

# PHYSICAL CHEMISTRY



## BASICS

<b>Adiabatic process</b>	Process in which no heat is transferred into or out of the system
<b>Boiling point</b>	Lowest temperature at which liquid under fixed pressure changes state from liquid to vapor (vapor pressure = pressure on liquid)
<b>Carnot cycle</b>	System undergoing a cyclic process involving two reversible isothermal processes and two reversible adiabatic processes
<b>Carnot engine</b>	The most efficient heat engine which follows the Carnot cycle
<b>Chemical potential (<math>\mu</math>)</b>	Measure of a chemical system's tendency to change (undergo a reaction, form a new phase)
<b>Critical point</b>	Temperature above liquid and vapor are identical
<b>Cyclic process</b>	A process which repeats a series of changes in the system
<b>Enthalpy (<math>H</math>)</b>	The quantity of heat in a substance per unit mass under constant pressure
<b>Entropy (<math>S</math>)</b>	A measure of degree of randomness of a system
<b>Equilibrium state</b>	State in which state's macroscopic properties (such as temperature) are well defined and do not change with time
<b>Heat (<math>Q</math> or <math>q</math>)</b>	A form of energy; an energy transfer due to temperature difference between system and surroundings
<b>Heat capacity (<math>C</math>)</b>	Total amount of heat needed to produce a one degree rise in temperature of a given substance
<b>Heat engine</b>	Device that converts heat into mechanical energy

## ENERGY CONVERSION FACTORS

<b>1 J</b>	$1 \text{ Nm} = 10 \text{ kg m}^2/\text{s}^2 = 0.239 \text{ cal} = 10^7 \text{ erg} = 3.79 \times 10^3 \text{ ft-lb}$ $= 9.483 \times 10^8 \text{ dyn-cm}$
<b>1 cal</b>	$1.763 \times 10^3 \text{ J} = 3.968 \times 10^7 \text{ erg} = 4.184 \times 10^3 \text{ ft-lb}$ $= 4.186 \text{ J}$
<b>1 kWh</b>	$3.6 \times 10^6 \text{ J} = 8.60 \times 10^5 \text{ cal} = 343.5 \text{ Btu} = 3.6 \times 10^{12} \text{ erg}$
<b>1 Btu</b>	$1055 \text{ J} = 252 \text{ cal} = 2.93 \times 10^5 \text{ erg} = 1.055 \times 10^{12} \text{ erg}$

## PRESSURE CONVERSION FACTORS

<b>1 atm</b>	$1.01325 \times 10^5 \text{ Pa} = 1.01 \times 10^5 \text{ N m}^{-2} = 1.01325 \text{ bar}$ $= 760 \text{ Torr} = 760 \text{ mm Hg} = 29.92 \text{ in. Hg}$
<b>1 Pa</b>	$9.869 \times 10^{-6} \text{ atm} = 7.5 \times 10^{-6} \text{ cm Hg} = 1 \text{ N m}^{-2}$
<b>1 millibar</b>	$10^3 \text{ Pa}$

## EQUILIBRIUM CONSTANTS

- For reaction,  $aA + bB \rightleftharpoons cC + dD$

### GAS EQUILIBRIUM

- For gases, the equilibrium constant is expressed in terms of partial pressures

$$K_p = \frac{\left(\frac{p_C}{p^\circ}\right)^c \left(\frac{p_D}{p^\circ}\right)^d}{\left(\frac{p_A}{p^\circ}\right)^a \left(\frac{p_B}{p^\circ}\right)^b} \quad K_p = K_p(p^\circ)^{\Delta n}$$

where  $\Delta n = (c + d) - (a + b)$

### CHEMICAL EQUILIBRIUM

- At equilibrium, concentrations are at a fixed ratio

$$K_c = \frac{\left(\frac{[C]}{[A]}\right)^c \left(\frac{[D]}{[B]}\right)^d}{\left(\frac{[A]}{[B]}\right)^a \left(\frac{[C]}{[D]}\right)^b}$$

### Internal energy ( $U$ or $E$ )

#### Reversible process

#### Isobaric process

#### Isochoric process

#### Isothermal process

#### Mass

#### Melting point

#### Pressure ( $p$ or $P$ )

#### Quantity of heat

#### Reversible process

### State function (state variables)

### Temperature ( $T$ )

### Triple point

### Work ( $W$ or $W$ )

The total kinetic and potential energy at the molecular level

Non-equilibrium process in which no small change in conditions could make the process go in reverse

Process in which pressure remains constant

Process in which volume remains constant

Process in which temperature remains constant

Amount of matter in an object

The lowest temperature at which a solid under a fixed pressure changes state from a solid to a liquid

The force acting on a unit area

Total kinetic energy of substance's molecules

Process whose direction may be reversed by small change in one factor; system is always near equilibrium

Property of system which has a definite value for each state, and does not depend on how the state is reached (such as temperature, pressure, volume)

