ALUPE UNIVERSITY COLLEGE
...Bastion of Knowledge...
P. O.Box 845-50400 Busia(K)
principal@auc.ac.ke
Tel: +254 741 217 185
+254 736 044 469
off Busia-Malaba road

OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, RESEARCH AND STUDENTS' AFFAIRS

UNIVERSITY EXAMINATIONS

2018 /2019 ACADEMIC YEAR

FIRST YEAR FIRST SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **PHY 113**

COURSE TITLE: **HEAT AND THERMODYNAMICS**

DATE: 14TH DECEMBER, 2018 **TIME: 9 A.M- 12 NOON**

INSTRUCTION TO CANDIDATES

- **SEE INSIDE**

THIS PAPER CONSISTS OF 6 PRINTED PAGES **PLEASE TURN OVER**

PHY 113: HEAT AND THERMODYNAMICS

STREAM: BED (Scie) **DURATION: 3 Hours**

INSTRUCTIONS TO CANDIDATES

i. *Answer**TWO** questions in sectionA and any other **THREE** questions in section B.*

- *Where necessary the following constants maybe used:*
  - *One standard atmosphere pressure*= $1.013\times10^{5}\,Nm^{-2}$
  - *Avogadro's constant,* $N_A = 6.023\times10^{23}$
  - $\frac{C_p}{C_v} = \gamma = 1.4$
  - *Universal gas constant,* $R = 8.314 JMOL^{-1}K^{-1}$
  - *Specific heat of ice*= $2.0\times10^{3}\,JKg^{-1}C^{-1}$
  - *Specific heat of water*= $4.2\times10^{3}\,JKg^{-1}C^{-1}$
  - *Specific latent heat of ice,* $L_f = 3.35\times10^{5}\,JKg^{-1}$
  - Specific latent heat of water vapour, $L_v = 2.26\times10^{5}\,JKg^{-1}$

SECTION A

Question One (12 Marks)

(a) State four equilibrium criteria that must be satisfied for the system to be in thermodynamic equilibrium. (4 Marks)

(b) Differentiate between an open system and isolated system. (2 Marks)

c) State the zeroth law of thermodynamics (1 mark)

d) Air in the cylinder of a diesel engine is compressed to $\frac{1}{15}$ of its initial volume, V_1. If the initial temperature is 300 K. Find the final temperature after compression. ($\gamma_{air} = 1.4$) (2 Marks)

e) The temperature difference between the inside and the outside of an automobile engine is 450°C. Express thistemperature difference in (i) Fahrenheit scale and (ii) Kelvin scale.

(2 Marks)

f) A typical room contains 2500 moles of air. Treating the air like an ideal gas, find C_v in air when the room is at constant pressure of 1 atmosphere. (Take $\gamma = 1.4$). (3 marks)

Question Two (12 Marks)

a) i) Define quasi-static processes (1 Mark)

(b) An ideal gas of V=0.2 m^3 at temperature of 273.15 K and pressure of 10^5 Nm^{-2} expands reversibly to 4 times its initial volume. Calculate work done at constant pressure. (2 Marks)

c) Differentiate between reversible and irreversible processes and give examples of such processes. (3 Marks)

d) Calculate the volume occupied by one mole of an ideal gas at a temperature of 273 K and a pressure of $1.01 \times 10^5\ Pa$. (2 Marks)

e) A square hole 8.00 cm along each side is cut in a sheet of copper.

(i) Calculate the change in the area of this hole if the temperature of the sheet is increased by 50.0 K. (2 Marks)

(ii) Does this change represent an increase or a decrease in the area enclosed by the hole?

(1 Mark)

f) Distinguish between adiabatic and isothermal processes (1Marks)

SECTION B

Question Three (12 Marks)

a) State three assumptions made in deriving the average kinetic energy of molecules (3 Marks)

b) Consider a rectangular box of volume V with N molecules, each of mass m and having speed v. . The magnitude of change of momentum when the molecules hit the wall is $\Delta P = \frac{N}{V} m v_x^2 A \Delta t$. Show that the average kinetic energy of molecules is $\frac{3}{2} kT$. (6 Marks) c)

(i) What is the average translational kinetic energy of an ideal-gas molecule at 27°C. (1 Mark)

(ii) What is the total random translational kinetic energy of the molecules in 1 mole of this gas (T= 27°C)? (1 Mark)

(iii) What is the root-mean-square speed of oxygen molecules at this temperature ($T = 27°C$) ?

(1 Mark)

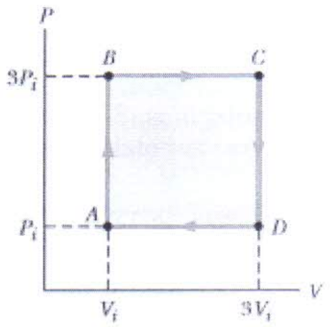
Question Four (12 Marks)

a)

i) State the first law of thermodynamics (1 mark)

ii) An ideal gas initially at 300 K undergoes an isobaric expansion at 2.50 kPa. If the volume increases from 1.00 m^3 to 3.00 m^3 and 12.5 kJ is transferred to the gas by heat, what arethe change in its internal energy andits final temperature? (3 Marks)

b) An ideal gas initially at Pi, Vi, and Ti is taken through a cycle as shown in Figure below.



(i) Find the net work done on the gas per cycle. (1 Mark)

(ii) What is the net energy added by heat to the system per cycle? (1 Mark) (iii)Obtain a numerical value for the net work done per cycle for 1.00 mol of gas initially at 0°C. (1 Mark)

b) If the 4g of oxygen gas (initially at STP) is isobarically compressed to half its original volume. Determine:

i) Work done for the compression (3 Marks)

ii) temperature change that occurs (2Marks)

Question Five (12 Marks)

a) The equation of state of an ideal gas is PV=RT. Show that i) β=1/T and b) k=1/P (6 Marks)

b) An approximate equation of state of a real 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) $\beta = \dfrac{\frac{1}{T}}{1+\frac{Pb}{RT}}$ (3 Marks)

ii) $k = \dfrac{\frac{1}{P}}{1+\frac{Pb}{RT}}$ (3 marks)

Question Six (12 Marks)

i) Show that the heat capacities of an ideal gas C_p, C_v at constant pressure and volume respectively are related by: $C_p = C_v + R$ where R is the universal gas constant. (6 marks) *i)* Define change in entropydS of a system. (1 Mark)

ii) What are the changes in entropy of a gas that expands: at constant temperature and adiabatically.(2 Marks)

iii) Calculate the change in entropy of 250 g of water heated slowly from 20.0°C to 80.0°C. (3 Marks)

Question Seven (12 Marks)

a) State the Kelvin–Planck and Clausius statement of the second law of thermodynamics. (2 Marks)

b) What is the difference between a refrigerator and a heat pump? (2 Marks)

c) What are the four processes that make up the Carnot cycle? (2 Marks)

d) Show that the efficiency of a heat engine operating in a Carnot cycle using an ideal gas is given by $e_c = 1 - \frac{|Q_L|}{|Q_H|} = 1 - \frac{T_L}{T_H}$. (6 Marks)

****