Classic Science

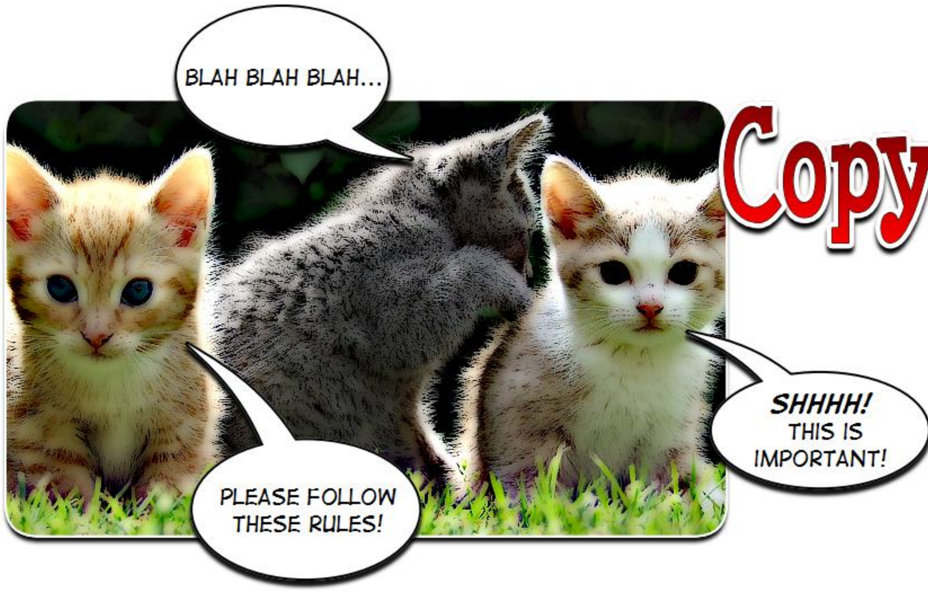
For the Family

STUDENT COPY

ELEMENTARY CHEMISTRY

The lab of MR.Q

Scott McQuerry



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Chapter 1

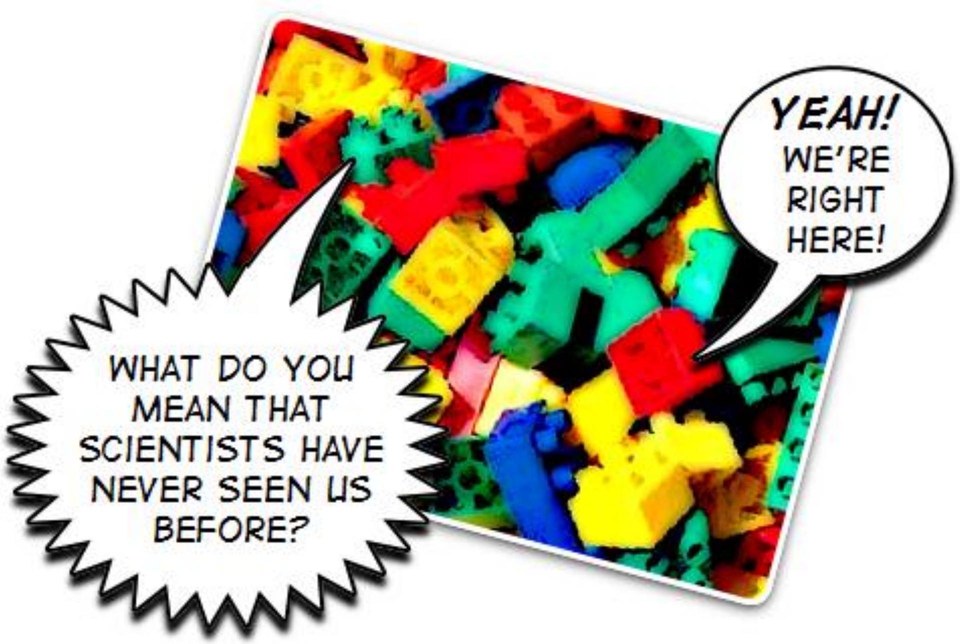
Before we get started, let me tell you something that may be a little hard to understand...

Most of the things you are going to learn in this book have never been seen before!

That's right! We are going to be studying things that are so tiny, nobody on the entire planet has **ever** seen them before! Weird, huh?

In fact, these tiny objects are the building blocks that make up **matter**. Matter is the name for all of the solids, liquids and gases in the universe.

So how do we know that these tiny little things even exist?



That is a very good question! Let me answer that question with another question:

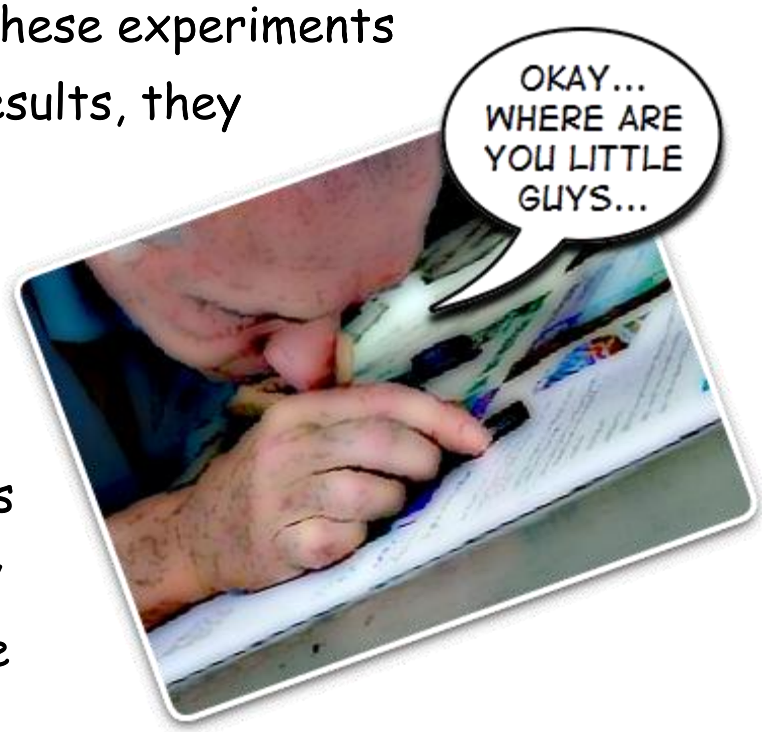
If I gave you a box filled with a handful of objects, how would you try to figure out what was inside? To make it harder, let's say that you can't look inside the box or reach inside. How would you do it?

- You could shake the box and see if the objects roll, tumble or slide around.
- You could smell the box and see if the objects are giving off an odor.
- You could turn the box upside down and see if the objects tumble around or sticks to the sides of the box.
- You could place a magnet next to the box and see if the objects are made of iron.

These are just a few experiments you could run to predict what is inside the box! You may not be able to see what is inside the box, but you can make a good prediction based on your experiments!

This is the same problem scientists have when they are studying matter. It has taken **years** for scientists to get an idea of what makes up matter and how it behaves. They have run thousands of experiments to test their ideas and collected a lot of information about matter.

Whenever scientists run all of these experiments and they always get the same results, they create what is called a **theory** ("thee-or-ee"). A theory is a statement about some scientific event that has been tested many times. What makes a theory so special is that every one of these tests had the same results!



Scientists have discovered several theories about matter through their experiments. Even though they have never seen the tiny building blocks that make up matter, they have a pretty good idea as to how they look, what they do and how they change. Scientists call the study of matter and how it changes by the name **chemistry** ("kem-iss-tree").

If matter is made up of all the solids, liquids and gases in the universe, then scientists need a way to measure all this "stuff". The measurement of how much matter there is in an object is known as **mass**. The mass of solids, liquids and gases can each be measured! You will learn how this is done throughout this book! But for now, you should learn some simple information about matter. For example...

All matter has two different kinds of properties:

Physical properties ("fizz-eh-kull")

and

Chemical properties

The **physical properties** of objects are what we see every day. For example, try to write down as many things as you can about a banana. Did you say that it is yellow (or green)? How about its shape? Did you say it was long and slender and could be peeled? What about its smell and its ability to be squished easily?

All these things are physical properties of matter!

Color, smell, shape and size are all physical properties. There are many more too, such as the ability to be moved by a magnet, whether the object sinks or floats in water, the ability to see through the object, etc.

When you are looking at the physical properties of an object, you are describing things about it that stay **(almost)** the same every day! There are always things that can change with an object.

I said "almost" because of one simple fact...

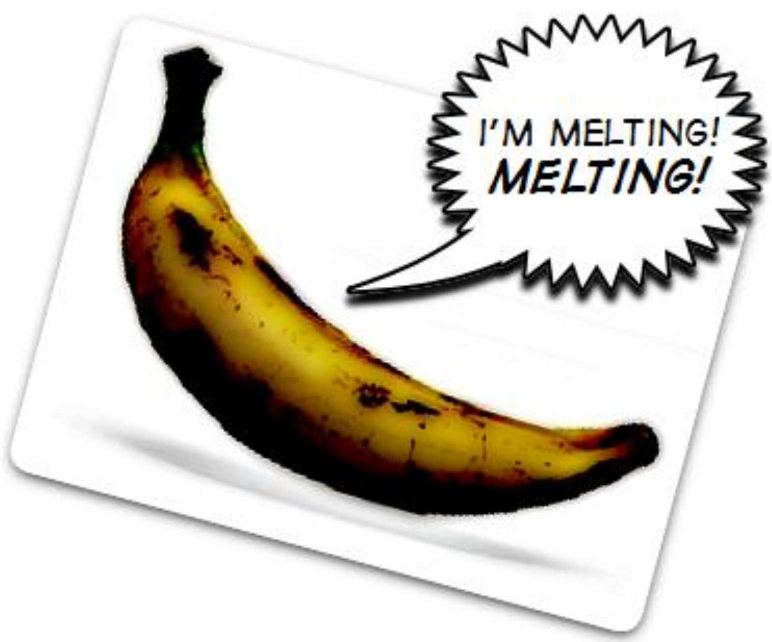
Everything changes!

For example, if you leave a banana on the counter for several days it is not going to look yellow anymore, is it? Nope! Not only will its color change, but it will start to get very squishy too! But why?

Well, do you remember earlier in this chapter when I said that all matter is made up of tiny objects too small to be seen? Well, these tiny objects sometimes rearrange themselves which causes the entire object to change too! When this happens, you have what are called **chemical properties.**

Let's go back to that banana again! After you leave a banana out on the counter for a few days it starts to turn dark brown in color. This is because the tiny objects that make up a banana are moving around. All of this movement of matter makes the banana look like it has changed color! And, when some of these tiny objects let go of each other, it can cause a solid object (like your banana) to become more squishy!

Chemical properties are the abilities of matter to change into different kinds of matter! The chemical properties of objects can be a little harder to find but I would guess that you have seen these properties in action...



If you have ever seen an object burning, you have seen one of the object's chemical properties.

If you have ever seen a metal object turn into rust, you have seen another chemical property of an object.

The ability to burn or turn into rust are two different chemical properties of objects. There are many more chemical properties out there! All chemical properties require the "tiny things" that make up matter to move around.

But what are all these "tiny things"?

Stay tuned. You are going to find out in the next chapter!

Use the definitions to fill in the missing letters.

---

1. _ _ _ m _ s _ ry
2. _ _ ss
3. _ he _ _ y
4. p _ _ _ ic _ _ pr _ _ _ _ _ i _ s
5. _ _ em _ c _ _ _ _ _ _ er _ ie _
6. _ at _ _ _

1. the study of matter and how it changes
2. the measurement of how much matter there is in an object
3. a statement about some scientific event that has been tested many times and have all had the same results
4. the characteristics of objects that stay the same such as color, shape and size
5. the characteristics of objects that can change such as through burning or rusting
6. the name for all of the solids, liquids and gases in the universe

Use the definitions to unscramble the words below.

1. yroeht ______________________
2. seitreporplacimehc ______________________
3. ssam ______________________
4. rettam ______________________
5. yrtsimehc ______________________
6. seitreporplacisyhp ______________________

1. a statement about some scientific event that has been tested many times and have all had the same results
2. the characteristics of objects that can change such as through burning or rusting
3. the measurement of how much matter there is in an object
4. the name for all of the solids, liquids and gases in the universe
5. the study of matter and how it changes
6. the characteristics of objects that stay the same such as color, shape and size

Circle the hidden words from below:

q	a	o	y	a	h	t	m	i	b	q	m	m	i	s	v	x	u	n	f
t	t	q	c	m	l	y	h	x	o	y	m	x	y	p	e	d	t	f	u
c	h	e	m	i	c	a	l	p	r	o	p	e	r	t	i	e	s	h	m
p	c	d	t	q	w	n	v	w	s	q	x	o	f	t	c	u	j	v	d
z	h	w	a	p	x	z	d	b	g	d	n	y	v	v	f	n	g	k	g
i	c	d	o	h	b	y	d	s	k	e	u	y	n	s	r	x	w	h	n
p	h	y	s	i	c	a	l	p	r	o	p	e	r	t	i	e	s	e	c
z	r	m	b	j	f	v	h	f	t	p	i	d	w	r	t	z	g	c	c
e	e	a	o	p	t	n	p	o	y	y	q	y	l	q	a	o	t	h	k
o	z	t	o	v	b	r	j	g	q	n	j	w	f	v	m	n	h	e	m
q	o	t	h	o	q	c	d	v	t	j	w	d	l	p	j	d	e	m	u
n	c	e	b	j	c	o	i	t	p	n	b	w	w	e	b	b	o	i	s
m	w	r	a	x	v	i	f	x	g	w	i	l	j	y	g	r	r	s	y
n	z	i	o	b	e	l	q	u	l	t	p	t	m	d	f	t	y	t	x
m	n	f	t	o	o	d	m	a	s	s	x	n	u	r	b	c	h	r	r
r	p	s	p	l	x	d	r	t	r	c	g	o	u	k	n	l	i	y	n

matter

theory

chemistry

mass

physical properties

chemical properties

Chapter 2

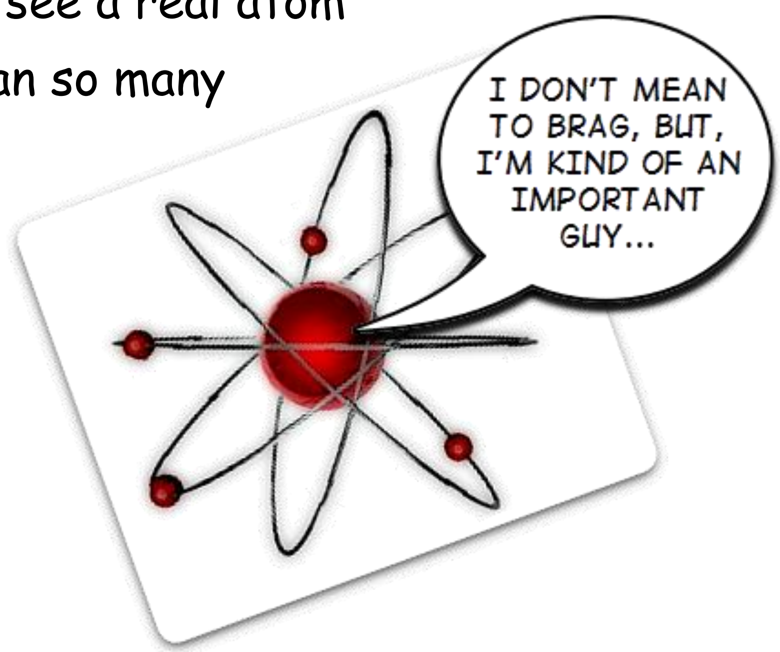
Okay! It's time for you to learn about these "tiny things" that make up matter. First of all, everything in the universe - our air, water and all solid objects are made up of matter. And, matter is made up of tiny objects that give an object its physical and chemical properties.

Scientists call each of these tiny objects an **atom.**

Atoms are like the building blocks of the universe. You can use building blocks to make all kinds of things, right? Of course! But the best thing about building blocks is that you can take apart the object and make something different over and over again.

This is how atoms work too!

Nobody has ever been able to see a real atom before. But scientists have ran so many experiments on these tiny pieces of matter that they have a pretty good guess as to what an atom is made of. For example...



Scientists have figured out that an atom is made up of three smaller pieces (Don't worry! We will not be getting any smaller than these guys!)...

Protons ("pro-tauns")

Neutrons ("noo-trahnz")

and

Electrons ("ee-leck-trahnz")

The center of each atom is where you would find the protons and neutrons. They tend to stick together in this area and are called the **nucleus** ("new-klee-us") of an atom.

If you want to find the electrons, they are always in motion and are spinning around the nucleus.

Protons and electrons act like different ends of a magnet. Have you ever tried to push two magnets together and had them move away from each other? However, when you turned one of the magnets around, they slid towards each other and attach to themselves?

This is how protons and electrons act too!

Protons have what is called a positive charge and electrons have a negative charge.

The most important rule for you to remember with these charges is...

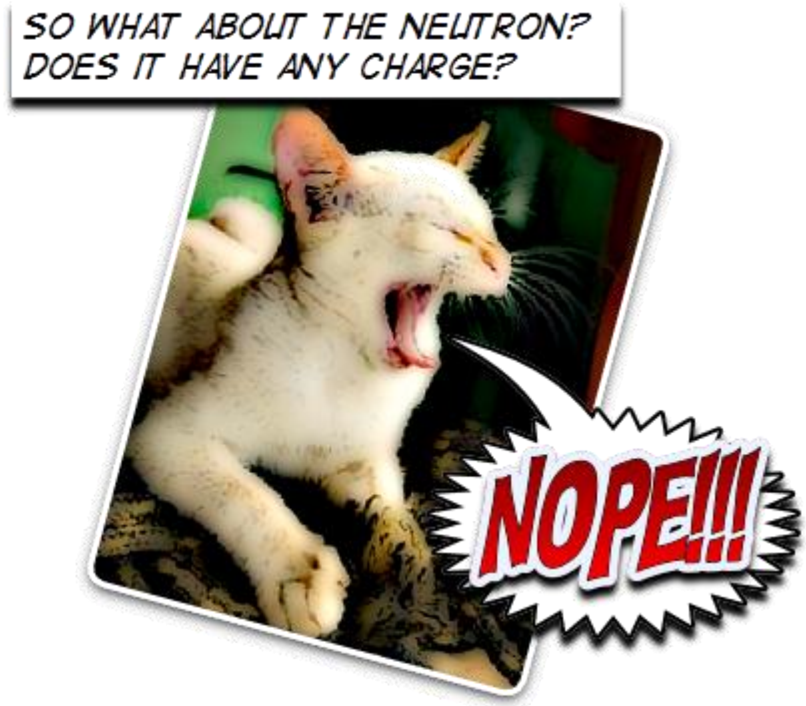
Opposite charges attract each other

and

Charges that are the same repel each other

Repel means "to move away". This means that all protons will move away from other protons because they have the same charge. However, if you put a proton close to an electron, they will move towards each other very quickly!

