

PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Midterm Examination : Semester I

Academic Year : 2008

Date : 2 August 2008

Time : 09.00 – 12.00

Subject : 230 - 463 Polymer Technology

Room : Robot's Head

Student Name: ID no. :

Number of questions : 4

Time : 3 hours

Total marks : 100

Books and notes are not allowed

Calculators are allowed

Writing in pencil is allowed

All notations used on this examination paper have their usual meanings.

Question	Full Marks	Marks Received
1	20	
2	20	
3	30	
4	30	
Total	100	

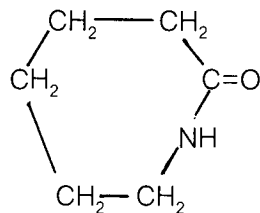
ทุจริตในการสอบโทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

Student Name: ID no. :

Question 1

- (a) Define the following terms: number-average degree of polymerization, tacticity, polydispersity index, glass transition temperature and crystalline polymer.
- (b) Explain the effects of increasing extent of reaction on weight fraction of x-mer for linear step polymerization.
- (c) Write termination reactions for the following chain reactions. Choose your own type of termination.
- (c.1) free radical polymerization of polypropylene
- (c.2) cationic polymerization of styrene
- (d) Some ring compounds can polymerize to yield high-molecular-weight polymers by ring-opening polymerizations. Write the reaction for polymerization of caprolactam monomer to form nylon6.

Chemical formula for caprolactam is shown below.



(20 marks)

Student Name: ID no. :

Question 2

The equivalent quantities of adipic acid $\text{HOOC}(\text{CH}_2)_2\text{COOH}$ and glycol $\text{HO}(\text{CH}_2)_2\text{OH}$ are used to produce a polyester. Methanol, CH_3OH is added to control the molecular weight of the polymer. If it is required to make $\bar{x}_n = 70$ at $p = 1$.

- (2.1) Write chemical structure and calculate molecular weight of the repeating unit formed.
- (2.2) Calculate the amount of methanol required as mole per cent of adipic acid.
- (2.3) Calculate the \bar{M}_n of the polymer produced.
- (2.4) If the same number of moles of glycerol $\text{HOCH}_2\text{CHOH}\text{CH}_2\text{OH}$ was added by error instead of glycol, will gelation occur?

Note:

When reactants are present in equivalent reactant mixture:

$$\bar{x}_n = \frac{1}{1-p}$$
$$p = \frac{2}{f_{av}} - \frac{2}{\bar{X}_n f_{av}}$$

When reactants are present in non-equivalent reactant mixture:

$$\bar{x}_n = \frac{1+r}{1+r-2rp}$$

where $r = N_A / N_B$ and $r < 1$

All notations have their usual meanings.

Atomic weights: C = 12, O = 16, H = 1

(20 marks)

Student Name: ID no. :

Question 3

- (a) Derive the rate of free radical chain polymerization to show that

$$- \frac{d[M]}{dt} = \frac{k_p}{k_t^{1/2}} (fk_d [I])^{1/2} [M]$$

State your reasons and assumptions used.

- (b) In the bulk polymerization of polystyrene no solvent is used. The density of styrene monomer is 0.8 g/cm^3 and its molecular weight is 104.14 g/mole . Benzoyl peroxide initiator (mol. wt. = 242 g/mole ; half life, $t_{1/2} = 44 \text{ hours}$) is used at 0.3% by weight. Termination occurs mainly by combination. The rate constants are:

$$k_p = 145 \quad \text{l/(mole.sec)}$$

$$k_t = 0.13 \times 10^7 \quad \text{l/(mole.sec)}$$

$f = 1.0$, and initiator concentration is assumed to be constant.

Calculate the time in hours required for 80% conversion.

(Hint: 1 litre of reactor volume contains 800 g of styrene)

Note:

$$t_{1/2} = \frac{\ln 2}{k_d}$$

$$- \ln \frac{[M]}{[M]_0} = \frac{k_p}{k_t^{1/2}} (f \cdot k_d [I])^{1/2} \cdot t$$

All notations have their usual meanings.

(30 marks)

Student Name: ID no. :

Question 4

- (a) Briefly explain the types of catalysts used in co-ordination polymerization.
- (b) The copolymer equation in terms of concentrations is given by:

$$\frac{d[M_1]}{d[M_2]} = \frac{[M_1](r_1[M_1] + [M_2])}{[M_2]([M_1] + r_2[M_2])}$$

It can also be written in mole fractions as shown below.

$$F_1 = \frac{r_1 f_1^2 + f_1 f_2}{r_1 f_1^2 + 2f_1 f_2 + r_2 f_2^2}$$

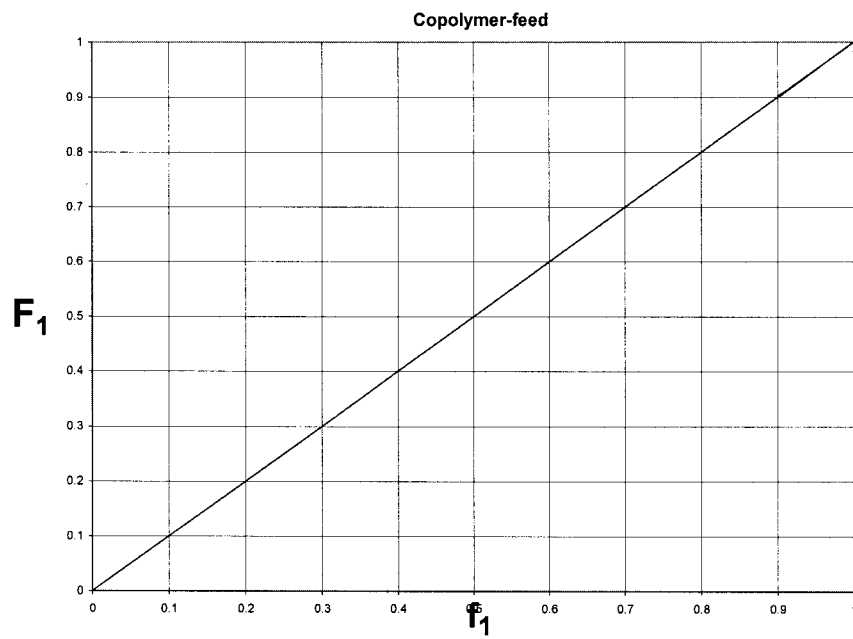
All notations have their usual meanings.

In a free radical copolymerization of monomer M_1 and monomer M_2 at 60°C , $r_1 = 0.64$, $r_2 = 0.28$, calculate F_1 at different values of f_1 .

- (b.1) Show f_1 and the corresponding F_1 in table form.
- (b.2) Plot f_1 versus F_1 .
- (b.3) Comment on the structure of the copolymer formed.
- (b.4) Comment on feed composition for this monomer pair.
- (b.5) Derive an equation for azeotropic copolymer composition.

(30 marks)

Student Name: ID no. :
Answer to Q4 (Continued)



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