JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

1ST YEAR 1ST SEMESTER 2018/2019 ACADEMIC YEAR

MAIN

REGULAR

COURSE CODE: SPH 104

COURSE TITLE: THERMAL PHYSICS

EXAM VENUE: **STREAM: EDUCATION**

DATE: **EXAM SESSION:**

TIME: 2:00 HRS

Instructions:

1. **Answer question 1 (Compulsory) and ANY other 2 questions.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

Useful Constants

Specific heat capacity of water $c_w = 4200 Jkg^{-1}K^{-1}$

Boltzmann's constant $k_B = 1.38 \times 10^{-23} JK^{-1}$

Mass of oxygen molecule $= 0.032kg$

Stefan's constant $\sigma = 5.67 \times 10^{-8} Wm^{-2}K^{-4}$

Latent heat of fusion of water $= 334 kJkg^{-1}$

Latent heat of vaporization of water $= 2256 kJkg^{-1}$

SECTION A

QUESTION 1(30 MARKS)

(a) Distinguish between heat and temperature. **(2 marks)**

(b) Explain the following terms.

(i) Thermal equilibrium **(1 mark)**

(ii) Triple point of water **(1 mark)**

(iii) Convection **(1 mark)**

(iv)The Zeroth law of thermodynamics **(1 mark)**

(c) Consider a temperature scale called the Z scale in which the boiling point of water is $65°Z$ and the freezing point is $-14.0°Z$. Assuming the Z scale is linear, determine the temperature on the Fahrenheit scale that corresponds to $-98.0°Z$ **(4 marks)**

(d) Calculate the quantity of heat conducted through $2m^2$ of a brick wall $12cm$ thick in 1 hour if the temperature on one side is $8°C$ and on the other side is $28°C$.(Thermal conductivity of brick $= 0.13 Wm^{-1}K^{-1}$) **(3 marks)**

(e) A metal of mass $200g$ at $100°C$ is dropped into $80g$ of water at $15°C$ contained in a calorimeter of mass $120g$ and specific heat capacity $0.4 kJkg^{-1}K^{-1}$. The final temperature reached is $35°C$. Determine the specific heat capacity of the metal. **(3 marks)**

(f) Show that the work done by a gas confined to a cylinder is given by $W = \int_{V_i}^{V_f} PdV$ where the symbols have their usual meanings. **(3 marks)**

(g) State Charles' and Boyle's laws. **(2 marks)**

(h) One mole of ideal gas expands at a constant temperature of $310K$ from an initial volume of $12l$ to a final volume of $19l$. Determine the work done by the gas during the expansion. **(3 marks)**

(i) Calculate the root mean square speed for oxygen molecule at $300K$. **(3 marks)**

(j) When a gas is compressed, it is found that its pressure increases. Explain this phenomenon of increase in pressure in terms of motion of molecules of the gas. **(3 marks)**

SECTION B

Answer any TWO questions in this section

QUESTION 2 (20 MARKS)

(a)Derive the mathematical relationship between the coefficient of volume expansion and the coefficient of linear expansion. **(7 marks)**

(b) In order to make connection to the carbon anode of a transmitting valve, it is necessary to thread a copper wire of diameter $2mm$ at a temperature of $20°C$ through a smaller hole in the carbon block. If the process is just carried out by immersing both specimens in dry ice at $-80°C$ and the coefficient of linear expansion of copper and carbon are $1.7\times10^{-5}K^{-1}$ and $5\times10^{-6}K^{-1}$, calculate the size of the hole at $20°C$. **(7 marks)**

(c) Determine the heat lossed through radiation in 10 minutes from the human body of surface area $1m^2$ and temperature $37°C$ to the environment at a temperature of $23°C$. Take the emissivity of the body as 0.7 **(6 marks)**

QUESTION 3 (20 MARKS)

(a) (i) State the difference between heat capacity and specific heat capacity **(2 marks)**

(ii) Calculate the amount of heat required to convert $12.0g$ of ice at $-10°C$ to steam at $100°C$ **(9 marks)**

(b) Explain the following quasistatic processes and write down the mathematical form that each reduces the first law of thermodynamics to.

(i) Adiabatic process **(2 marks)**

(ii) Isochoric process **(2 marks)**

(iii) Cyclical process **(2 marks)**

(iv) Free expansion **(2 marks)**

(c) State Dalton's law of partial pressures. **(1 mark)**

QUESTION 4 (20 MARKS)

(a) State **any FOUR** assumptions in the study of kinetic theory of gases. **(4 marks)**

(b) Derive the equation for the root mean square velocity of an ideal gas in the form $v_{rms} = \sqrt{\frac{3RT}{M}}$

where the symbols have their usual meanings that must be stated in the derivation.

(11 marks)

(c) Using the result in 4 (b), obtain the equation for the average translational kinetic energy of the gas. **(5 marks)**

QUESTION 5 (20 MARKS)

(a) By starting with a composite slab consisting of two materials having different thickness L_1 and L_2 and different thermal conductivities k_1 and k_2 , show that if each face of the slab has an area A and the outer surfaces of the slab are at temperature T_H and T_C ,then for n such materials the rate of conduction of heat is given by $P_{cond} = \frac{A(T_H - T_C)}{\sum_{i=1}^{n}\left(\frac{L_i}{k_i}\right)}$ **(10 marks)**

(b) A sheet of rubber and a sheet of cardboard each $2mm$ thick are pressed together and their outer faces are maintained respectively at $0°C$ and $25°C$. If the thermal conductivities of rubber and cardboard are respectively 0.13 and $0.05 Wm^{-1}K^{-1}$, find the quantity of heat which flows in 1 hour across a piece of composite sheet of area. **(10 marks)**