**DEPARTMENT OF MECHANICAL ENGINEERING**

**ME6301 - ENGINEERING THERMODYNAMICS**

**QUESTION BANK**

**UNIT – I**

**PART - A**

1. Define Thermodynamics
2. What is the difference between classical and statistical approaches in thermodynamics?
3. Define the term thermal engineering.
4. Distinguish between “Macroscopic Energy” & “Microscopic Energy”.
5. Distinguish between open and closed systems.
6. What is meant by Open system with examples?
7. What is meant by closed system with examples?
8. Define a thermodynamic system.
9. Classify the following systems as open/closed/isolated (a). Mixture of ice & water in a metal container

 (b). A wind mill.

1. Define Specific heat at constant pressure, Specific heat at constant volume
2. What is meant by thermodynamic property?
3. How will you classify the thermodynamic property?
4. Define Extensive and Intensive properties with examples.
5. Define flow energy.
6. What is meant by Internal energy?
7. Distinguish between state and process of thermodynamics.
8. What do you understand by flow work?
9. When a system said to be in “Thermodynamic Equilibrium”?
10. Define heat and thermodynamic work.
11. Define quasi static process.
12. What is meant by concept of continuum?
13. Define path and point function with examples.
14. Distinguish between point and path function.
15. Define pressure, absolute pressure with its unit.
16. Define the following terms (i).state, (ii). process,(iii).cycle
17. What is the law of conservation energy and conservation of mass?
18. What are different forms of energy available?
19. Define enthalpy and write its unit.
20. Define work and heat transfer.
21. Distinguish between work transfer and heat transfer.
22. Define “Zeroth law of thermodynamics”
23. Define ideal and real gas and write the equation of state.
24. Write the relationship between Celsius Scale and Fahrenheit Scale.
25. Write the relationship between Celsius Scale and Kelvin Scale.
26. State first law for (i). a cycle (ii). A process of a closed systems
27. What are limitations of first law of thermodynamics?
28. What is a PMM1? Why it is impossible?
29. Define flow and non flow process.
30. Write down the steady flow energy equation.
31. Is it correct to say “total heat” or “heat content of a closed system”?
32. Show that energy of a isolated system is always constant.
33. Determine the molecular volume of any perfect gas at 600 N/m2 and 30°C.Universal gas constant is 8314J/kgmole K.
34. Prove that for an isolated system, there is no change in internal energy.
35. What are assumptions made in SFEE analysis?

**PART – B**

1. The following data refer to a closed system which undergoes a thermodynamics cycle consisting of four processes.

|  |  |  |
| --- | --- | --- |
| Process | Heat Transfer (KJ/min) | Work Transfer (KJ/min) |
| a - b | 50,000 | ------- |
| b - c | -5000 | 34200 |
| c - d | -16000 | -2200 |
| d - a | -------- | -3000 |

Show that the data is consistent with Ist law of Thermodynamics and Calculate (a). Net rate of work output in MW, (b). Efficiency of the cycle.

1. A fluid system contained in a piston and cylinder machine, passes through a complete cycle of 4 processes. The sum of all heat transferred during a cycle -340 kJ. The system completes 200 cycles per min.

|  |  |  |  |
| --- | --- | --- | --- |
| Process | Q (kJ/min) | W (kJ/min) | ΔE(kJ/min ) |
| 1 -2 | 0 | 4340 | ---- |
| 2 – 3 | 42,000 | 0 | ---- |
| 3 – 4 | -4200 | ----- | -73200 |
| 4 - 1 | -------- | ------ | ------ |

Compute the above table showing a method for each item and compute the net rate of work output in kW.

