

Figure 2-1. Illustration of the states of a system in terms of the gravitational energy of a ball.

Table 2-1 Henry's Law constants for gases at 1 bar total pressure in mol L⁻¹ bar⁻¹

T(°C)	O ₂	N ₂	CO ₂	H ₂ S	SO ₂
0	2.18 x 10 ⁻³	1.05 x 10 ⁻³	7.64 x 10 ⁻²	2.08 x 10 ⁻¹	3.56
5	1.91 x 10 ⁻³	9.31 x 10 ⁻⁴	6.35 x 10 ⁻²	1.77 x 10 ⁻¹	3.01
10	1.70 x 10 ⁻³	8.30 x 10 ⁻⁴	5.33 x 10 ⁻²	1.52 x 10 ⁻¹	2.53
15	1.52 x 10 ⁻³	7.52 x 10 ⁻⁴	4.55 x 10 ⁻²	1.31 x 10 ⁻¹	2.11
20	1.38 x 10 ⁻³	6.89 x 10 ⁻⁴	3.92 x 10 ⁻²	1.15 x 10 ⁻¹	1.76
25	1.26 x 10 ⁻³	6.40 x 10 ⁻⁴	3.39 x 10 ⁻²	1.02 x 10 ⁻¹	1.46
30	1.16 x 10 ⁻³	5.99 x 10 ⁻⁴	2.97 x 10 ⁻²	9.09 x 10 ⁻²	1.21
35	1.09 x 10 ⁻³	5.60 x 10 ⁻⁴	2.64 x 10 ⁻²	8.17 x 10 ⁻²	1.00
40	1.03 x 10 ⁻³	5.28 x 10 ⁻⁴	2.36 x 10 ⁻²	7.41 x 10 ⁻²	0.837
50	9.32 x 10 ⁻⁴	4.85 x 10 ⁻⁴	1.95 x 10 ⁻²	6.21 x 10 ⁻²	—

Table 2-2. Density of water, dielectric constant and Debye-Hückel and Truesdell-Jones constants at 1 bar pressure

Temperature (°C)	Density of water (kg m ⁻³)	Dielectric constant	Debye-Hückel constants	
			A	B
0	0.99984	87.8191	0.4912	0.3248
5	0.99977	85.8838	0.4942	0.3254
10	0.99970	83.9785	0.4976	0.3262
115	0.99896	82.1042	0.5012	0.3270
20	0.99821	80.2618	0.5052	0.3279
25	0.99693	78.4520	0.5094	0.3289
30	0.99565	76.6755	0.5138	0.3299
35	0.99394	74.9326	0.5185	0.3310
40	0.99222	73.2238	0.5235	0.3322
45	0.99013	71.5493	0.5287	0.3334
50	0.98803	69.9094	0.5342	0.3347
55	0.98562	68.3043	0.5399	0.3360
60	0.98320	66.7342	0.5459	0.3373

Table 2-3. Parameters for the Debye-Hückel and Truesdell-Jones equations at 1 Atm

Ion	Debye-Hückel		Truesdell-Jones	
	a_i (Å)		a_i (Å)	b (L mol ⁻¹)
H ⁺	9.0		4.78	0.24
Na ⁺	4.0		4.32	0.06
K ⁺	3.0		3.71	0.01
Mg ²⁺	8.0		5.46	0.22
Ca ²⁺	6.0		4.86	0.15
Sr ²⁺	5.0		5.48	0.11
Ba ²⁺	5.0		4.55	0.09
Mn ²⁺	6.0		7.04	0.22
Fe ²⁺	6.0		5.08	0.16
Co ²⁺	6.0		6.17	0.22
Ni ²⁺	6.0		5.51	0.22
Zn ²⁺	6.0		4.87	0.24
Cd ²⁺	5.0		5.80	0.10
Pb ²⁺	4.5		4.80	0.01
Al ³⁺	9.0		6.65	0.19
OH ⁻	3.5		10.65	0.21
F ⁻	3.5		3.46	0.08
Cl ⁻	3.0		3.71	0.01
HCO ₃ ⁻	4.0		5.4	0
CO ₃ ²⁻	4.5		5.4	0
SO ₄ ²⁻	4.0		5.31	-0.07

Table 2-4. Appropriate ranges of ionic strengths for activity coefficient models.

