Chapter–12:

Thermodynamics

CBSE CLASS XI NOTES

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1. Explain adiabatic and diathermic wall?

Adiabatic wall.

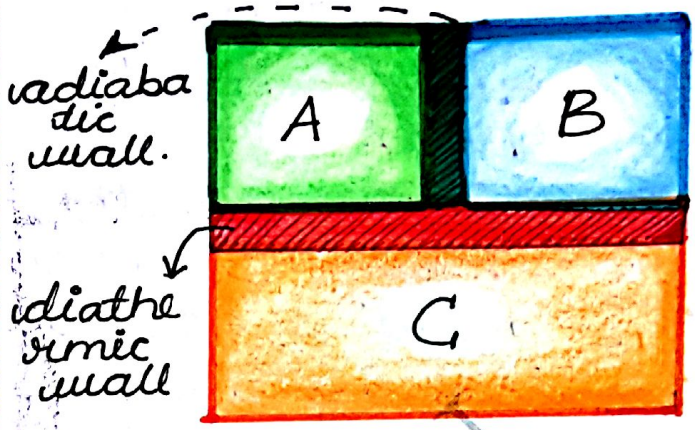
Two system are said to be seperated by adiabatic wall if the thermodynamic variables of one system can be changed without affecting that of other system. An adiabatic wall does not allow heat flow.

Diathermic wall.

If two systems are seperated by diathermic wall, a change in thermodynamic variables of one system will affect that of other system. The diathermic wall is a perfect conductor of heat.

2. State Zeroth law of thermodynamics?

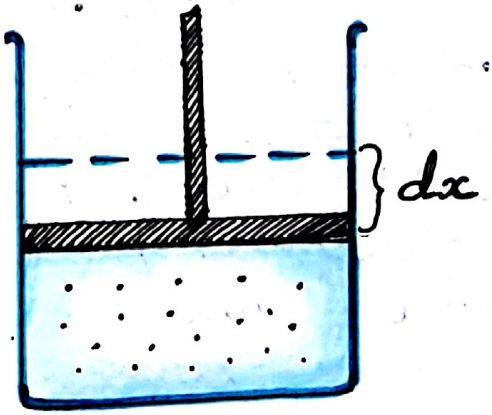
Zeroth law states that 'If two systems A and B are seperately in thermal equilibrium with a third system C, then the systems A and B are in thermal equilibrium with each other.



* A and B are seperated by adiabatic wall
* C is seperated from A and B by diathermic wall.
* A and B will be seperately in equilibrium with C. After sometime A and B will be in equilibrium with each other

3. Explain work done by a thermodynamic process?

consider a gaseous system enclosed in a cylinder fitted with a piston



A → area of cross section of piston
P → pressure exerted

by the gas.

Force exerted by the gas on the piston,

$F = PA$

Due to this force, the piston moves through a small distance 'dx'

Work done by the gas.

$dW = F\,dx$ ∘∘

$= P A\,dx$

$= P\,dV$

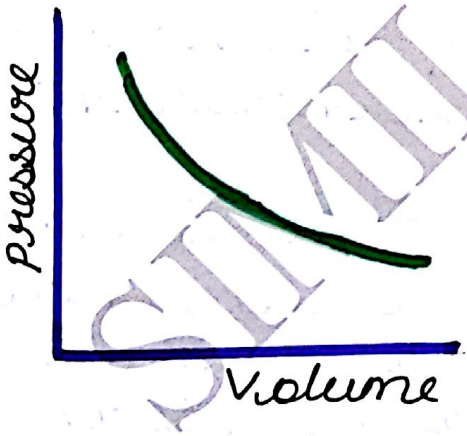
$W = \int_{V_1}^{V_2} P\,dV$ ∘∘

$P = \frac{F}{A}$

$F = PA$

$\therefore A\,dx = V$

4. What do you mean by indicator diagram?



It is a graph drawn with volume along X-axis and pressure along Y-axis. It gives complete information about the change in pressure and volume during a thermodynamic process. The area under the graph gives total work done during the process.