Remember, (negative) electrons spin around a (positive) proton in the nucleus.



The only parts of an atom that have a charge are the protons and the electrons!

It takes a lot of energy to hold protons, neutrons and electrons together. This energy is called **nuclear energy** ("nuke-lee-er").

Earlier, we called an atom a "building block". Imagine if you had a single building block in your hand – How much energy do you think it would take to split that one building block in half?

It would take more energy than you have in your body!

Now let's imagine you spend the day building a huge house out of building blocks. Wouldn't it be easier to separate the building blocks from each other?

Oh yeah !

Remember - the best thing about building blocks is that you can take apart the object you have made and create something different over and over again!

In the next chapter, you are going to learn what we get when atoms start connecting to each other!

Compare and Contrast the following vocabulary words:

Proton

Electron

How are they the same? (Compare)

1. ____

____

2. ____

____

How are they different? (Contrast)

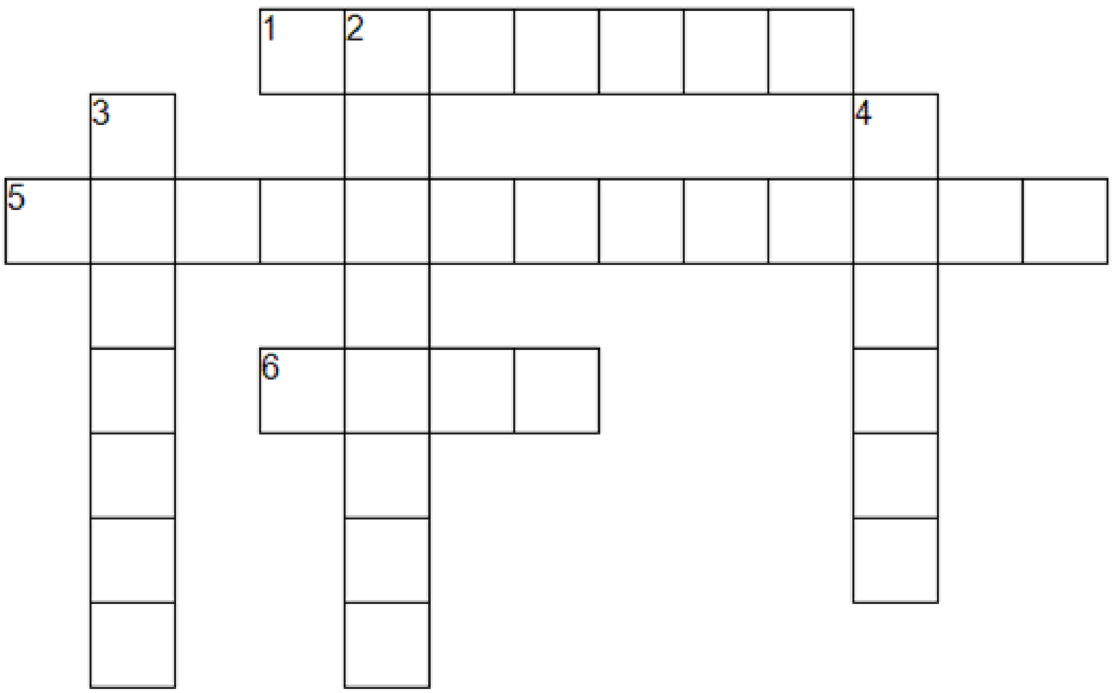
1. ____

____

2. ____

____

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

1. small piece of an atom that no charge and sits inside the nucleus
5. the amount of energy that holds an atom together
6. the building blocks of the universe

DOWN

2. small piece of an atom with a negative charge that moves around the nucleus
3. combination of protons and neutrons within every atom
4. small piece of an atom with a positive charge that sits inside the nucleus

Match the definitions with the correct words

1. ____________________ the amount of energy that holds an atom together

2. ____________________ the building blocks of the universe

3. ____________________ combination of protons and neutrons within every atom

4. ____________________ small piece of an atom that no charge and sits inside the nucleus

5. ____________________ small piece of an atom with a positive charge that sits inside the nucleus

6. ____________________ small piece of an atom with a negative charge that moves around the nucleus

Atom	Proton	Nucleus
Electron	Neutron	Nuclear energy

Chapter 3

In the last chapter, you learned that...

- all matter is made up of atoms;
- atoms are made up of three objects called protons, neutrons and electrons; and,
- atoms are held together with nuclear energy.

In this chapter, you are going to take a closer look at how these atoms behave!

First of all...

Not all atoms are the same!

That's right!

Some atoms have different amounts of protons in their nucleus! Groups of atoms with the same number of protons in its nucleus are called **elements** ("ell-uh-ments").

There are over 100 elements that scientists have discovered so far! Some elements, like **hydrogen** ("hi-droe-jen"), are very small and have only one proton in its nucleus. Other elements have more protons in its nucleus. One example is **oxygen** ("ox-ee-jen"), which has eight protons in its nucleus.

We are going to be looking at several different elements in the next chapter! But for now, let's see how these atoms stick together.

You have learned so far that atoms are like "building blocks" because they can join together. This is true! In fact, the energy that holds two or more atoms together is known as **chemical energy**. Scientists sometimes call chemical energy by another name – a **chemical bond**.

When two or more atoms join together, scientists call this group of atoms a **molecule** ("maul-ee-koo-el"). Almost all atoms can join together with other atoms to form molecules. This process can also go in reverse – molecules can be taken apart into individual atoms. This is why we say that atoms are like building blocks!

Sometimes two or more identical atoms join together.

This happens all the time! Maybe this will help you...

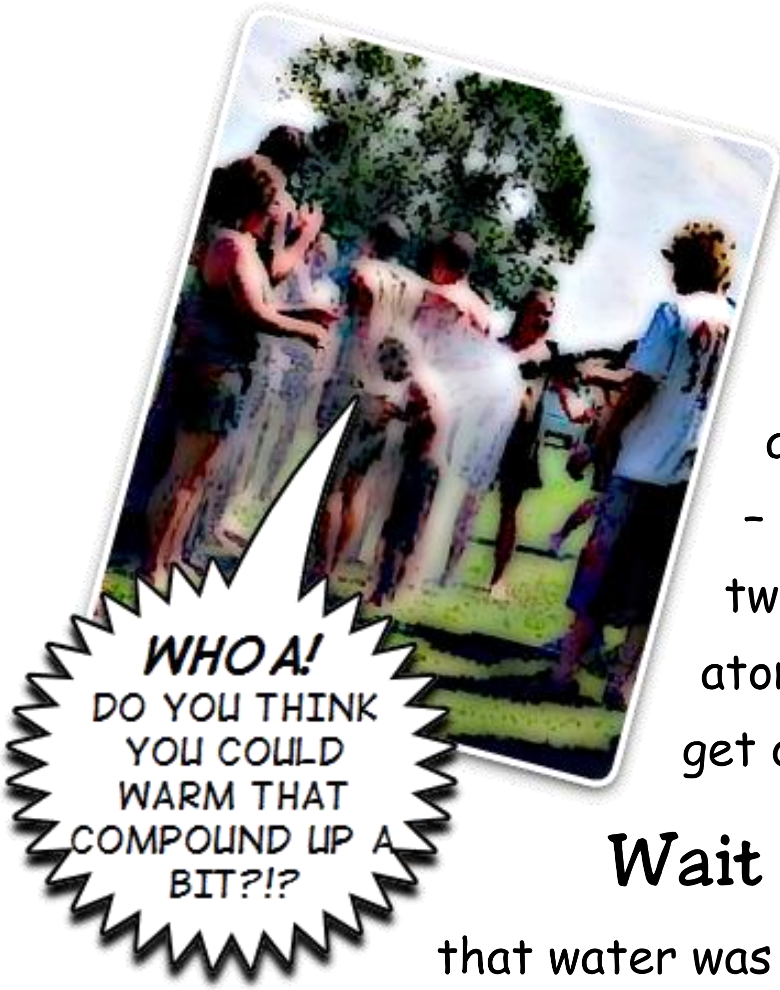
Imagine your favorite toy. Do you have that image in your head? Good! Now imagine that is made out of pure gold!

If you could cut your golden toy in half and hold on to both pieces in your hands, you would still have pure gold in both hands! In fact, you could break your toy down into its individual atoms and you **still** would only have atoms of gold!

Large amounts of pure elements are not easy to find on the Earth. This is because...

...sometimes two or more DIFFERENT atoms join together too!

When two different atoms join together, scientists have a different name for this group – a **compound** ("kom-pownd").



A good example of a compound is water. That right, water is made up of two different elements we have already studied in this chapter – hydrogen and oxygen. When two atoms of hydrogen and one atom of oxygen bond together, we get one molecule of water.

Wait a minute! You just said that water was a **compound** and then you called it a **molecule**! Did you make a mistake? Nope! Here's why...

All compounds are molecules, but not all molecules are compounds.

Huh? Okay, let me explain by using the definitions of compounds and molecules.

#1 Compounds are made up of two or more different atoms.

#2 Molecules are made up of two atoms of any kind.

Now let's look at the group of atoms in water (two hydrogens and one oxygen). Would you say that water is made up of two or more different atoms? I hope you said yes! And is water made up of two atoms of any kind? You should have said yes again!

Water is both a compound and a molecule!

But you learned earlier that sometimes, two or more identical atoms join together. Let's look back at your golden toy and the definitions of compounds and molecules again...

#1 Compounds are made up of two or more different atoms.

#2 Molecules are made up of two atoms of any kind.

Would you say your golden toy is made up of two or more different atoms? Nope! Your toy is made up of only gold atoms!

But is your toy made up of two atoms of any kind? Oh yes it does!

Your golden toy is made up of only one kind of atom – gold! And it takes a lot of gold atoms bonded together to make your golden toy. Your toy is only made up of molecules of gold! Because there are no other atoms in your toy, it is not made up of any compounds! So...

"...not all molecules are compounds."

In the next chapter, you are going to learn more about all the elements in the universe! See you next week!

Use the definitions to fill in the missing letters.

1. _ h _ _ i _ _ _ _ bo _ d
2. _ _ yg _ _
3. _ he _ _ _ a _ _ ene _ _ _
4. co _ _ _ u _ _
5. mo _ _ _ u _ _
6. _ _ _ _ _ gen
7. e _ _ m _ _ _ s

1. another name for "chemical energy"
2. an element with six protons in its nucleus
3. the energy that holds two or more atoms together
4. two or more different atoms joined together
5. two or more atoms joined together
6. an element with only one proton in its nucleus
7. groups of atoms with the same number of protons in their nucleus

Circle the hidden words from below:

s	a	x	i	k	m	o	l	e	c	u	l	e	y	e	l	m	v	r	z
c	h	e	m	i	c	a	l	b	o	n	d	d	g	m	i	x	y	t	c
j	l	r	h	c	l	i	o	v	b	k	p	w	n	j	b	z	a	o	l
d	y	b	l	u	d	i	m	k	o	c	o	m	p	o	u	n	d	k	i
a	j	b	h	k	u	q	k	y	r	o	y	l	d	t	e	p	h	r	l
a	q	b	i	l	f	s	g	f	l	p	f	y	w	b	u	j	j	q	l
t	l	p	y	h	c	g	e	l	e	m	e	n	t	s	g	p	m	f	m
a	d	v	e	n	i	h	s	h	w	l	i	l	o	x	y	g	e	n	s
h	w	x	j	m	e	s	d	d	q	i	t	a	u	m	k	u	p	c	t
n	l	l	g	s	w	n	c	d	e	a	h	y	d	r	o	g	e	n	r
k	n	z	d	c	h	e	m	i	c	a	l	e	n	e	r	g	y	i	e
d	m	w	a	l	j	f	i	p	w	c	u	d	t	i	u	o	u	q	u
u	j	w	h	a	o	b	u	l	y	i	y	n	i	k	e	p	e	z	k
j	p	u	d	a	k	i	q	h	q	t	l	b	b	s	f	x	c	x	s
f	b	q	a	g	k	l	c	q	n	l	o	f	k	m	q	r	a	t	o
b	q	q	w	d	j	w	l	b	c	q	h	f	t	l	x	s	o	q	v

elements

hydrogen

oxygen

chemical energy

chemical bond

molecule

compound

Use the definitions to unscramble the words below.

1. eeemlnts ______________________________
2. cemgciayleenhr ______________________________
3. bdceoncahmil ______________________________
4. oucmndop ______________________________
5. grdenhyo ______________________________
6. culmeeol ______________________________
7. xeyong ______________________________

1. groups of atoms with the same number of protons in their nucleus
2. the energy that holds two or more atoms together
3. another name for "chemical energy"
4. two or more different atoms joined together
5. an element with only one proton in its nucleus
6. two or more atoms joined together
7. an element with six protons in its nucleus

Chapter 4

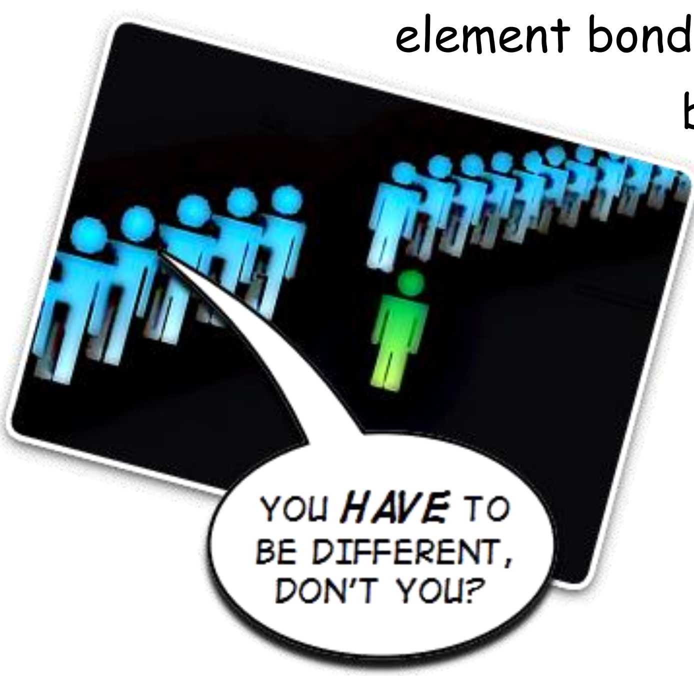
Before we dive into our study of elements, let's review a few things:

- all matter is made up of atoms;
- atoms are made up of three objects called protons, neutrons and electrons;
- elements are made up of only one kind of atom;
- every atom of an element are made up of the same number of protons; and…
- all compounds are molecules, but not all molecules are compounds.

The #1 thing you are going to learn about in this chapter is...

All elements and compounds have different physical and chemical properties!

Every element has its own special physical and chemical properties. You have already learned that each atom of an element bonds with similar atoms. When they bond together, each element may exist as a solid, liquid or gas naturally. Let's look at a couple elements and their chemical and physical properties!

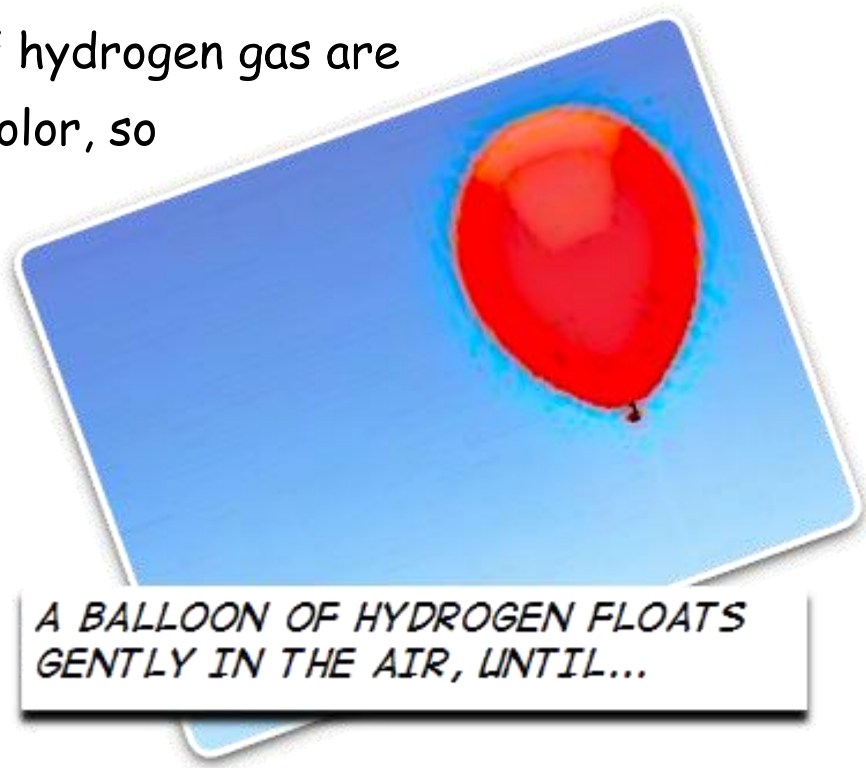


Hydrogen is the smallest element that has been discovered. It has only one proton, neutron and electron. Scientists call the number of protons in the nucleus of an atom the **atomic number**. The atomic number of hydrogen is 1.

The atoms of an element can have a different number of neutrons in the nucleus. Atoms with the same number of protons but a different number of neutrons are known as **isotopes** ("i-sow-topes").

You may know that if a group of hydrogen atoms are placed in the same area, they tend to bond with each other to form hydrogen gas. That means at the normal temperature on Earth, hydrogen exists as a gas.

The physical properties of hydrogen gas are pretty boring! It has no color, so smell and it is much lighter than the regular air. So if you had a balloon full of hydrogen gas and let it go, it would quickly float into the air!



However, the chemical properties of hydrogen gas are a little more exciting. You really would not want to place that hydrogen balloon near a fire because if you do...

Hydrogen gas is very explosive! You shouldn't hold that balloon full of hydrogen gas near a fireplace! That would be bad!

Oxygen has similar physical and chemical properties as hydrogen. However, oxygen is much larger than hydrogen. This element has eight protons, neutrons and electrons in each atom! This means the atomic number of oxygen is 8. Even though it is much larger than hydrogen, its atoms still bond with each other to form a gas. This gas has no color or odor and if you were to place oxygen gas into a balloon, it would float through the air too!

You wouldn't want to place your oxygen balloon near the stove either! Oxygen gas is even more explosive!

Wait a minute! If hydrogen and oxygen are normally gases that can explode, why doesn't water explode?

GREAT QUESTION!

Not only do elements have their own physical and chemical properties... **so do compounds!** Don't forget that water is a compound because it is a group of two different atoms (two atoms of hydrogen and one atom of oxygen) bonded together!

The physical properties water is that it is a liquid at **room temperature** (this means the normal temperature of the air that we, as humans, are used to). Although it is also clear and has no odor it has much different chemical properties.