Model	Ionic strength (moles L ⁻¹)
Debye-Hückel	0 to 0.1
Davies	0 to 0.6
Truesdell-Jones	0 to 2
Specific Ion Interaction	0 to 4
Pitzer	0 to 6

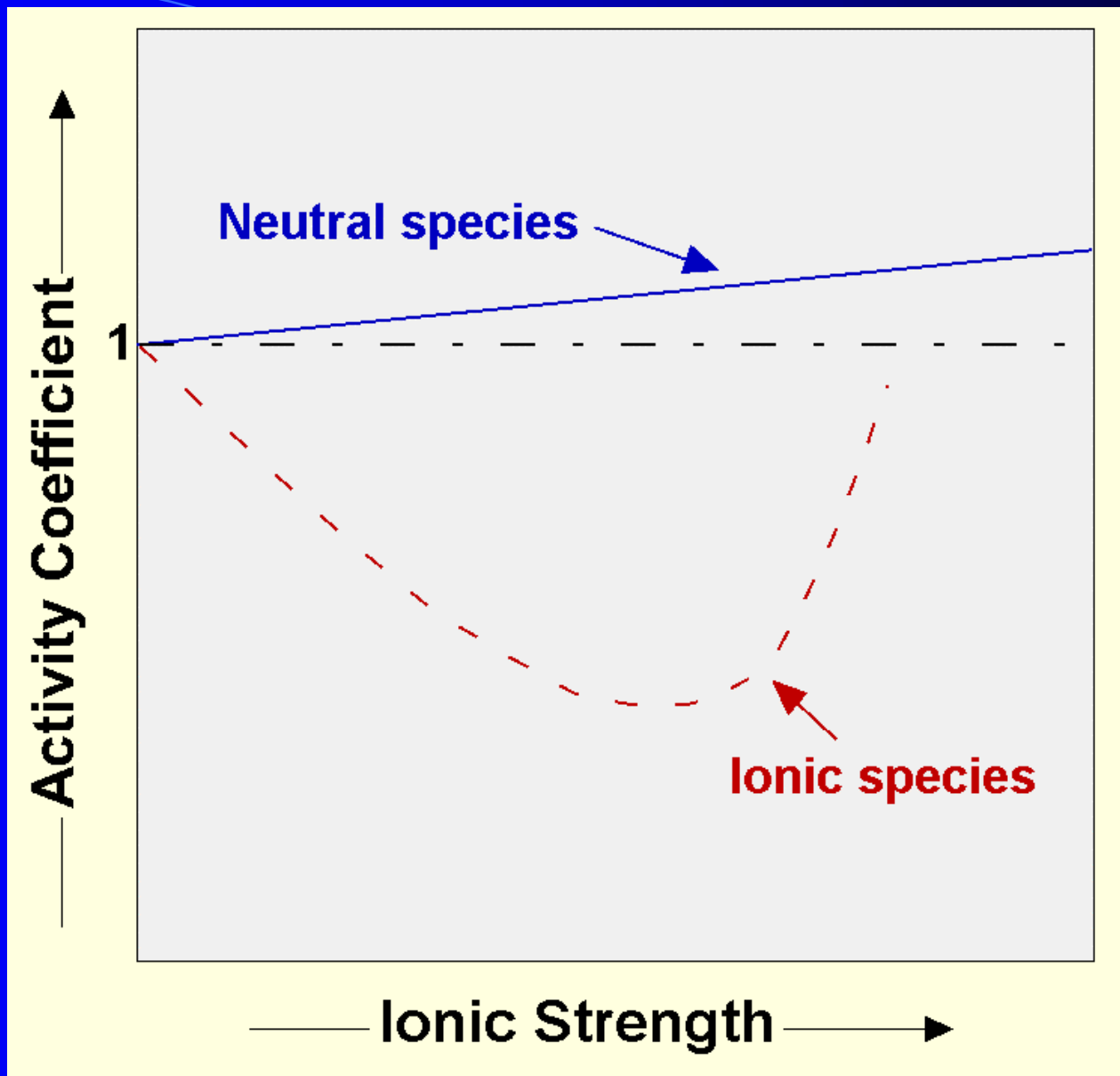
