



KENYATTA UNIVERSITY
UNIVERSITY EXAMINATIONS 2011/2012
MOMBASA CAMPUS

**FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF
SCIENCE AND BACHELOR OF EDUCATION (SCIENCE)**

SPH 302: STRUCTURE AND PROPERTIES OF MATTER

DATE: Monday, 5th December, 2011

TIME: 8.00 a.m. – 10.00 a.m.

INSTRUCTION: Answer Question **ONE** and any other **TWO** Questions.

Take: $R = 8.31 JK^{-1} mol^{-1}$, Density of mercury = $13,600 \text{ kgm}^{-3}$, Density of water = $1,000 \text{ kgm}^{-3}$.

Question One (30 Marks)

- a) Define the following terms:
 - i) Unit cell (1 mark)
 - ii) Crystal lattice (1 mark)
 - iii) Atomic packing fraction (1 mark)
 - iv) Co-ordination number (1 mark)
- b) Distinguish between atomic structure and crystal structure (2 marks)
- c) Briefly describe the FOUR types of bonds (8 marks)
- d) Sketch a graph of binding energy (eV) against inter-atomic separation (nm) and explain the shape of your graph (4 marks)
- e) State why X-rays are used in crystallographic analysis and not any other type of electromagnetic waves (3 marks)
- f) Given that the radius of aluminum atom is $1.43 \text{ \AA}$, calculate the volume of a unit cell of aluminum, taking into consideration that it has an FCC structure (5 marks)
- g) Water flows inside a horizontal pipe of non-uniform cross-sectional area. It is observed that pressure of 10 mmHg exists at a point where the velocity is 20 m/s. Find the pressure at a point where the velocity is 10 m/s. (4 marks)

Question Two (20 Marks)

- a) Define 'Miller indices' (2 marks)
- b) Obtain Miller indices of a plane with intercept at a , $b/2$, $c/3$ in a simple cubic unit a , b , and c are crystal axis vectors. (3 marks)
- c) Give any three differences between amorphous and crystalline solids (3 marks)

- d) The inter-atomic spacing of silicon is 0.235 nm. Calculate the density of silicon (W=28). Assume that it has a simple FCC structure (3 marks)
- e) Show that the packing fraction for BCC structure is 0.68 (4 marks)
- f) Consider two parallel rays of wavelength λ incident on a crystal plane at an angle θ . One ray is reflected at the top plane while the other is reflected at the plane below the top one. Using this geometry, verify Bragg's law $n\lambda = 2d \sin \theta$ where n is an integer and d is the interplanar spacing. (5 marks)

Question Three (20 Marks)

- a) Distinguish between streamline and turbulent flow (4 marks)
- b) Explain the significance of Reynold's number in fluid flow (3 marks)
- c) State the factors determining the magnitude of viscous drag experienced by an object moving in a liquid (3 marks)
- d) Derive the Poiseuille's law, $Q = \frac{(\Delta P)\pi R^4}{8\eta l}$ defining each term in your working and stating any assumption used (10 marks)

Question Four (20 Marks)

- a) State the Avogadro's hypothesis of gases (2 marks)
- b) Write the Van der Waal's equation and explain its significance and how it corrects the ideal gas equation (5 marks)
- c) A diatomic gas of volume 250 ml is enclosed in a flask at 22 °C. If the flask was placed in ice bath at 0 °C, calculate the new gas volume if the pressure is held constant. (4 marks)
- d) Suppose the expansion of the gas in (c) above is adiabatic, calculate its new volume under the same conditions (5 marks)
- e) Given the nearest neighbor distance (R_0) and the Madelung constant (α) for potassium chloride crystal are 3.14 Å and 1.64 respectively, calculate minimum the binding energy per mole for the solid. [Charge on an ion in KCl lattice = 1.6×10^{-19} C] (4 marks)

Question Five (20 Marks)

- a) Define 'specific heat capacity of a substance' (2 marks)
- b) Explain the difference between classical and Einstein's theory on specific heat capacity (4 marks)
- c) Show that the excess pressure of a soap bubble is given by $\Delta P = \frac{4S}{R}$, where the terms have their usual meaning (4 marks)
- d) PCl_5 dissociates according to the equation: PCl_5 dissociates according to the equation: $\text{PCl}_{5(g)} \rightarrow \text{PCl}_{3(g)} + \text{Cl}_{2(g)}$. If half of the total number of moles of PCl_5 dissociates and the observed pressure is 1.25 atm, what is the partial pressure of Cl_2 ? (10 marks)

