Total number of printed pages:3

UG/3rd/UME301

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 $\int_1^2 pdV$? 2

   b) Prove that, when PV = constant, P-V work done for a quasi-static process (state 1 to state 2) is $W_{1\text{-}2} = P_1 V_1 \text{Ln}\frac{P1}{P2}$ 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 = constant, P-V work done for a quasi-static process is $W_{1\text{-}2}=\frac{P1V1-P2V2}{n-1}$ 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 kPa, V_1 = 0.019 m^3/Kg to P_2 = 150 kPa during which the P-V relation is given by PV = 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 $(Q)v = \int_{T1}^{T2} Cv\Delta T$ and $(Q)p = \int_{T1}^{T2} Cp\Delta T$ 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 ΔU = 100 cal. How much heat has been absorbed? 4

d) A stationary mass of gas is compressed without friction from an initial state of 0.3m^3 and 0.105MPa to a final state of 0.15m^3 and 0.105 Mpa, the pressure remains constant during the process. There is a transfer of 37.6kJ 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 $pv^{1.2} = constant$

(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 stoke petrol engine 8

b) Differentiate the following 3+3 =6

i) SI engine and CI engine

ii) Two stroke engine and Four stroke engine