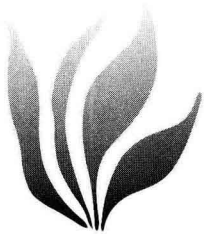
An Introduction to Chemistry for Biology Students

Seventh Edition

George I. Sackheim



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George I. Sackheim
Associate Professor Emeritus, Chemistry
University of Illinois at Chicago

formerly
Coordinator of Biological and Physical Sciences
Michael Reese Hospital and Medical Center, Chicago

Science Instructor
St. Francis Hospital School of Nursing
Evanston, Illinois

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To the Student

Introduction to Chemistry for Biology Students, Seventh Edition, is not an ordinary book. It has been programmed to help you review the basic facts, concepts, and terminology of chemistry that are essential to an understanding of biological phenomena. Today's biology courses place increasing emphasis on the chemical processes that underlie the critical biological functions. This book will help you to understand those processes.

The topics involved are among the most critical and exciting that science will explore in the years ahead. What are the basic chemical processes underlying biological phenomena? What are the essential differences between living and nonliving matter? What are the conditions under which molecules organize into living matter? Can these conditions be duplicated experimentally?

If you have already had a course in chemistry, this programmed book can serve as an effective review of the fundamental concepts. If you have had no previous chemistry, the program will give you the background you need to gain a clear understanding of the biological processes you will be studying.

The material covered in this book will help you most if you complete it during the first two weeks of your biology course. Having done that, you will be ready to handle the chemical aspects of biology as they come up.

When you have completed the program, you may want to repeat certain material. To simplify this process, use the book's Index to help you locate specific topics.

If you follow the directions and complete this program, you will learn to:

- recognize elements present in various compounds
- know what is meant by pH and by ionization
- recognize acids, bases, and salts
- discriminate between electrolytes and nonelectrolytes
- understand osmosis and diffusion
- distinguish between passive and active transport
- understand osmotic pressure

- understand transmission of nerve impulses, including depolarization and repolarization
- understand how neurotransmitters work
- know how DNA replicates
- know how mRNA is formed and how it regulates protein synthesis
- understand oxidation and reduction
- know what isotopes are
- recognize various organic functional groups
- differentiate among carbohydrates, fats, and proteins
- understand how enzymes function
- recognize nucleic acids
- understand biologic oxidation, including glycolysis, the Krebs cycle, and the electron transport chain
- understand reactions involved in photosynthesis, including light reactions and the Calvin cycle
- follow the flow of oxygen from the lungs to cells and of carbon dioxide from cells to the lungs on gas partial pressure gradients

How to Use This Book

This type of instructional book may be new to you. Its subject matter has been presented as a series of numbered problems. Each builds on information you have learned in the preceding problems. For that reason, it is important not to skip around. The sequence of the problems is important because it is programmed to help you learn more efficiently.

Respond to Every Problem

Some problems present new information; others review material presented earlier. Every problem presents a learning task that requires some response from you.

You may be asked to make any of the following types of responses:

- write an answer in a blank space
- label a diagram
- draw a simple diagram
- select the correct answer from among several alternatives
- write a sentence in answer to a question

When you have written or marked your answer, you will want to find out whether you are correct. Programmed instruction provides you with important feedback by giving you easy access to the answers, which are located in shaded areas on the outer side of each page. *Do not look at the correct answer until after you have marked your own answer.* If you look before answering, you will only impair your own learning process.

Use an Answer Mask

Bound into the back of the book is a sheet of heavy paper that is perforated. Tear off the outer portion of the sheet for use as an answer mask. Here is what to do:

1. As you start working on the first page, a right-hand page, cover the shaded answer column with the answer mask *before* looking at the problems. When you turn the page, shift your answer mask to cover the answer column on the left-hand page before reading the problems on that page. *Be sure you have covered the answers before you read anything.*

2. Each problem number is centered on the page with a shaded rectangle behind it. Read the problem carefully, then record your answer. Make sure you either write each answer or do whatever the directions say. Do not simply think of the answer and then go on. Actually writing or marking your answer reinforces your learning.

3. Now move the answer mask aside to reveal the answer, which you will find aligned with the problem number. (If the main part of the problem runs onto the next page, you will find the answer at the top of that page.)

4. If your answer was correct, move on to the next problem.

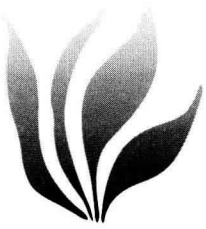
5. If your answer was incorrect, reread the problem (if necessary, reread several of the preceding problems) until you understand your error and know why the given answer is correct. Then go on.

When you have completely worked your way through this book, you should have the knowledge of chemistry you need to succeed in your biology courses.

To find a topic or to review a topic already completed, look in the index to locate the reference(s) to that subject.

