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Degree / Branch: BE / Mechanical Engineering Semester /Year: III / II

Sub Code / Name: ME3391 / Engineering Thermodynamics

Question Bank (2Mark & 16 Mark)

UNIT I - BASICS, ZEROTH AND FIRST LAW

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 attention in 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? Equilibrium state or 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, Therefore dU = 0 by integrating the above equation U = constant, therefore the internal energy is constant for isolated system.

12. Indicate the practical application of steady flow energy equation1. 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.

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 form 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.

16 Marks

1. In an isentropic flow through nozzle, air flows at the rate of 600 kg/hr. At inlet to the nozzle, pressure is 2 MPa and temperature is 127°C. The exit pressure is 0.5 MPa. Initial air velocity is 300 mig determine (i) Exit velocity of air (ii) Inlet and exit area of nozzle.

2. A centrifugal pump delivers 2750 kg of water per minute from initial pressure of 0.8 bar absolute to a final pressure of 2.8 bar absolute. The suction is 2 m below and the delivery is 5 m above the centre of pump. If the suction and delivery pipes are of 15 cm and 1.0 cm diameter respectively, make calculation for power required to run the pump

3. A reciprocating air compressor takes in 2 m3 /min air at 0.11 MPa, 293 K which it delivers at 1.5 MPa, 384 K to an after cooler where the air is cooled at constant pressure to 298 K. The power absorbed by the compressor is 4.15 kW. Determine the heat transfer in (i) the compressor (ii) the cooler. State your assumptions.

4. A rigid tank containing 0.4 m3 of air at 400 kPa and 30°C is connected by a valve to a piston cylinder device with zero clearance. The mass of the piston is such that a pressure of 200 kPa is required to raise the piston. The valve is opened slightly and air is allowed to flow into the cylinder until the pressure of the tank drops to 200 kPa. During this process, heat is exchanged with the surrounding such that the entire air remains at 30°C at all times. Determine the heat transfer for this process.

5. The electric heating system used in many houses consists of simple duct with resistance wire. Air is heated as it flows over resistance wires. Consider a 15 kW electric heating system. Air enters the heating section at 100 kPa and 17°C with a volume flow rate of 150 m3 /min. If heat is lost from the air in the duct to the surroundings at a rate of 200 W, determine the exit temperature of air.

6. In a gas turbine installation air is heated inside heat exchanger up to 750o C from ambient temperature of 27 0 C. Hot air then enters into gas turbine with the velocity of 50 m/s and leaves at 600 0 C. Air leaving turbine enters a nozzle at 60 m/s velocity and leaves nozzle at temperature of 500 o C For unit mass flow rate of air determine the following assuming adiabatic expansion in turbine and nozzle, a. Heat transfer to air in heat exchanger b. Power output from turbine c. Velocity at exit of nozzle. Take up for air as 1.005 kJ / kg. K.

7. 25 people attended a farewell party in a small room of size 10 _ 8 m and have a 5 m ceiling. Each person gives up 350 kJ of heat per hour. Assuming that the room is completely sealed off and insulated, calculate the air temperature rise occurring in 10 minutes. Assume Cv of air 0.718

kJ/kg K and R = 0:287 kJ/kg K and each person occupies a volume of 0.05 m3. Take p = 101.325 kPa and T = 20o C.

8. Air at a temperature of 15o C passes through a heat exchanger at a velocity of 30 m/s where its temperature is raised to 800o C. It then enters a turbine with the same velocity of 30 m/s and expands until the temperature falls to 650o C. On leaving the turbine, the air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 500o C. If the air flow rate is 2 kg /s, Calculate (a) the rate of heat transfer to the air in the heat exchanger (b) the power output from the turbine assuming no heat loss, and (c) the velocity at exit from the nozzle, assuming no heat loss. Take the enthalpy of air as h = Cp.t, where Cp is the specific heat equal to 1.005 kJ / kg.K and t is the temperature.