1. A gas of mass 1.5 kg undergoes a quasi-static expansion which follows a relationship P = a+bV, a& b are constants. The initial and final pressures are 1000 kPa and 200 kPa respectively and the corresponding volumes are 0.2 m3 and 1.2 m3. The specific internal energy of the gas is given by the relation u = 1.5 Pv – 85 kJ/kg. Where P is in kPa and V is in m3. Calculate the net heat transfer and the maximum internal energy of the gas attained during expansion.
2. A work done by substance in a reversible non flow manner is in accordance with V = (15/p)m3, where p is in bar. Evaluate the work done on or by the system as pressure increases from 10 to 100 bar. Indicate whether it is a compression process or expansion process. If the change in internal energy is 500 kJ, Calculate the direction and magnitude of heat transfer.
3. Determine the heat transfer and its direction for a system in which a perfect gas having molecular weight of 17.76 is compressed from 101.3 kPa , 20°C to a pressure of 600 kPa following the law pV1.3 = Constant. Take specific heat at constant pressure of gas as 1.7 kJ/kgK.
4. 5 kg of air at 40°C and 1 bar is heated in a reversible non flow constant pressure until the volume is doubled. Find (a). Change in volume (b). work done (c). change in internal energy (d). change in enthalpy.
5. A three cycle operating with nitrogen as the working substance has constant temperature compression at 34°C with initial pressure of 100 kPa. Then the gas undergoes a constant volume heating and then polytropic 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 = 0.731 kJ/kgK.
6. A fluid at a pressure of 3 bar and with specific volume of 0.18 m3/kg contained in a cylinder behind a piston and expands reversibly to a pressure of 0.6 bar according to the law p = C/v2 where C is a constant. Calculate the work done by the piston on fluid.
7. Derive the steady flow energy equation, stating the assumptions made and reduce it for a turbine, pump, nozzle and heat exchanger.
8. Prove that energy is a property of a system.
9. In a gas turbine installations air is heated inside heat exchanger up to 750°C from ambient temperature of 27°C.Hot air then enters into gas turbine with the velocity of 50 m/s and leaves at 600°C. Air leaving turbine enters a nozzle at 60 m/s velocity and leaves nozzle at temperature of 500°C.For unit mass flow rate of air. Determine the following assuming adiabatic expansions in turbine and nozzle, (i). Heat transfer to air in heat exchanger (ii). Power output from turbine (iii). Velocity at exit of nozzle, Take Cp for air as 1.005 kJ/kg°K
10. In an air compressor air flows steadily at the rate of 0.5 kg/s through an air compressor. It enters the compressor at 6 m/s with a pressure of 1 bar and a specific volume of 0.85 m3/kg and leaves at 5 m/s with a pressure of 7 bar and a specific volume of 0.16 m3/kg. the internal energy of the air leaving is 90 kJ/kg greater than that of the air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at the rate of 60kJ/s. Calculate (i). The power required to drive the compressor (ii). The inlet and outlet pipe cross – sectional area
11. At the inlet to a certain nozzle the enthalpy of fluid passing is 2800 kJ/kg and the velocity is 50 m/s. At the discharge end the enthalpy is 2600 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it. (i). Find the velocity at exit of nozzle (ii). If the inlet area is 900 cm2 and the specific volume at inlet is 0.187 m3/kg. Find the mass flow rate. (iii). If the specific volume at the nozzle exit is 0.498 m3/kg, find exit area of nozzle.
12. A 1.6 m3 tank is filled with air at a pressure of 5 bar and a temperature of 100°C.The air is then let off to the atmosphere through a valve. Assuming no heat transfer, determine the work obtainable by utilising the kinetic energy of the discharge air to run a frictionless turbine. Take Atmospheric pressure = 1 bar.