Contents

PART I



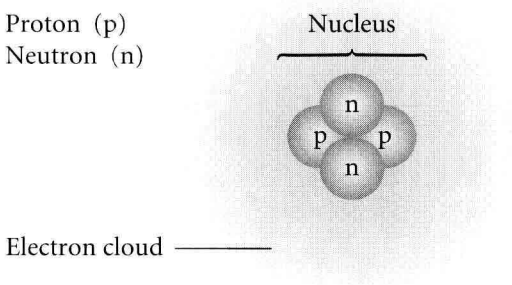
Inorganic Chemistry

Atomic Structure 1

ELEMENTARY PARTICLES

Atoms are made up of several components. Collectively these components are called the *elementary particles*. We will be discussing the three major elementary particles: *protons*, *neutrons*, and *electrons*.

Here is a diagram of an atom:



1

The protons (p) and the neutrons (n) are packed together in an inner core called the _____. The outer part of the atom, which contains electrons, is called the _____.

nucleus; electron cloud

a negative electrical charge, because the electron cloud consists of electrons

2

The electron cloud has a negative electrical charge. What type of charge would you expect the electron to have? _____

_____

a. repel
b. attract
c. repel
d. attract

3

The electron has a *negative electrical charge* and is symbolized by e^-. Remember that *like* electrical charges repel each other, and *unlike* charges attract.

Indicate whether the following pairs of charges would attract or repel each other.

a. $\oplus\oplus$ _____ b. $\ominus\oplus$ _____

c. $\ominus\ominus$ _____ d. $\oplus\ominus$ _____

positive

4

The nucleus attracts the negatively charged electrons. Therefore, the overall charge of the nucleus must be _____ (negative/positive).

proton

5

The neutron was named for its electrical characteristics. It has no electrical charge; it is neutral. This means that the positive charge of the nucleus must be due to the *second type of particle* it contains. This second type of particle is the _____.

6

So far, then, we have this picture of atomic structure:

a. An atom consists of an inner part, or _____, that is made up of _____ and _____.

b. The electron has what type of charge? _____

c. The proton has what type of charge? _____

d. The neutron has a charge of _____.

a. nucleus; protons; neutrons
b. negative
c. positive
d. zero (0)

7

The charge on the electron balances the charge on the proton. If the electron has a charge of –1, then the proton would have a charge of _____ $(-1, +1, \pm 1)$.

+1

8

An atom with one proton in its nucleus and one electron outside that nucleus would therefore have an overall charge of _____ $(+1, -1, 0)$.

0

9

Atoms are electrically neutral. This means that an atom will contain: (check one)

__ more protons than electrons
__ more electrons than protons
__ an equal number of protons and electrons

an equal number of protons and electrons

12

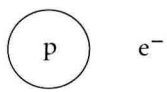
10

An atom with 12 protons in the nucleus would have how many electrons outside the nucleus? _____

a. proton
b. electron

11

The atom with the simplest atomic structure is hydrogen. (For simplicity we shall merely indicate the electron(s) outside the nucleus, and omit the electron cloud.)



Hydrogen

a. The nucleus of the hydrogen atom consists of one _____.

b. The outer part of the atom, the electron cloud, contains one _____.

2; 2; 2

12

The helium atom is a little more complicated.

Helium

It contains: (how many?)

_____ neutrons
_____ protons
_____ electrons

ATOMIC NUMBER

There are over 100 known elements. Each element has two numbers associated with it—numbers that give certain facts about the structure of its atoms.

The first number is the atomic number. This is the number of protons in the nucleus of the atom.

13

Hydrogen, the simplest atom, contains only one proton, so the atomic number of hydrogen is _____.

1

14

Uranium is the most complicated of the elements that occur naturally. A uranium atom contains 92 protons, 146 neutrons, and 92 electrons. The atomic number of uranium is _____.

92

15

An atom of magnesium, atomic number 12, must have a nucleus containing _____ protons.

If the nucleus contains 12 protons, there must be how many electrons? _____

12; 12

16

Therefore, the atomic number of an element indicates the number of _____ in the nucleus of the atom, and also the number of _____ outside the nucleus.

protons; electrons

MASS NUMBER

The second number associated with each atom is the *mass number*. The mass number expresses the sum of the masses of the particles in the atom.

A proton has a mass of 1 atomic mass unit. An electron is considered to have zero mass, or a mass of 0.

1

17

A hydrogen atom has a mass of _____. (If you don't know, see problem 11.)

a. 2
b. 0
c. 2
d. 1

18

The helium atom has a mass number of 4.

a. The 2 protons in the helium atom have a total of how many atomic mass units? _____

b. The 2 electrons in the helium atom have a total of how many atomic mass units? _____

c. Therefore, for the helium atom to have a mass number of 4, the 2 neutrons must contain how many atomic mass units? _____

d. If 2 neutrons have a total of 2 atomic mass units, a neutron must have an atomic mass of _____.

in the nucleus

19

Because the electrons, which have practically no mass, are located outside the nucleus, the entire mass of the atom can be considered to be located:

__ in its electron cloud __ in the nucleus