RONGO

UNIVERSITY COLLEGE

Goldmine of Knowledge and Innovation

(A Constituent College of Moi University)

OFFICE OF THE DEPUTY PRINCIPAL- ACADEMICS AND STUDENTS AFFAIRS

UNIVERSITY EXAMINATIONS

2013/2014 ACADEMIC YEAR

FIRST YEAR FIRST SEMESTER EXAMINATION

FOR

DEGREE

IN

BACHELOR OF EDUCATION (SCIENCE)

COURSE CODE: PHY 111

COURSE TITLE: HEAT & THERMODYNAMICS

DATE: 6/3/2014 **TIME: 9.00AM-12.00NOON**

INSTRUCTIONS TO CANDIDATES

- Answer question ONE and any TWO questions.
- Show workings in the answer booklet for award of full marks
- Do not write on the question paper.
- Switch off your mobile phones.
- Each question should begin on a fresh page
- Marks are shown at the end of each question
- Duration is 3 hours

THIS PAPER CONSISTS (5) PRINTED PAGES

PLEASE TURN OVER

Physical constants

Linear thermal expansion coefficient of copper (α)	$17\times10^{-6}\,{}^0C^{-1}$
universal gas constant (R)	8.314 J/Mol.K
Boltzmann constant (k)	1.381×10^{-23} $J.K^{-1}$.
Stefen- Boltzmann constant (δ)	5.7×10^{-8} $W.m^{-2}.K^{-4}$
Volume coefficient of glass (β)	$27\times10^{-6}\,{}^0C^{-1}$.
Specific heat of aluminium (c)	900 J/Kg.K
Specific heat of water (c)	4200 J/Kg.K
Specific latent heat of fusion of ice (L)	3.34×10^5 J/kg
Volume expansion coefficient of water	$525\times10^{-6}\,{}^0C^{-1}$

QUESTION ONE:

(a) At atmospheric pressure, the boiling point of helium is 4.2 K. What is the boiling point ofheliumon the Fahrenheit scale? **(2 marks)**

(b) Show that the volume coefficient of thermal expansion β is approximately three times the value of the linear coefficient of thermal expansion α: $\beta=3\alpha$. **(3 marks)**

(c) State Zeroth law of thermodynamics **(1 mark)**

(d) A cook pours 400 g of hot water at 98 ^0C into a 235 g aluminium pot initially at 15 ^0C. If they come to thermal equilibrium quickly, what is the final temperature? Assume no heat is lost to the surroundings. **(4 marks)**

(e) Explain the difference between heat and temperature, based on kinetic theory. **(2 marks)**

(f) A small oven has a surface area of 0.2 m^2. The insulated walls are 1.5 mthick with an average thermal conductivity of 0.04 W/ m.^0C. What is the rate of heat loss if the temperature inside the oven is maintained at 245 ^0C and the outside temperature is 20 ^0C? **(3 marks)**

(g) Show that in an isovolumetric process the change in temperature is proportional to the change in internal energy. **(3 marks)**

(h) A 1 liter glass bottle is filled to the brim with water at room temperature of 20 ^0C. The temperature of the bottle and water is then raised to 95 ^0C. Does the water spill over, or does the level go down, and by how much? **(4 marks)**

(i) What is the rms speed of a nitrogen molecule at a temperature of 400 K? Assume that nitrogen behaves as an ideal gas. The mass of nitrogen molecule $m = 4.65 \times 10^{-26}$ Kg. **(4 marks)**

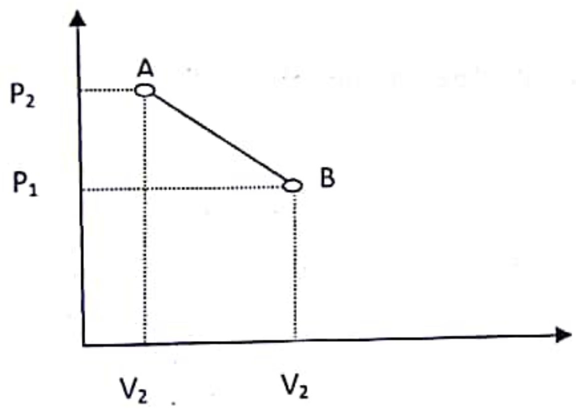
(j) A student mixes 0.1 kg of water at 60 ^{0}C with 0.2 kg of water at 40^{0}C. Determine the change in entropy. **(4 marks)**

