MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

P.O. Box 972-60200 – Meru-Kenya.
Tel: +254(0) 799 529 958, +254(0) 799 529 959, +254 (0)712 524 293
Website: www.must.ac.ke Email: info@mucst.ac.ke

UNIVERSITY EXAMINATIONS 2022/2023

SECOND YEAR, SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN PHYSICS, BACHELOR OF SCIENCE IN MATHEMATICS AND PHYSICS, BACHELOR OF EDUCATION SCIENCE

SPH 3250: THERMAL PHYSICS I

DATE: APRIL 2023 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a) State the thermometric property for a liquid in glass and thermocouple thermometers. (2 Marks)

b) Explain the importance of anomalous expansion of water to animals living in water. (3 Marks)

c) A metal block of mass 400 g and specific heat capacity of $720 J/kg/K$ was immersed in pure boiling water. Given that the mass of water that vaporized was 12 g and the latent heat of vaporization of water $=336000 J/kg$. Find the initial temperature of the block. (4 Marks)

d) Briefly explain how a gas in a cylinder fitted with a frictionless piston can be taken through an adiabatic expansion giving reasons. (5 Marks)

e) A gas contains $1.24 \times 10^{22}\ atoms$, if the pressure of the gas is 1280 mmHg and the temperature is 27^0C, find the volume occupied by the gas. (5 Marks)

f) A thermocouple thermometer has its temperature coefficients = 0.60 and $\beta = 1.2$ the scale is calibrated in Volts. Find the temperature at which the emf is $24V$. (4 Marks)

g) A long pipe of 0.6m outside diameter is buried in earth with axis at a depth of 1.8m. the surface temperature of pipe and earth are 95^0C and 25^0C respectively. Calculate the heat loss from the pipe per unit length. The conductivity of earth is 0.51W/mk. (5 Marks)

h) Explain why water heated at the top of a deep narrow cylinder will remain cold at the bottom. (2 Marks)

QUESTION TWO (20 MARKS)

a) In an experiment it was found that an electric heater could convert 2.4 kg of ice at -10^0C to water at 20^0C in 4 minutes. Find the power of the heater assuming heat losses accounted for 32% (SPC of water=4200J/Kg/K, Latent of ice 336000J/Kg, SHC of ice 2100J/kg/k). (8 Marks)

b) Show that the average translational kinetic energy of a molecule is directly proportional to the absolute temperature of the gas. (6 Marks)

c) A container of volume 11200 cm^3 is filled with oxygen gas at a pressure of 740 mmHg. Calculate the root mean square speed of the molecules given oxygen molecule is diatomic (molar mass of oxygen molecule=32, $1amu = 1.66 \times 10^{-27}kg$) (6 Marks)

QUESTION THREE (20 MARKS)

a) Shown that the work done by an ideal gas during expansion is given by $W = pdV$ where P is p is the pressure of the gas, and dV is the change in volume. (5 Marks)

b) The molar heat capacity of an ideal gas at constant pressure is $28.12J/mol/K0.40$ moles of the gas occupy a volume of 18000cm^3 at a temperature of 320 K. Find

   i. The pressure of the gas (4 Marks)

   ii. If the gas is cooled to 120k at constant volume find the new pressure of the gas. (3 Marks)

iii. Find the quantity of heat required to raise the temperature of the gas from 120 K to 400 k at constant volume. (3 Marks)

c) A gas containing 1.2×10^{23} molecules is contained in a cylinder of volume 4000 cm^3 at a pressure of 960 mmHg. Find the absolute temperature of the gas. (5 Marks)

QUESTION FOUR (20 MARKS)

a) A long pipe of 0.6 m outside diameter is buried in earth with axis at a depth of 1.8 m. The surface temperature of pipe and earth are 950^0C and 250^0C respectively. Calculate the heat loss from the pipe per unit length. The conductivity of earth is $0.51 W/mk$. (6 Marks)

b) A 12 cm diameter long bar initially at a uniform temperature of 40^0C is placed in a medium at 650^0C with a convective co efficient of 22 W/m^2K calculate the time required for the bar to reach 2550C. Take $k = mk, \rho = 580 kg/m^3$ and $c = 1050 J/kgK$. Given: Unsteady state. (6 Marks)

c) Two large plates are maintained at a temperature of 900 K and 500 k respectively. Each plate has area of $6m^2$. Compare the net heat exchange between the plates for the following case

i. Both plates are black (3 Marks)

ii. The plate at 900 K is black while the plate at 500 K has a thermal emissivity of 0.5. (4 Marks)