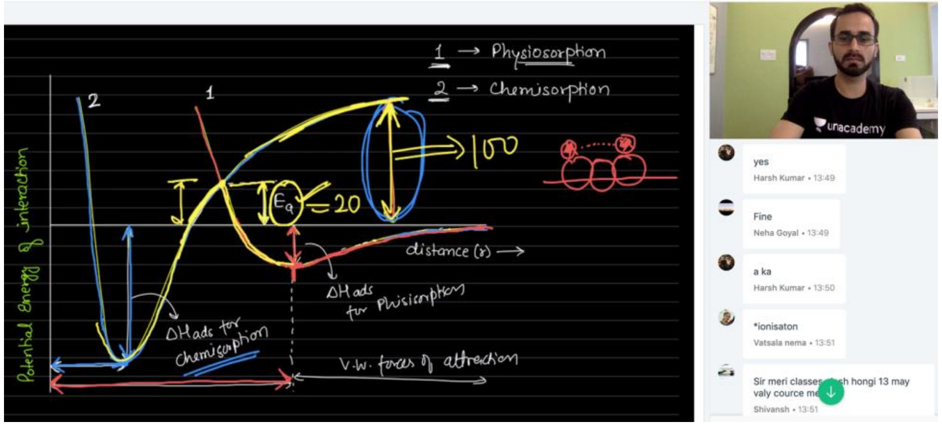

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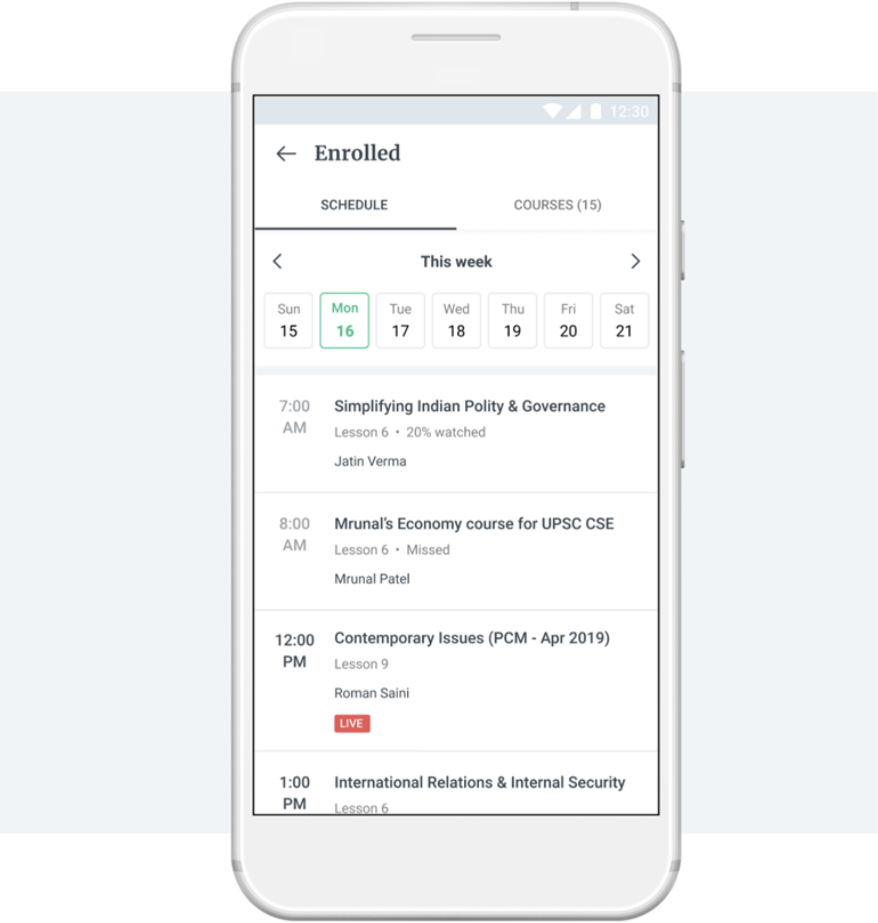

