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DEPARTMENT OF MECHANICAL ENGINEERING

ME6301-ENGINEERING THERMODYNAMICS

(TWO MARK QUESTION ANSWERS)

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UNIT – 1 -BASIC COMCEPTS AND FIRST LAW

1. **Define thermodynamic system.**
   Thermodynamics is the science of energy transfer which deals with the relations among heat, work and properties of systems.
   The name 'thermodynamics' is derived from the Greek words therme, meaning'heat' and dynamis meaning power. Thus, thermodynamics is basically the study of heat and power.
2. **Name the different types of system.**
   There are three types of thermodynamic systems :
   1. Closed System
   2. Open System and
   3. Isolated System
3. **Define an isolated system.**
   Isolated system is not affected by surroundings. There is no heat, work and mass transfer take place. In this system total energy remains constant.
   Example: Entire Universe
4. **Differentiate closed and open system.**

Closed System	**Open System**
There is no mass transfer. Only heat and work will transfer.	Mass transfer will take place, in addition to the heat and work transfer.
System boundary is fixed one	System boundary may or may not change.
Ex: Piston &cylinder arrangement	Air compressor, boiler

5. **What is meant by surroundings and boundary?**
   Any other matter out side the system boundary is called as surroundings.
   System and surroundings are separated by an imaginary line is called boundary.
6. **What is meant by thermodynamic property?**
   Thermodynamic property is any characteristic of a substance which is used to identify the state of the system and can be measured, when the system remains in an equilibrium state.
7. **How do you classify the property?**
   Thermodynamic property can be classified into two types.
   Extensive and Extrinsic property.
8. **State the First law of thermodynamics.**
   First law of thermodynamics states that when system undergoes a cyclic process the net heat transfer is equal to work transfer.
9. **Define: PMM of first kind.**
   PMM of first kind delivers work continuously without any input. It violates first law of thermodynamics, it is impossible to construct an engine working with this principle.
10. **Define the term process**
    It is defined as the change of state undergone by a gas due to energy flow.

11. Define the term Cycle

When a system undergoes a series of processes and return to its initial condition, it is known as cycle.

12. .Define thermodynamic equilibrium.

The word equilibrium means balance. An equilibrium state of a thermodynamic system is a state that cannot be changed without any interaction with its surroundings.

If a system is balanced in all respects, it is in a state of thermodynamic equilibrium. Balanced in all respects means :

- There should not be any temperature difference within the system, so that the system is thermally balanced.
- No pressure difference exists between any two points within the system and between the system and surroundings, so that it is mechanically balanced.
- No chemical reaction is taking place, so that it is chemically balanced.
- If two phases are involved, mass of each phase remains constant so that phase equilibrium is achieved.

13. What do you mean by quasi-static process?

When a system is taken from one equilibrium state to another, the change is known as process. The series of intermediate states through which a system passes during a process is called the path of the process. If all these intermediate states are equilibrium states, the process is known as quasi equilibrium or quasi-static process.

14. Define Path and point function.

Point functions are those for which the change depends on only the end states and not on the path followed. Hence point functions are inexact differentials Path functions are those for which the change depends not only on the end states but also on the path followed. Hence path functionsare exact differentials.

15. Explain homogeneous and heterogeneous system.

Matter can exist in any one of the three phases namely solid, liquid and gas. A system consisting of a single phase is known as homogeneous systems. If the matter exists in more than one phase, the system is known as heterogeneous system.

16. What is meant by thermodynamic work?

It is the work done by the system when the energy transferred across the boundary of the system. It is mainly due to intensive property difference between the system and surroundings.

17. Define Heat.

Heat is the energy crossing the boundary due to the temperature difference between the system and surroundings.

18. What is a steady flow process?

During the process the rate of flow of mass and energy across the boundary remains constant, is known as steady flow process.

19. Define Zeroth law of Thermodynamics.

Consider three bodies A, B and C. If the bodies A and B are in thermal equilibrium with C when brought into contact separately, they are also in thermal equilibrium with each other. This concept is known as zeroth law of thermodynamics.

