

UNIVERSITY OF RUHUNA

BACHELOR OF SCIENCE GENERAL DEGREE (LEVEL III)

SEMESTER II EXAMINATIONS - JANUARY 2022

SUBJECT: Chemistry

COURSE UNIT: CHE 3222 (Industrial Polymer Chemistry)

TIME: 1.5 hours

Answer **three (03)** questions only.

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01. Answer **all** parts.

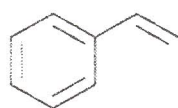
(a) The practical significance of tacticity rests on the effects on physical properties of a polymer. Precise knowledge of tacticity of a polymer helps understanding at what temperature a polymer melts, how soluble it is in a solvent and its mechanical properties.

(i) Explain the term "*Tacticity*" pertaining to polymer chemistry.

(15 marks)

(ii) Styrene can be subjected to the polymerization under specific conditions to obtain an *isotactic* polymer.

Explain what is meant by *isotactic* with respect to the *mode of arrangement of monomer units* in the polymer chain.



Styrene

(20 marks)

(iii) Sketch suitable diagrams to show the structures of the following:

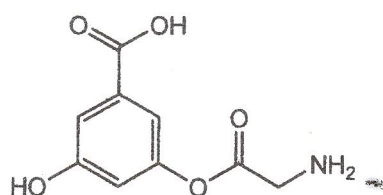
(I) A linear polymer, a branched polymer, and a cross-linked polymer.

(15 marks)

(II) Random copolymer and a graft copolymer.

(10 marks)

- (b) Comment on the “*nature of the structure*” of a polymer likely to be formed by identifying the *functional groups* present in the monomer given below and sketch the *repeating unit* of the polymer.



(20 marks)

- (c) “Glyptal” is a polymer synthesized by condensation polymerization of two monomers viz., phthalic anhydride and glycerol, in the presence of sodium acetate. In a typical laboratory synthesis following amounts were used.
- 5 g of phthalic anhydride
  - 2 mL of glycerol in the presence of 0.25 g of sodium acetate

Calculate the mole ratio of phthalic anhydride to glycerol used in the “Glyptal” polymer synthesis.

**Note:** RMM of glycerol = 92.09, phthalic anhydride = 148.12. and density of glycerol = 1.261 g mL<sup>-1</sup>.

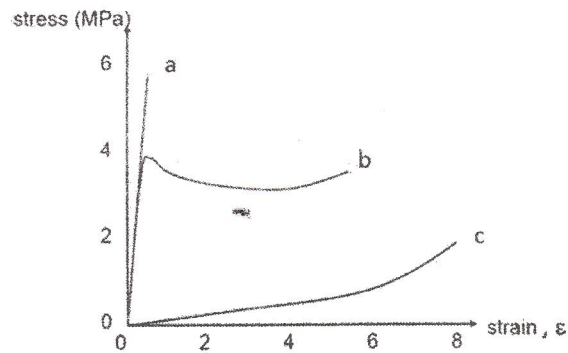
(20 marks)

02. Answer all parts.

- (a) Define the following terms applicable to the field of polymer science
- Stress of a polymeric material
  - Strain of a polymeric material
  - Young’s modulus
  - Glass transition temperature ( $T_g$ )

(20 marks)

- (b) The sketch of stress versus strain behaviors for three different polymeric materials is given below. Identify the three different polymeric materials.



(15 marks)

- (c) Sketch a diagram to distinguish between *amorphous* and *crystalline* regions of a semi-crystalline polymer.

(10 marks)

- (d) Sketch the shapes of the following polymers.

- (i) Linear polymer
- (ii) Ring polymer
- (iii) Star polymer

(15 marks)

- (e) What do you understand by the term “*a composite*”?

(10 marks)

- (f) Identify **five** (5) modern sophisticated instruments available in polymer analysis.

(15 marks)

- (g) Sketch a diagram to distinguish thermosetting polymers versus thermoplastic polymers.

(15 marks)

03. Answer **all** parts.

- (a) Imagine that you are a production manager of a dry rubber-based product manufacturing industry. Name **five** (05) test parameters to be checked for the main raw material and briefly explain their significances. (20 marks)

- (b) What are the main categories of compounding ingredients used in dry rubber product manufacturing?

(20 marks)

(c) A typical rubber carpet formulae is given below;

Ingredient	Phr
Technically Specified Rubber (SLR 20)	100
Zinc oxide (ZnO)	5
Stearic acid	2
Carbon Black N 660	30
Paraffinic oil	3
N-isopropyl-N-phenylenediamine (IPPD)	2
N-tert-butyl benzothiazole sulphenamide (TBBS)	1
Sulphur	2

- (i) Give a detailed flow diagram for the manufacture of a carpet related to the above formula starting from the raw material.
- (ii) Comment on the vulcanization system used in the carpet formulae.
- (iii) If the factory daily produces 150 carpets and each carpet has 2 kg weight, calculate the daily requirement of each ingredient for rubber compounding.
- (iv) Suggest a modification for the carpet rubber formulae to improve the oil resistance property of the final product.

(60 marks)

04. Answer all parts.

- (a) The degree of polymerization ( $D_p$ ) may be defined as the average number of base units per molecule if the molecules are composed of regularly repeating units, or as the average number of monomeric units per molecule.
  - (i) Write an expression for the "Degree of Polymerization".
  - (ii) A given monomer has a relative molar mass of 40. When this monomer is subjected to the addition polymerization, the polymer formed has an average molar mass of 28,000. Calculate the average number of repeating units in this polymer.

(15 Marks)



- (b) Comment briefly on the statement “ionic salts have sharp melting points, whereas polymers do not”.  
(10 marks)
- (c) What are the properties that should be fulfilled by fillers to be used in polymer processing formulations?  
(15 marks)
- (d) Explain briefly the following terms in the field of thermoplastic resins.  
(15 marks)
- (i) Gel time
  - (ii) Pot life
  - (iii) Shelf-life
- (e) Amino resins are class of thermosetting plastics produced by the condensation reaction of an amine such as urea or melamine with an aldehyde like formaldehyde. Amino resins are used for molded plastics, coatings, adhesives, laminating, textile finishes, and paper manufacture.  
(10 marks)
- (i) Identify the advantages of amino resins to be used as a wood adhesives.  
(10 marks)
  - (ii) What are the *parameters* to be considered when you are synthesizing a urea-formaldehyde resin?  
(10 marks)
  - (iii) Explain why these parameters are so important?  
(10 marks)
- (f) Explain briefly how you experimentally measure the gel time of a thermosetting resin (e.g., urea - formaldehyde resin = UF) at 100 °C.  
(15 marks)

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