53 (ME 301) BTDM

2018

BASIC THERMODYNAMICS

Paper : ME 301

Full Marks : 100

Time : Three hours

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

*Answer **any five** questions.*

1. *(a)* Explain what do you mean by the thermodynamic property of a system. How will you classify it ? 2+2=4

   (b) What is the Zeroth law of thermodynamics ? 3

   (c) Distinguish between stored energy and energy in transit. 3

   (d) What do you mean by thermodynamic equilibrium ? 5

   (e) Explain the difference between point function and path function. 3

(f) Give the thermodynamic definition of work. What is positive and negative work ? 2

2. (a) Define Internal energy. 2

(b) What is the difference between non-flow and steady-flow process ? 3

(c) Explain the general steady-flow energy equation. 4

(d) Explain *(i)* specific heat and *(ii)* molecular heat. 2+2=4

(e) Fill in the blanks : 1×7=7

(i) In a _____, transfer of mass does not take place.

(ii) The energy contained within the system boundaries is known as _____.

(iii) Internal energy of ideal gas is a function of _____ alone.

(iv) Internal energy is a _____ function.

(v) In an isolated system the energy remains _____.

(vi) Heat is also energy in _____.

(vii) Work is a _____ function.

3. (a) In a system $80kJ$ of heat is supplied from state 1 to state 2 by constant volume process. The internal energy at state 1 is $90kJ$. The system rejects $95kJ$ of heat from state 2 to state 3 by constant pressure process and $30kJ$ of work is done on it. The system is brought back from state 3 to state 1 by a reversible adiabatic process. Calculate the adiabatic work and the values of internal energy at state 2 and state 3. 7

(b) A steam turbine developing $34kW$ receives steam at $15bar$ with an internal energy of $2720kJ/kg$ and specific volume of $0{\cdot}17m^3/kg$ and velocity of $110m/s$. Steam is exhausted from turbine and at $0{\cdot}1bar$ with internal energy $2177kJ/kg$ and specific volume $15m^3/kg$ and velocity $320m/s$. The heat loss over the surface of the turbine is $20kJ/kg$. Neglecting change in potential energy, determine *(i)* work done per *kg* of steam *(ii)* steam flow through the turbine. 7

(c) Steam enters a steam condenser with an enthalpy of $2090 kJ/kg$ and a velocity of $510 m/s$. The condensate leaves the condenser with an enthalpy of $209 kJ/kg$ and with a velocity of $10 m/s$. Determine the heat received by the cooling water per kg of steam condensed. 6

4. (a) What are the limitations of the First law of thermodynamics ? 3

(b) State the Second law of thermodynamics as per (i) Kelvin-Planck (ii) Clausius. 2+2=4

(c) (i) Define COP. 2

(ii) Show that $COP_{Heat\ Pump} = COP_{Ref} + 1$. 4

(d) What is a Heat pump ? What is the function of a heat pump ? 2·5×2=5

(e) What are the four processes that constitute a Carnot cycle ? 2

5. (a) A heat engine, one heat pump and a refrigerator are embedded between two heat reservoirs — one at $600 K$ while the other at $300 K$. Determine —

(i) the efficiency of the heat engine

(ii) the COP of the heat pump

(iii) the COP of the refrigerator. 7

(b) A Carnot engine works between temperature limits of $825°C$ and $125°C$. The engine receives $3600 kJ$ of heat per minute. Determine the power of the engine and the amount of heat rejected to the sink per second. 7

(c) A heat engine, a heat pump and a refrigerator receives $500 kJ$ of heat each. But they reject $250 kJ$, $600 kJ$ and $700 kJ$ of heat respectively. Determine —

(i) the efficiency of the heat engine

(ii) the COP of the heat pump

(iii) the COP of refrigerator. 6

6. *(a)* Define a pure substance. 2

(b) Differentiate between a triple point and a critical point. 3+3=6

(c) A steam vessel of holding capacity $4m^3$ contains a mixture of saturated water and saturated steam at 250°*C*. The mass of the liquid present is 1*ton*. Determine the —

(i) pressure

(ii) mass of vapour

(iii) dryness fraction

(iv) specific volume

(v) specific enthalpy

(vi) specific entropy. 8

(d) State the conditions of steam in the following cases : 1×4=4

(i) At a pressure of 10*bar*, total heat is 2646*kJ/kg*

(ii) At a pressure of 15*bar*, temperature is 197·4°*C*

(iii) At a pressure of 20*bar*, temperature is 225°*C*

(iv) At a pressure of 7*bar*, specific volume is $0{\cdot}26m^3$.

7. Write short notes on : ***(any five)*** 5×4=20

(i) Macroscopic and Microscopic approaches

(ii) Intensive and Extensive properties

(iii) Carnot cycle

(iv) Rankine cycle

(v) Heat engine and heat pump

(vi) Dryness fraction of saturated steam.

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