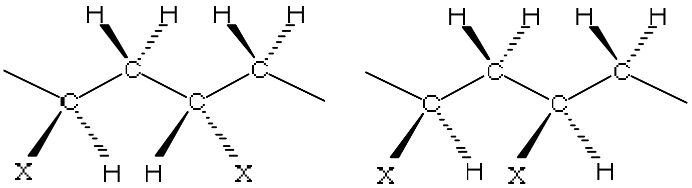
MULTIPLE CHOICE QUESTIONS

Chapter 1

1. I mentioned in class that you don’t need to know the difference between a racemic and meso diad. I lied!

   Alright, I suppose that’s not fair. Below is figure 1.5 from the book, showing these diads.

   racemic diad
   r

   meso diad
   m

   Figure 1.5 Schematic diagram depicting racemic and meso diads

   An NMR analysis of a polystyrene sample showed that it had close to 100% racemic diads. the sample would be

   A. Isotactic polystyrene
   B. Syndiotactic polystyrene
   C. Atactic polystyrene

2. A second sample had about 50% meso diads and 50% racemic. What is the most probable tacticity of this sample (A – C in Q1).

3. This polystyrene has a number average molecular weight of 100,000 and a polydispersity of 5. What is the weight average molecular weight?

   A) 20,000
   B) 100,000
   C) 500,000
   D) 100,005
   E) 5,000,000

4. Consider the following copolymers

A. (B–B–B - - - B–B) (A–A–A - - - - A–A) (B–B - - - - B–B–B)
~5% ~90% ~5%

B. A–A–A - - - - A–A – B–B - - - - B–B

C. – – A – B – A – A – B – B – A – A – A – B – A – B – B – –

D. – A – B – A – B – A – B – A – B – –

E.
```
– – A – A – A – A – A – A – A – A – – –
    |       |           |
    B       B           B
    |       |           |
    B       B           B
    |       |           |
    B       B           B
    '       '           '
    '       '           '
    '       '           '
    '       '           '
    B       B           B
```

Which of these is a triblock copolymer?

5. Consider the properties of the following two polyethylene samples. Sample 1 was produced by a high pressure process while sample 2 was synthesized using a catalyst.

	Polyethylene 1	Polyethylene 2
Mol wt.	200,000	200,000
Density (g/cm^3)	0.92	0.96
Crystalline melting pt.	108°C	133°C
Stiffness (lb/in^{2}x10^3)	25	125
Hardness (Shore D)	45	65

Which of the following statements is true?

A. Sample 2 is more branched than sample 1
B. Sample 1 is more branched than sample 2
C. Sample 1 is more atactic
D. Sample 1 is more isotactic
E. Painter shouldn't set such easy gift questions

6. Which of these do you think would be more appropriate for use in making bottles for detergent?

   A. Sample 1
   B. Sample 2

7. Which would make a better film for wrapping up leftover food? (A or B in Q6).

8. Which of the following polymers is least likely to be optically transparent

   A. Atactic polystyrene
   B. Isotactic polystyrene
   C. An ethylene/propylene random copolymer (50/50 composition)
   D. A styrene/butadiene random copolymer

9. Consider the following copolymers

   A. {Styrene}-{butadiene}-{Styrene} triblock copolymer (10%; 80%; 10%)
   B. A cross-linked styrene/butadiene random copolymer (20%/80%)
   C. A 50/50 ethylene/propylene random copolymer (also cross-linked)
   D. A 50/50 ethylene (linear)/atactic polypropylene block copolymer

   Which of these copolymers is likely to have at least some crystallinity?

10. A sample of atactic polystyrene is separated into 5 fractions;

Fraction	Number of Moles	Molecular Weight
1	20	10,000
2	20	20,000
3	20	30,000
4	20	40,000
5	20	50,000

   What is the number average molecular weight?

   A. 2.33 x 10^4
   B. 3.0 x 10^4
   C. 3.66 x 10^4
   D. 4.33 x 10^4

11. What is the weight average? (A – D in Q10).

12. What is the polydispersity?

- A) 1
- B) 2
- C) 1.22
- D) 1.44

Chapter 2

1. Styrene is almost a unique monomer, in that it can be polymerized by practically all methods of chain polymerization.

   A. Free radical
   B. Anionic
   C. Cationic
   D. Co-ordination (i.e., with a catalyst)

   Which of these methods would you use to make isotactic polystyrene?

2. If you needed to synthesize a set of narrow molecular weight standards (i.e., with polydispersities close to 1), which of the above methods would you use?

3. Commercial atactic polystyrene is synthesized by which of the above methods?

4. What method would you use to synthesize a triblock copolymer?

   A) Free radical polymerization
   B) Anionic polymerization
   C) Using a Ziegler Natta catalyst
   D) By putting it into a bloody great pot and spitting on it to initiate polymerization
   E) Condensation polymerization

5. Suspension free radical polymerization of styrene would be preferred over bulk polymerization to overcome the problem of

   A) Branching
   B) Cross-linking
   C) Stereo-isomerism
   D) Polymeric impurities
   E) Temperature control during polymerization

6. In emulsion polymerization, the principal place where the monomer polymerizes is

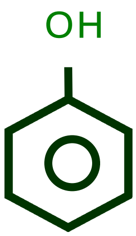
   A) Monomer droplets
   B) Aqueous phase
   C) Surfactant micelles
   D) Surface of reactor
   E) Air-liquid interface

7. Polypropylene produced commercially using a Ziegler-Natta catalyst is predominantly

   A) Atactic
   B) Isotactic
   C) Syndiotactic

8. Consider the following monomers or pairs of monomers:

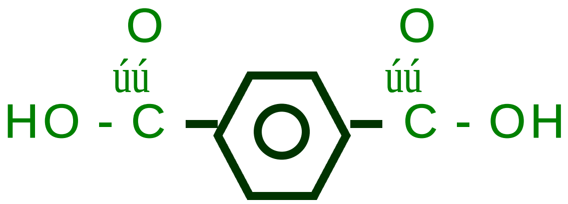
A.



and CH_2O

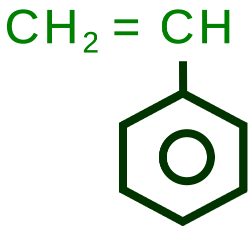
(phenol) (formaldahyde)

B.



and $HO - CH_2 - CH_2 - OH$

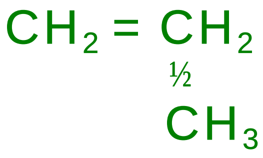
C.



and $CH_2 = CH - CH = CH_2$

(styrene) (butadiene)

D.



