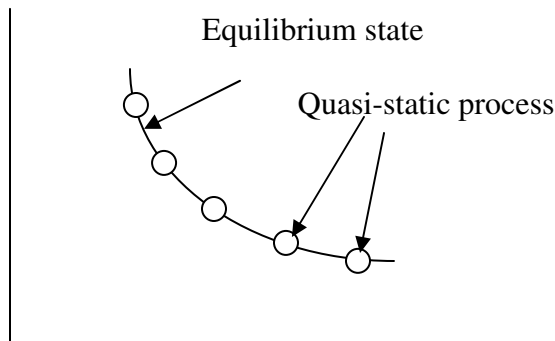


### *Third Semester Mechanical Engineering*

#### **ENGINEERING THERMO DYNAMICS (ME 1201)**

1. What do you understand by pure substance?  
A pure substance is defined as one that is homogeneous and invariable in chemical composition throughout its mass.
2. Define thermodynamic system.  
A thermodynamic system is defined as a quantity of matter or a region in space, on which the analysis of the problem is concentrated.
3. Name the different types of system.
  1. Closed system (only energy transfer and no mass transfer)
  2. Open system (Both energy and mass transfer)
  3. Isolated system (No mass and energy transfer)
4. Define thermodynamic equilibrium.  
If a system is in Mechanical, Thermal and Chemical Equilibrium then the system is in thermodynamically equilibrium. (or)  
If the system is isolated from its surrounding there will be no change in the macroscopic property, then the system is said to exist in a state of thermodynamic equilibrium.
5. What do you mean by quasi-static process?



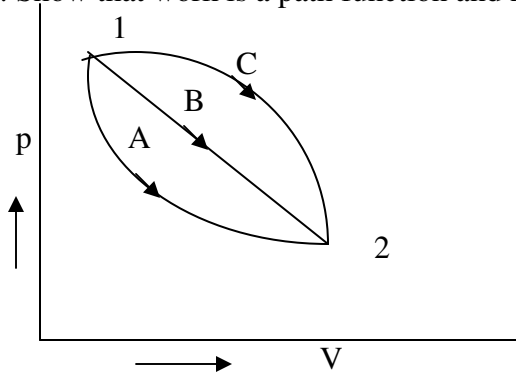
Infinite slowness is the characteristic feature of a quasi-static process. A quasi-static process is that a succession of equilibrium states. A quasi-static process is also called as reversible process.

6. Define Path function.  
The work done by a process does not depend upon the end of the process. It depends on the path of the system follows from state 1 to state 2. Hence work is called a path function.
7. Define point function.  
Thermodynamic properties are point functions. The change in a thermodynamic property of a system is a change of state is independent of the path and depends only on the initial and final states of the system.
8. Name and explain the two types of properties.  
The two types of properties are intensive property and extensive property.

**Intensive Property:** It is independent of the mass of the system. **Example:** pressure, temperature, specific volume, specific energy, density.

**Extensive Property:** It is dependent on the mass of the system. **Example:** Volume, energy. If the mass is increased the values of the extensive properties also increase.

9. Explain homogeneous and heterogeneous system.  
The system consist of single phase is called homogeneous system and the system consist of more than one phase is called heterogeneous system.
10. What is a steady flow process?  
Steady flow means that the rates of flow of mass and energy across the control surface are constant.
11. Prove that for an isolated system, there is no change in internal energy.  
In isolated system there is no interaction between the system and the surroundings. There is no mass transfer and energy transfer. According to first law of thermodynamics as  $dQ = dU + dW$ ;  $dU = dQ - dW$ ;  $dQ = 0$ ,  $dW = 0$ , There fore  $dU = 0$  by integrating the above equation  $U = \text{constant}$ , therefore the internal energy is constant for isolated system.
12. Indicate the practical application of steady flow energy equation.  
1. Turbine, 2. Nozzle, 3. Condenser, 4. Compressor.
13. Define system.  
It is defined as the quantity of the matter or a region in space upon which we focus attention to study its property.
14. Define cycle.  
It is defined as a series of state changes such that the final state is identical with the initial state.
15. Show that work is a path function and not a property.