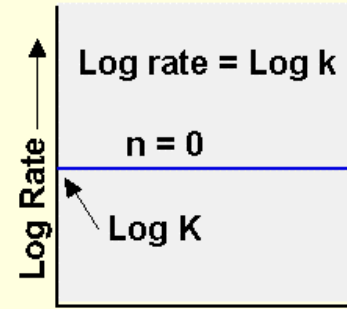
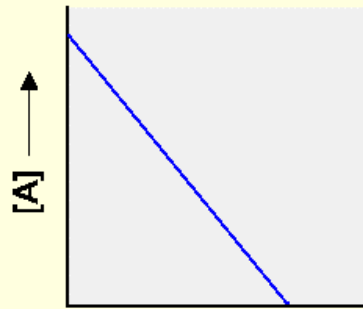
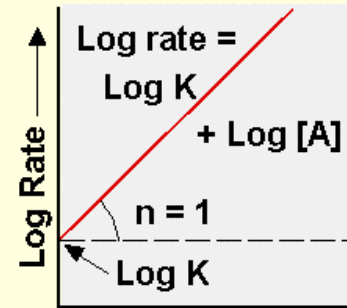
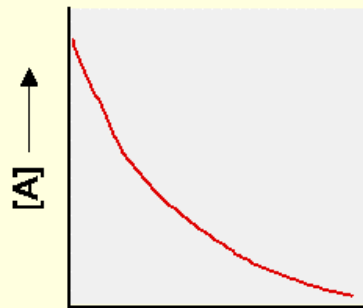


