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10ME/AU33

Third Semester B.E. Degree Examination, June/July 2017

Basic Thermodynamics

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. Use of thermodynamic data hand book is permitted.

PART – A

1 a. What is meant by thermodynamic equilibrium? Explain mechanical, chemical and thermal equilibrium. **(08 Marks)**

b. Distinguish between:
 (i) Macroscopic and microscopic approaches.
 (ii) Point and path functions.
 (iii) Cyclic and non cyclic process. **(06 Marks)**

c. The temperature on a thermometric scale is defined in terms of a property K by the relation $t = M\ln(K) + N$, where M and N are constants. The values of K are found to be 1.83 and 6.78 at Ice and steam points respectively. Determine the temperature corresponding to a value of K = 2.42 on the thermometer. **(06 Marks)**

2 a. Define work according to:
 (i) Mechanics.
 (ii) Thermodynamics. **(04 Marks)**

b. State the conditions to be satisfied for displacement work. Derive an expressions for displacement work in,
 (i) Isothermal process.
 (ii) Polytropic process. **(10 Marks)**

c. A spherical balloon has an initial diameter of 25 cm and contain air at 1.2 bar. Because of heating, the diameter of balloon increases to 30 cm and during the heating process, the pressure is found to be proportional to the diameter. Calculate the work done during the process. **(06 Marks)**

3 a. Prove that energy (E) is a property of a system. **(08 Marks)**

b. Derive steady flow energy equation with usual notations. **(06 Marks)**

c. A slow chemical reaction takes place in a fluid at constant pressure of 0.1 MPa. The fluid is surrounded by a perfect heat insulator during the reaction which begins at state 1 and ends at state 2. The insulation is removed and 150 KJ of heat flow to the surrounding as the fluid goes to state 3. The following data are observed for the fluid at states 1, 2 and 3.

State	Volume (m^3)	Temperature (°C)
1	0.003	20
2	0.3	70
3	0.06	20

Find the energy for this fluid system at states 2 and 3, if the energy at state 1 is zero. **(06 Marks)**

4 a. Show that COP of the heat pump is greater than COP of a refrigerator by unity. **(06 Marks)**
b. State and prove Carnot's theorem. **(06 Marks)**
c. An ice plant working on a reversed Carnot cycle; heat pump produces 15 tonnes of ice per day. The ice is formed from water at 0° C and formed ice is maintained at 0° C. The heat is rejected to the atmosphere at 25°C. The heat pump used to run the plant is coupled to Carnot engine which absorbs heat from the source which is maintained at 220°C by burning fuel of 44.5 MJ/kg calorific value and rejecting heat to atmosphere.
Determine (i) Power developed by the engine. (ii) Fuel consumed / hr.
Take enthalpy of fusion of ice = 334.5 KJ/kg. **(08 Marks)**

PART – B

5 a. With usual notations, explain Clausius theorem. **(08 Marks)**
b. Explain principle of increase of entropy. **(04 Marks)**
c. One kg of ice at -5°C is exposed to the atmosphere which is at 20°C. The ice melts and comes into thermal equilibrium with the atmosphere. Determine the entropy increase of the universe.
Take C_P of ice 2.093 KJ/kg K and
Latent heat of fusion of ice 333.3 KJ/kg. **(08 Marks)**

6 a. With the help of PV-diagram, explain the various regions of a pure substance. **(06 Marks)**
b. Sketch and explain combined separating and throttling calorimeter. **(06 Marks)**
c. Steam at 10 bar and 230°C is cooled under constant pressure until it becomes 0.85 dry. Using steam tables find the work done, change in enthalpy, heat transferred and change in entropy. **(08 Marks)**

7 a. Define Ideal gas. **(02 Marks)**
b. Show that the change in entropy for ideal gas is given by the expression:
$$(S_2 - S_1) = C_P \ln\left(\frac{T_2}{T_1}\right) - R \ln\left(\frac{P_2}{P_1}\right)$$ **(10 Marks)**
c. An ideal gas cycle consisting of three processes uses Argon (molecular weight = 40) as a working substance. Process 1 – 2 is reversible adiabatic process from 0.14 m^3, 700 KPa and 280°C to 0.056 m^3. The process 2 – 3 is a reversible isothermal process. Process 3 – 1 is an isobaric process. Sketch the cycle on P – V and T – S diagrams and find,
(i) Work transfer in process 1 – 2
(ii) Work transfer in process 2 – 3
(iii) Net work output from the cycle.
Assume $\gamma = 1.67$ **(08 Marks)**

8 a. Distinguish between ideal and real gases. **(04 Marks)**
b. Explain (i) Compressibility factor and
(ii) Compressibility chart. **(04 Marks)**
c. Define Dalton's law of partial pressure. **(04 Marks)**
d. Find the gas constant and apparent molar mass of a mixture of 2 kg O_2 and 3 kg N_2, given that universal gas constant is 8314.3 J/kgmoleK. Molar masses of O_2 and N_2 are respectively 32 and 28. **(08 Marks)**

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