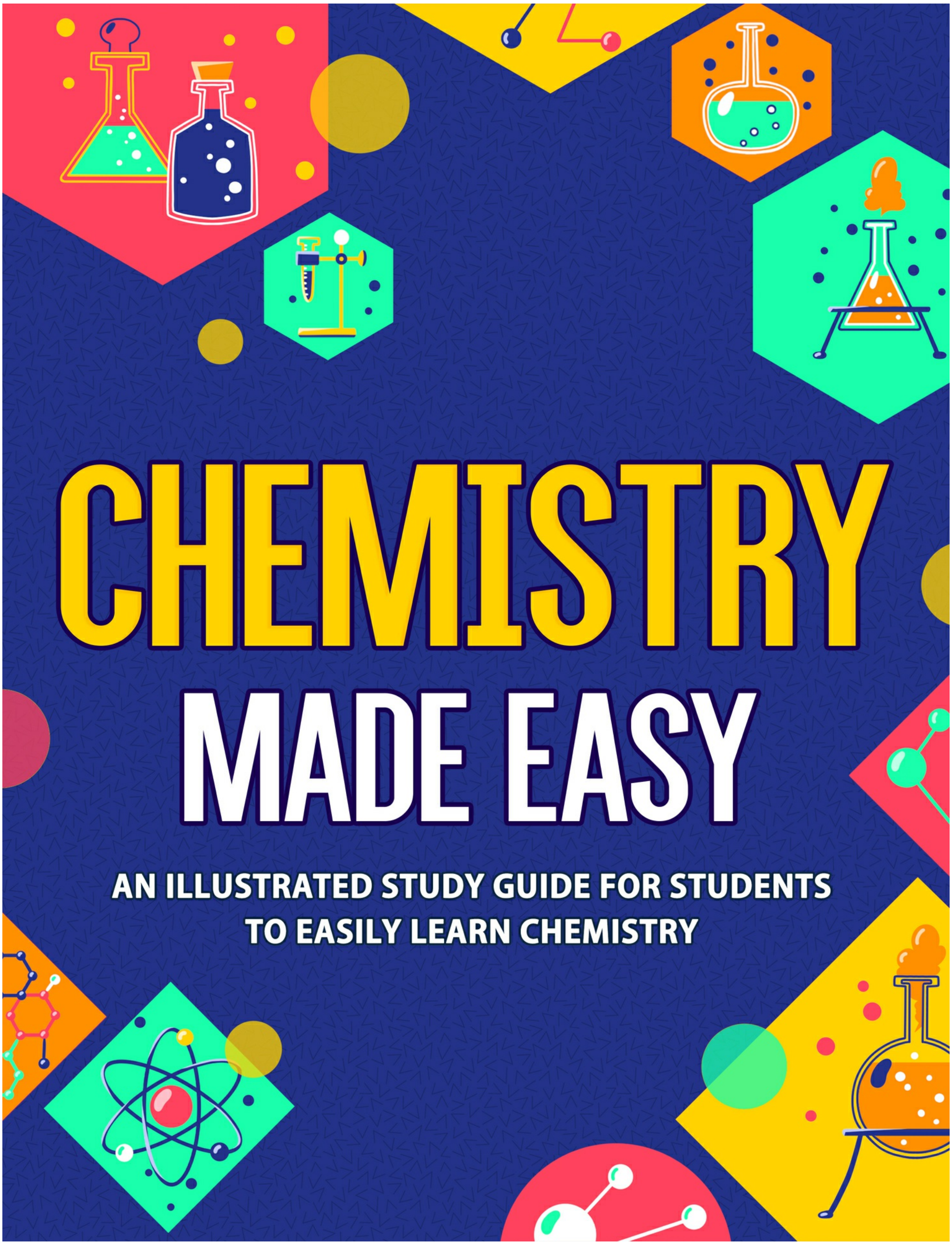
CHEMISTRY MADE EASY

AN ILLUSTRATED STUDY GUIDE FOR STUDENTS TO EASILY LEARN CHEMISTRY


CHEMISTRY
MADE EASY
AN ILLUSTRATED STUDY GUIDE FOR STUDENTS
TO EASILY LEARN CHEMISTRY

CHEMISTRY MADE EASY!

