ALUPE UNIVERSITY

OFFICE OF THE DEPUTY VICE CHANCELLOR

ACADEMICS, RESEARCH AND STUDENTS AFFAIRS

UNIVERSITY EXAMINATIONS

2024/2025 ACADEMIC YEAR

FIRST YEAR FIRST SEMESTER MAIN EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **PHY 112**

COURSE TITLE: **HEAT AND THERMODYNAMICS**

DATE: 15th January 2025 **TIME: 0800-1100 HRS**

INSTRUCTION TO CANDIDATES

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MAIN –EXAM

PHY 112: HEAT AND THERMODYNAMICS

STREAM: BED (SCIENCE) **DURATION: 3 Hours**

INSTRUCTIONS

i. *Answer questions **ONE** and **TWO** in **SECTION A** and **ANY OTHER THREE** questions in **SECTION B**.*

ii. *Use the following constants where necessary.*

1atmosphere=1.013×10^{5}Pa

Specific heat capacity of water=4.2×10^{3}Jkg^{-1}K^{-1}

Wiens displacement constant =2.90×10^{-3} m.k1

Universal gas constant R =8.315 j/mol./k

Stefans constant =5.67×10^{-8}W/m^2.k^4

Latent heat of fusion of water = 3.35×10^{5}j/kg^{-1}

1calorie -4.18 joules

SECTION A (24 MARKS)

Question One (12 Marks)

(a) What happens to volume (V) and pressure (P) of ideal gas when, the gas is expanded at constant temperature (2 Marks)

(b) state three theories that explains spectral distribution of radiation (3 Marks)

(c) List any three key characteristics of heat engine (3 marks)

(d) What do we mean by the term "***Irreversibilities***"? List any three factors that cause them. (4 marks)

Question Two (12 Marks)

(a) What will be the change in entropy of a gas which expands adiabatically and reversibly. (2 Marks)

(b) Distinguish between the following terms

(i) entropy and enthalpy of a system. (2 Marks

(ii) classical thermodynamics and statistical thermodynamics. (2 Marks)

(c) State the Zeroth law of thermodynamics (2 Marks)

(d) An ideal gas occupies a volume of 100 cm^3 at 20°C and 10^{-3} atm. Determine the number of moles of gas in the container (4 Marks)

SECTION B (36 MARKS)

Question Three (12 Marks)

(a) With aid of a diagram explain cavity radiation? (2 Mark)

(b) List four factors on which a black body radiation depends on. (4 marks)

(c) State any two assumptions made in the kinetic theory of gases. (2 marks)

(d) An automobile has a 60 liter steel tank. The tank is filled with gasoline at 15 °C from an underground storage tank. If the automobile is then parked in a warm place until the tank temperature is 37 °C, how much gasoline will spill out of the automobile tank? ($\alpha_{steel} = 1.2*10^{-6}$ ° C^{-1} and $\beta_{gasoline} = 9.5*10^{-4}$ ° C^{-1}). (4 Marks)

Question Four (12 Marks)

(a) An ideal gas of volume 0.3 m^3 at a temperature of 273.15 K and a pressure of 10^5 Nm^{-2} expands reversibly to 3 times its volume. Calculate work done:

(i) At constant pressure. (2 Marks)

(ii) At constant temperature. (3 Marks)

(b) The compression ratio of a diesel engine is 15:1. This means that air in the cylinder is compressed to $^1/_{15}$ of its initial volume. If the initial pressure and temperature are $1.01 * 10^5$Pa and 300 K respectively. Find the final pressure and temperature after compression. Take $\gamma_{air} = 1.40$ (3 Marks)

(c) Find the area of a square having an initial length L_0 after a temperature increases *to* ΔT. (4 Marks)

Question Five (12 Marks)

(e) If an ideal gas for which $C_v = 12.56$ J/Mol K and $C_p = 20.88$ *J*/Mol K expands reversibly and adiabatically from the initial state $T_1 = 450$ K and $V_1 = 3cm^3$ to a final volume $V_2 = 5cm^3$, find the temperature T_2 and the work done during the process and then calculate the enthalpy change H. (5 Marks)

(b) 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) $\beta = \frac{^1/_\theta}{1+^{Pb}/_{R\theta}}$ and (ii) $K = \frac{^1/_P}{1+^{Pb}/_{R\theta}}$ where $\beta = \frac{1}{V}\left(\frac{\partial V}{\partial \theta}\right)_P$ *is* the volume expansivity and $\beta = \frac{^1/_\theta}{1+^{Pb}/_{R\theta}}$ is the isothermal compressibility, where all the symbols means as usual. (5 Marks)

(c) Describe the the reversibility and irreversibility of thermal processes. (2 Marks)

Question Six (12 Marks)

(a) Define adiabatic and isothermal processes. (2 Marks)

(b) Show that for adiabatic process $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$ and $P_1V_1^{\gamma} = P_2V_2^{\gamma}$ (5 Marks)

(c) Consider a cube of initial dimensions L_o. As the temperature increases by ΔT, the length increases by ΔL. Show that $\beta = 3\alpha$, where β is the coefficient of volume expansion and α is the coefficient of linear expansion. (5 Marks)

Question Seven (12 Marks)

a) Consider a rectangular box of volume V with N molecules, each of mass m and having speed v. The magnitude of change of momentum when the molecules hit the wall is $\Delta P = \frac{N}{V} m v_x^2 A \Delta t$. Show that the average kinetic energy of molecules is $\frac{3}{2} K_B T$ (5 Marks)

b) Distinguish between specific heat capacity and latent heat. (2 Marks)

c) Prove that the heat capacities of an ideal gas at constant pressure, C_p and constant volume, C_v are related by: $C_p = C_v + R$ where R is the universal gas constant. (5 Marks)