9. A three process cycle operating with nitrogen as the working substance has constant temperature compression at 34o C with initial pressure 100 kPa. Then the gas undergoes a constant volume heating and then polytrophic expansion with 1.35 as index of compression. The isothermal compression requires – 67 kJ / kg of work. Determine (i) P, v and T around the cycle. (ii) Heat in and out (iii) Net work. For nitrogen gas, Cv = 0.7431 kJ / kg.K.

10. A room of four persons has two fans has two fans, each consuming 0.18 kW power, and three 100 W lamps. Ventilation air at the rate of 80 kg / hr enters with an enthalpy of 84 kJ / kg and leaves with an enthalpy of 59 kJ / kg. If each person puts out heat at the rate of 630 kJ / hr. Determine the rate at which heat is to be removed by a room cooler, so that a steady state is maintained in the room

11. A gas flows steadily through compressor. The gas enters the compressor at a temperature of 16o C, a pressure of 100 kpa, and an enthalpy of 391.2 kJ / kg. The gas leaves the compressor at a temperature of 245o C, a pressure of 0.6 MPa, and an enthalpy of 535.5 kJ /kg. There is no heat transfer to (or) from the gas as it flows through the compressor. Evaluate the external work done per unit mass of gas when the velocity at entry 80 m /s and that at exit is 160 m/s

UNIT II - SECOND LAW & ENTROPY

1. 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.

2. 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.

3. 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.

4. Define Heat pump. A heat pump is a device, which is working in a cycle and transfers heat from lower temperature to higher temperature.

5. Define Heat engine. Heat engine is a machine, which is used to convert the heat energy into mechanical work in a cyclic process.

6. What are the assumptions made on heat engine1. The source and sink are maintained at constant temperature. 2. The source and sink has infinite heat capacity.

7. 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.

8. 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.

9. What is meant by irreversible process?The mixing of two substances and combustion also leads to irreversibility. All spontaneous process is irreversible.

10. 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.

11. What is absolute entropy? (The entropy measured for all perfect crystalline solids at absolute zero temperature is known as absolute entropy.

16 MARK

1. A heat engine operating between two reservoirs at 100 K and 300 K is used to drive heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which engine rejects heat to it. If the efficiency of the engine is 40% of the maximum possible and the co-efficient of performance of the heat pump is 50% of the maximum possible, make calculations for the temperature of the reservoir to which the heat pump rejects heat. Also work out the rate of heat rejection from the heat pump if the rate of supply of heat to the engine is 50 kW.

2. One kg of ail' is contained in a piston cylinder assembly at 10 bar pressure and 500 K temperature. The piston moves outwards and the air expands to 2 bar pressure and 350 K temperature. Determine the maximum work obtainable. Assume the environmental conditions to be 1 bar and 290 K. Also make calculations for the availability in the initial and final states.

3. The interior lighting of refrigerators is provided by incandescent lamps whose switches are actuated by the opening of the refrigerator door. Consider a refrigerator whose 40W light bulb remains on continuously as a result of a malfunction of the switch. If the refrigerator has a coefficient of performance of 1.3 and the cost of electricity is Rs. 8 per kWh, determine the increase in the energy consumption of the refrigerator and its cost per year if the switch is not fixed.

4. A Carnot heat engine receives 650 kJ of heat from a source of unknown temperature and rejects 250 kJ of it to a sink at 297 K. Determine the temperature of the source and the thermal efficiency of the heat engine

5. A Carnot heat engine receives heat from a reservoir at 1173 K at a rate of 800kJ/min and rejects the waste heat to the ambient air at 300 K. The entire work output of the heat engine is used to drive a refrigerator that removes heat from the refrigerated space at 268 K and transfers it to the same ambient air at 300 K. Determine the maximum rate of heat removal from the refrigerated space and the total rate of heat rejection to the ambient air.

6. Air is compressed by an adiabatic compressor from 100 kPa and 12 °C to a pressure of 800 kPa at a steady rate of 0.2 kg/s. If the isentropic efficiency of the compressor is 80 percent, determine the exit temperature of air and the required power input to the compressor.

