JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THEDEGREE OF BACHELOR OF EDUCATION (SCIENCE)

1ST YEAR 1ST SEMESTER ACADEMIC YEAR

MAIN

COURSE CODE: SPH 104

COURSE TITLE: THERMAL PHYSICS

EXAM VENUE: LAB 4 **STREAM: REGULAR**

DATE: 27/04/16 **EXAM SESSION: 9.00 – 11.00 AM**

TIME: 2 HOURS

Instructions:

1. Answer Question 1 (compulsory) and ANY other 2 questions
2. Question one carries 30 marks while all the other questions 20 marks each
3. Candidates must hand in their answer booklets to the invigilator while in the examination room.

Symbols used bear usual meaning.

- Linear expansivity α for steel = 11.7 x $10^{-6}K^{-1}$
- Stefan-Boltzman constant $\sigma = 5.67\ x\ 10^{-8}\ Wm^{-2}K^{-4}$
- $Volume\ expansivity\ \ \beta = \frac{1}{V}\left(\frac{\delta V}{\delta T}\right)\ and\ \ volume\ compresibility\ k = \frac{1}{V}\left(\frac{\delta V}{\delta p}\right)$
- $Latent\ heat\ of\ fusion\ L_f = \ 3.35x10^5\ Jkg^{-1}$
- $Latent\ heat\ of\ vaporization\ L_v\ 2.256x10^5 Jkg^{-1}$
- $Specific\ heat\ capacity\ of\ ice = 2100 Jkg^{-1}K^{-1}$
- $Specific\ heat\ capacity\ of\ water = 2100 Jkg^{-1}K^{-1}$

QUESTION 1

(a) State what is meant by the following terms:

(i) Temperature **(1mark)**

(ii) Isolated system **(1mark)**

(iii)Environment or surrounding **(1mark)**

(b) In each of the cases below, systems A and B are initially in thermal equilibrium with each other and are connected by a wall. Explain in each case whether the wall must be diathermic or adiabatic. **(3marks)**

(i) When P_A is increased at constant volume, P_B and V_A do not change.

(ii) When P_A is increased at constant volume, V_B is increases at constant pressure.

(c) How much work is required to compress isothermally 2g of oxygen initially at S.T.P to half its original volume? Assume that oxygen behaves as an ideal gas ($R = 8.31 Jmol^{-1}K^{-1}$, molecular mass of oxygen is 32. **(3marks)**

(d) A rectangular plate has a length L and a width W**.** The coefficient of linear expansivity is **α** Show that the change in area caused by a change in temperature ΔT is $\Delta A = 2\alpha A\Delta T$. Where A = LW. **(3marks)**

(e) A rail road is laid at 15^0C with steel tracks 20m long. What is the minimum required separation between the ends of the tracks if the maximum temperature expected is 35^0C. **(3marks)**

(f) A constant- volume gas thermometer reads 30mmHg pressure at the triple point of water. What will the pressure be when the thermometer measures a temperature of 373K. **(3marks)**

(g) Write down the mathematical expression of the first law of thermodynamics and define the terms. **(3marks)**

(h) The equation of state of an ideal gas is PV = RT. show that $\beta = \frac{1}{T}$ **(3marks)**

(i) Calculate the net loss in radiated energy of a person without clothes in a room at 20^0C. Assuming the person to be a blackbody, the area of the body to be 1.4 m^2 and its surface temperature to be 33^0C. **(3marks)**

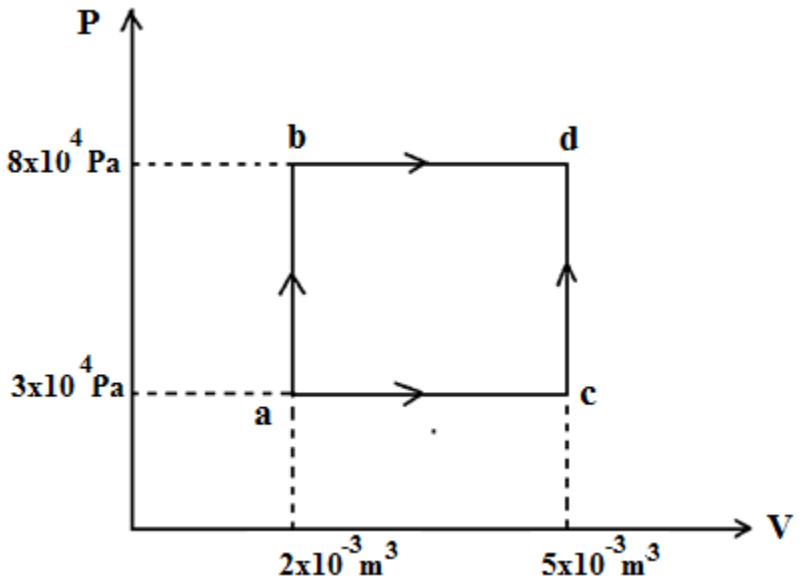
(j) The highest and the lowest temperature ever recorded in the United States are 134 ^{0}F in California in 1913 and -80^0F in Alaska in 1971. Express these temperatures ranges on the Celsius scale. **(3marks)**