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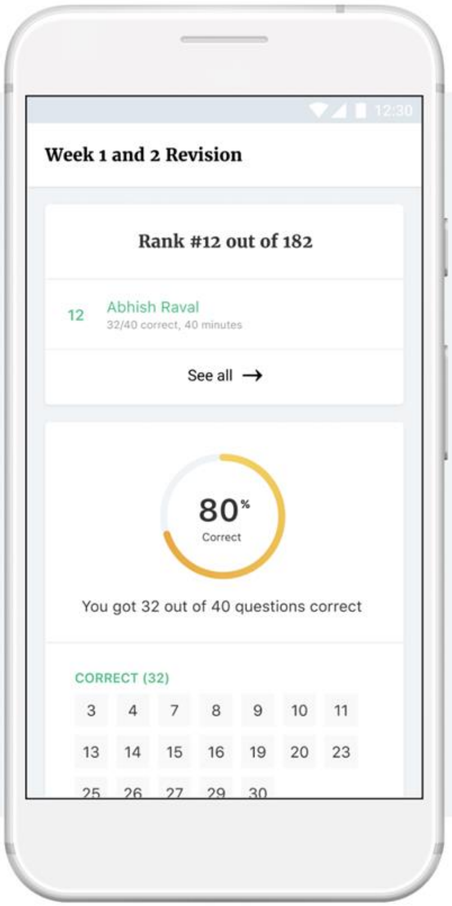

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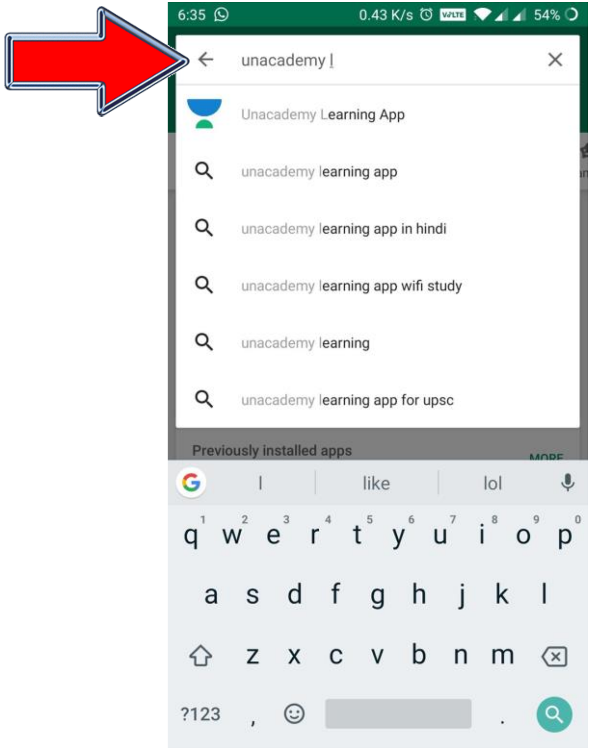

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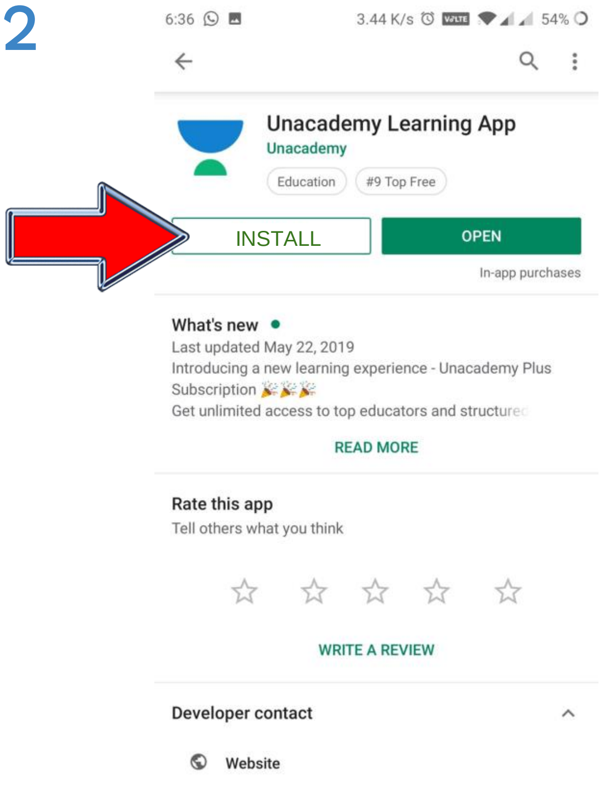

