DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

UNIVERSITY EXAMINATIONS 2014/2015

YEAR TWO SEMESTER II EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN INDUSTRIAL CHEMISTRY

SCH 2362: POLYMER SYNTHESIS AND STRUCTURE

DATE: 2ND FEBRUARY 2015 **TIME: 11.00AM-1.00 PM**

INSTRUCTIONS:

1. This examination set consists of **5** questions. Please ensure that your copy of this examination is complete. Answer Question **ONE** and any other **TWO** questions**.**
2. Your attention is drawn to the University policy on cheating.

QUESTION ONE (30 MARKS)

a) The disposal of non-biodegradable polymers is a significant problem. List three options used in their disposal: (3 marks)

b) What is a polymeric fibre? (2 marks)

c) List any six polymers which can be drawn into fibres. (3 marks)

d) Nylon is strong when pulled or stretched, but is usually weak when pulled in the direction at right angles to their orientation. Explain. (4 marks)

e) Write an equation for the formation of nylon 6. (2 marks)

f) Why are condensation reactions performed under a vacuum? (2 marks)

g) Define the following terms: (5 marks)
   i. Linear polymers
   ii. Branched polymers
   iii. Cross-linking in polymers
   iv. Homopolymers
   v. Copolymers

h) Give two differences between step growth polymerization and chain growth polymerization reactions? (2 marks)

i) Ethylene (ethene) is a hydrocarbon. Give names and structural formulae of two other hydrocarbons that, like ethylene, can serve as monomers. (2 marks)

j) Determine the number of $H_2C=CH_2$ monomeric units, *n*, in one molecule of polyethylene with a molar mass of 40,000 g. How many carbon atoms are in this molecule? (3 marks)

k) Sodium polyacrylate can absorb 800 times its weight in distilled water, but only 300 times its weight in tap water and 30 times its own weight in urine. Explain. (2 marks)

QUESTION TWO (20 MARKS)

a) Discuss any four properties of condensation polymers. (8 marks)

b) Giving examples, discuss any four uses of condensation polymers based on their properties. (4 marks)

c) Copolymers can have several configurations or arrangements of the monomers along the chain. Illustrate four main configurations. (4 marks)

d) Draw a diagram to show the relationships among these terms: silk, synthetic, natural, Kevlar, polymer, nylon, protein, bakelite, cellulose. Add other terms as needed. (4 marks)

QUESTION THREE (20 MARKS)

a) Discuss the physical structure of polymers. (10 marks)

b) Discuss any two features of thermosets. (4 marks)

c) Although thermosets are difficult to reform, they have many distinct advantages in engineering design applications. List four advantages of thermosets. (2 marks)

d) Discuss the applications of polymers in any four of the following areas: (4 marks)

i. Agriculture and Agribusiness
ii. Medicine
iii. Consumer Science
iv. Industry
v. Sports

QUESTION FOUR (20 MARKS)

a) Celluloid was the first commercial plastic, developed in response to the need to replace ivory for billiard balls and piano keys. Speculate on the properties of celluloid that made it a successful substitute for ivory in these products. (2 marks)

b) In 2007, Cargill won a green chemistry award for using soybeans instead of petroleum to produce polyols. What is a polyol, and how are polyols used to produce "soybean plastics"? (4 marks)

c) Silk is an example of a natural polymer.

i. Name three properties that make silk desirable. (3 marks)

ii. Which synthetic polymer has a chemical structure modelled after silk? (1 mark)

d) Which of the "Big Six" polymers would most likely be used for these applications? (7 marks)

i. clear soda bottles
ii. opaque laundry detergent bottles
iii. clear, shiny shower curtains
iv. tough indoor–outdoor carpet
v. plastic baggies for food
vi. packaging "peanuts"
vii. containers for milk

e) Name the functional group(s) in each of these monomers. (3 marks)

i. styrene
ii. ethylene glycol
iii. terephthalic acid
iv. the amino acid where R = H
v. hexamethylenediamine
vi. adipic acid

QUESTION FIVE (20 MARKS)

a) Discuss any four properties of addition polymers. (8 marks)

b) There is much controversy concerning the recycling and reuse of PVC due to health and safety issues. Discuss. (4 marks)

c) Catalysts are used to help control the average molar mass of polyethylene, an important strategy to control polymer chain length. During World War II, low-pressure polyethylene production used varying mixtures of triethylaluminum, $Al(C_2H_5)_3$, and titanium tetrachloride, $TiCl_4$, as a catalyst. Here is some data showing how the molar ratio of the two components of the catalyst affects the average molar mass of the polymer produced.

Moles of $Al(C_2H_5)_3$	Moles of $TiCl_4$	Average molar ass of Polymer, g
12	1	272,000
6	1	292,000
3	1	298,000
1	1	284,000
0.63	1	160,000
0.53	1	40,000
0.50	1	21,000
0.20	1	31,000

i. Prepare a graph to show how the molar mass of the polymer varies with the mole ratio of $Al(C_2H_5)_3$/ $TiCl_4$. (3 marks)

ii. What conclusion can be drawn about the relationship between the molar mass of the polymer and the mole ratio of $Al(C_2H_5)_3/TiCl_4$? (1 mark)

iii. Use the graph to predict the molar mass of the polymer if an 8:1 ratio of $Al(C_2H_5)_3$ to $TiCl_4$ were used. (1 mark)

iv. What ratio of $Al(C_2H_5)_3$ to $TiCl_4$ would be used to produce a polymer with a molar mass of 200,000? (1 mark)

v. Can this graph be used to predict the molar mass of a polymer if either pure $Al(C_2H_5)_3$ or pure $TiCl_4$ were used as the catalyst? Explain. (2 marks)