Average kinetic energy of molecules of a substance (Never lost to be confused with quantity of heat)

Temperature and pressure at which 3 phases of a substance (solid, liquid, vapor) co-exist in equilibrium

Form of energy transfer that may be represented as a force acting through a distance

## TEMPERATURE CONVERSION FACTORS

$$T_F = 9/5 \times T_C + 32$$

$$T_K = T_F + 459.67$$

$$T_F = T_C + 273.15$$

$T$  = Fahrenheit,  $C$  = Celsius,  $K$  = Kelvin,  $R$  = Rankine

## CONSTANTS

<b>Avogadro Constant (<math>N_A</math>)</b>	$6.0221367 \times 10^{23}$ molecules/mol
<b>Boltzmann Constant (<math>k</math>)</b>	$1.380658 \times 10^{-23} \text{ J/K}$
<b>Stefan-Boltzmann Constant (<math>\sigma</math>)</b>	$5.67037 \times 10^{-8} \text{ W/m}^2\text{K}^4$
<b>Molar Gas Constant (<math>R</math>)</b>	$8.314510 \text{ J/mol K}$ $0.082056 \text{ L atm/mol K}$
<b>Molar Volume of an Ideal Gas (<math>V_m</math>)</b>	$22.41410 \text{ L/mol at } 0^\circ\text{C, 1 atm}$



- At start of a reaction, concentrations are at a ratio

$$Q_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

- If  $Q_c < K_c$ , then the reaction proceeds from left to right

- If  $Q_c = K_c$ , then the system is at equilibrium

- If  $Q_c > K_c$ , then the reaction proceeds from right to left

# Physical Chemistry Guide

**Daniel F McAuley**



## **Physical Chemistry Guide:**

*Survival Guide for Physical Chemistry* Michelle M. Francl, 2001-01-01 In writing this book I've aimed to give students a portable and readable compendium of information needed in physical chemistry. The approach taken throughout this book emphasizes mechanics at the expense of theory. Examples of techniques discussed are provided along with heavily annotated solutions. This is meant to be a reference, not an additional text book. P iv

**Exam Survival Guide: Physical Chemistry** Jochen Vogt, 2017-02-24 A text and exercise book for physical chemistry students. This book deals with the fundamental aspects of physical chemistry taught at the undergraduate level in chemistry and the engineering sciences in a compact and practice-oriented form. Numerous problems and detailed solutions offer the possibility of an in-depth reflection of topics like chemical thermodynamics and kinetics, atomic structure and spectroscopy. Every chapter starts with a recapitulation of important background information before leading over to representative exercises and problems. Detailed descriptions systematically present and explain the solutions to the problems so that readers can carefully check their own solutions and get clear-cut introductions on how to approach similar problems systematically. The book addresses students at the upper undergraduate level as well as tutors and teachers. It is a rich source of exercises for exam preparation and can be used alongside classical textbooks. Furthermore, it can serve teachers and tutors for the conception of their lessons. Its well-thought-through presentation structure and design make the book appeal to everybody who wants to succeed with the physical chemistry lessons and exercises.

**A Life Scientist's Guide to Physical Chemistry** Marc R. Roussel, 2012-04-05 Motivating students to engage with physical chemistry through biological examples, this textbook demonstrates how the tools of physical chemistry can be used to illuminate biological questions. It clearly explains key principles and their relevance to life science students using only the most straightforward and relevant mathematical tools. More than 350 exercises are spread throughout the chapters, covering a wide range of biological applications and explaining issues that students often find challenging. These, along with problems at the end of each chapter and end-of-term review questions, encourage active and continuous study. Over 130 worked examples, many deriving directly from life sciences, help students connect principles and theories to their own laboratory studies. Connections between experimental measurements and key theoretical quantities are frequently highlighted and reinforced. Answers to the exercises are included in the book. Fully worked solutions and answers to the review problems, password-protected for instructors, are available at [www.cambridge.org/roussel](http://www.cambridge.org/roussel).

**Physical Chemistry** Gaurav Madan, 2007 A textbook for B.Sc. Classes as per the UGC Model Syllabus. The book is visually beautiful and authors communicate their enthusiasm and enjoyment of the subject in every chapter. This textbook is currently in use at hundreds of colleges and universities throughout the country and is a national best-seller. There are hundreds of computer-generated coloured diagrams, graphs, photos, and tables.