7. A 200 m3 rigid tank initially contains atmospheric air at 100 kPa and 300 K and is to be used as storage vessel for compressed air at 1 Mpa and 300 K. Compressed air is to be supplied by a compressor that takes in atmospheric air at P0 = 100 kPa and T0 = 300 K. Determine the minimum work required for this process.

8. An engine is supplied with 1120 kJ/s of heat. The source and sink temperature are maintained at 560 K and 280 K. Determine whether the following cases represent the reversible, irreversible or impossible heat engines. (1) 900 kW of heat rejected (2) 560 kW of heat rejected (3) 108 kW of heat rejected.

9. A heat pump working on the Carnot cycle takes in heat from a reservoir at 5o C and delivers heat to a reservoir at 60o C. A heat engine is driven by a source at 840o C and rejects heat to a reservoir at 60o C. The reversible heat engine, in addition to driving the heat pump, also drives a machine that absorbs 30 kW. If the heat pump extracts 17 kJ/s from the 5o C reservoir, determine (1) the rate of heat supply from the 840 C source, and (2) the rate of heat rejection to the 60o C sink.

10. A heat exchanger circulates 5000 kg/hr of water to cool oil from 150o C to 50o C. The rate of flow of oil is 2500 kg/hr. The average specific heat of oil is 2.5 kJ/kgK. The water enters the heat exchanger at 21o C. Determine the net change in the entropy due to heat exchange process, and the amount of work obtained if cooling of oil is done by using the heat to run a Carnot engine with sink temperature of 21o C.

11. An ideal gas of 0.12 m3 is allowed to expand isentropically from 300kPa and 120o C to 100 kPa. 5 kJ of heat is then transferred to the gas at constant pressure. Calculate the change in entropy for each process. Assume γ = 1.4 and Cp=1.0035 kJ/kg.K. If these two processes are replaced by a reversible polytropic expansion, find the index of expansion between original and final states. What will be the total changes in entropy?

12. A house hold refrigerator is maintained at a temperature of 275 K. Every time the door is opened, warm material is placed inside, introducing an average of 420 kJ, but making only a small change in the temperature of the refrigerator. The door is opened 20 times a day, and the

refrigerator operates at 15% of the ideal COP. The cost of work is Rs 2.50 per kWhr. What is the bill for the month of April for this refrigerator? The atmospheric is at 303 K.

13. A heat pump working on the Carnot cycle takes in heat from a reservoir at 5o C and delivers heat to a reservoir at 60o C. The heat pump is driven by a reversible heat engine which takes heat from reservoir at 840o C and rejects heat to a reservoir at 60o C. The reversible heat engine also drives a machine that absorbs 30 kW. If the heat pump extracts 17 kJ / s from the reservoir at 5o C, determine (1) the rate of heat supply from 840o C source, and (2) the rate of heat rejection to 60o C sink.

UNIT III AVAILABILITY AND APPLICATIONS OF II LAW

1. 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.

2. 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.**

3. 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.

4.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.

5. 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.

6. 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.

7. Name the various vapour power cycle. Carnot cycle and Rankine cycle.

8. Define efficiency ration. The ratio of actual cycle efficiency to that of the ideal cycle efficiency is termed as efficiency ratio.

9. 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 MARK

1. In a Carnot heat engine 50g of air acts as the working substance. The peak cycle temperature is 930 K and the maximum pressure is 8.4x 103 kPa. The heat addition per cycle is 4.2 kJ. Determine the maximum cylinder volume if the minimum temperature during the cycle is 315 K.

2. 5 kg of air expands isothermally from 1 m3 to 5 m3 . Assuming air to be ideal gas with constant specific heats, compute the change in entropy of air during the process.