An Illustrated Study Guide For Students To Easily Learn Chemistry

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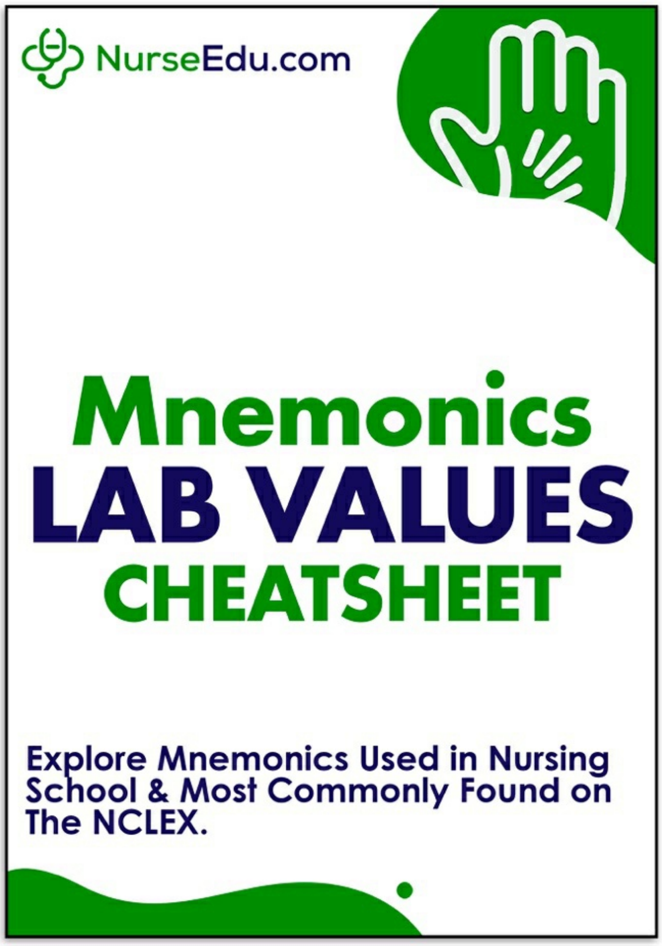

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TABLE OF CONTENTS

Section 9: Biochemistry

SECTION 1: INTRODUCTION

Chemistry is a huge topic; some students spend their entire college careers studying each and every aspect of it. There are many subtopics in the study of chemistry that are woven together to create an image of what we know about atoms, molecules, and chemical reactions. There are probably millions of different chemical reactions out there. As there are currently 118 elements in the periodic table, the possibilities in the numbers and types of molecules out there are endless.

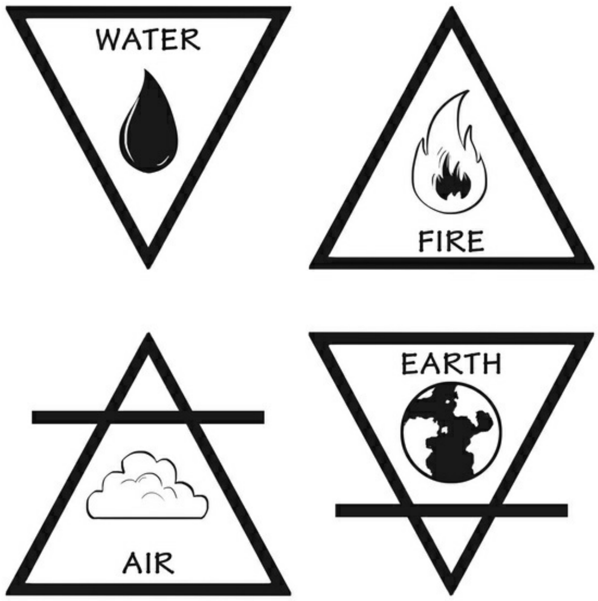
You probably don't have four years of college to devote to studying chemistry. You may not even have a semester to cram in what you need to know. No worries! This book has you covered. You will surely not be a chemistry newbie after reading this, even as you will not be able to get a chemist job anytime soon. No matter; it's probably not a job you aspire to have, anyway.

