KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2019/2020 ACADEMIC YEAR

FIRST YEAR FIRST SEMESTER
SUPP/SPECIAL EXAMINATIONS

FOR THE DEGREE OF B.ED (SCIENCE)

COURSE CODE: SPH 115

COURSE TITLE: HEAT AND THERMODYNAMICS I

DATE: 9/02/2021 **TIME:** 2:00 – 4:00 Pm

INSTRUCTIONS TO CANDIDATES

TIME: 2 Hours

1. Attempt question **ONE** and any other **TWO** questions.

2. Question one carries **30 marks** while the rest carry **20 marks each**

KIBU observes ZERO tolerance to examination cheating

Question One (30 marks)

a) Define a thermodynamic system. (1mark)

b) Differentiate between intensive and extensive quantities giving an example for each (4 marks)

c) Given the following constants for the van der Waals equation for carbon dioxide $a = 0.37Nm4mol^{-2}$and $b = 43Cm^3mol^{-1}$.Using the Van der Waals equation find the pressure exerted by carbon dioxide gas at 0^0C if it has a specific volume of $0.55Lmol^{-1}$. (3 marks)

d) A cast iron cylinder ingot, 2m long, has a diameter of 0.5m. Determine the radiant flux from its surface whose temperature is 1000^{0}C (emissivity of cast iron ingot is ε = 0.95 and black body radiation coefficient, $C_0 = 5.67\mathrm{Wm^2K^{-1}}$). (4 marks)

e) i) Define the term work. (1 mark)

ii) A fluid of volume 0.05m^3 is contained behind a piston at pressure of$10^6 N/m^2$. After a reversible expansion of constant pressure, the final volume is $0.2m^3$. Calculate the work done by the fluid. (2 marks)

f) When a gas expands adiabatically its volume is doubled while its absolute temperature is decreased by a factor of 1.32. Calculate the degree of freedom for the gas molecule. (3 marks)

g) State the second law of thermodynamics. (1 mark)

h) An ideal gas absorbs $5\,\mathrm{x}10^3 J$ of energy while doing work of $2\,\mathrm{x}10^3 J$ to its surroundings. Find the change in internal energy. (3 marks)

i) A reversible engine has an efficiency of $\frac{1}{6}$. When the temperature of the heat sink is reduced by 62^0C its efficiency gets doubled. Find the temperatures of the source and the sink. (3 marks)

j) State the third law of thermodynamics. (1 mark)

k) Determine the value of the specific entropy of water at$100^0\mathrm{C}$. (3 marks)

l) Show that for a monoatomic ideal gas undergoing adiabatic process$\mathrm{TV}^{2/3} = \mathrm{C}$ where C is a constant. (3 marks)

Question Two (marks)

a) Define forced convection. (1 mark)

b) Air, at a temperature, t =24^{0}C flows perpendicularly to the outer tube wall at a mean velocity of 2ms^{-1}. The tube, 2.5m long, has an outer diameter of 20mm and tube wall temperature t_w = 130^{0}C. Given that the corresponding density is$\rho = 0.995\text{kgm}^{-1}$; the specific heat capacity at a constant pressure, $C_p = 1.009\text{kJkg}^{-1}$ and the thermal conductivity, $\lambda = 0.03\text{Wm}^{-1}\text{K}^{-1}$ and the dynamic viscocity $\eta = 20.82 \text{ x } 10^{-6}\text{Pas}$. Calculate:

i) the Prandtl number (Pr) and the Reynolds number (Re). (4 marks)

ii) the heat transfer rate $\dot{Q}$ by convection of the moving air if K = 0.615, m = 0.466 and C = 0.8134. (6 marks)

c) i) Define thermal radiation (1 mark)

ii) A cast iron cylinder ingot, 2m long, has a diameter of 0.5m. Determine the radiant flux from its surface whose temperature is 1000^{0}C (emissivity of cast iron ingot is ε = 0.95 and black body radiation coefficient, $C_0 = 5.67\text{Wm}^2\text{K}^{-1}$). (4 marks)

iii) Calculate the net radioactive heat transfer rate of 1m^2 surface area between two parallel surfaces. The furnace wall is covered by a corroded steel sheet with the emissivity ε = 0.8 and the temperature t_1 = 650^{0}C. The second wall is made of bricks, its surface has the emissivity ε = 0.95 and its temperature t_2 = 50^{0}C. (4 marks)

Question Three (20 marks)

a) Given the ideal gas equation $PV = nRT$ where all the symbols have their usual meaning: Derive the expression for work done on the gas and hence Calculate the work done for $2\,moles$ if an ideal gas were kept constant temperature 0^0C if the gas was compressed from a volume of $4L$ to $1L$. (8 marks)

b) 1 litre of a gas is at a pressure of 3 atm and temperature of27^0C. It expands at constant pressure until its volume is 3 litres, after which it's cooled at constant volume until its pressure is 1 atm. It's the compressed at constant pressure until its volume is again 1 litre and then it's heated at constant volume until it comes back to its original state. Draw a PV-diagram for the process and hence calculate the total work done by the gas and total heat energy added to the gas system. (12 marks)

Question Four (20 marks)

a) A simple heat engine contains an ideal monoatomic gas confined to a cylinder by a movable piston. The gas in the piston at $T = 3 \times 10^2$K and V= 5 litres, first undergoes an isochoric process and its pressure changes from 1 atm to 3 atm. Then it passes through an isothermal expansion process where its volume changes from 5 litres to 15 litres after which it goes back to its original state by passing through an isobaric compression process. Find the number of moles of a gas and temperature at stage II of the gas. (4 marks)

b) Find the change in thermal energy (ΔU) thermal energy added (Q) and work done (W) between stage I and II. (4 marks)

c) Repeat (b) above between stage II and III. (4 marks)

d) Repeat (b) above between stage III and I. (2 marks)

e) Find the net change in internal energy. (2 marks)

f) Find the thermal energy (Qh) transferred to the system and thermal energy rejected (Qc) and hence find the efficiency of the heat engine. (4 marks)

Question Five (20 marks)

a) Define a thermodynamic process. (1mark)

b) Convert 300K, 56^0R and 158^0F into ^{0}C. (6 marks)

c) Determine values of oxygen state variables at temperature 20^0C and pressure 0.10132 MPa if the molar mass for oxygen (O_2) is 31.999 kg(kmol)$^{-1}$ and R_m = 8314.51J(kmol^{-1})K^{-1}. (8 marks)

d) Determine the amount of heat required to for the temperature change from 20^0C to 180^0C of 5kg of Oxygen at standard pressure 0.10132MPa given that $a_1 = 27.1769$, $a_2 = 51.995 \times 10^{-4}$, $a_3 = - 11.5873 \times 10^{-7}$ and $a_4 = 11.9421 \times 10^{-11}$. (5 marks)