3. An inventor claims to have developed an engine which receives 1000 kJ at a temperature of 160o C. It rejects heat at a temperature of 5o C and delivers 0.12 kWh of

4. In a closed system air is at a pressure of 1 bar, temperature of 300 K and volume of 0.025 m3 . The system executes the following processes during the completion of thermodynamic cycle: 1-2; constant volume heat addition till pressure reaches 3.8 bar, 2- 3; constant pressure cooling of air, 3-1; isothermal heating to initial state. Determine the change in entropy in each process. Take Cv = 0.718 kJ / kg K, R=287 J/kgK.

5. 1 kg of ice at -10o C is exposed to atmosphere at 30o C. After some time, the ice melts to water and water temperature becomes 30o C. Determine the entropy increase of the universe. Take Cp ice = 2.093 kJ / kgK and the latent heat of ice =333.3 kJ/Kg.

6. An refrigerator operating between two identical bodies cools one of the bodies to a temperature T2. Initially both bodies are at temperature T1. Deduce the expression for the minimum specific work input, taking their specific heat as c.

7. 5 m3 of air at 2 bar, 27o C is compressed up to 6 bar pressure following pv1.3 = constant. It is subsequently expanded adiabatically to 2 bar. Considering the two processes to be reversible, determine the network, net heat transfer, and change in entropy. Also plot the processes on T-S and P-V diagrams.

8. If the required input to run the pump is developed by a reversible engine which receives heat at 380o C and rejects heat to atmosphere, then determine the overall C.O. P. of the system.

9. A reversible heat pump is used to maintain a temperature of 0o C in a refrigerator when it rejects the heat to the surroundings at 25o C. If the heat removal rate from the refrigerator is 1440 kJ / min, determine the C.O.P. of the machine and work input required.

10. 3 kg of air at 500 kPa, 90o C expands adiabatically in a closed system until its volume is doubled and its temperature becomes equal to that of the surroundings at 100 kPa and 10o C. Find the maximum work, change in availability and irreversibility.

11. Two Carnot engines A and B are operated in series. The first one receives heat at 870o K and rejects to a reservoir at T. B receives heat rejected by the first engine and it turns rejects to a sink at 300o K. Find the temperature T for (1) Equal work outputs of both engines (2) Same efficiencies

12. Helium enters an actual turbine at 300 kPa, 300o C and expands to 100 kPa, 150o C. Heat transfer to atmosphere at 101.325 kPa, 25o C amounts to 7 kJ / kg. Calculate the entering

stream availability, leaving stream availability and maximum work. For helium, Cp = 5.2 kJ / kg and molecular weight = 4.003 kg /kg- mol.

13. An irreversible heat engine with 66% efficiency of the maximum possible is operating between 1000 K and 300 K. If it delivers 3 kW of work, determine the heat extracted from the high temperature reservoir and heat rejected to low temperature reservoir.

14. A metal block with m = 5 kg, c = 0.4 kJ / kg.K at 40o C is kept in a room at 20o C. It is cooled in the following two days: (1) Using a Carnot engine (executing integral number of cycles) with the room itself as the cold reservoir; (2) Naturally. In each case, calculate the changes in entropy of the block, of the air of the room and of the universe, Assume that the metal bIock has constant specific heat.

15. An aluminium block (Cp = 400 J / kgK) with a mass of 5 kg is initially at 40o C in room air at 20o C. It is cooled reversibly by transferring heat to a completely reversible cyclic heat engine until the block reaches 20o C. The 20o C room air serves as a constant temperature sink for the engine. Compute (1) The change in entropy for the block, (2) The change in entropy for the room air, (3) The work done by the engine

UNIT IV PROPERTIES OF PURE SUBSTANCES

1**. Define specific steam consumption of an ideal Rankine cycle**It is defined as the mass flow of steam required per unit power output.

2. Name the different components in steam power plant working on Rankine cycle.Boiler, Turbine, Cooling Tower or Condenser and Pump.

3. 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 raise the wetness of steam. Isentropic compression of a very wet vapour is very difficult.

4. Mention the improvements made to increase the ideal efficiency of Rankine cycle1. 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.

5. 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.