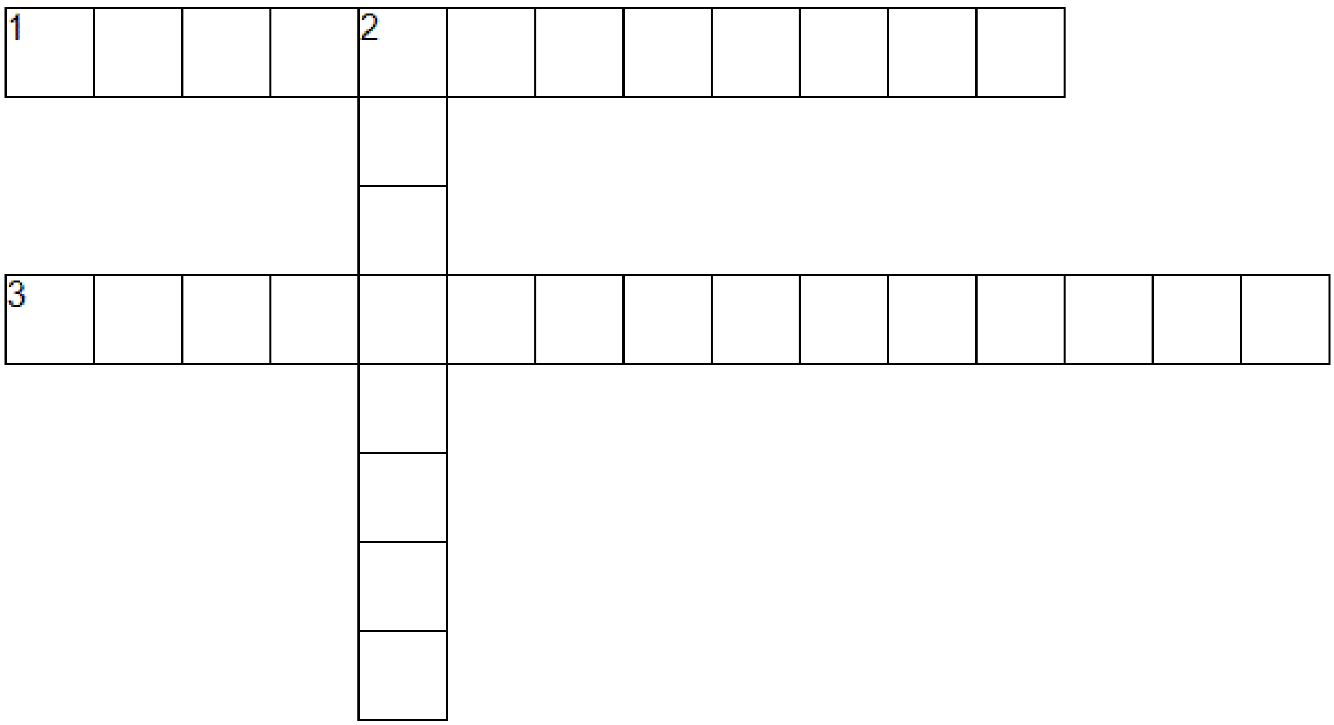
The most important difference in its chemical properties is that liquid water is not explosive.

Now if you turn on the show and fire starts shooting out of the faucet, you have a serious problem!

Don't forget that when two or more elements join, their physical and chemical properties change. Because of this, a compound (like water) will have chemical and physical properties that are different from the elements (hydrogen and oxygen) it is made of.

You have done an excellent job in this first unit! Give yourself a pat on the back! Now spend a little time reviewing these past four chapters to prepare for your exam! Don't worry! You are going to see all of this information again during our next unit!

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

1. the number of protons in the nucleus of an atom

3. the normal temperature of the air that we, as humans, are used to

DOWN

2. atoms with the same number of protons but a different number of neutrons

Match the definitions with the correct words

1. ______________________ the number of protons in the nucleus of an atom

2. ______________________ atoms with the same number of protons but a different number of neutrons

3. ______________________ the normal temperature of the air that we, as humans, are used to

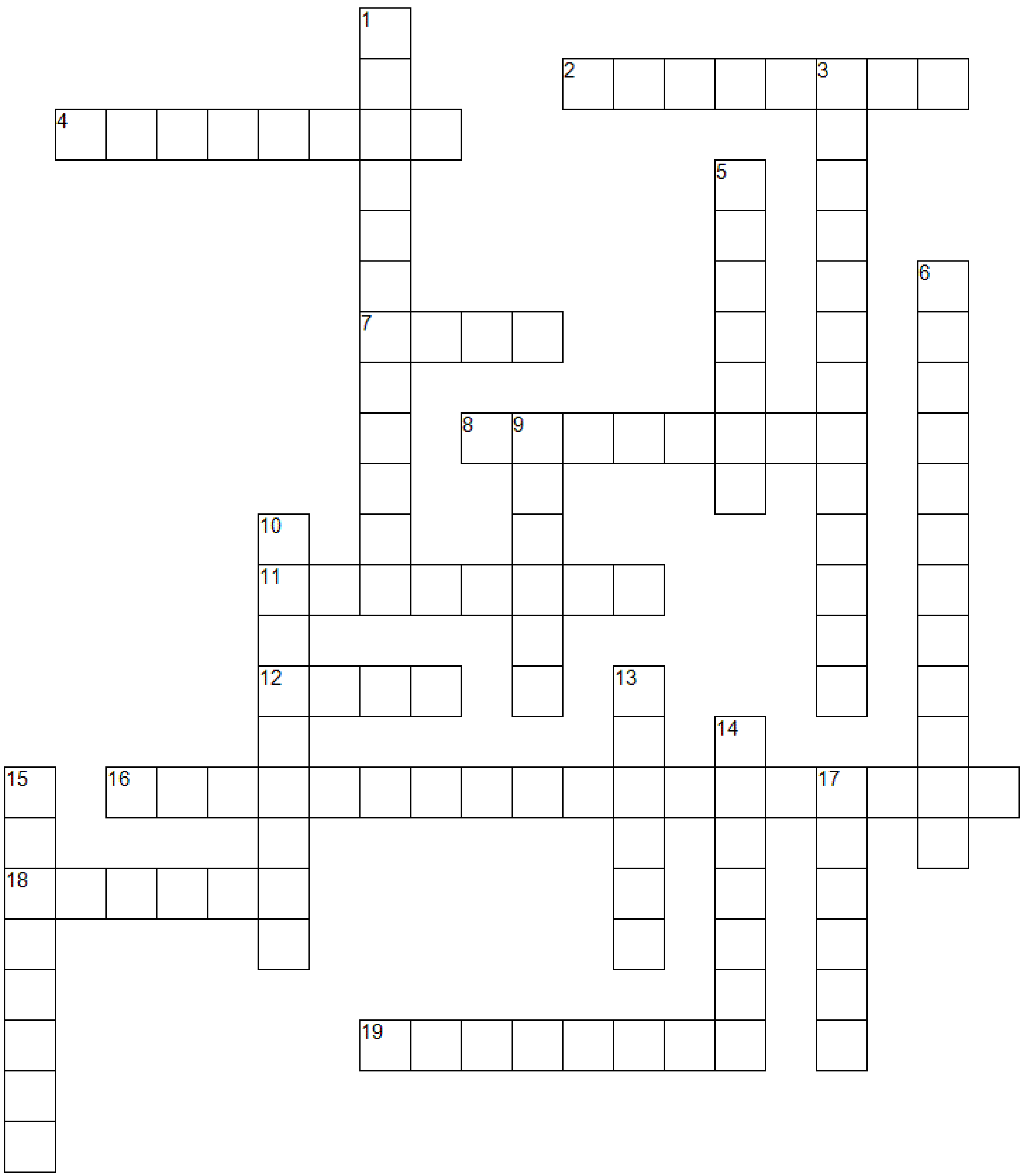
Isotopes
Atomic number
Room temperature

Answer the following question:

If hydrogen and oxygen are normally gases that can explode, why doesn't water explode?

Unit 1 Review

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

2. groups of atoms with the same number of protons in their nucleus
4. atoms with the same number of protons but a different number of neutrons
7. the building blocks of the universe
8. two or more atoms joined together
11. an element with only one proton in its nucleus
12. the measurement of how much matter there is in an object
16. the characteristics of objects that stay the same such as color, shape and size
18. the name for all of the solids, liquids and gases in the universe
19. small piece of an atom with a negative charge that moves around the nucleus

DOWN

1. another name for "chemical energy"
3. the amount of energy that holds an atom together
5. combination of protons and neutrons within every atom
6. the number of protons in the nucleus of an atom
9. an element with six protons in its nucleus
10. the study of matter and how it changes
13. small piece of an atom with a positive charge that sits inside the nucleus
14. small piece of an atom that no charge and sits inside the nucleus
15. two or more different atoms joined together
17. a statement about some scientific event that has been tested many times and have all had the same results

Be certain to go over your definitions for the test!!!

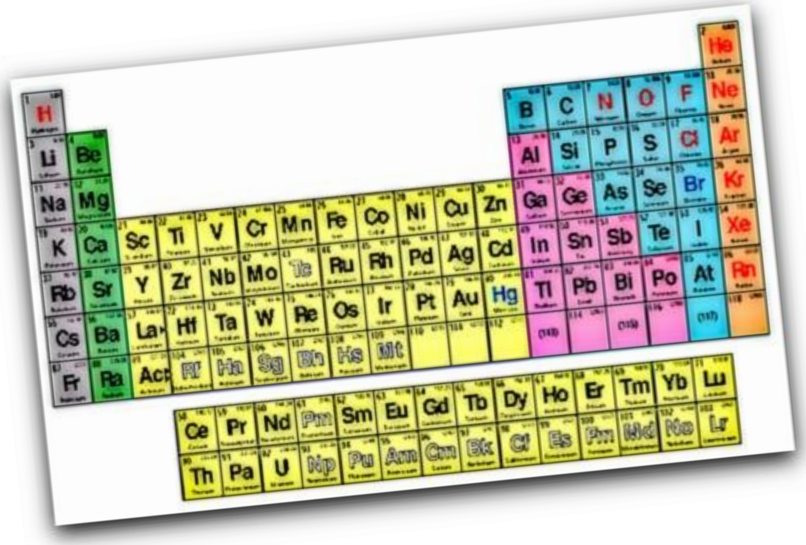
Chapter 5

In the last unit, you learned that each element in the universe is made up of atoms with the same number of protons in their nucleus. In addition, each of these elements has their own chemical and physical properties.

So how do we organize over 100 elements? Well, it is easy to do if you learn how to use the...

PERIODIC TABLE

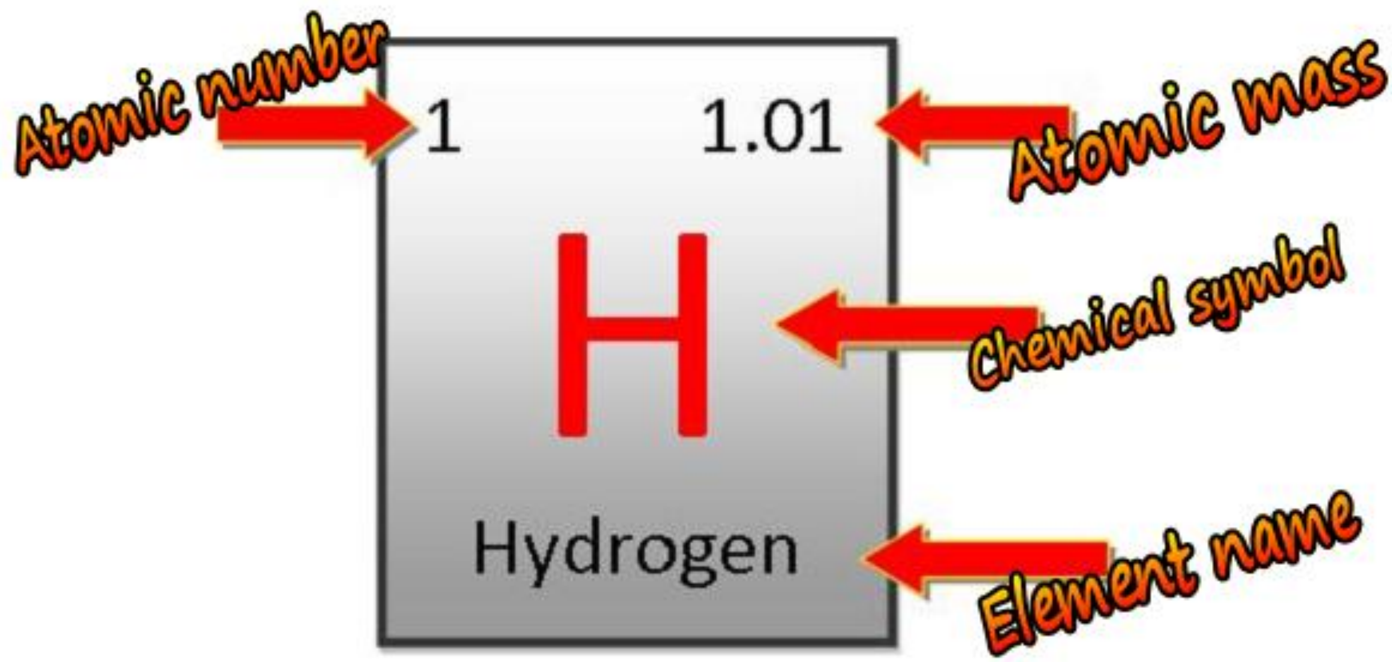
("peer-ee-ah-tick")



The **periodic table** is a way scientists have arranged all of the elements that have been discovered. Every little square on this table has a lot of information about one element! You already know that the number of protons an element has in its nucleus is called the atomic number. Now it is time to learn about an element's **atomic mass**. The atomic mass of an element is the average mass of the protons and neutrons for an element. You have to take an average of all the isotopes for each element to find its atomic mass.

Don't forget! An isotope is an element with the same number of protons but a different number of neutrons. Some elements have many different isotopes!

Let's take a look at one square on the periodic table:



You can get four different pieces of information out of each square in the periodic table:

Atomic number	Chemical symbol
Atomic mass	Element name

#1 Atomic number - You already know this one! It's the total number of protons in the nucleus!

#2 Atomic mass - This is an easy one too! You just learned how we get the atomic mass!

#3 Chemical symbol - Now this one is a little different. The **chemical symbol** of an element is made up of one or two letters in the alphabet. The chemical symbol for hydrogen is "H". The chemical symbol for oxygen is "O". So what do you think the chemical symbol for gold is? Well, if you said "G" you'd be absolutely wrong! Sorry! Sometimes, the chemical symbol is not as easy to figure out for an element. Gold's symbol is "Au"! It received this symbol because an ancient name for gold is "aurum" which means "shining dawn". Don't worry! You will not have to memorize the chemical symbol for every element. But you will know several of them by the time you finish this book!

#4 Element Name -

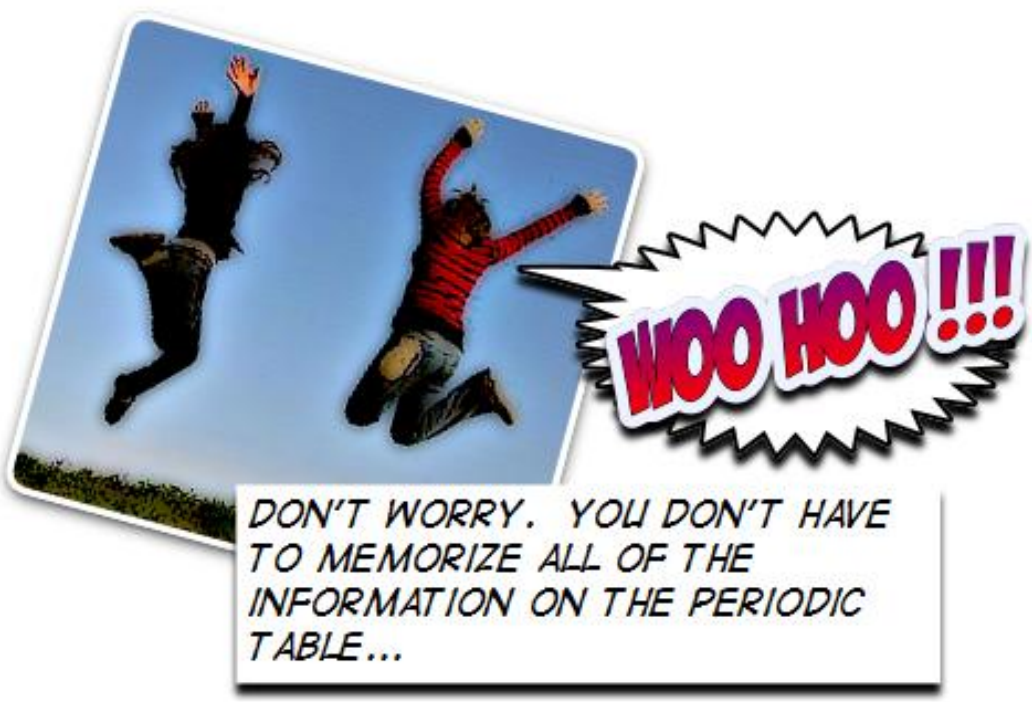
As you can see in the example on the previous page, the name of the element is "Hydrogen".

You might think there is a lot of information in the periodic table about all these elements. And you are right! But there is something else that is really cool about how these elements are placed on the table. Let's go back to the last unit to help you out...

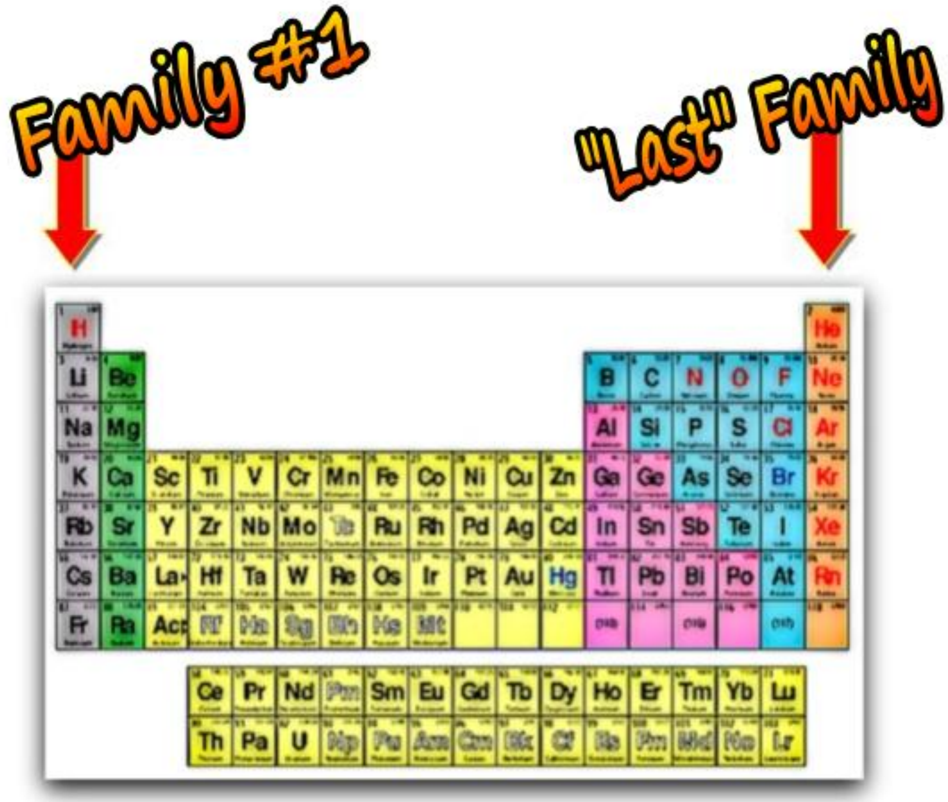
Remember when I told you that the chemical and physical properties of elements are all different? But you still learned that some properties are pretty similar, right? For example, both oxygen and hydrogen gas have no odor, float in the air and explode rather easily!

