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The Assam Royal Global University, Guwahati

Royal School of Engineering & Technology

B.Tech. Mechanical Engineering – 3rd Semester

Semester End Examination, January 2023

Course Title: **Basic Thermodynamics**

Course Code: **MEE022C305**

Time: 3 Hours **Maximum Marks: 70**

Note: Attempt all questions as per instructions given.

The figures in the right-hand margin indicate marks.

Use steam tables and scientific calculator are permitted

Section – A

1. Attempt **all questions**. (Maximum word limit 50) **2 x 8**

a. Define with examples (i) Open system and (ii) Closed system.

b. Explain with examples path function and point function.

c. Explain the terms wet steam and superheated steam.

d. Define critical point and triple point.

e. Explain steady flow with examples or steady-flow devices.

f. What are the factors that cause a process to be irreversible?

g. Explain the Clausius inequality.

h. Explain the term isentropic efficiency of a turbine.

Section – B

2. Attempt **any two** of the following: **6 x 2**

a. (i) Explain concept of temperature measurement. 2

(ii) A temperature scale of certain thermometer is given by the relations $t = a \ln p + b$, where a and b are constants. The thermometric properties at ice point and steam point are found to be 1.5 and 7.5 respectively. What will be the temperature corresponding to the thermometric property of 3.5 on Celsius scale. 4

b. (i) What is displacement work? 2

(ii) Calculate the displacement work of a gas in a closed system undergoing a process from initial state of 2 m^3 & 1.5 bar to a final state of 7.5 bar when the process is (1) isothermal and (2) adiabatic. 4

c. (i) Explain the First law of thermodynamics as referred to a closed system undergoing a change in state. 2

(ii) During one cycle the working fluid of an engine engages in two work interactions: 17 kJ to the fluid and 46 kJ from the fluid and three heat interactions, two of which are 77 kJ to the fluid and 42 kJ from the fluid. Evaluate the magnitude and direction of the third heat transfer. 4

3. Attempt **any two** of the following: **7 x 2**

a. (i) With reference to mixtures and multiple phases, what are pure substances? 3

(ii) The pressure and temperature of mixture of 4 kg of O_2 and 6 kg of N_2 are 4 bar and 27°C respectively. For the mixture, determine the mole fractions and partial pressure of each component. 4

b. (i) Write the equation of state of an ideal gas on mole basis. What is the relationship between mole and mass of an ideal gas? 3

(ii) An automobile tire has volume of 0.025 m^3. Calculate the mass of nitrogen in the tire when the pressure and temperature of nitrogen inside the tire is 300 KPa and 25°C. When the temperature of nitrogen in the tire rises to 50°C with negligible increase in volume of tire, what will be the rise in pressure. 4

c. (i) With help of p-V diagram, explain the different regions for a pure substance 3

(ii) Estimate the heat required at constant pressure of 2.5 MPa to convert 10 kg of wet steam with dryness fraction of 0.5 to superheat steam at 300°C. 4

4. Attempt **any two** of the following: **7 x 2**

a. (i) Write the steady flow energy equation and explain each term in the equation with the help of a diagram. 3

(ii) A turbine operates under steady flow conditions. The flow rate of steam is 0.4 kg/s. The inlet condition of steam is enthalpy 2785 kJ/kg, velocity 34 m/s and elevation 3m. The exit condition of steam is enthalpy 2525 kJ/kg, velocity 100 m/s and elevation 0.5 m. Heat is lost to surrounding at rate of 100 kJ/kg. Determine the power output from the turbine. 4

b. (i) State the second law of thermodynamics that is applicable to heat engines and define thermal efficiency. 3

(ii) A refrigerator removes heat from a compartment that is at a temperature of $-20°C$. The refrigerator rejects heat to the surrounding that is at a temperature of 40°C. The work supplied to the refrigerator is 360 kJ. Determine the COP of refrigerator and heat removed from compartment. 4

c. (i) Draw the p-V diagram of the Carnot cycle and explain each process. 3

(ii) A Carnot heat engine rejects 200 kJ of heat per cycle to a low temperature sink at $27°C$ while receiving heat from high temperature source at $627°C$. Determine (a) the thermal efficiency of this Carnot engine and (b) the amount of heat received from the source per cycle. 4

5. Attempt **any two** of the following: **7 x 2**

a. (i) Explain the increase of entropy principle. 3

(ii) A heat is transferred steady from two TERs at (A) 850 K and (B) 300 K through a rod. Determine the change in entropy of the universe. 4

b. (i) Represent available and unavailable energy as referred to a process on a T-s diagram and explain. 3

(ii) Steam at rate of 2 kg/s is throttled in valve during a steady process. The entropy at inlet and exit of valve are 5.655 KJ/kgK and 6.025 KJ/kgK respectively. Calculate the entropy generated and the irreversibility. The surrounding temperature is 27°C. 4

c. (i) Explain the ideal Otto cycle as executed in a closed system illustrated on p-V and T-s diagrams 4

(ii) An ideal Brayton cycle with air as the working fluid has a pressure ratio of 8. The work output of the cycle is 362.4 kJ/kg. Calculate the heat input per kg of air. 3