A Workbook for Learning Chemistry

Paul Perkins Seattle Lutheran High School

Mare Sullivan Bellevue Christian School

August 2012 edition

Acknowledgements

2012 Version

Text compiled and partially written by Mare Sullivan, Bellevue Christian School, Clyde Hill WA and Paul Perkins, Seattle Lutheran School, Seattle WA.

Since this *Workbook* contains copyrighted material, it may be used only by instructors who have purchased their own copy of the book, *POGIL Activities for High School Chemistry*. For purchasing information: https://pogil.org/activity-collections/chemistry/activities-high-school-chem

DO NOT SHARE ELECTRONIC OR HARD COPIES OF THIS WORKBOOK WITHOUT PRIOR PERMISSION OF THE AUTHORS.

Text Revision Team

Chemistry Helper sections written by Chris Chu, David Dean, and Ryan Thorlakson, BCS AP Chemistry 2000 – 2001.
Original artwork by David Thorpe, BCS '01.
Content and copy editing by Pat Perkins and Mare Sullivan, 2005.
Technical writing assistance by Katie Ferguson, BCS '02.

Initial Text

- Much of this text is taken directly from *POGIL Activities for High School Chemistry*, by Laura Trout, editor; Flinn Scientific, Inc., Batavia, IL; 2012. May be used only by teachers who have purchased their own copy of the POGIL book.
- Additional text, labs, and exercises have been adapted from the National Science Foundation *CHEM STUDY* curriculum, which is no longer in print.

Some activities are from the *Target Inquiry* website, and **may be used only by teachers who** have registered online with the *Target Inquiry Project*. http://www.gvsu.edu/targetinquiry/tidocuments-login_register.htm

Song Lyrics

Lyrics from the CDs *Chemistry Songbag* © 2002, and *Chemistry Songbag II* © 2000, by Michael Offutt. Used with permission of the artist.

Mare Sullivan joe.mare.sullivan@gmail.com Paul Perkins perkins48@q.net

Table of Contents

Chapter 1 CSI: Chemistry Scene Investigations

Lab 1-1: Burn, baby, burn! Observations and Interpretations

Significant Digits

Lab 1-2: A Race to the Finish...

Organizing Data

Lab 1-3: Feelin' the Heat Heating Curves Changes of State or Phase Changes $\int H_2O$ Song

Significant Zeros

Significant? I Don't Think So

Lab 1-4: Mystery of the Disappearing Wax Chemical reactions: basic vocabulary terms

Lab 1-5: Further Investigations into the Burning of a Candle

Classification of Matter

Isotopes

Ions

Lab 1-6: Feelin' the Heat: The Sequel Heat Effects in Chemical and Physical Changes Calories

Average Atomic Mass

Chapter Review Notes Chapter Helper

Chapter 2 The answer is blowin' in the wind

Lab 2-1: A gas is a gas is a gas... or is it? Amedeo Avogadro

Relative Mass and the Mole

Mole Ratios

Inventory Time in the Chemistry Lab

Exercises Chapter Review Notes Chapter Helper

Chapter 3 Chemical Reactions

Lab 3-1: Chemical Reactions and Mole Ratios

Limiting and Excess Reactants

Change You Can Believe In

Lab: The Only Thing Constant in Life Is Change

Chapter 4 It's a Gas!

Gas Variables

Lab 4-1: Bubble Up!

Model 1: Calculating the volume of a mole of gas at 25 °C and 1 atm

Model 2: Barometers and manometers

STP: Standard Temperature and Pressure for Gases

Model 3: How total gas pressure changes when you mix gases together

Dalton's Law of Partial Pressures

Charles's Law, Absolute Zero, and Kelvins

Chapter 5 Physical Properties Matter!

Phase Changes

Model 1: Evaporation of Water

Model 2: Normal Boiling Points and Molar Heats of Vaporization of Some Pure Substances

Boiling Point and Vapor Pressure

Model 3: Melting Points and Heats of Melting of Some Pure Substances

Mixtures and Pure Substances

Model 4: Boiling Points of Pure Substances and Mixtures

Lab 5-1: How does the melting point of a pure substance compare to the melting point of a mixture?

Saturated and Unsaturated Solutions

Molarity

Lab 5-2: To be or not to be... an electrolyte

Sweet and Salty Aren't Just Different Flavors

Lab 5-3: If you're not part of the solution... you're part of the precipitate!

Chapter 6 Thinking About Atoms & Interpreting the Data

Noble Gases

Model 1: Some Properties of the Inert Gas Elements

Model 2: The Electron Populations of the Inert Gases

Alkali Metals

Model 3: Some Properties of the Alkali Metals

Alkali Metal Reactions

Halogens

Model 4: Some Properties of the Halogens

Model 5: Relative Diameters of Selected Molecules, Atoms, and Ions

Hydrogen

Naming Ionic Compounds

Naming Molecular Compounds

Polyatomic Ions

What's in a Name?

Empirical Formulas and Molecular Formulas

Song: Chemistry Nerd

Chapter 7 Energy and Chemical Reactions

Mini-Lab: Rubber band stretching and contracting: endothermic or exothermic?

How Much Energy Does It Take to Melt an Ice Cube?

Lab 7-1: What is the heat of reaction?

Calorimetry

Bond Energy

Hess's Law

Exercises Chapter Review Notes Chapter Helper

Chapter 8 Go, Molecules, Go

Lab 8-1: The Iodine "Clock" Reaction: How can you change the speed of a reaction?