5. What do you mean by internal energy of a thermodynamic system?

According to kinetic theory gas molecules are constantly in motion and hence they possess kinetic energy. Due to inter molecular forces they possess potential energy. The sum of kinetic and potential energies of all molecules of a system is called internal energy.

6. State the first law of thermodynamics?

It states that the amount of heat energy (ΔQ) supplied to a system is utilised to increase its internal energy (ΔU) and to do external work (ΔW)

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

$\Delta Q = \Delta U + P\Delta V$

In differential form

$dQ = dV + P\,dV$

7. Explain two applications of first law of thermodynamics?

(i) Isolated system

It does not interact with the surroundings so heat flow and work done is zero.

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

$\therefore$ Internal energy of an isolated system remains constant.

(ii) cyclic process

Here the system returns to initial states after passing through intermediate states $\Delta U = 0$

According to Ist law

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

$\Delta Q = \Delta W$ $(\because \Delta U = 0)$

Amount of heat energy = work done

* This is the principle of heat engine.

8. What do you mean by isothermal process. Explain isothermal expansion and isothermal compression?

When a system undergoes physical change at constant temperature. the process is called isothermal process.

Equation

$PV = RT$

conditions

1. changes should be slow
2. system must be contained in a perfectly conducting chamber.

According to first law

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

$\Delta Q = \Delta W$ $\because \Delta U = 0$, T-const

Isothermal Expansion

consider a gas inside a conducting cylinder fitted with a conducting piston. The gas is allowed to expand slowly. The volume increases pressure decreases and temperature remains constant by absorbing heat from the surroundings.

Isothermal compression

* The gas is compressed slowly

work is done on gas.
* volume decreases, pressure increases.
* temperature remains constant by releasing heat into the surroundings.

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9. Explain adiabatic process. What do you mean by adiabatic expansion and adiabatic compression?

The process in which no heat enters or leaves the system is called adiabatic process.

Equation : $PV^{\gamma} = \text{constant}$

conditions :-

1. The process should be quick
2. The system should be perfectly insulated from the surroundings.

According to first law

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

$$\Delta U + \Delta W = 0$$

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

[$\because \Delta Q = 0$, no heat transfer]

Adiabatic expansion.

* The gas is enclosed in a non-conducting cylinder with a non conducting piston.
* The gas is allowed to expand - work is done by the gas..
* volume increases, pressure decreases and temperature decreases.

Adiabatic compression

* The gas is compressed quickly - work is done on the gas.
* volume decreases, pressure increases and temperature increases since there is no heat transfer.

Examples:-

1. Top of mountain, air expands adiabatically due to low pressure. During adiabatic expansion temperature decreases. Hence mountain tops are cooler.
2. when a tyre bursts the sudden expansion of air is adiabatic. During adiabatic expansion temperature decreases. so air is cooled.

10, Explain reversible and irreversible process?

Reversible process.

A process is said to be reversible if it can be retraced in the opposite direction at any stage such that it passes through the same states as in the direct process.

condition for a process to be reversible.

1. The process should takes place very slow.
2. Dissipative forces like friction, viscocity etc should be absent.
3. Pressure and temperature of the system should not vary appreciably from that of surroundings.

eg. melting and boiling process.

Irreversible process

A process which cannot be retraced in the opposite direction by reversing the controlling factors is called irreversible process.

conditions

* changes occur suddenly
* accompanied by dissipative forces.

eg. passage of electric current through a resistor.

