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(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

2022/2023 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER EXAMINATIONS

FOR THE DEGREE

OF

BACHELOR OF SCIENCE IN EDUCATION TECHNOLOGY

COURSE CODE: TEM 371

COURSE TITLE: THERMODYNAMICS I

DATE: 11TH APRIL 2023 **TIME:** 8:00 AM - 10:00 AM

INSTRUCTIONS TO CANDIDATES

1. This paper consists of **FOUR** questions
2. Answer Question **ONE (Compulsory)** and any other **TWO** Questions
3. All symbols have their usual meaning

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 4 Printed Pages. Please Turn Over

QUESTION ONE [30 marks]

A. An air compressor requires shaft work of 200 kJ/kg of air and the compression of air causes increase in enthalpy of air by 100 kJ/kg of air. Cooling water required for cooling the compressor picks up heat of 90 kJ/kg of air. Determine the heat transferred from compressor to atmosphere (4 Marks).

B. Gas in a cylinder is expanded by a piston in a process for which $PV^n = C$, where C and n are constants. The initial pressure and volume are 3 bar and 0.2 m^3 respectively and the final volume is 0.6 m^3. Determine the work done by the gas if (a) n = 1.4 and (b) n = 1.0. (6 Marks)

C. Unit mass of a fluid at a pressure of 3 bar, and with a specific volume of 0.18 m^3/kg, contained in a cylinder behind a piston expands reversibly to a pressure of 0.6 bar according to a law $P=C/v^2$, where C is constant, calculate the work done during the process (4 Marks)

D. In a certain steam plant the turbine develops 1000 kW. The heat supplied to the steam in the boiler is 2800 KJ/kg, the heat rejected by the steam to the cooling water in the condenser is 2100KJ/kg and the feed-pump work required to pump the condensate back into the boiler is 5 kW. Calculate the steam flow rate (3 Marks)

E. Two tanks of methane, one with a volume 1 m^3, temperature 20 °C and pressure 300 kPa and the other with volume 0.2 m^3, temperature 30 °C and pressure 800 kPa are connected by a valve that is opened. The two tanks are allowed to come to equilibrium, when their temperature is 27 °C. What is the equilibrium pressure? Given that Gas constant for methane R = 0.5184 kJ / kgK (5 Marks)

F. 1 kg of steam at 7 bar, entropy 6.5 kJ/kgK, is heated reversibly at constant pressure until the temperature is 250 °C. Calculate the heat supplied and show on a T-s diagram the area which presents the heat flow. (8 Marks)

QUESTION TWO [20 marks]

A. In a compression stroke of an internal-combustion engine the heat rejected to a cooling water is 45 kJ/kg and the work input is 90 kJ/kg. Calculate the change in specific internal energy of the working fluid stating whether it is a gain or a loss. (3 Marks)

a) In a 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 the inlet and outlet are 1200 kJ/kg and 360 kJ/kg respectively, and the velocities of the gases at inlet and outlet are 60m/s and 150m/s respectively.

(i) Calculate the rate at which heat is rejected from the turbine (7 Marks).

(ii) Find also the area of the inlet pipe given the specific volume of the gases at the inlet is 0.5 m^3/kg (3 Marks)

a) Determine the heat transfer and its direction for a system in which a perfect gas having molecular weight of 16 is compressed from 101.3 kPa, 20°C to a pressure of 600 kPa following the law $pV^{1.3}$ = constant. Take specific heat at constant pressure of gas as 1.7 kJ/kg.K. The universal gas constant=8.3143×10^3 kJ/kg.K. (7 Marks)

(i) QUESTION THREE [20 marks]

A. Air flows steadily at the rate of 0.4 kg/s through an air compressor, entering at 6 m/s with a pressure of 1 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 kJ/kg greater than that of the air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at a rate of 59 kW.

(i) Calculate the power required to drive the compressor (7 Marks)

(ii) the inlet and outlet pipe cross sectional areas. (6 Marks)

B. A vessel of volume 0.2 m^3 contains nitrogen at 1.013 bar and 15 °C. If 0.2 kg of nitrogen is now pumped into the vessel, calculate the new pressure when the vessel has returned to its initial temperature. The molar mass of nitrogen is 28 kg/kmol, and it may be assumed to be a perfect gas (4 Marks)

C. A gas at 65 kPa, 200°C is heated in a closed, rigid vessel till it reaches to 400°C. Determine the amount of heat required for 0.5 kg of this gas if internal energy at 200°C and 400°C are 26.6 kJ/kg and 37.8 kJ/kg respectively. (3 Marks)

QUESTION FOUR [20 marks]

A. Explain A cylinder fitted with a frictionless piston with 0.5 m^2 cross-sectional area contains 0.10 m^3 of air. The piston is in contact with an uncompressed spring with a spring constant of 800 kN / m. The air is heated so that the piston rises and pushes against the spring until

the air volume increases to 0.15 m^3. Find the work done in compressing the spring and the final air pressure. (10 Marks)

B. In a nozzle air at 627°C and twice atmospheric pressure enters with negligible velocity and leaves at a temperature of 27°C. Determine velocity of air at exit, assuming no heat loss and nozzle being horizontal. Take CP = 1.005 kJ/kg.K for air. (4 Marks)

C. A piston driven by compressed air at 200 kPa in a cylinder is required to do 500 J of work while moving through a distance of 0.25 m. What should the diameter of the cylinder be? (6 Marks)