$CH_2 = \underset{\underset{CH_3}{½}}{CH_2}$

E. $CH_2 = CH_2$

Which of the monomers (A-E) listed above gives a densely cross-linked network when polymerized under the appropriate conditions?

7. Which of the above monomers is polymerized free radically at high pressures to give a polymer containing some short chain branches?

8. Which monomers form a polyester?

9. Which of the monomers containing a C = C double bond cannot be polymerized free radically?

10. Which monomers are used to make a thermoplastic rubber?

11. The method of polymerization used to make this rubber is:

    A. Free radical
    B. Anionic
    C. Cationic

14. Which pairs of monomers would you use to make an ethylene/propylene random copolymer?

    A. Pair (A) above
    B. Pair (B) above
    C. Pair (C) above
    D. Monomers (D) and (E) above

15. Would you make this polymer using:

    A. Free radical polymerization
    B. Anionic polymerization
    C. Cationic polymerization
    D. Using a catalyst (coordination polymerization)

Chapter 3

1. In the steady state assumption the concentration of radical species is given by

A. $[M\cdot] = \left[f \frac{k_d}{k_t} [I] \right]^2$

B. $[M\cdot] = \left[f \frac{k_d}{k_t} [I] \right]$

C. $[M\cdot] = \left[f \frac{k_d}{k_t} [I] \right]^{1/2}$

D. $[M\cdot] = \left[f \frac{k_t}{k_d} [I] \right]^{1/2}$

NOTE, USE

$$r_i = \frac{d[M\cdot]}{dt} = 2f\, k_d\, [I]$$

$$r_p = -\frac{d[M]}{dt} = k_p\, [M\cdot]\ [M]$$

$$r_t = -\frac{d[M\cdot]}{dt} = 2k_t\, [M\cdot]^2$$

2. Accordingly, if we assume that the concentration of initiator remains constant the rate of polymerization is given by

A. $R_p = k_p \left[\frac{f\, k_d\, [I]}{k_t}\right]^{1/2} [M]$

B. $R_p = r_p + r_i = \left[\frac{f\, k_d\, [I]}{k_t}\right]^{1/2} [M] + 2\, f\, k_d\, [I]$

C. $R_p = -r_t = 2k_t \left[\frac{f\, k_d\, [I]}{k_t}\right]^{1/2}$

D. $R_p = \left[\frac{k_p}{2(f\, k_d\, k_t)^{1/2}}\right] \frac{[M]}{[I]^{1/2}}$

4. AIBN is used to initiate the polymerization of methylmethacrylate in benzene at 60°C and

$[I]_o = 0.02$ mol/l
$[M]_o = 2$ mol/l

Assuming f is 1, what is the initial rate of polymerization?

[$k_p = 705$, $k_t = 50 \times 10^{-6}$, $k_d = 0.85 \times 10^{-5}$, in appropriate units]

A. 82.2
B. 4108.3
C. 8216.7
D. 11.6

4. What is the initial degree of polymerization? You can assume termination by disproportionation and that the kinetic chain length is given by

$$\left[\frac{k_p}{2(fk_d k_t)^{1/2}}\right] f\{[M],[I]\}$$

where $f\{[M],[I]\}$ is a function of [M] and [I] that you should know! (i.e., $f\{[M],[I]\} = [M][I]$ or [M]/[I], or something like that.)

A. 6.84×10^5
B. 1.71×10^7
C. 24.2×10^7
E. 4.83×10^6

If styrene is polymerized anionically and all the initiator is dissociated immediately, then the polydispersity of the sample is:

A. very large
B. 2.0
C. Given by (1+p)
D. <1
E. Slightly larger than 1.

6. The Tromsdorff effect is

A. When the Swedish Bikini team drops from the sky with cases of Old Milwaukee beer.
B. When the rate of initiation increases as the nature of the polymerization mass (i.e. all the stuff in the pot) changes from the initial conditions
C. When the rate constant for propagation, k_p, increases due to an increase in viscosity of the reaction mass
D. When the rate constant for termination decreases due to the same increase in viscosity.

7. In dealing with the kinetics of free radical polymerization, it is usual to

A. Assume that reactivity depends on chain length, unlike the situation in condensation or step-growth polymerization.
B. The concentration of radical species changes dramatically during the time a chain is being polymerized.
C. The concentration of radical species is constant during the time that a chain is being polymerized.
D. Molecular weight is independent of the concentration of radicals during the time that a particular chain is being polymerized.

8. In an anionic polymerization the rate of polymerization is given by

$$R_p = - \frac{d[M]}{dt} = k_p [M^*]]M]$$

where [M*] is the concentration of active sites. If $[M]_o$ is the initial monomer concentration, what time is required for [M] to be 1/10 of its initial value? (i.e., $[M] = 0.1\ [M]_o$. Use k_p = 100 1 mol. l^{-1} sec^{-1} and $[M^*] = 10^{-4}$ (NOTE: you need to make an assumption about [M*].)

