



# UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

SECOND SEMESTER EXAMINATIONS, MAY, 2018

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COURSE NO: GL/MN/PE/ES 154

COURSE NAME: PHYSICAL & ANALYTICAL CHEMISTRY

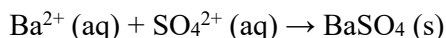
CLASS: GL/MN/PE/ES 1 TIME: 3 HOURS

Name: \_\_\_\_\_ Index Number: \_\_\_\_\_

## ANSWER QUESTION ONE AND ANY OTHER THREE QUESTIONS

### Question 1

- a. Calculate the solubility of O<sub>2</sub> in water if  $K = 1.28 \times 10^{-3} \text{ mol L}^{-1} \text{ atm}^{-1}$  and the  $P_{\text{O}_2} = 0.2029 \text{ atm}$ . Leave your answer in ppm units. **(2 marks)**
- b. A solution of density 0.903 g/mL contains 0.255 mol of an organic compound (solute) (Molar mass of organic compound = 165 g/mol) in 298 g of benzene (solvent). Calculate its molarity and its molality. **(5 marks)**
- c. State the 3 properties of a sample. **(3 marks)**
- d. A solution containing 4.5 ppm of a coloured species has an absorbance of 0.3 in a 2 cm cell. Calculate its molar absorptivity. **(2 marks)**
- e. A patient has a cholesterol count of 986 mg/dL. What is the molarity of cholesterol in this patient's blood if the molecular mass of cholesterol is 386.64 g/mol? (1 L = 10 dL) **(3 marks)**
- f. How would you prepare 200 mL of 6 M H<sub>2</sub>SO<sub>4</sub> solution from a stock solution that is 36% and has a specific gravity of 3.14? **(5 marks)**
- g. A 2.50 g sample of a fertilizer was dissolved in water. Barium sulphate was precipitated by adding barium chloride solution. The relevant equation is



The precipitate was filtered, washed, dried and had a mass of 0.566 g.

- i) Calculate the number of moles of barium sulphate precipitated
- ii) Calculate the mass of sulphate in the sample of fertilizer
- iii) What is the percentage of sulphate in the fertilizer? **(5 marks)**

## Question 2

- a. Fill in the missing information in the following table: (3 marks)

Symbol	Protons	Neutrons	Electrons
$^{80}_{35}\text{Br}$			
$^{190}_{76}\text{Os}$			
$^{207}_{82}\text{Pb}$			

- b. Bromine contains 50.5% Br-79 and 49.5% Br-85. Calculate the relative atomic mass of naturally occurring bromine. (3 marks)

- c. State;

- i) Pauli's exclusion principle (2 marks)
- ii) Hund's rule (2 marks)
- iii) Aufbau's principle (2 marks)

- d. Write the electronic configuration of the following:

- i)  $^{56}_{26}\text{Fe}$  (1 mark)
- ii) Why are  $^{65}_{30}\text{Zn}$  and  $^{64}_{29}\text{Cu}$  not considered as transition metals? (2 marks)

- e. State two properties each of the following:

- i) s block elements (2 marks)
- ii) d block elements (2 marks)

- f.
  - i) What are heavy metals? (2 marks)
  - ii) List four adverse health effects of heavy metals. (4 marks)

### Question 3

- a. Describe how the following types of bonds are formed:
- i) Electrovalent bond (2 marks)
  - ii) Polar covalent bond (2 marks)
  - iii) Semi-polar bond (2 marks)
- b. What are the two factors used in determining the shape of an ionic structure? (2 marks)
- c. List four differences between electrovalent and covalent compounds. (4 marks)
- d. List two differences between simple covalent structures and giant covalent structures. (2 marks)
- e. i) What is hybridization of atomic orbitals? (2 marks)  
ii) What hybridization occurs in H<sub>2</sub>O and what is its bond angle? (2 marks)
- f. i) What are hydrogen bonds? (2 marks)  
ii) List three compounds which have hydrogen bonds. (3 marks)

