KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2010/2011

MAY INTAKE SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

SPH 203: THERMAL PHYSICS

DATE: Monday, 8th August, 2011 TIME: 2.00 p.m. – 4.00 p.m.

INSTRUCTIONS: Answer question **ONE** and any **THREE** other questions. Question **ONE** carries **28 marks** while the other questions have **14 marks** each.

Constants:
$g = 9.81\ m/s^2$, $G = 6.67 \times 10^{-11} Nm^2/kg$, Radius the Earth = 63000km, Mass of Earth = 5.9736×10^{24} kg

Question One (28 marks)

(a) State the zeroth law of thermodynamics **(1mk)**

(b) Discuss the following **(3mks)**
   (i) Conduction
   (ii) Convection
   (iii) Radiation

(c) Briefly explain the postulates of the kinetics theory of gases **(6mks)**

(d) A gas in a cylinder is kept at a constant temperature while a piston compresses it to half its original volume. What is the effect of this compression on the pressure the gas exerts on the walls of the cylinder? **(3mks)**

(e) 80 J of heat are injected into a heat engine, causing it to do work. The engine then exhausts 20 J of heat into a cool reservoir. What is the efficiency of the engine? **(3mks)**

(f) An ideal gas is enclosed in a sealed container. Upon heating, which property of the gas does not change? **(4mks)**

(g) When water freezes, its molecules take on a more structured order. Why doesn't this contradict the Second Law of Thermodynamics? **(4mks)**

(h) A heat engine produces 100 J of heat, does 30 J of work, and emits 70 J into a cold reservoir. What is the efficiency of the heat engine? **(4mks)**

Question Two (14 marks)

(a) A system consists of 200g of water that is initially ice at -20^{0}C. Energy is added to the system until the water in converted to steam at 100^{0}C. The system is otherwise isolated from its environment.

(i) Describe in words and calculate the energy of the four processes in which energy must be added to the system during this heating. **(4mks)**

(ii) What is the total energy required for the heating, and what fraction of the total is added in each process? **(2mks)**

(iii) Graph the energy added as heat versus temperature **(2mks)**

(iv) Suppose that the energy is provided by an electric heater at the rate of 240W. Graph the temperature of the system versus time **(2mks)**

(b) An external wall measuring 2m by 3m and consisting of a layer of white thickness $L_p = 1.9$ cm and a layer of rock wool. The thermal conductivity of the wall should not exceed 120W during a winter night when the temperature is 36K below the indoor temperature.

(i) What thickness of the wool is needed? **(2mks)**

(ii) If the rock wool is sold only in layers of 2cm, what *R*-values would you expect to be listed on packages? **(2mks)**

Question Three (14 marks)

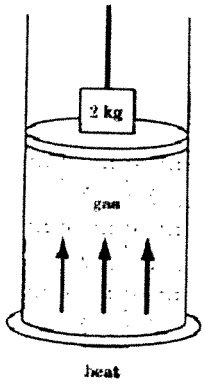
(a) Ice is kept in a freezer at -18^{0}C. An insulated container has 250ml of water at 27^{0}C. What mass of ice from the freezer is needed to cool the water at 4^{0}C? **(3mks)**

(b) A 500g block of copper (C_{Cu}=390JKgK^{-1}) at T_c is placed in 2l of water at 20^{0}C in an insulated container. If the final temperature $T_f = 24^0$C, what is T_c? **(3mks)**

(c) Discuss the four process of the Carnot cycle when acting as a heat engine **(8mks)**

Question Four (14 marks)

(a) Some heat is added to a gas container that is topped by a movable piston. The piston is weighed down with a 2 kg mass. The piston rises a distance of 0.2 m at a constant velocity. Throughout this process, the temperature of the gas in the container remains constant. How much heat was added to the container? **(5mks)**



(b) (i) An ideal gas is heated in a closed container at constant volume. Discuss the properties of the gas that increases as the gas is heated? **(4mks)**

(ii) State the Charles, Boyles and Avogadro's laws **(5mks)**

Question Five (14 marks)

(a) Evaluate the root-mean-square speed of H_2, He, N_2, O_2 and CO_2 at 310 K (the human body temperature) **(2mks)**

(b) Assume air and helium molecules pass through the undetected holes in balloons with equal opportunities. If a helium balloon takes 10.0 hours to reduce its size by 5.0 %, how long will it take a nitrogen balloon to reduce its size by 5.0 %? **(4mks)**

(c) Show that $\frac{K}{3N} = \frac{\kappa_B T}{2}$ **(8mk)**