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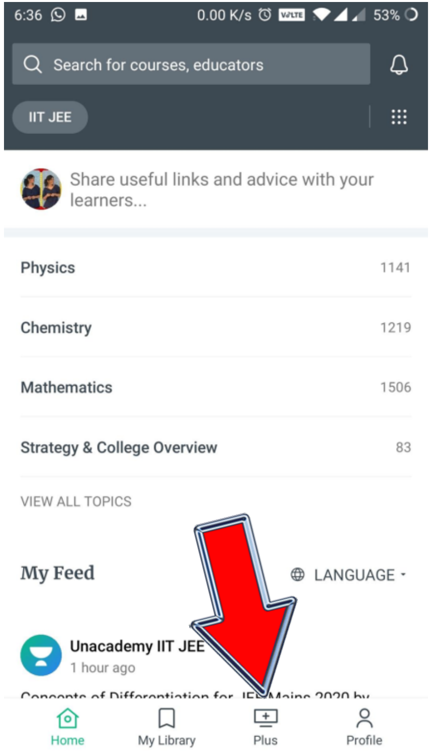
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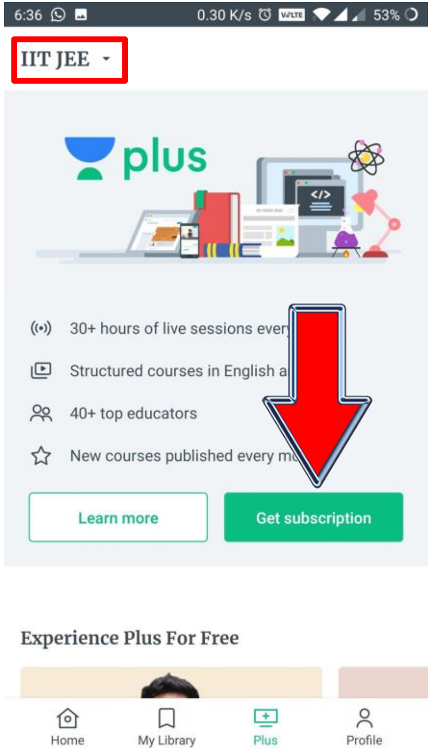
