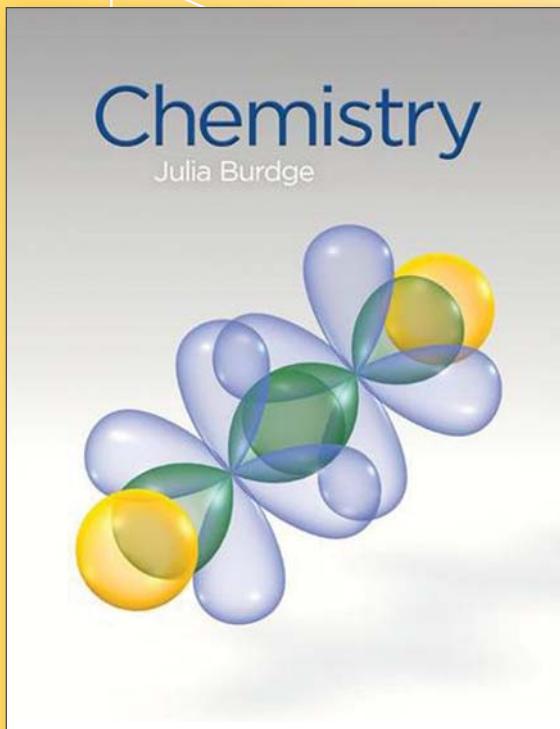




• PRECISION GRAPHICS

CASE STUDY:

BURDGE CHEMISTRY



MISSION

Create a visually dynamic first-edition book and 3-D media program.

Author Julia Burdge had collaborated on textbooks before beginning work on *Chemistry*, and she had definite ideas about the look and feel of her first solo project. Precision Graphics took the initiative in taking the author's preferred art style and making it our own. By creating a detailed style sheet that began with the general design of the art, we were able to ensure that the unique and complex style would be successfully implemented throughout the entire project.

While the usual workflow means sending project communications through project managers, Precision's lead artist for *Chemistry* was encouraged to communicate directly with the author. We took full advantage of this, leading not only to email and phone conversations, but to several working meetings in our office. This allowed for valuable interaction in the early stages of art production that ensured we were meeting the author's expectations before we were very far into the process.

“We've built a strong relationship with the author that will serve as a foundation for future editions.”

—Lead Artist, Gary Hunt

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Chemistry
The Central Science

1.1 • The Study of Chemistry Chemistry You May Already Know	1.2 • The Scientific Method Classification of Matter	1.3 • Units of Measurement Compounds	1.4 • Scientific Measurement Data Units	1.5 • The Properties of Matter Properties	1.6 • Uncertainty in Measurements Significant Figures	1.7 • Calculations with Measured Values	1.8 • Accuracy and Precision Conversion Factors	1.9 • Using Dimensional Analysis Tracing Units
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Smallpox
Smallpox is one of the diseases classified by the Center for Disease Control and Prevention (CDC) as a Category A bioterrorism agent. This disease has had an immeasurable impact on human history. During the sixteenth century, European explorers brought smallpox to the Americas. Native Americans had no natural immunity to the disease, making them vulnerable to attack—in effect, shaping the course of the New World. In the twentieth century alone the disease killed an estimated half a billion people worldwide—leaving more than 10 million orphans.

Late in the eighteenth century, an English doctor named Edward Jenner observed that even during outbreaks of smallpox in Europe, milkmaids often contracted the disease but did not become seriously ill. He hypothesized that because they had接触过牛痘, they developed a natural immunity to smallpox. He tested his theory on a 8-year-old boy named James Phipps by inoculating him with the cowpox virus using pus from the cowpox lesions of a milkmaid named Sarah Nelmes. Six weeks later, when James was exposed to smallpox, he did not contract the disease. This moment is considered the first successful vaccination. In 1980 the World Health Organization declared smallpox officially eradicated. The disease, though over a thousand years old, was one of the greatest medical advances of the twentieth century; begun with Jenner's astute observations, deductive reasoning, and careful experimentation—the essential elements of the scientific method.

Until recently, almost everyone had a smallpox vaccine scar—usually on the upper arm.

In This Chapter, You Will Learn some of what chemistry is and how it is studied using the scientific method. You will learn about the systems of units used by scientists and about expressing and dealing with the numbers that result from scientific measurements.

