CBCS SCHEME

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15ME33

Third Semester B.E. Degree Examination, Aug./Sept.2020
Basic Thermodynamics

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. What is thermodynamic equilibrium? Explain mechanical, chemical and thermal equilibrium. **(04 Marks)**

b. What are the similarities and dissimilarities between work and heat? **(04 Marks)**

c. The readings T_A and T_B of two Celsius thermometers A and B agree at ice and steam points, elsewhere the temperatures are related by $T_A = L + MT_B + NT_B^2$, where L, M and N are constants. When the two thermometer are immersed in a well stirred oil bath, A reads 51°C and B reads 50°C. Determine:
(i) What thermometer A reads when thermometer B reads 30°C?
(ii) What thermometer B reads when A reads 30°C?
(iii) Discuss the question which thermometer is correct.
Take ice point = 0°C and steam point = 100°C. **(08 Marks)**

OR

2 a. Define displacement work. Define an expression for displacement work for the case of polytropic process with PV^n = constant. **(05 Marks)**

b. Distinguish between following with an example for each:
(i) Intensive and extensive property
(ii) Point and path function **(04 Marks)**

c. A gaseous system undergoes three quasi-static process in sequence. The gas is initially at 5 bar, 0.01 m^3 is expanded at constant pressure. It is then further expanded according to the law $PV^{1.4}$ = constant to 2 bar, 0.025 m^3. The gas is then returned to its initial state following the process PV = constant. Show the process on PV diagram. Calculate the work interaction in each process and the network for the system. **(07 Marks)**

Module-2

3 a. Clearly write steady flow energy equation for an open system and explain the terms involved. **(04 Marks)**

b. Simplify steady flow energy equation for the following:
(i) Steam turbine (ii) Nozzle (iii) Boiler **(06 Marks)**

c. A gas undergoes a thermodynamic cycle consisting of the following process:
Process 1-2 : constant pressure P = 1.4 bars, $V_1 = 0.028\ m^3$, $W_{1-2} = 10.5$ kJ.
Process 2-3 : compression with PV = constant, $U_3 = U_2$.
Process 3-1: constant volume, $(U_1 - U_3) = -26.4$ kJ.
There are no significant changes in KE and PE. Sketch the cycle on P-V diagram. Calculate the network for the cycle in kJ. Calculate the net heat transfer for process 1-2, and show that $\sum_{cycle} Q = \sum_{cycle} W$. **(06 Marks)**

OR

4 a. State and prove that Kelvin-Planck and Clausius statements of second law of thermodynamics are equivalent. **(09 Marks)**

b. A reversible heat engine operating between two thermal reservoirs at 800°C and 30°C respectively. It drives a reversible refrigerator operating between −15°C and 30°C. The heat input to the heat engine is 1900 kJ and net work output from the combined plant (engine and the refrigerator both) is 290 kJ. Calculate the heat absorbed by the refrigerant and total heat transferred to 30°C reservoir. **(07 Marks)**

Module-3

5 a. Define the terms reversible and irreversible process. List the factors that makes a process irreversible. Explain them briefly. **(06 Marks)**

b. With the help of suitable sketches, explain reversible heat engine cycle. Show that the efficiency of reversible heat engine is independent of the nature of working substance and depends upon the temperature limits between which it is operating. **(10 Marks)**

OR

6 a. State and prove Clausius inequality. What is its significance? **(04 Marks)**

b. State and prove principle of increase of entropy. **(04 Marks)**

c. One kg of ice at −5°C is exposed to atmosphere which is at 20°C. The ice melts and comes into thermal equilibrium with atmosphere. Determine change in entropy of the universe. Take C_p of ice = 2.093 kJ/kgK as latent geat of fusion of ice = 333.3 kJ/kg. **(08 Marks)**

Module-4

7 a. Briefly explain what is meant by
   (i) Available energy
   (ii) Unavailable energy
   (iii) Dead state with respect to system. **(06 Marks)**

b. Derive Claperyon's equation. What are its uses and limitations? **(05 Marks)**

c. 2000 kJ/min of heat is supplied to a system at 500 K from a source at 1000 K. The temperature of the atmosphere is 27°C. Assuming the temperature of system and source remains constant during heat transfer, find:
   (i) Change in entropy during heat transfer
   (ii) The decrease in available energy after heat transfer. **(05 Marks)**

OR

8 a. Define the following terms as applied to a pure substance :
   (i) Triple point
   (ii) Critical point
   (iii) Sub-cooled liquid state
   (iv) Saturated liquid state
   (v) Dryness fraction **(05 Marks)**

b. Explain with the help of diagram, how one could estimate the dryness fraction of steam using throttling calorimeter. What are limitations of this calorimeter? **(07 Marks)**

c. Select a point in a wet region and show the following processes starting from this common point on a h-s diagram for steam:
   (i) Throttling of wet steam
   (ii) Isobaric compression to superheated state
   (iii) Isochoric heat addition till it becomes superheated steam
   (iv) Isentropic compression till it becomes dry saturated. **(04 Marks)**

Module-5

9 a. Define the following terms:
- (i) Perfect and semi-perfect gas
- (ii) Specific humidity and relative humidity
- (iii) Dew point temperature and dew point depression **(06 Marks)**

b. Write down the Vander Waal's equation of state. How does it differ from ideal gas equation? **(04 Marks)**

c. 0.5 kg of Nitrogen is cooled in a rigid vessel from 227°C to 27°C. The initial pressure is 15 Bar. Calculate the final pressure and change in internal energy, changer in enthalpy and entropy. Assume that nitrogen behaves as an ideal gas with C_p = 1.042 kJ/kgK and C_v = 0.745 kJ/kgK. Also show the process on PV and TS diagram. **(06 Marks)**

OR

10 a. Explain the following:
- (i) Compressibility factor
- (ii) Law of corresponding states
- (iii) Psychrometric chart and its use **(10 Marks)**

b. Determine the specific volume of CO_2 at 200°C and 60 bar by using:
- (i) Ideal gas equation
- (ii) Compressibility chart

Take compressibility factor Z = 0.96. **(06 Marks)**

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