



MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR
BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

SAN 409: POLYMER SYNTHESIS AND APPLICATIONS

DATE:

TIME:

INSTRUCTIONS:

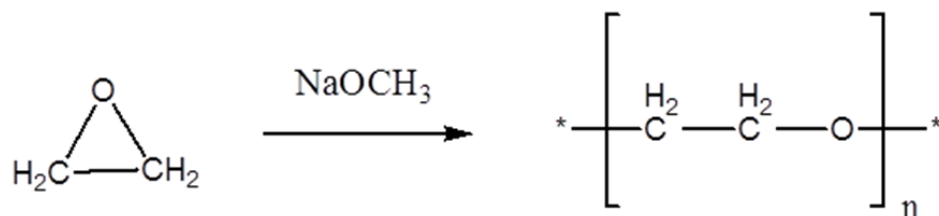
- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

SECTION A

QUESTION ONE (COMPUOLSORY) (30 MARKS)

- a) Differentiate between the following polymer classifications. (6 marks)
- Isotactic and Syndiotactic
 - Thermoplastic and thermoset
 - Fibers and elastomers
- b) Differentiate between synthetic and natural polymers and give example in each. (4 marks)
- c) Explain the following terms as used in the polymer molecular weight measurements. (6 marks)
- End group analysis
 - Light-scattering technique

- (iii) Freezing point depression
- d) Gel permeation chromatography (GPC) is the most commonly used for both molecular weight and dispersity measurement nowadays. Explain its major limitations. (2 marks)
- e) Provide the detailed mechanism for the formation of the following polymer and name its uses. (4 marks)

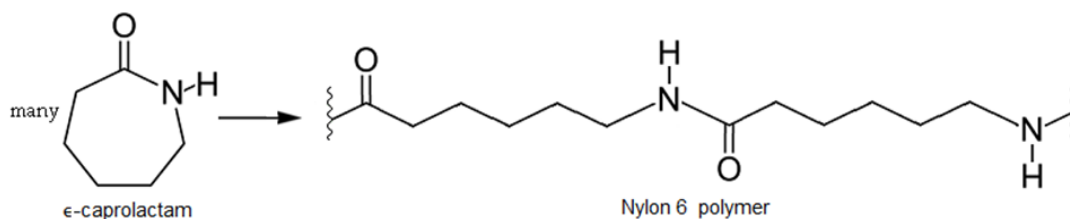


- f) Draw the structures and name the copolymers that may be formed from the following monomers, give at least one use in each. (6 marks)
- (i) $\text{H}_2\text{C}=\text{C}(\text{CH}_3)_2$ $\text{H}_2\text{C}=\text{C}-\text{CH}=\text{CH}_2$
- (ii) $\text{H}_2\text{C}=\text{CHCN}$ $\text{H}_2\text{C}=\text{C}-\text{CH}=\text{CH}_2$
- g) The degree of polymerisation indicates the number average molecular weight of the polymer (M_n). Calculate M_n of polymethacrylamide ($\text{C}_4\text{H}_7\text{NO}$), with DP of 750. (2 marks)

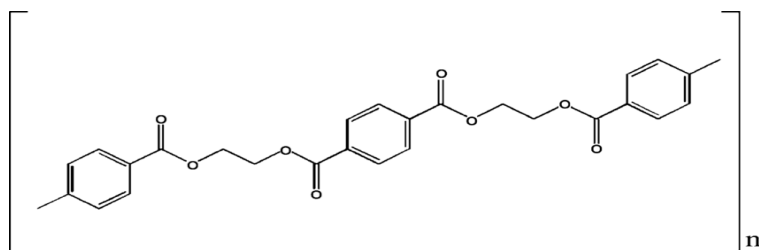
SECTION B

QUESTION TWO (20 MARKS)

- a) Both $-\text{CO}(\text{CH}_2)_4\text{CO}-\text{OCH}_2\text{CH}_2\text{O}-$ and $-\text{CO}(\text{C}_6\text{H}_4)\text{CO}-\text{OCH}_2\text{CH}_2\text{O}-$ are polyesters however, they vary greatly in terms of both melting and glass transition temperatures, explain these differences. (3 marks)
- b) What are polyamides? (2 marks)
- c) Both Nylon 6 and Nylon 6,6 are polyimides, however, they are formed differently. Explain these differences. (4 marks)
- d) Provide a detailed mechanism for the formation of Nylon 6 from ϵ -caprolactam. (6 marks)



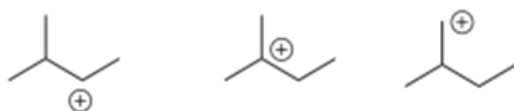
- e) The following polyester is sometimes called PET or Terylene depending on the uses, explain these differences. (2 marks)



- f) With help of schematic diagram explain what is Cold-drawing used in formation of polymer fibres. (3 marks)

QUESTION THREE (20 MARKS)

- a) List three factors that can enhance the stability of carbocations. (3 marks)
- b) Choose the most stable cation and provide a reason for the stability of that cation. (2 marks)



- c) Provide a reason why isobutylene, $(\text{CH}_3)_2\text{C}=\text{CH}_2$, is a good example of an alkene that can form a stable cation upon protonation. (2 marks)
- d) The obvious way to initiate cationic polymerizations is through addition of a strong acid such as hydrochloric acid (HCl), however, addition of dry HCl gas would doom polymerization to an early death. Using an example of isobutylene explain the reason for this phenomenon. (3 marks)
- e) Between the isolated and conjugated alkenes which one is suitable for anionic polymerization, explain the reason. (4 marks)
- f) What is “chain transfer” as used in addition polymerization. (2 marks)
- g) Using an example, write equations that differentiate between intermolecular and intramolecular chain transfer. (4 marks)

QUESTION FOUR (20 MARKS)

- a) What is Free Radical Polymerization? (2 marks)
- b) Using R-O-O-R and $\text{CH}_2=\text{CH}_2$ as an example, explain in detail the three major steps of Free Radical Polymerization. (9 marks)

- c) Explain thermodynamics of Free Radical Polymerization using Gibbs free energy (ΔG_p). (2 marks)
- d) Using thermodynamic equation ($\Delta G = \Delta H - T\Delta S$), explain the situations in which polymerization, depolymerization or equilibrium may be favored. (4 marks)
- e) What are the applications of Free Radical Polymerization? (3 marks)

QUESTION FIVE (20 MARKS)

- a) Explain the following polymerization processes. (12 marks)
- (i) Atom transfer radical polymerization (ATRP)
 - (ii) Reversible addition-fragmentation chain transfer (RAFT)
 - (iii) Nitroxide mediated free radical polymerization (NMRP)
- b) Show how metal complex EtTiCl_4 reacts with alkenes to initiate Ziegler-Natta polymerization. (4 marks)
- c) Give two polymers commonly synthesized via Ziegler-Natta polymerization. (2 marks)
- d) Explain what is gelation in polymerization. (2 marks)

END