THERMODYNAMICS

Zeroth law of Thermodynamics

According to this law, two systems in thermal equilibrium with a third system separately are also in thermal equilibrium in each other

First law of Thermodynamics

Heat given to a thermodynamic system (ΔQ) is partially utilised in doing work (ΔW) against the surrounding and the remaining part increases the internal energy (ΔU) of the system.	$Q = \Delta U + \Delta W$

Second law of Thermodynamics

It is impossible to transfer heat from a lower temperature body to a higher temperature body without use of an external agency.

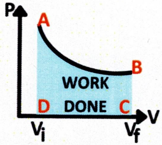
Kelvin-Plank Statement

It is impossible for any device that operates on a cycle to receive heat from a single reservoir and produce only a net amount of work.

Clausius Statement

It is impossible to construct a device that operates in a cycle and produces no effect other than the transfer of heat from a lower-temperature bod[y to a h]igher-temperature body.

Work done by a thermodynamic system



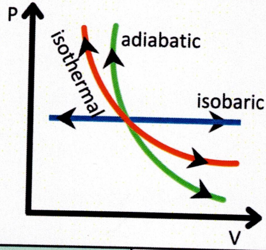
$$W = p \times \Delta V$$

$$W = \int_{V_i}^{V_F} p\Delta V = \text{Area ABCDA}$$

Quantity	Sign	Condition
ΔQ	+	When heat is supplied to a system
	-	When heat is drawn to a system
ΔW	+	When work done by the gas (expansion)
	-	When work done on a system (compression)
ΔU	+	With temp. rise, internal energy decreases
	-	With temp. fall, internal energy decreases

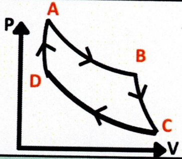
Internal Energy	$U = nf\frac{RT}{2}$
Polytropic Process	$W.D. = \frac{nR\Delta T}{1-x}$
Ideal Gas Relation	$C_P - C_V = R$

Thermodynamic Processes	
Quasistatic Process	$ds = \frac{\delta q}{T}$
Isothermal Process	$\Delta U = 0$
Adiabatic Process	$\Delta Q = 0$
Isobaric Process	$\Delta P = 0$
Isochoric Process	$\Delta V = 0$
Cyclic Process	$\Delta U = 0$



Entropy	$dS = \frac{dQ_{rev}}{T}$
	$dS = \frac{dQ_p}{T} = \frac{dH}{T} = \frac{mL}{T}$

Carnot's Cycle



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

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

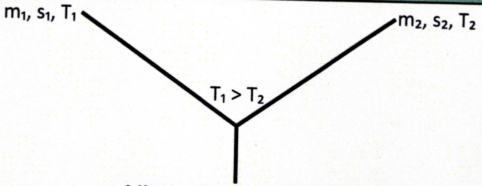
Expansions
AB : Isothermal
BC : Adiabatic
Compressions
CD : Isothermal
DA : Adiabatic

Isothermal Expansion	**Adiabatic Expansion**
$W_1 = 2.303\, nRT_1 \log_{10} \frac{V_2}{V_1}$	$W_2 = \frac{nR}{\gamma - 1}(T_1 - T_2)$
Isothermal Compression	**Adiabatic Compression**
$W_3 = 2.303\, nRT_2 \log_{10} \frac{V_4}{V_3}$	$W_4 = \frac{nR}{\gamma - 1}(T_2 - T_1)$
Work done in Carnot Cycle	$W = nR(T_1 - T_2) \ln \frac{V_2}{V_1}$

Refrigerator

Co-efficient of Performance	$\beta = \frac{Q_2}{W}$
	$\beta = \frac{Q_2}{Q_1 - Q_2}$
	$\beta = \frac{T_2}{T_1 - T_2}$

Law of Mixtures

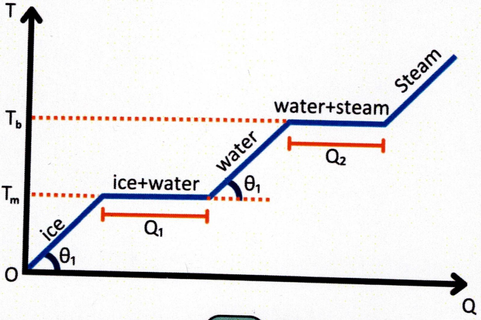


Mixture Temperature = T_m

Heat taken by one system = Heat given by another substance

$$m_1 s_1 (T_1 - T_m) = m_2 s_2 (T_m - T_2)$$

Water at different temperature

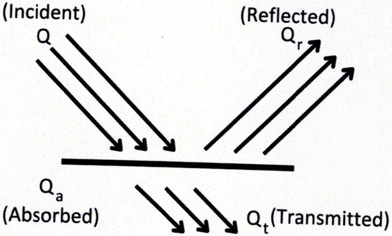


Absorption, Reflection and Emission of Radiation

$$Q = Q_R + Q_T + Q_a$$

$$1 = \frac{Q_R}{Q} + \frac{Q_T}{Q} + \frac{Q_a}{Q}$$

$$1 = r + t + a$$



r = 0, t = 0, a=1, perfect black body
r = 1, t = 0, a=0, perfect reflector
r = 0, t = 1, a=0, perfect transmitter

Emissivity

$$e = \frac{\text{Emission power of a body at temperature T}}{\text{Emission power of a black body at same temperature T}}$$