In this book, you will learn that chemistry is about matter. You can break matter down a great deal—all the way down to molecules, atoms, and subatomic particles. The smaller the matter, the weirder it gets because none of these aspects of matter can be seen under a microscope, and some are nothing more than a mathematical idea (and not a *real* thing). Don't worry; none of this is Greek, and you'll soon feel like a pro as you come to understand the language of chemistry. Let's start with the easy parts first then work our way up to more complex aspects of this fascinating (yes, really!) topic.

CHAPTER 1:

MATTER AND MEASUREMENTS IN CHEMISTRY

You may already know what matter is and what it's made of. However, way back in the day, Empedocles (a pre-Socratic Greek who lived around 450 BC), thought he knew matter, too. He said that matter was made of one of four elements. These were air, fire, earth, and water. Most people believed this as well, until relatively recently.



Even before Empedocles, the Greek philosophers knew of the four elements but thought only one of these was the *main* element and that the others were mostly secondary. You now know most likely that these guys had it all wrong.

Democrates in 400 BC and others had a better idea. He believed that matter was only made of two things: 1) lots of empty space and 2) tiny particles he called atoms or "atomos, " which could not be divided. In Greek, the word *atomos* means indivisible. You can see where the modern word *atom* came from! Despite being pretty close to correct about matter, Democrates was largely ignored in favor of the earlier concepts on what matter was made from.

Others (much later on) revisited this novel idea. Robert Boyle was one of these more modern-day scientists. He published a paper in 1861 where he said that an element is made of atoms that cannot be broken down under any circumstances. This put to rest the idea of four main elements. You'll see he was mostly right, too, but couldn't then have known much about atom-splitting bombs.

Boyle didn't get much credit for his work. John Dalton must have had a better publicity agent because he is credited with what we now know is modern atomic theory. In reality, he was first, after all, having published his atomic theory in 1803. He had some great theories on atoms. These include:

1. All matter is made from atoms. Atoms cannot be destroyed or divided.
2. All atoms of the same element will also be the same or identical.
3. Atoms from different elements have different properties and different atomic weights.
4. One can combine different atoms in whole numbers to create a new molecule.
5. If a compound decomposes, all atoms can be recovered as they can't be destroyed.
6. Atoms cannot be created from nothing.
7. Chemical reactions just rearrange atoms in molecules. They do not make new atoms.

Mass or matter is always conserved in any isolated system. This is a fact best explained by the Law of Conservation of Mass. This idea also came from the Greeks, who believed that all the matter in the universe is neither created nor destroyed. Antoine Lavoisier described this principle in 1789. This statement is absolutely true when you maintain a closed system.

Think about it: *If you mix two substances in solution and one of the end products is a gaseous substance, you might doubt the Law of Conservation of Matter if you weigh the products left in the reaction flask. The end products will not have the same weight as the beginning substrates. This is because, unless you close the system up and keep the gas inside the "system," the gas escapes and isn't counted. Anytime you do a chemical reaction, you need to think about what might leave the system afterward for any reason.*

Einstein extended the law of conservation of mass to add energy into the equation. Energy and mass are both parts of any reaction system. Because of this, the total energy plus the mass in a system are always constant. This gets a little more complicated, so most chemists ignore the energy aspect of a reaction. This is because most lab-table chemical reactions don't make much energy.

Joseph Proust got a law named after himself in the early 1800s by conducting experiments on the composition of simple molecules. He realized that all compounds are made by mixing elements in fixed proportions. The molecule of carbon dioxide, or CO2, for example, will always be made from a single atom of carbon and two of oxygen. He went further by noting that the mass of CO2 in a system will be fixed in how much of it is carbon and how much is oxygen. Two oxygen atoms have an atomic mass of 16 x 2 or 32, while one carbon atom has an atomic mass of 12. The ratio then is 12:32 or about 3:8 (by weight).

Classification of Matter

Now that you know what matter is (atoms with a lot of space around them), you should be curious about some of the details that define matter more clearly. An enclosed box with a kilogram of carbon dioxide gas and a block of dry ice are both matter, but you would never call them the same thing. Chemically, they are the same, but nothing else about them would indicate this.