6. 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.

7. What are the advantages of reheat cycles? 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.

8. 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.

9. 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.

10. Explain heat of super heat or super heat enthalpy. The heat added to dry steam at 100oC to convert it into super heated steam at the temperature Tsup is called as heat of superheat or super heat enthalpy

11. 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 374.15oC. The corresponding pressure is called critical pressure.

12. 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.

13. 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.

14. How do you determine the state of steam? If V > vg then super heated steam, V = vg then dry steam and V < vg then wet steam.

15. Define triple point. The triple point is merely the point of intersection of sublimation and vaporization curves. 1

16. Define heat of vaporization. The amount of heat required to convert the liquid water completely into vapour under this condition is called the heat of vaporization.

17. 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.

18. 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

16MARK

1.Steam at 30 bar and 3500 C is expanded in a non flow isothermal process to a pressure of 1 bar. The temperature and pressure of the surroundings are 250 C and 100 kPa respectively.

Determine the maximum work that can be obtained from this process per kg of steam. Also find the maximum useful work.

2.A vessel of volume 0.04m3 contains a mixture of saturated water and steam at a temperature of 2500 C. The mass of the liquid present is 9 kg. Find the pressure, mass, specific volume, enthalpy, entropy and internal energy.

A rigid tank of 0.03m3 capacity contains wet vapour at 80 kPa. If the wet vapour mass is 12kg, calculate the heat added and the quality of the mixture when the pressure inside the tank reaches 7 Mpa

4. Steam initially at 0.3Mpa, 2500 C is cooled at constant volume. At what temperature will the steam become saturated vapour? What is the quality at 800 C.Also find what is the heat transferred per kg of steam in cooling from 2500 C to 800 C.

5. Ten kg of water of 45o C is heated at a constant pressure of 10 bars until it becomes superheated vapour at 3000 C. Find the changes in volume, enthalpy, internal energy and entropy.

6. 1 kg of steam initially dry saturated at 1.1 MPa expands in a cylinder following the law pv1.13= C. The pressure at the end of expansion is 0.1MPa. Determine: (i) The final volume (ii) final dryness fraction (iii) work done (iv) The change in internal energy (v) the heat transferred.

7. Steam at a pressure of 15bar and 2500 C expands according to the law pV1.25=C to a pressure of 1.5 bar. Evaluate the final conditions, work done, heat transfer and change in entropy. The mass of the system is 0.8kg.

8. . In steam generator compressed water at 10 MPa, 300 C enters a 30 mm diameter tube at the rate of 3 litres /sec. Steam at 9 MPa and 4000 C exit the tube. Find the rate of heat transfer.

9. Steam at 0.8 MPa, 2500 C and flowing at the rate of 1 kg/s passes into a pipe carrying wet steam at 0.8 MPa, 0.95 dry. After adiabatic mixing the flow rate is 2.3 kg/s. Determine the properties of the steam after mixing.

10. Two streams of steam, one at 2 MPa, 3000 C and the other at 2 MPa, 4000 C, mix in a steady flow adiabatic process. The rates of flow of the two streams are 3 kg/min and 2 kg/min respectively. Evaluate the final temperature of the emerging steam, if there is no pressure drop due to the mixing process. What would be the rate of increase in the entropy of the universe? This steam with negligible velocity now expands adiabatically in a nozzle to a pressure of 1 kPa. Determine the exit velocity of the stream and exit area of the nozzle.

11. A rigid tank with a volume of 2.5 m3 contains 15 kg of saturated liquid vapour mixture of water at 75°C. Now the water is slowly heated. Determine the temperature at which the liquid in the tank is completely vaporized. Also, show the processes on T-v diagram with respect to saturation lines.

12. Steam flows through a small turbine at the rate of 5000 kg/h entering at 15 bar, 3000 C and leaving at 0.1bar with 4% moisture. The steam enters at 80m/s at a point 2 m above the

discharge and leaves at 40m/s. compute the shaft power assuming that the device is adiabatic but considering kinetic and potential energies. Calculate the diameters of the inlet and discharge tubes.