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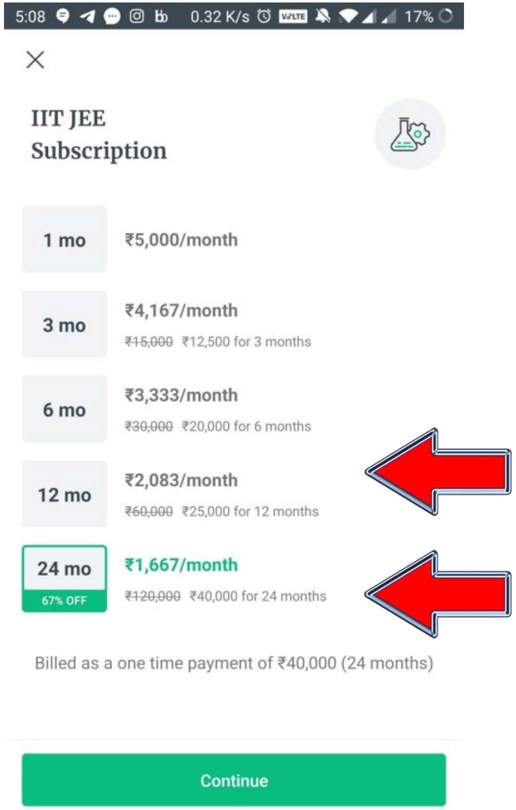
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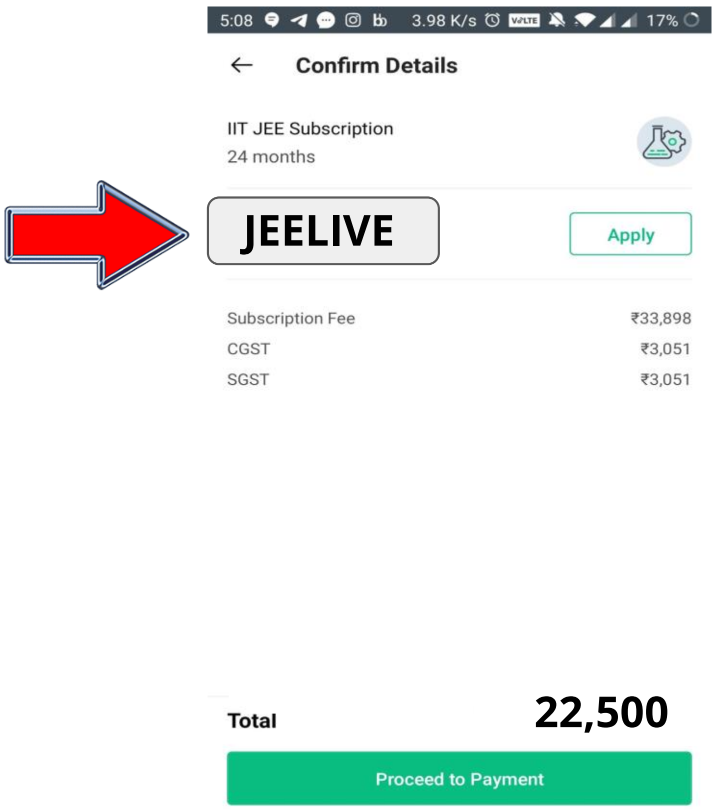
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