Suppose you got a mystery box with matter in it, without knowing what it was. Without being able to name the substance or matter in the box, how would you describe it to others? How would you go about this descriptive process, and what properties would you talk about in telling others about it? Let's look at ways chemists talk about the different properties of matter; these would be terms you would use to describe your mystery matter.

Start with recognizing two separate categories of *properties of matter* . One of these is its physical properties. You don't have to do much to identify these besides measure, weigh, and observe. Physical properties are also divided into two segments: 1) those unrelated to how much of the substance you have (intensive physical properties) and 2) those dependent on how much you have (extensive physical properties). They break down like this:

Intensive Physical Properties	Extensive Physical Properties	Chemical Properties

Color	Mass	Reaction with acids
Density	Volume	Response to air exposure
Melting point	Length	Reaction with bases
Boiling point	Shape	Reaction in water
Conductivity		Reaction in other substances
Malleability		

With your mystery matter, start with the easy things:

Extensive Physical Properties

These are obvious and just involve a few measuring tools, like a scale and measuring tape.

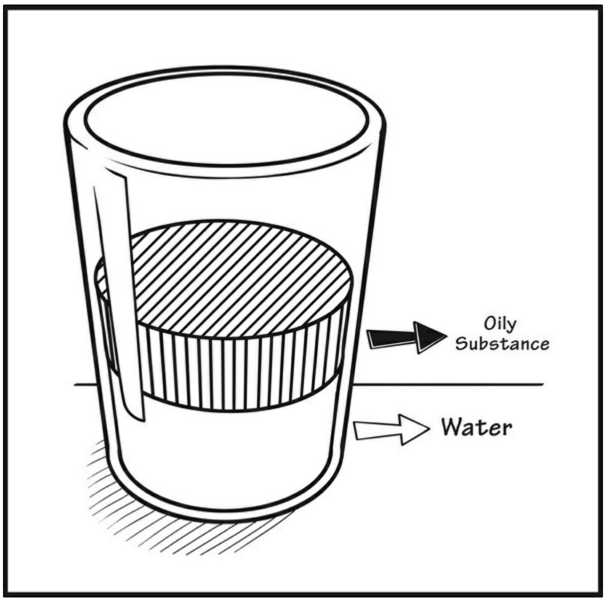
1. **How much does it weigh?** Measure this in grams or kilograms, generally.
2. **What volume is it?** Measure this in cubic centimeters (millimeters) or another convenient measurement, remembering that volume is height x width x depth.
3. **What length is it?** Obviously, this works best with solids. Get its dimensions in centimeters or meters on all possible sides, knowing it may not be a nice rectangular shape. A ball of something would still be measured using the volume of a sphere: $V = 4/3\ \pi r^3$.
4. **What shape is it?** Be creative. If you think it's a shape you can identify, go ahead and call it as you see it. Otherwise, take your best guess on what shape it is (for solids, obviously).

Intensive Physical Properties

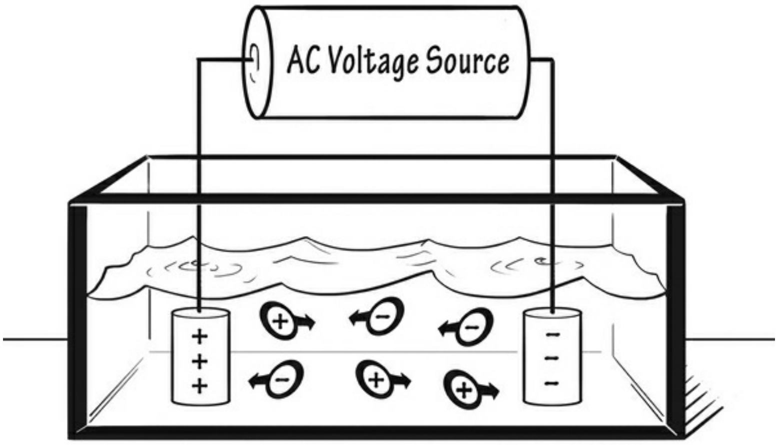
Some of these are easy, like color and malleability. FYI: Malleability means whether or not you can flatten the substance out. Here are a few others:

