CBCS SCHEME

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17ME33

Third Semester B.E. Degree Examination, July/August 2021
Basic Thermodynamics

Time: 3 hrs. Max. Marks: 100

Note: 1. ***Answer any FIVE full questions.***
2. ***Use of thermodynamic data book is permitted.***

1 a. Differentiate between open system and control volume. Give examples. **(06 Marks)**

b. With examples, define the following :
(i) Intensive property (ii) Extensive property
(iii) Path function (iv) Point function **(08 Marks)**

c. A constant volume gas thermometer containing a gas gives the reading of gas pressure of 1 bar and 1.5 bar at ice point and steam point respectively. Assuming $T = a + bP$, where P is in N/m^2, express the gas thermometer Celsius temperature T in terms of gas pressure. What is the temperature recorded by the thermometer when it registers a pressure of 1.2 bar. **(06 Marks)**

2 a. List out the similarities and dissimilarities between work and heat. **(06 Marks)**

b. Derive the work done expression for, (i) Isothermal process (ii) Isentropic process. **(06 Marks)**

c. A fluid is heated reversibly at a constant pressure of 1.013 bar until it has a specific volume of 0.1 m^3/kg. It is then compressed reversibly according to a law $PV = C$ to a pressure of 4.2 bar, then allowed to expand reversibly according to a law $PV^{1.3} = C$ to the initial conditions. The work done in the constant pressure process is 515 Nm and the mass of fluid present is 0.2 kg. Calculate the net work done on or by the fluid in the process. Sketch the cycle on P-V diagram. **(08 Marks)**

3 a. Describe Joule's experiment to verify First law of thermodynamics. **(06 Marks)**

b. Why PMMKI and PMMKII are impossible? **(06 Marks)**

c. A centrifugal pump delivers 50 kg of water per second. The inlet and outlet pressures are 1 bar and 4.2 bar. The suction is 2.2 m below the centre of the pump and delivery is 8.5 m above the centre of the pump. The suction and delivery pipe diameters are 20 cm and 10 cm respectively. Determine the capacity of the electric motor to run the pump if pump efficiency is 85%. **(08 Marks)**

4 a. Show that reversible heat engine has higher efficiency than irreversible heat engine. **(10 Marks)**

b. A refrigerator produces 2 tonnes of ice at 0°C per day from water maintained at 0°C. It rejects heat to atmosphere at 27°C. The power to the refrigerator is supplied by an angine which absorbs heat from a source, which is maintained at 227°C by burning fuel of calorific value 20×10^3 KJ/kg. Find the consumption of fuel per hour and the power developed by the engine. Assume both the devices to run on Carnot cycle. Take latent heat of ice as 335 KJ/kg. **(10 Marks)**

5 a. Clearly explain the factors that make a process irreversible. **(10 Marks)**

b. What is internal and external irreversibility? **(04 Marks)**

c. Show that entropy change is an irreversible process. **(06 Marks)**

6 a. State and prove Clausius inequality. **(08 Marks)**

b. The heat engine receives 300 kJ/min of heat from a source at 327°C and rejects heat to a sink at 27°C. Three hypothetical amounts of heat rejections are given below:

(i) 200 kJ/min, (ii) 150 kJ/min (iii) 100 kJ/min

Using entropy concept, state which of these cases is a reversible, irreversible or an impossible one. **(06 Marks)**

c. A perfect gas of mass 1.7 kg and volume 1.5 m^3/kg are compressed reversibly and polytropically from pressure 1 bar to 7.5 bar in a cylinder. The index of compression is 1.25, R = 0.540 kJ/kg K, C_v = 1.687 kJ/kgK. Calculate the work done, heat transfer and change in entropy. **(06 Marks)**

7 a. Define the following:

(i) Available and Unavailable energy.

(ii) Availability.

(iii) II law efficiency. **(06 Marks)**

b. Draw pressure-temperature diagram for a pure substance. Explain its salient features. **(07 Marks)**

c. 15 kg of water is heated in an insulated tank by a churning process from 300 K to 340 K. If the surrounding temperature is 300 K, find the loss in availability for the process. **(07 Marks)**

8 a. With a neat sketch, explain the working of Throttling calorimeter. What are its advantages and disadvantages? **(10 Marks)**

b. A certain quantity of steam in a closed vessel of fixed volume of 0.14 m^3 exerts pressure of 10 bar and 250°C. If the vessel is cooled so that the pressure falls to 3.6 bar, determine (i) final quality of steam (ii) final temperature (iii) change in internal energy (iv) heat transferred during the process. Take C_p = 2.1 kJ/kgK. **(10 Marks)**

9 a. State the following :

(i) Dalton's law of additive pressures.

(ii) Amagat's law of volume additives. **(04 Marks)**

b. Define the psychrometric properties given below:

(i) Wet bulb temperature

(ii) Dew point temperature.

(iii) Specific humidity

(iv) Relative humidity

(v) Degree of saturation

(vi) Dry bulb depression. **(09 Marks)**

c. A mixture of ideal gases consists of N_2 of 3 kg and CO_2 of 5 kg at a pressure of 300 KPa and temperature of 20°C. Find (i) Mole fraction of each constituent (ii) Gas constant of mixture (iii) Molecular weight of mixture (iv) Partial pressures and volumes. **(07 Marks)**

10 a. Write a note on : (i) Law of corresponding states (ii) Compressibility chart. **(06 Marks)**

b. With usual notations, write the Vander-Waal's equation of state. What is the significance of constants 'a' and 'b'. **(06 Marks)**

c. Determine the pressure in a steel vessel having a volume of 15 lit and containing 3.4 kg of N_2 at 400°C using,

(i) Ideal gas equation (ii) Vanderwaal's equation.

Also calculate the compressibility factor by using the answer obtained from the Vanderwaal's equation of state. **(08 Marks)**

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