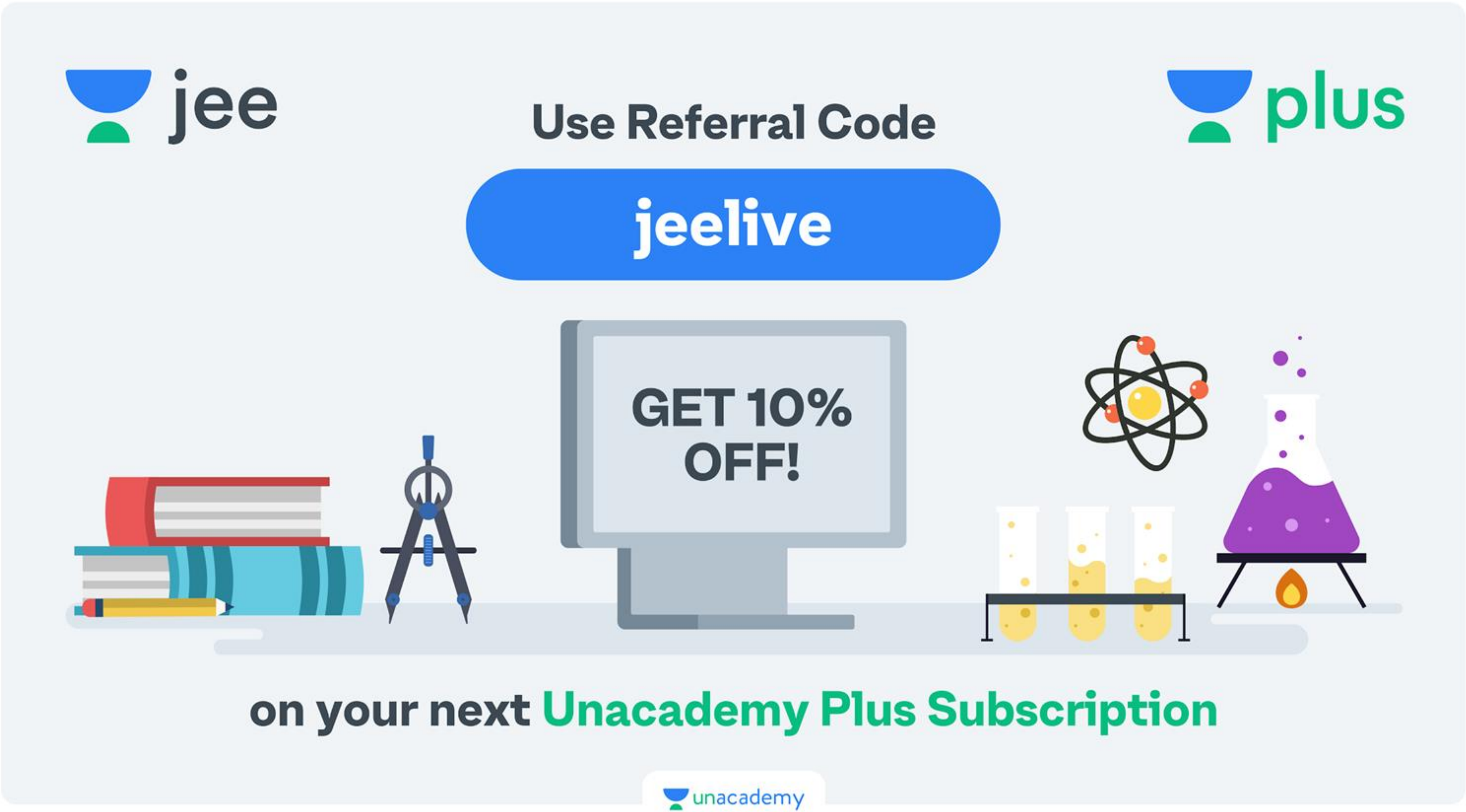
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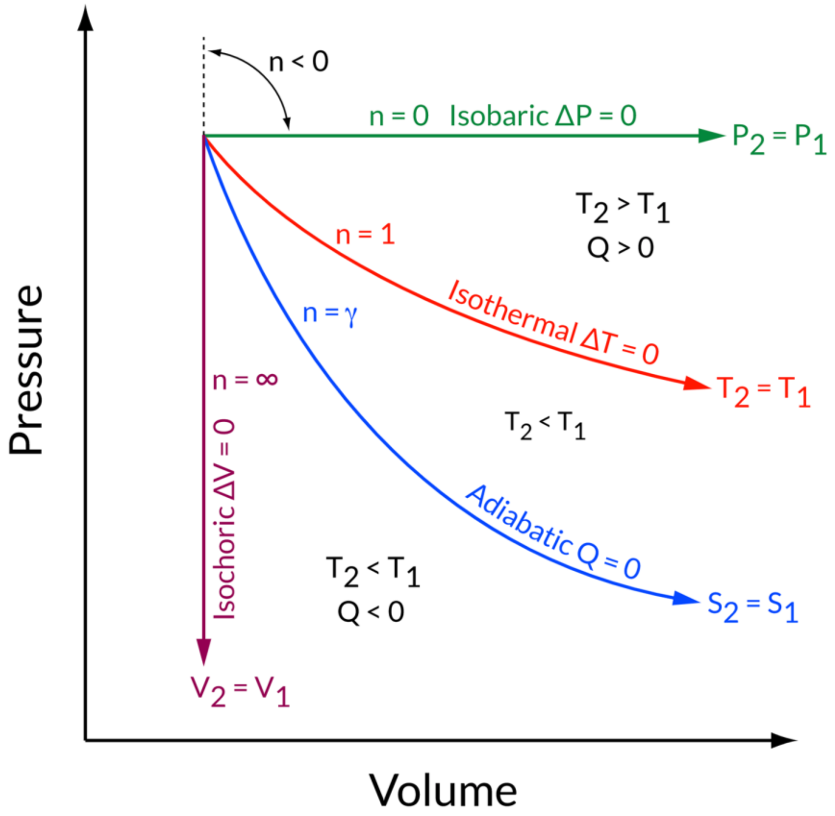
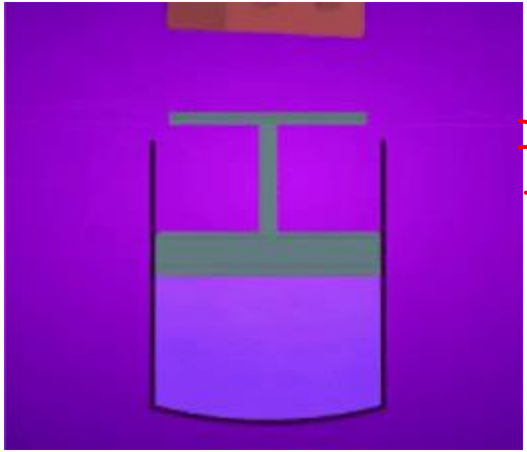
Thermodynamic Process