A. 100 secs
B. 230.2 secs
C. 460.5 secs
D. 1000 secs

9. In an addition polymerization the kinetic chain length is the number of monomer molecules reacted for a single initiator radical produced. It may be expressed quantitatively as the ratio of the rate of propagation to the rate of initiation.

$$\nu = R_p/R_i$$

If termination is by combination then the degree of polymerization is:

A. Equal to the kinetic chain length, ν
B. = 2ν
C. = 1.5ν
D. Approaches 2ν at high degrees of conversion.

10. Which of the following equations is the correct expression for the number average degree of polymerization when chain transfer occurs in a free radical synthesis

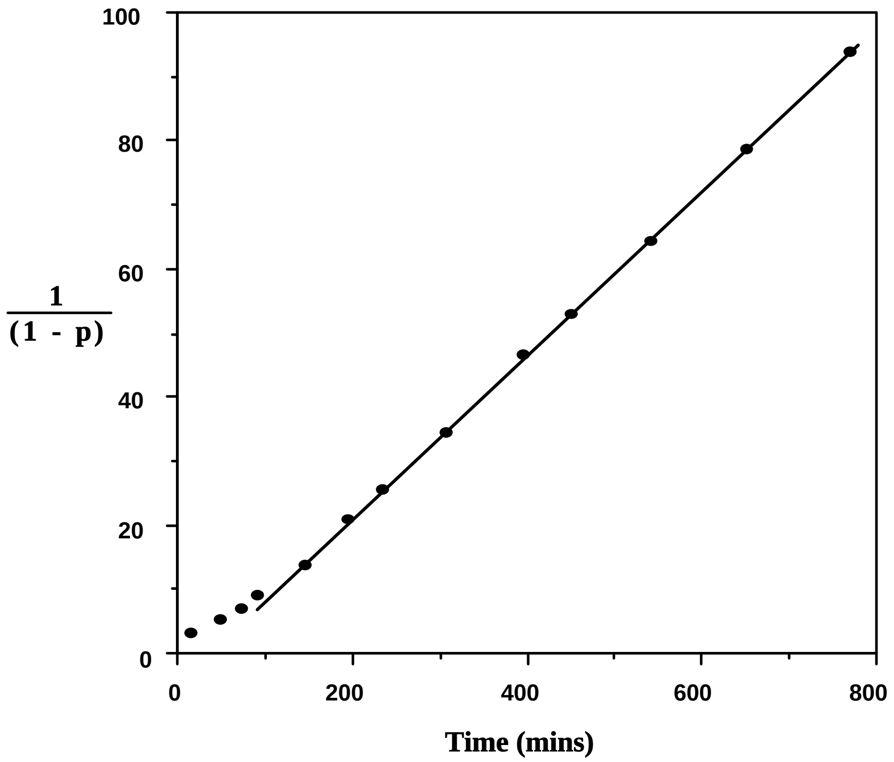
A. $\overline{x_n} = \overline{x_o} + C\frac{[T]}{[M]}$

B. $\overline{x_n} = \overline{x_o} + C\frac{[M]}{[T]}$

C. $\frac{1}{\overline{x_n}} = \frac{1}{\overline{x_o}} + C\frac{[T]}{[M]}$

D. $\frac{1}{\overline{x_n}} = \frac{1}{\overline{x_o}} + C\frac{[M]}{[T]}$

11. Consider the following plot showing kinetic data for a polyesterification.



Was this polymerization catalyzed by adding a strong acid?

A. yes
B. no

Chapter 4

1. The equation describing the mole fraction of x-mer present in a polycondensation reaction at an extent of reaction p is

A. $X_x = Xp^{x-1}(1-p)^2$

B. $X_x = \frac{1}{(1-p)}$

C. $X_x = \frac{1+p}{(1-p)}$

D. $X_x = p^{x-1}(1-p)$

E. $X_x = p^{x-1}(1-p)^2$

2. In a condensation polymerization between monomers containing A and B functional groups a 2% excess of groups B is used. What is the maximum degree of polymerization that can be achieved? (Assume $r = \frac{100}{102}$).

A. 199
B. 99
C. 200
D. Infinite (i.e., all the monomers polymerize)

3. If there had been exactly equal numbers of monomers used in the condensation reaction of question 2 what extent of reaction (p) would be necessary to achieve a number average degree of polymerization of 200?

A. 0.900
B. 0.990
C. 0.995

4. What would the weight average degree of polymerization of this sample be?

A. 39
B. 200
C. 399
D. 79,800

Chapter 5

1. In a copolymerization of monomers 1 and 2, initially present in the mole ratio 3:1, what is the composition of the copolymer formed initially, if $r_1 = 30$ and $r_2 = 0.033$?

   A. F_1 (mole fraction 1 in copolymer) = 0.67
   B. $F_1 = 0.5$
   C. $F_1 = 0.75$
   D. $F_1 = 0.25$
   E. $F_1 = 0.99$

2. What would be the composition of this copolymer at the end of the reaction?

   A. This cannot be worked out simply, because the composition of the feed changes with conversion.
   B. $F_1 = 0.67$
   C. $F_1 = 0.5$
   D. $F_1 = 0.75$
   E. $F_2 \sim 1$ (almost pure monomer 2, because all the 1 has been used up.)

3. What would be the ratio of butadiene to styrene repeating units initially produced by free radical polymerization of a mixture of 9 moles of butadiene with one mole of styrene?

M_1	M_2	r_1	r_2
Styrene	Butadiene	0.58	1.35

   A. 0.081
   B. 1.06
   C. 2.66
   D. 12.3
   E. 24.6

4. Two monomers M_1 and M_2 have reactivity ratios $r_1 = \infty$ and $r_2 = \infty$. The most likely structure of the polymer produced from an equimolar mixture of the two monomers will be:

   A. $-M_1M_2M_1M_2M_1M_2M_1M_2-$
   B. $-M_1M_1M_1M_1M_2M_2M_2M_2-$
   C. $-M_1M_2M_2M_1M_1M_1M_2M_1M_2M2M_1M_2-$ (random, "coin toss" statistics)
   D. $-M_1M_1M_1M_1$ - and - $M_2M_2M_2M_2$ - (homopolymers)

