Quiz 4 4/24/01 Polymer Properties

a) For a polymer chain with \( N_p = 300 \) and \( l_p = 6\text{Å} \) calculate:
   - \( R_F \) for a very good solvent
   - \( R_F \) for a theta solvent
   - \( R_F \) for a good solvent with \( \xi_t = 30\text{Å} \)
   - \( R_F \) for a very good solvent in the semi-dilute regime with \( \xi_{sp} = 30\text{Å} \)

b) Sketch the log I versus log q scattering curves for the above 4 cases. Make sure to indicate any changes in the radius of gyration.

c) How does the overlap concentration, \( c^* \), depend on molecular weight, \( N \)?

d) Calculate the dependence of the concentration blob size \( \xi_p \) on concentration, \( c \), given that:
   \[ \xi_p = R_{f0} \left( c/c^* \right)^P \]
   where \( P \) is a power you need to determine, and \( R_{f0} \) is the coil size in the dilute regime for a very good solvent. (Hint: You need to know the \( N \) dependence of \( \xi_p \) to do this calculation.)

e) Write an expression for the themal (thermic) blob size, \( \xi_t \), as a function of the persistence length, \( l_p \), and the interaction parameter \( \chi_{12} \).
   - Give and explain the three regimes defined by this expression.
Answers: Quiz 4 4/24/01 Polymer Properties

a) Very Good Solvent  \[ R_F = N^{3/5} l_p = 300^{3/5} \times 6 = 184 \text{ Å} \]
Theta Solvent  \[ R_F = N^{1/2} l_p = 300^{1/2} \times 6 = 104 \text{ Å} \]
Good Solvent  \[ \xi_t = 30 \text{ Å} = n_i^{1/2} l_p, n_i = 25 \text{ so } N_i = (300/25) = 12 \]
  \[ R_F = N_i^{3/5} \xi_t = 133 \text{ Å} \]
Semi-Dilute  \[ \xi_p = 30 \text{ Å} = n_i^{3/5} l_p, n_i = 14.6 \text{ so } N_i = (300/14.6) = 20.5 \]
  \[ R_F = N_p^{1/2} \xi_p = 136 \text{ Å} \]

b)

\[ \log I = \frac{\log q}{VGS: -5/3 \text{ to } -2} \]
\[ TS: -2 \]
\[ GS: -5/3 \]

\[ \log q \]

\[ Semi-Dilute: -5/3 \]

c)  \[ c^* = N/R_F^3 = N^{1-3/df} = N^{-4/5} \]

d)  \[ \xi_p \] doesn't depend on molecular weight, while \( c^* \) has the dependence in c) and \( R_{F0} \) goes as \( N^{3/5} \). \( N^0 = N^{3/5} (N^{4/5})^P \), so \( P \) must equal \(-3/4\).

e)  \[ \xi_t = l_p/(1-2\chi_{12}) \]
  This equation defines three regimes:
  \( \chi_{12} < 0 \) where \( \xi_t \) doesn't exist
  \( \chi_{12} = 0 \) where \( \xi_t \) just equals \( l_p \)
  and the thermic blob regime, \( \chi_{12} > 0 \) where \( \xi_t > l_p \). The thermic blob exists as a compromise between entropically driven miscibility at large scales and enthalpically driven phase separation at small scales.