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, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2020 /2021 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER MAIN EXAM

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: PHY 415E

COURSE TITLE: STATISTICAL MECHANICS

DATE: 15/07/2021 **TIME: 1300 – 1600 HRS**

INSTRUCTION TO CANDIDATES

- SEE INSIDE

THIS PAPER CONSISTS OF 4 PRINTED PAGES **PLEASE TURN OVER**

REGULAR –MAIN

PHY 415E: STATISTICAL MECHANICS

STREAM: BED (Science) **DURATION: 3 HOURS**

INSTRUCTIONS TO CANDIDATES

i. *Answer **TWO** questions in section **A** and any other **THREE** questions in section **B**.*
You may need to use the following constants

$h = 6.6.63 \times 10^{-34}\, Js$, $c = 3 \times 10^{8}\, m/s$ and Ts = 5,800 K

SECTION A (28 MARKS)

Question One (14 Marks)

(a) Explain the following fundamental terms as used in statistical mechanics
  (i) Micro-canonical ensemble (2 Marks)
  (ii) Canonical ensemble (1 Marks)
  (iii) Grand canonical ensemble (1 Mark)

(b) Distinguish between microstate and macrostate and their importance in study of statistical mechanics (3 Marks)

(c) Explain the difference between the terms entropy and enthalpy (4 Marks)

(d) 1.5kg of a copper material was cooled from 150°C to 45°C. Calculate its change in entropy. (3 Marks)

Question Two (14 Marks)

(a) Distinguish between a T-space and a phase point. (2 Marks)

(b) Define the partition function in statistical mechanics (2 Marks)

(c) What is ensemble average? Show that the ensemble average $\overline{R} = \frac{\int_{-\infty}^{+\infty} R(x)N(x).dx}{\int_{-\infty}^{+\infty} N(x).dx}$ (4 Marks)

(d) State the second law of thermodynamics (1 Mark)

(e) Estimate the temperature T_E of the earth, assuming that it is in radiation equilibrium with the sun (assume the radius of sun Rs = 7×10^8 m, the earth-sun distance r = 1.5×10^{11} m, the temperature of solar surface Ts = 5,800 K) (5 Marks)

SECTION B (42 MARKS)

Question Three (14 Marks)

(a) The energy S is defined as $S = KlogC$ and the most probable distribution is given by $n_i = w_i \exp(-\alpha - \beta\epsilon_i)$ where $\beta = {}^{1}/_{KT}$ and $\exp(\alpha) = {}^{V}/_{Nh^3}(2\pi mKT)^{3}/_{2}$. Derive an expression for the ideal gas equation given as $PV = NKT$ (7Marks)

(b) What does the Zeroth law of thermodynamics state? (1 Marks)

(c) For an assembly of a classical gas, express the Pressure, Energy and Specific heat in terms of the partition function Q. (6 Marks)

Question Four (14 Marks)

(a) What is meant by a blackbody radiation (2 Mark)
(b) Discuss the properties of a blackbody radiation (2 Marks)
(c) Describe the Bose-Einstein statistical distribution and derive its most probable distribution (10 Marks)

Question Five (14 Marks)

(a) Derive Boltzmann's formula for the probability of atoms in thermal equilibrium occupying a state E, at absolute temperature T (9 Marks)
(b) If n is the number of conduction electrons per unit volume and m the electron mass then show that the Fermi energy is given by the expression $E_F = \frac{h^2}{8m}\left(\frac{3n}{\pi}\right)^{\frac{2}{3}}$ (5 Marks)

Question Six (14 Marks)

(a) (i) Define density of state (1 Mark)
(ii) The density of states functions for electrons in a metal is given by $Z(E)dE = 13.6\times10^{27}E^{1/2}dE$ Calculate the Fermi level at a temperature few degrees above absolute zero for copper which has 8.5×10^{28} electrons per cubic metre. (2 Marks)

(iii) Using the results of problem (ii), Calculate the velocity of electrons at the Fermi level in copper (3Marks)
(b) Obtain the expression for the Fermi-Dirac distribution given as $n_k = \frac{w_k}{e^{(\alpha+\beta\epsilon_k+1}}$ (8 Marks)

Question Seven (14 Marks)

(a) Explain the Bose-Einstein condensation (3 Marks)
(b) Briefly describe the free electron model, and state any three area of application (5 Marks)
(c) State any two properties of Laser radiation (2 Marks)
(d) Determine the wavelength of radiation given out by a laser with an energy of $3\,eV$, (4 Marks)

****