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OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, RESEARCHAND STUDENTS' AFFAIRS

UNIVERSITY EXAMINATIONS

2018 /2019 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

COURSE CODE: PHY 222

COURSE TITLE: PROPERTIES OF MATTER

DATE: 23RD APRIL, 2019 **TIME: 2.00 PM – 5.00 PM**

INSTRUCTION TO CANDIDATES

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INSTRUCTIONS TO CANDIDATES

i. *Answer the **TWO** question in **SECTION A** and any other **THREE** questions in **SECTION B.***

ii. *The following constants maybe useful*

Avogadro's number	6.02×10^{23} molecules/mole
Boltzmann's constant, k	1.38×10^{-23} J/molecule. K
Density of mercury	13,600 kg/m^3
Universal gas constant, R	8.314 J/Mol.K
1 atm	1.01×10^5 Pa
1atomic mass unit (u)	1.66×10^{-27} kg

SECTION A (28 MARKS)

Question One (14 Marks)

a) State the difference between following terms

i) Crystalline solids and amorphous solids (2 Marks)

ii) lattice and basis (2 Marks)

b) Aluminum has FCC structure. If the density of Aluminum is 2.7×10^{-3} kg/m^3 . Calculate the unit cell dimensions and atomic diameter. (Atomic weight of Al=26.98g) (4 Marks)

c) Using a well-labeled diagram, explain Bragg's law of diffraction. (3 Marks)

d) Briefly differentiate between ionic, covalent, and metallic bonding. (3 Marks)

Question Two (14 Marks)

a) Distinguish between steady flow and turbulent flow. (2 Marks)

b) The pressure difference between two points along a horizontal pipe, through which water is flowing, is 1.4 cm of mercury. If due to non-uniform cross-section, the speed of flow of water at the point of greater cross-section is 60cm/sec. calculate the speed at the other part. (3 Marks)

c) Consider a container of nitrogen gas molecules at 900 K. Calculate

(i) the most probable speed (1 Mark)

(ii) the average speed (1 Mark)

(iii) the rms speed for the molecules. (1 Mark)

d)

(i) Distinguish between surface tension and surface energy. (2 Marks)

(ii) A drop of water of diameter 0.2cm is broken up into 27000 droplets of equal volume. How much work will be done against surface tension in the process? (Surface tension of water = 7×10^{-2} N/m). (1 Mark)

e)

i) What is the meaning of viscosity? (1 Mark)

ii) A drop of water of radius 0.0015 m is falling in air. If the coefficient of viscosity of air is 1.8×10^{-5} Kg/m s, what will be the terminal velocity of the drop? (Density of water is 1000 Kgm^{-3}, neglect density of air). (2 Marks)

SECTION B (42 MARKS)

Question Three (14 Marks)

a) Define coordination number and state the coordination number of SC, BCC and FCC cubic lattices. (4 Marks)

b) Show that for the body-centered cubic (BCC) crystal structure that the unit cell edge length a and the atomic radius r are related through $a = \frac{4r}{\sqrt{3}}$. Hence determine BCC atomic packing factor. (5 Marks)

c) For FCC crystal structure, show that the atomic packing factor is 74%. (5 Marks)

Question Four (14 Marks)

a) An atomic plane in a crystal lattice makes intercept of 3a, 4b and 6c with the crystallographic axes where a, b and c are the dimensions of the unit cell. Show that the Miller indices of the atomic plane are (432). (2 Marks)

b) Sketch the crystallographic planes represented by the following Miller Indices in a simple cubic structure: (100), (110) and (111). (3 Marks)

c) List any three 2-dimensional bravais lattice. (3 Marks)

d) Sketch the three types of 3-dimensional bravais cubic lattices and highlight the relationship between the lattice parameters. (3 Marks)

e) Find the interplanar distance of (200) plane and (111) plane of Nickel crystal. The radius of Nickel atom is 1.245 Å. (3 Marks)

Question Five (14 Marks)

a) Sketch the Maxwell-Boltzmann distribution curves for a gas at different temperatures of 300K and 900K. Indicate the most probable speed in each curve. (4 Marks)

b) Define the mean free path. Estimate the mean free path of a molecule of air at 1 atm of pressure. Assume the molecules of air have $r = 2.0 \times 10^{-10} m$. (3 Marks)

c) Using the average kinetic energy of gas molecules, show that the root mean square speed of gas molecules, $V_{r.m.s}$ is given by $V_{r.m.s}=\sqrt{\frac{3RT}{M}}$. Where R is a constant, M is the molar mass of the gas and T is the absolute temperature. (3 Marks)

d) Explain the assumptions made by Van der Waals in deriving his equation of state from the simple gas law $PV = RT$, where the symbols have their usual meanings. Hence write the Van der Waals equation of state. (4 Marks)

Question Six (14 Marks)

(a) Define the terms tensile stress and tensile strain. (2 Marks)

(b) In a test of the mechanical properties of animal tendon, a sample of tendon is subjected to stretching. The sample is cylindrical in shape, with a diameter of 3.00 mm and an initial length of 50.0 mm. It is found that the sample obeys Hooke's law up to a tensile force of 250 N, at which point the sample has increased in length to 53.0 mm. At larger tensile forces the sample shows plastic deformation, and then breaks when the tensile force is 580 N and the length is 59.0 mm. Calculate both the stress and strain values at,

(i) The elastic limit (2 Marks)
(ii) The breaking point (2 Marks)

c)

Describe the following methods used in determination of crystal structure.

(i) Laue method (2 Marks)
(ii) The rotating-crystal method (2 Marks)
(iii) The powder method (2 Marks)

d) Describe how to construct a Wigner-Seitz cell. (2 Marks)

Question Seven (14 Marks)

a) Differentiate between the following,
   (i) Heat and temperature (2 Marks)

   (ii) Heat capacity and specific heat capacity? (2 Marks)

b) A chemist wishes to determine the specific heat of a new alloy. A 0.15kg sample of the alloy is heated to 540 °C. It is then quickly placed in 400g of water at 10 °C, which is contained in a 200g aluminum calorimeter cup. The final temperature of the mixture is 30.5 °C. Calculate the specific heat capacity of the alloy. (The specific heats of water and aluminum are 4186J/kg °C and 900J/kg °C). (6 Marks)

c) The wall of an industrial furnace is constructed from 0.15m thick fireclay brick having a thermal conductivity of1.7 $W/m.K$. Measurements made during steady state operation reveal temperatures of 1400K and 1150K at the inner and outer surfaces respectively. What is the rate of heat loss through a wall that is 0.5m by 1.2m? (6 Marks)

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