How to Study Better Quicker

6 evidence-based strategies

based on cognitive research by the Learning Scientists

Taffeta M. Elliott, PhD. New Mexico Institute of Mining and Technology.

After a video, you will read the following passage that begins the textbook readings in General Chemistry I. Then you will identify the relevant learning objective and write questions. The goal of our activity will be to apply various study strategies that can generalize to other types of material in STEM courses.

Chapter 1 Learning Objectives

By the end of this section, you will be able to:

- Describe the basic properties of each physical state of matter: solid, liquid, and gas
- Distinguish between mass and weight
- Apply the law of conservation of matter
- Classify matter as an element, compound, homogeneous mixture, or heterogeneous mixture with regard to its physical state and composition ...

Classifying Matter

Matter can be classified into several categories. Two broad categories are mixtures and pure substances. A pure substance has a constant composition. All specimens of a pure substance have exactly the same makeup and properties. Any sample of sucrose (table sugar) consists of 42.1% carbon, 6.5% hydrogen, and 51.4% oxygen by mass. Any sample of sucrose also has the same physical properties, such as melting point, color, and sweetness, regardless of the source from which it is isolated.

Pure substances may be divided into two classes: elements and compounds. Pure substances that cannot be broken down into simpler substances by chemical changes are called elements. **Iron, silver, gold, aluminum, sulfur, oxygen**, and **copper** are familiar examples of the more than 100 known elements, of which about 90 occur naturally on the earth, and two dozen or so have been created in laboratories.

Pure substances that are comprised of two or more elements are called compounds. Compounds may be broken down by chemical changes to yield either elements or other compounds, or both. **Mercury(II) oxide**, an orange, crystalline solid, can be broken down by heat into the elements mercury and oxygen (Figure 1.9). When heated in the absence of air, the compound **sucrose** is broken down into the element carbon and the compound water. (The initial stage of this process, when the sugar is turning brown, is known as caramelization—this is what imparts the characteristic sweet and nutty flavor to caramel apples, caramelized onions, and caramel). **Silver(I) chloride** is a white solid that can be broken down into its elements, silver and chlorine, by absorption of light. This property is the basis for the use of this compound in photographic films and photochromic eyeglasses (those with lenses that darken when exposed to light).

…A **mixture** is composed of two or more types of matter that can be present in varying amounts and can be separated by physical changes, such as evaporation.

Fig. 1.9 (a) The compound mercury(II) oxide, (b) when

(a) (b) (c)

heated, (c) decomposes into silvery droplets of liquid mercury and invisible oxygen gas. (credit: modification of work by Paul Flowers)

Study Strategy 3. **Elaboration**

a. What are your **questions** about how things work, and why, in Figure 1.9 (or 1.15 or some other passage)?

(Stuck? Compare your questions with my own examples: How does the chemist begin to observe the characteristics of the gas in the tube in order to test its composition? How do we know during the decomposition that heated glass from the test tube contributed nothing to forming some novel compounds not present before?)

b. **Find answers** to your questions in the book or your class notes, etc. In this case, the following "Learning Link" box of the textbook gives you links to YouTube videos that would answer my first question: "Many compounds break down when heated [or illuminated]. This site http://openstax.org/l/16mercury shows the breakdown of mercury oxide, HgO. Another example is the photochemical decomposition of silver chloride (AgCl), the basis of early photography."

c. Make **connections** to show how ideas work together.

One way to make connections in this case is to compare and contrast concepts. For example, compare and contrast chemical *production* and *decomposition*, or *composition* in sentence 3 of the 1st paragraph you read.

Similarities: Both *production* and *decomposition* involve transitions...

Contrast *Production* and *Decomposition*:

Contrast *Production* and *Composition*:

Now, try to make your own connection between a couple of ideas in the reading.

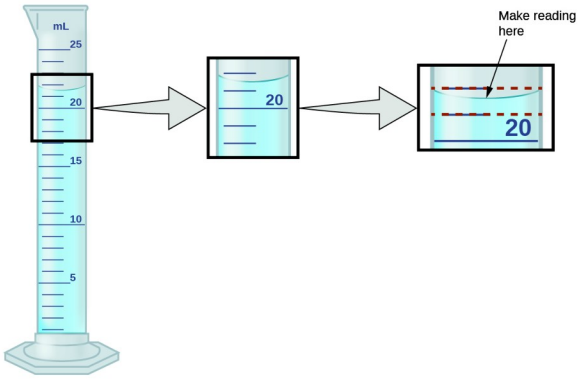
Study Strategy 1. **Concrete Examples** of an abstract concept (like chemical *compounds vs. mixtures*)

Write 3 of your examples of *compounds* that can be broken down into *elements*, and contrast with your own concrete example of a *mixture* involving some of the same element:

*<u>Note:</u> Compounds should be your **own** examples, distinct from the three examples in the reading.*

Study Strategy 2. **Dual Coding**

In your own words, **write** about what Figure 1.9 (first page of handout) is illustrating and expressing. Explain it. What is important to notice?