**Thermodynamics Problem Solving in Physical Chemistry** Kathleen E. Murphy, 2020-03-23 Thermodynamics Problem Solving in Physical Chemistry Study Guide and Map is an

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A Textbook of Physical Chemistry Arthur Adamson, 2012-12-02 A Textbook of Physical Chemistry Second Edition serves as an introductory text to physical chemistry Topics covered range from wave mechanics and chemical bonding to molecular spectroscopy and photochemistry ideal and nonideal gases the three laws of thermodynamics thermochemistry and solutions of nonelectrolytes The kinetics of gas phase reactions colloids and macromolecules and nuclear chemistry and radiochemistry are also discussed This edition is comprised of 22 chapters the first of which introduces the reader to the behavior of ideal and nonideal gases with particular emphasis on the van der Waals equation The discussion then turns to the kinetic molecular theory of gases and the application of the Boltzmann principle to the treatment of molar polarization dipole and magnetic moments the phenomenology of light absorption and classical and statistical thermodynamics The chapters that follow focus on the traditional sequence of chemical and phase equilibria electrochemistry and chemical kinetics in gas phase and solution phase This book also considers wave mechanics and its applications molecular spectroscopy and photochemistry and the excited state and then concludes with an analysis of crystal structure colloid and polymer chemistry and radio and nuclear chemistry This reference material is intended primarily as an introductory text for students of physical chemistry

*Physical Chemistry: A Molecular Approach* Donald A. McQuarrie, John D. Simon, 1997-08-20 Emphasizes a molecular approach to physical chemistry discussing principles of quantum mechanics first and then using those ideas in development of thermodynamics and kinetics Chapters on quantum subjects are interspersed with ten math chapters reviewing mathematical topics used in subsequent chapters Includes material on current physical chemical research with chapters on

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**A to Z of Thermodynamics** Pierre Perrot, 1998 The title is a perfect description Arranged alphabetically this book explains the words and phrases that crop up in thermodynamics The author does this without resorting to pages of mathematics and algebra the author's main aim is to explain and clarify the jargon and concepts Thermodynamics is often difficult and confusing for students The author knows this after 20 years of teaching and does something about it with this dictionary

**Preparing for Your ACS Examination in Physical Chemistry** Thomas A. Holme, Kristen Murphy, 2009 *Quantities, Units and Symbols in Physical Chemistry* International Union of Pure and Applied Chemistry. Physical and Biophysical Chemistry Division, 2007 Prepared by the IUPAC Physical Chemistry Division this definitive manual now in its third edition is designed to improve the exchange of scientific information among the readers in different disciplines and across different nations This book has been systematically brought up to date and new sections added to reflect the increasing volume of scientific literature and terminology and expressions being used The Third Edition reflects the experience of the contributors with the previous editions and the comments and feedback have been integrated into this essential resource This edition has been compiled in machine readable form and will be available online

**Physical Chemistry for the Life Sciences** Peter Atkins, Julio de Paula, 2011-01-30 Peter Atkins and Julio de Paula offer a fully integrated approach to the study of physical chemistry and biology

*Atkins' Physical Chemistry 11e* Peter Atkins, Julio De Paula, James Keeler, 2019-09-06 Atkins Physical Chemistry Molecular Thermodynamics and Kinetics is designed for use on the second semester of a quantum first physical chemistry course Based on the hugely popular Atkins Physical Chemistry this volume approaches molecular thermodynamics with the assumption that students will have studied quantum mechanics in their first semester The exceptional quality of previous editions has been built upon to make this new edition of Atkins Physical Chemistry even more

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**Molecular Physical Chemistry** José J. C. Teixeira-Dias, 2017-01-16 This is the physical chemistry textbook for students with an affinity for computers It offers basic and advanced knowledge for students in the second year of chemistry masters studies and beyond In seven chapters the book presents thermodynamics chemical kinetics quantum mechanics and molecular structure including an introduction to quantum chemical calculations molecular symmetry and crystals The application of physical chemical knowledge and problem solving is demonstrated in a chapter on water treating both the water molecule as well as water in condensed phases Instead of a traditional textbook top down approach this book presents the subjects on the basis of examples exploring and running computer programs Mathematica discussing the results of molecular orbital calculations performed using Gaussian on small molecules and turning to suitable reference works to obtain thermodynamic data Selected Mathematica codes are explained at the end of each chapter and cross referenced with the text enabling students to plot functions solve equations fit data normalize probability functions manipulate matrices and test physical models In addition the book presents clear and step by step explanations and provides detailed and complete answers to all exercises In this way it creates an active learning environment that can prepare students for pursuing their own research projects further down the road Students who are not yet familiar with Mathematica or Gaussian will find a valuable introduction to computer based problem solving in the molecular sciences Other computer applications can alternatively be used For every chapter learning goals are clearly listed in the beginning so that readers can easily spot the highlights and a glossary in the end of the chapter offers a quick look up of important terms Principles of Physical Chemistry: Part B Lionel M. Raff, 2001 Modern Physical Chemistry for Bioscience Students Kazushige Yokoyama, 2011

**Physical Chemistry** Peter Atkins, Peter William Atkins, 2014-04 Peter Atkins Very Short Introduction explores the contributions physical chemistry has made to all branches of chemistry Providing insight into its central concepts Atkins reveals the cultural contributions physical chemistry has made to our understanding of the natural world The Pearson Guide to Physical Chemistry for the IIT JEE Singhal,

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