Well, when you arrange all of the elements in order of their atomic mass, you can see patterns in how similar these elements are to each other! Let me explain...

Each column in the periodic table is called a **family**. The elements in each family all have similar properties.



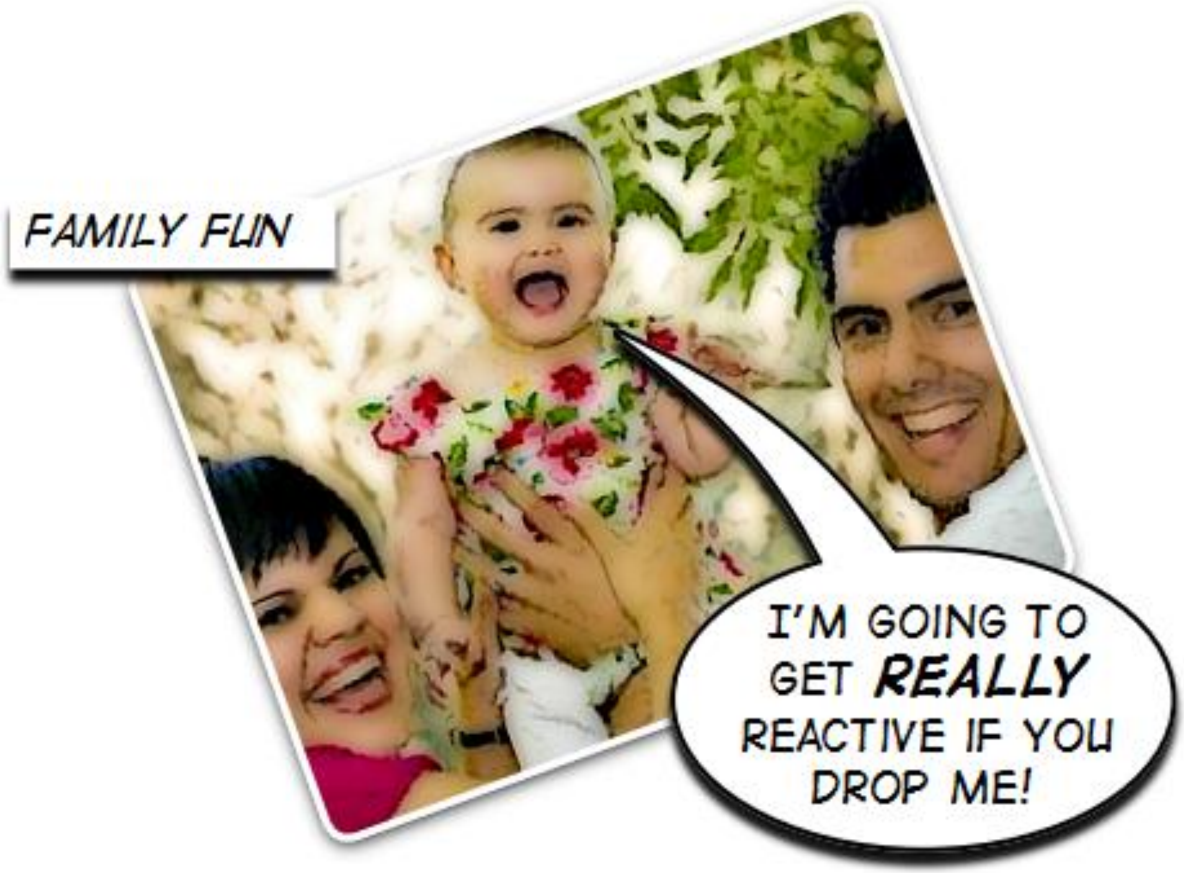
The first family (the column of elements from H to Fr) tend to react with other elements very easily. A good example of this is if you put a pure piece of sodium (Na) into water it will burst into flame!



The last family (the column from He to Rn) do not react with other elements at all!

So the first family is very reactive and the last family is not reactive at all! What can you predict about the other families in the middle? That's right! As you move from the first family, the elements tend to get less reactive until they reach the last family...

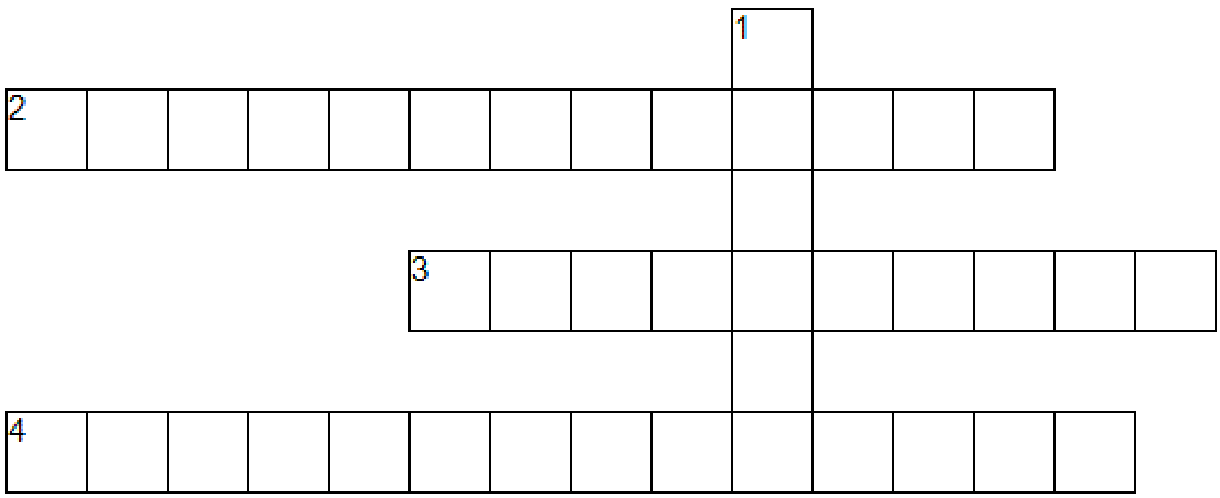
Where they are not reactive at all!



In the next chapter, you are going to start looking at each of the different groups inside the periodic table starting with:

Metals!

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

2. an arrangement of all the elements that have been discovered
3. average mass of the protons and neutrons for an element and all its isotopes
4. one or two letters in the alphabet that identifies one element in the periodic table

DOWN

1. a column of elements on the periodic table; each contains similar chemical and physical properties of elements

Use the definitions to unscramble the words below.

1. asmatmoics ______________________________
2. flymai ______________________________
3. cbmoyicamehlsl ______________________________
4. ebclepriditoa ______________________________

1. average mass of the protons and neutrons for an element and all its isotopes
2. a column of elements on the periodic table; each contains similar chemical and physical properties of elements
3. one or two letters in the alphabet that identifies one element in the periodic table
4. an arrangement of all the elements that have been discovered

Circle the hidden words from below:

a	e	p	l	k	e	i	a	t	o	m	i	c	m	a	s	s	k	l	l
l	g	m	e	l	g	v	d	o	b	z	f	b	p	k	w	i	i	f	b
f	j	o	o	e	t	i	s	n	l	g	d	u	e	t	x	y	w	o	f
a	g	m	g	p	e	r	i	o	d	i	c	t	a	b	l	e	l	q	c
m	l	h	h	y	t	c	h	e	m	i	c	a	l	s	y	m	b	o	l
i	z	l	d	m	b	m	j	e	i	f	w	n	t	p	v	t	e	j	r
l	x	s	g	d	q	q	g	x	d	t	g	g	j	n	u	h	l	w	f
y	x	k	a	x	p	d	p	z	y	o	d	b	y	e	p	g	z	p	h
r	n	q	b	w	u	o	p	s	x	h	f	n	x	l	o	f	q	a	y
d	a	r	o	q	r	h	f	k	o	o	f	n	a	w	m	i	c	r	a
x	a	y	k	o	y	r	u	v	b	a	b	e	r	m	e	v	x	f	u
x	l	x	e	o	j	r	j	t	r	f	n	a	q	i	r	n	o	n	l
k	w	d	g	h	j	i	u	h	r	t	q	w	d	b	y	i	q	a	x
i	c	n	y	s	u	h	j	n	f	j	h	o	c	e	u	q	q	r	f
p	z	x	z	l	d	l	i	o	w	t	m	f	w	a	b	p	n	u	t
t	m	q	d	z	u	c	x	i	a	y	f	m	x	m	e	w	b	m	c

atomic mass

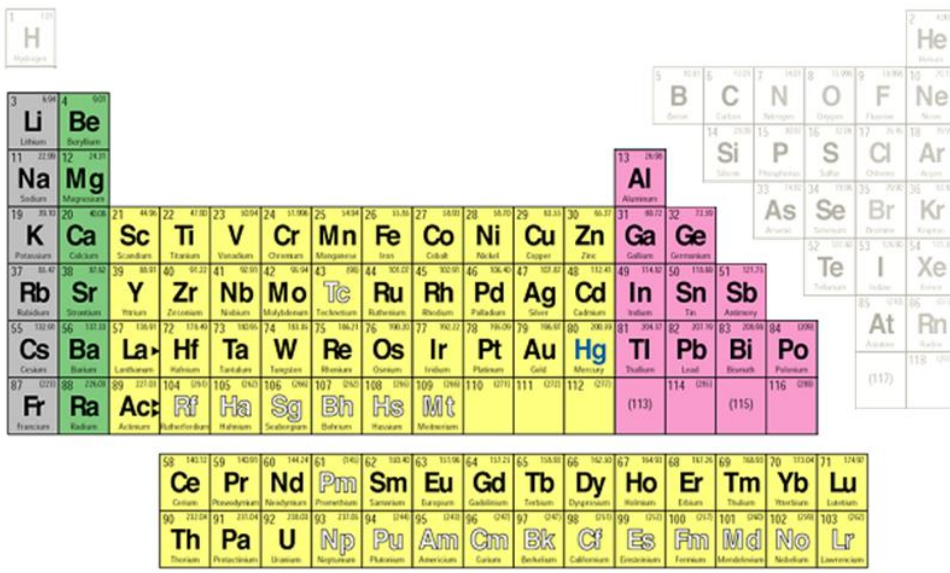
periodic table

chemical symbol

family

Chapter 6

By far, most elements on the periodic table are metals. If you look at the table below, all of the boxes with color inside them are metals. You will study the other elements later in this unit.



Scientists have identified the physical properties of metals in four different ways:

#1 Metals are shiny

I think you should understand what this means!

#2 Metals are **malleable** ("mal-ee-uh-bull")

Metals are called malleable because they can be hammered or rolled into a flat sheet.

#3 Metals are **ductile** ("duck-tull")

A solid that is ductile can be pulled into the shape of a thin wire.

#4 Metals are **conductive** ("kon-duck-tiv")

Metals are conductive because they have the ability to transfer electricity, heat or sound very easily. This why we send electricity through metal wires and cook with metal pots and pans!

Shiny, malleable, ductile and conductive are all physical properties of metals.

All metals share these abilities. Some metals are shinier than others. Some metals are more conductive than others. Scientists have amazing resources for you to use if you wanted to see which element is best to transfer heat or electricity or sound. You don't need to remember all these facts!

But you do have to understand that metals have chemical properties too! Here is what you need to know…

You learned in earlier chapters that atoms have the ability to bond with other atoms. Well, the ability and speed that atoms have in bonding with other atoms is known as **reactivity**. The atoms of metals react with other atoms by giving away some of their electrons! Don't worry! They usually get them back! You'll learn how they do that in a later chapter! For now, you need to remember that…

…not all chemicals have the same reactivity!

That's right! But here's a cool trick - You can use the periodic table to see which metals are more reactive than others. The metals that are on the left side of the periodic table are more reactive than the metals on the right side.

Now it's time to start learning about the different families of metals inside the periodic table!

You learned in the last chapter that each column of the periodic table is known as a family. And you probably have noticed that some of these families are colored differently on the periodic table. Well, there's a reason for that!

The metals on the left side of the periodic table (except for hydrogen!) are known as **alkali metals** ("al-kah-lie"). Most alkali metals are very shiny and very malleable. They also react with other elements very easily (and violently too!) In fact, if you placed a piece of pure sodium (The chemical symbol of sodium is "Na") in a container of water...

...it would burst into flame!

Cool, huh?

The metals inside the second family are called **alkaline metals** ("al-kah-line"). These metals are not very malleable. In fact, they are pretty hard! Most of them are grey or white colored too and they are very good conductors! The alkaline metals are not as reactive as the alkali metals. However, they are still more reactive than the rest of the metals which are known as – **transition metals** ("tranz-ish-shun").

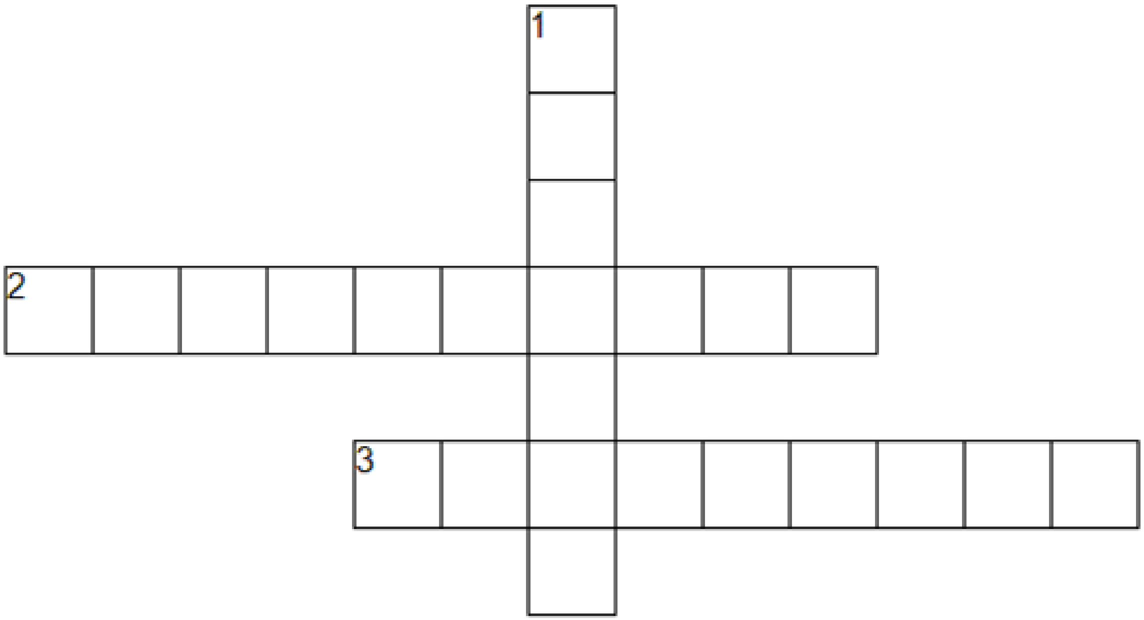
Transition metals are found in families 3-12. That's right! There are a lot of transition metals! Most of them are very shiny and very good conductors. However, they are normally very hard metals and have poor reactivity.

The few metals in families 13-15 are not very reactive at all!

In fact, they sit right next to the next group of elements we are going to study in the next chapter. Stay tuned!

What are four physical properties of minerals? List and describe each of them below:

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

2. a physical property of solids that can transfer electricity, heat or sound very easily

3. a physical property of solids that can be hammered or rolled into a flat sheet

DOWN

1. physical property of solids that can be pulled into the shape of a wire

Use the definitions to fill in the missing letters.

1. _ uc _ i _ _
2. _ _ _ _ u _ tiv _
3. m _ l _ _ _ bl _

1. physical property of solids that can be pulled into the shape of a wire
2. a physical property of solids that can transfer electricity, heat or sound very easily
3. a physical property of solids that can be hammered or rolled into a flat sheet

Chapter 7

So far, you have looked at the chemical and physical properties of metals. You have discovered that metals are:

Shiny
Malleable
Ductile
Conductive
and **Reactive**

But what about all those other elements on the right side of the periodic table? Are those elements metals too?

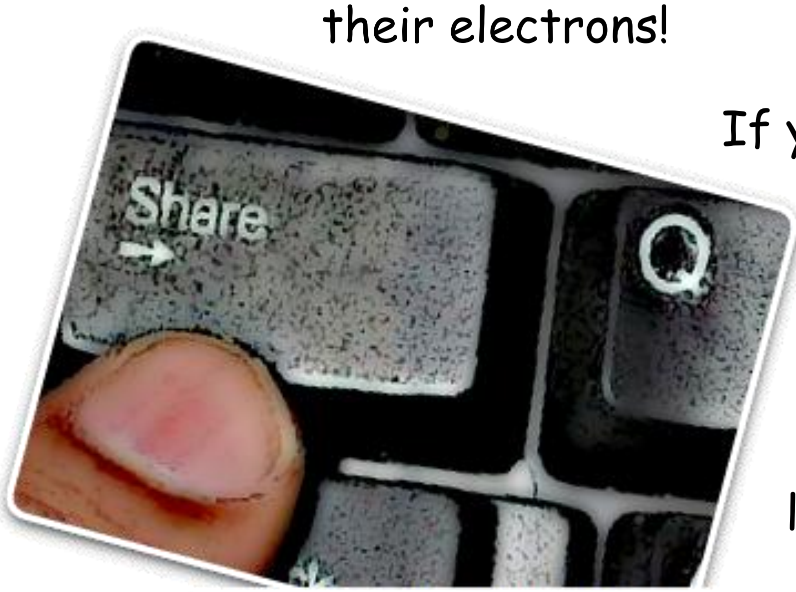
The elements that we have not studied so far are called **nonmetals.** The physical and chemical properties of nonmetals are easy to learn (if you were paying attention in the last chapter). The properties of nonmetals are so easy to learn because...

...they are the exact opposite of metals!

Most nonmetals are gases! This means they are not shiny, bendable or able to transfer heat, electricity or sound very well. The nonmetals that are solids have dull colors and are very easily broken apart when they are hammered. These physical properties are the opposite of most metals.

The same is true for the chemical properties of nonmetals.

Although nonmetals **are** reactive with other elements, they tend to react with other atoms by **taking** electrons away or sharing from other elements. This is the opposite of metal elements which react with other atoms by giving away some of their electrons!



SHARING IS COMMON AMONG NONMETALS...