20. Differentiate between Microscopic and Macroscopic?

Statistical Thermodynamics is microscopic approach in which, the matter is assumed to be made of numerous individual molecules. Hence, it can be regarded as a branch of statistical mechanics dealing with the average behaviour of a large number of molecules.

Classical thermodynamics is macroscopic approach. Here, the matter is considered to be a continuum without any concern to its atomic structure.

21. **Differentiate reversible process and irreversible process?**
    A process is said to be reversible, it should trace the same path in the reverse direction when the process is reversed. It is possible only when the system passes through a continuous series of equilibrium state.
    If a system does not pass through continuous equilibrium state, then the process is said to be irreversible.

UNIT II SECOND LAW AND AVAILABILITY ANALYSIS

1. **State the Kelvin – Plank statement of second law of thermodynamics**
   Kelvin – Plank states that it is impossible to construct a heat engine working on cyclic process, whose only purpose is to convert all the heat energy given to it into an equal amount of work.
2. **State Clausius statement of second law of thermodynamics.**
   It states that heat can flow from hot body to cold without any external aid but heat cannot flow from cold body to hot body without any external aid.
3. **What are the Corollaries of Carnot theorem?**
   - All the reversible engines operating between the two given thermal reservoirs with fixed temperature have the same efficiency.
   - The efficiency of any reversible heat engine operating between two reservoirs is independent of the nature of the working fluid and depends only on the temperature of the reservoirs.
4. **State Carnot"stheorem**
   No heat engine operating in a cyclic process between two fixed temperature, can be more efficient than a reversible engine operating between the same temperature limits.
5. **Define – PMM of second kind.**
   Perpetual motion machine of second kind draws heat continuously from single reservoir and converts it into equivalent amount of work. Thus it gives 100% efficiency.
6. **What is the difference between a heat pump and a refrigerator?**
   Heat pump is a device which operating in cyclic process, maintains the temperature of a hot body at a temperature higher than the temperature of surroundings.
   A refrigerator is a device which operating in a cyclic process, maintains the temperature of a cold body at a temperature lower than the temperature of the surroundings.
7. **What is meant by heat engine?**
   A heat engine is a device which is used to convert the thermal energy into mechanical energy.
8. **Define the term COP?**
   Co-efficient of performance is defined as the ratio of heat extracted or rejected to work input.

$$\text{COP} = \frac{\text{Heat extracted or rejected}}{\text{Work input}}$$

9. **Write the expression for COP of a heat pump and a refrigerator?**

COP of heat pump

$$COP_{HP} = \frac{\text{Heat rejected}}{\text{Work input}} = \frac{T_2}{T_2 - T_1}$$

COP of Refrigerator

$$COP_{ref} == \frac{\text{Heat extracted}}{\text{Work input}} = \frac{T_1}{T_2 - T_1}$$

10. Why Carnot cycle cannot be realized in practice?

- In a Carnot cycle all the four processes are reversible but in actual practice there is no process is reversible.
- There are two processes to be carried out during compression and expansion. For isothermal process the piston moves very slowly and for adiabatic process the piston moves as fast as possible. This speed variation during the same stroke of the piston is not possible.

It is not possible to avoid friction moving parts completely

11. What are the processes involved in Carnot cycle.

Carnot cycle consist of
Reversible isothermal compression
Isentropic compression
Reversible isothermal expansion
Isentropic expansion

12. Write the two statements of the Second law of thermodynamics.

Kelwin plank statement: It is impossible to construct an engine working on an cyclic process which converts all the heat energy supplied to it into equivalent amount of useful amount of work.

Clausis statement: Heat cannot flow from cold reservoir to hot reservoir without any external aid. But heat can flow hot reservoir to cold reservoir without any external aid.

13. Define entropy.

Entropy is an index of unavailability or degradation of energy.

14. Define change of entropy. How is entropy compared with heat transfer and absolute temperature?

The measure of irreversibility when the energy transfer takes place within the system or between system and surrounding is called as change of entropy. It is simply known as unaccounted heat loss.

15. Explain the term "Reversibility".

If the process traces the same path during the process reversed is called as reversibility.

