Index

Bold page numbers refer to bold entries in the text, where terms are first introduced. Italic page numbers refer to homework problems.

Conversion Factors

Length
$1\ \text{m} = 10^2\ \text{cm} = 10^3\ \text{mm} = 10^6\ \mu\text{m} = 10^9\ \text{nm} = 10^{10}\ \text{Å}$

Volume
$1\ \text{Litre} = 10^{-3}\ \text{m}^3 = 10^3\ \text{cm}^3$

Mass
$1\ \text{kg} = 10^3\ \text{g}$

Force
$1\ \text{N} = 1\ \text{kg m s}^{-2} = 10^5\ \text{g cm s}^{-2} = 10^5\ \text{dyne}$

Energy
$1\ \text{J} = 1\ \text{kg m}^2\ \text{s}^{-2} = 1\ \text{N m} = 10^7\ \text{g cm}^2\ \text{s}^{-2} = 10^7\ \text{erg}$
$1\ \text{cal} = 4.18\ \text{J}$
$1\ \text{eV} = 1.602 \times 10^{-19}\ \text{J}$
$1\ \text{cm}^{-1}$ (wavenumber unit of energy) $= 1.986 \times 10^{-23}\ \text{J}$

Stress (also Modulus or Pressure)
$1\ \text{Pa} = 1\ \text{N m}^{-2} = 1\ \text{J m}^{-3} = 1\ \text{kg m}^{-1}\ \text{s}^{-2} = 10\ \text{dyne cm}^{-2} = 10\ \text{g cm}^{-1}\ \text{s}^{-2}$
$1\ \text{bar} = 10^5\ \text{Pa}$
$1\ \text{atm} = 1.013 \times 10^5\ \text{Pa} = 1.013\ \text{bar}$
$1\ \text{torr} = 1\ \text{mm Hg} = 133.3\ \text{Pa}$

Viscosity
$1\ \text{Pa s} = 1\ \text{kg m}^{-1}\ \text{s}^{-1} = 10\ \text{g cm}^{-1}\ \text{s}^{-1} = 10\ \text{Poise}$

Surace tension
$1\ \text{N m}^{-1} = 1\ \text{J m}^{-2} = 10^3\ \text{dyne cm}^{-1}$

Power
$1\ \text{W} = 1\ \text{kg m}^2\ \text{s}^{-3} = 1\ \text{J s}^{-1} = 10^7\ \text{erg s}^{-1}$
Metric horse power $= 735.5\ \text{W}$

Electric charge
$1\ \text{C} = 2.998 \times 10^9\ \text{cm}^{3/2}\ \text{g}^{1/2}\ \text{s}^{-1}$

Electric dipole moment
$1\ \text{C m} = 2.998 \times 10^{11}\ \text{cm}^{5/2}\ \text{g}^{1/2}\ \text{s}^{-1} = 2.998 \times 10^{29}\ \text{Debye}$

Fundamental Constants

Avogadro's number $\mathcal{N}_{Av} = 6.02 \times 10^{23}\,\text{mol}^{-1}$
Boltzmann constant $k = 1.38 \times 10^{-23}\,\text{J K}^{-1} = 1.38 \times 10^{7}\,\text{Pa Å}^{3}\,\text{K}^{-1}$
Gas constant $\mathcal{R} = k\mathcal{N}_{Av} = 8.31\,\text{J mol}^{-1}\,\text{K}^{-1}$
Speed of light in vacuum $c = 2.998 \times 10^{8}\,\text{m s}^{-1}$
Elementary charge $e = 1.60 \times 10^{-19}\,\text{C}$
Gravitational constant $G = 6.67 \times 10^{-11}\,\text{m}^{3}\,\text{s}^{-2}\,\text{kg}^{-1}$
Atomic mass unit (1/12 of the mass of ^{12}C atom) $= 1.66 \times 10^{-27}\,\text{kg}$
Planck constant $h = 6.63 \times 10^{-34}\,\text{J s}$

Defined Constants

Zero of the Celsius scale (0° C) $\equiv 273.15\,\text{K}$
Standard gravitational acceleration $g \equiv 9.80665\,\text{m s}^{-2}$
$kT = 4.114 \times 10^{-21}\,\text{J}$ at 298 K
$\mathcal{R}T = 2.478\,\text{kJ mol}^{-1} = 0.592\,\text{kcal mol}^{-1}$ at 298 K