Before you begin, you should review

- Basic skills
- Scientific notation (see Appendix 1)

The “Epidemic Memorial” masks on display at the Washington State History Museum in Tacoma, Washington, were created by four Native American artists. They represent the effects of smallpox and other diseases on the Native American population.

Media Player
MEDIA PLAYER
MEDIA CENTER

474 CHAPTER 12 Intermolecular Forces and the Physical Properties of Liquids and Solids

Figure 12.15 Arrangement of identical spheres in a simple cubic cell. (a) Top view of one layer of spheres. (b) Definition of a simple cubic cell.

Figure 12.16 Three types of cubic cells. The top view makes it easier to see the locations of the lattice points, but the bottom view is more realistic, with the spheres touching one another.

Figure 12.17 In the body-centered cubic arrangement, the spheres in one layer rest in the depressions between spheres in the previous layer.

The other types of cubic cells, shown in Figure 12.16, are the **face-centered cubic cell** (bcc) and the **body-centered cubic cell** (bcc). Unlike the simple cube, the second layer of atoms in the bcc cell is offset from the first layer so that the corner atoms do not fall directly into the depressions of the second layer (Figure 12.17).

In the face-centered cubic cell, there are 8 touch spheres in contact with four others in the layer above and four others in the layer below. In the face-centered cubic cell, each corner atom is shared by eight adjacent unit cells, and each face center atom is shared by two adjacent unit cells. The coordination number in the face-centered cubic cell is 12 (each sphere is in contact with four others in its own layer, four others in the layer above, and four others in the layer below).

Because every unit cell in a crystalline solid is adjacent to other unit cells, most of a corner atom is shared by neighboring cells. One atom at the center of the body-centered

Figure 12.18 (a) A corner atom is in contact with eight unit cells. (b) An edge atom is shared by four unit cells. (c) A face-center atom is in contact with three unit cells.

SECTION 12.3 Crystal Structure 475

Figure 12.19 Because each sphere is shared by eight unit cells and there are eight corners in a cube, the equivalent of one complete sphere inside a simple cubic unit cell.

cubic cell is an exception. In all types of cubic cells, for example, each corner atom belongs to eight cells, and is shared by four adjacent unit cells (Figure 12.18a). An edge atom is shared by four unit cells (Figure 12.18b). Because a simple cubic cell has lattice points only at each corner, the equivalent of only one complete atom is contained within a simple cubic unit cell (Figure 12.19). A face-center atom is in contact with three unit cells, so the equivalent of one complete atom is contained within a face-centered cubic cell (Figure 12.20a). A face-centered cubic cell contains the equivalent of four complete atoms: three from the six face-centered atoms and one from the eight shared corner atoms.

Closely Packing

corner atoms in the simple cube and body-centered cubic cells that in the face-centered cubic cell. Closest packing, the most efficient arrangement of atoms, starts with the structure shown in Figure 12.20(a), which we call layer A. Focusing on the only atom that is not part of a corner, we see that it is surrounded by six other atoms in its own layer. In the second layer, which we call layer B, atoms are packed into the depressions between atoms in the first layer, so that each atom in the second layer is surrounded by twelve atoms (Figure 12.20b).

It is important to note that a third layer of atoms can be added. They may sit on the depressions between second-layer atoms such that the third-layer atoms lie directly over atoms in the first layer (Figure 12.20c). In this case, the third layer is also labeled A. Alternatively, atoms in the third layer may sit on the depressions between second-layer atoms such that the third-layer atoms are in the same layer as the second-layer atoms (Figure 12.20d). In this case, we label the third layer C.

Figure 12.20 (a) In a close-packed layer, each atom is surrounded by six other atoms. (b) In the first layer of a close-packed structure, each third-layer sphere is directly above a site in the second layer. (c) In the first layer of a close-packed structure, each third-layer sphere is directly over atoms in the first layer. (d) In the first layer of a close-packed structure, each third-layer sphere is in the same layer as the second-layer atoms.

“Meeting the author really helped personalize our work on this book. I feel like this book is not just hers, but ours.”

—Lead Compositor, Karen Hawk



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Figure 17.8 Common Ion Effect

We prepare a saturated solution of AgCl by adding AgNO_3 to water and stirring.

