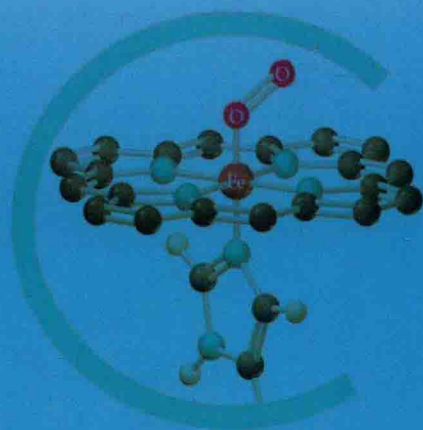


# Elementary Chemistry for Medical Students

王兴坡 赵全芹 主编

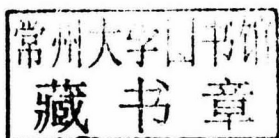


山东大学出版社

# 医学基础化学

(英文版)

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# 前 言

《医学基础化学(英文版)》(*Elementary Chemistry for Medical Students*)是为了配合医学专业《医学基础化学》的双语教学而编写的。本书得到了山东大学本科生院领导的大力支持和山东大学出版基金的资助,于2003年正式出版,并于2008年获山东大学教学成果二等奖。

当前的医学科技发展日新月异,本教材已经出版使用了十余年之久,有些内容已经不能满足现代医学的发展要求。因此,编者根据多年积累的教学经验,参考了大量国外原版教材,结合我国医学专业的实际情况,依据高等医药院校《医学基础化学教学大纲》,以培养高素质医学人才为目标,对原教材进行了补充、更新和修订,出版了本教材。

本教材系统介绍了溶液、电解质溶液、缓冲溶液、化学热力学、化学动力学、电化学、原子结构、分子结构、配位化合物、滴定分析、分光光度法、胶体和表面现象等化学基本知识。其内容与中文教材基本对应,便于学生对照学习。本教材内容简洁,层次分明,概念清晰,不仅适合于医学专业的学生,而且也适合于化学及生物学等相近专业的学生学习参考。

参与本书编写的有:山东大学王兴坡(第一章、第二章、第四章、第六章),山东大学赵全芹(第三章、第五章、第七章、第八章),山东大学孙颀(第九章、第十二章),山东省产品质量检验研究院邹惠玲,潍坊医学院石玮玮(第十章、第十一章)。

本书的出版发行得到了山东大学本科生院及化学与化工学院的大力支持,在此深表感谢。

鉴于编者的水平有限及时间仓促,错误和不妥之处在所难免,敬请读者批评指正。

编 者

2018年6月

# To the Students

So you are taking chemistry now.

Congratulations!

Believe it or not,  
chemistry is important  
in most of the things we see and do.  
The food we eat ,  
the cars we drive ,  
the air we breathe ,  
and the water and beverages we drink ,  
all serve us through the impact of chemistry.

Chemistry is a very important and interesting subject for study.

Chemistry is concerned with two questions :

What is the nature of the matter making up our Universe?

How is matter transformed from one form to another?

Examples of the first question might include :

Why is wood different from a piece of gold?

Why does mercury have such interesting properties?

What gives a piece of glass its properties?

Examples of the second question might include:

Can I turn a piece of wood into gold?

What happens to a piece of coal when it burns and how do we get those clinkers that are left in the furnace when we are finished burning the coal?

How is polyester made?

When I eat a candy bar, where do I get all the energy?

The answers to these questions will require us to think both in an abstract conceptual sense

to develop models of particles we cannot see,  
to develop rules for how these particles will act,  
to make predictions based on these models

and to think in a mathematical sense.

We will need numerical measures of the properties of matter.

We will need to test our predictions of our models.

**Enjoy your study in chemistry!**

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## CHAPTER ONE

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# Solution

Solutions play a very important role in our life.

During digestion, foods are changed to soluble substances so that they may pass into the bloodstream and be carried to all parts of the body. At the same time the waste products of the body are dissolved in the blood and carried to other parts of the body where they can be eliminated. Plants obtain minerals from the groundwater in which those minerals have dissolved.

Many chemical reactions take place in solution. When solid silver nitrate ( $\text{AgNO}_3$ ) is mixed with solid sodium chloride ( $\text{NaCl}$ ), no reaction takes place because the movement of the ions in the solid state is highly restricted. However, when a solution of silver nitrate is mixed with a solution of sodium chloride, a precipitate of silver chloride is formed instantaneously. This reaction occurs because the ions in the solution are free to move and react with other ions.

Many medications are administered orally, subcutaneously, or intravenously as solutions.

Drugs must be in solution before they can be absorbed from the gastrointestinal (GI) tract. As you might expect, when drugs are taken in solution, such as syrups and elixirs, they are absorbed more rapidly than drugs in a solid form, such as tablets and capsules.

## 1-1 Basic Terms of Solution

To discuss solutions, we need to define a few basic terms. A **solution** is *a homogeneous mixture of two or more substances evenly distributed in each other*. When one of these substances is a liquid and the others are solids or gases, we tend to think

of the liquid as the substance that dissolves the solid or gas. The liquid is referred to as the solvent and the solids and gases as the solutes. In the case of a solution of sucrose (table sugar) in water, sucrose is the solute and water is the solvent. You make up the solution by dissolving sucrose (the solute) in water (the solvent). Similarly, you dissolve air (the solute) in water (the solvent) by bubbling air into water.

