



UNIVERSITY OF KELANIYA - SRI LANKA  
FACULTY OF SCIENCE

B.Sc. Honours Degree in Applied Chemistry Examination—  
November 2023 Academic Year 2022/2022 – Semester I

APCH- 21672- Polymer Chemistry

Number of Questions: Four (04)

Time: Two (02) hours

Number of pages: Four (04)

Answer all questions.

1. (a) "Terylene" is a condensation polymer that can be formed from benzene-1,4-dicarboxylic acid and ethane-1,2-diol. Draw chemical formulae to represent,

- (i) benzene-1,4-dicarboxylic acid
- (ii) ethane-1,2-diol
- (iii) the polymer "Terylene"

(15 marks)

(b) Sketch the structure of the **repeat unit** of each of the following **alternating copolymers**:

- (i) poly(butadiene-chloroprene)
- (ii) poly(styrene-methyl methacrylate)
- (iii) poly(acrylonitrile-vinyl chloride)

(30 marks)

(c) (i) State the virial expression for osmotic pressure and define all the terms.

$$\frac{\pi}{c} = \frac{RT}{M_n} + A_2C$$

(ii) Briefly describe the Membrane Osmometry method which can be used to determine the number average molecular weight of a polymer.

(iii) State limitation/s in Membrane Osmometry method.

(iv) What is a theta solvent? → a good solvent?

(v) Following data were obtained by membrane osmometry of solutions of a polychloroprene sample in toluene at 30°C. Try to use SI units.

|                           |      |      |      |      |      |
|---------------------------|------|------|------|------|------|
| $c$ (mg/cm <sup>3</sup> ) | 1.33 | 2.10 | 4.52 | 7.18 | 9.87 |
| $\Pi$ (N/m <sup>2</sup> ) | 30   | 51   | 132  | 246  | 390  |

(I) Calculate the average molecular weight of the sample.

(II) Calculate the second virial coefficient,  $A_2$ . What can you say about the ?  
interaction between polystyrene and xylene at this temperature?

(55 marks)

2. (a) Explain the rationale behind the following statements.

(i) Poly(tetrafluoroethylene) is used in making non-stick cookware.

(ii) Polyamides are best used as fibers.

(iii) Both low density polyethylene and high-density polyethylene are polymers made using the monomer ethylene, but there are marked differences in their properties.

(20 marks)

(b) Explain the following terms that can be used to describe the mechanical properties of polymers with the aid of suitable diagrams.

(i) Elastic deformation

(ii) Toughness

(iii) Resilience

(20 marks)

(c) Answer the following questions regarding Ziegler Natta catalyst:

(i) What is the major structural feature of an alkene that is required to undergo Ziegler Natta catalytic polymerization?

(ii) Show the structure of catalytic compound formed by  $\text{TiCl}_4$  and  $\text{Al}(\text{C}_2\text{H}_5)_3$ .

(iii) Explain schematically how a Ziegler Natta catalyst facilitates the conversion of ethylene to a representative oligomer.

(40 marks)

(d) Define the "glass transition temperature" of a polymer. How can it be measured? What molecular characteristics determine its value?

*the temperature at which the polymer becomes a hard glassy*

(20 marks)

3. (a) The molecular weight data for a polypropylene material are tabulated below.

Compute

(i) the number-average molecular weight

(ii) the weight-average molecular weight, and

(iii) Polydispersity index

(iv) Degree of polymerization of this polymer matrix.

| Molecular weight range (g/mol) | $x_i$ | $w_i$ |
|--------------------------------|-------|-------|
| 10,000-20,000                  | 0.03  | 0.01  |
| 20,000-30,000                  | 0.09  | 0.04  |
| 30,000-40,000                  | 0.15  | 0.11  |
| 40,000-50,000                  | 0.25  | 0.23  |
| 50,000-60,000                  | 0.22  | 0.24  |
| 60,000-70,000                  | 0.14  | 0.18  |
| 70,000-80,000                  | 0.08  | 0.12  |
| 80,000-90,000                  | 0.04  | 0.07  |

(50 marks)

- (b) The following data were obtained represents the Mark-Houwink-Sakurada constants,  $K$  and  $a$  of a polymer, polyisobutylene in benzene and cyclohexane solution at 25 °C. Determine the intrinsic viscosity of polyisobutylene in these solutions if the viscosity average molecular weight of the polymer is 104,160 g/mol.

| Polymer / solvent            | $K$ (mL/g)           | $a$ |
|------------------------------|----------------------|-----|
| Polyisobutylene / benzene    | $8.3 \times 10^{-2}$ | 0.5 |
| Polyisobutylene/ cyclohexane | $2.6 \times 10^{-1}$ | 0.7 |

(25 marks)

- (d) State the function of the following additives used in polymer industry and give an example for each.

- (i) Antioxidants
- (ii) Plasticizers  $\rightarrow$  processability, flexibility
- (iii) Fillers  $\rightarrow$  bulk and mechanical
- (iv) Lubricants  $\rightarrow$  easy to get from world

(25 marks)

- 4 (a) (i) State the raw materials used in solvent-based paint manufacture and explain how they react to form a network polymer.
- (ii) Differentiate between alkyd paint and acrylic paint
- (iii) What are the most important properties of a solvent used in paint manufacture?
- (iv) Explain the drying process of alkyd paints.  $\rightarrow$  solvent evaporation.
- (v) State the quality parameters that are tested during the manufacturing process of alkyd resin. Show how these parameters change as the reaction proceeds.

(40 marks)

- (b) Draw the structures of the polymers having following trade names

- (i) Lexan
- (ii) BUNA-N
- (iii) BUNA-S
- (iv) Saran
- (v) Nylon 6,12

(25 marks)

- (c) (i) Natural rubber becomes stiff by the vulcanization with sulfur. Briefly explain this statement.  $S-S-S$

- (ii) Applications of vulcanized rubber depend upon the **amount of sulfur added**. Briefly discuss this statement.

- (iii) State two other vulcanization agents of rubber and illustrate the process with an example for each

(35 marks)