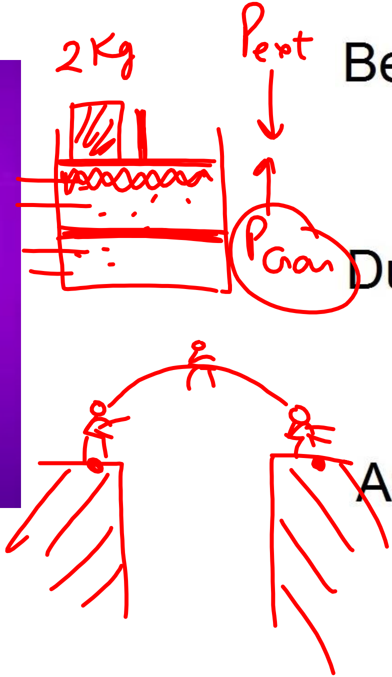
$$PV^n = \text{constant}$$

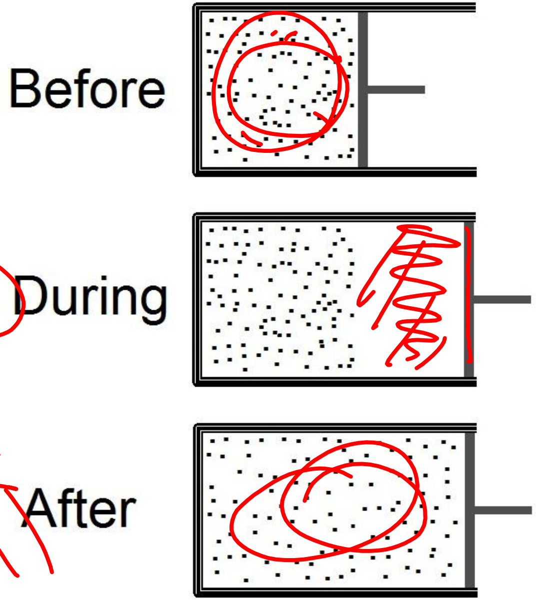


Thermodynamic Process

Irreversible process



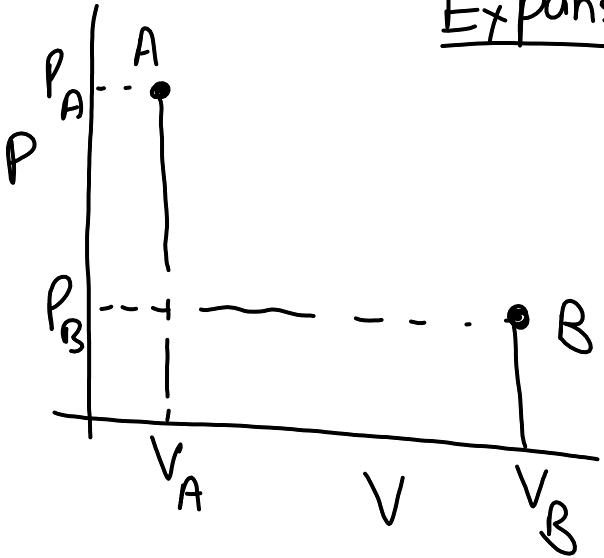




Thermodynamic Process

Irreversible process

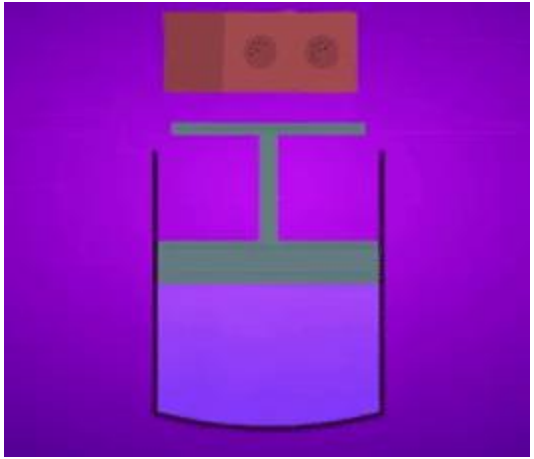
<u>Expansion</u>

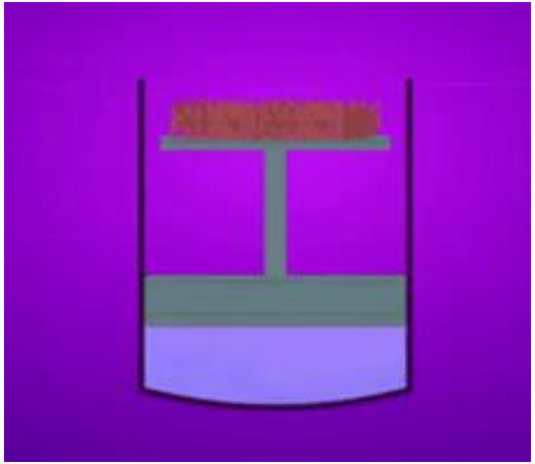


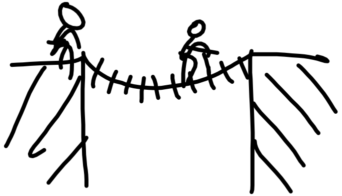
- system & surr are in equilibrium only at initial & final positions but not during the process.
- Driving force is much greater than opposing force