16. What do you mean by "Calusius inequality"?

It is impossible for a self acting machine working in a cyclic process unaided by any external agency to convey heat from a body at a lower temperature to a body at a higher temperature

17. Define the term absolute entropy.

The change entropy of the system with respect to ambient conditions or any other standard reference condition is known as absolute entropy.

UNIT – 3 -PROPERTIES OF PURE SUBSTANCE

1. **What do you understand by pure substance?**
   Substances of fixed chemical composition throughout are known as pure substances. That is, pure substances have homogenous and invariable chemical composition irrespective of the phase or phases in which they exist.
   Example
   Atmosphere air
   Water
   Nitrogen
   Water-steam mixture
   Product of combustion.
2. **Define latent heat of ice.**
   Total amount of heat added during conversion of $0^{\circ}C$ into water of $0^{\circ}C$.
3. **Define latent heat of evaporation.**
   The amount of heat added during heating of water boiling point to dry saturated stage is called as latent heat of vaporization or enthalpy of **vaporization** or latent heat of steam.
4. **Find the saturation temp and latent heat of vaporization of steam at 1 Mpa.**
   From steam table of 1 Mpa or 10 bar Saturation temperature, $T_{sat} = 179.88^{\circ}C$
   Latent heat of vaporization, $h_{fg} = 2013.6$ kJ/kg
5. **Define the terms „Boiling point" and „Melting point".**
   Boiling point: It is the temperature at which the liquid starts to change its state from liquid to vapour.
   Melting point: It is the temperature at which the solid starts to change its state from solid to liquid.
6. **What is meant by super heated steam? and indicate its use.**
   If the dry steam is further, then the process is called superheating and steam obtained is known as heated steam.
   Uses:
   Superheated steam has more heat energy and more work can be obtained using it.
   Thermal efficiency increases as the temperature of superheated steam is high.
   Heat losses be to condensation of stream an cylinder wall is reduced.
7. **Define dryness fraction of steam. (or) What is quality of steam?**
   It is defined as the ratio of the mass of the dry steam actually present to the mass of the total steam.
   Dryness fraction = mass of the dry steam/ the mass of the total steam.
8. **Define: sensible heat of water**
   The amount of heat required to raise the temperature of unit mass of water from $0^{\circ}C$ to the saturation temperature under a constant pressure. It is denoted by h_f.
9. **Define the term "Super heat enthalpy".**
   The heat supplied to the dry steam at saturation temperature, to convert it into superheated steam at the temperature T_{sup} is called superheat enthalpy.
10. **Explain the terms: Degree of super heat, Degree of subcooling.**
    Degree of super heat: It is the difference between superheated temperature and saturated temperature at the same pressure.
    Degree of subcooling: It is the amount by which the water is cooled beyond the saturated temperature at the same pressure.
11. **Define triple point and critical point for pure substance.**

Triple point: Triple point is the state where all the three phases i.e. solid, liquid and vapour to exist in equilibrium.

Critical point: It represents the highest pressure and temperature at which the liquid and vapour phases coexist in equilibrium. At the critical point the liquid and vapour phases are indistinguishable i. e. Liquid directly converted in to vapour.

12. When saturation pressure increases, what happens to saturation temperature and freezing point?

When saturation pressure increases, then the saturation temperature is increasing and the freezing point decreasing.

13. Why Rankine cycle is modified?

The work obtained at the end of the expansion is very less. The work is too inadequate to overcome the friction. Therefore the adiabatic expansion is terminated at the point before the end of the expansion in the turbine and pressure decreases suddenly, while the volume remains constant.

14. Name the various vapour power cycle.

Carnot cycle and
Rankine cycle.

15. Define overall efficiency.

It is the ratio of the mechanical work to the energy supplied in the fuel. It is also defined as the product of combustion efficiency and the cycle efficiency.

16. Define specific steam consumption of an ideal Rankine cycle.

It is defined as the mass flow of steam required per unit power output.

17. Name the different components in steam power plant working on Rankine cycle.

Boiler, Turbine, Cooling Tower or Condenser and Pump.

18. What are the effects of condenser pressure on the Rankine Cycle?

By lowering the condenser pressure, we can increase the cycle efficiency. The main disadvantage is lowering the back pressure in rease the wetness of steam. Isentropic compression of a very wet vapour is very difficult.

