KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR

FOURTH YEAR FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF BSC (PHYICS)

COURSE CODE: **SPM 412**

COURSE TITLE: **POLYMERS I**

DURATION: **2HRS**

DATE: 17/04/2023   **TIME:** 9:00-11:00AM


INSTRUCTIONS TO CANDIDATES

- Answer question ONE (compulsory) and any TWO of the remaining questions.
  - Attempted questions must be indicated on front cover of answer booklet.
  - Every question should be started on new page and question indicated respectively.
  - The symbols used bears the usual meaning.

Question One (30 Marks)

a. Define polymer.   2mks

b. Discuss the general structural and chemical characteristics of polymer molecules. 4mks

c. What are some of the common polymeric materials, and how do they differ chemically? (4mks)

d. How is the crystalline state in polymers different from that in metals and ceramics? 2mks

e. Discuss the concept Viscoelasticity as used in polymers. 4mks

f. During classification of different categories of terms that is; macromolecule, polymer and plastics, we note that plastics are polymers and macromolecules while polymers are macromolecules; but not all macromolecules are polymers and all polymers are not plastics.

    i. Give an example of a macromolecule that is not a polymer.   2mks

    ii. Give an example of a polymer that is not a plastic.   2mks

    iii. Define plastic.   1mk

    iv. Define macromolecule.   1mk

g. The zero-shear rate viscosity, η_0, displays power-law behavior in molecular weight in two distinct and universal regimes. Sketch log viscosity versus log of molecular weight showing these two regimes and give the slope of the curve in these two regimes and explain why two regimes are observed.   4mks

h. Derive the Relaxation Modulus $E(t)$ for the Maxwell material.   4mks

Question Two (20 Marks)

a. As an alternative to bulk polymerization, it is possible to run polymerization reactions in the presence of solvent and under several other unique conditions. Briefly discuss polymerization hence discuss any four classification methods used to classify polymer, discussing two examples under each category. (10 marks).

b. Termination of chain growth can occur by disproportionation *or* through a variety of chain transfer reactions. Explain what is meant by chain transfer. Also, a chain transfer to initiator [I2] involves the reaction

$$P + I_2 \rightarrow PI + I$$
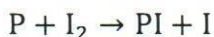
Write an expression for the rate of chain transfer to initiator using the initiator concentration $[I_2]$ and the concentration of propagating species [P]. At steady state [P] ~ $[I_2]^{\frac{1}{2}}$. Write an expression for the kinetic chain length, v = Rp/Rt, where Rt includes all reactions that end chain growth and explain why $1/v$ is a more useful function that v.   (10 marks)

Question Three (20 Marks)

a. Hydrolysis/condensation reactions are the basis for a wide range of ceramic and polymer synthesis reactions. Show how silica (SiO_2) is made from TEOS ($Si(OC_2H_5)_4$) and water in a two-step reaction. Sketch the chemical structure of the reactants and products. What catalyst is used in this reaction and what is the by-product from this reaction. (10 Marks)

i. Polymer melts are processed at high rates of strain, $\frac{d\gamma}{dt}$, in an extruder or injection molder. Sketch a typical plot of polymer viscosity versus rate of strain on a log-log plot showing the power-law region and the Newtonian plateau at low rates of strain. Explain using this plot why polymers are processed at high rates of strain. (10 marks)

Question Four

a. Explain how the polyurethane shown below is a hybrid of a polyester and a polyamide. What monomers would be used to make this polymer and what is the by-product of this reaction. Explain why the by-product in this reaction might might be important to a coating application. (10 Marks)
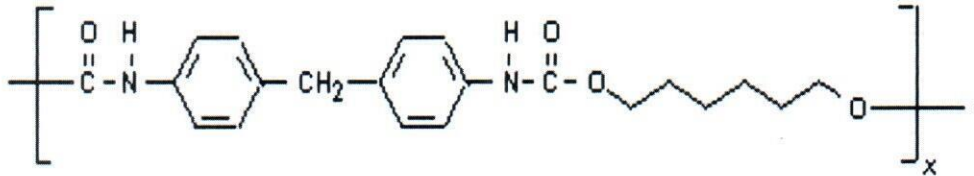
b. Nylon is commonly made by step-growth polymerization. Give the structure of nylon circling the chemical group that defines this polymer as nylon. Explain why this is a condensation polymerization and what molecule condenses. How is this reaction driven to completion and why is driving the reaction to completion important to condensation polymerizations? (10 Marks)