KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF BSC (PHYSICS) AND BED (SCIENCE)

COURSE CODE: SPH 415

COURSE TITLE: THERMODYNAMICS

DURATION: 2 HOURS

DATE: 6/10/2021 **TIME:** 8:00-10:00AM

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- Indicate **answered questions** on the front cover.

Start every question on a new page and make sure question's number is written on each page
This paper consists of **3** printed pages. Please Turn Over

Gas constant R=8.314 J/mol. K, specific heat capacities for water=4186 J/kg. K; specific heat capacity for steam=2010 J/Kg. K; specific heat capacity for glass=837 J/Kg. K; Latent heat of vaporization for steam=2.26x10 ^{6} J/Kg. Legendre transformation of y is $\phi(\xi) = y - \xi x$; $\phi(\xi) = y(x) - x(dy/dx)$

QUESTION ONE [30 Marks]

a. Describe the difference between an intensive and extensive property. Give one example of each type. (3 marks)

b. Define isolated system, closed system and open system. (3 marks)

c. A household refrigerator with a coefficient of performance (COP) of 1.2 removes heat from the refrigerated space at a rate of 60 KJ/min. Determine:
   i. The electric power consumed by the refrigerator, and (2 marks)
   ii. The rate of heat transfer to the kitchen air. (2 marks)

d. A piston-cylinder device contains a liquid-vapour mixture of water at 300K. During the constant-pressure process, 750 KJ of heat is transferred to the water. As a result, part of the liquid in the cylinder vaporizes. Determine the entropy change of water during this process. (2 marks)

e. Two solid spheres A and B have the same emissivity. The radius of A is four times the radius of B and the temperature of A is twice the temperature of B. Work out the ratio of the rate of heat radiated from A to that from B. (3 marks)

f. State the first law of Thermodynamics. (1 mark)

g. An ideal gas at 17^0C has a pressure of 760mmHg, and is compressed (i) isothermally, and (ii) adiabatically until its volume is halved, in each case reversibly. Calculate in each case the final pressure and temperature of the gas, assuming C_p=2100J/Kg. K and C_v=1500J/Kg. K (4 marks)

h.
   i. What is a Carnot cycle? (1 mark)
   ii. Derive the efficiency of an engine using Carnot cycle. (3 marks)

i. A perfect gas may be defined as one whose equation of state is PV=NKT and whose internal energy is only the function of temperature. For a perfect gas show that;
   a. $C_p=C_v+k$, where Cp and Cv are heat capacities (per molecule) at constant pressure and volume respectively. (2 marks)
   b. The quantity PV^γ is constant during an adiabatic expansion (Assume $\gamma=C_p/C_v$ is constant). (2 marks)

j. A 1.0 mol sample of an ideal gas is kept at 0.0 ^{0}C during an expansion from 3.0L to 10.0L. How much work is done by the gas during the expansion? (2 marks)

QUESTION TWO [20 Marks]

a) what mass of steam initially 130 ^{0}C is needed to warm water in 100-g glass container from 20.0 ^{0}C to 50.0 ^{0}C? (7 marks)

f) A body of constant heat capacity C_p and a temperature T_i is put into with a reservoir at temperature T_f, equilibrium between the body and reservoir is established at constant pressure. Determine the total entropy change and prove that it is positive for either sign of $\left(T_f - T_i\right)/T_f$. You may regard $\frac{|T_f - T_i|}{T_f} < 1$.

(5 marks)

QUESTION FOUR [20 Marks]

a) Consider a gas tank of volume V containing N gas molecules with total energy E. Given equation of state E (S, V, N) show $T \equiv \left(\frac{\partial E}{\partial S}\right)_{V,N}$, $P \equiv -\left(\frac{\partial E}{\partial V}\right)_{S,V}$ and $\mu \equiv \left(\frac{\partial E}{\partial N}\right)_{S,V}$ where T is the definition of temperature, P is the definition of pressure and μ is the definition of chemical potential. (9 marks)

b) Classify the variables in (a) above as extensive and intensive (2 marks)

c) Consider an ideal gas whose entropy is given as $s = n/2\ [\sigma + 5R \ln U/n + 2R \ln V/n]$, where n= number of moles, R= universal gas constant, U= internal energy, V= volume and σ =constant. Calculate C_p and C_v , the specific heats at constant pressure and volume. (9 marks)

QUESTION FIVE [20 Marks]

a) State the First-law of thermodynamics (2 marks)

b) One mole of a monatomic perfect gas initially at temperature T0 expands from volume V0 to 2V0. (a) at constant temperature (b) at constant pressure, calculate the work of expansion and the heat absorbed by the gas in each case. (5 marks)

c) For a mole of ideal gas at $t=0\ ^0C$, calculate the work W (in Joules) in an isothermal expansion from V0 to 10V0 in volume. (3 marks)

d) An ideal gas at 170C has a pressure of 760mmHg, and is compressed (i) isothermally (ii) adiabatically until its volume is halved, in each case reversibly. Calculate in each case the final pressure and temperature of the gas; (Cp=2100 Jkg-1K-1 and Cv=1500 JKg-1K-1). (6 marks)

e) Given E=E (S, V; n_1,…….,n_r), find a function whose natural variables are T,V;n_1,…..,n_r. (4marks)

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