When two gases or two liquids are mixed, the distinction between the substance that dissolves and the substance that is dissolved is not so clear. In those cases, we refer to the substance in greater amount as the solvent; the other substance is the solute. In summary, we define the terms solvent and solute as follows: the **solvent** is *the substance in a solution that dissolves another substance; if it is not clear which substance does the dissolving, it is the substance in the solution that is in greater amount.* A **solute** is *either a substance in a solution considered to have been dissolved by a solvent, or else a substance in a solution that is in smaller amount.*

Generally, when you mix substances together to make a solution, you find that you can dissolve only a limited amount of one substance in another. As you dissolve more and more sucrose in water, you reach a point when no more sucrose dissolves no matter how much you stir the solution. When you mix two liquids together, however, you may find that they dissolve completely in one another, whatever proportions you take. Suppose, for example, that you have 100 mL of water in a beaker, and you begin adding ethyl alcohol to it. You find that no matter how much alcohol you add to the water, the liquids mix to form a homogeneous mixture, or solution. Eventually, you will have added so much alcohol that the solution is essentially alcohol with some water in it. *Two liquids that mix completely in one another to form a solution, no matter what the proportions of liquids,* are said to be **miscible**.

On the other hand, the two liquids might not mix appreciably. Consider what happens when you try to mix oil in water. You find that, rather than mixing, the oil forms a layer that floats on the water. Similarly, if you try to mix gasoline and water, you obtain two liquid layers. The bottom layer is mostly water with a small amount of gasoline dissolved in it, whereas the top layer is mostly gasoline with a small amount of water dissolved in it. (If the gasoline in your car has water dissolved in it, the water may separate out and freeze in the winter if it is cold enough, blocking the gasoline intake line.) *Two liquids that do not mix together or dissolve in one another in significant amounts, but rather tend to separate into two distinct layers,* are said to be **immiscible**.

## ● Solution Process

What happens when a substance like NaCl dissolves in water? When NaCl is added to water, the water molecules orient themselves on the surface of the NaCl crystals. The positive end of the water dipole is oriented towards the  $\text{Cl}^-$  ions, while the negative end of the water dipole is oriented towards the  $\text{Na}^+$  ions. The dipole-ion attractions between water molecules and  $\text{Na}^+$  and  $\text{Cl}^-$  ions are sufficiently strong to pull these ions from their positions in the crystal. Once removed from the crystal, the  $\text{Na}^+$  and  $\text{Cl}^-$  ions are surrounded by water molecules. Such *interaction between solute and solvent molecules* is known as **solvation**. When the solvent is water it is known as **hydration**.

Sodium chloride dissolves in water because the water molecules interact with the  $\text{Na}^+$  and  $\text{Cl}^-$  ions sufficiently strongly to overcome the attraction between  $\text{Na}^+$  and  $\text{Cl}^-$  ions in the crystal. To form a solution, the water molecules must also separate to make room for the ions. Therefore, we can visualize three types of interaction that take place in the **solution** process: (1) solute-solute interactions, (2) solute-solvent interactions, and (3) solvent-solvent interactions. Energy is required to overcome solute-solute and solvent-solvent attractions in the **diffusion** process which is *endothermic*, while **energy** is released when solute and solvent interact with one another in the **solvation** process which is *exothermic*. The net solution process can be either exothermic or endothermic. For example, ammonium nitrate,  $\text{NH}_4\text{NO}_3$ , dissolves by an endothermic reaction ( $\Delta H = 26.4 \text{ kJ/mole}$ ). It has consequently been used to make instant ice packs, which are used in athletics. The solid  $\text{NH}_4\text{NO}_3$  is placed inside a thin-walled plastic bag. This in turn, is sealed inside a thicker-walled bag together with some water. The small bag can be broken by kneading the larger bag. The resultant solution gets quite cold.

## 1-2 Solubility of Solution

When you stir a small quantity of sodium chloride into water, it dissolves to form a solution. If you continue adding similar samples of sodium chloride to the solution, the first samples dissolve as before, but eventually you reach a point where any

additional salt that you add remains undissolved at the bottom of the container. Continued investigation would show you that there is a definite maximum amount of salt that you can dissolve in a given quantity of water. 100 mL water dissolves a maximum of 36 g of sodium chloride at 20 °C. Therefore, we say that the solubility of sodium chloride at 20 °C is 36 g per 100 mL of water. Now, we will look at this concept of solubility more closely.

To explore the concept of solubility in more detail, we will use sodium thiosulfate ( $\text{Na}_2\text{S}_2\text{O}_3$ ) as our example. This is a white, crystalline compound used in photography to fix the image on a negative.

Suppose you add 60 g of sodium thiosulfate to 100 mL of water contained in a flask at 20 °C. After stirring vigorously, you find that 50 g of the crystalline compound dissolves, leaving 10 g at the bottom of the flask. Thus, the maximum amount of the compound that you can dissolve in this quantity of water at this temperature is 50 g.

**Solubility** is the maximum amount of substance that dissolves in a given volume of solvent at a specified temperature. Thus, the solubility of sodium thiosulfate at 20 °C is 50 g in 100 mL of water.

It is important to understand that it takes time for a substance to dissolve. It is also important to understand the factors that determine the rate, or speed, of dissolving when trying to determine the solubility of a substance. Fine crystals dissolve faster than large crystals. Stirring also accelerates the solution process. When you use fine crystals of sucrose, they dissolve readily in water with only a little stirring. When you try to dissolve a large chunk of sucrose, however, it dissolves very slowly. If you are not careful to stir thoroughly and to wait long enough, you might think that the maximum has dissolved when it has not. You would then obtain the wrong value for the solubility. The solubility of sucrose is 200 g in 100 mL of water at 20 °C, independent of the initial size of the sucrose crystals and independent of how vigorously you stir the solution. It simply takes longer for the crystals to dissolve if they are larger or if you do not stir the solution vigorously.

## 1-2.1 Saturated and Unsaturated Solutions

The solution you obtain after you have dissolved the maximum amount of solute in a solvent at a given temperature is said to be a **saturated solution**. Thus, the