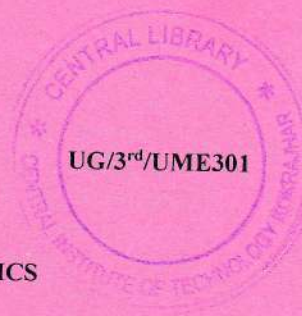


Total number of printed pages:3



2021

BASIC THERMODYNAMICS

Full Marks: 100

Time: Three hours

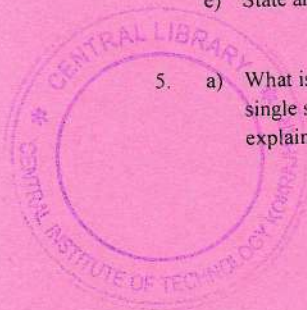
The figures in the margin indicate full marks for the questions.

Answer any five questions.

1. a) Define thermodynamic systems. What are different types of system? Explain with examples. 2 + 3 =5
- b) How the mass of a substance can be used to classify different thermodynamic properties? Give example 4
- c) How will you differentiate between steady state and equilibrium state? Discuss with example. 4
- d) Define with example: (a) Adiabatic process (b) Isothermal process (c) Isobaric process (d) Isochoric process. 4
- e) What are positive and negative work interaction? 2
- f) What is quasi-static process? 1

2. a) Under what condition is the work done equal to $\int_1^2 p dV$? 2
- b) Prove that, when $PV = \text{constant}$, P-V work done for a quasi-static process (state 1 to state 2) is $W_{1-2} = P_1 V_1 \ln \frac{P_1}{P_2}$ 5
- c) What do you understand by path function and point function (or state function)? What are exact and inexact differential? Graphically explain that work done is a path function but not point function. 5
- d) Discuss the matters behaviour in terms of macroscopic and microscopic view point and explain the concept of continuum. 5
- e) What are the modes in which energy is stored in a system? Define internal energy. How is energy stored in molecules and atoms. 3

3. a) State and explain with diagram the first law of thermodynamics for a closed system undergoing a cycle. 4
- b) Which property of a system changes when heat is transferred (a) at a constant volume and (b) at constant pressure? 2
- c) What is displacement work? How does free expansion have zero work transfer? 2
- d) Prove that, when $PV^n = \text{constant}$, P-V work done for a quasi-static process is $W_{1-2} = \frac{P_1V_1 - P_2V_2}{n-1}$ 4
- e) A gas expands from an initial state where the pressure is 340kPa and the volume is 0.0425 m^3 to a final pressure of 136 kPa. The relationship between the pressure and volume of the gas is $PV^2 = C$ (constant). Determine the work for the process. 4
- f) Air undergoes two processes : Process 1-2 expansion from $P_1 = 300 \text{ kPa}$, $V_1 = 0.019 \text{ m}^3/\text{kg}$ to $P_2 = 150 \text{ kPa}$ during which the P-V relation is given by $PV = \text{constant}$. Process 2-3 is constant pressure compression to V_3 where $V_3 = V_1$. Sketch the process on a P-V diagram and determine the work done per unit mass. 4
4. a) Explain the role of air compressor (With diagram) as an open system. 4
- b) Prove that $(Q)_v = \int_{T_1}^{T_2} C_v \Delta T$ and $(Q)_p = \int_{T_1}^{T_2} C_p \Delta T$ where $(Q)_v$ and $(Q)_p$ are heat change change at constant volume and at constant pressure respectively. C_v is specific heat at constant volume and C_p is specific heat at constant pressure, T is temperature in K. 5
- c) A gas expands against a variable external pressure given by $P = 10/V$, where V is the volume of the gas at each stage of expansion. Further in expanding from 10 to 100 litres, the gas undergoes a change in internal energy $\Delta U = 100 \text{ cal}$. How much heat has been absorbed? 4
- d) A stationary mass of gas is compressed without friction from an initial state of 0.3 m^3 and 0.105 MPa to a final state of 0.15 m^3 and 0.105 MPa , the pressure remains constant during the process. There is a transfer of 37.6 kJ of heat from the gas during the process. How much does the internal energy of the gas change? 4
- e) State and explain zeroth law of thermodynamics. 3
5. a) What is a steady flow process? Write the steady flow energy equation for a single stream entering and a single stream leaving a control volume and explain the various terms in it. 2+3



- b) Internal energy of a certain substance is given by the following equation: 8
 $u = 3.56pv + 84$, where u is given in kJ/kg , p is kPa and v is in m^3/kg
 A system composed of 3kg of this substance expands from an initial pressure of 500 kPa and a volume of 0.22m^3 to a final pressure 100kPa in a process in which pressure and volume are related by $pv^{1.2} = \text{constant}$
- (a) If the expansion is quasi-static, find Q , ΔU and W for the process
 (b) In another process the same system expands according to the same pressure-volume relationship as in part (a), and from the same initial state to the same final state as in part (a), but the heat transfer in this case is 30kJ . Find the work transfer for this process.
 (c) Explain the difference in work transfer as in parts (a) and (b).
- c) Explain limitations of 1st law of thermodynamics? 3
 d) For cyclical process, explain how heat and work are interchangeable with each other 4
6. a) Deduce an expression of thermal efficiency of a cyclic heat engine. 4
 b) Describe Kelvin's statement of second law of thermodynamics and justify that a heat engine with "perpetual motion of second kind" is impossible. 3
 c) Describe each steps of Carnot cycle in a P-V diagram. 5
 d) Prove two reversible adiabatic path cannot intersect each other. 4
 e) What is entropy? Explain the properties of entropy. 4
7. a) Describe Otto cycle or constant volume cycle 6
 b) Describe with neat sketch the working of a four stroke petrol engine 8
 b) Differentiate the following 3+3=6
 i) SI engine and CI engine
 ii) Two stroke engine and Four stroke engine