If you look at the periodic table, nonmetals start in family 14 and end in family 18. Let's take a closer look at the nonmetals. As you do, try to look for a pattern in their chemical properties...

The only nonmetal in family 14 is known as **carbon** ("kar-bon"). This element is going to be a very important for you to learn about. In fact, we are spending an entire unit on this element! When carbon reacts with other atoms, it gains or shares 4 electrons!

In family 15 we have the elements **nitrogen** ("nigh-trow-gen") and **phosphorus** ("foss-for-us"). When nitrogen or phosphorus react with other elements, they gain or share three electrons!

Family 16 has three nonmetals: **oxygen** ("ox-ee-gen"), **sulfur** ("sull-fur") and **selenium** ("seh-len-ee-um"). When these nonmetals react with other atoms, they gain or share two electrons!

See a pattern yet? Maybe you need a couple more families to study then…

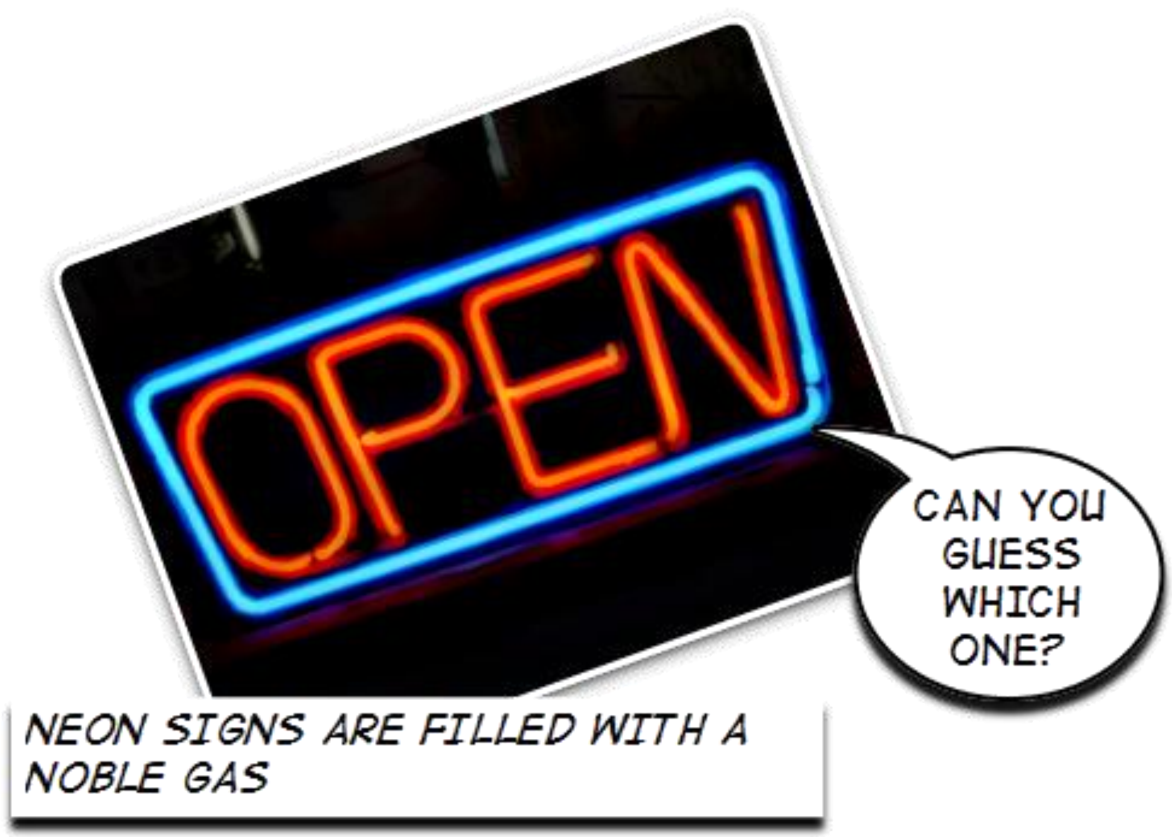
Family 17 is known as the **halogens** ("hal-oh-gens"). There are five halogens that we have discovered in nature: **fluorine** ("floor-een"), **chlorine** ("klor-een"), **bromine** ("bro-meen"), **iodine** ("i-oh-dyne") and **astatine** ("az-tah-teen"). All of the halogens with take or share one electron when they react with other atoms.

So have you figured out the pattern yet?

As you move through the nonmetals from left from right, they gain or share fewer electrons when they are reactive!

So can you guess what the chemical properties of the last family are going to be? Well, if you said that these elements are not going to share any of their electrons you would be correct! The last family in the periodic table is known as the **noble gases**. These elements are all gases and they do not react with any other elements at all! Not only do these elements not share or gain any electrons… they don't give any electrons either! These elements keep to themselves!

There are a few elements that are between the metals and nonmetals. These elements are known as the **metalloids** ("met-ahl-oidz"). Metalloids have physical and chemical properties of metals and nonmetals! All of them are solids and break very easily. They are also reactive with other elements. But the coolest thing about metalloids is that they can conduct electricity only at certain temperatures or in certain amounts of light! Because of this property, metalloids are called **semiconductors!** The ability to conduct electricity through your computer or through lasers would be impossible without the use of semiconductors!



Okay! Pat yourself on the back because you have learned a lot about the periodic table. Next week, we are going to look at how scientists can combine metals with other elements to form amazing new compounds!

Match the definitions with the correct words

1. ____________________ the ability of metalloids to conduct electricity only at certain temperatures or in certain amounts of light

2. ____________________ a nonmetal in family 14 that gains or shares four electrons during a reaction

3. ____________________ a nonmetal in family 16 that gains or shares two electrons during a reaction

4. ____________________ elements that have the opposite physical and chemical properties of metals; most are gases; solid nonmetals are dull, brittle and not conductive

5. __________________ nonmetal elements in family 17 (Fluorine, Chlorine, Bromine, Iodine and Astatine) that gains or shares one electron during a reaction

6. __________________ nonmetal elements in family 18 that do not react with any other elements in the periodic table

7. __________________ elements that have chemical and physical properties of both metals and nonmetals; these elements conduct electricity only at certain temperatures or in certain amounts of light

Carbon

Noble gases

Halogens

Nonmetals

Oxygen

Semiconductors

Metalloids

Use the definitions to unscramble the words below.

1. girnoten ____________________
2. geyxno ____________________
3. scctoduroneims ____________________
4. ocbnar ____________________
5. nmealonts ____________________
6. neobseglas ____________________
7. maltlseoid ____________________
8. srlufu ____________________
9. lohansge ____________________
10. srphospuho ____________________
11. leismeun ____________________

1. a nonmetal in family 15 that gains or shares three electrons during a reaction
2. a nonmetal in family 16 that gains or shares two electrons during a reaction
3. the ability of metalloids to conduct electricity only at certain temperatures or in certain amounts of light
4. a nonmetal in family 14 that gains or shares four electrons during a reaction
5. elements that have the opposite physical and chemical properties of metals; most are gases; solid nonmetals are dull, brittle and not conductive
6. nonmetal elements in family 18 that do not react with any other elements in the periodic table
7. elements that have chemical and physical properties of both metals and nonmetals; these elements conduct electricity only at certain temperatures or in certain amounts of light
8. a nonmetal in family 16 that gains or shares two electrons during a reaction
9. nonmetal elements in family 17 (Fluorine, Chlorine, Bromine, Iodine and Astatine) that gains or shares one electron during a reaction
10. a nonmetal in family 15 that gains or shares three electrons during a reaction
11. a nonmetal in family 16 that gains or shares two electrons during a reaction

Use the definitions to fill in the missing letters.

1. _ ho _ _ ho _ _ _
2. no _ _ _ _ _ s _ _
3. _ _ r _ o _
4. _ _ _ f _ r
5. s _ l _ n _ _ _
6. n _ t _ _ g _ _
7. _ o _ _ _ ta _ s
8. _ _ _ _ en
9. _ _ mic _ _ _ u _ _ _ rs
10. _ _ _ o _ en _
11. m _ _ _ ll _ i _ _

1. a nonmetal in family 15 that gains or shares three electrons during a reaction
2. nonmetal elements in family 18 that do not react with any other elements in the periodic table
3. a nonmetal in family 14 that gains or shares four electrons during a reaction
4. a nonmetal in family 16 that gains or shares two electrons during a reaction
5. a nonmetal in family 16 that gains or shares two electrons during a reaction
6. a nonmetal in family 15 that gains or shares three electrons during a reaction
7. elements that have the opposite physical and chemical properties of metals; most are gases; solid nonmetals are dull, brittle and not conductive
8. a nonmetal in family 16 that gains or shares two electrons during a reaction
9. the ability of metalloids to conduct electricity only at certain temperatures or in certain amounts of light
10. nonmetal elements in family 17 (Fluorine, Chlorine, Bromine, Iodine and Astatine) that gains or shares one electron during a reaction
11. elements that have chemical and physical properties of both metals and nonmetals; these elements conduct electricity only at certain temperatures or in certain amounts of light

Chapter 8

In this chapter, you are going to learn about the cool things you can get when you create a **mixture** of two or more objects! A mixture is a group of two or more substances mixed together. Simple, right? Oh yeah!

And there are a lot more mixtures out there than you may think!


THIS LOOKS LIKE A GREAT MIXTURE!

Let's imagine a very simple mixture of salt, water and nails. If I gave you this mixture, how would you pull all of these objects apart? I'll give you a minute to think about this one. It may be a little tricky.

Ready to go? Great! First of all, the nails that you have in the mixture are probably made up of many different metals. This would make each nail a mixture too! Cool, huh? I would guess that the nails you have in this mixture have a certain element inside them called **iron**. Iron is a transition metal (Atomic Number = 26) that has a very cool physical property...

...it is attracted to magnets very easily!

So if you wanted to get the nails out of the mixture easily, all you would have to do is place a magnet on the side of the jar. The nails would be attracted to the magnet through the jar. As you move the magnet up the side of the jar, the nails would follow and will come out of the mixture!

Now, how are we going to get the salt out of the water?

We could ask the salt nicely to come out of the water, but I don't think that will work. (And people may look at you a little funny if they saw you do that too!) But if you boil the saltwater, only the water will turn into steam! The salt will remain in the jar!

The number one rule of mixtures is this:

The "stuff" you put into a mixture can always be taken back out and used again!

Let's see how this works when we mix together metals. When you combine two or more metals (or other elements) together you get something called an **alloy** ("al-oi"). An alloy has different chemical and physical properties than the metal atoms used to make it. Some of these differences can help to make better kinds of metals. Scientists who study new ways to mix metals together are called **metallurgists** ("meh-tall-ur-jists"). Metallurgists have found all kinds of cool metals by mixing them together. For example:

Mixing the elements copper and zinc will give you an alloy called **brass**. Most of your metal musical instruments are made of brass because you can bend this alloy a lot easier than both copper and zinc.

If you mix copper with a different element called tin, you get an alloy called **bronze**. Bronze has been used throughout history because it is harder and less brittle than copper and tin.

Mixing iron with the element carbon gives us a very strong alloy called **steel**. Steel is stronger than iron or carbon and is used in almost every building, car or tool that we use today.

Besides being more malleable (bendable) or stronger, most alloys have different chemical properties too! For example, most alloys using iron do not rust very easily. You probably have metal forks or spoons in your kitchen right now. If you look closely you may be able to find the words "**stainless steel**" on your forks and spoons. Stainless steel means that the tool:

#1 Contains iron (remember, iron is used to make steel); and,

#2 since it is "stainless" it is not going to go through a chemical change and turn to rust very easily!

You see, if you place anything made of iron outside or where you'll find a lot of water, something will start to happen to the iron...

Rust is a compound that is created when iron mixes with water and the oxygen in the air. Rust will continue to be created until there is no more iron left on an object!

Since your forks and spoons are made of an iron alloy, you don't want them to turn into rust after you wash them! So, when you make "stainless" steel you add another element called **chromium** ("kroh-me-um"; Atomic Number 24) into the iron. Chromium keeps the iron in the steel from rusting very easily!

You can make all kinds of cool alloys by studying the different metal elements in the periodic table. However, scientists would never be able to remember how to make all these cool alloys if they didn't know how to measure the elements or learn how they move around. In the next unit you are going to learn how they do all this...

...and more!

Compare and Contrast the following vocabulary words:

Brass

Bronze

How are they the same? (Compare)

1. ____________________

____

2. ____________________

____

How are they different? (Contrast)

1. ____________________

____

2. ____________________

____

Circle the hidden words from below:

m	e	y	m	j	h	s	u	t	v	m	u	e	n	r	q	r	d	q	n
e	q	i	i	w	l	j	c	d	j	w	b	x	a	b	l	g	s	y	z
t	o	q	x	g	d	u	y	k	t	c	s	h	t	i	q	x	c	c	f
a	s	d	t	x	g	a	o	c	r	g	u	v	k	o	n	v	d	k	b
l	e	o	u	d	g	l	l	v	k	l	f	s	h	e	z	o	n	p	r
l	m	a	r	l	d	l	j	y	g	h	k	u	a	h	u	w	k	l	a
u	q	o	e	y	l	o	y	s	m	c	p	o	x	z	p	s	c	v	s
r	x	h	c	w	a	y	p	o	j	i	r	o	n	c	w	n	p	k	s
g	d	g	z	v	r	o	k	p	l	g	y	p	u	p	u	k	p	s	g
i	c	h	r	o	m	i	u	m	d	l	i	f	c	e	m	v	y	p	h
s	j	a	r	p	h	w	m	m	u	b	b	o	i	j	x	u	k	a	g
t	g	b	h	s	a	m	x	h	p	z	x	e	n	s	i	h	m	h	s
s	x	m	a	t	m	s	t	a	i	n	l	e	s	s	s	t	e	e	l
y	p	k	l	e	b	n	w	q	c	s	q	b	r	o	n	z	e	q	n
o	a	u	g	e	z	x	x	x	e	g	g	w	p	i	m	d	f	q	f
x	c	q	q	l	w	c	f	f	i	z	t	e	a	p	i	p	r	j	e

mixture

iron

alloy

metallurgists

brass

bronze

steel

stainless steel

chromium

Match the definitions with the correct words

1. __________________ alloy of the elements copper and tin

2. __________________ used in the making of stainless steel as it prevents iron from turning into rust

3. __________________ alloy of the elements copper and zinc

4. __________________ alloy of the elements iron and carbon or chromium

5. __________________ a group of two or more metals that are connected together

6. __________________ a transition metal (Atomic Number = 26) that has is magnetic and is used to create the alloy called steel

7. __________________ alloy of the elements iron and chromium

8. ______________ scientists who study new ways to mix metals together

9. ______________ a combination of two or more metals (or other elements) together to form a different kind of metal

Alloy
Chromium
Iron
Steel
Brass
Mixture
Stainless steel
Bronze
Metallurgists

Unit 2 Review

Match the definitions with the correct words

1. ____________________ a nonmetal in family 14 that gains or shares four electrons during a reaction

2. ____________________ one or two letters in the alphabet that identifies one element in the periodic table

3. ____________________ the ability of metalloids to conduct electricity only at certain temperatures or in certain amounts of light

4. ____________________ nonmetal elements in family 17 (Fluorine, Chlorine, Bromine, Iodine and Astatine) that gains or shares one electron during a reaction

5. ____________________ average mass of the protons and neutrons for an element and all its isotopes

6. ____________________ alloy of the elements iron and chromium

7. ____________________ elements that have chemical and physical properties of both metals and nonmetals; these elements conduct electricity only at certain temperatures or in certain amounts of light

8. ____________________ elements that have the opposite physical and chemical properties of metals; most are gases; solid nonmetals are dull, brittle and not conductive

9. ____________________ an arrangement of all the elements that have been discovered

10. ____________________ nonmetal elements in family 18 that do not react with any other elements in the periodic table

11. ____________________ a nonmetal in family 16 that gains or shares two electrons during a reaction

12. ______________ a physical property of solids that can be hammered or rolled into a flat sheet

13. ______________ a nonmetal in family 15 that gains or shares three electrons during a reaction

14. ______________ a column of elements on the periodic table; each contains similar chemical and physical properties of elements

15. ______________ physical property of solids that can be pulled into the shape of a wire

16. ______________ a nonmetal in family 15 that gains or shares three electrons during a reaction

17. ______________ a physical property of solids that can transfer electricity, heat or sound very easily

18. ______________ a combination of two or more metals (or other elements) together to form a different kind of metal

19. ______________ a nonmetal in family 16 that gains or shares two electrons during a reaction

20. ______________ used in the making of stainless steel as it prevents iron from turning into rust

21. ______________ a nonmetal in family 16 that gains or shares two electrons during a reaction

22. ______________ a group of two or more metals that are connected together

23. ______________ alloy of the elements iron and carbon or chromium

24. ______________ a transition metal (Atomic Number = 26) that has is magnetic and is used to create the alloy called steel

Alloy
Sulfur
Mixture
Malleable
Stainless steel
Carbon
Periodic table
Nitrogen
Metalloids
Ductile
Atomic mass
Chromium
Semiconductors
Conductive
Family
Iron
Nonmetals
Phosphorus
Oxygen
Noble gases
Selenium
Steel
Chemical symbol
Halogens

Be certain to go over your definitions for the test!!!

Chapter 9

You have learned a lot about elements on the periodic table in the last two units. Now it's time for you to learn how to measure all of this matter!

In an earlier chapter, you learned that mass is the measurement of the amount of matter in an object. And everything in the universe is made up of matter! What you may not know is that a lot of people get confused about two different scientific measurements:

Mass and Weight

("wayt")

There is a huge difference between these two measurements. You see...

Mass is a measurement of the amount of matter in an object.

but...

Weight is a measurement of the force of gravity on an object!

Wait a minute! What does weight have to do with the force of gravity?

Well, **gravity** is a force that pulls objects towards each other. What does this mean? Since everything in the universe is made up of matter...

...everything in the universe has gravity!

So even though **you** may have some gravity, larger objects (like the Earth or the moon) would have even **more** gravity! Let's look at an example of this by using our imagination...

If I were standing on the moon, I would have the same amount of matter that I would on have on Earth. This means my mass would stay the same! But, the force of gravity on the moon is much smaller (because it is tiny compared to Earth!) So, my weight on the moon would be much smaller too!

Scientists use a set of measurements to determine the mass and weight of an object. It is called the **gram**. You've seen a paperclip before, right? Well, a single paperclip has the mass and weight of one gram.

Now let's look at another way to measure matter – **volume** ("vahl-yoom"). Volume is the amount of space that an object takes up. It sounds familiar to the definition of mass, doesn't it? Perhaps this story will help:

Imagine you are going on a trip. You pack a suitcase with so much stuff that it cannot hold anything more! You could measure how tall it is, how long it is and how wide it is too! These three measurements would tell you the volume of the suitcase. Now imagine trying to fit that suitcase into your car. And it **barely** fits!

Oh no! You forgot to pack a coat!