Thermodynamic Process

Reversible process







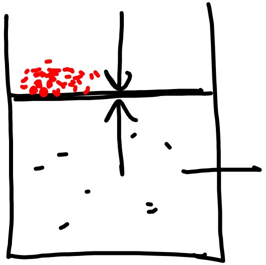
Thermodynamic Process

Reversible process

Isothermal

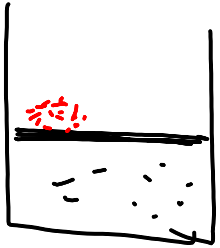
initially

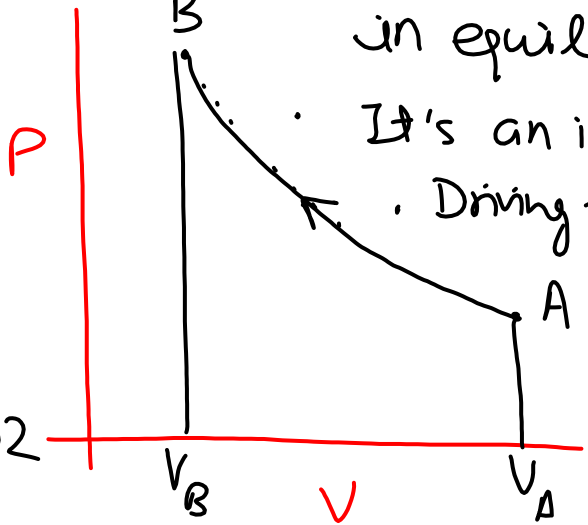
$P_{Gas} = P_{ext}$



$P_{ext} = 1\,0001$

$P_{Gas} = 1\,0002$





- System & surroundings are almost always in equilibrium
- It's an ideal process
- Driving force is infinitesimally greater than opp. force

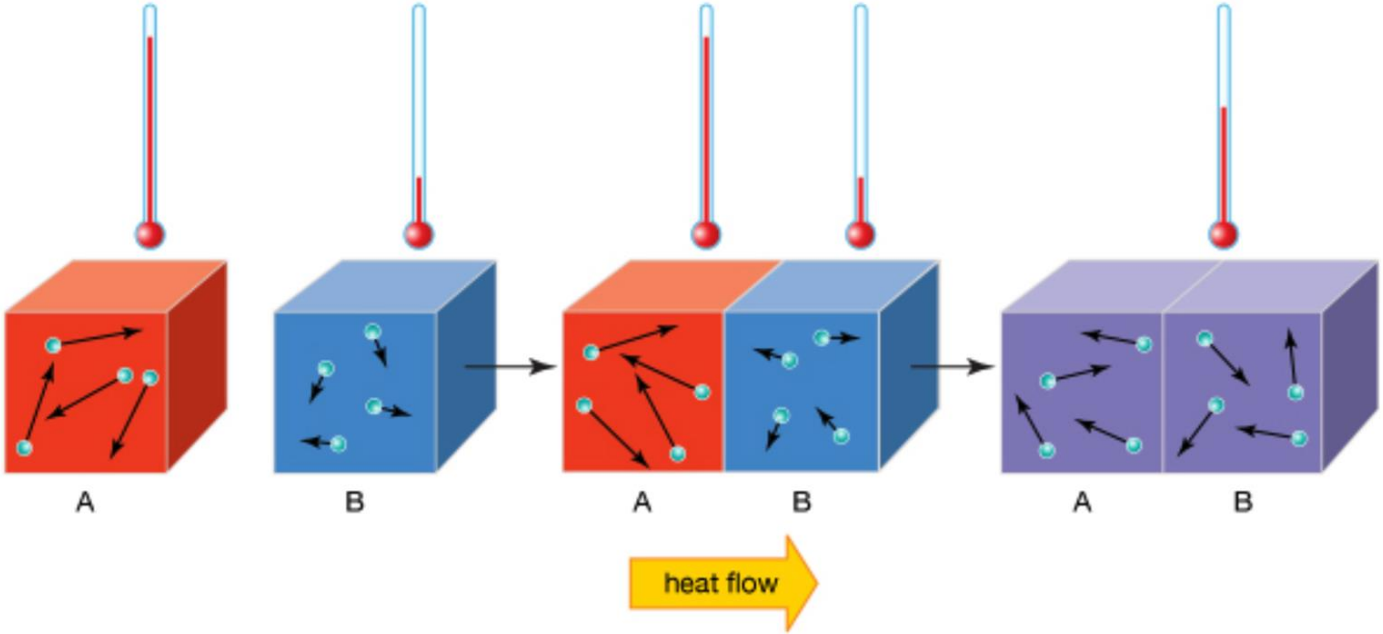
Modes of Energy Exchange

These are two ways by which a system can interact or can exchange energy with its surroundings.

- Heat
- Work

Heat: When the energy transfer takes place because of temperature difference between system & surroundings. It is known as heat.

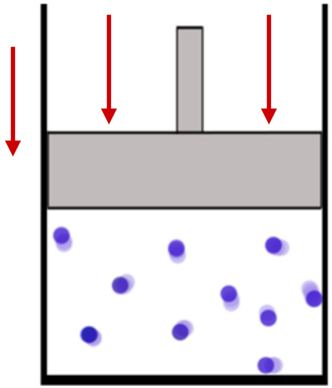
Modes of Energy Exchange



Modes of Energy Exchange

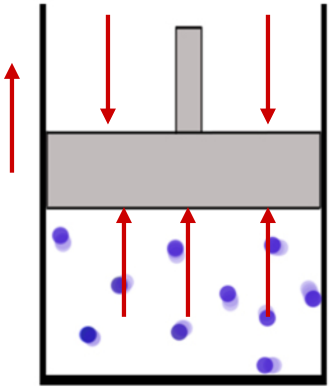
Work : Energy transfer which is not heat or which is not because of temperature difference is called work.