**UNIT – II**

**PART - A**

1. Define the term COP?
2. State the kelvin – Planck statement of second law of thermodynamics?
3. State Clausius statement of second law of thermodynamics?
4. Why is the second law of thermodynamics called a directional law of nature?
5. State Carnot’s theorem?
6. What are the Corollaries of Carnot theorems?
7. Define – PMM of second kind?
8. What is difference between a heat pump and refrigerator?
9. What is mean by cyclic heat engine?
10. Draw a schematic of a heat pump?
11. Write the expression for COP of a heat pump and a refrigerator?
12. Why Carnot cycle cannot be realized in practice?
13. Why cannot a heat engine have 100% efficiency?
14. When the Carnot cycle efficiency will be maximum?
15. Sketch the P-V and T-S diagram for Carnot cycle?
16. Write the expression for efficiency for the Carnot cycle?
17. Define Entropy?
18. Deduce the relation between the COP of heat pump and refrigerator?
19. Define the terms source, sink and reservoir?
20. What is the principle of increase of entropy?
21. Define Exergy?
22. What do mean by “Clausius inequality”?
23. What is the difference between adiabatic and isentropic processes?
24. What do you understand by the concept of entropy?
25. Explain the term “Reversibility”?
26. “Two reversible adiabatic lines cannot intersect”. Is this statement true or false? Justify the answer?
27. What is meant by thermodynamic temperature scale? How do you device such scale?
28. What is meant by dead state?
29. What are ‘available energy’ and ‘unavailable energy’?
30. What is loss of availability? How is it related to entropy of universe?
31. Define the term absolute entropy?
32. What is the essence of the second law of thermodynamics?
33. Can entropy of universe ever decrease? Why?
34. If Carnot engine efficiency is 50%.Find COP of Carnot refrigerator working between same temperatures?
35. Give the expressions to find change in entropy during constant pressure and polytropic process. Show in T-S diagram?
36. Find the entropy of universe when 1000KJ of heat is transferred from 800K to 500K.
37. A heat pump pumps 10MJ/KWhr to the high temperature reservoir. What is COP?
38. Is the second law independent of first law? Explain.
39. Define thermal efficiency?
40. What is meant by absolute temperature?
41. Draw a schematic diagram of a heat engine?
42. What is meant by EER?
43. Define perpetual motion machine II?
44. What is the difference between internally and externally reversible processes?
45. What is meant by totally reversible process?
46. Explain the two Carnot principles?
47. What is meant by Carnot efficiency?
48. Explain the quality of energy?
49. Write second law of efficiency?
50. Define stream availability?
51. What is meant by effectiveness?
52. What is meant by “Reversible work”?
53. What is meant by ‘availability’?
54. Evaluate the steady flow availability per unit mass of water at 2000C and 0.7MPa. Estimate the availability if the temperature is 3500C.
55. Calculate the increase in availability of 1.5 kg of air when heated reversibly from 550°C to 3750°C at constant pressure of 4 atm. Assume the environment to be at 200°C.
56. A thermal reservoir at 1500K can supply heat at a steady rate of 3000KJ/s. Determine the availability of this energy if the environment is at 250°C.
57. Explain the term “Irreversibility”?
58. Determine the stream availability of a nitrogen gas stream at 10MPa, 320K and 10m/s, if the environment is at 101KPa and 298K?
59. How much of the 1200KJ of thermal energy at 750K can be converted to useful work when the environment is at 300K?
60. Determine the closed system availability of nitrogen gas at 10MPa and 320K, when the environment is at 101KPa and 250°C?
61. Name two alternative methods by which the efficiency of a Carnot cycle can be increased?
62. Define change of entropy. How is entropy compared with heat transfer and absolute temperature?
63. Why the performances of refrigerator and heat pump are given in terms of COP and not in terms of efficiency?
64. Define Availability.
65. Define Second Law Efficiency.
66. What is mean by COP?
67. Define Entropy Generation.
68. An inventor claims to have developed an efficient heat engine which would have a heat source at 1000°C and reject heat to a sink at 50°C and gives an efficiency of 90%. Justify whether his claim is possible or not?