With reference to the above figure, it is possible to take the system from 1 to 2 along many quasi-static paths such as A, B or C. Since the area under each curve represents the work for each process, the amount of work involved in each case is not a function of the end states of the process and it depends on the path of the system, follows in going from state 1 to state 2. For this reason, work is a path function and not a property.

16. Explain Mechanical equilibrium.  
If the forces are balanced between the system and surroundings are called Mechanical equilibrium

17. Explain Chemical equilibrium.  
If there is no chemical reaction or transfer of matter from one part of the system to another is called Chemical equilibrium
18. Explain Thermal equilibrium.  
If the temperature difference between the system and surroundings is zero then it is in Thermal equilibrium.
19. Define Zeroth law of Thermodynamics.  
When two systems are separately in thermal equilibrium with a third system then they themselves are in thermal equilibrium with each other.
20. What are the limitations of first law of thermodynamics?
1. According to first law of thermodynamics heat and work are mutually convertible during any cycle of a closed system. But this law does not specify the possible conditions under which the heat is converted into work.
  2. According to the first law of thermodynamics it is impossible to transfer heat from lower temperature to higher temperature.
  3. It does not give any information regarding change of state or whether the process is possible or not.
  4. The law does not specify the direction of heat and work.
21. What is perpetual motion machine of first kind?  
It is defined as a machine, which produces work energy without consuming an equivalent of energy from other source. It is impossible to obtain in actual practice, because no machine can produce energy of its own without consuming any other form of energy.
22. Define Clausius statement.  
It is impossible for a self-acting machine working in a cyclic process, to transfer heat from a body at lower temperature to a body at a higher temperature without the aid of an external agency.
23. What is Perpetual motion machine of the second kind?  
A heat engine, which converts whole of the heat energy into mechanical work is known as Perpetual motion machine of the second kind.
24. Define Kelvin Planck Statement.  
It is impossible to construct a heat engine to produce network in a complete cycle if it exchanges heat from a single reservoir at single fixed temperature.
25. Define Heat pump.  
A heat pump is a device, which is working in a cycle and transfers heat from lower temperature to higher temperature.
26. Define Heat engine.  
Heat engine is a machine, which is used to convert the heat energy into mechanical work in a cyclic process.
27. What are the assumptions made on heat engine?
1. The source and sink are maintained at constant temperature.
  2. The source and sink has infinite heat capacity.
28. State Carnot theorem.

It states that no heat engine operating in a cycle between two constant temperature heat reservoir can be more efficient than a reversible engine operating between the same reservoir.

29. What is meant by reversible process?  
A reversible process is one, which is performed in such a way that at the conclusion of process, both system and surroundings may be restored to their initial state, without producing any changes in rest of the universe.
30. What is meant by irreversible process?  
The mixing of two substances and combustion also leads to irreversibility. All spontaneous process is irreversible.
31. Explain entropy?  
It is an important thermodynamic property of the substance. It is the measure of molecular disorder. It is denoted by  $S$ . The measurement of change in entropy for reversible process is obtained by the quantity of heat received or rejected to absolute temperature.
32. What is absolute entropy?  
The entropy measured for all perfect crystalline solids at absolute zero temperature is known as absolute entropy.
33. Define availability.  
The maximum useful work obtained during a process in which the final condition of the system is the same as that of the surrounding is called availability of the system.
34. Define available energy and unavailable energy.  
Available energy is the maximum thermal useful work under ideal condition. The remaining part, which cannot be converted into work, is known as unavailable energy.
35. Explain the term source and sink.  
Source is a thermal reservoir, which supplies heat to the system and sink is a thermal reservoir, which takes the heat from the system.
36. What do you understand by the entropy principle?  
The entropy of an isolated system can never decrease. It always increases and remains constant only when the process is reversible. This is known as principle of increase in entropy or entropy principle.
37. What are the important characteristics of entropy?
1. If the heat is supplied to the system then the entropy will increase.
  2. If the heat is rejected to the system then the entropy will decrease.
  3. The entropy is constant for all adiabatic frictionless process.
  4. The entropy increases if temperature of heat is lowered without work being done as in throttling process.
  5. If the entropy is maximum, then there is a minimum availability for conversion in to work.
  6. If the entropy is minimum then there is a maximum availability for conversion into work.
38. What is reversed carnot heat engine? What are the limitations of carnot cycle?
1. No friction is considered for moving parts of the engine.
  2. There should not be any heat loss.