Model 1: Eight Marbles in a Double-box System

Model 2: Reaction Coordinate Diagrams

A Theory of Reaction Rates

Model 3: Catalysts

Chapter 9 Reactions that Go Forward and Backward

Lab 9-1: How can you detect the direction of a chemical reaction? (Chemical equilibrium)

Equilibrium Song: Dynamic Equilibrium

Dynamic equilibrium

Le Chatelier's Principle

Equilibrium

K_c and K_p

Exercises Chapter Review Notes Chapter Helper

Chapter 10 Solubility and Equilibrium

Solubility

Model 3: Magnesium Hydroxide is Insoluble in Water

Model 4: Solubility of Common Compounds in Water

Lab 10-1: What is the maximum amount of a salt that can dissolve in water? (K_{sp})

Net Ionic Equations

Chapter 11 Acids and Bases

Mini-Lab: Acid/base classification of common household solutions

Acids and Bases Song: Acids and Bases

Strong vs. Weak Acids

Model 1: Acid Concentration Tables

The Acid Dissociation Constant, Ka

Calculating pH

Model 5: Neutral, Acidic, and Basic Solutions

Acids and Bases Lab Bonanza

Lab 11-1: When you mix acids and bases, what are the heats of reaction? Lab 11-2: How can you use "pH Indicator Solutions" to determine a solution's hydrogen ion concentration?

Naming Acids

Chapter 12 Oxidation-Reduction Reactions

Oxidation and Reduction Song: Redox Blues

The Activity Series

Batteries

Cathodes & Anodes

Lab 12-1: Which metals are "pushier"?

Model 1: Oxidation Number Conventions

Cell Voltage

Lab 12-2: How does a lead storage battery work?

Chapter 13 Why We Believe in Atoms

John Dalton and Atomic Theory Song: Atomic Theory Polka

Lab 13-1: How do moles of copper oxidized and reduced compare with moles of electrons transferred in an electrolysis reaction?

Faraday and Electrolysis

"Magic" Rays

J.J. Thomson and Cathode Rays

The "Plum Pudding" Model of the Atom

Song: Alpha, Beta, Gamma Radiation

Rutherford's Gold Foil Experiment

Chapter 14 The Periodic Table and... Electrons!

Coulombic Attraction

Electron Energy and Light

Electron Configurations Song: Quantum Number Rag Song: Electron Configuration Polka

Cracking the Periodic Table Code

Periodic Trends

Exercises Chapter Review Notes Chapter Helper

Chapter 15 Bonding in Gas Molecules

To Share or Not to Share: How Does It Shape Thee? Song: If It Isn't Love, What's Going On?

Molecular Geometry

Types of Chemical Reactions

Fundamentals of Experimental Design

Vocabulary

Chapter 1	Chapter 2	Chapter 3
Calories	Atomic mass	Acid
Combustion	Atomic weight	
	0	Balanced chemical equation Chemical reaction
Interpretation	Avogadro's Hypothesis	
Observation	Avogadro's number	Concentration
Phase Change	Mole	Conservation of atoms
Qualitative	Molecular weight	Endothermic
Quantitative	Molecules	Exothermic reaction
	Pressure	Filtrate
	Volume	Molar heat of combustion
		Phase change
		Precipitate
Chapter 4	Chapter 5	
		Phase change
Absolute zero	Alloy	Precipitate
Barometer	Anions	Pure substance
Density	Boiling point	Saturation
Kelvins	Cations	Solid
Kelvin scale	Heterogeneous	Solubility
Kinetic theory	Homogeneous	Solute
Molar volume	Gas	Solution
Partial pressure	Liquid	Solvent
Pressure	Molarity	Strong electrolyte
	Nonelectrolyte	System
STP	Normal boiling point	Vapor pressure
	Phase	Weak electrolyte
	1 11400	weak electrolyte
Chapter 6	Chapter 7	Chapter 8
Alkali metals	Calorimetry	Activated complex
Atoms	Enthalpy	Activation energy
Electrons	Fission	Catalysts
Ionic bonds	Hess's Law	Collision frequency
Ions	Nuclear reactions	Reaction coordination
Noble gases	Nucleons	diagrams
Nucleus	Potential Energy	Reaction rate
Neutrons		Transition state
Protons		

Chapter 9	Chapter 11	Chapter 12
Equilibrium Le Châtelier's Principle Macroscopic Chapter 10 K _{sp} solubility product Precipitate Saturated Solubility	Acid disassociation constant K _a Acidic Arrhenius acid Arrhenius base Basic Brønsted-Lowry acid Brønsted-Lowry base Conjugate acid-base pair Indicator solution Ionization Neutral pH pOH Strong acid Titration Water disassociation equilibrium constant K _w Weak acid	Anode Cathode Electronegativity Oxidation numbers Oxidation-Reduction Oxidized Reduced Reduced Reduction potential Standard half cell Standard reduction potential Voltage Voltaic cell
Chapter 13	Chapter 14	Chapter 15
Ampere Electron-to-mass ratio Empirical Formula Gold Foil Experiment J. J. Thompson John Dalton Rutherford Experiment	1s orbital 2s orbital Electron configuration Frequency Ionization Energy Niels Bøhr Orbital p orbital Quantum mechanics Quantum numbers Speed (c) Wavelength	Chemical bond Covalent bond Electric dipole Hybridize Ionic bond Lewis structures Polar molecule Tetravalent