QUESTION TWO:

(a)State the first law of thermodynamics **(1 mark)**

(b) In a laboratory experiment, a heat engine takes in 200 J of heat and does 50 J of work by expanding in a reversible process. What is the change in internal energy of the engine duringthis process? **(3 marks)**

(c) A gas in a heat engine expands from its initial volume V_1 to a final volume $V_2=2V_1$along thepath AB shown in the figure below.



i. Show that the work done during this process is given by W=1/2(P1+P2)(V1). **(4 marks)**

ii. Compute the work done if the initial pressure is 230 kPa, the initial volume is 2.001×10^{-4} m^3 and the final pressure is 150 kPa. **(4 marks)**

(d) A Carnot engine always takes in heat at the same input temperature T_H. When the exhaust temperature is 120 ^{0}C, the efficiency is 30 %.

(i) What is the input temperature? **(4 marks)**

(ii) If the exhaust temperature is changed so that the efficiency rises to 37 %, what is the new exhaust temperature? **(4 marks)**

QUESTION THREE:

(a) (i) Distinguish between a refrigerator and a heat pump. **(2 marks)**

(ii) Give one example of a refrigerator and one example of a heat pump. **(2 marks)**

(b) A household heat pump is used to maintain an inside temperature of 15 ^{0}C on a day When the outside temperature is 0 ^{0}C.

(i) What is the theoretical maximum coefficient of performance for this heat pump? **(4 marks)**

(ii) If the heat pump delivers heat to the house at a rate of 20 kW, how much power must be supplied to run the heat pump? **(4 marks)**

(c) A household refrigerator has a coefficient of performance of 5. If the room Temperature outside the refrigerator is 25 ^{0}C, what is the lowest temperature that can be obtained inside the refrigerator? **(4 marks)**

(d) Show that the efficiency e of a Carnot engine and the coefficient of performance $c.p_{refrig.}$ of aCarnot refrigerator operating between the same temperatures are related by

$$e = \frac{1}{1 + c.p_{refrig.}}$$

(4 marks)

QUESTION FOUR:

(a) Give (i) Clausius statementof the second law of thermodynamics. **(1 mark)**

(ii)Kelvin- Planck statement of the second law of thermodynamics.**(1 mark)**

(b) A child takes a 0.45 kg block of ice at 0 ^{0}C, places it on a large marble slab, and watches the ice melt.

(i) What is the entropy change of the ice (water) **(4 marks)**

(ii) If the source of heat (the marble slab) is very massive and remains at a constant 20 ^{0}C, what is the entropy change of the marble? **(4 marks)**

(iii) What is the total entropy change? **(4 marks)**

(c) State the third law of thermodynamics. **(1 mark)**

(d) Explain the meaning of an irreversible process and give one everyday example of such a Process **(2 marks)**

(e) A fluid is heated so that its original volume V_o is doubled. The pressure is observed to vary linearly with the volume according to $P=P_0(1+bV)$, where b and P_0 are constants. Find an expression for thework done by the expanding fluid. **(3marks)**

QUESTION FIVE:

(a) State any **four**assumptions of the kinetic theory of gases **(4 marks)**

(b) Starting with $v_{rms}=\sqrt{\frac{3P}{\rho}}$, where P is pressure and ρ is the density of an ideal gas, show that therms speed can be put in the form $v_{rms}=\sqrt{\frac{3kT}{m}}$, where k is Boltzmann's constant, T the temperature, and m the molecular mass. **(4 marks)**

(c) What is the average kinetic energy of oxygen molecules at a temperature of 300 K. Assume oxygen to be an ideal gas. **(4 marks)**

(d) A parade balloon contains 400 m^3 of helium gas at a pressure of 110 kPa. What is the internal energy of helium in the balloon? **(4 marks)**

(e) A flat plate with area A_0 at temperature T_0 is characterized by a linear expansion coefficient α.

Show that to a good approximation the area A of the plate at temperature T is given by

$A=A_0[1+2\alpha(T-T_0)]$ **(4 marks)**