5. For a copolymerization with $r_1 = r_2 = 1$, which of the structures in question 4 would be found (A -- D).

Chapter 7

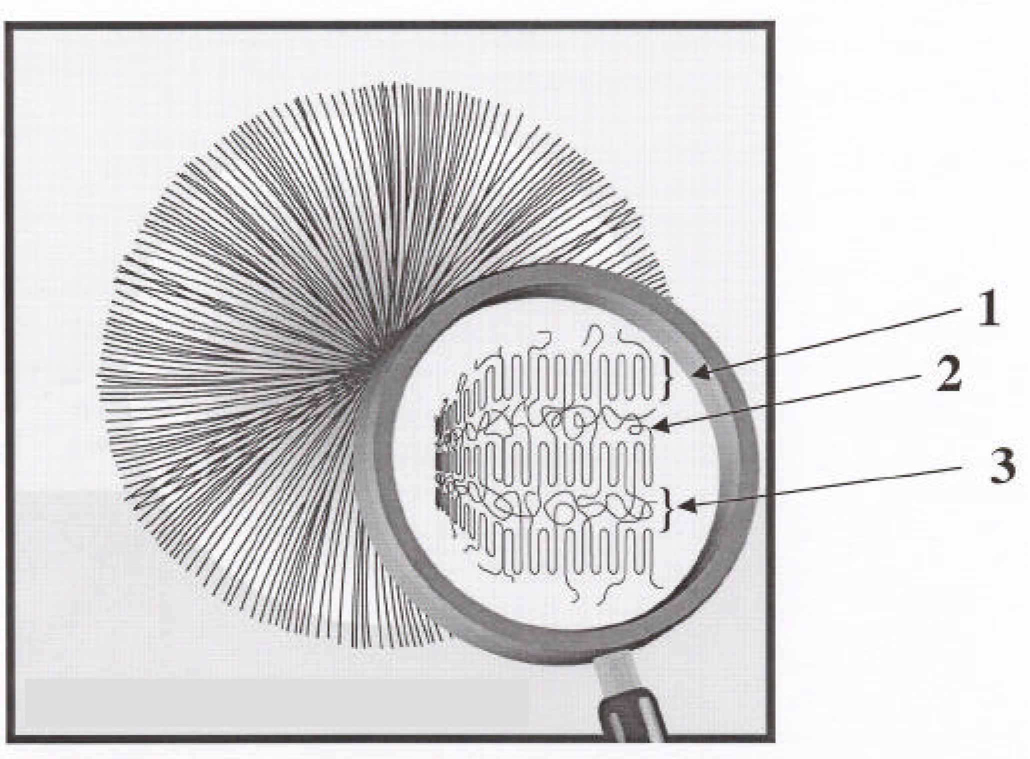
1. A polymer chain in the melt or in the rubbery state has an average end-to-end distance that is proportional to which of these (A-E) where N is the number of units in the chain?

   A. N
   B. $N^{0.75}$
   C. $N^{0.6}$
   D. $N^{0.5}$
   E. $N^{0.33}$

2. Which of the following polymers would you expect to have the best barrier properties (i.e., provide the best barrier to diffusion of a gas and hence prove most effective as a beverage container)?

   A. Atactic polystyrene
   B. A random ethylene/propylene copolymer (50/50) composition.
   C. Low density polyethylene
   D. High density polyethylene

3. Consider the following polymer crystal form:



This is a schematic picture of

A. A spherulite.

B. A fringed micelle.
C. A single crystal lamellae.

4. The material marked 3 is

A. Folded chain crystals.
B. Crystalline chains.
C. Amorphous material.

5. The thing labeled 2 is

A. A fold.
B. A randomly coiled chain.
C. A tie molecule.

6. Atactic polystyrene (Tg - 100°C) quenched (i.e., cooled very quickly) from 120°C to room temperature

A. Is a rubbery material.
B. Crystallizes.
C. Is a glassy material.

7. High density polyethylene cooled slowly from 160°C to room temperature

A. Is still amorphous.
B. Crystallizes.
C. Is a glass.
D. Is a mixture where some regions are rubbery and some regions are glassy.

8. When a single polymer chain is stretched, the origin of the restoring force is related to

A. The entropy of chain conformations.
B. The enthalpy of chain conformations.
C. The degree of cross-linking.
D. The elastic forces in each of the individual bonds in the chain.

9. A polymer drawn from the melt usually forms

A. Fringed micelles
B. Single crystal lamellae.
C. Spherulites.
D. Extended chain fibers.

10. Polyethylene and polypropylene (in the melt) will

A. Form hydrogen bonds with one another.
B. Interact strongly due to polar forces.

C. Only interact weakly through dispersion forces.

11. What is the root mean square end-to-end distance of a chain of 100 freely hinged and jointed monomer units, each of which has a length of 4 Å?

A. 200 Å
B. 400 Å
C. 20 Å
D. 40 Å
E. 100 $\sqrt{2}$ Å

12. If rotations around a bond in a polymer chain can take on any one of four conformations (i.e. arrangements of the groups it is linking relative to one another), then for a polymer chain consisting of 1000, bonds there are the following number of possible conformations (ignoring redundancies):

A. 41000
B. 4 x 1000
C. 1000^4
D. 1000 x 41000

13. A fringed micelle is

A. An exotic form of nightware that can be purchased at Victoria's Secret.
B. A model for polymer crystals where polymer chains have parts of themselves in crystal domains and parts in amorphous regions.
C. A sphere shaped crystal form obtained by cooling from the melt.
D. A flat lozenge shape crystal obtained from dilute solutions

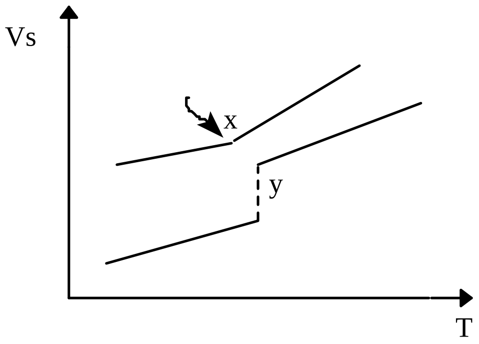
Chapter 8

1. Which of the following polymers would you expect to be most suitable for the production of a rubber car bumper guard?

   A. Atactic polystyrene (Tg ~ 100°C)
   B. A random ethylene/propylene copolymer (50/50 composition) Tg ~ 40°C).
   C. Low density polyethylene.
   D. High density polyethylene.

2. Which of the polymers in question 1 would be most suitable for use as a flexible film wrap?

3. Consider the two transitions from the "solid" to the liquid or rubbery state shown below on a plot of specific volume vs. temperature;



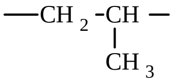
   A. The transition X is a Tg while transition Y is a crystalline melting point.
   B. Y is the Tg while X is the Tm.
   C. X and Y are melting points, but X is the Tm of a semi-crystalline material and Y is the Tm of an almost perfect crystal.