13. . A steam power plant running on Rankine cycle has steam entering HP turbine at 20 MPa, 5000 C and leaving LP turbine at 90% dryness. Considering condenser pressure of 0.005 MPa and reheating occurring up to the temperature of 5000 C determine, (i) The pressure at which steam leaves HP turbine (ii) The thermal efficiency. (iii) Work done.

14. . In a Rankine cycle, the steam at inlet to turbine is saturated at a pressure of 35 bar and the exhaust pressure is 0.2 bar. The flow rate of steam is 9.5 kg/s. Determine (1) the pump work (2) the turbine work (3) Rankine efficiency (4) condenser heat flow (5) work ratio and (6) specific steam consumption

15. Steam at a pressure of 2.5 MPa and 500°C is expanded in a steam turbine to a condenser pressure of 0.05 MPa. Determine for Rankine cycle: (i) The thermal efficiency of Rankine cycle (ii) Specific steam consumption. If the steam pressure is reduced to 1 MPa and the temperature is kept same 500°C. Determine the thermal efficiency and the specific steam consumption. Neglect feed pump work,

16. . Consider a steam power plant operating on the ideal Rankine cycle. Steam enters the turbine at 3 MPa and 623 K and is condensed in the condenser at a pressure of 10 kPa. Determine (i) the thermal efficiency of this power plant, (ii) the thermal efficiency if steam is superheated to 873 K instead of 623 K, and (iii) the thermal efficiency if the boiler pressure is raised to 15 MPa while the turbine inlet temperature is maintained at 873 K.

UNIT-V GASE MIXTURES AND THERMODYNAMIC RELATIONS

1. Define Ideal gas. (AU DEC 2009) 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.

5. State Charle's law. It states that if any gas is heated at constant pressure, its volume changes directly as its absolute temperature.

6. 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.

7. 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.

8. 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.

9. 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 = mA+mB+mC+……. = _mi mi = mass of the constituent. P = PA+PB+PC+……. = _Pi, Pi = the partial pressure of a constituent.

10. State Avogadro's Law. (AU DEC 2011) The number of moles of any gas is proportional to the volume of gas at a given pressure and temperature.

11. What is Joule-Thomson coefficient?

The temperature behaviors of a fluid during a throttling (h = constant) process is described by the Joule-Thomson coefficient defined as: =[T/ P]n

12. 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.

13. 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.

14. 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.

15. 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. T his 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. T

he real gas deviate considerably from the ideal gas equation [p+(a/V2)](V-b) = RT

16 MARK

1. Write down the Dalton's Law of Partial Pressure and Explain its importance
2. ''Deive maxwell's equation''
3. Derive the clausis-clapey Equation
4. Derive the Vander waal's equation
5. Derive Tds equation taking temp, volume, and temp pressure a independent properties
6. Show that the Joule-Thamson Co-efficient of an ideal gas is zero
7. Describe Joule Kelvin effect with the help of T -P diagram
8. A certain ideal gas has (R)=290 J/kg.K and γ=1.35
    a. Determine the values of a C_p and C_v
    b. The mass of the gas it is filled in a vessel of 0.5m^3 capacity till the pressure
    c. c.inside becomes 4 bar gauge and the temp is 27^{0}C

If 40 kJ of heat is given to the vessel, when the vessel is closed.

Determine the resting temp and pressure take the atm presser=100 Kpa.

(9)A container of 3m^3 capacity contains 10 kg of co_2 at 27^0. Estimate the pressuree Exereted by co_2 by using

(1) Perfect gas equation
(2) Vander Waal's equation
9. (3) Beattie Bridgeman equation

10.One kg of ideal gas is heated from 50^oC to 150^oC. If R = 280 kj/kg.k and γ = 1.35 for the gas,

Determine,

(1) C_p and C_v

(2) Change in Internal energy

(3) Change in enthalpy

(4) Change in flow energy