

National Exams

98-Chem-B8, Polymer Engineering

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. Candidates may use any nonprogrammable calculator,
This is an Open Book Exam.
3. Any four questions constitute a complete paper. Only the first four questions as they appear in your answer book will be marked.
4. All questions have equal value.

Question 1
(20 marks)

- (a) Some polyesters may be either thermoplastic or thermosetting. Suggest 1 reason for this.
(3 marks)
- (b) Why does an injection-molded polystyrene protractor show a complicated pattern when viewed in polarized light?
(5 marks)
- (c) Two copolymers of ethylene ($\text{CH}_2 = \text{CH}_2$) and propylene ($\text{CH}_2 = \text{CH CH}_3$) have the same ratio of monomers. However, one is rubbery at room temperature and does not stiffen until the temperature is lowered to about -70°C , while the other is rather stiff, tough, and opaque at room temperature. Explain the difference.
(8 marks)
- (d) What is wrong with describing a sample of polyisobutylene as “predominantly cis” or “syndiotactic”?
(4 marks)

Question 2
(20 marks)

- (i) Why must fiber materials that are melt spun and then drawn be thermoplastic? Give 2 reasons.
(4 marks)
- (ii) List 2 important characteristics for polymers that are to be used in fiber applications?
(4 marks)
- (iii) Outline a suitable method of manufacture for:
(12 marks)
- (a) 100,000 ft of garden hose from plasticized poly(vinyl chloride).
 - (b) 50,000 pocket combs from polystyrene.
 - (c) two boat hulls each 15 ft long, from glass cloth and a solution of an unsaturated polyester in styrene monomer.

Question 3
(20 marks)

- (i) Polycaprolactone has a $T_g = -60^\circ\text{C}$ and $T_m = +60^\circ\text{C}$. In the study of biodegradability at 25°C it would be desirable to vary the degree of crystallinity holding all variables constant. Why is it difficult with polycaprolactone?
(5 marks)

Why should it be easier with poly(ethylene terephthalate), which has $T_g = +60^\circ\text{C}$ and $T_m = 250^\circ\text{C}$?

- (ii) A polymer shipment is to be made up by blending three lots of polyethylene, A, B, and C. How much of each lot is needed to make up a shipment of 50,000 lb with a weight-average molecular weight of 250,000 and polydispersity index (PDI) of 3.65?
(15 marks)

Lot	Weight-average mol wt	PDI
A	500,000	2.50
B	250,000	2.00
C	125,000	2.50

Question 4
(20 marks)

(a) (i) In what way do emulsion and suspension polymerizations differ basically?
(8 marks)

(ii) In an unstirred, bulk polymerization that proceeds to 100% conversion, how can the effects of shrinkage and heat of polymerization be handled?

(b) The following data are obtained for the polymerization of a new monomer:
(12 marks)

Run	Temperature, °C	Conversion, %	Time, min	Initial monomer conc., mol/liter	Initial initiator conc., mol/liter
A	60	50	500	1.00	0.0025
B	80	75	700	0.50	0.0010
C	60	40	600	0.80	0.0010
D	60	50	-----	0.25	0.0100

(i) Predict the time for 50% conversion in run D.

(ii) Calculate the energy of activation for the polymerization.

Note: The initiator concentration is assumed to be constant. For each run, the variation of monomer concentration $[M]$ with time (t) can be taken as:

$$\ln \frac{[M]}{[M]_0} = -KI^{1/2} \cdot t$$

where $[I]$ = initiator concentration

K = combined rate constant

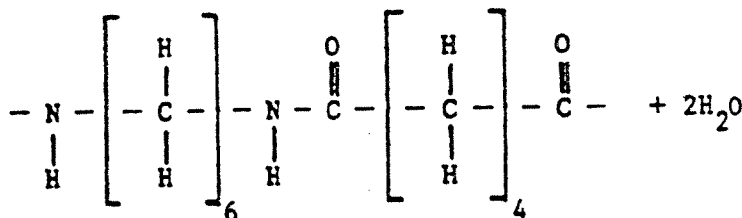
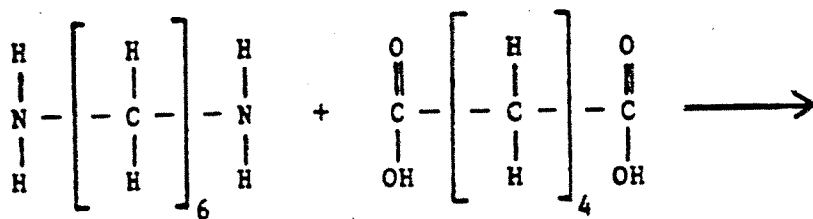
$[M]_0$ = initial monomer concentration

Question 5
(20 marks)

- (a) (10 marks)
- (i) Why must the vapor pressure of a plasticizer be relatively low?
 - (ii) How does the addition of plasticizer influence the tensile strength of a polymer? Why?
 - (iii) Contrast (briefly) compression, injection, and transfer molding techniques that are used to form plastic materials.
- (b) (10 marks) Nylon 6,6 may be formed by means of a condensation polymerization reaction as shown.

Hexamethylene diamine

Adipic acid



Nylon 6,6

What masses of hexamethylene diamine and adipic acid are necessary to yield 37.5 kg of completely linear nylon 6,6?