You pull out your suitcase and stuff a coat inside. It's pretty hard to zip it back up now, but you get the job done! But something has changed! Your suitcase is now so full that it is much wider than it was! It's not going to fit in your car because...

It's taking up more space!

This means you increased the volume of the suitcase since it is now taking up more space! Now do you see how volume works?

Now let's imagine what would have happened if you used something other than a suitcase to pack your gear for the trip. Let's say instead of a suitcase, you packed all your stuff in a big metal box! The box doesn't stretch very much when you pack your extra coat. This means the volume of the box doesn't change...

But you did put more matter into the box, right? So that means you increased the **density** ("den-city") of the box. Density is the amount of atoms found in an object. When you added your coat, you placed more atoms into the box.

But what if your box gets dropped into a big pool of water? Will it sink or float? Well, that depends on the density of the box. If the box is more dense than the water, it will sink. If it is less dense than water, it will float.

Density can also be used to explain how gases work. For example, if a balloon is filled with a special gas called **helium** ("hee-lee-um") it is going to float to the top of your house. (Unless you hold onto them all the time!)

Can you guess which is denser - the air in your house or the gas in the balloon?

The gas in the balloon is less dense! That's why it floats to the top of your house!

You are going to see how density affects a lot of matter in this book! Next week, you are going to use your knowledge of shape, volume and density to study the different states of matter! Stay tuned!

Use the definitions to fill in the missing letters.

1. gr _ _
2. g _ _ _ i _ y
3. d _ _ _ _ ty
4. _ _ _ _ me
5. w _ i _ _ _
6. he _ _ _ _

1. unit of measurement for weight and mass
2. a force that pulls objects towards each other
3. the amount of atoms that can be found in an object
4. the amount of space that an object takes up
5. a measurement of the force of gravity on an object
6. a gas which is less dense than air

Use the definitions to unscramble the words below.

1. vmouel ______________________________
2. rmga ______________________________
3. mhliue ______________________________
4. wgeiht ______________________________
5. sdeynit ______________________________
6. rviatgy ______________________________

1. the amount of space that an object takes up
2. unit of measurement for weight and mass
3. a gas which is less dense than air
4. a measurement of the force of gravity on an object
5. the amount of atoms that can be found in an object
6. a force that pulls objects towards each other

Circle the hidden words from below:

v	a	q	j	s	j	t	g	r	a	v	i	t	y	o	q	k	t	o	n
d	y	p	z	w	o	c	m	o	h	v	v	j	q	w	z	m	t	d	l
e	k	d	v	a	w	g	b	p	i	q	z	h	m	a	r	v	a	a	y
n	i	w	v	v	z	i	g	n	k	u	w	t	v	o	r	b	w	w	v
s	p	j	f	q	b	o	y	t	y	l	d	v	o	l	u	m	e	x	u
i	l	p	i	f	g	g	e	n	c	s	k	f	w	a	h	q	f	c	x
t	q	r	p	x	m	z	r	b	t	t	p	v	f	n	e	c	x	i	j
y	k	v	k	u	g	j	z	y	j	k	c	g	a	b	l	e	u	c	a
d	o	y	b	n	n	c	u	a	b	q	z	h	t	f	i	s	a	f	f
x	b	k	b	j	a	a	y	o	a	h	q	h	s	u	u	q	z	o	s
s	r	i	i	g	z	w	s	l	n	b	r	f	o	f	m	x	t	o	m
m	c	o	q	p	z	j	e	n	b	c	l	q	f	c	e	f	g	z	m
s	w	z	m	d	o	k	y	x	g	q	m	m	u	e	q	d	y	v	p
q	k	m	q	u	j	t	q	p	z	g	s	d	h	r	j	l	n	q	u
w	e	i	g	h	t	u	h	h	c	z	i	p	m	h	h	k	z	d	b
i	t	n	a	i	r	k	q	w	c	j	n	h	u	o	k	g	r	a	m

weight

gravity

gram

volume

density

helium

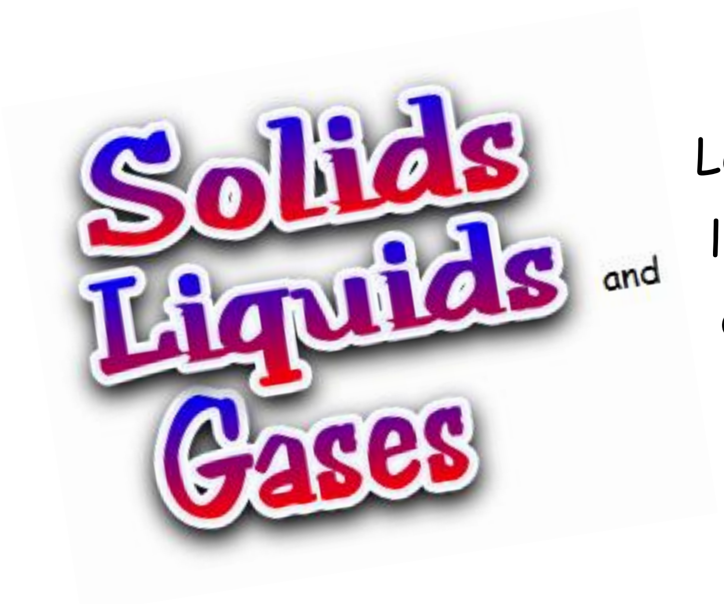
Chapter 10

Okay, we are going to start this week off with a story. Imagine if you had a large bucket filled with tennis balls. If you just held the bucket still, would all those tennis balls be moving around? Nope!

Now what would happen if we started to move the bucket around a little bit? Could the tennis balls start rolling around on top of each other? Sure!

But what would happen if you started to shake that bucket as hard as you could? You guessed it! Those tennis balls would be bouncing around and flying out of that bucket!

This little story is what I want you to remember this week when we start talking about...



Let's start by looking at **solids**. A solid is a group of atoms that have a fixed shape and a fixed volume.

What does it mean to have a "fixed" shape? Well, let's take a look at a piece of paper. There are all kinds of atoms stuck together to make up that piece of paper, right? Right! Your paper is a solid because you can move it around your room and it is going to stay the same shape! It has a "fixed" shape because its atoms are "fixed" into one place and are not moving around.

Now what about all those tennis balls?

Well, let's pretend that each tennis ball is an atom. When the bucket was sitting still, were the tennis balls moving around? No way! In fact, you could say those tennis balls were "fixed" in one place...

...just like a solid!

When you started moving the bucket around a little, those tennis balls started rolling around on each other. They were still touching each other, but they were not staying in one place were they? Well, let's imagine if you put the same amount of tennis balls in a larger bucket and move this new bucket around a little. The tennis balls would spread out more **and** they would still roll around on each other. This is the same thing that happens when we study **liquids**.

A liquid is a group of atoms that have a fixed volume but its shape changes with the shape of its container. Each atom in a liquid takes up a certain amount of space (just like the tennis balls!). This means if you place a certain amount of liquid water into a cup and then pour it into a huge empty bowl...

...there would still be the same volume of water in both of them. So every liquid has a "fixed" volume!

But, this same volume of water you poured into the glass and the bowl spread out in different ways.   The water took the shape of the container it was in. This is why liquids do not have a definite shape!

When we shook the bucket of tennis balls, they started to bounce all over the place. This can happen with atoms too! A group of atoms with no fixed volume or shape is known as a **gas**. The air we breathe is a gas! When you blow air into a balloon, the air takes the shape of the balloon... until you **POP** the balloon! Then the atoms mix with the other atoms in the air (this changes the volume of air) and takes the shape of the room (which means that its shape changes too!)

If you are going to study anything at all about gases, you need to know the volume, **temperature** ("tem-pur-ah-chur") and **pressure** of the gas.

The volume of the gas is the same as the volume of its container. The **temperature** of the gas is the measurement of the motion of atoms. The faster the atoms move, the higher the temperature...

... and atoms of gas move very fast!

Since atoms of gas are moving around a lot, they bounce into the walls of the container that is holding them. The measurement of how hard these atoms are pushing on the walls of its container is known as the **pressure** of the gas.

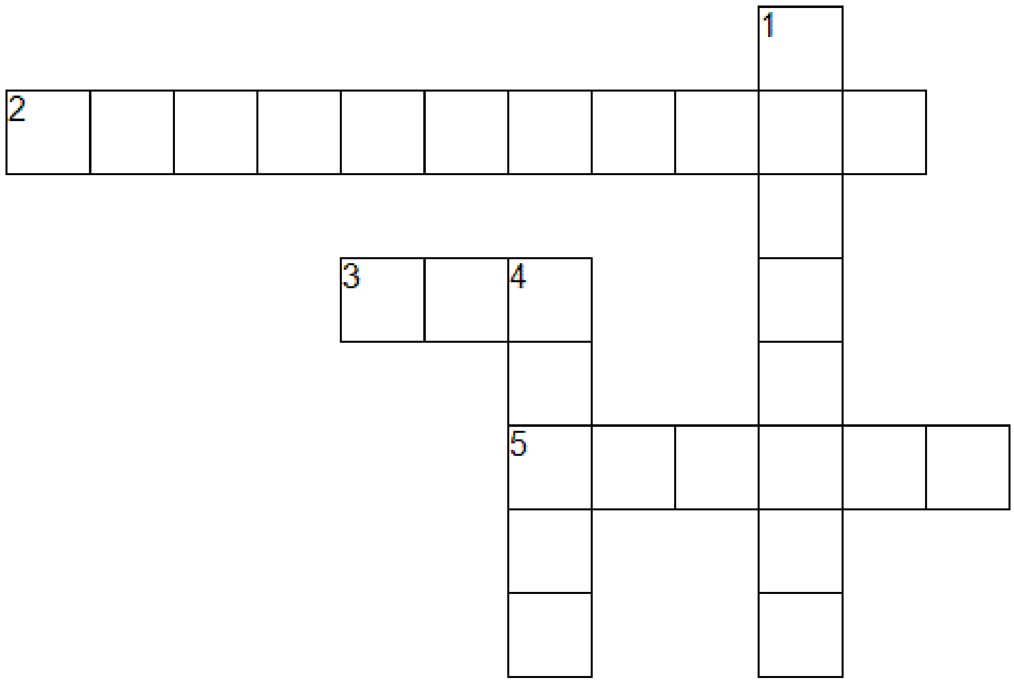
Volume, temperature and pressure of a gas have a pretty cool relationship! You see, whenever you increase the volume of a gas, its pressure goes down! And if you decrease the volume of a gas, its pressure goes up!

This should make sense to you if you think back to our bucket of tennis balls...

We had to put a lot of energy into the bucket to make those tennis balls bounce all over the place. And, as these tennis balls were bouncing into the walls of the bucket, they would be creating pressure inside the container. If you kept shaking the bucket with the SAME energy but put the tennis balls into a LARGER bucket, they wouldn't bounce into the walls as much would they? Nope! (In fact, you would have to shake the bucket a lot harder to get the tennis balls to bounce off the walls!)

This means if the volume of the container of gas is increased, its pressure will decrease!

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

2. the measurement of the motion of atoms
3. a group of atoms that have no fixed volume or shape
5. a group of atoms that have a fixed volume but its shape changes with the shape of its container

DOWN

1. the measurement of how hard atoms of gas push on the walls of its container
4. a group of atoms that have a fixed shape and a fixed volume

Match the definitions with the correct words

1. ________________ a group of atoms that have no fixed volume or shape

2. ________________ the measurement of the motion of atoms

3. ________________ a group of atoms that have a fixed volume but its shape changes with the shape of its container

4. ________________ the measurement of how hard atoms of gas push on the walls of its container

5. ________________ a group of atoms that have a fixed shape and a fixed volume

Liquid
Solid
Pressure
Temperature
Gas

Use the definitions to unscramble the words below.

1. qduili ______________________________
2. serepsur ______________________________
3. lisdo ______________________________
4. sag ______________________________
5. reerateutmp ______________________________

1. a group of atoms that have a fixed volume but its shape changes with the shape of its container
2. the measurement of how hard atoms of gas push on the walls of its container
3. a group of atoms that have a fixed shape and a fixed volume
4. a group of atoms that have no fixed volume or shape
5. the measurement of the motion of atoms

Chapter 11

In the last chapter, you explored how matter can be in the form of a solid, liquid or gas. This week, you will learn how these three **states of matter** can change back and forth into each other! When this happens, scientists call it a **physical change**.

The cool thing about physical changes is that they can be reversed. That's right! A solid can turn into a liquid which can be turned back into a solid again!

Let's go back to our story of the tennis balls in the bucket from last week...

You should remember that when the tennis balls (atoms) did not have much energy moving them around (shaking the bucket) they sat still. This is like the atoms in a solid. But, when you started to add energy (in the form of shaking the bucket), the tennis balls started to move around. This is what happens when atoms go through a physical change between a solid and a liquid!

The really cool thing is...

...you can always lower the amount of energy and reverse what has happened!

The number one rule of physical changes is this:

There is ALWAYS a change in energy during a physical change!

Scientists define **energy** as the ability to do work, or move things around. What's moving around during a physical change are the atoms that make up the solid, liquid or gas.

There are many kinds of energy, but the one that we will be looking at the most is **thermal energy**. Thermal energy is a measurement of the amount of energy given off by atoms in motion. We feel thermal energy as heat!

Let's use our story of the tennis balls in the bucket to explain all of the different kinds of physical changes:

When the tennis balls (atoms) are sitting still and are connected to each other, they have reached their **freezing point**. When a liquid reaches its freezing point, there is not enough energy for its atoms to be moving around. The freezing point of a liquid is the temperature at which liquids turn into solids. Now don't forget...

...all physical changes can be reversed!

The opposite of a freezing point is a **melting point**. The melting point of a solid is the temperature at which a solid turns into a liquid. This is just like what happened when you started shaking the bucket of tennis balls! When you added energy to the bucket (by shaking it), the tennis balls started moving around on each other. They were still touching, but they were in motion!

And what happened when you added so much energy that the tennis balls started bouncing out of the bucket? Well, that is called **vaporization** ("vay-puhr-ih-zay-shun"). Vaporization takes place when a liquid turns into a gas. The atoms of the liquid get so much energy that they break away from each other and start bouncing all over the place!

Once all of the tennis balls bound out of the bucket, is it possible to place them back into the bucket? Sure it is!

Remember...

All physical changes can be reversed!

It is easy to get the tennis balls back into the bucket! You would have to slow them down enough so that you could place them back into the bucket. This is just like atoms of gas! When energy is removed from a gas, the atoms start to slow down and go through a process called **condensation** ("kon-den-say-shun"). Condensation is the process in which a gas turns back into a liquid.

Here's another cool thing for you to know. If you remember from earlier chapters, you learned that every element has different physical properties. Well...

Every element has its own melting point and freezing point too! They also go through vaporization at different temperatures as well!

In the next chapter, you are going to learn how matter can go through a different kind of change! Stay tuned!

Imagine you are a molecule of water changing from a solid to a gas. Describe what you are doing as you go through these changes. Use the following words in your answer:

Melting Point
Vaporization

Use the definitions to fill in the missing letters.

1. _ _ lti _ g _ _ _ _ _
2. s _ _ tes _ _ _ _ _ a _ _ _ r
3. _ _ _ _ r _ z _ t _ on
4. _ h _ sica _ _ c _ _ _ _ _
5. t _ e _ _ a _ _ _ n _ r _ y
6. f _ _ ez _ _ g _ _ _ in _
7. c _ _ d _ _ _ at _ _ n
8. _ _ _ r _ y

1. temperature at which solids turn into liquids
2. a solid, liquid or gas
3. the process by which a liquid turns into a gas
4. the act of changing the state of matter; a reversible change in matter
5. measurement of the amount of energy given off by atoms in motion; felt as heat on our bodies
6. temperature at which liquids turn into solids
7. the process in which a gas turns back into a liquid
8. the ability to do work, or move things around

Circle the hidden words from below:

j	r	r	z	u	w	a	m	s	u	h	q	m	a	e	n	p	q	u	c
r	t	g	o	n	e	c	m	t	w	f	q	a	d	l	b	m	n	x	o
c	h	p	z	q	z	v	z	v	x	x	k	v	e	f	c	y	s	p	n
m	e	l	t	i	n	g	p	o	i	n	t	n	b	y	o	q	s	h	d
e	r	f	s	q	z	k	s	f	x	w	v	u	t	v	n	z	l	y	e
e	m	r	i	h	k	x	y	o	i	h	v	f	o	c	a	z	q	s	n
e	a	g	m	c	c	r	w	b	y	d	p	u	f	h	k	s	v	i	s
k	l	e	l	s	r	x	d	i	c	t	n	v	y	m	p	u	p	c	a
c	e	n	l	p	k	o	u	q	h	c	s	g	r	o	r	m	q	a	t
u	n	e	x	l	g	q	r	r	g	w	h	u	y	t	b	q	i	l	i
i	e	r	l	f	l	n	s	l	b	y	p	p	q	m	j	j	i	c	o
s	r	g	c	f	r	e	e	z	i	n	g	p	o	i	n	t	c	h	n
l	g	y	t	s	t	a	t	e	s	o	f	m	a	t	t	e	r	a	f
f	y	a	k	d	w	w	l	l	a	p	e	a	l	z	f	r	l	n	q
t	u	g	z	q	l	g	g	g	q	a	a	y	v	w	r	n	o	g	m
n	g	t	w	v	a	p	o	r	i	z	a	t	i	o	n	s	s	e	r

states of matter

physical change

energy

thermal energy

freezing point

melting point

condensation

vaporization

Chapter 12

In the last chapter you learned that matter only changes its shape during a physical change! In fact, you can take matter that is solid, turn it into a liquid and then turn it **back** into a solid again! Nothing new is created during a physical change!

In this chapter, you are going to look at a different kind of change which is called a...

Chemical change

In a **chemical change** (also known as a **chemical reaction**), molecules that react together are broken apart and rearranged into different molecules. This new product has brand new properties from the original matter!

I would guess that you know a great example of a chemical change... **burning**! When wood burns, the elements inside the wood bond with oxygen in the air to form brand new kinds of matter (ashes and smoke).

However, it is not just a new kind of matter that is made during a chemical change! Something else is changed too...

CHEMICAL ENERGY!

That's right! Energy is being changed during every physical and chemical change!

You should remember that chemical energy is the energy that holds two or more atoms together. Whenever you break apart two or more atoms during a chemical change, you change that energy into a different kind of energy!

Let's take a look at our example of the burning wood again:

Wood (like everything else in the universe) is made up of atoms that are stuck together in the form of a solid. When you add enough energy to the wood, its atoms start to move around a lot. (Do you remember reading about this in the last chapter? You should!) Well, when these atoms in the wood start to break apart from each other, the chemical energy that is holding them together has to go somewhere!

You can't just make energy disappear!

A MESSAGE FROM MR. INVISIBLE...

The chemical energy that holds these atoms together changes into **thermal energy** ("thur-mull") and **visible energy** ("viz-uh-bull"). I know you've felt thermal energy before because all of us call it "heat!" And I know all of you have used visible energy because we usually call it "light!"