Greek Alphabet

Alpha	A	α	Iota	I	ι	Rho	P	ρ
Beta	B	β	Kappa	K	κ	Sigma	Σ	σ
Gamma	Γ	γ	Lambda	Λ	λ	Tau	T	τ
Delta	Δ	δ	Mu	M	μ	Upsilon	Υ	υ
Epsilon	E	ε, ϵ	Nu	N	ν	Phi	Φ	ϕ, φ
Zeta	Z	ζ	Xi	Ξ	ξ	Chi	X	χ
Eta	H	η	Omicron	O	o	Psi	Ψ	ψ
Theta	Θ	θ	Pi	Π	π	Omega	Ω	ω

SI Prefixes

10^{-1}	deci	d	10	deca	da
10^{-2}	centi	c	10^{2}	hecto	h
10^{-3}	milli	m	10^{3}	kilo	k
10^{-6}	micro	μ	10^{6}	mega	M
10^{-9}	nano	n	10^{9}	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	fempto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E
10^{-21}	zepto	z	10^{21}	zetta	Z

Correction to the first (2003) printing of the textbook "Polymer Physics", corrected in 2004-2006 printings

PAGE 3: Above the middle equation "such molecules weigh 28 000g or one molecule weighs" should we change it to "… the mass of N_{av} such molecules is 28 000g or the mass of one molecule is …"?

PAGE 13: add to Eq. 1.21 " = M/VN_{Av}" with script "N" as in Eq. 1.18.

PAGE 14: End of the first paragraph replace "is necessary" with "arises": "In practice this ambiguity arises because polymer overlap occurs over a range of concentrations."

PAGE 15: end of section 1.5.3 cut one "collagen".

PAGE 27: middle of third paragraph should read "membrane makes the chemical potential the same on both sides of the membrane"

PAGE 36: middle of third paragraph: "cut space after "infrared "

PAGE 42: problem 1.25 Replace "molar mass" with "mass" in parts (i) and (ii) of the problem and cut M_n and M_w.

PAGE 45: Problem 1.45 should read: "Determine what moment of the molar mass distribution is measured by …"

PAGE 53: Table 2.1 add "at 413 K" to the end of caption.

PAGE 63: Table 2.3 should read "$(Nb^2/6)$ 89/125" instead of "$(Nb^2/6)$ 89/625"

PAGE 83: add "[see Eq. (2.49)]" to the end of the sentence below 2.146

PAGE 90: problem 2.8. replace part of text and equation 2.177 with the new equation (see attached).

PAGE 94: Problem 2.41 Add ", within a Gaussian approximation"?

PAGE 96: Problem 2.47 Add "reciprocal of the" after the last "the".

PAGE 114: add to the end of the Fig. 3.14 caption: "Note that the conformation of a dilute globule in a poor solvent is a random walk of thermal blobs up to the globule size. There is almost no change in chain conformation at the length scale of a thermal blob. Density fluctuations in space saturate at this length scale and the density of a globule is uniform at length scales larger than the thermal blob."

PAGE 116: below Eq. 3.83 missing exponent 2: "R^2=Nb^2".

PAGE 131: In problem 3.23 change the text to "A is a dimensionless parameter proportional to the Hamaker constant" and also at the end "effective polymer-surface interaction parameter A".

PAGE 131: Problem 3.26 Replace "use the scaling law" by "use the Flory theory".

PAGE 169-170: Replace Problem 4.22 with the new version (see attached page and file Problem 4-22.tex)

PAGE 186: End of the first paragraph missing "in" "smaller than in cyclohexane by …"

PAGE 186: modify the third sentence in section 5.5: " … grafted to the repulsive surface in an …"

PAGE 188: modify the second sentence below Eq. 5.72: "Notice that the integral in Eq. (5.72) for ν>1/2 is dominated by the lower limit $z=\xi_{ads}$ and therefore the adsorbed amount Γ is almost independent …" Note that we also added "almost".

PAGE 196: Problem 5.26 ii Capital K on the second line of the page.

PAGE 196: Problem 5.26 In the last equations in part (ii) the first term is $(l_H-l_D)^2$ not $(l_H-l_0)^2$

PAGE 196: Problem 5.26 In the last equations in part (ii) add superscript 2 between square brackets "$]^2[$".

PAGE 196: Problem 5.26 In the last equations in part (iii) the coefficient should be $(l_H-l_D)^2$ not $(l_H-l_0)^2$

PAGE 210: Add "$+(f-3)/(2(f-2))\varepsilon^2$" after "$-\varepsilon)]$" to the second line of Equations 6.29 add "(f-1)/(2(f-2)) in front of "ε^2)" in third and fourth lines of Eq. 6.29 and in Eq. 6.30.

PAGE 210 & 211: Add "2(f-2)/(f-1)" in front of "ε^{-2}" in equation for N* above equation 6.31 and in equation 6.34on page 211.