19. Mention the improvements made to increase the ideal efficiency of Rankine cycle

Lowering the condenser pressure.
Superheated steam is supplied to the turbine.
Increasing the boiler pressure to certain limit.
Implementing reheat and regeneration in the cycle.

20. Why reheat cycle is not used for low boiler pressure?

At the low reheat pressure the heat cycle efficiency may be less than the Rankine cycle efficiency. Since the average temperature during heating will then be low.

21. What are the disadvantages of reheating?

Reheating increases the condenser capacity due to increased dryness fraction, increases the cost of the plant due to the reheats and its very long connections.

22. What are the advantages of reheat cycle?

It increases the turbine work.
It increases the heat supply.
It increases the efficiency of the plant.
It reduces the wear on the blade because of low moisture content in LP state of the turbine.

23. Explain the term super heated steam and super heating.

The dry steam is further heated its temperature raises, this process is called as superheating and the steam obtained is known as superheated steam.

24. Define enthalpy of steam.

It is the sum of heat added to water from freezing point to saturation temperature and the

heat absorbed during evaporation.

25. **Define heat of vapourisation.**
    The amount of heat required to convert the liquid water completely into vapour under this condition is called the heat of vapourisation.
26. **Explain the terms, Degree of super heat, degree of sub-cooling.**
    The difference between the temperature of the superheated vapour and the saturation temperature at the same pressure. The temperature between the saturation temperature and the temperature in the sub cooled region of liquid.
27. **What is the purpose of reheating?**
    The purpose of reheating is to increase the dryness fraction of the steam passing out of the later stages of the turbine.

UNIT – 4-IDEAL AND REAL GASES AND THERMODYNAMIC RELATIONS

1. **Define Ideal gas.**
   It is defined as a gas having no forces of intermolecular attraction. These gases will follow the gas laws at all ranges of pressures and temperatures.
2. **Define Real gas.**
   It is defined, as a gas having the forces of attraction between molecules tends to be very small at reduced pressures and elevated temperatures.
3. **What is equation of state?**
   The relation between the independent properties such as pressure, specific volume and temperature for a pure substance is known as the equation of state.
4. **State Boyle‟s law.**
   It states that volume of a given mass of a perfect gas varies inversely as the absolute pressure when temperature is constant.
   $v \propto 1/P$
5. **State Charle‟s law.**
   It states that if any gas is heated at constant pressure, its volume changes directly as its absolute temperature.
   $v \propto T$
6. **State Joule‟s law.**
   Joule's law states, "The internal energy of a given quantity of a gas depends only on the temperature".
7. **State Regnault‟s law.**
   Regnault's law states that C_p and C_v of a gas always remains constant.
8. **Explain the construction and give the use of generalized compressibility chart.**
   The general compressibility chart is plotted with Z versus Pr for various values of Tr. This is constructed by plotting the known data of one of mole gases and can be used for any gas. This chart gives best results for the regions well removed from the critical state for all gases.
9. **What do you mean by reduced properties?**
   The ratios of pressure, temperature and specific volume of a real gas to the corresponding critical values are called the reduced properties.

10. Explain law of corresponding states.

If any two gases have equal values of reduced pressure and reduced temperature, then they have same values of reduced volume.

11. State Avogardo‟s Law.

The number of moles of any gas is proportional to the volume of gas at a given pressure and temperature.

Explain Dalton‟s law of partial pressure

The pressure of a mixture of gases is equal to the sum of the partial pressures exerted by individual gases if each one of them occupied separately in the total volume of the mixture at mixture temperature.

$$p = p_1 + p_2 + p_3 + \ldots p_k$$

12. What is Joule-Thomson coefficient?

The change in temperature with change in pressure, keeping the enthalpy remains constant. It is denoted by the

$$\mu = \left(\frac{\partial T}{\partial p}\right)_h$$

13. What is meant by virtual expansion?

Viral or virtual expansions are only applicable to gases of low and medium densities. The equations state of a substance is given by p =

$$p = \frac{RT}{v} + \frac{a(T)}{v^2} + \frac{b(T)}{v^3} + \frac{c(T)}{v^4} + \frac{d(T)}{v^5} + \cdots$$

The coefficient of a(T), b(T), c(T), d(T), …are virial coefficients. The virial coefficient will vanish when the pressure becomes zero. Finally, the equation of state reduces to the ideal-gas equation.