Next, go the other direction and *draw* what measurements would look like in a graduated cylinder for each of the kinds of precision and accuracy in the three measurement samples of Fig. 1.27 (below).

Accuracy and Precision

Scientists typically make repeated measurements of a quantity to ensure the quality of their findings and to evaluate both the precision and the accuracy of their results. Measurements are said to be precise if they yield very similar results when repeated in the same manner. A measurement is considered accurate if it yields a result that is very close to the true or accepted value. Precise values agree with each other; accurate values agree with a true value. These characterizations can be extended to other contexts, such as the results of an archery competition (Figure 1.27).

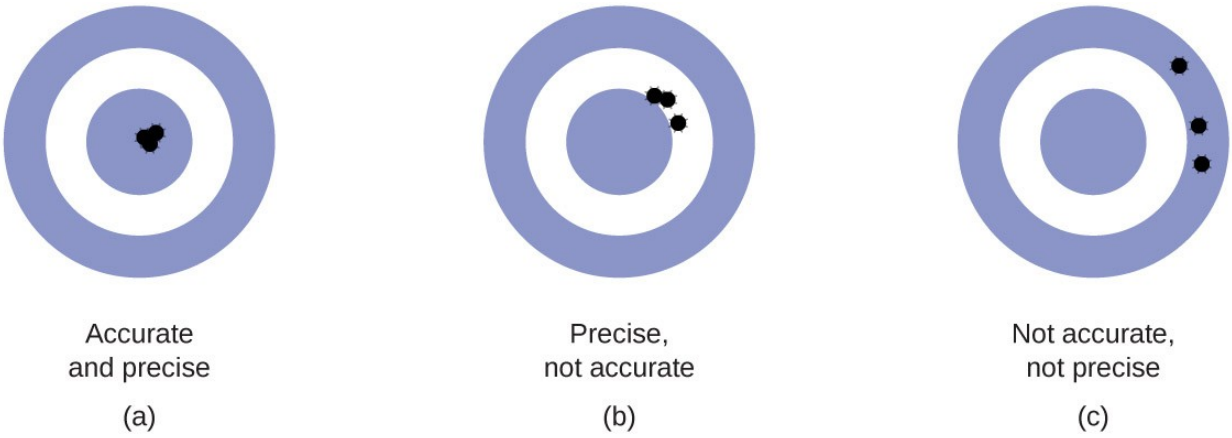


Figure 1.27 (a) These arrows are close to both the bull's eye and one another, so they are both accurate and precise. (b) These arrows are close to one another but not on target, so they are precise but not accurate. (c) These arrows are neither on target nor close to one another, so they are neither accurate nor precise.

Here's another chance for a concrete example that you can draw from the text: What would a measurement sample look like, against a bull's-eye truth represented as a target, if the measurements were accurate but ***not*** precise? Take for example sewage sampling for covid rates in a community. How would that category of measurement look, as an addition "(d)" to Fig. 1.27?

Study strategy 4. **Retrieval practice**. Leave some time after your most recent encounter before practicing remembering the same topic! Put away your class notes, and the textbook, and write or draw everything you know about the Learning Objective you're going to study (*retrieve* means to recall a describable memory):

"Classify matter as an element, compound, **homogeneous mixture, or heterogeneous mixture** with regard to its **physical state and composition**"

In the present case, you haven't read the later sections about mixtures, or physical versus chemical properties, so you would need to go back to the textbook or your lecture notes to find out what you missed (or to correct the misunderstandings that you find you have when you check your practice).

Practice the same Learning Objective using exercise 17 from Chapter 1:

Retrieval Exercise 17. Classify each of the following as *E* an element, *C* a compound, or *M* a mixture:

(a) iron

(b) oxygen

(c) mercury oxide

(d) pancake syrup

(e) carbon dioxide

(f) a substance composed of molecules each of which contains one hydrogen atom and one chlorine atom

(g) baking soda

(h) baking powder

Study strategy 5. **Spaced practice**

How does the ideal of "Spaced Practice" compare to the your own schedule? What questions do you have about implementing more spacing?

Study strategy 6. **Interleaving**

What questions do you have about switching topics while you study?