PAGE 216: Replace "probability", with "average number of bonds" twice.

PAGE 223: add "(f-1)/(2(f-2)) in front of "ε^2)" in Equations 6.76 and 6.77 and replace Equation 6.80 with $N^* = ((2(f-2))/(f-1))\varepsilon^{-2}$

PAGE 224 & 225: Add angular brackets in $\langle R_g^2 \rangle$ in Eqs. 6.83 and 6.85.

PAGE 225 & 226: add "(f-1)/(2(f-2)) in front of "ε^2)" in Equations 6.88 and equation 6.88 on page 226,

PAGES 226 & 227: last sentence on page 226 continuing onto 227: " spaces), ideal randomly branched polymers become too dense as reflected in the overlap parameter *decreasing* with degree of polymerization" "*increasing*" is replaced by "*decreasing*".

PAGE 227: Eq. 6.92 switch numerators and denominators and add minus sign to the last superscript.

PAGE 231: add "(f-1)/(2(f-2)) in front of "ε^2)" **twice** in equation 6.107

PAGE 232: add "(f-1)/(2(f-2)) in front of "z^2)" in Eq. 6.109,

PAGE 233: Add "2(f-2)/(f-1)" and replace $1/(1-p/p_c)^2$ with $2(f-2)/((f-1)(1/p/p_c)^2)$ in Eq. 6.119,

PAGE 233: add "(f-1)/(2(f-2)) in front of "z^2)" in Eq. 6.120,

PAGE 233: replace eq.6.121 with "$z=-(1-p/p_c)N^{1/2}$"

PAGE 234: add "… for functionality of cross-links f=3." to figure caption of Fig.6.28.

PAGE 248: problem 6.13 – add "without loops".

PAGE 249: problem 6.19 – should read "near the gel point", instead of "at the gel point".

PAGE 250: problem 6.27 – Change "crosslinking units" to "crosslinks" Add "distribution function" Replace $w_N(p)$ by "w(p,N)", where p has a hat!

PAGE 251: change values to p=0.4, 0.45, 0.48. Add "*Hint*: Plot the cutoff function against N/N_w."

PAGE 265: Cut "a great". should read "Since then many models of entanglement have been proposed."

PAGE 283: below Eq. 7.99 Change ν into v in "γ=v/h".

PAGE 298: Problem 7.18 "Demonstrate that I_1, I_2, and I_3 (defined in Eqs. 7.49, 7.50, and 7.51) are invariant with respect to any change in coordinate system.".

PAGE 300: End of problem 7.22 add "in the limit n>>p. What is the mean-square fluctuation of the junction point in the opposite limit (p>>n)?"

PAGE 304: Problem 7.45 – rephrase the end of the second sentence. "When rapidly cooled into the lamellar phase from the isotropic phase, the layers formed by diblock copolymers are roughly parallel to each other locally."

PAGE 330: Fig. 8.11 vertical axis should have symbol "η_{sp}"

PAGE 341: sixth line from the bottom $M>10^6$ g/mol (add "g/mol")

PAGE 352: Problem 8.5 (i) First sentence – cut "for diffusion".

PAGE 352: Problem 8.6 (i) "rod polymers" plural (cut "a" add "s").

PAGE 357: Problem 8.29 (iii) replace "50" by "130" and add " ... from initial temperature $T_1=400$ K ..."

PAGE 364: replace v_0 by v_0 in denominator of Eq 9.17.

PAGE 368: replace b^3 by v_0 in denominator of Eq. 9.84.

1. p. 53, Table 2.1 needs to be changed:
   - (i) 1,4-PI: Replace “4.6” with “4.7”; Replace “8.2” with “8.4”; Replace “113” with “120”.
   - (ii) 1,4-PB: Replace “5.3” with “5.5; Replace “9.6” with “9.9’; Replace “105” with “113”.
   - (iii) PP: Replace “5.9” with “6.0”; Replace “180” with “183”.
   - (iv) PEO is fine as is
   - (v) PDMS is fine as is
   - (vi) PE is fine as is
   - (vii) PMMA: Replace “9.0” with “8.2”; Replace “17” with “15”; Replace “655” with “598”.
   - (viii) PS is fine as is
2. p. 58, Equation 2.37 Insert $-\frac{1}{6}\left(\frac{R_{max}}{l_p}\right)^3$ after $\frac{1}{2}\left(\frac{R_{max}}{l_p}\right)^2$.