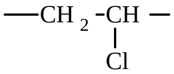
4. Polymer crystalline in a folded chain form because

   A. This is the shape that minimizes the free energy, because folds are created.
   B. Extended chain crystals have a lower free energy, but the probability of forming the first nuclei with fully stretched out chains is vanishingly small. Therefore folded chain nuclei are formed first and become kinetically trapped.
   C. Extended chain crystals have a higher free energy because there are less folds and therefore stronger interactions between the segments in the crystals. Again the folded chain form becomes kinetically trapped.

Consider the following polymers

A. $—CH_2-CH_2—$

B. 
$—CH_2-\underset{\displaystyle CH_3}{\underset{|}{CH}}—$

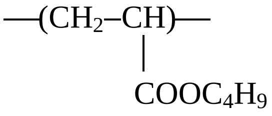
C. 
$—CH_2-\underset{\displaystyle Cl}{\underset{|}{CH}}—$

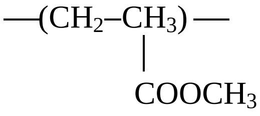
D. $—CH_2-CH_2-O—$

Which of these will have the highest Tg?

7. Which will have the lowest? (A-D of previous question)

8. Poly(n-butyl acrylate) has a lower Tg than poly(methyl methacrylate)


$—(CH_2–\underset{\displaystyle COOC_4H_9}{\underset{|}{CH}})—$


$—(CH_2–\underset{\displaystyle COOCH_3}{\underset{|}{CH_3}})—$

because of:

A. Weaker intermolecular attractions
B. Free Volume effects
C. The stiffness of the side chain

Chapter 9

1. What is the value of χ for a mixture of polycrud (δ_p = 9.0) and the solvent Etarte (Extremely Toxic And Ruins The Earth) (δ_s = 7.5)?
   NOTE: Assume Vs/RT = 1/6 and a fudge factor of 0.34

   A. 0.375
   B. 0.5
   C. 0.715
   D. 0.035
   E. Ask Al Gore

2. Will polycrud dissolve completely in Etarte?

   A. Yes
   B. No
   C. Ask Al Gore

3. Assume that the solubility parameter of a mixture of solvents A and B is given by their volume fraction average; i.e., the mixture behaves like a single solvent with a solubility parameter given by;

$$\delta_{mix} = \phi_A\delta_A + \phi_B\delta_B$$

   Would polycrud dissolve in a 50:50 mixture (by volume) of Etarte and Emtan (Even More Toxic And Nasty) (δ = 10.5)?

   A. Yes
   B. No
   C. Stop picking on Al Gore. I like his beard.

4. The dimensions of the polycrud backbone chain in this mixed solvent (dilute solution) is given by

   A. $R_{rms} \propto N^1$
   B. $R_{rms} \propto N^{0.75}$
   C. $R_{rms} \propto N^{0.6}$
   D. $R_{rms} \propto N^{0.5}$

   where R_{rms} is the root mean square end to end distance and N is the number of segments in the chain. (Assume that if χ is less than 0.4 the solvent is "good").

5. For a polymer to be completely miscible with a solvent at a given temperature (i.e. form a single phase mixture at ALL compositions)

   A. The free energy change ΔGm must be negative and the second derivative of the free energy (with respect to composition) must be positive
   B. ΔGm must be positive and the second derivative negative
   C. ΔGm must be negative and the second derivative must also be negative
   D. They must both be positive

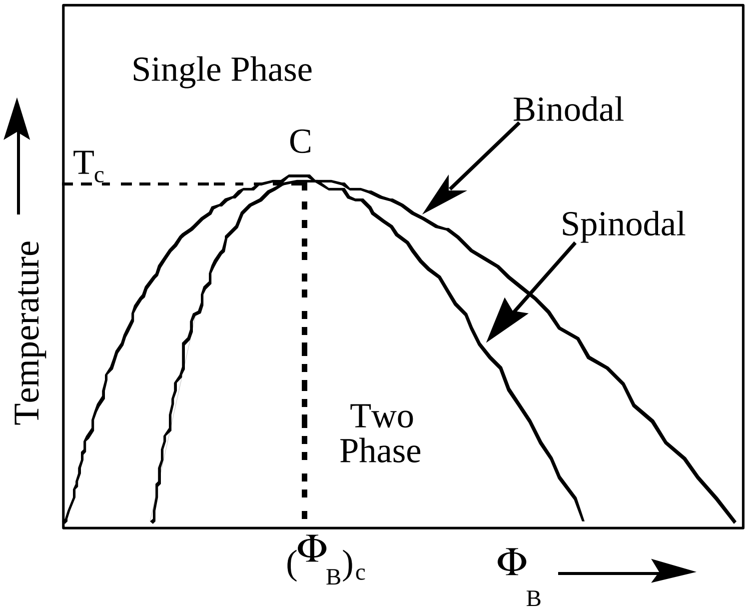
6. A monodisperse polymer with a degree of polymerization of 50,000 is to be mixed with a solvent. The molar volume of a segment of the polymer is equal to that of the solvent, and their molecular weights (solvent and polymer SEGMENT) are both equal to 100. How many grams of each would have to be mixed to obtain a 50:50 mixture by VOLUME (i.e. one where the volume fraction of each is 0.5) whose total weight is 100 grams?

   A. Cannot be calculated because there is insufficient information
   B. 50 grams of each
   C. 1/50,000 grams of polymer and 100- 1/50,000 grams of solvent

7. What would be the entropy of mixing, expressed in terms of $\Delta Sm/R$ (i.e. a molar basis)?

   A. -0.693
   B. + 0.693
   C. - 1733
   D. + 1733
   E. + 0.347

8. Consider the following phase diagram for a polymer solution



   In the Flory Huggins theory at point C we have

   A. $\Delta\mu = 0$ (i.e., the difference in the chemical potential is zero)
   B. $\chi = 1$
   C. $\chi = 0.5$
   D. $\chi = \propto$ (infinite value, as this is where phase separation starts)

9. At the composition given by the point C, but at temperatures just slightly above this point

   A. The solution phase separates

B. The polymer coils collapse
C. The polymer chains are expanded
D. The polymer chains are ideal (follow random flight statistics)

