# KIBABII UNIVERSITY
# (KIBU)

## UNIVERSITY EXAMINATIONS
## 2021/2022 ACADEMIC YEAR

## THIRD YEAR FIRST SEMESTER MAIN EXAMINATIONS

## FOR THE DEGREE
## OF
## BACHELOR OF EDUCATION SCIENCE

**COURSE CODE:** SPM 317

**COURSE TITLE:** PROPERTIES OF MATTER

**DATE:** 23/05/2022 **TIME: 2:00PM-4:00PM**

**INSTRUCTIONS TO CANDIDATES**

TIME: 2 Hours

**Answer question ONE and any TWO of the remaining.**

**Symbols used bear the usual meaning.**

KIBU observes ZERO tolerance to examination cheating

This Paper Consists of 2 Printed Pages. Please Turn Over.

## Question One (30 marks)

a) State four assumptions made in an ideal fluid flow model (4 marks)

b) Normal atmospheric pressure is $1.013 \times 10^5 Pa$. The approach of a storm causes the height of a mercury barometer to drop by 20 mm from the normal height. What is the atmospheric pressure? (The density of mercury is 13.59 g/cm$^3$.) (4 marks)

c) Describe a simple model to show Van der waals London interaction in atoms (3 marks)

d) In a car lift used in a service station, compressed air exerts a force on a small piston that has a circular cross section and a radius of 5 cm. This pressure is transmitted by a liquid to a piston that has a radius of 15 cm. What force must the compressed air exert to lift a car weighing 13 300 N? What air pressure produces this force? (4 marks)

e) From thermal energy equation determine the Debye Temperature term (4 marks)

f) State four assumptions of molecular model of an ideal gas (4 marks)

g) Illustrate the crystal structure of Diamond showing the tetrahedral bond arrangement (4 marks)

h) State the flux of thermal energy and the relationship with heat capacity of phonon of particles (3 marks)

## Question Two (20 marks)

3a) A cylinder contains 3mol of Helium gas at a temperature of 300K (i) If the gas is heated at a constant volume, how much energy must transferred by heat to the gas for the temperature to increase to 500K? (ii) How much energy must transferred by heat at constant pressure to the gas for the temperature to increase to 500K? ($C_V = 12.5 J/mol.K$, $C_P = 20.8 J/mol.K$) (6 marks)

3b) Nine particles have speeds 5, 8, 12, 12, 12, 14, 14, 17 and $20 m/s$ (i) Find the particles average speed? (ii) What is the rms speed of the particles? (iii) What is the most probable speed of the particles? (9 marks)

3c) Approximate the air around you at $20^0 C$ as a collection of nitrogen molecules, each having a diameter of $2 \times 10^{-10} m$ (i) How far does a typical molecule move before it collides with another molecule (ii) On average how frequently does one molecule collide with another? ($Atm\ pressure = 1.01 \times 10^5\ N/m^2$, $k_B = 1.38 \times 10^{-23} J/K$, $\bar{v} = 473\ m/s\ for\ nitrogen$ ) (5 marks)

## Question Three (20 marks)

a) The pressure of a gas is proportional to the number of molecules per unit volume and to the average translational kinetic energy of the molecules, show that this is true for N number of

molecules confined in a container of dimension d and mass per unit volume m.

(14marks)

b) Show that for an ideal gas the temperature is a direct measure of average molecular kinetic energy (6 marks)

**Question Four (20 marks)**

a) A water hose 2.5 cm in diameter is used by a gardener to fill a 30L bucket. The gardener notes that it takes 1 min to fill the bucket. A nozzle with an opening of cross-sectional area 0.5 $cm^2$ is then attached to the hose. The nozzle is held so that water is projected horizontally from a point 1 m above the ground. Over what horizontal distance can the water be projected?

(6 marks)

b) Considering an ionic crystal like sodium chloride, derive the madelung energy and hence show how the madelung constant can be determined (14 marks)

**Question Five (20 marks)**

a) Discuss the lattice types in two and three dimensional (10 marks)

b) Prove that the set of reciprocal lattice vectors G determines the x-ray reflections

(10 marks)