Qualification Code : Thermodynamics I

Qualification :
AUTOMOTIVE/ELECTRICAL/MECHATRONICS/CIVIL,MECHANICAL PLANT/MECHANICAL TECH./MECH. TECH

Unit Code :ENG/CU/ME/CC/5/06/A

Unit of Competency : Prepare and interpret technical drawings

MARCH/APRIL 2024

INSTRUCTIONS TO STUDENT:

1. The paper consists of **TWO** sections: **A** and **B.**
2. Answer **ALL** questions in section **A** and any 3 in section **B.**
3. Answer ALL questions in sections A and B in the answer booklet provided.
4. Marks for each section are indicated in the brackets .
5. Do not write on this question paper.
6. Answer the questions in English.

This paper consists of six(6) printed pages.
Candidate should check the question paper to ascertain that all pages are printed as indicated and that no questions are missing.

SECTION A (40 marks)

Answer **all** questions from this section

1. Define the following terms as used in thermodynamics (3 marks)

a. Open System

b. Boundary

c. Closed system

2. State the first law of thermodynamics (2 marks)

3.Explain the difference between heat and work in thermodynamics. (2 marks)

4. In a certain steam plant operating in a closed cycle, the turbine develops 1000 kW. The heat supplied to the steam in the boiler is 2800 kJ/kg, the heat rejected by the system to the cooling water in the condenser is 2100 kJ/kg and the feed pump work required to pump the condensate back into the boiler is 5 kW. Calculate the mass flow rate of steam round the cycle in kg/s. (4 marks)

4. Steam at 7 bar, dryness fraction 0.9 expands reversibly at constant pressure until the temperature is 200^c.Calculate the work input and heat supplied per unit mass of steam during the process. (5 marks)

5. Derive the steady flow equation (5 marks)

6. Determine the dryness fraction, specific volume and specific internal energy of steam at 7 bar and enthalpy 2600 kJ/kg. (5 marks)

7. A perfect gas has a molar mass of 26 kg/kmol and a λ value of 1.26.

Calculate the heat rejected:

1. (i) when unit mass of the gas is contained in a rigid vessel at 3 bar and 315°C, and is then cooled until the pressure falls to I.5 bar; (3 marks)
2. (ii) when unit mass flow rate of the gas enters a pipe tine at 280°C, and flows steadily to the end of the pipe where the temperature is W·C. Neglect changes in velocity of the gas in the pipeline. (3 marks)

9. Explain the behavior of ideal gases using the ideal gas law equation $PV=nRT$. Discuss the variables involved and their units, as well as the assumptions underlying the ideal gas model.. (3 marks)

10. Explain the concept of superheated steam in thermodynamics. Define what superheated steam is and describe how it differs from saturated steam. (2 marks)

11. 1 kg or air enclosed in a rigid container is initially at 4.8 bar and 150°C. The container

is heated until the temperature is 200 °C. Calculate the pressure or the air finally and

the heat supplied during the process. (4 marks)

SECTION B (60 marks)

Answer **any** three questions from this section

12

(a). In the cylinder of an air motor the compressed air has a specific internal energy of 620 Kj/kg at the beginning of the expansion and a specific internal energy of 100 Kj/kg after expansion. Calculate the heat flow to or from the cylinder when the work done by the air during the expansion is 170 kJ/kg. (7 Marks)

(b).A unit mass of steam at 100 bar and 375ºC expands reversibly in a perfectly thermally insulated cylinder behind a piston until the pressure is 38 bar and the steam is then dry saturated. Calculate the work done.

(7 marks)

(c).0.05 kg of steam at 15 bar is contained in a rigid vessel of volume 0.0076 m3. What is the temperature of the steam? If the vessel is cooled until the pressure in the vessel is 11 bar, calculate the dryness fraction of the steam and the total heat rejected. (6 marks)

13.

(a)Dry saturated steam at 100 bar expands isothermally and reversibly to a pressure of 10 bar. Calculate the heat supplied and the work done per kilogram of steam during the process.

(6 marks)

(b) A mass of 0.05 kg of a fluid is heated at a constant pressure of 2 bar until the volume occupied is 0.0658 m'. Calculate the heat supplied and the work done. (14 marks)

14. (a) In the turbine of a gas turbine unit the gases flow through the turbine at 17 kg/s and the power developed by the turbine is 14000 kW. The specific enthalpies of the gases at inlet and outlet are 1200 kJ/kg and 360 kJ/kg respectively, and the velocities of the gases at inlet and outlet are 60 m/s and 150 m/s respectively. Calculate the rate at which heat is rejected from the turbine. Find also the area of the inlet pipe given that the specific volume of the gases at inlet is 0.5 m^3/kg

(12 marks)

(b) Air flows steadily at the rate of 0.4 kg/s through an air compressor, entering at 6 m/s with a pressure of I bar and a specific volume of 0.85 m^3/kg. and leaving at 4.5 m/s with a pressure of 6.9 bar and a specific volume of 0.16 m^3/kg. The specific internal energy of the air leaving is 88 leJ/kg greater than that of the air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at the rate of 59 kW. Calculate the power required to drive the compressor and the inlet and outlet pipe cross-sectional areas. (8 marks)

15.

(a)1.1 kg of steam at 20 bar, and temperature 250°C is heated reversibly at constant pressure until the pressure is 3.5 bar according to the law PV1.25=constant. Determine for this expansion the;

a. Final condition of the steam

b. Specific heat transfer

c. Change of entropy

Sketch the process on a T-S diagram. (14 Marks)

(b) 2.0.05 m^3 of a gas at 6.9 bar expands reversibly in a cylinder behind a piston according to the law PV1.2=constant until the volume is 0.08m^3.Calculate the work done (6 marks)