39. 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.
40. Name the various vapour power cycle.  
Carnot cycle and Rankine cycle.
41. Define efficiency ration.  
The ratio of actual cycle efficiency to that of the ideal cycle efficiency is termed as efficiency ratio.
42. 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.
43. Define specific steam consumption of an ideal Rankine cycle.  
It is defined as the mass flow of steam required per unit power output.
44. Name the different components in steam power plant working on Rankine cycle.  
Boiler, Turbine, Cooling Tower or Condenser and Pump.
45. 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.
46. Mention the improvements made to increase the ideal efficiency of Rankine cycle.
1. Lowering the condenser pressure.
  2. Superheated steam is supplied to the turbine.
  3. Increasing the boiler pressure to certain limit.
  4. Implementing reheat and regeneration in the cycle.
47. 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.
48. 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.
49. What are the advantages of reheat cycle?
1. It increases the turbine work.
  2. It increases the heat supply.
  3. It increases the efficiency of the plant.
  4. It reduces the wear on the blade because of low moisture content in LP state of the turbine.
50. Define latent heat of evaporation or Enthalpy of evaporation.  
The amount of heat added during heating of water up to dry steam from boiling point is known as Latent heat of evaporation or enthalpy of evaporation.
51. 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.
52. Explain heat of super heat or super heat enthalpy.

- The heat added to dry steam at  $100^{\circ}\text{C}$  to convert it into super heated steam at the temperature  $T_{\text{sup}}$  is called as heat of superheat or super heat enthalpy.
53. Explain the term critical point, critical temperature and critical pressure.  
 In the T-S diagram the region left of the waterline, the water exists as liquid. In right of the dry steam line, the water exists as a super heated steam. In between water and dry steam line the water exists as a wet steam.  
 At a particular point, the water is directly converted into dry steam without formation of wet steam. The point is called critical point.  
 The critical temperature is the temperature above which a substance cannot exist as a liquid, the critical temperature of water is  $374.15^{\circ}\text{C}$ . The corresponding pressure is called critical pressure.
54. Define dryness fraction (or) What is the quality of steam?  
 It is defined as the ratio of mass of the dry steam to the mass of the total steam.
55. 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.
56. How do you determine the state of steam?  
 If  $V > v_g$  then super heated steam,  $V = v_g$  then dry steam and  $V < v_g$  then wet steam.
57. Define triple point.  
 The triple point is merely the point of intersection of sublimation and vapourisation curves.
58. 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.
59. 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.
60. 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.
61. 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.
62. 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.
63. 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.
64. 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.
65. State Charle's law.

It states that if any gas is heated at constant pressure, its volume changes directly as its absolute temperature.

66. Explain the construction and give the use of generalized compressibility chart.  
The general compressibility chart is plotted with  $Z$  versus  $P_r$  for various values of  $T_r$ . 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.
67. 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.
68. 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.
69. Explain Dalton's law of partial pressure.  
The pressure of a mixture of gases is equal to the sum of the partial pressures of the constituents. The partial pressure of each constituent is that pressure which the gas would expect if it occupied alone that volume occupied by the mixtures at the same temperatures.  $m = m_A + m_B + m_C + \dots = \sum m_i$   
 $m_i$  = mass of the constituent.  
 $P = P_A + P_B + P_C + \dots = \sum P_i$ ,  $P_i$  – the partial pressure of a constituent.
70. State Avogadro's Law.  
The number of moles of any gas is proportional to the volume of gas at a given pressure and temperature.
71. What is Joule-Thomson coefficient?  
The temperature behaviors of a fluid during a throttling ( $h = \text{constant}$ ) process is described by the Joule-Thomson coefficient defined as  
 $\mu = [\delta T / \delta P]_h$
72. 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.
73. 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.
74. Define Dalton's law of partial pressure.  
The total pressure exerted in a closed vessel containing a number of gases is equal to the sum of the pressures of each gas and the volume of each gas equal to the volume of the vessel.
75. How does the Vander Waal's equation differ from the ideal gas equation of state?  
The ideal gas equation  $pV = mRT$  has two important assumptions,  
1. There is little or no attraction between the molecules of the gas.  
2. That the volume occupied by the molecules themselves is negligibly small compared to the volume of the gas. This equation holds good for low pressure and high temperature ranges as the intermolecular attraction and the volume of the molecules are not of much significance.

