MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS
2016/2017 ACADEMIC YEAR
YEAR ONE SEMESTER ONE

SCHOOL OF ……..
BACHELOR OF SCIENCE

COURSE CODE: CHE 1104
COURSE TITLE: PHYSICAL CHEMISTRY

DATE: **TIME:**

INSTRUCTIONS TO CANDIDATES

1. Answer Question **ONE** and any other **TWO** questions.
2. All Examination Rules Apply.

3. You should ensure that you have the following materials for this examination;

   Answer booklet

   Scientific calculator

4. $R = 8.314\ JK^{-1}\ Mol^{-1}$
5. $N = 6.023 \times 10^{23}\ Mol^{-1}$
6. $1Pa = 1\ Nm^{-2}$
7. $1\ atm = 1.013 \times 10^{5}\ NM^{-2}$
8. Answer **Question One** from Section I and ANY other **TWO** from Section II

SECTION I

Question One

a) Briefly state three postulates of the Kinetic Theory of Gases. (3marks)

b) Based on the above postulates, and given that $PV = 1/3nMu^2$ derive the following;

   i) Boyle's law (2 marks)

   ii) Charles' law (2 marks)

   iii) Avogadro's law (2 marks)

c) A mixture of helium and neon gases has a total pressure of 1.2 atm. if the mixture contains twice as many moles of helium as neon, determine the partial pressure due to neon.(3 marks)

d) The Maxwell-Boltzmann distribution applies not just to gases, but also to the molecular motions within liquids. The fact that not all molecules have the same speed helps us understand the process of evaporation.

   i. Explain in terms of molecular motion why a drop of water becomes cooler as molecules evaporate from the drop's surface. (2 marks)

   ii. Use the Maxwell-Boltzmann distribution to explain why even a slight increase in temperature can greatly increase the rate at which a drop of water evaporates. (2 marks)

e) State Raoult's law and using a pair of liquids A and B, derive the equation that relates the total vapour pressure with the individual partial pressure of the volatile liquid A and B. (3 marks)

f) Define mean free path and state why the mean free path of a gas is inversely proportional to its density. (2 marks)

g) Define relative lowering of vapour pressure. Establish the relationship between the relative lowering of vapour pressure of a solution containing a non-volatile solute and the mole fraction of the solute.(2 marks)

h) The boiling point of a pure solvent is increased by the addition of a non-volatile solute, and the elevation can be measured by **ebullioscopy**. It is found that

$$\Delta T_b = T_b(solution) - T_b(solvent) = i \cdot K_b \cdot m$$

Define I, K_b and m and state their significance. (3 marks)

i) Balance the following equations;

I. $Ca_3(PO_4)_2 + H_2SO_4 \rightarrow CaSO_4 + Ca(H_2PO_4)_2$ (2 marks)

II. $(NH_4)_3PO_4 + Pb(NO_3)_4 \rightarrow Pb_3(PO_4)_4 + NH_4NO_3$ (2 marks)

SECTION II

Question Two

a) Two liquids A and B were assumed to form an ideal solution. The vapour pressure of A was determined to be 44.5 mm Hg and that of B to be 88.7 mm Hg at 298 K. Given that the molar masses of A and B are 46 and 32 g mol^{-1} respectively;

i) Determine the mole fraction of A and B in the solution obtained by mixing 0.1 kg of each. (4 marks)

ii) Calculate the partial pressures and the total vapour pressure of the solution. (4 marks)

b) Explain why

i. The solubility of solids in water increases as the temperature increases. (2 marks)

ii. Sea water has a lower freezing point than fresh water (2 marks)

c) Define elevation in boiling points. With the help of a graph diagram explain how the addition of a non-volatile solute elevates the boiling point of a solvent. (8 marks)

Question Three

a) Determine the temperature at which oxygen molecules will have the same r.m.s. velocity as carbon dioxide molecules at 50^0 C. (5 marks)

b) Suppose that you compress an ideal gas to half its original volume, while also halving its absolute temperature; during this process, explain what happens to the pressure of the gas. (3 marks)

c) Caproic acid, the substance responsible for the aroma of dirty gym socks and running shoes, contain C, H, and O only. On combustion, 0.450g of sample of caproic acid gives 0.418g of H_2O and 1.023g CO_2. The molecular weight of caproic acid is 116.2g/mol. Determine;

i. The empirical formula of caproic acid (8 marks)

ii. The molecular formula of caproic acid (4 marks)

Question Four

a) If 12.0 gms of N_2 , 0.40 gms of H_2 and 9.0 gms of O_2 are put into a 1.0 litre container at 27^0 C, determine the;

i) Number of moles of N_2 (2 marks)

ii) Number of moles of H_2 (2 marks)

iii) Number of moles of O_2 (2 marks)

iv) Calculate the total pressure in the container (3 marks)

b) A vessel holds a mixture of helium (He) and methane (CH_4). Calculate the ratio of the rms speed of the He atoms to that of the CH_4 molecules given that V rms = $\sqrt{3RT/M}$. (7 marks)

c) Under the same conditions of temperature and pressure, which of the following gases would behave most ideally and why?

i. Ne ii N_2 iii CH_4 (4 marks)

Question Five

a) Account for the following observations in terms of kinetic molecular theory;

i) The volume of a gas can be readily reduced by increasing the applied pressure. (3 marks)

ii) The pressure exerted by a gas increases as its temperature is raised. (3 marks)

b) When 4.0 moles of oxygen are confined in a 24-liter vessel at 176ºC, the pressure is 6.0 atm. If the oxygen is allowed to expand isothermally until it occupies 36 liters, determine the new pressure attained. (6 marks)

c) Calculate the rate of diffusion for hydrogen molecules compared to those of oxygen at the same temperature. (8 marks)