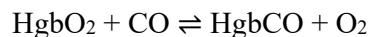
### Question 4

- a. i) What is an ideal gas? (1 mark)  
ii) List four characteristics of gases. (2 marks)
- b. State the following laws;
- i) Dalton's law of partial pressures (2 marks)
  - ii) Henry's law (2 marks)
- c. An iron cylinder contains helium at a pressure of 250 kPa at 300K. The cylinder can withstand a pressure of  $1 \times 10^6$  Pa. The room in which cylinder is placed catches fire. Predict whether the cylinder will blow up before it melts or not (melting point of iron = 1800K). (3 marks)
- d. A sample of air occupying 4.0 dm<sup>3</sup> at 127°C and 1.5 atm is cooled to 27°C and its pressure is reduced to 1 atm. What is the new volume of the sample? (3 marks)
- e. i) What is surface tension? (2 marks)  
ii) List three factors responsible for capillary action. (3 marks)

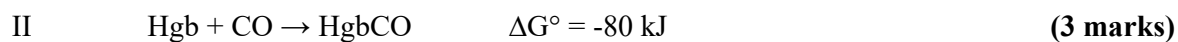
- f. i) What is viscosity? **(2 marks)**  
 ii) What are the three types of flow? **(3 marks)**  
 iii) Differentiate between a crystalline and amorphous solid. **(2 marks)**

### Question 5

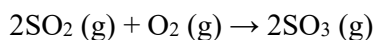
- a. Carbon monoxide is toxic because it bonds much more strongly to the iron in haemoglobin (Hgb) than does O<sub>2</sub>. Estimate the equilibrium constant value at 25°C for the reaction



using the following data:



- b. Consider the reaction



carried out at 25°C and 1 atm. Using the following data, calculate

- i)  $\Delta H^\circ$  **(2 marks)**  
 ii)  $\Delta S^\circ$  **(2 marks)**  
 iii)  $\Delta G^\circ$  **(2 marks)**

Substance	$\Delta H^\circ$ (kJ mol <sup>-1</sup> )	$\Delta S^\circ$ (J K <sup>-1</sup> mol <sup>-1</sup> )
SO <sub>2</sub> (g)	-297	248
O <sub>2</sub> (g)	-396	257
SO <sub>3</sub> (g)	0	205

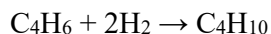
- c. Define the following and give an example each

- i) Open system **(1 mark)**  
 ii) Closed system **(1 mark)**

iii) Isolated system

(1 mark)

d. Calculate  $\Delta H^\circ$  for

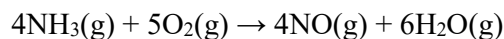


Using the following data below

Reaction	$\Delta H^\circ$ (kJ)
I $\text{C}_4\text{H}_6 + 11/2 \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	-2600
II $2\text{C}_4\text{H}_{10} + 13\text{O}_2 \rightarrow 8\text{CO}_2 + 10\text{H}_2\text{O}$	-5760
III $\text{H}_2 + 1/2 \text{O}_2 \rightarrow \text{H}_2\text{O}$	-286
IV $\text{C}_4\text{H}_8 + 6\text{O}_2 \rightarrow 4\text{CO}_2 + 4\text{H}_2\text{O}$	-2710

(3 marks)

e. The following reaction shows the combustion of ammonia:



The table below gives the thermodynamic data at 298 K

Substance	$\Delta H^\circ$ (kJ mol <sup>-1</sup> )	$\Delta G^\circ$ (kJ mol <sup>-1</sup> )	$S^\circ$ (J K <sup>-1</sup> mol <sup>-1</sup> )
NH <sub>3</sub> (g)	-80	-27	111
O <sub>2</sub> (g)	0	0	205
NO(g)	90	87	211
H <sub>2</sub> O(g)	-242	-229	189

i) Calculate  $\Delta H^\circ$ ,  $\Delta S^\circ$ ,  $\Delta G^\circ$  and K (at 298 K) for each of the three steps in the Ostwald process.

(8 marks)

ii) Calculate the equilibrium constant for these first step at 825°C, assuming  $\Delta H^\circ$  and  $\Delta S^\circ$  do not depend on temperature.

(2 marks)

*Examiner: Assoc Prof Samuel Ndur*