SECTION B

(Answer any two questions from this section)

QUESTION 2

(a) The diagram below shows a series of thermodynamic processes. In process ab, 150 J of heat are added to the system. In bd, 600 J of heat are added.



Find:

(i) Change in internal energy in process ab (**2marks)**
(ii) Change in internal energy in process abd. **(4marks)**
(iii) The heat added in process acd. **(4marks)**

(b) One gram of water ($1cm^3$) becomes $1671cm^3$ of steam when boiled at constant pressure Of 1.013 x 10^5 Pa. The latent heat of vaporization at this pressure is $L_v = 2.256x10^6\ J/kg$.

Find;

(i) Work done by water when it vaporizes. **(2marks)**
(ii) Its increase in internal energy. **(3marks)**

(c). When 100 g of aluminium shot is heated to 100^0 C and placed in 500 g of water initially at 18.3^0 C, the final equilibrium temperature of the mixture is 21.7^0 C. What is the specific heat capacity of aluminium. **(4marks)**

QUESTION 3

(a) A gas cylinder kept in a room explodes when the room catches fire. Use the kinetic theory of gases to explain what caused the explosion. **(2marks)**

(b) For nitrogen the molar volume at S.T.P. is 0.0224 m^3 and the relative molecular mass is 28. Calculate.

(i) The mass of one mole of nitrogen. **(2marks)**

(ii) The mass of one molecule of nitrogen. **(2marks)**

(iii) The number of molecules in one cm^3 of nitrogen at S.T.P. **(3marks)**

(iv) The root mean square molecular speed at S.T.P. **(3marks)**

(c) An approximate equation of state of areal gas at moderate pressure, devised to take into account the finite size of molecules is P (V-b) = RT, where b is a constant. Show that:

(i) $\beta = \frac{\frac{1}{T}}{1+\frac{Pb}{RT}}$ **(4marks)**

(ii) $k = \frac{\frac{1}{P}}{1+\frac{PT}{RT}}$ **(4marks)**

QUESTION 4;

(a) Differentiate between positive work and negative work **(1marks)**

(b) Show that work of an ideal gas undergoing a quasi-static isothermal process from an initial state 1 to a final state 2 is

$$W = nRTIn(\frac{V_2}{V_1})$$ **(5marks)**

(c) An ideal gas of volume V= 0.1 m^3 at a temperature of 23.15 K and a pressure of 10^5 Nm^{-2} expands reversibly to 3 times its volume. Calculate work done:

(i) At constant Pressure **(3marks)**

(ii) At constant temperature **(3marks)**

(d) 20g ice, initially at -20°C is heated to become water vapour at 100°C. What amount of heat is used in this process? **(6marks)**

(e) Give a reason why when liquid ether is poured on the back of the palm, one feels cold. **(2marks)**

QUESTION 5

(a) (i) What is adiabatic process **(2marks)**

(ii). Enthalpy, H, is heat. What type of heat, in thermodynamic considerations, is it. **(2marks)**

(b) One hundred grams of CO_2 occupies a volume of 55 litres at a pressure of 1 atmosphere (Take R=0.0821L.atm/mol.K and Molar mass of CO_2= 44g/mol)

(i) Find the temperature **(3marks)**

(ii) If the volume is increased to 80 litres and temperature is kept constant, determine the new pressure. **(3marks)**

(c) The compression ratio of a diesel engine is 15:1. This means that air in the cylinder is compressed to 1/15 of its initial volume. If the initial pressure and temperature are 1.01 x 10^5 Pa and 300 K respectively.

Find

(i) The final pressure and **(3marks)**

(ii) Temperature after compression. (Take $\gamma_{air} = 1.4$) **(3marks)**

(iii) A typical room contains 2500 moles of air. Treating the air like an ideal gas, find the change in internal energy of this air when the room is cooled from 23.9°C to 11.6°C at a constant pressure of 1 atmosphere. ($take\ \gamma = 1.4$) **(4marks)**