Chemical Thermodynamics and Chemical Kinetics

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Contents

Physical Constants and Values

(The NIST Reference on Constants, Units, and Uncertainty, 2014)

Quantity	Symbol	Value
Speed of Light	c	299 792 458 m/s
Electron Charge	e	1.602 176 6208(98) x 10^{-19} C
Faraday Constant	F	96 485.332 89(59) C mol^{-1}
Boltzmann Constant	k_B	1.380 648 52(79) x 10^{-23} J K^{-1}
Gas Law Constant	R	8.314 4598(48) J mol^{-1} K^{-1}
Planck's Constant	h	6.626 070 040(81) x 10^{-34} J s
Avogadro's Number	N_A	6.022 140 857(74) x 10^{23} mol^{-1}
Atomic Mass Unit	amu	1.660 539 040(20) x 10^{-27} kg
Electron Mass	m_e	9.109 383 56(11) x 10^{-31} kg
Proton Mass	m_p	1.672 621 898(21) x 10^{-27} kg
Neutron Mass	m_n	1.674 927 471(21) x 10^{-27} kg
Magnetic Constant	μ_0	12.566 370 614... x 10^{-7} N A^{-2}
Electric Constant	ε_0	8.854 187 817... x 10^{-12} F m^{-1}
Rydberg Constant	R_∞	10 973 731.568 508(65) m^{-1}

References

The NIST Reference on Constants, Units, and Uncertainty. (2014). Retrieved March 13, 2016, from CODATA Internationally recommended 2014 values of the Fundamental Physical Constants: http://physics.nist.gov/cuu/index.html

Preface

This work represents a textbook suitable to be used in a one-semester course in physical chemistry covering the topics of Chemical Thermodynamics and Chemical Kinetics. The approach is that of classical (caloric) thermodynamics, rather than statistical in nature. Both approaches are of significant value. The latter, however, requires an introduction to quantum chemistry that is not assumed in this text.

The book is written for an audience with a presupposed knowledge of math up through the calculus of functions with multiple variables. It is hoped that the text is written clearly enough to explain concepts that might otherwise be to the student simply as a mass of equations and symbols. That notwithstanding, a great deal of care has been taken in mathematical derivation to keep things complete, while still being simple and clear. It is also assumed that the learner has completed a course in general chemistry and also one in quantitative analysis. Many of the examples in this book rely on (and/or review) material that is typically covered in those courses. It is also assumed that the student has completed a physics course covering kinematics, so that concepts of kinetic and potential energy are not new.

A great deal of historical information has been included, including comments about some of the pioneers of thermodynamics. It should be noted that while the scientists from these earlier eras are almost exclusively male, white, and of European ancestry, it should be noted that this pattern reflects social norms (which included the exclusion of women and those not of European decent to a great extent) are not the norm today. While the vast field s of science have a great ways to go in order to be more inclusive, it is my hope that books that describe the accomplishments and contributions of the current and future generations will reflect these more inclusive attitudes. We all benefit when we welcome and embrace contributions from talented individuals, rather than dismissing them for arbitrary reasons.

Finally, I would like to comment about the perceived nature of physical chemistry as a particularly challenging topic. In short, every individual's experiences will differ as to just how challenging physical chemistry is, and why exactly that is. Sometimes it is because the math is overbearing and the qualitative value of the concepts gets lost in the symbolism. For some it is the vast array of assumptions we make to create simpler models to describe systems. For others, it is the small number of symbols we use while having to describe so many different types of physical variables. Unfortunately, the Latin alphabet has only 26 letters, and even if we use the entire Greek alphabet, we only get 23 additional symbols to use. But there are far more than 49 important physical properties and/or constant that we need to describe. Alas. At least as far as this text is concerned, I have attempted to keep things simple and standardized so that this text can be used in conjunction with other reference materials and texts on the topics without a great deal of translation from non-standard notation usages.

I wish all of the students studying physical chemistry the very best of success.

Periodic Table of the Elements

(with rounded atomic masses)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
I A	II A	III B	IV B	V B	VI B	VII B	VIII B			I B	II B	III A	IV A	V A	VI A	VII A	VIII A
1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.944	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.30											13 **Al** 27.00	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.84	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.64	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.7	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	* 	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	** 	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (266)	107 **Bh** (264)	108 **Hs** (269)	109 **Mt** (268)	110 **Ds** (271)	111 **Rg** (272)	112 **Cn** (277)	113 **Nh** (284)	114 **Fl** (285)	115 **Mc** (288)	116 **Lv** (289)	117 **Ts** (294)	118 **Og** (294)

*Lanthanides	57 **La** 138.8	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
**Actinides	89 **Ac** (227)	90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

Place Chapter RD Fields here:

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