Figure 2-2. Schematic representation of the variation in activity coefficients versus the ionic strength of solutions.

Zeroth-order



First-order



Second-order

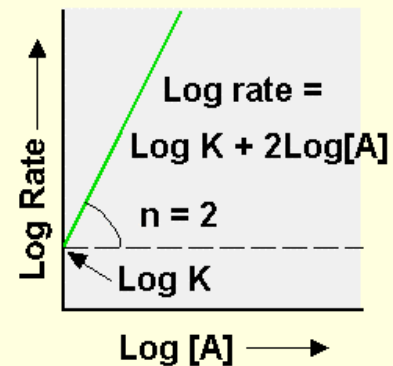
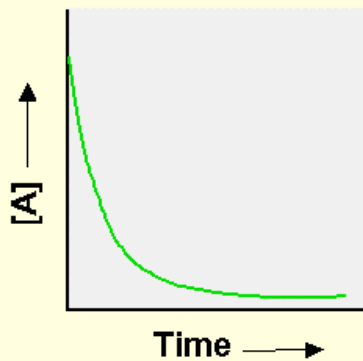


Figure 2-3. Graphical illustration of various reaction orders in terms of the variation in concentration of species A versus time and reaction rate versus concentration of species A. After Appelo and Postma (1996).

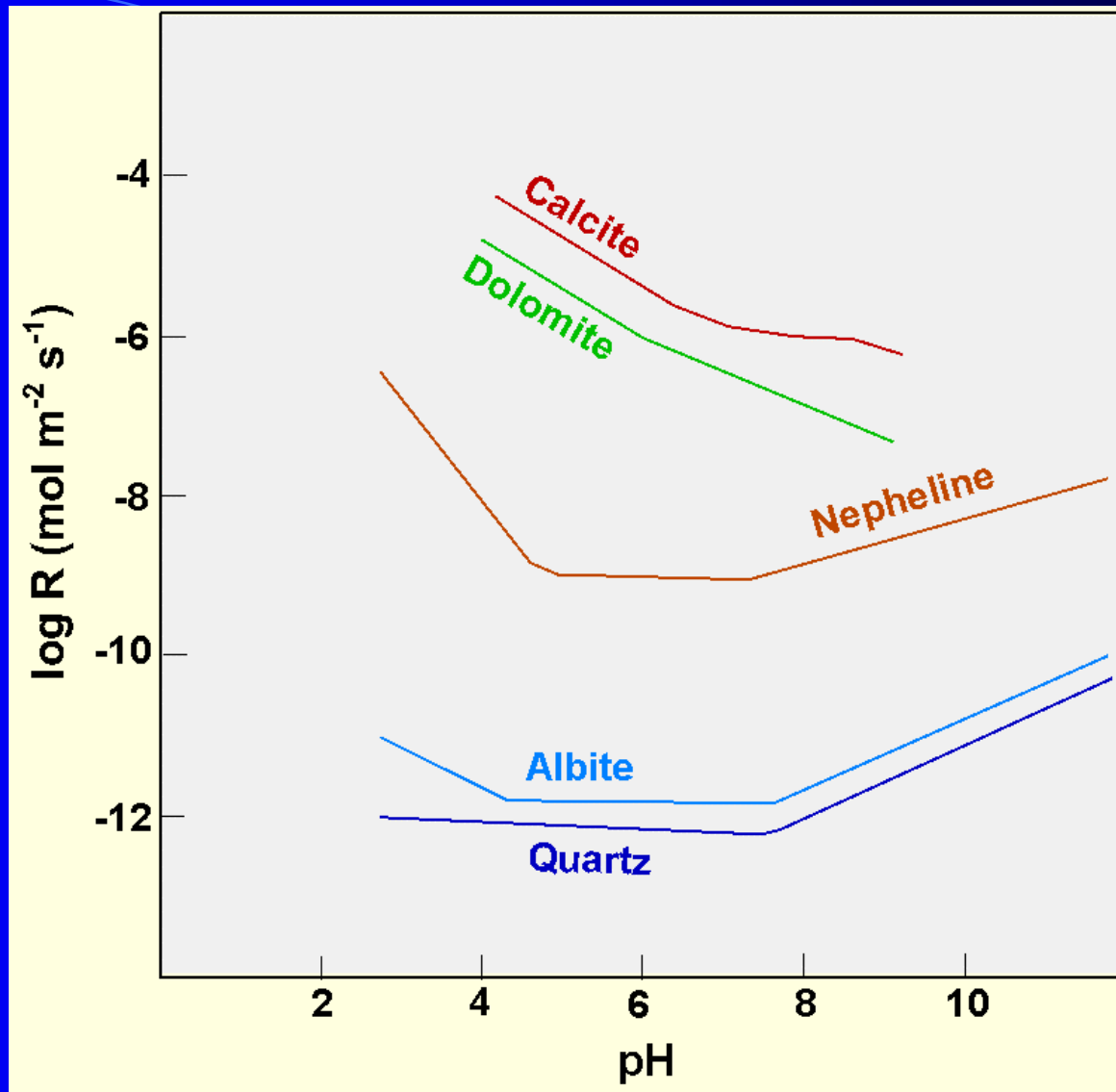


Figure 2-4. Dissolution rates ($\text{mol m}^{-2} \text{s}^{-1}$) for common minerals, carbonates, and silicates, as a function of pH. After Lerman (1990). From "Transport and kinetics in surficial processes" by A. Lerman in *AQUATIC CHEMICAL KINETICS* edited by W. Stumm, pp. 505-534. Copyright 1990. This material used by permission of John Wiley & Sons, Inc.

