KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION AND BACHELOR OF SCIENCE

SPH 302: STRUCTURE AND PROPERTIES OF MATTER

DATE: Monday, 2nd April, 2012 TIME: 11.00 a.m. – 1.00 p.m.

INSTRUCTIONS:

Answer question **one** and any other **two**. Question one carries 30 marks while each of the others carries 20 marks. *Credit will be awarded for clear explanations and illustrations.*

Useful information

1 atmosphere	1.013×10^5 pascals
1 electronvolt	1.6×10^{-19} Joules
$4\pi\varepsilon_0$	0.11×10^{-9} $C^2N^{-1}m^{-2}$
Angle of contact of mercury with clean glass	130^0
Avogadro number (N_a)	6.0×10^{23} mol^{-1}
Boltzmann's constant (k_B)	1.38×10^{-23} JK^{-1}
Density of air at 20^0C	1.20 kgm^{-3}
Density of mercury	1.36×10^4 kgm^{-3}
Electronic charge	1.602×10^{-19} Coulombs
Gravitational intensity (g)	9.81 Nkg^{-1}
Permittivity of free space	8.85×10^{-12} $C^2N^{-1}m^{-2}$
Radius of silicon	$a\frac{\sqrt{3}}{8}$
Surface tension of mercury	5.47×10^{-1} Nm^{-1}
Surface tension of water (γ)	7.25×10^{-2} Nm^{-1}
Viscosity of air at 20^0C	1.81×10^{-5} Pascals
Young's Modulus for steel	2.0×10^{11} Nm^{-2}

Question 1 [COMPULSORY]

(a) Given that the nearest neighbour distance (R_o) and the Madelung constant (α) for the potassium chloride crystal are 3.14 Å and 1.64 respectively, calculate the binding energy per mole for the solid. [Charge on an ion in a KCl lattice = $1.6 \times 10^{-19} C$]. [5]

(b) A family of planes in a crystalline solid has intercepts on the axes of the unit cell at x = 2, y = 2 and z = 2. If the lattice parameter is 3.0×10^{-10}m, calculate the separation of these planes which consist of a simple cubic lattice. [5]

(c) The inter-atomic spacing of silicon is 0.235 nm. Calculate the density of silicon (W = 28). [5]

(d) 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 the point where velocity is 10 m/s. [5]

(e) A soap bubble was slowly enlarged from a radius of 4 cm to one of 6 cm. The amount of work necessary for enlargement was 1.5×10^4 joules. Calculate the surface tension of the soap bubble. [5]

(f) The equation governing the behaviour of a real (imperfect) gas may be written as

$$P(v-b) = RT$$

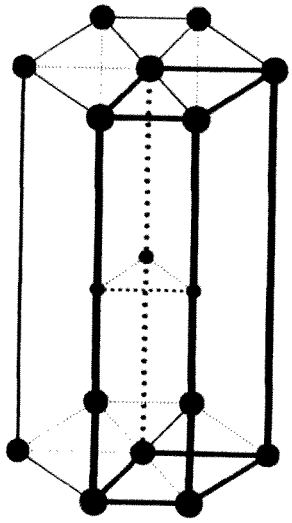
where terms have their usual meaning. Given that b for the hydrogen molecule is $2.64 \times 10^{-5}\ m^3$, calculate the molecular diameter for hydrogen (H_2). [5]

Q2. (a) Suppose the short range repulsion force between two ions "i" and "j" is represented by Ar^{-n} instead of $Ae^{(-rij/\rho)}$ where A and n are constants. What value of n will give 0.9 of the Madelung energy for the lattice energy of the ionic solid? [10]

(b) Both crystals and glasses are bonafide solids and share the essential attributes of the solid state. What would you consider to constitute their fundamental difference? [5]

(c) Metal copper crystallizes on a face-centred cubic lattice. If the unit cell edge a = 0.36 n m, calculate the radius of the copper atom. [5]

Q3.



(a) The hexagonal close-packed structure is built up from layers of hexagons. A "unit cell" of this structure is shown in Fig. 1. Analyze the packing of atoms in this structure as follows:

(i) Determine the axial ratio.
(ii) Calculate the packing.

Fig. 1: The relative atom positions in the hcp crystal. The unit cell is outlined with heavy lines.

[8,7]

(b) Aluminium has a density of about 2,700 kg/m^3. Its atomic weight is 27.0. Determine the number of atoms which are contained in one cubic metre of the solid. [5]

Q4. **(a)** What is the significance of Bernoulli's equation of motion for fluids? [2]

(b) State the four conditions (as well as the corresponding implications) under which Bernoulli's equation can be used. [8]

(c) (i) Derive Bernoulli's equation of motion for an ideal liquid considering that the velocity V of an elementary fluid particle is a function of position and time. [8]

(ii) What physical principle is expressed in Bernoulli's equation of motion? [2]

Q5. **(a)** The perfect gas equation $P_{ideal}V_{ideal} = RT$, assumes the size of the molecules to be zero.

(i) Discuss how the ideal gas equation is modified if provision is made for the size of the gas molecules.
(ii) Hence obtain an expression for imperfect gases on the basis of this modification. [5,10]

(b) **(i)** To explain the variation of molar heat capacity with temperature, four assumptions were made in the Einstein model. State the four assumptions.
(ii) What is the significance of the value of the Boltzman factor? [4,1]