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

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN RENEWABLE ENERGY

1ST YEAR 2ND SEMESTER 2013/2014 ACADEMIC YEAR

CENTRE: MAIN

COURSE CODE: SPH 3122

COURSE TITLE: HEAT AND THERMODYNAMICS

EXAM VENUE: AH **STREAM: BSc. .Education**

DATE: 13/12/2013 **EXAM SESSION: 9.00 – 11.00 AM**

TIME: 2 HOURS

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.**

Q1. a) A Carnot engine has low temperature reservoir of 7 ^{o}C and efficiency of 40 %. What value of temperature of the hot reservoir would increase the efficiency of the engine to 60 %? (4 marks)

(ii) Distinguish between isothermal and adiabatic changes. (2 marks)

b) (i) What is a quasi-static process? (2 marks)

(ii) State the relationship between entropy and the second law of thermodynamics. (3 marks)

c) A quantity is compressed isothermally until its pressure is doubled. It is then allowed to expand adiabatically until its original volume is restored. Find the final pressure in terms of the initial pressure.

(the ratio of the specific heat capacities of Oxygen, γ = 1.4)

(3 marks)

(ii) Under what conditions is the **work done** on a system reversible? (2 marks)

d) (i) A new temperature scale has just been implemented. In this new temperature scale, the interval between the freezing point of ice and the boiling point of ice has been decided to be 260 ^{0}N. the freezing point is set at 14 ^{0}N and the boiling point at 274 ^{0}N ? Convert 100 ^{0}N into degree Celcius. (4 marks)

(ii) Differentiate between a heat engine and a refrigerator. (4 marks)

e) Why must heat energy be supplied to a solid to change it into liquid? (2 marks)

(ii) What is a thermometric function? Give two examples. (4 marks)

Q2. a) (i) Calculate the rate of heat flow by conduction through a length of 20 cm of brick, with ends 10 cm $\times$ 7 cm if its thermal conductivity is 0.6 W m^{-1}K^{-1} and its ends are kept at 100 ^{0}C temperature difference. (5 marks)

ii) Given that the pressure exerted by an ideal gas is $p = \frac{1}{3}\frac{N}{V} m v_{av}{}^{2}$ and hence show that $p \propto E_k$ (where E_k is the average translational energy of the molecule). (5 marks)

b) a) An Otto engine works on a gasoline vapour and air with an overall heat capacity C_v. If the input $Q_{in} = MC_V(T_3 - T_2)$, while heat rejected

$Q_{in} = mC_V(T_4 - T_1)$, show that the efficiency ¦ $= 1 - \frac{T_4 - T_1}{T_3 - T_2}$ (6 marks)

ii) Taking the average temperature of the Earths' atmosphere to be 293 K, calculate the root mean square velocity V_{rms} for Nitrogen (molar mass 28 g/ k mol) and Hydrogen (21 g/ k mol) in the earths' atmosphere. (4 marks)

Q3.a) (i) Show that the change in entropy for an ideal gas which undergoes a reversible isothermal expansion from a volume of V_i to V_f is given by

$$\Delta S = nRIn\frac{V_f}{V_i}$$ (6 marks)

(ii) Determine the external work done by 1×10^3 kg of an ideal gas when its temperature is raised from 0 ^{o} C to 100 ^{o} C at a constant pressure of $1.01\times10^5\,Pa.$ The density of the gas at S.T.P. is $1.25Kg/m^3$. (7 marks)

b) A heat pump made by a local artisan has a coefficient of performance C.P. of 3, when the indoor temperature is 6 ^{o} C while the outside is 20 ^{o} C.

(i) What is the maximum value of the C. P. (3 marks)

(ii) How much work is required to operate this pump if it is pump $3\times10^6\,J$ of heat to the room per hour? (4 marks)

Q4.a) Given that entropy is a function of temperature and pressure only, $S = S(T,P)$ use the appropriate Maxwell's equation to show that:

$$TdS = C_p dT - T\left[\frac{\partial V}{\partial T}\right]_P dP$$ (7 marks)

b) 20.0 g of hydrogen gas ($c = 1.42\times10^4\,J/Kg/K$) starting at a temperature of 30 ^{0} C is heated to 40 ^{0} C during which the volume of the container grows by $7.00\times10^{-4}\,m^3$ as the pressure is constant at 1 atmosphere.

(i) What is the work done by the hydrogen gas. (3 marks)

(ii) What is the change in internal energy of the system? (4 marks)

c) Show that $C_p - C_v = nR$ where C_p and C_v are the specific heat capacities at constant pressure and volume respectively, n is the number of moles of gas and R is the universal gas constant. (6 marks)

Q5. a) Assuming the human body has an exposed surface area of 1 m^2 and body temperature of 37 ^{0} C. determine the rate of heat loss by radiation to the environment at 23 ^{0} C. Take Stefan's constant ± $= 5.67\times10^{-8}\,W/m^2/K^4$ and emissivity $e = 0.7$. (5 marks)

b) Water of mass 400g at a temperature of 60 ^{o}C is put in a well lagged copper calorimeter of mass 160g. A piece of ice at 0^{o}C and 40g is placed in the calorimeter and the mixture stirred gently until all the ice melts. Determine the final temperature of the mixture. (specific latent of heat of fusion of ice = 33400 J/kg, specific heat capacity of water = 4200 J/kg K, specific heat capacity of copper = 900 J/kg K). (7 marks)

ii) Air is compressed adiabatically in a diesel engine from atmospheric pressure and room temperature, to $1/16$ of its original volume. Find the final temperature. (Assume the process is reversible, and take ¥$_{air} = 1.6$). (5 marks)