11, Derive Mayer's Relation

According to first law of thermodynamics

$$dQ = dU + PdV$$

Differentiating w.r.t T at constant volume

$$\left(\frac{dQ}{dT}\right)_V = \left(\frac{dU}{dT}\right)_V + P\left(\frac{dV}{dT}\right)_V$$

$$C_V = \frac{dU}{dT} \quad \ldots (1)$$

differentiating w.r.t T at constant pressure

$$\left(\frac{dQ}{dT}\right)_P = \left(\frac{dU}{dT}\right)_P + P\left(\frac{dV}{dT}\right)_P$$

$$C_P = C_V + R$$

$$C_P - C_V = R$$

$\left(\frac{dQ}{dt}\right)_V = C_V$

$\left(\frac{dU}{dt}\right)_V = \frac{dU}{dT}$ since U independent of P, V

$\left(\frac{dU}{dT}\right)_V = 0$ V = const

$$\left(\frac{dQ}{dT}\right)_P = C_P$$

$$PV = RT$$

$$P\frac{dV}{dT} = R\frac{dT}{dT} = R$$

$$C_P - C_V = R$$

12. Explain the parts of carnot's Engine?

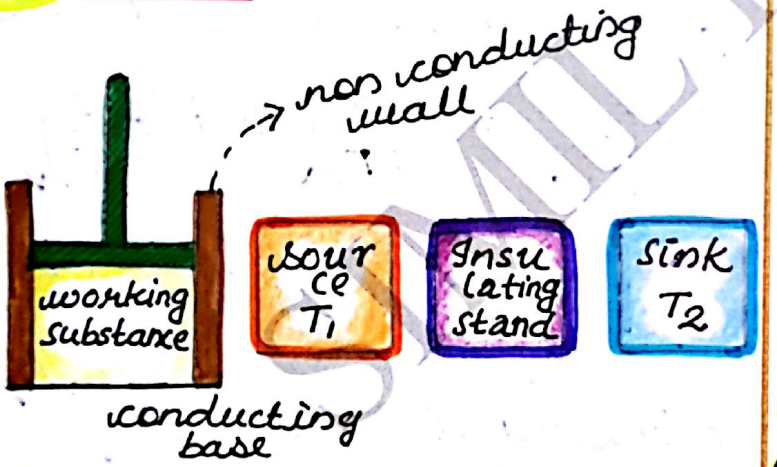
carnot Engine is an ideal heat Engine.

Essential parts of the Engine

(1) source (2) working substance

(3) Insulating stand

(4) sink.



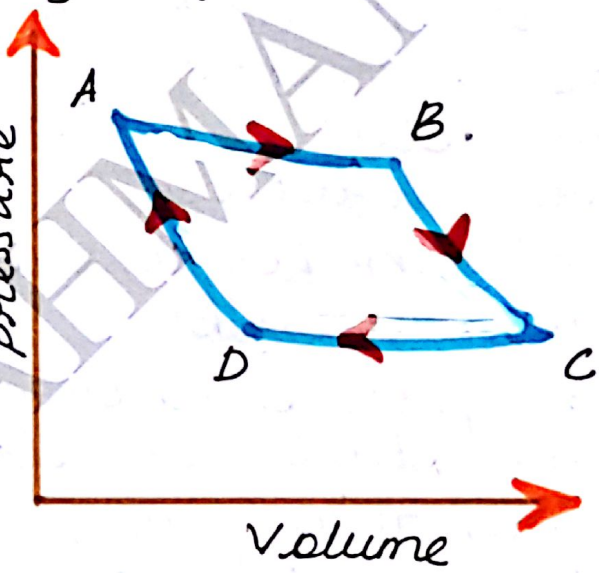
(1) working substance is an ideal gas enclosed in a cylinder with conducting base and non-conducting walls.

(2) source is a hot body of infinite thermal capacity at a higher temperature T_1.

(3) sink is a cold body of infinite thermal capacity at a lower temperature T_2.

(4) Insulating stand is made up of perfectly insulating material.

13. Explain carnot's cycle?



carnots cycle consists of four operations

(1) Isothermal expansion

(2) Adiabatic Expansion

(3) Isothermal compression

(4) Adiabatic compression.