14. What are Maxwell relations?

$$\left(\frac{\partial T}{\partial v}\right)_s = -\left(\frac{\partial p}{\partial s}\right)_v$$

$$\left(\frac{\partial T}{\partial p}\right)_s = \left(\frac{\partial v}{\partial s}\right)_p$$

$$\left(\frac{\partial p}{\partial T}\right)_v = \left(\frac{\partial s}{\partial v}\right)_T \text{ and } \left(\frac{\partial v}{\partial T}\right)_p = -\left(\frac{\partial s}{\partial p}\right)_T$$

15. What is compressibility factor?

The gas equation for an ideal gas is given by (PV/RT) = 1, for real gas (PV/RT) is not equal to 1 (PV/RT = Z) for real gas is called the compressibility factor.

16. What is partial pressure?

The partial pressure of each constituent is that pressure which the gas would exert if it occupied alone that volume occupied by the mixtures at the same temperature.

17. Define Dalton"s law of partial pressure.

The total pressure exerted in a closed vessel containing a number of gases is equl to the sum of the pressures of each gas and the volume of each gas equal to the volume of the vessel.

19. How does the Vander Waal"s equation differ from the ideal gas equation of state?

1. Intermolecular attractive study is made.
2. Shape factor is consider

These assumptions are not made in ideal gas equation of state.

20. What is Clasius Clapeyron Equation?

Clapeyron equation which involves relationship between the saturation pressure, saturation temperature, the enthalpy of evaporation and the specific volume of the two phases involved.

$$\frac{dp}{dT} = \frac{h_{fg}}{Tv_{fg}}$$

21.State Tds Equations.

Tds Equation are

$$Tds = C_p\, dT - T\left(\frac{\partial v}{\partial T}\right)_p dp$$

$$Tds = C_v\, dT + T\left(\frac{\partial p}{\partial T}\right)_T dv$$

22. State Helmholtz function.

Helmholtz function is property of a system and is given by subtracting the product of absolute temperature (T) and entropy(s) from the internal energy u.

i.e. Helmholtz function = u-Ts

23. State Gibbs function.

Gibbs function is property of a system and is given by

G = u – Ts + pv = h – Ts [i.e. = u+ pv]

Where

h – Enthalpy

T – Temperature

s – Entropy.

UNIT – 5 - GAS MIXTURES AND PSYCHROMETRY

1. Define psychrometry.

The science which deals with the study of behaviour of moist air (mixture of dry air and water vapour) is known as psychrometry.

2. What is humidification and dehumidification?

The addition of water vapour into air is humidification and the removal of water vapour from air is dehumidification.

3. Define specific humidity.

It is defined as the ratio of the mass of water vapour (ms) in a given volume to the mass of dry air in a given volume (ma).

4. Differentiate absolute humidity and relative humidity.

Absolute humidity is the mass of water vapour present in one kg of dry air.

Relative humidity is the ratio of the actual mass of water vapour present in one kg of dry air at the given temperature to the maximum mass of water vapour it can with hold at the same temperature. Absolute humidity is expressed in terms of kg/kg of dry air. Relative humidity is expressed in terms of percentage.

5. **What is effective temperature?**
   The effective temperature is a measure of feeling warmth or cold to the human body in response to the air temperature, moisture content and air motion. If the air at different DBT and RH condition carries the same amount of heat as the heat carried by the air at temperature T and 100% RH, then the temperature T is known as effective temperature.
6. **Represent the following psychrometric process using skeleton psychrometric chart?**
   - Cooling and dehumidification
   - Evaporative cooling.

