KISII UNIVERSITY

UNIVERSITY EXAMINATIONS

FIRST YEAR EXAMINATION FOR THE AWARD OF THE DEGREE OF BACHELOR OF SCIENCE IN PHYSICS
SECOND SEMESTER 2021/2022
(FEBRUARY-JUNE, 2022)

PHYS 112: HEAT & THERMODYNAMICS

STREAM: Y1 S2 **TIME: 2 HOURS**

DAY: THURSDAY,9.00 AM – 11.00 AM **DATE: 19/05/2022**

INSTRUCTIONS:

1. ***Do not write anything on this question paper.***
2. ***Answer question ONE (compulsory) and any other TWO Questions.***

R = 8.31 J/mol/K,

QUESTION ONE (COMPULSORY 30MKS)

a) (i) State the second law of thermodynamics (2 marks)

(ii) Define the term absolute temperature? (1mark)

b) Differentiate real and ideal gas (2 marks)

(i).A circular copper ring at 40.0°C has a hole with an area of 47.68 cm^2. What minimum temperature must it have so that it can be slipped onto a steel metal rod having a cross-sectional area of48cm^2
(α copper is $17x10^{-6}$ and α steel is $11x10^{-6}$). (4 marks)

(ii). Suppose the ring and the rod are heated simultaneously. What minimum change in temperature of both will allow the ring to be slipped onto the end of the rod. (5 marks)

c) A beam of electrons moving in the positive *x*-direction impacts a target in a vacuum chamber. If 5 x 10^{14} electrons traveling at a speed of2.9x 10^{7} m/s strike the target in a brief pulse lasting 7 x10^{-8} s, Determine:
(i). Force exerted on the target during the pulse. (5 marks)
(ii). Pressure is exerted on the beam spot, which has radius 4mm. (4 marks)

d) Convert each of the following as indicated in brackets (6 marks)

i) 350 K (^{0}F)

ii) 647^{0}F (^{0}C)

iii). 260^{0}C (^{0}F)

QUESTION TWO

(a) State three scales of thermometric measurements. (3 marks)
(b) A box contains 1000 moles of air find the change in the internal energy when cooled from 67^{0}C to 20^{0}C at a constant volume of 5 liters given (γ = 1.4). (5 marks)
(c) Consider molar heat capacities of an ideal gas to Show that: (5 marks)
$C_p = C_v + R$
(d) Considering an adiabatic ideal gas show that work done by the system is given as: (7 marks)
$W = \frac{1}{\gamma-1}(P_1V_1 - P_2V_2)$

QUESTION THREE

a) What is a Carnot engine? (1 mark)
b) State three assumptions in the kinetic theory of gases (3 marks)
c) Differentiate between the isobaric and isothermal processes (2 marks)
d) (i) Estimate the fractional change in the volume of Earth's oceans due to an average temperature change of 10°C . (β water is 2.07x10^{-4} (°C) (3 marks)
(ii)Use the fact that the average depth of the ocean is 4 x 10^3 m to estimate the change in depth (3 marks)
(g) Show that K.E = $\frac{3}{2}$nRT (5 marks)
(f) Determine the efficiency of a heat engine supplied with 200J of heat, if it consumes 100J to deliver mechanical work per cycle determine. (3 marks)

QUESTION FOUR

a) Define the term heat engine (1 mark)
b) Distinguish between reversible and irreversible processes and give examples of such processes. (2 marks)

c) A gasoline engine is supplied with 1000J of heat, if it consumes 800J to deliver mechanical work per cycle determine.
   (i) Thermal efficiency of the machine (3 marks)
   (ii) Heat discarded in each cycle (3 marks)
d) A Carnot engine takes 3000J of heat from a reservoir at 300k, it does some work and discards some heat to a reservoir at 150k. How much work does it do, what quantity of heat does it discard and at what efficiency (6 marks)
e) Give the assumptions of kinetic theory of gases based on the thermodynamic principle. (5 marks)

QUESTION FIVE

a) Distinguish the term thermal equilibrium and thermal contact? (2 marks)
b) An ideal gas at 37^0C and pressure of 7 atmospheres inside a container of volume 3L. Determine:
   (i). The number of moles of the gas in the container (5 marks)
   (ii). If the gas particles pushes against the piston expanding it to twice its original volume while pressure falls to atmospheric pressure. Calculate the final temperature. (5 marks)
c) (i) Outline the major steps in a Carnot cycle for a Carnot engine (3 marks)
   (ii) show that the efficiency of a Carnot engine is given by: (5 marks)

$$e = 1 - \frac{T_c}{T_H}$$