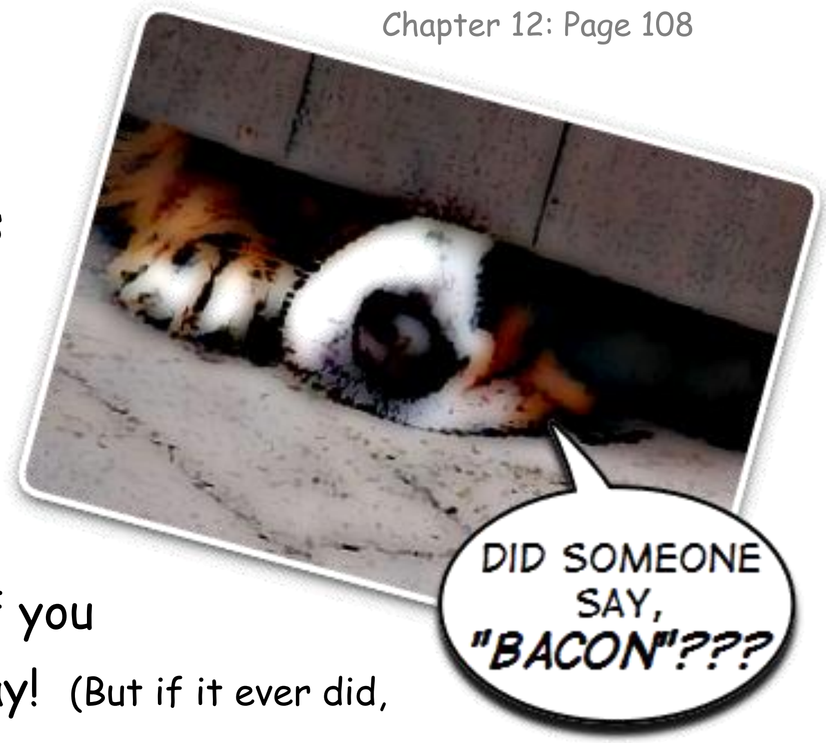
So do you usually get heat and light from burning wood? Of course you do!

There are two different kinds of chemical reactions:

Endothermic reactions ("en-doh-thur-mik")

and

Exothermic reactions ("ex-oh-thur-mik")



During **endothermic reactions**, thermal energy is being absorbed by the new form of matter. For example, imagine cooking bacon on the stove. Would that bacon keep on cooking if you turned the stove off? No way! (But if it ever did, let me know! That would be so cool!) The cooked bacon needs energy to continue cooking because it is not making its own thermal energy!

The opposite happens during **exothermic reactions**. In these kinds of reactions, thermal energy is being released by the new form of matter. You have been studying a very good example of an exothermic reaction in this chapter... burning wood! Once you start burning a piece of wood, do you have to keep adding more fire so that it will burn? Nope! The burning of wood gives off plenty of thermal energy – enough to keep it burning all on its own!

Now that you know that chemical energy holds atoms together, it's time to start looking at what is holding a single atom together! In the next unit you are going to be studying about a much more powerful form of energy! See you soon!

Match the definitions with the correct words

1. ______________________ a chemical change in which elements inside wood combine with oxygen to form ashes and smoke

2. ______________________ heat

3. ______________________ a chemical reaction in which thermal energy is being absorbed by the new form of matter

4. ______________________ light

5. ______________________ a change in matter in which a new kind of matter, with brand new properties, is formed

6. ______________________ a chemical reaction in which thermal energy is being released by the new form of matter

Chemical change	Burning
Thermal energy	Endothermic reaction
Exothermic reaction	Light energy

Use the definitions to fill in the missing letters.

1. _ _ d _ _ h _ r _ ic _ _ _ a _ _ _ on
2. c _ e _ _ ca _ _ _ _ n _ _
3. _ x _ _ _ _ _ _ ic _ _ ac _ io _
4. _ i _ _ t _ _ er _ _ _
5. b _ r _ _ _ g
6. _ h _ rma _ _ _ _ e _ _ y _

1. a chemical reaction in which thermal energy is being absorbed by the new form of matter
2. a change in matter in which a new kind of matter, with brand new properties, is formed
3. a chemical reaction in which thermal energy is being released by the new form of matter
4. light
5. a chemical change in which elements inside wood combine with oxygen to form ashes and smoke
6. heat

List three ways that "burning" is an example of a chemical change.

1. ____

____

2. ____

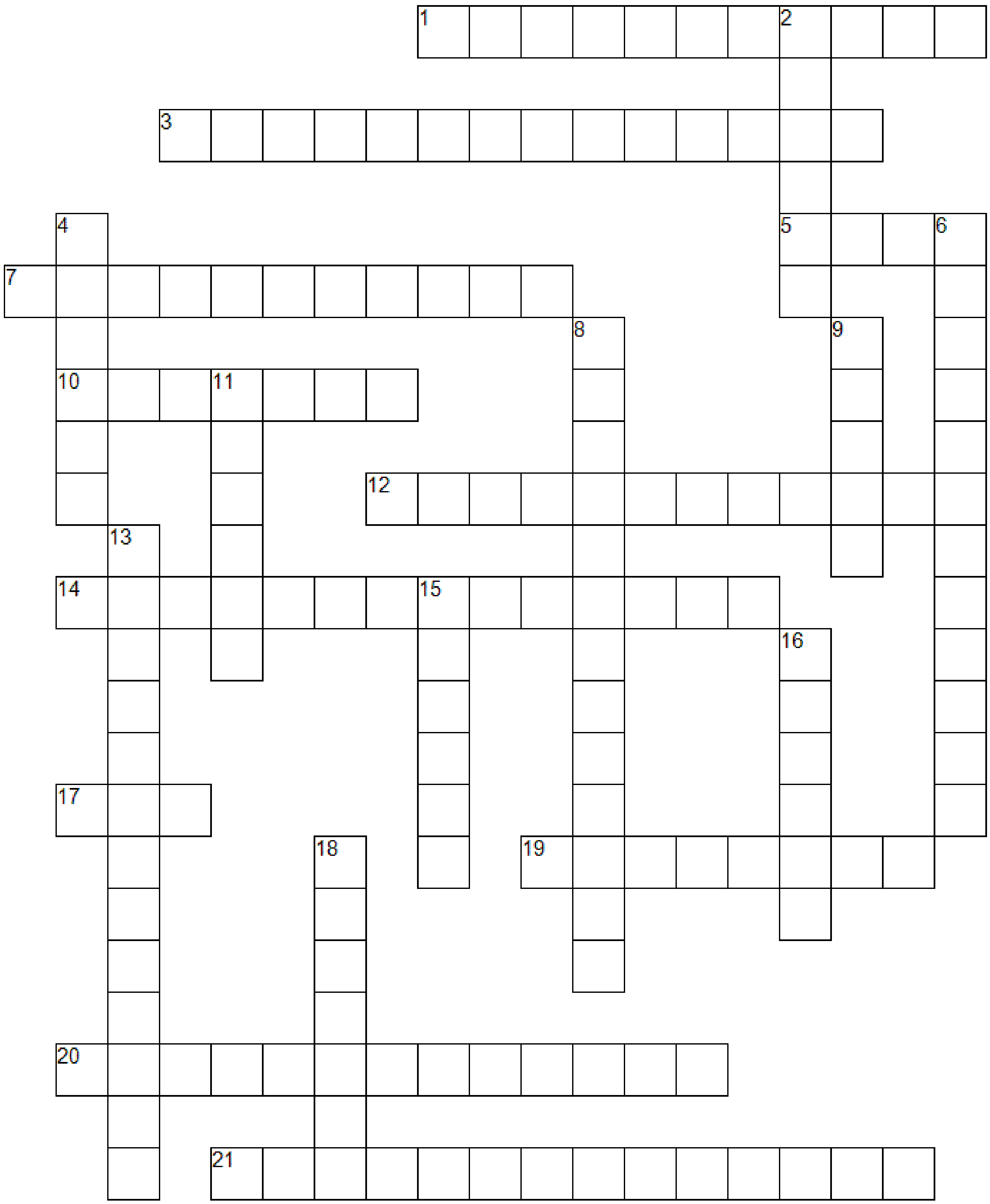
____

3. ____

____

Unit 3 Review

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

1. light
3. a solid, liquid or gas
5. unit of measurement for weight and mass
7. the measurement of the motion of atoms
10. a force that pulls objects towards each other
12. the process by which a liquid turns into a gas
14. a change in matter in which a new kind of matter, with brand new properties, is formed
17. a group of atoms that have no fixed volume or shape
19. the measurement of how hard atoms of gas push on the walls of its container
20. temperature at which liquids turn into solids
21. the act of changing the state of matter; a reversible change in matter

DOWN

2. the ability to do work, or move things around
4. a measurement of the force of gravity on an object
6. temperature at which solids turn into liquids
8. heat
9. a group of atoms that have a fixed shape and a fixed volume
11. the amount of space that an object takes up
13. measurement of the amount of energy given off by atoms in motion; felt as heat on our bodies
15. a group of atoms that have a fixed volume but its shape changes with the shape of its container
16. a gas which is less dense than air
18. the amount of atoms that can be found in an object

Be certain to go over your definitions for the test!!!

Chapter 13

Before we get started in this unit, you need to review two definitions from previous chapters:

Nucleus ("new-klee-us") – A nucleus is a combination of protons and neutrons within every atom.

and

Isotope – Isotopes are atoms with the same number of protons but a different number of neutrons.

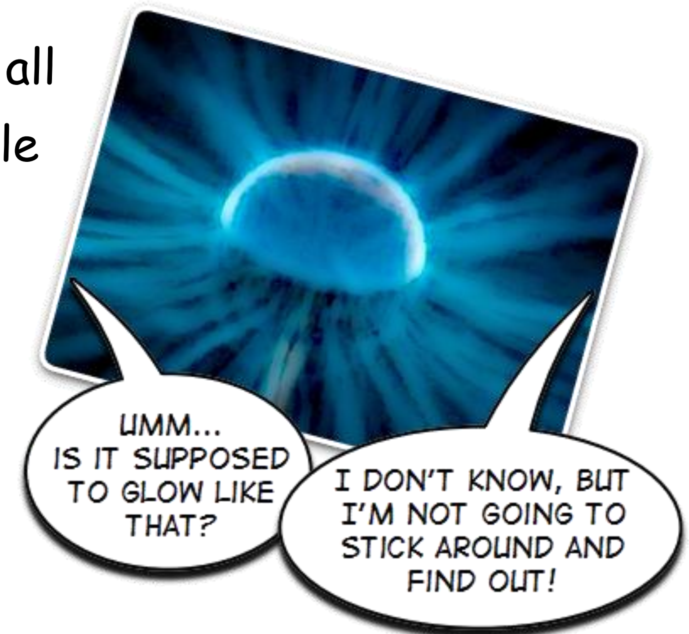
(We are going to be spending a lot of time looking at isotopes in this unit!)

You have already learned that chemical energy is what holds two or more atoms together...

You see, it takes energy to hold the protons, neutrons and electrons together too! This energy is called nuclear energy.

Some of this energy is released naturally by isotopes of elements. The release of energy or **atomic particles** from isotopes of elements is known as **radioactivity** ("ray-dee-oh-ack-tiv-eh-tee").

Radioactivity takes place naturally all of the time! In fact, it is impossible to know when the isotopes of an atom are going to break down and release energy or atomic particles!



But what causes these isotopes to be radioactive?

Some isotopes of elements do not have enough nuclear energy to hold all their protons, neutrons and electrons together. Since they do not have enough nuclear energy, these isotopes break apart very easily. The "pieces" that fall off of isotopes that are radioactive are called **atomic particles.**

There are three different kinds of atomic particles that are given off by radioactive isotopes:

Alpha particles
Beta particles
and
Gamma radiation

Alpha particles are made up of two protons and two neutrons. When a radioactive element breaks apart and gives off an alpha particle, something really cool happens...

The isotope changes into a smaller element!

Remember! Each element on the periodic table is made up of its own number of protons in its nucleus. Hydrogen has one proton; Helium has two protons, and so on...

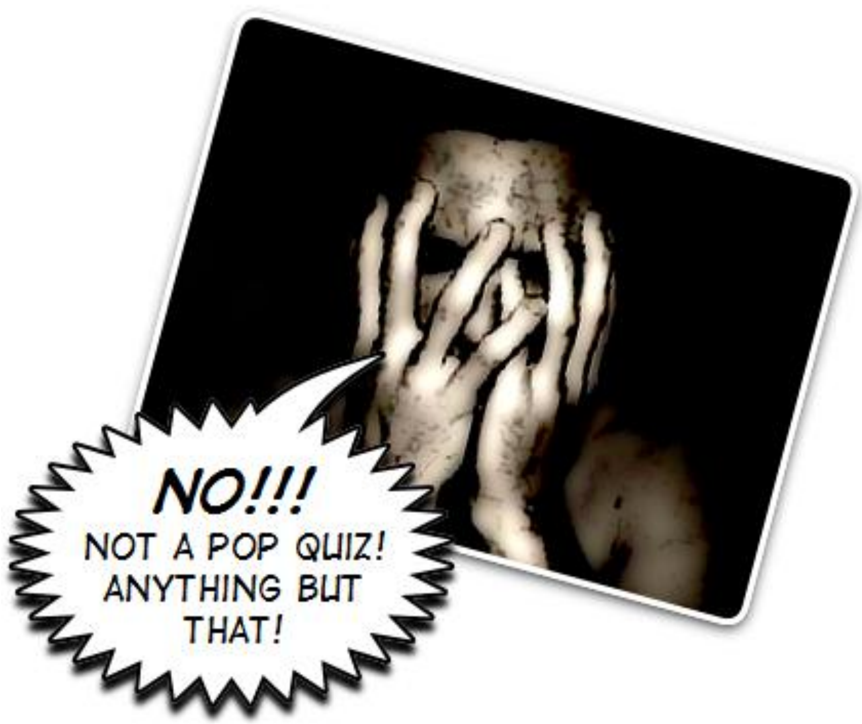
The isotope that gives off an alpha particle becomes a new element with two fewer protons!

Sometimes, a neutron inside a radioactive isotope splits into a proton and an electron. The new proton stays in the nucleus of the atom. The new electron speeds away from the nucleus and is known as a **beta particle**. Once the beta particle speeds off, what is left behind is a new element with one more proton in its nucleus!

The energy that is given off while an isotope is breaking apart is called **gamma radiation.** Gamma radiation is always released whenever an alpha or beta particle is created!

Are you ready?

Time for a POP QUIZ!!!



Let's say a single atom of Carbon-14...

(this is an isotope of the element Carbon with an atomic number of 6)

...gives off radiation and turns into Nitrogen-14

(this is another isotope of a different element – Nitrogen, and has an atomic number of 7).

What atomic particles were created during this change? If you said a beta particle and gamma radiation, you are correct!

Since the atomic number of the new element (Nitrogen-14) is one proton greater than when it started (Carbon-14)...

... a beta particle HAD to be created!

Radioactivity is only one way that the nucleus of an element can be changed. In the next chapter, you will be diving into a study of one of the most powerful events in the universe! See you soon!

List all three types of atomic particles created by radioactivity. Describe each one.

1. ____

____

2. ____

____

3. ____

____

Match the definitions with the correct words

1. ____________________ one of three atomic particles; made up of two protons and two neutrons

2. ____________________ three different "pieces" of matter that fall off of isotopes that are radioactive

3. ____________________ one of three atomic particles; a super fast electron created from a nuclear reaction

4. ____________________ one of three atomic particles; the energy that is given off during a nuclear reaction

5. ____________________ the release of energy and atomic particles during a nuclear reaction

Alpha particle
Gamma radiation
Radioactivity
Atomic particles
Beta particle

Use the definitions to unscramble the words below.

1. tapclehaplari ______________________________
2. miaclestparocti ______________________________
3. amgdiaionatmar ______________________________
4. tyaacridiotiv ______________________________
5. pbetcleaatir ______________________________

1. one of three atomic particles; made up of two protons and two neutrons
2. three different "pieces" of matter that fall off of isotopes that are radioactive
3. one of three atomic particles; the energy that is given off during a nuclear reaction
4. the release of energy and atomic particles during a nuclear reaction
5. one of three atomic particles; a super fast electron created from a nuclear reaction

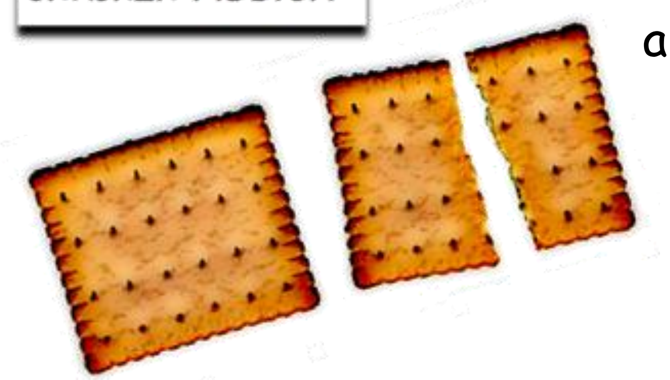
Chapter 14

You learned in the last chapter that some isotopes of elements do not have enough nuclear energy to hold all their protons, neutrons and electrons together. Since they do not have enough nuclear energy, these isotopes break apart very easily.

Radioactive isotopes can break down at any time... there is no way of knowing when this is going to happen! However, there are other ways of changing the nucleus of an atom which scientists call **nuclear reactions.** There are two different kinds of nuclear reactions:

Fission ("fizz-shun") and **Fusion** ("fewz-shun")

There are a few things about **fission** that are the same as the radioactive elements you learned about in the last chapter. During fission, a large isotope is broken down into smaller (different) elements. Also, a huge amount of energy is given off when the nucleus is split apart! In fact, there are millions of times more energy in a small amount of **nuclear fuel** than you would find in an equal amount of gasoline!


CRACKER FISSION

Different isotopes can be nuclear fuels, and all of them can be broken apart through fission. The most common nuclear fuels are **U-235** (an isotope of the element **uranium** "yoo-rain-ee-um") and **Pu-239** (an isotope of the element **plutonium** "plew-tone-ee-um").

Nuclear fission is **different** in a couple of important ways from radioactive elements -

Nuclear fission takes place when a nucleus gets hit by a moving neutron!

and

At least one neutron escapes from the reaction and flies away from the nucleus.

Because of these abilities, the really cool thing about fission is...

...scientists can create and control fission reactions!

Okay!

So if we shoot a neutron into the nucleus of a U-235 atom here's what happens...

#1 The U-235 nucleus absorbs (takes in) the neutron. This makes the nucleus so large that there is not enough nuclear energy to hold the nucleus together, so...

#2 ...the large nucleus splits apart into two smaller elements, and...

#3 ...three neutrons are released as well!

#4 A huge amount of energy is released from the reaction in the form of heat and light!

Each of these three neutrons can run into three other atoms of U-235 if they are nearby! So, one neutron can fire off three neutrons, which can then fire off nine more neutrons, then 27, then...

