050506 Quiz 6 Polymer Properties

Renormalization of disordered structures has been used as a tool to describe the structural adaptation of thermally equilibrated macromolecules. For macromolecules renormalization involves the concept of a "blob". We discussed two kinds of blobs in class, the thermal blob (or thermic blob) and the concentration blob.

a) How is the thermal blob used to renormalize a polymer chain? Give the conditions (you may need a plot of R_g vs T); an equation for R_F (in terms of N, b, and χ); an equation for the blob size, and sketch in a plot of log I versus log q the behavior of a SAW chain, a Gaussian Chain and a chain displaying thermal blobs. Be sure to indicate intransigent parts of the curves.

b) Explain the analogy between Debye screening of static charges and screening in semi-dilute polymer solutions. What are the main differences?

c) How is the concentration blob used to renormalize a polymer chain? Give the conditions; an equation for R_F; an equation for the blob size; and sketch in a plot of log I versus log q the behavior of a SAW chain, a Gaussian Chain and a chain displaying concentration blobs. Be sure to indicate intransigent parts of the curves.

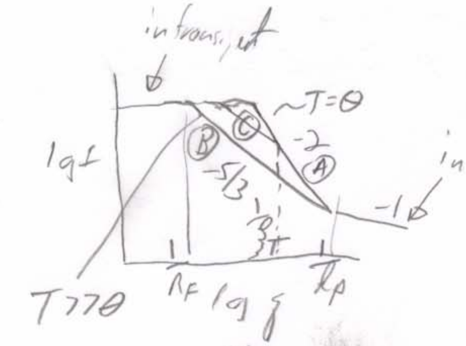
d) Could blob theory be used to understand ceramic aggregate structures? Explain why or why not. Try to be as specific as you can and give an example sketch of the structure.

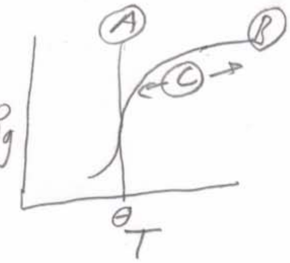
e) Could the persistence length be viewed as a blob? Explain your answer.

Answers: 050506 Quiz 6 Polymer Properties

a)

Condition
High > T > θ





$$R_F = \left(\frac{N}{n_\xi}\right)^{3/5} (\xi_T)$$

$$\boxed{\xi_T = \frac{b}{(1-2\chi)}}$$

$$\chi \sim \frac{1}{T}$$

$$R_F = N^{3/5}\, b \left(\frac{b}{\xi_T}\right)^{1/5} = R_{F_\theta} \left(\frac{b}{\xi}\right)^{1/5} N^{1/10}$$

$$\boxed{R_{F_{TRUE}} = N^{3/5}\, b\, (1-2\chi)^{1/5}}$$

b)

Debye Screening

- Long distance interactions are affected

$$u(r) = \frac{q_1 q_2}{\varepsilon \varepsilon_0\, r\, 4\pi}\, e^{(-r/\lambda_d)}$$

- Binary Interactions are considered

- Limits Vacuum

$$U(r) = \frac{q_1 q_2}{4\pi \varepsilon_0 r}$$

Media

$$U(r) = \frac{q_1 q_2}{4\pi \varepsilon \varepsilon_0 r}$$

Concentration Blob

- Gaussian scaling at $r > \xi_\phi$, so long distance interactions

- Binary interactions

$\phi = 0$ Dilute SAW

$\phi = 1$ Concentrated Gaussian

b) cont.

At intermediate sizes the system introduces a size to accomodate thermodynamics

λ_D vs. ξ_ϕ

Both display a mean field at long distances $r \gg \lambda_D$ or $r \gg \xi_\phi$

<u>Differences</u>

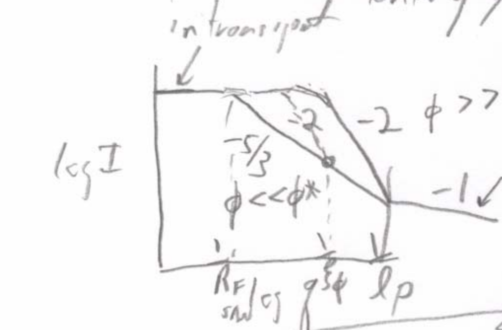
Static Charge vs. Enthalpic

Functional Dependences are different

Polymers display scaling features

Static charge displays a discrete Energy dependence

c)



Condition $1 > \phi > \phi^*$

semi Dilute Regime

$$\boxed{\phi^* = \frac{N}{R^3_{F_{SAW}}} = N^{-4/5}\, b^{-3}}$$

$$\boxed{R_F = \left(\frac{N}{n_\phi}\right)^{1/2} \xi_\phi = R_{F_{SAW}} \left(\frac{\phi}{\phi^*}\right)^{-1/8}}$$

$$\boxed{\xi_\phi = \left(\frac{\phi}{\phi^*}\right)^{-3/4} R_{F_{SAW}}}$$

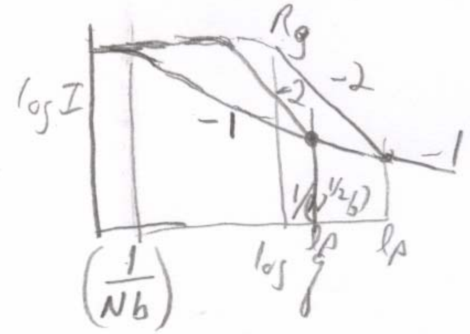
$R_{F_{SAW}} = N^{3/5}\, b$

d) No, since ceramic aggregates are not thermally equilibrated.

(Or
Perhaps Yes if you bend the rules & consider variable growth conditions & branching.)

e) Yes. Persistence is determined by thermal equilibration of bond rotation energies.

here we could construct:



$$R_F = \left(\frac{N}{n_p}\right)^{1/2} l_p(T) \qquad l_p(T) = n_p' b$$

Persistence is a linear "blob".
We could consider changes in persistence @ T,