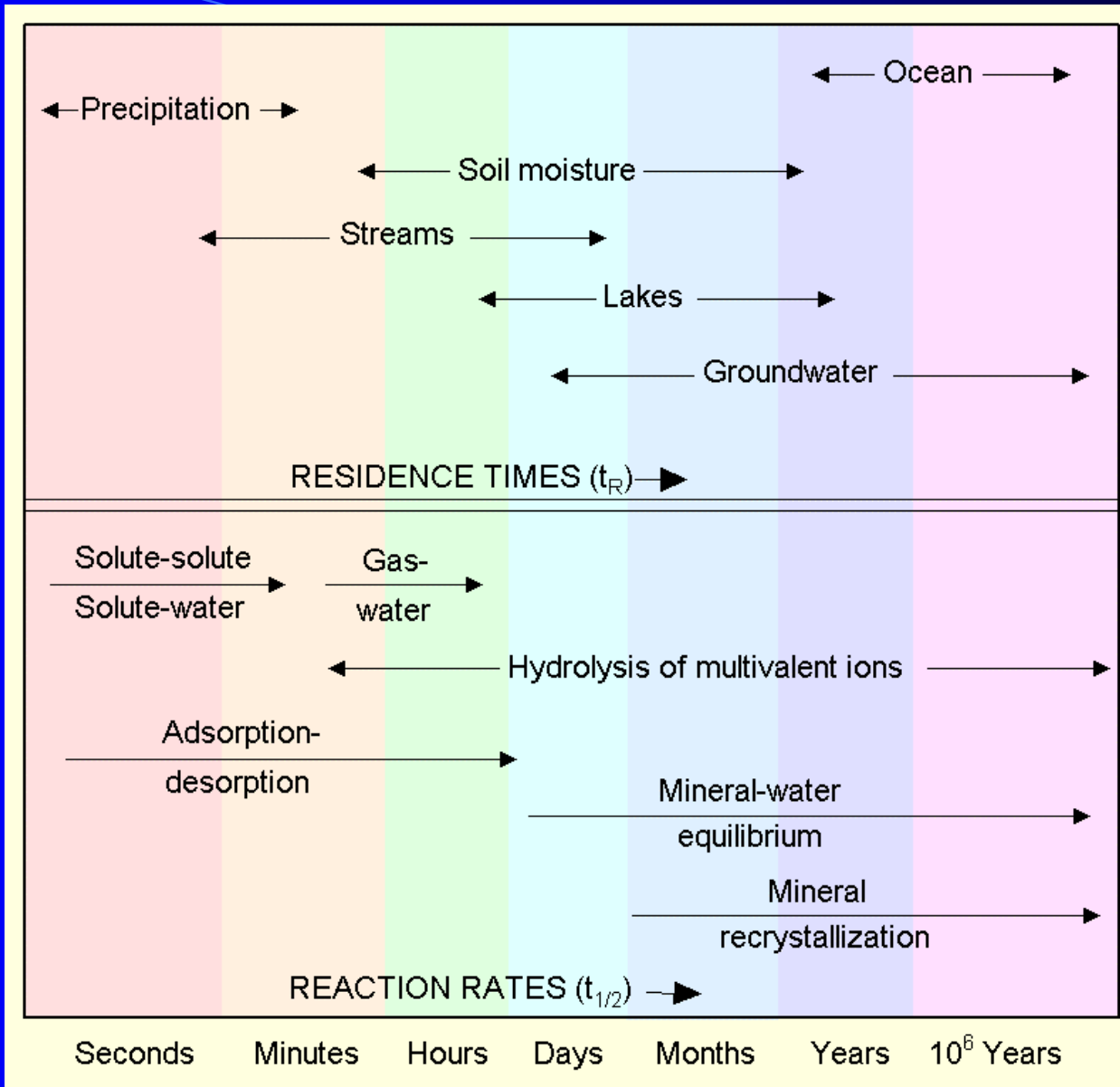


Figure 2-5. Comparison of half-lives of various reactions and residence times of water in different reservoirs. From Langmuir (1997).