As the pressure increases, the inter molecular forces of attraction and repulsion increases and the volume of the molecules are not negligible. The real gas deviate considerably from the ideal gas equation

$$[p + (a/V^2)](V - b) = RT$$

76. What is humidification and dehumidification?

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

77. Differentiate absolute humidity and relative humidity.

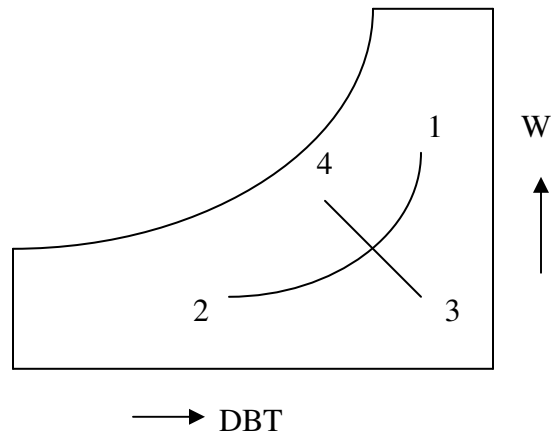
Absolute humidity is the mass of water vapour present in one kg of dry air.

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 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.

78. 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.

79. Represent the following psychrometric process using skeleton psychrometric chart? a) Cooling and dehumidification, b) Evaporative cooling.



Process 1 – 2 : Cooling and dehumidification

Process 3 – 4 : Evaporative cooling.

80. Define Relative humidity.

It is defined as the ratio of partial pressure of water vapour ( $p_w$ ) in a mixture to the saturation pressure ( $p_s$ ) of pure water at the same temperature of mixture.

81. Define specific humidity.

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

82. 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.

83. What is dew point temperature?



- 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.
84. What is meant by dry bulb temperature (DBT)?  
The temperature recorded by the thermometer with a dry bulb. The dry bulb thermometer cannot be affected by the moisture present in the air. It is the measure of sensible heat of the air.
85. 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 a moistened bulb.
86. Define dew point depression.  
It is the difference between dry bulb temperature and dew point temperature of air vapour mixture.
87. 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 vapourisation.
88. What is psychrometer?  
Psychrometer is an instrument which measures both dry bulb temperature and wet bulb temperature.
89. 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.
90. 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.
91. What are the important psychrometric processes?  
1. Sensible heating and sensible cooling, 2. Cooling and dehumidification, 3. Heating and humidification, 4. Mixing of air streams, 5. Chemical dehumidification, 6. Adiabatic evaporative cooling.
92. What is meant by adiabatic mixing?  
The process of mixing two or more streams of air without any heat transfer to the surrounding is known as adiabatic mixing. It happens in air conditioning systems.
93. What are the assumptions made in Vanderwaal's equation of state?  
1. There are no intermolecular forces between particles.  
2. The volume of molecules is negligible in comparison with the gas.
94. 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. It is denoted by  $\beta$ .

95. State Helmholtz function.

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

$$\text{Helmholtz function} = U - TS$$

96. What are thermodynamic properties?

Thermodynamic properties are pressure (p), temperature (T), volume (V), internal energy (U), enthalpy(H), entropy (S), Helmholtz function ( $\alpha$ ) and Gibbs function (g).

97. Define throttling process.

When a fluid expands through a minute orifice or slightly opened valve, the process is called as throttling process. During this process, pressure and velocity are reduced.

98. Define Molecular mass.

Molecular mass is defined as the ratio between total mass of the mixture to the total number of moles available in the mixture.

99. Define isothermal compressibility.

Isothermal compressibility is defined as the change in volume with change in pressure per unit volume keeping the temperature constant.

100. 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.