THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

A. M. E. C. E. A

P.O. Box 62157
00200 Nairobi - KENYA
Telephone: 891601-6
Ext 1022/23/25

MAIN EXAMINATION

SEPTEMBER –DECEMBER 2021

FACULTY OF SCIENCE

DEPARTMENT OF NATURAL SCIENCES

REGULAR PROGRAMME

PHY 103: THERMODYNAMICS 1

Date: DECEMBER 2021	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and any TWO Questions	

You may use the following constants where applicable

Universal gas constant, R = 8.314 $JK^{-1}(mol)^{-1}$
Avogadro's constant N_o = 6.023 x 10^{23} $(mol)^{-1}$
Plank's constant, h = 6.626 x 10^{-34} J.s
One atmosphere (1 atm) = 1.013 x 10^5 N/m^2
Boltzmann constant, k = 1.38 x 10^{-23} J/K
Stefan-Boltzmann constant, σ = 5.67 x 10^{-8} $Wm^{-2}K^{-4}$
Latent heat of fusion of water = 3.34 x 10^5 J/kg
Latent heat of vaporization of water = 2.256 x 10^6 J/kg
Specific heat capacity of water = 4190 J(kg°C)
1 kcal = 4186 Joules

Q1.

a) What is thermodynamics **(1 mark)**
b) State and describe the two classes of thermodynamics **(4 marks)**
c) An ideal gas at constant temperature T undergoes an isothermal an isothermal expansion in which its volume changes from v1 to v2. How much work does the gas do? **(4 marks)**
d) State the following laws
    i). First law of thermodynamics **(1 mark)**
    ii). Zeroth law of thermodynamics **(1 mark)**

e) An ideal gas of volume 0.3 cm3 at a temperature of 0°c and standard pressure expands reversibly to three times its volume at constant pressure. Calculate the work done in this process. **(5 marks)**

f) Calculate the change in volume of an aluminium rectangular bar of dimensions 20mm x 40 mm x 60 mm when it is heated from 0 to 100 oC. Take the coefficient of linear expansivity for aluminium to be $\alpha = 12\,x\,10^{-6}/o_C$. (5 marks)

g) An approximate equation of state of a real gas at moderate pressure, devised to take into account the finite size of molecules is P(V-b) = Rθ, where b is a constant. Show that;

i). $\beta = \dfrac{\frac{1}{\theta}}{1+\frac{PB}{R\theta}}$ **(5marks)**

ii). $k = \dfrac{\frac{1}{P}}{1+\frac{PB}{R\theta}}$ **(4 marks)**

$\beta \wedge k$ *are the volume expansivity* $\wedge$ *isothermal compresibility respectively*

Q2.

a) Show that the work done in compressing an ideal gas is given as **(5 marks)**

$$W = nRTln\frac{V_2}{V_1}$$

b) How much work is required to compress isothermally 4g of oxygen initialy at a pressure of 10^5 N/m^2 to half its original volume? Assume an ideal gas **(5 marks)**

c) By employing molecular interpretation, describe how temperature affect pressure at constant volume. **(4 marks)**

d) A system gains 300J of heat energy, while the internal energy of the system increases by 9000J and the volume decreases by 0.010 m^3. Assuming the pressure is constant, determine its value. **(6 marks)**

Q3.

a) Differentiate the following terms as used in thermodynamics **(4 marks)**
   i). Heat capacity and specific heat capacity
   ii). Latent heat of fusion and latent heat of vaporization

b) 20g ice, initially at –20°C is heated to become water vapor at 100 °C. Calculate the amount of heat used in this process.

(10 marks)

c) A substance of mass M1, specific heat C1 and temperature T1 is mixed with a second substance of mass M2, specific heat C2 and initial temperature T2. Derive an expression for the final temperature T of the system after the equilibrium is established. **(6 marks)**

Q4.

a) Consider a thermodynamic state f which is a function of pressure, P temperature θ and volume V. Show that the change in pressure for the system is given as; **(15 marks)**

$$P_f - P_i = \frac{\beta}{\kappa}\int_{\theta_1}^{\theta_2} d\theta$$

$\beta \wedge k$ *are the volume expansivity* $\wedge$ *isothermal compresibility respectively*

b) A mass of mercury is at STP. Determine final temperature if the temperature is raised to 20^0C at constant volume. Take β = 1.81 x 10^{-4} K^{-1} and κ = 3.82 x 10^{-11} Pa^{-1} for mercury. **(5 marks)**

Q5.

a) What is linear expansion **(1 mark)**

b) Show that the coefficient of volume expansivity is given by three times the coefficient of linear expansivity**.** **(5 marks)**

c) An automobile has a 45-liter tank steel tank. The tank is filled with gasoline at 14ºC from an underground storage tank. If the automobile is then parked in a warm place until the tank temperature is 38 ºC, how much gasoline will spill out of the automobile tank? (Take α_{steel} = 1.2x10^{-6} $^oC^{-1}$ and $\gamma_{gasoline}$ = 9.5 x10^{-4o} C^{-1}) **(5 marks)**

a) An instrument records temperature of a body as 68^0F. What value would another instrument calibrated in Kelvin give for the same temperature. **(4 marks)**

d) Show that for a hydrostatic system, the change in pressure is given by; **(5 marks)**

$$dP = \frac{\beta}{\kappa}d\theta - \frac{1}{\kappa V}dV$$

β, k, θ, V *are the volume expansivity , isothermal compresibility , temperature* $\wedge$ *¿ volume respectively*

END