Chapter 10

1. Consider the following viscosity parameters

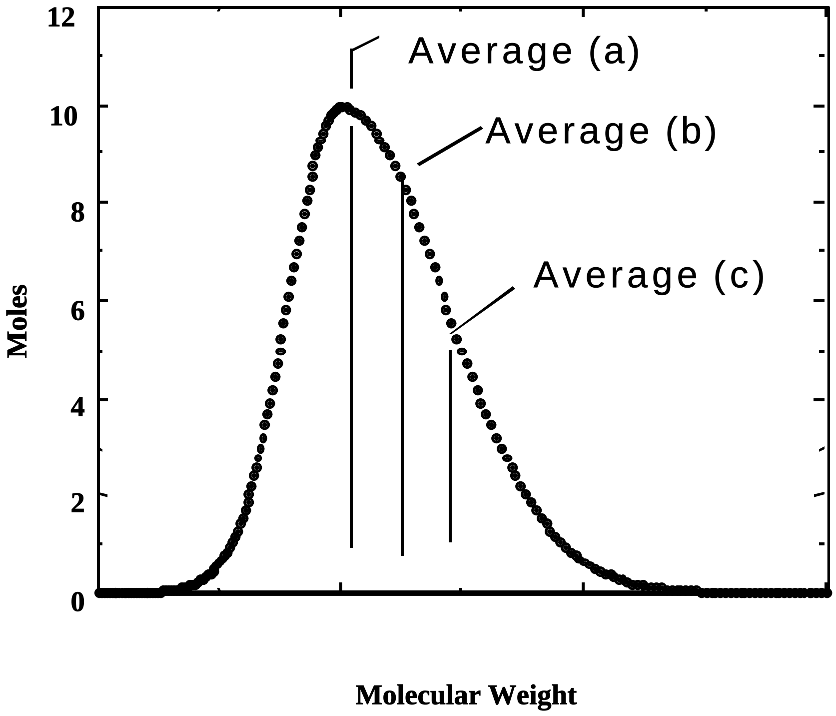
   A. Relative viscosity
   B. Inherent viscosity
   C. Specific viscosity
   D. Intrinsic viscosity
   E. Reduced viscosity

   Which of these is equal to η/η_o, the viscosity of the solution divided by the viscosity of the pure solvent?

2. Which of the above parameters is determined by the appropriate plots and used in the Mark-Houwink-Sakaruda equation?

3. Consider the molecular weight distribution shown below. The average indicated by (a) is

   A. The number average
   B. The weight average
   C. A higher order z average



4. The average indicated as (b) is most likely the

A. number average
B. weight average
C. a higher order z average

5. Three monodisperse polystyrene samples of molecular weight 10,000, 20,000 and 30,000 are available. What would be the number average molecular weight of a mixture of 10 moles of each?

   A. 15,000
   B. 23,333
   C. 20,000
   D. 25,000

6. What would be the weight average molecular weight of a mixture of 10 moles of each?

   A. 15,000
   B. 20,000
   C. 23,333
   D. 26,666

7. A Zimm plot of light scattering date gives an intercept of 3.33×10^{-7} (where RT is 600 in consistent units). What is the resulting molecular weight?

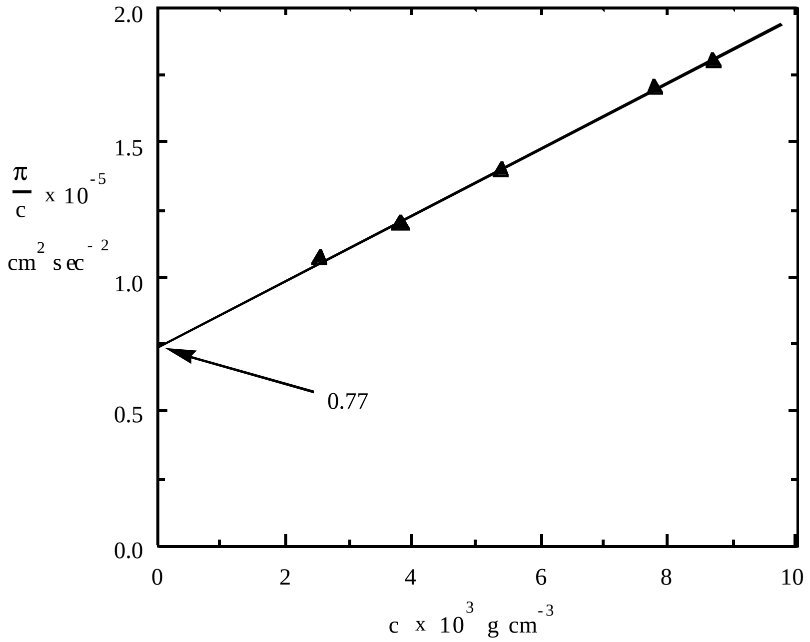
   A. $M_n = 1.8 \times 10^9$
   B. $M_n = 3.0 \times 10^6$
   C. $M_w = 1.8 \times 10^9$
   D. $M_w = 3.0 \times 10^6$
   E. $M_w = 3.0 \times 10^7$

8. If the two polystyrene samples are dissolved in a common "good" solvent and run through a GPC (or SEC) column

   A. the low molecular weight sample would elute first
   B. the high molecular weight sample would elute first
   C. because the samples mix and interact with one another, chains would elute at random

9. Consider the plot of π/c (π = osmotic pressure) vs. c shown below. The intercept is 0.77×10^5 units; RT is equal to 2.48×10^{10} in corresponding units; and the slope 1.2×10^7 units. The average molecular weight is

   A. 1.2×10^7
   B. 3.22×10^5
   C. 2.06×10^3
   D. $1.3 \times 10\text{-}^5$



10. Is this:

- A. a number average?
- B. a weight average?