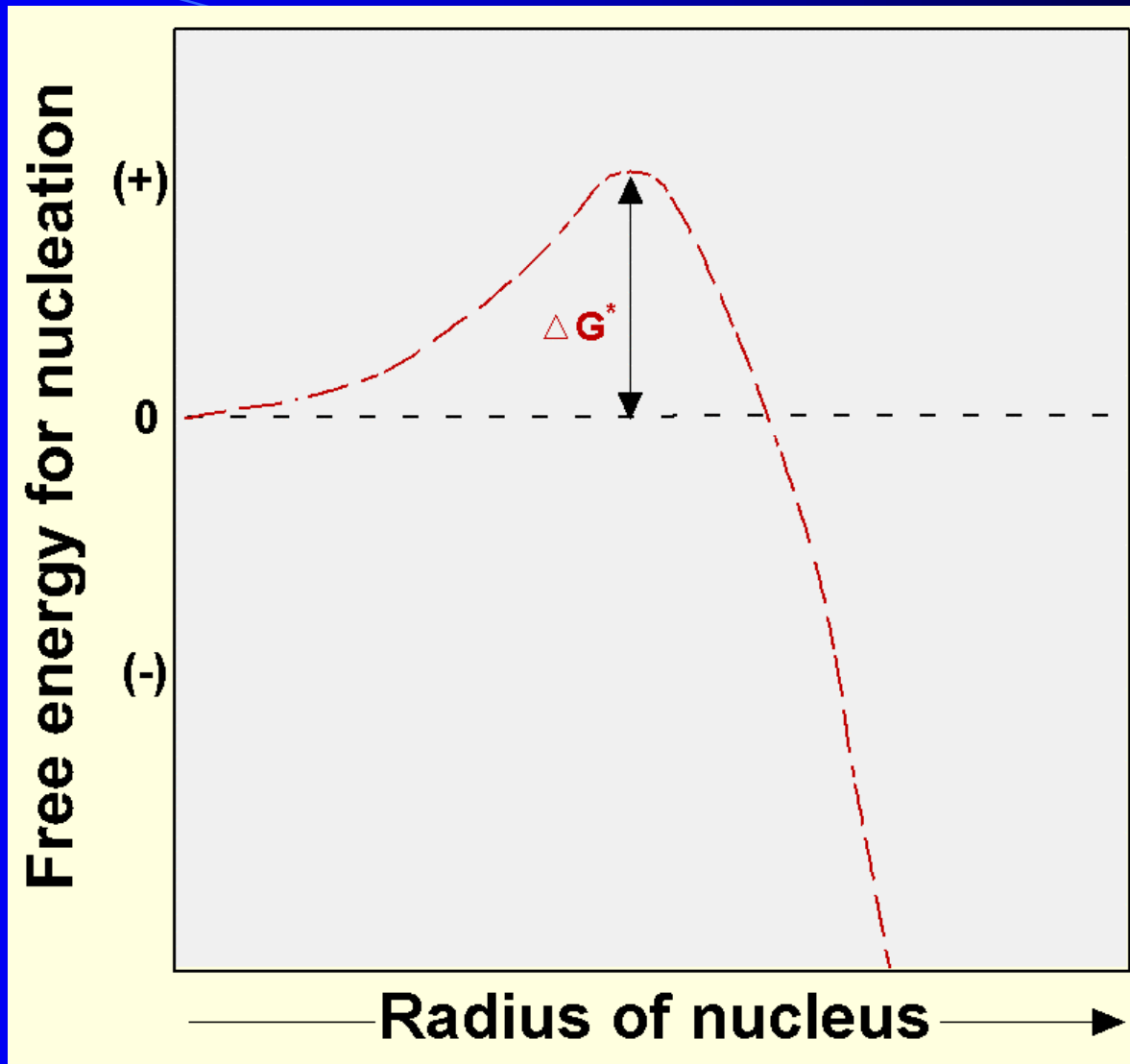


Figure 2-6. Variation of free energy of nucleation as a function of particle radius. The maximum free energy of formation corresponds to the maximum energy barrier. At greater particle radii the free energy of nucleation decreases and eventually becomes negative, and nucleation will proceed spontaneously. Modified from Drever (1997).

