THE COUNCIL OF COMMUNITY COLLEGES OF JAMAICA

ASSOCIATE OF SCIENCE EXAMINATION

SEMESTER II – 2019 MAY

PROGRAMME:	**ENGINEERING**
COURSE NAME:	**CHEMISTRY FOR ENGINEERS**
CODE:	**CHEM2401**
YEAR GROUP:	**TWO**
DATE:	**TUESDAY, MAY 14**
TIME:	**3:00 P.M. – 5:00 P.M.**
DURATION:	**2 HOURS**
EXAMINATION TYPE:	**FINAL**

This Examination Paper has 7 Pages

INSTRUCTIONS:

1. **THIS PAPER CONSISTS OF SIX (6) QUESTIONS. ANSWER ANY FOUR (4)**

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

SECTION A

Instruction: Answer any <u>FOUR (4)</u> questions in the booklet provided.

Question 1

The safety air bags used in many vehicles are inflated on impact by a gas that is produced from the rapid decomposition of sodium azide (NaN_3).

A. Assuming that the gas produced behaves as an ideal gas under these conditions:

i. State **<u>TWO (2)</u>** properties of an ideal gas. ***(2 marks)***

ii. Use the ideal gas equation to calculate the number of moles of gas produced in an airbag of volume 4.0×10^{-3} m^3 at a pressure of 2.0×10^5 $N.m^{-2}$ and a temperature of 298 K. ***(4 marks)***

iii. Given that the mass of gas produced in the airbag is 87.5g, use the answer from (**A.** part **ii.**) to calculate the molar mass of the gas. ***(3 marks)***

B. State Boyle's Law and Charles' Law and display both graphically. ***(4 marks)***

C. The foul odour of dirty socks may be attributed to caproic acid, which is an organic acid made of 62% carbon, 10.3% hydrogen and 27.6% oxygen.

i. Define the terms *empirical formula* and *molecular formula* ***(2 marks)***

ii. Calculate the empirical formula of caproic acid. ***(3 marks)***

iii. Calculate the molecular formula of caproic acid, given that its molar mass is $116 g.mol^{-1}$. ***(2 marks)***

(Total 20 marks)

Question 2

A. Draw and describe the shapes of the *s* and *p* orbitals. *(3 marks)*

B. i. Water (H_2O) and hydrogen chloride gas (HCl) molecules exhibit different intermolecular, but similar intramolecular forces of attraction. With the aid of diagrams, differentiate between these specific types of bonds. *(10 marks)*

ii. Using $MgCl_2$ and FBr as examples:

1. show how ionic and covalent bonds are formed. *(4 marks)*

2. state **THREE (3)** properties of any **ONE (1)** of the two compounds. *(3 marks)*

(Total 20 marks)

Question 3

A. The following data was obtained for the reaction between two reactants A and B at 55 °C.

Exp. #	[A]/ mol dm^{-3}	[B] / mol dm^{-3}	Initial Rate/ mol dm^{-3}
1	0.10	0.10	1.0×10^{-3}
2	0.20	0.10	2.0×10^{-3}
3	0.30	0.10	3.0×10^{-3}
4	0.10	0.20	1.0×10^{-3}
5	0.10	0.30	1.0×10^{-3}

i. Calculate the order of the reaction with respect to A and B and hence write the rate law. *(5 marks)*

ii. Determine the value of the rate constant at this temperature. Include units. *(3 marks)*

iii. Calculate the initial rate of the reaction when both reactants have an initial concentration of 0.20 mol dm^{-3}. *(3 marks)*

iv. Calculate the half-life of the reaction at this temperature. *(3 marks)*

B. With the aid of a suitable diagram, describe how the rate of a chemical reaction is affected by an increase in temperature. *(6 marks)*

(Total 20 marks)

Question 4

A. Define the term galyanic cell. *(2 marks)*

B. Draw a diagram of a galvanic cell which has the following overall cell reaction

$$Zn(s) + Pb^{2+}(aq) \rightarrow Zn^{2+}(aq) + Pb(s)$$

i. Label the anode and the cathode. *(2 marks)*

ii. Identify the ions in the solutions, with their respective concentrations. *(2 marks)*

iii. Indicate the direction of electron flow in the wire. *(1 mark)*

iv. Indicate an appropriate electrolyte for the salt bridge and the direction of ion flow. *(2 marks)*

C. With reference to part (**B.**) above:

i. State **TWO (2)** purposes of the salt bridge? *(2 marks)*

ii. Use the data booklet provided to calculate the standard EMF of the cell, and further state if the reaction is spontaneous or non-spontaneous. *(3 marks)*

iii. Write balanced half equations for the reaction at each electrode. *(2 marks)*

iv. Identify the oxidising and reducing agents and write the shorthand cell notation. *(4 marks)*

(Total 20 marks)

Question 5

A. i. State *Le Chatelier's Principle.* ***(2 marks)***

ii. Based on *Le Chatelier's Principle*, briefly explain the effect on the equilibrium amount of ammonia (NH_3) in the equilibrium reaction below, if:

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H^{\theta} = -906\ kJ$$

1. oxygen gas is removed from the system
2. the volume of the container is increased
3. the temperature is increased
4. a metal catalyst is added

(8 marks)

iii. Write the equilibrium expressions for K_c and K_p for the reaction in (**A.** part **ii.**) above. ***(2 marks)***

iv. Calculate the equilibrium concentration of ammonia (NH_3) at 25 °C, if $K_c = 0.828$ (at 25 °C) and the concentrations at equilibrium for O_2, NO and H_2O are 0.112, 0.332 and 0.233 mol dm^{-3} respectively. ***(3 marks)***

B. Formic acid (HCOOH) naturally occurs in ant stings.

i. Write the balanced chemical equation to show formic acid acting as a Bronsted-Lowry acid. ***(1 mark)***

ii. Calculate the pH of a 0.025 mol dm^{-3} formic acid solution, if $K_a = 1.8 \times 10^{-4}$. ***(4 marks)***

(Total 20 marks)

Question 6

A. What do you understand by the term bond energy? *(1 mark)*

B. The lattice energy of lithium chloride can be calculated from a Born-Haber cycle using the following data:

	$\Delta H°$/kJ mol^{-1}
first ionization energy of lithium,	+520
enthalpy change of atomization of lithium,	+159
enthalpy change of atomization of chlorine,	+121
electron affinity of chlorine atoms,	-364
enthalpy of formation of lithium chloride	-409

Required:

i. Write an equation, including state symbols, for each of the enthalpy changes listed below:

1. First ionization energy of lithium
2. Enthalpy change of formation of lithium chloride
3. The lattice energy of lithium chloride *(6 marks)*

ii. Construct a labelled Born-Haber cycle for lithium chloride and use the cycle to calculate the lattice energy of lithium chloride. *(11 marks)*

iii. Explain how you could expect the numerical magnitude of the lattice energy of lithium chloride to compare with that of sodium chloride. *(2 marks)*

(Total 20 marks)

END OF EXAMINATION