(1) Isothermal Expansion

The cylinder is placed on source. The working substance attains a temperature T_1, pressure P_1 and volume V_1. The gas is expanded slowly. Pressure

decreases to P_2, Volume increases to V_2 temperature remains constant by absorbing Q_1 amount of heat from source. The curve AB represents this process.

(2) Adiabatic expansion

Now the cylinder is kept on insulating stand. The gas is allowed to expand adiabatically. There is no heat flow. So temperature fall to T_2. Pressure and volume changes to P_3 and V_3. curve BC represents this process.

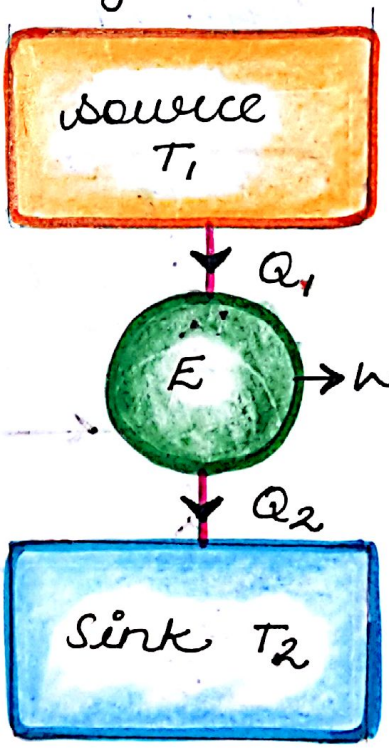
(3) Isothermal Compression

Now the cylinder is placed on the sink. The gas is compressed Isothermally. Temperature remains constant by rejecting Q_2 amount of heat into the sink. Pressure and volume changes to P_4 and V_4. curve CD represents this process.

(4) Adiabatic compression

Now the cylinder is placed on the insulating stand. The gas is compressed adiabatically. No heat enters or leaves the system. pressure increases to P_1 and volume decreases to V_1. Temperature increases to T_1. curve DA represents this process.

14, Derive an expression for effeciency of Carnot's engine ?



Effeciency :- Ratio of net work done by the heat engine to the heat taken from the source in one complete cycle.

$$\eta = \frac{W}{Q_1}$$

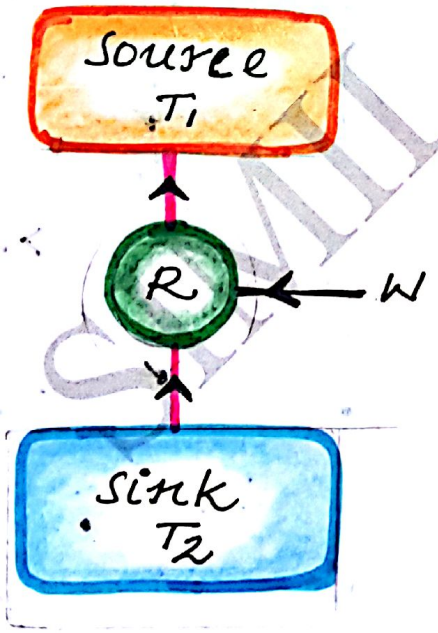
$$\eta = \frac{Q_1 - Q_2}{Q_1}$$

$$\eta = \frac{T_1 - T_2}{T_1}$$

$$\eta = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$

$$\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$$

15. Explain Refrigerator what do you mean by co-effecient of perfosmance?



Refrigerator is the reverse process of carnots engine. Here the working substance absorbs Q_2 amount of heat from freezer (sink), an amount of work is done by external agency. working substance gives large amount of heat to the surroundings (source)

co-efficient of performance :-

Ratio of quantity of heat removed from freezer to the work done by the external agency in one complete cycle.

$$\beta = \frac{Q_2}{W}$$

$$\beta = \frac{Q_2}{Q_1 - Q_2}$$