In the resulting saturated solution, the concentrations of Ag^+ and Cl^- are equal, and the solubility product is equal to K_{sp} .

$$[\text{Ag}^+] = [\text{Cl}^-] = 1.3 \times 10^{-5} \text{ M}$$

$$\text{Therefore, the concentrations are } [\text{Ag}^+] = 1.3 \times 10^{-5} \text{ M}$$
 and $[\text{Cl}^-] = 1.3 \times 10^{-5} \text{ M}$

Now, if we add a small amount of NaCl to the beaker, the color changes to white. This illustrates to clarify the process.

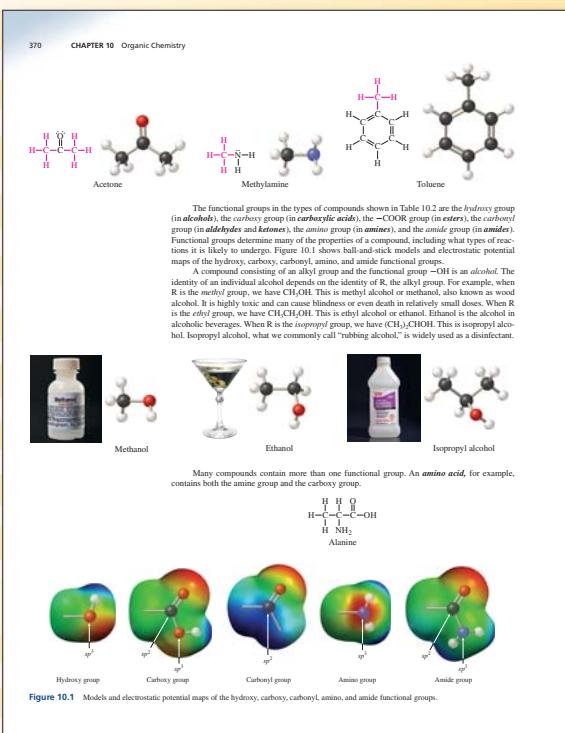
Because the concentration of Cl^- is now higher than the product of $[\text{Ag}^+]$ and $[\text{Cl}^-]$, the equilibrium shifts to the left according to Le Chatelier's principle. The concentration of Ag^+ is now lower than the K_{sp} value, so precipitation ceases. The equilibrium constant of Ag^+ and Cl^- ions equals the K_{sp} of AgCl . Therefore, the new equilibrium constant of Ag^+ and Cl^- ions is equal to the original equilibrium constant of Ag^+ and Cl^- .

Note that the common ion effect of the added Ag^+ is negligible. With Cl^- ion, the concentration of Ag^+ is $1.6 \times 10^{-5} \text{ M}$ and the concentration of Cl^- is $1.3 \times 10^{-5} \text{ M}$. This means that the concentration of Cl^- is higher than the concentration of Ag^+ by a factor of $1.3 / 1.6 = 0.81$. Therefore, the concentration of Cl^- ions equals the K_{sp} of AgCl . Therefore, the new equilibrium constant of Ag^+ and Cl^- ions is equal to the original equilibrium constant of Ag^+ and Cl^- .

The amount of AgCl precipitated is exaggerated for emphasis. The actual amount of AgCl would be extremely small.

What's the point?

When two salts contain the same ion, the ion they both contain is called a common ion. The common ion effect of a salt such as AgCl can be decreased by the addition of a soluble salt with a common ion. In this example, AgCl is precipitated by adding NaCl to a solution of AgNO_3 . By adding a soluble salt containing the Ag^+ ion, such as AgNO_3 ,



Much of the art for this book was rendered initially using 3D software, which can be time-consuming and expensive. By initiating early and direct author collaboration, we were able to ensure that we stayed within the budget. Further, when the client saw what Precision was creating, they added media elements to the package. What began as an art and composition project expanded to include high-end animations and the cover illustration.

In addition to our contact with the author, the PG team stayed in close touch with the client's book team. We were able to stay on top of the client's many marketing goals and deadlines, which helped make Burdge *Chemistry* a successful book for the publisher as well.

Finally, the early collaboration with the author enhanced personal ownership in the project on the part of Precision's book team. We were not just working with a name on the spine. Dr. Burdge became a valued colleague, and it became important to each member of PG's book team to make her proud of what we created. Every member of the book team, from the author to the proofreader to the illustrators, can claim this project as a personal success.