1. **How dense is it?** Density is determined by weighing it and getting its volume. The density of a liquid, for example, is often in grams/milliliters. You get this by taking the weight and dividing it by the volume. You can plainly see without measuring, however, that an oily substance is less dense than water, just by mixing the two and seeing if the density is

different:



2. **What is its melting point?** Melting point and freezing point are the same things. As we will discuss soon, the melting point is best found by melting a solid first and sticking a thermometer in it. Then cool it down and determine when it freezes again. If you can't do that, it's harder to measure. You need to heat up the solid and then determine the temperature in the system when it melts.
3. **What is its boiling point?** Again, the boiling point is the same as the condensation temperature. Both of these measure the liquid-to-gas phase change of a substance. You would do the same thing as with the melting point. Put a thermometer in a liquid and add heat. Then find out when it begins to boil. This is your boiling point.
4. **Does it have conductivity?** This is a substance that conducts electricity. You will need to have two electrodes (be creative about this). Then measure if any electricity flows from one electrode to another. If yes, it conducts electricity. This is how it's done in liquids:



Chemical Properties

These are more sophisticated and depend on knowing much more about chemistry (like what acids and bases are, for example) than you are expected to know yet. The fact is that most matter will respond in some way to another bit of matter. The sky is the limit here. You can describe what a substance dissolves in (or doesn't dissolve in). Many metals will react in acid...try putting some zinc metal in hydrochloric acid, but beware of the hydrogen gas it gives off.

> ***Don't try this at home!*** *Obviously, you can put as much sodium chloride (NaCl or table salt) in water without much risk. Try this with sodium metal, however, and the results are remarkable (and dangerous!). Sodium metal comes packed in oil to keep it away from moisture. Throw it in water and watch it violently explode to make sodium hydroxi* d *e and a lot of hydrogen gas! Definitely not something to try at home...*

You can only do so much when describing chemical properties. If you tried to describe a chunk of sodium metal by putting the whole thing in water, you'd have a solution of sodium hydroxide and no more sodium metal to experiment with. Still, a few judicious experiments might clue you in as to the properties of the matter you have.

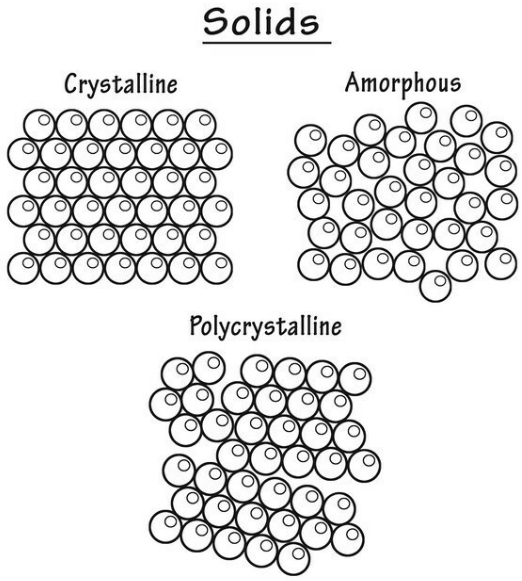
Phases of Matter

If you think this is an easy section, you might want to consider this: is water (H20) a solid, liquid, or gas? The answer is obvious, which is that *it all depends* . But what does it depend on? Temperature? Yes, partly, but you'll see it's more complicated than that. Let's start with getting clear on what the different phases of matter look like:

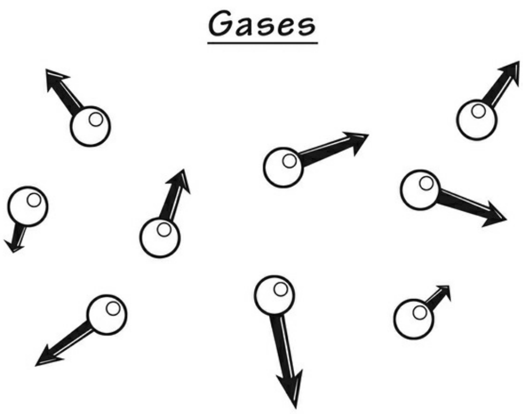
- **Solids—** these are substances that do not need a container to hold their shape. The molecules tend to be fixed in space and are generally tightly packed. While they cannot move freely in relation to one another, molecules in solid form will still vibrate.