   New Eq. 2.37 should read

   $$\exp\left(-\frac{R_{max}}{l_p}\right) \cong 1 - \frac{R_{max}}{l_p} + \frac{1}{2}\left(\frac{R_{max}}{l_p}\right)^2 - \frac{1}{6}\left(\frac{R_{max}}{l_p}\right)^3 + \ldots\ldots \quad \text{for} \quad R_{max} \ll l_p$$

3. p. 59, Equation 2.38: Insert $-\frac{R_{max}^3}{3l_p} + \ldots\ldots$ after R_{max}^2. New Eq. 2.38 should read

   $$\langle R^2 \rangle \cong R_{max}^2 - \frac{R_{max}^3}{3l_p} + \ldots\ldots \quad \text{for} \quad R_{max} \ll l_p$$

4. p. 60, Table 2.2 C_∞ for HR model: Replace <cosθ> with <cosφ> so that the result agrees with Eq. 2.40.
5. p. 91, Problem 2.19 insert “for v – u = 1000” at the end of the problem.
6. p. 111, Equation 3.65 insert a minus sign after the ≈ sign.
7. p. 219, Equation 6.57 remove extra parenthesis. Replace “)]” by “]”.
8. p. 221, Figure 6.21 has curves miss-labeled.
   The top one should be 0.4 and the bottom one should be 0.49.
9. p. 223, Equation 6.80 Delete the minus sign.
10. p. 247, Problem 6.3 first line replace “percolation” with “gelation”.
11. p. 247, Problem 6.7 add * after **6.7**.
12. p. 251, Problem 6.32 Insert “N_0-dependent” after “Calculate the”.
13. p. 280, Figure7.17 The right edge is not fully printed (only partly fixed in the second printing).
14. p. 295, Problem 7.2 Replace 10^4 by 10^2 in the table four times.
15. p. 297, Problem 7.14 Insert “true” before “stress” twice in first two lines.
16. p. 314, Second line Replace $1/\sqrt{3\pi}$ with $1/\left(2\sqrt{3\pi}\right)$.
17. p. 322, Figure 8.6 The x-axis tick labels should be “10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7” instead of “10^{-0} 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7}”
18. p. 335, near mid-page Replace “1 K” with “3 K”.

19. p. 347, Fifth line Replace "Fig. 8.20" with "Fig. 8.21".
20. p. 357, Problem 8.29: Replace "*k*" in Eqs 8.182 and 8.183 with "*R*" (in Calligraphic font).
21. p. 362, Table 9.1 needs to be changed:
    - (i) Polyethylene: Replace "2.60" with "2.6".
    - (ii) Poly(ethylene oxide): Replace "140 °C" with "80 °C"; Replace "1.80" with "1.8"; Replace "2000" with "1700"; Replace "15" with "13"; Replace "40" with "37"; Replace "21" with "19".
    - (iii) 1,4-PB is fine as is.
    - (iv) PP is fine as is.
    - (v) 1,4-Polyisoprene: Replace "56" with "53"; Replace "8.2" with "8.4"; Replace "210" with "220".
    - (vi) Polyisobutylene: Replace "0.32" with "0.34"; Replace "7100" with "6700"; Replace "26" with "24"; Replace "64" with "62"; Replace "20" with "19".
    - (vii) PDMS is fine as is.
    - (viii) PS is fine as is.
    - (ix) PVCH is fine as is.
22. p. 365, End of the first paragraph, Replace "(9.16)" with "(9.10)".
23. p. 385, line 10: Delete "is" to read "this correction is 0.77".
24. p. 388, footnote 7, Replace " $P/N_e > (N/N_e)^{2.4}$ " with "$(P/N_e)^{1.4} > (N/N_e)^{3.4}$ "
25. p. 407, Eq. 9.132 Replace exponent (2/3) of v/b^3 with *2(15ν-8)/[3(3ν-1)]* to read

$$\left(\frac{v}{b^3}\right)^{2(15\nu-8)/[3(3\nu-1)]}.$$

26. p. 407, Eq. 9.133 Replace exponent of b^3/v with *(24ν+13)/[3(3ν-1)]* to read

$$\left(\frac{b^3}{v}\right)^{(24\nu+13)/[3(3\nu-1)]}$$

27. p. 407, Eq. 9.134 Replace exponent of v/b^3 with *(42ν-23)/[3(3ν-1)]* to read

$$\left(\frac{v}{b^3}\right)^{(42\nu-23)/[3(3\nu-1)]}.$$

28. p. 408, Problem 9.15: Replace part (ii) with:

(ii) Derive the following relation for the overlap concentration of a wormlike chain

$$c^* \approx \frac{M}{(R_{\max} b)^{3/2} N_{Av}}$$

and determine the overlap concentration if the Kuhn length of DNA is $b = 100$ nm (approximately 300 base pairs).

29. Additions to the Index: