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Lecture 2 Basic concepts

[Thermodynamics] The study of the initial and final equilibrium states of a system which has been subjected to a specified energy process or transformation.

[System] A specified region, not necessarily of constant volume, where transfers of energy and/or mass occurred is to be studied.

The systems of interest in thermodynamics are finite and the point of view taken is macroscopic rather than microscopic, i.e., only coarse characteristics of the system, such as T, p, ρ, not detailed structure, are studied.

An atmospheric thermodynamic system is a portion of atmosphere undergoing transformations in the atmosphere. Example: a cumulus cloud.

[Boundary] Boundary is an actual or imaginary envelope enclosing the system.

[Surroundings] Surrounding is the region outside the system. For example, the rest of the atmosphere outside of the cumulus cloud.

[Closed System] A system which cannot change matter with its surroundings, i.e., mass is constant, but the energy exchange is allowed.

[Open System] An open system is a system which can exchange matter with its surroundings.

[Isolated System] An isolated closed system is a system which does not exchange energy and matter with its surroundings.

[Phase] Phase is a quantity of matter, homogeneous throughout in chemical composition and in physical structure. Example: water vapor, water, and ice.

[Homogeneous System] A homogeneous system is a system of a single phase, e.g., a dry air parcel.

[Heterogeneous System] A heterogeneous system is a system which consists of more than one phase, e.g., a hail storm (water vapor, cloud water, cloud ice, snow and hail).

[Property] Property is a characteristic of the system, such as T, p, and V (or *density*). They are also known as thermodynamic variables.

[State] State is the condition of the system (or part of the system) at an instant of time measured by its properties.

[Process] The system undergoes a change in state. Example: isobaric, isothermal, adiabatic, reversible processes.

[Intensive Property] An intensive property is a property which is independent of the mass of the system, e.g., T, viscosity, velocity, height, etc.

[Extensive Property] An extensive proper is a property which is related to the mass of the system, e.g., pressure, volume, weight, energy, surface area, etc.

[Specific value of an extensive property] Values per unit mass, e.g., specific volume, $\alpha = V/m = 1/\rho$. The specific value of an extensive property is an intensive property.

[Equilibrium] The state of a system remains constant in time in a given environment and the constancy of properties with time should hold for every portion of the system, even if we isolate it from the rest of the system and from the surroundings.

[Thermal Equilibrium] A system is in thermal equilibrium if its temperature is constant throughout the system and balanced by an equal temperature of the surroundings, e.g., a thermometer measures temperature at the thermal equilibrium.

[Mechanical Equilibrium] A system is in mechanical equilibrium if its pressure is constant throughout the system and balanced by an opposing force in the surroundings, e.g., mixture of vinegar and oil.

[Chemical Equilibrium] If all possible chemical reactions have taken place in a system, it it is called in chemical equilibrium. For example, oxygen and hydrogen at normal temperature are in chemical equilibrium.

[Thermodynamic Equilibrium] A system which is in thermal, mechanical and chemical equilibrium is called thermodynamic equilibrium.

[Dimensions and Units]

Dimension: A name given to a measurable quality or characteristic of an entity.

Units: The current systems of units for mechanical quantities are based on the choice of particular units for three fundamental quantities: length, mass and time.

MKS system: meter (m), kilogramme (kg), and second (s).

SI Units (The Systeme International d'Units): adopts the MKS mechanical units and the Kelvin (K) for thermodynamic temperature.

CGS system: centimeter (cm), gramme (g), and second (s).

Table of primary units

Physical Quantity	Dimension	Units (MKS or SI)
mass	M	kg
length	L	m
time	T	s
temperature	θ	K

Table of derived units

Physical Quantity	Dimension	Unit MKS (SI) system	Physical Law
Acceleration	LT^{-2}	m s^{-2}	$a=d^2x/dt^2$
Force	MLT^{-2}	N or kg m s^{-2}	F=ma
Density	ML^{-3}	kg m^{-3}	$\rho=m/V$
Pressure	$ML^{-1}T^{-2}$	Pa or N m^{-2}	p=F/A
Energy	ML^2T^{-2}	J or kg m^2 s^{-2}	W=Fd
Power	ML^2T^{-3}	Watt or J s^{-1}	P=dW/dt

x=spatial coordinate, A=area, V=volume, d=distance

Other units:

Pressure: hpa=100 Pa=millibar (mb), 1bar=10^5 Pa=10^6dyne cm^{-2},
1 atmosphere (atm)=1013.25 mb=1.01325×10^5 Pa.

Temperature: ^{o}C (degrees Celsius).

Energy: calorie (cal)=4.1855 J= heat to raise by 1K of temperature of 1 gramme of water at 15^{o}C.

Chemical mass unit: mole (mol)=6.022×10^{23} molecules, kmole=103 mole=6.022x1026 molecules=NA (Avogadros' constant). (1/17/17)