7. **Define Relative humidity.**
   It is defined as the ratio of partial pressure of water vapour (pw) in a mixture to the saturation pressure (ps) of pure water at the same temperature of mixture.
8. **Define degree of saturation.**
   It is the ratio of the actual specific humidity and the saturated specific humidity at the same temperature of the mixture.

$$\mu = \frac{specific\ humidity\ of\ moist\ air}{specific\ humidity\ of\ saturated\ air} = \frac{\omega}{\omega_s}$$

9. **What is meant by adiabatic saturation temperature (or) thermodynamic wet bulb temperature?**
   It is the temperature at which the outlet air can be brought into saturation state by passing through the water in the long insulated duct (adiabatic) by the evaporation of water due to latent heat of vaporization.
10. **What is dew point temperature? How it is related to dry bulb and wet bulb temperature at the saturation condition?**
    The temperature at which the vapour starts condensing is called dew point temperature. It is also equal to the saturation temperature at the partial pressure of water vapour in the mixture. The dew point temperature is an indication of specific humidity.
    For saturated air, the dry bulb, wet bulb and dew point temperature are all same.
11. **What is meant by dry bulb temperature (DBT)?**
    The temperature recorded by the thermometer with a dry bulb. The dry bulb thermometer cannot affect by the moisture present in the air. It is the measure of sensible heat of the air.
12. **what is meant by wet bulb temperature (WBT)?**
    It is the temperature recorded by a thermometer whose bulb is covered with cotton wick (wet) saturated with water. The wet bulb temperature may be the measure of enthalpy of air. WBT is the lowest temperature recorded by moistened bulb.
13. **Define dew point depression.**
    It is the difference between dry bulb temperature and dew point temperature of air vapour mixture.
14. **What is psychrometer?**
    Psychrometer is an instrument which measures both dry bulb temperature and wet bulb temperature.
15. **What is psychrometric chart?**

It is the graphical plot with specific humidity and partial pressure of water vapour in y axis and dry bulb temperature along x axis. The specific volume of mixture, wet bulb temperature, relative humidity and enthalpy are the properties appeared in the psychrometric chart.

16. **Define sensible heat and latent heat.**
    Sensible heat is the heat that changes the temperature of the substance when added to it or when abstracted from it. Latent heat is the heat that does not affect the temperature but change of state occurred by adding the heat or by abstracting the heat.
17. **What are the important psychrometric processes?**
    - Sensible heating and sensible cooling
    - Cooling and dehumidification
    - Heating and humidification
    - Mixing of air streams
    - Chemical dehumidification
    - Adiabatic evaporative cooling.

18. **Define coefficient of volume expansion.**
    The coefficient of volume expansion is defined as the change in volume with the change in temperature per unit volume keeping the pressure constant.
19. **Define bypass factor (BPF) of a coil.**
    The ratio of the amount of air which does not contact the cooling coil (amount of bypassing air) to the amount of supply air is called BPF.

$$BPF = \frac{amount\ of\ air\ bypassing\ the\ coil}{total\ amount\ of\ air\ passed}$$

20. **What factors affect by pass factor?**
    - Pitch of fines
    - Number of coil tubes
    - Air velocity over the coil
    - Direction of air flow.
21. **What is meant by adiabatic mixing?**
    The process of mixing two or more stream of air without any heat transfer to the surrounding is known as adiabatic mixing. It is happened in air conditioning system.
22. **What is the difference between air conditioning and refrigeration?**
    Refrigeration is the process of providing and maintaining the temperature in space below atmospheric temperature.
    Air conditioning is the process of supplying sufficient volume of clean air containing a specific amount of water vapour and maintaining the predetermined atmospheric condition with in a selected enclosure.
23. **Define Dalton‟s law of partial pressure.**
    The total pressure exerted by air and water vapour mixture is equal to the barometric pressure.

$$P_b = p_a + p_v$$

where,

p_b = barometric pressure.
P_a = partial pressure of dry air.
P_v = partial pressure of water vapour.

24. What is the difference between complete (or) perfect inter cooling and incomplete (or) imperfect inter cooling.

Perfect Inter cooling When the temperature of air leaving the intercooler (T_3) is equal to the original atmospheric air temperature (T_1), then the inter cooling is known as perfect inter cooling.

Imperfect Inter cooling When the temperature of air leaving the inter cooler (T_3) is more than original atmospheric air temperature (T_1), then the inter cooling is known as Imperfect inter cooling.