UNIVERSITY OF EMBU

2016/2017 ACADEMIC YEAR

SECOND SEMESTER EXAMINATION

THIRD YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE AND BACHELOR OF EDUCATION SCIENCE

SPH 302: THERMODYNAMICS

DATE: APRIL 5, 2017 **TIME: 2:00-4:00PM**

INSTRUCTIONS:

Answer Question ONE and ANY Other TWO Questions.

Constants:

$m_e = 9.1 \times 10^{-31}$ kg

$_0 = 8.86 \times 10^{-12}$ C^2/Nm^2

Y for brass = $10^{11} Nm^{-2}$

C water = 4200J/ug°k

$e = 1.6 \times 10^{-19}$ C

$h = 6.6 \times 10^{-34}$ JS

$c = 3.0 \times 10^8$ ms^{-1}

Y for steel = 2×10^{11} Nm^{-2}

C_{pb} =460J/µg°k

QUESTION ONE (30 MARKS)

a) An internal combustion engine takes in a mixture of fuel and air at 27 ^{0}C and the highest temperature after combustion is 427 ^{0}C. Calculate the Carnot efficiency of an engine working between these two limits of temperature. (3 marks)

b) A gas was heated such that its volume increased from 82 cm^3 while the pressure remained constant at 1 X 10^5 N/m^2. Find the heat needed for the work done against the external pressure. (2 marks)

c) A 750 g block of steel heats in stamping when subjected to a stroke by a hammer of mass 400 kg; the velocity of the hammer at the instant of the hit is 7.0 ms^{-1} , and 60 % of the hammer energy is used up in the heating of steel. What is the rise in temperature of the block? (4 marks)

d) Describe the equilibrium state of a system and the conditions for its achievement. (3 marks)

e) Differentiate between availability and irreversibility. (2 marks)

f) By giving an example, explain thermodynamic potentials. (3 marks)

g) Describe important features of the liquid-gas condensation transitions. (3 marks)

h) Briefly explain the triple point of benzene. (4 marks)

i) Explain useful observations made at cryogenic temperatures. (4 marks)

j) Describe the third law of thermodynamics. (2 marks)

QUESTION TWO (20 MARKS)

a) A reversible engine converts one-sixth of the heat input into work. When the temperature of the sink is reduced by 62 ^{0}C, its efficiency is doubled. Find the temperature of the source and then sink. (10 marks)

b) Consider a constant mass of gas with internal energy E. suppose it has a mass, m and is heated from T_1 to T_2 temperatures, show that its change in internal energy is given by

$$dE = \frac{R(T_2 - T_1)}{\gamma - 1}$$

(10 marks)

QUESTION THREE (20 MARKS)

a) In an experiment 200 g of lead at 200 ^{0}C was mixed with 400 g of water at 20 ^{0}C. Determine the entropy of the system. (Cp for lead = 145 J/Kg-K). (13 marks)

b) A piece of 300 g of brass was heated to 100^{0}C and placed in 150g of a liquid at 10^{0}C kept in a copper calorimeter of mass 500 g. If the final temperature of the mixture becomes 30 ^{0}C, find the specific heat of the liquid given that the specific heat of brass and copper are 370 J/Kg^{0}C and 391 J/Kg^{0}C respectively. (7 marks)

QUESTION FOUR (20 MARKS)

a) Consider m grams of air enclosed in a cylinder whose walls are perfectly non-conducting and the bottom is perfectly conducting. The cycle also consists of a hot source, an insulating cap and a cold sink. Suppose the initial pressure, volume and temperature of the air is P_1, V_1 and T_1, show that the efficiency of a diesel engine cycle is given by:

$$\eta = 1 - \left(\frac{1}{e}\right)^{\gamma-1} \frac{K^{\gamma} - 1}{\gamma(K-1)}$$

(20 marks)

QUESTION FIVE (20 MARKS)

a) 32g of a gas at N.T.P. occupied 22.3 liters. Find the r.m.s. velocity of the molecules at 20^0C.

(7 marks)

b) One liter of hydrogen at 0 ^{0}C and a pressure of 760 mmHg has a weight of 0.0896. Find the value of J given that Cp = 3.409 Cal/g/^{0}C and Cv = 2.411 Cal/g/^{0}C. (8 marks)

c) A motor cycle engine develops 10kw and consumes petrol at the rate of 2.4 Kg/h. if the calorific value of the petrol is 40 MJ/Kg, calculate the efficiency of the engine and estimate the rate at which heat is rejected to the exhaust. Neglect all other losses.

(5 marks)

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