IUPAC Sign convention about Heat and Work



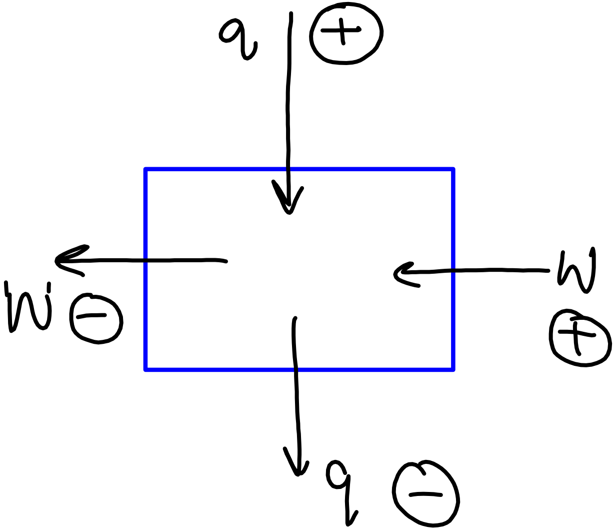
Work done on the system = **+ve**

e.g. compression



Work done by the system = **-ve**

eg expansion



Example

A system is provided 50 J of heat and work done on the system is 10 J.
What is the change in internal energy?

$$q = +50$$

$$W = +10$$

Example

Which of the following pair shows extensive properties?

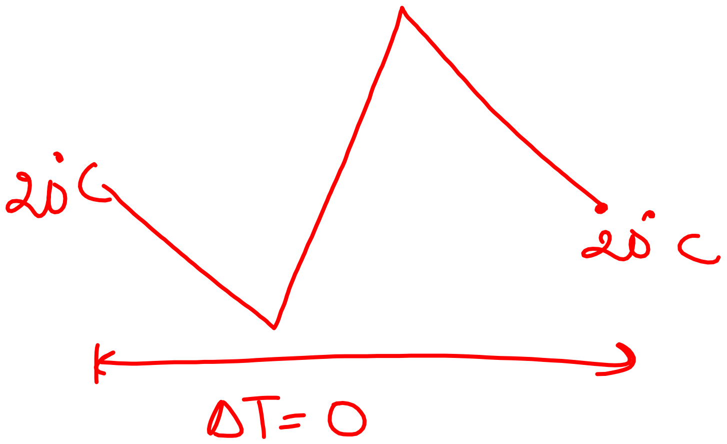
a) T and P
b) Viscosity & surface tension
c) Volume and internal energy
d) Refractive index & specific heat

Example

For an isothermal process, the essential condition is

T=const

a) ~~$\Delta T = 0$~~
b) $\Delta H = 0$
c) $\Delta U = 0$
d) $dT = 0$
e) T= const



First Law of Thermodynamics (FLOT)

Law of Energy Conservation

Energy of **total universe** is always conserved.

or

Total energy of an **isolated system** is always conserved.

Hence absolute value of **E** can never be calculated only change in value of E can be calculated for a particular process.

$$\left.\begin{aligned} \Delta U &= q + w \\ \Delta E &= q + w \end{aligned}\right\}$$

1st law

eg

$$\Delta U = 50 - 20$$
$$= 80$$

Internal Energy (E, also denoted by U)

Every system having some quantity of matter is associated with a definite amount of energy, called internal energy .

$\frac{dx}{dy}$

It is the sum of all forms of energies present in the system.

$$E = E_{Translational} + E_{Rotational} + E_{Vibrational} + E_{bonding} + \ldots..$$

$$\Delta E = E_{Final} - E_{Initial} \; .$$

$\Rightarrow$ ΔE or ΔU

$E \xrightarrow{100\,J} E+100$

If for a gas the internal energy is directly proportional to its absolute temperature then the gas is termed as an ideal gas. $U \propto$ Temp (ideal gas)

$$\left.\begin{array}{l} \text{so } \left(\dfrac{\partial E}{\partial V}\right)_{\underset{\text{const.}}{T}} = 0 \; , \; \left(\dfrac{\partial E}{\partial P}\right)_T = 0 \end{array}\right\} \text{ideal gas}$$

Example

Which has maximum internal energy at 290K?

a) Ne (g)
b) N2 (g)
c) O3 (g)
d) Equal for all

U doesnt depend on frame of reference