**PART – B**

1. Deduce the efficiency of carnot cycle in terms of temperature from its P-V diagram.
2. Bring out the concept of the Entropy and importance of T-S diagram.
3. Define the terms ‘Irreversible process’ and ‘Reversible process’. Give an example of each.
4. State and prove Clausius inequality.
5. Show that there is a decrease in available energy when heat is transferred through a finite temperature difference.
6. Prove that increase in entropy in a polytropic process is $∆$ s = mCv$ γ$-n/nln(p1/p2).
7. List out and explain various causes of irreversibility.
8. Show that a violation of the kelvin planck statement of the second law implies a violation of the clausius statement.
9. State and prove carnot’s principle.
10. Mention the Clausius inequality for open, closed and isolated systems.
11. Briefly discuss about the concept of Entropy.
12. An office room which was heated by electric resistance heater consumed 1200 kW-hr of electrical energy in a winter month. Instead of this heater if the same office room is heated by a heat pump which is having 20% of COP of the ideal Carnot pump. The room temperature is 24®C while surrounding is at 0®C. If heat supplied from the surrounding by the heat pump is 0.65kJ, determine COP and money saved per month. Assume cost of Electricity is Rs.1.75kW/hr
13. An Inventor claims that his new engine will develop 3 kW for a heat addition of 240kJ/min. The highest and lowest temperature of the cycle are 1527®C and 327®C respectively. Would you agree his claim? Use Clausius inequality method.
14. In a steam generator, the steam generating tubes receive heat from hot gases passing over the oxide surface evaporating water inside the tubes. Flue gas flow rate is 20kg/s with an average specific heat of 1.04kJ/kgK. The gas T decreases from 650®C to 400®C while generating steam at 300®C water enters the tube as a saturated liquid and leaves with a quality of 90%. Assume environment temperature as T0= 27®C. Determine the water flow rate , availability of hot fluid and cold fluid, Irreversibility and second law efficiency.
15. A metal block with m=5kg, c=0.4kJ/kgK at 40®C is kept in a room at 20®C. It is cooled in the following two ways:
16. Using a Carnot engine (executing integral number of cycles) with the room itself as the cold reservoir;
17. 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 block has the constant specific heat.

1. In a Closed system, air is at a pressure of 1bar, temperature of 300K and volume of 0.025 m3. The system executes the following processes during the completion of Thermodynamic cycles: 1-2; constant volume heat addition till pressure reaches 3.8bar, 2-3: constant pressure cooling of air, 3-1: isothermal heating to initial state. Determine the change in entropy in each process. Take Cv= 0.718kJ/kgK. R=287kJ/kgK.
2. In a boiler furnace, the hot gases while transferring heat to the water are cooled from 1000°C to 500°C at a constant pressure. The water is evaporated at a constant temperature of 179°C, the latent heat of water being 2018.4kJ/kg. Determine per kg of water evaporated (a) the total entropy change of the universe (b) the increase in unavailable energy referred to the surrounding temperature of 25°C. Take Cp of gases 1.05kJ/kgK.
3. Two Carnot refrigerators A and B operates in series. The refrigerator A absorbs energy at the rate of 1kJ/s from a body at 300K and rejects energy as heat to a body at T. The refrigerator B absorbs same quantity of energy which is rejected by the refrigerator A from the body at T, and rejects energy as heat to a body at 1000K. If both refrigerator have the same COP, calculate; (a) the temperature T of the body, (b) The COP of the refrigerators and (c) the rate at which energy is rejected as heat to the body at 1000K and (d) total power consumed.
4. During the process of compression, the air is compressed from 95 kpa, 0.12 m3, 303K to 950kpa as per the polytropic process with n=1.3. Taking the surrounding temperature condition as 101kpa and 288K.
5. Show that the irreversibility is zero if the compression process is reversible and calculate the average surface boundary temperature.
6. Calculate the irreversibility if the average surface boundary temperature is 350K due to insulation.
7. If a student measures the average boundary temperature as 500K, check the correctness of the value.
8. A gas mixture (Molar mass=23kg/kmol, specific heat ratio = 1.33) enters a large pipeline at a rate of 50kg/min and 400K and flows over a certain distance to reach the exit at constant pressure. The temperature at the exit is found to be 333K. Taking the surrounding temperature as 300K, calculate the loss of availability of the gas.