Ser. No. EDU 056/17

GARISSA UNIVERSITY

UNIVERSITY EXAMINATION 2017/2018 ACADEMIC YEAR ONE FIRST SEMESTER EXAMINATION

SCHOOL OF EDUCATION, ARTS AND SOCIAL SCIENCES

FOR THE DEGREE OF BACHELOR OF EDUCATION (ARTS)

COURSE CODE: PHY 113

COURSE TITLE: HEAT AND THERMODYNAMICS

EXAMINATION DURATION: 3 HOURS

DATE: 05/12/17 **TIME: 09.00-12.00 PM**

INSTRUCTION TO CANDIDATES

- **The examination has SIX (6) questions**
- **Question ONE (1) is COMPULSORY**
- **Choose any other THREE (3) questions from the remaining FIVE (5) questions**
- **Use sketch diagrams to illustrate your answer whenever necessary**
- **Do not carry mobile phones or any other written materials in examination room**
- **Do not write on this paper**

This paper consists of FOUR (4) printed pages ***please turn over***

USE THE FOLLOWING CONSTANTS WHERE NECESSARY

Specific heat capacity of water 4185J/kg/k

Universal gas constant R= 8.314 J/(mol.k)

Wien's constant 2.9×10^{-3} m.K

Stefan Boltzmann constant $5.67 \times 10^{-8} W/m^2k^4$

$$\gamma = \frac{C_P}{C_V}$$

QUESTION ONE (COMPULSORY)

(a) State

i. Stefans-Boltzman law **[1 mark]**

ii. First law of thermodynamics **[1 mark]**

iii. Zeroth law **[1 mark]**

(b) When is a thermodynamic system said to be in a state of equilibrium **[2 marks]**

(c) Define the following processes

i. Quasi-static process **[1 mark]**

ii. Isothermal process **[1 mark]**

(d) Show that the coefficient of area expansivity is given by two times the coefficient of linear expansion **[4 marks]**

(e) (i) state Wien's displacement law **[1 mark]**

(ii) Calculate the temperature of the solar surface if the radiant intensity at the sun's surface is 63 MW/m^2. **[3 marks]**

(f) The reading on the pressure scale at steam and ice points are 800mm and 200mm respectively. Determine the equivalent Temperature (in ^oC) when it reads 450mm **[3 marks]**

(g) Show that the work done on a gas during an adiabatic compression from initial conditions ($P1$, $V1$) to final conditions ($P2$, $V2$) is given by the equation **[4 marks]**

$$W = \frac{1}{\gamma - 1}(P_2V_2 - P_1V_1)$$

(h) A gas is heated and allowed to expand doing some work equal to 1.01×10^5J. If 3×10^5J of heat is used to expand the gas. What is the change in internal energy of the gas **[3 marks]**

QUESTION TWO

(a) Define the term thermal equilibrium **[1 mark]**

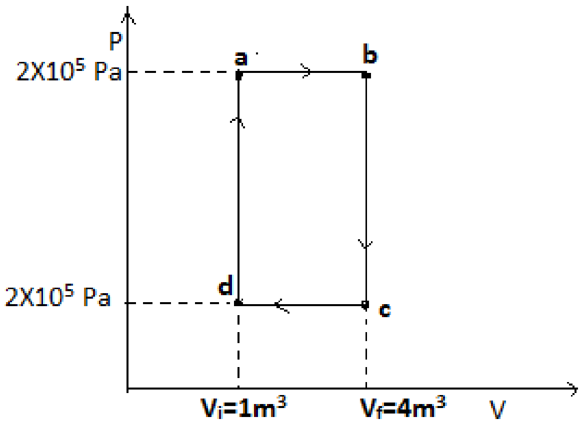
(b) A 5.0-gram lead bullet traveling at 300 m/s is stopped by a large tree. If half the

i. kinetic energy of the bullet is transformed into internal energy and remains with the

ii. Bullet while the other half is transmitted to the tree. Calculate the increase in temperature of the bullet **[4 marks]**

(c) Define the terms latent heat and specific heat capacity **[2 marks]**

(d) A gas undergoes a series of pressure and volume changes as shown below. Calculate



(f) Define the terms adiabatic changes and Isothermal process **[2 marks]**

i. Work done by the gas along the path **abc** **[2 marks]**

ii. Work done along the path **cda** **[3 marks]**

(g) State the second law of thermodynamics **[1 mark]**

QUESTION THREE

(a) i) Show that work done in compressing an ideal gas at constant temperature is given by

$$W = nRT \ln \frac{v_2}{v_1}$$ **[5 marks]**

(ii) How much work is required to compress isothermally 2g of oxygen initially at STP to half its original volume? (Assume that oxygen behaves as an ideal gas) **[5 marks]**

(b) Starting with the first law of thermodynamics $dQ = dU + PdV$ and using the equation of state, $PV = RT$; show that the equation of reversible adiabatic change for ideal gas is given by

$$PV^{\gamma} = Constant$$ **[5 marks]**

QUESTION FOUR

(a) Define the term blackbody **[1 mark]**

(b) What happens to radiant heat when it falls on a body **[3 marks]**

(c) The tungsten filament of an electric lamp is of length 0.5m, and diameter $6x10^{-5}$m. The power rating of the lamp is 60W. Assuming the radiation from the filament is 80% that of a blackbody at the same temperature, find the steady temperature of the filament **[4 marks]**

(d) A closed metal vessel contains water at 75 ^{o}C. the vessel has a surface area of $0.5m^2$ and a uniform thickness of 4mm. if the outside temperature is 15 ^{o}C and the thermal conductivity of the metal is 400W/M/K, calculate the heat lost per minute by the metal **[4 marks]**

(e) Using the kinetic theory of gases show that the root-mean square speed is given by

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$ **[3 marks]**

QUESTION FIVE

(a) $P_1V_1^{\gamma} = P_2V_2^{\gamma}$ The symbols have their usual meaning Show the equation can also be written as

$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$ **[6 marks]**

(b) 2g of oxygen gas initially at STP is adiabatically compressed to half its original volume, find the final values of:

i. The pressure and **[3 marks]**

ii. The temperature. Take the value of γ =1.4 for oxygen **[3 marks]**

(c) Calculate the quantity of heat conducted through $2m^3$ of a brick wall 12cm thick in 1 hour. If the temperature of one side is 8^0C and on the other side is

28^0C$(Thermal\ conductivity\ of\ brick = 0.13wm^{-1}k^{-1})$ **[3 marks]**

QUESTION SIX

(a) State the second law of thermodynamics **[1 mark]**

(b) State the three parts of the heat engine **[3 marks]**

(c) Write down the efficiency for a Carnot cycle as a function of

i. The heat flows to and from the reservoirs and **[2 marks]**

ii. The temperatures of the two reservoirs **[2 marks]**

(d) d) Describe the working of an Carnot engine start by sketching this cycle in a standard

P–V diagram. Explain the four steps of this cycle in terms of associated temperature and volume changes as well as the heat exchanged with external reservoirs. **[7 marks]**