ACHARYA INSTITUTE OF TECHNOLOGY
Bangalore - 560090

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10ME33

Third Semester B.E. Degree Examination, Dec.2016/Jan.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 steam table permitted.

PART – A

1 a. Distinguish between:
i) Intensive and extensive properties.
ii) Microscopic and macroscopic point of view.
iii) Adiabatic boundary and a diathermic boundary. **(06 Marks)**

b. With neat diagram, explain the working of constant volume gas thermometer for measurement of temperature. **(08 Marks)**

c. State Zeroth law of thermodynamics. The temperature T on a thermometric scale is defined as T = a/n k + b where a and b are constant. The values of K are found to be 1.83 and 6.78 at 0°C and 100°C respectively calculate the temperature for a value of K = 2.42. **(06 Marks)**

2 a. With a neat P-V diagram, derive an expression for work done during polytropic process ($PV^n = C$). **(05 Marks)**

b. Explain p-dv work and prove that work in a path function. **(06 Marks)**

c. A fluid contained in a horizontal cylinder with a frictionless lead proof piston is continuously agitation by means of a stirrer passing through the cylinder cover. The cylinder diameter is 0.4m. During the stirring process lasting 10 minutes, the piston slowly moves out a distance of 0.485m against the atmospheric pressure of 101kpa. The network done by fluid during the process is 2kJ. The speed of the electric motor driving the stirrer is 840 rpm. Determine the torque in the shaft. **(09 Marks)**

3 a. Write the steady flow energy equation and modify the SFEE for the following cases:
i) Adiabatic expansion of steam in turbine.
ii) Horizontal steam nozzle with negligible entrance velocity. **(06 Marks)**

b. A slow chemical reaction takes place in a fluid at a 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 then removed and 105 kJ of heat flow to the surroundings as the fluid goes to state 3. The following data are observed for the fluid at state 1, 2 and 3.

State	Volume (m^3)	t°C
1	0.03	20
2	0.3	370
3	0.06	20

For the fluid system calculate E_2 and E_3 if $E_1 = 0$. **(08 Marks)**

c. Steam having a specific enthalpy of 2930 kJ/kg flows through a turbine nozzle and after expansion leave the nozzle with an enthalpy 2260 kJ/kg. If the flow is adiabatic determine the exit velocity if (i) the initial velocity is 3600 m/min; (ii) the initial velocity is neglected. **(06 Marks)**

4 a. State and prove carnot theorem. **(06 Marks)**

b. Define Kelvin-Plank and Clausius statements of second law of thermodynamics. **(04 Marks)**

c. Define the following terms: i) Heat engine cycle; ii) Refrigeration effect. **(04 Marks)**

d. An inventor claims that his engine has the following specification. Heating value of the fuel = 74,500 kJ/kg temperature limits 750°C and 25°C. Power developed 75kW fuel burned 0.07kg/min state whether the claim is valid or not. **(06 Marks)**

PART – B

5 a. State and prove Clausius inequality. **(06 Marks)**

b. Starting from first law of thermodynamics. Show that the change in entropy for a reversible isobaric compression process is given by $(s_2 - s_1) = mC_p \log_e \frac{v_2}{v_1}$. **(06 Marks)**

c. $0.04m^3$ of nitrogen contained in a cylinder behind a piston is initially at 1.05 bar and 15°C. The gas is compressed isothermally and reversibly until the pressure is 4.8 bar calculate:

i) The change in entropy.

ii) The heat flow and

iii) The workdone.

Sketch the process on a p-v and T-s diagram. Assume nitrogen to act as a perfect gas molecular weight (M) of nitrogen is 28. **(08 Marks)**

6 a. Define: i) Triple point; ii) Saturated liquid; iii) Dryness fraction. **(04 Marks)**

b. What is the main objective of quality measurement? With the neat sketch explain throttling calorimeter. **(07 Marks)**

c. Steam at 10 bar and 200°C undergoes a reversible polytropic process to 1 bar according to the law $pv^{1.15} = c$. Determine the final specific volume, the final temperature and heat transferred for the process. **(09 Marks)**

7 a. Write Maxwell's equations and state their importance in thermodynamics. **(06 Marks)**

b. Derive the first and second T-ds equations. **(06 Marks)**

c. Show that for a perfect gas, the difference between the specific heats ($C_p - C_v$) can be expressed as

$$C_p - C_v = \left[p + \left(\frac{\partial u}{\partial v}\right)_T\right]\left(\frac{\partial v}{\partial T}\right)_P = pv\beta + v\beta\left(\frac{\partial u}{\partial v}\right)_T$$

where β is the coefficient of volume expansion. **(08 Marks)**

8 a. Define the following terms:

i) Partial pressure of a gas in a mixture.

ii) Mole fraction of gas.

iii) Mass fraction of a gas. **(06 Marks)**

b. Derive Vander Waal's constants in terms of critical properties. **(06 Marks)**

c. $0.1m^3$ of hydrogen initially at 1.2 MPa, 200°C undergoes a reversible isothermal expansion process to 0.1 MPa. Determine: i) The work done; ii) The heat transfer; iii) Change in enthalpy and iv) Change in entropy. R = 4.124 kJ/kg K. For hydrogen C_p = 14.4 kJ/kg K, C_v = 10.276 kJ/kg K. **(08 Marks)**

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