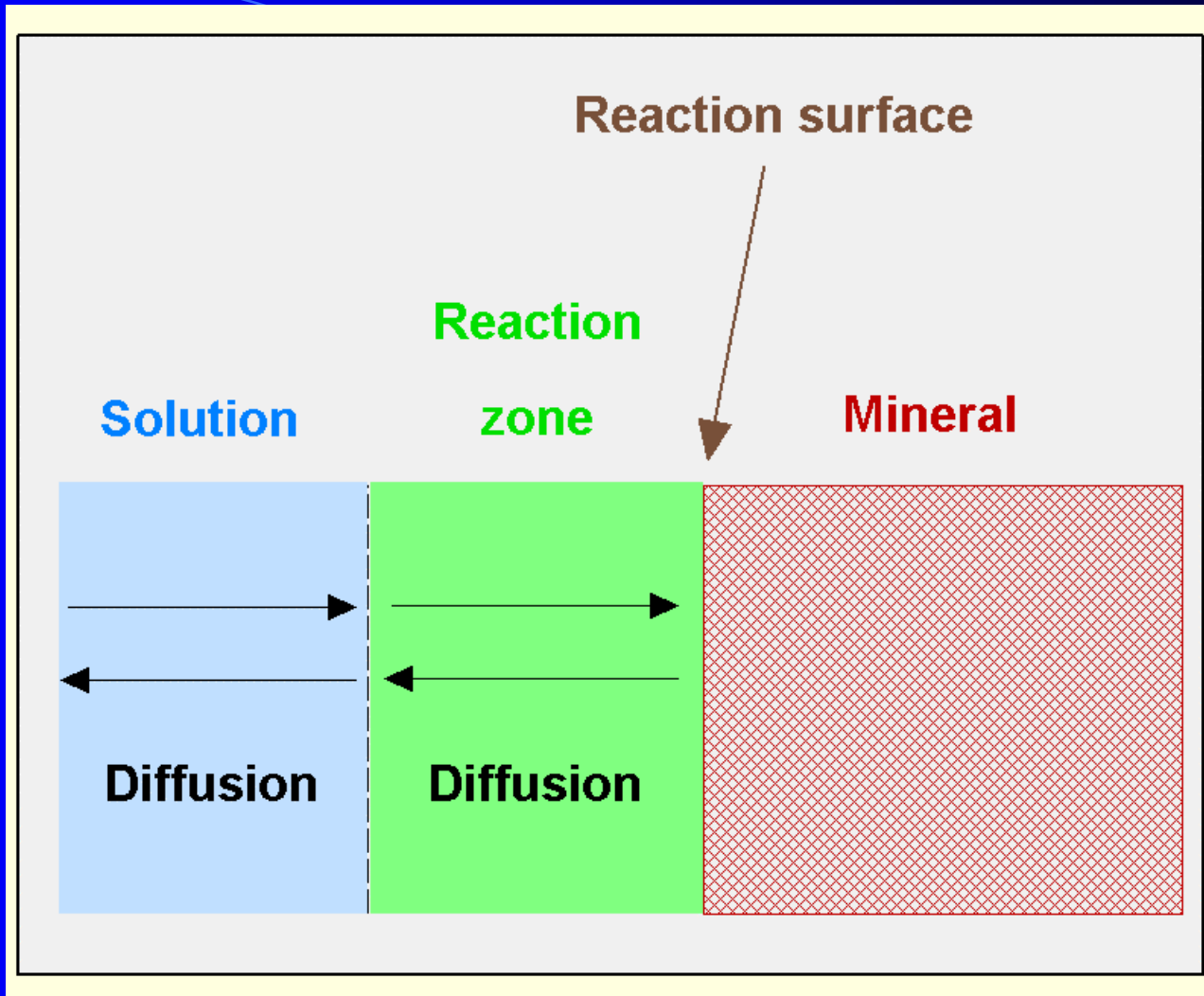


Figure 2-7. Schematic representation of a mineral reacting with a solution during dissolution. The rate-controlling step can be the diffusion of species through the solution, diffusion of species through the reaction zone, or the rate of the surface reaction. Given the slow rate of diffusion of species through the reaction zone, at some point the thickness of this zone will become sufficiently great that the diffusion of species through the reaction zone will become the rate-controlling step. Modified from Drever (1997).