11. Is the second virial coefficient, related to the quantity (1/2-χ), given by

- A. The slope of the line
- B . The intercept
- C. Neither
- D. The ratio of the slope to the intercept
- E. RT/Slope

Chapter 11

1. The WLF Equation is:
   - A. A combination of Voigt and Maxwell models that describes creep
   - B. A four parameter model for stress relaxation
   - C. An expression for the shift factor that is used in the time-temperature superposition principle
   - D. The relationship between intrinsic viscosity and molecular weight
   - E. The power law dependence of melt viscosity on molecular weight

2. Which of the following equations describes the dependence of melt viscosity on molecular weight for chains that are longer than the critical entanglement length.
   - A. $\eta = k(DP)^{1.0}$
   - B. $\eta = k(DP)^{2.0}$
   - C. $\eta = k(DP)^{3.4}$
   - D. $\eta = k(DP)^{2.4}$
   - E. $\eta = k(DP)^{3.0}$

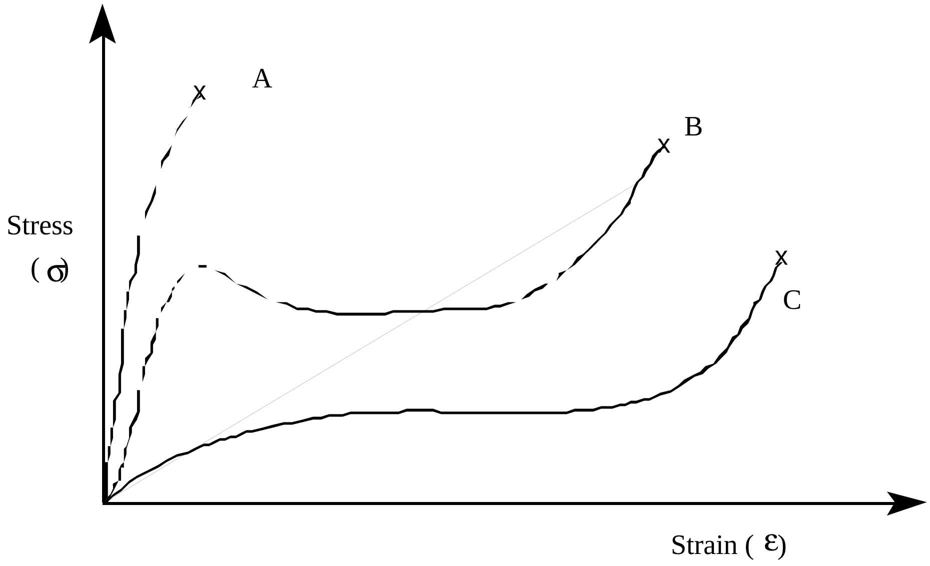
3. Which of these describes the melt viscosity of short chains (< critical entanglement length)?

4. Melt fracture occurs
   - A. When chain molecular weight is too high
   - B. When a polymer is extruded too quickly
   - C. When a polymer is extruded too slowly
   - D. When an extruder is hit by a bloody great sledgehammer
   - E. When a polymer close to its Tg is extruded.

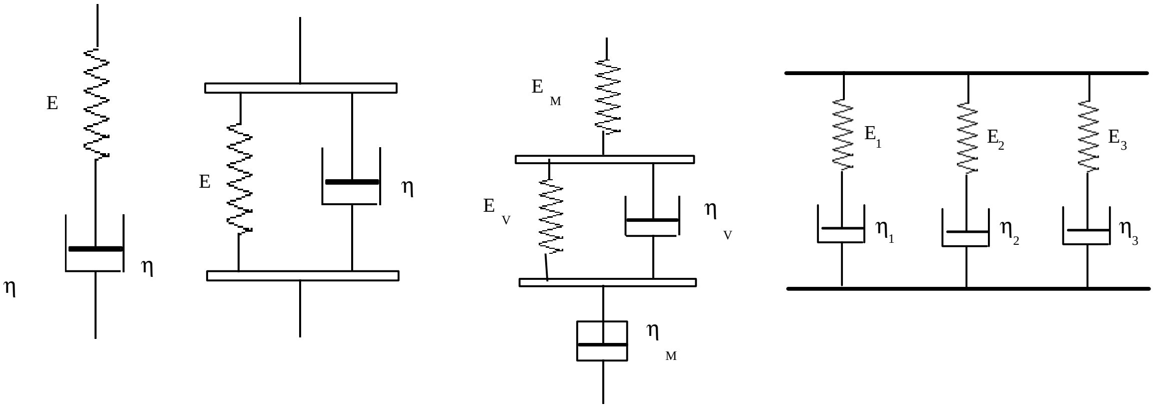
5. Consider the stress/strain diagrams shown below. Which of these would most closely correspond to the mechanical behavior of Atactic polystyrene?

6. Consider the stress/strain diagrams shown below. Which of these would most closely correspond to the mechanical behavior of Isotactic polypropylene?

Consider the stress/strain diagrams shown below. Which of these would most closely correspond to the mechanical behavior of Natural rubber?



8. Consider the following mechanical models



Maxwell mode	Voigt model	Four parameter model	Maxwell-Weichert model
A	B	C	D

Which of these models does not do a good job of describing the retarded elastic response that is characteristic of creep?

9. Which of these models (in the above question) would not do a good job of describing stress relaxation?

1. Which of these models (in the above question) would best give a description of viscoelastic behavior in terms of a spectrum of relaxation times.

2. For the Maxwell model we can write

$$\frac{d\varepsilon}{dt} = \frac{\sigma}{\eta} + \frac{1}{E}\frac{d\sigma}{dt}$$

In a stress relaxation experiment this would give us:

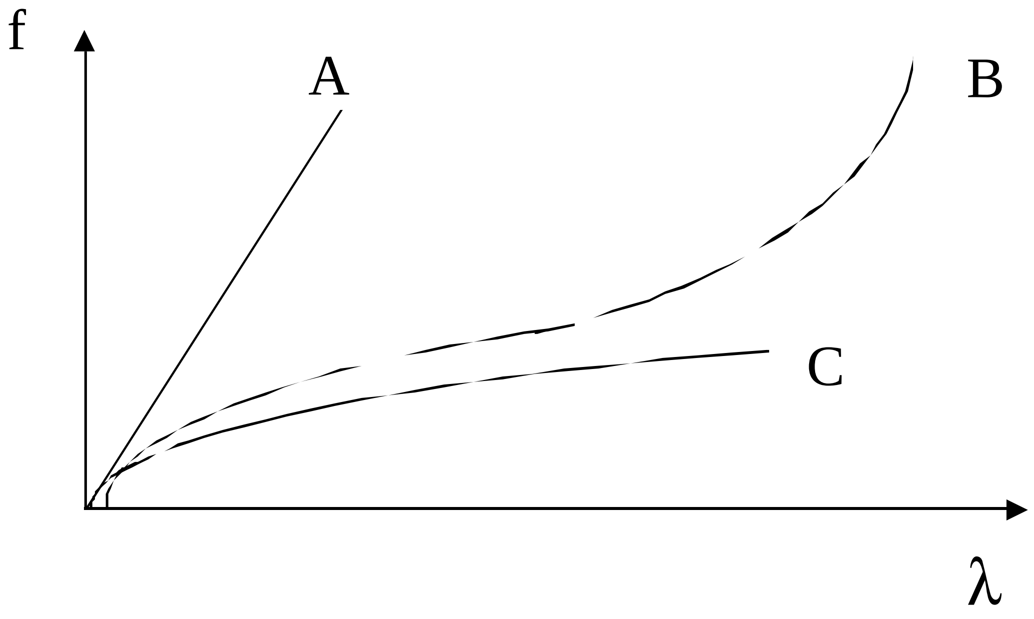
A. $e = \frac{s_{O}}{E}\{1 - \exp(-t/t)\}$ where $t = h$/E

B. $\sigma = \sigma \exp(-t/\tau)$

C. D = DO{1-exp(-t/τ)} where D is the compliance

D. $\sigma = E\varepsilon$

12. Consider the following load-deformation plots.



Which of the following equations best describes plot B

A. $f = FkT\left(\lambda - \frac{1}{\lambda^2}\right)$

B. $f = 2kT\beta^2\lambda$

C. $f = 2C_1\left(\lambda - \frac{1}{\lambda^2}\right) + 2C_2\left[\lambda - \frac{1}{\lambda^3}\right]$

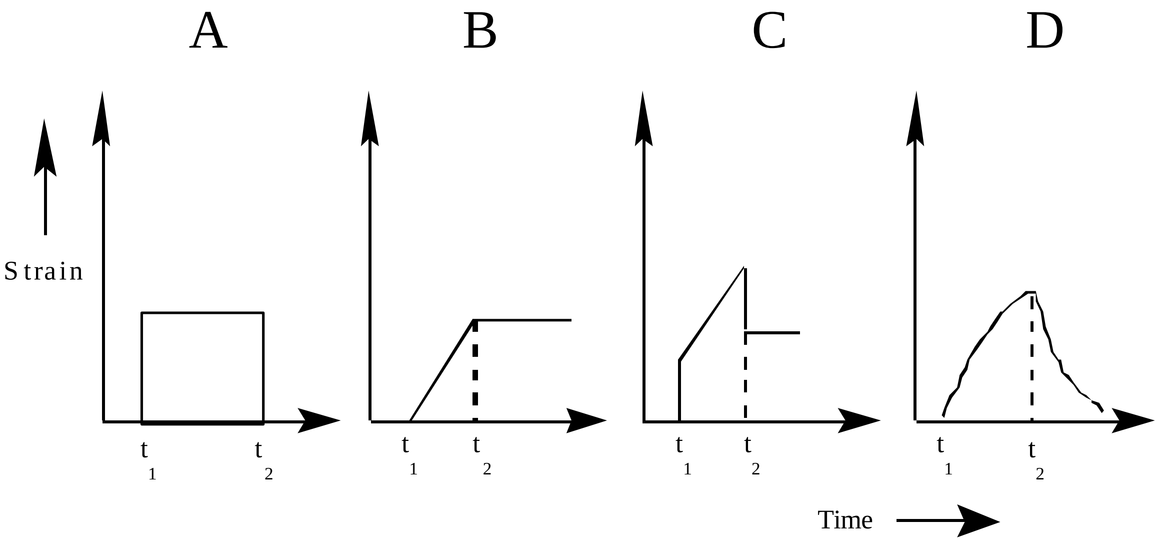
13. Which of the above equations best describes the elastic behavior of a single Gaussian polymer chain?

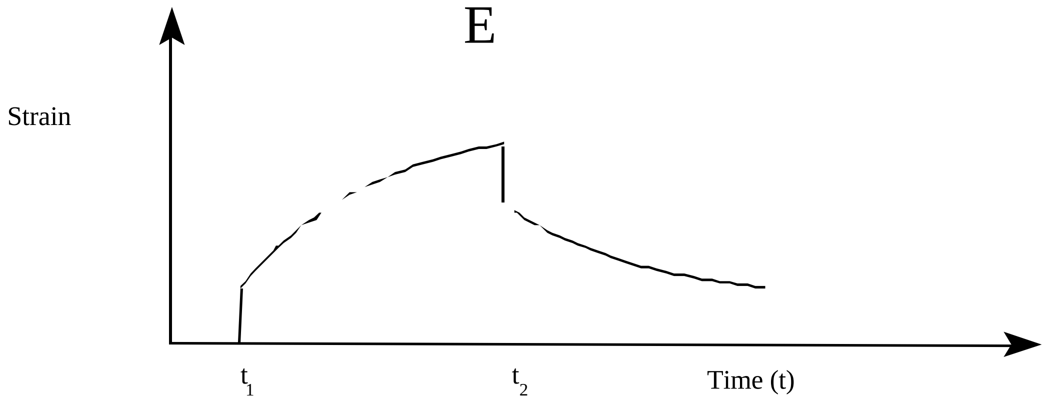
14. Which of these equations is obtained by simple theories of rubber elasticity applied to a network of chains?

15. With increasing concentration of plasticizer the modulus of PVC

A. increases
B. decreases
C. stays the same

16. Consider the plots of strain vs. time shown below. Which of these is given by the Maxwell model?





17. If you take a strip of rubber and hang a weight on it so that it stretches say 300%, then heat the rubber, it

A. Stretches some more
B. Contracts
C. Maintains the same length

18. If you take an ideal rubber (i.e., one where the modulus is given by G=nRT) and fill it with an ideal gas (which obeys PV=nRT) and then heat it

    A. The balloon expands
    B. The balloon contracts
    C. The balloon stays the same

    (NOTE: Assume the number of moles (n) of rubber and gas are equal)