  Many solids are crystalline, meaning they are packed tightly in an ordered shape. The crystals can be unique to a substance or can change in the same substance, depending on pressure and temperature issues.

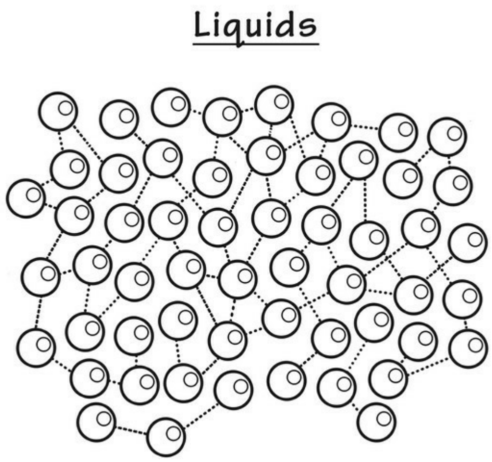
  This is how crystalline and amorphous solids might look:



- **Gases—** these are substances that must be fully contained in a container with sides everywhere, although gravity can hold some gases in a collection without borders. There are intermolecular interactions, but these are small, so the molecules in gaseous form move freely. Gaseous molecules move very fast compared to solid and liquid molecules; their kinetic energy (tendency to be zippy, that is) overrides most of the forces between any two gaseous molecules. Gases have large spaces between the tiny molecules.



- **Liquids—** these will flow and cannot maintain a definite shape unless held in a container on most of its sides. The molecules move freely but stay within the boundaries of the volume they reside in. The volume of a liquid always stays the same, but the shape does not. There are some intermolecular forces important in liquids, but these are not so great at keeping the molecules fixed in space. Most of the time, a liquid will be less dense than its corresponding solid (water, aka ice, is a notable exception).



There are several phases of matter you won't encounter often. One of these is called *plasma* . Plasma is interesting. It's the gaseous stuff the sun gives off of its surface. While it is gaseous, plasma differs from a true gas in that it is a mixture of charged molecules that interact with one another and that generate long-range magnetic and electric fields. One glob of plasma would be electrically neutral, but a lot of electrical interactions are going on within the glob.

***Trick question** : Is glass a liquid or solid? The real answer is* *neither. It is referred to as an amorphous solid because the molecules are not in any orderly structure (like a crystal lattice). Over time, the molecules do move, but it takes billions of years for a glass (silicate) molecule to travel even a small distance.*

Phase Changes

Obviously, matter can change phases. Some of these you know well, such as melting, freezing, and boiling. These are not all the possible choices, however. You'll see just how many choices a chunk of matter can go through.

The reality is that no matter is anything but solid at absolute zero (-273 degrees Celsius). Even helium gas would be solid at that temperature. In the same way, at high enough temperatures, all things will be liquid. To be certain, it is impossible to get absolute zero, and, in order to make gaseous iron, you'd need to reach 2861 degrees Celsius. Still, you get the idea...

Next order of business : is a phase change all about raising or lowering the temperature of matter? Not in the slightest. Pressure has a lot to do with it. If you add enough pressure to something, you can change its phase from gas to liquid to solid without cooling anything at all.

When it comes to phase changes, these are the ones you should know:

- **Freezing—** going from a liquid to a solid by removing thermal heat or cooling a substance (generally, the pressure remains the same).
- **Melting—** going from a solid to a liquid by adding heat to a substance (molecules vibrate from the added energy and reach a liquid state).
- **Sublimation—** going from a solid to a gas, skipping the liquid stage. You will see sublimation when you watch dry ice in a warm temperature; you will see a mist coming off the dry ice. This is sublimation. Freeze-drying involves removing water in a vacuum, which essentially sublimates it, leaving the dried matter behind.
- **Vaporization—** going from a liquid to a gas, which can happen by boiling or allowing the liquid to evaporate. When boiling is the type of vaporization happening, heat is added to a system to give the internal energy they need to move about in gaseous