Each time a neutron splits a U-235 nucleus, a HUGE amount of energy is released! Whenever one neutron sets off a huge amount of fission reactions, scientists call this a **chain reaction**. A chain reaction is what scientists have used to create nuclear bombs. A small amount of U-235 (about 15 pounds or the weight of a bowling ball) has enough atoms to create a very large explosion – enough to blow up an entire city!

That is a lot of energy!

Don't panic!

Not all nuclear fuel is used to create nuclear bombs. Scientists have learned how to slow down the neutrons that are fired off after a fission reaction. Even if the neutrons are slowed down, the amount of energy that is released from the fission reaction is very strong! All of this energy that is released can be used to generate electricity in large factories called nuclear reactors. Nuclear reactors are used all over the world to provide electricity to people. Unfortunately, the new elements that are created through nuclear fission are radioactive! This is dangerous because the alpha and beta particles and gamma radiation that are being produced is harmful to humans! This nuclear waste problem is something that people have been worried about for a long time!

But that is not YOUR worry right now because you still have a lot more to learn about nuclear reactions!

List two ways that fission is similar to radioactivity.

1. ____

____

2. ____

____

Use the definitions to fill in the missing letters.

1. u _ a _ _ u _
2. _ uc _ ea _ _ f _ _ _
3. _ is _ i _ _
4. chain _ _ _ _ _ t _ _ _
5. n _ c _ e _ _ _ r _ _ _ _ _ on
6. _ _ u _ on _ u _

1. one of several radioactive elements; an isotope of this element (U-235) is commonly used as a nuclear fuel
2. different isotopes of elements that can be broken apart through fission
3. process of splitting the nucleus of an element by striking it with a moving neutron
4. a process in which one neutron sets off a huge amount of fission reactions
5. a reaction involving a change in the nucleus of an atom; examples include fission and fusion
6. one of several radioactive elements; an isotope of this element (Pu-239) is commonly used as a nuclear fuel

Circle the hidden words from below:

e	b	j	u	k	s	u	l	u	v	a	g	b	g	n	j	q	w	b	k
i	l	r	r	q	n	l	i	i	y	z	l	w	z	u	h	q	g	d	c
s	x	u	a	p	z	q	b	t	y	x	c	j	z	c	i	n	c	b	l
p	a	y	n	c	g	l	t	p	c	y	j	k	r	l	l	m	h	t	c
g	f	a	i	w	n	u	c	l	e	a	r	f	u	e	l	f	a	p	k
l	r	t	u	o	n	d	o	v	w	v	p	o	i	a	s	h	i	p	d
t	f	f	m	k	d	w	a	v	h	k	p	u	q	r	y	t	n	p	u
t	l	f	i	s	s	i	o	n	a	d	e	a	z	r	k	g	r	k	p
t	y	o	n	t	p	q	k	e	o	s	q	h	y	e	j	j	e	f	z
d	w	v	f	i	v	k	g	f	k	e	q	g	b	a	k	y	a	r	u
l	h	j	u	k	u	x	c	r	q	y	s	w	b	c	s	t	c	g	w
v	z	w	a	m	t	n	n	t	t	o	q	a	l	t	e	c	t	b	n
u	x	v	s	v	f	b	u	n	k	r	u	k	m	i	q	o	i	k	u
b	n	v	t	p	s	e	g	w	a	j	t	j	q	o	f	d	o	p	a
d	n	h	q	c	i	d	n	s	w	j	n	y	u	n	b	g	n	n	b
k	z	d	c	g	b	k	c	y	f	p	l	u	t	o	n	i	u	m	p

nuclear reaction

fission

nuclear fuel

uranium

plutonium

chain reaction

Chapter 15

Radioactivity and fission are two ways that the nucleus of an atom can be changed. Radioactivity tends to happen naturally when a large isotope breaks into two smaller atoms. Fission needs a moving neutron to break apart an isotope into two smaller atoms. Either way...

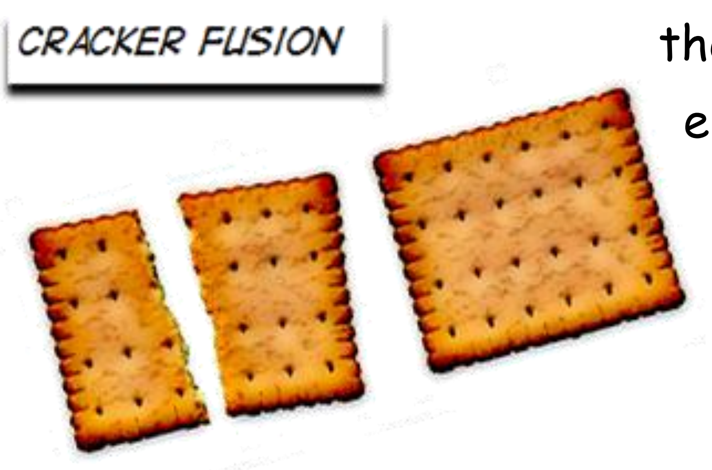
...a lot of energy is released when you break apart the nucleus of an atom!

So far, we have only broken apart the nucleus of an atom. It's time we did something a little different! And so, I give you...

Fusion

("fewz-shun")

Fusion is the process of creating **heavier** atoms by joining two smaller nuclei ("noo-klee-i"; this is the plural form of the word "nucleus"). Not only do you get a larger atom from fusion, there is also a HUGE amount of energy that is given off! In fact, every one of you has felt the energy that comes from fusion.



Do you know where this energy comes from?

That's right! The Sun!

The matter which makes up the sun is not a solid, liquid or gas because it is so hot. The huge amount of energy from the sun rips the electrons away from their nuclei. This creates a mixture of nuclei and electrons moving all over the place which is called **plasma** ("plaz-mah"). Plasma is known as the fourth state of matter.

With all of these electrons and nuclei bouncing around all over the sun, there is a huge amount of pressure on the sun!

(If you remember, pressure is a measurement of how hard atoms push against each other!)

The pressure is so great on the sun that the nuclei in plasma are squished together (That's right… "squished" It's a scientific word!) If the nuclei stick together, nuclear fusion has taken place!

So what nuclei are bonding together during nuclear fusion? Good question!

Almost all of the energy that is given off by the sun uses four different isotopes:

Protium ("pro-tee-um") is an isotope of hydrogen that is made up of only one proton and no neutrons. This isotope is the most common form of hydrogen and the most common element in the entire universe!

Deuterium ("doo-teer-ee-um") is another isotope of hydrogen with one proton and one neutron.

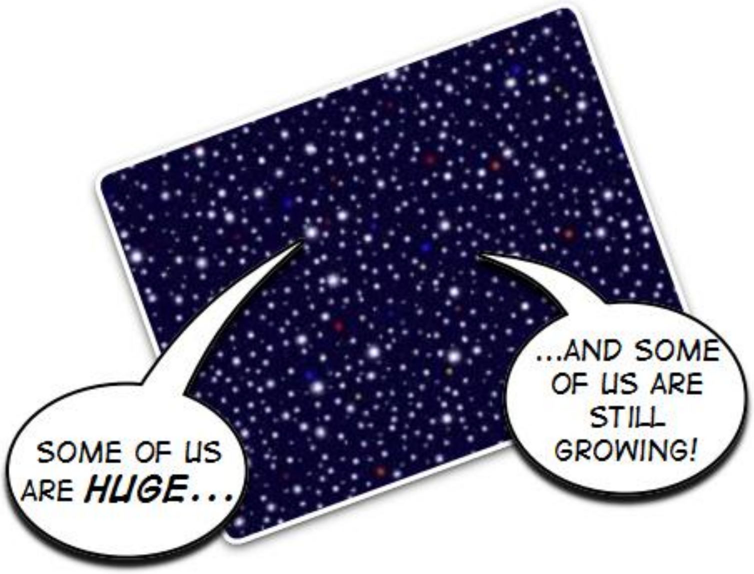
Helium-3 is an isotope of helium with two protons and one neutron.

Helium-4 is another isotope of helium with two protons and two neutrons.

HELIUM CAN GET JEALOUS

Whenever these four isotopes get stuck together, nuclear fusion takes place. The two most important results of nuclear fusion are the release of energy that takes place during this reaction and the creation of larger elements.

What do you mean, "creation of larger elements"?



Well, our sun has enough size and pressure to create larger elements found on the periodic table. To be specific, our sun has enough energy to squish no more than 8 protons and 8 neutrons together. This element is oxygen! But there is something very important you should know...

All stars, including our sun, give off light and heat because of nuclear fusion. However, not all stars are the same size!

Our sun is not the largest star in the universe. Larger stars have the ability to squish more protons and neutrons together! Therefore, larger stars produce heavier elements on the periodic table! The largest stars that scientists have discovered can produce elements as large as iron!

(In case you are interested, iron (Fe) has 26 protons in its nucleus!)

But where do all the other heavier elements come from?

Another great question! In order to have enough energy to press dozens of protons and neutrons together, we need a huge explosion known as a…

…supernova. A supernova is what scientists call a star that has blown up!

(Don't worry! Our sun has got a lot of fuel left! It's not going anywhere for a long time!)

During a supernova there is so much energy released that the largest elements on the period table are formed!

Here's something you can do that is really cool. Go get a penny and put it in your hand. Go on. I'll wait... Now, the metal we use to make that penny is copper. Copper has 29 protons in its nucleus. So that means there are no stars large enough to create this metal. **So?** That means the metal in your hand may have been created by an exploding star!

Isn't that cool ?!?!

In addition to creating the elements, nuclear reactions and radiation can be used to do some other pretty cool things. You are going to learn about a few of them in the next chapter!

Match the definitions with the correct words

1. ____________ the fourth state of matter which is made of a mixture of free electrons and nuclei

2. ____________ the process of creating heavier atoms by joining two smaller nuclei

3. ____________ an isotope of helium with two protons and two neutrons

4. ____________ an isotope of hydrogen that is made up of only one proton and no neutrons

5. ____________ a star that has blown up

6. ____________ the process of creating heavier atoms by joining two smaller nuclei

7. ____________ an isotope of hydrogen with one proton and one neutron

8. ____________ an isotope of helium with two protons and one neutron

Helium-4	Protium
Deuterium	Helium-3
Supernova	Fusion
Plasma	Fusion

Circle the hidden words from below:

r	t	v	w	m	e	f	w	d	e	u	t	e	r	i	u	m	e	b	w
i	r	i	e	g	q	j	l	s	u	t	e	i	x	o	h	g	n	y	z
c	o	n	l	h	k	q	b	t	h	p	r	o	t	i	u	m	k	u	q
o	e	x	j	r	i	q	c	z	b	o	e	h	s	x	a	d	i	f	f
o	a	c	u	j	h	p	v	c	z	j	h	q	v	m	b	h	c	f	f
j	s	z	h	h	d	u	c	m	x	l	m	o	i	r	p	e	b	k	a
b	g	c	d	i	z	x	e	f	o	n	l	b	g	a	m	l	q	u	y
e	n	i	w	f	a	f	h	v	s	s	r	m	t	p	f	i	v	e	v
i	m	i	j	c	k	y	l	k	u	x	i	x	l	l	u	u	v	x	g
h	b	d	c	o	e	j	a	z	p	g	j	s	k	a	s	m	c	u	w
y	f	u	s	i	o	n	p	a	e	b	o	i	k	s	i	3	k	o	o
g	l	t	g	t	p	n	m	q	r	o	i	e	e	m	o	c	m	y	t
b	h	e	l	i	u	m	4	w	n	e	e	r	k	a	n	m	s	b	k
g	c	x	g	u	t	q	i	c	o	n	n	h	n	l	i	m	j	u	y
s	q	m	p	a	j	o	v	c	v	w	b	j	p	m	e	n	x	j	k
n	b	r	h	o	z	z	f	k	a	y	y	j	e	d	b	f	i	v	x

fusion

fusion

plasma

protium

deuterium

helium-3

helium-4

supernova

Compare and Contrast the following vocabulary words:

Fission

Fusion

How are they the same? (Compare)

1. ______________________________

____

2. ______________________________

____

How are they different? (Contrast)

1. ______________________________

____

2. ______________________________

____

Chapter 16

Don't get me wrong, radioactive elements can be very dangerous to living organisms. In high amounts, the energy and atomic particles (alpha and beta particles) can break apart the cells in our bodies and cause us a lot of harm. The most import part of that last sentence is the statement, "IN HIGH AMOUNTS"!

Anything in high amounts can harm us!

Too much oxygen, too much water, too much chocolate cake...

In SMALL amounts, radiation helps us out every single day of our lives. In fact, I would guess that radioactive materials have made your life safer or easier already today! Let me explain...

Do you have a smoke detector in your home? I would guess that you do! You can thank the radioactive isotope **Americium-241** ("ah-mare-eh-see-um")! As this isotope breaks down it gives off a tiny amount of alpha particles which is measured by the smoke detector. When smoke enters the device it gets in the way of the alpha particles and slows them down. This change is measured by the smoke detector and sets off an alarm!

Have you or anyone you know gone through surgery before? If so, you can thank the isotope **Cobalt-60** ("ko-balt"). The particles of Cobalt-60 do a very good job of destroying bacteria and viruses that may be found on the tools doctors use in surgery.

Believe me! You don't want extra bacteria or viruses in your body!

Cobalt-60 is also used to destroy bacteria in a lot of the chicken, fruits and spices we eat.

People use radioactivity on the foods we eat!

Don't panic! Many people are afraid of this because they don't understand how it works. The atomic particles that are released from Cobalt-60 flood the food and destroy the bacteria, viruses and insects that may be inside. There are many people who are afraid this causes problems in humans. However, it is a fact that scientists have never known of a single time where this process has caused serious harm to humans.

Look around your house for those little lights on machines in your home like the washer or dryer. You can thank **Krypton-85** ("krip-tawn") for those lights!

How about those long skinny light bulbs you may have around your home? It is the isotope **Thorium-229** ("thor-ee-um") that helps them last longer!

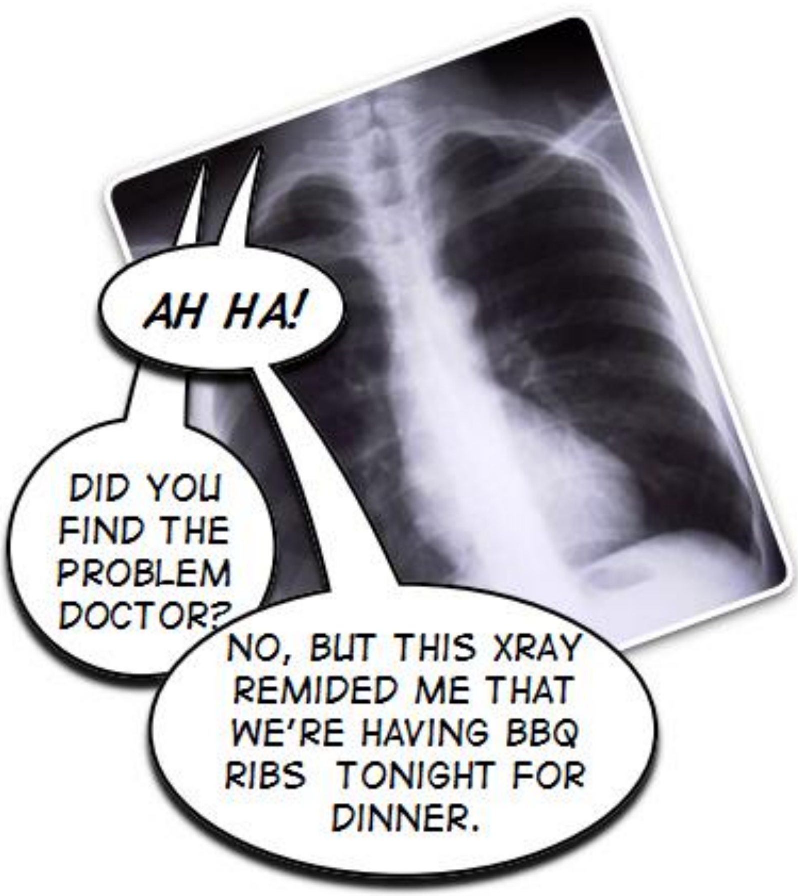
Do you have any colored glass in your home? That's right! You can thank **Uranium-235**. You learned about this isotope earlier in this unit! Not only does it make some pretty glass, it's also used as fuel for nuclear reactors! Oh yeah! That's cool!

What about cancer? Are radioactive isotopes used to treat cancer?

Yes! In fact, there are many isotopes used to treat different cancers. There are so many of them, we could spend the rest of this entire book discussing each one!

How else do doctor's use radioactivity?

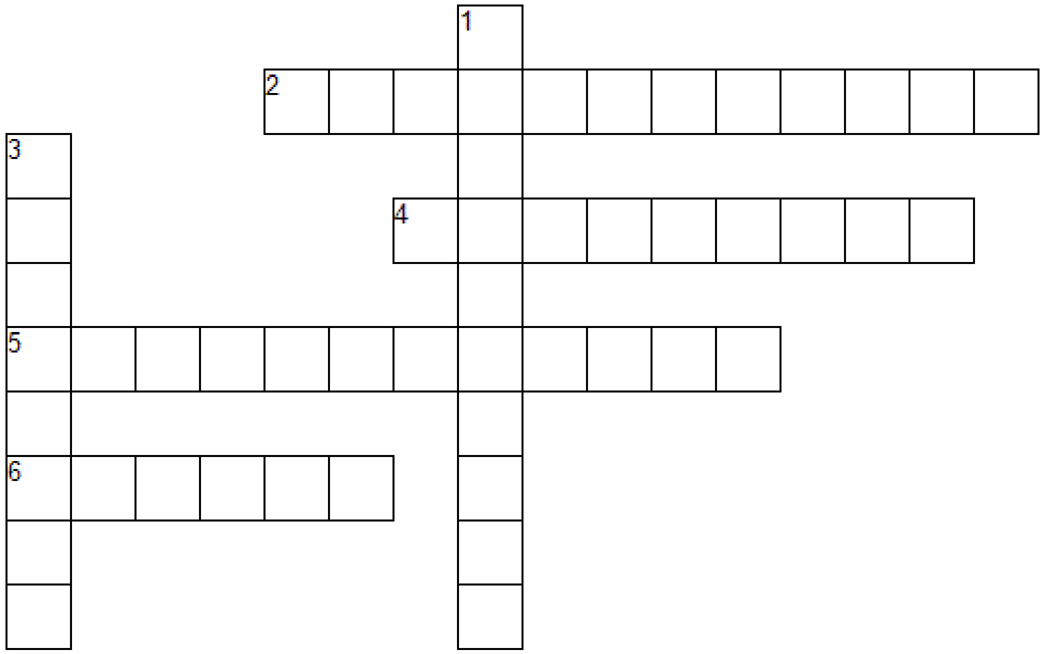
The most common use of radioactive isotopes by doctors is for **tracers**. Small amounts of isotopes can be added to a liquid and placed inside our bodies. Doctors can then take X-Rays of the patient and watch how the liquid passes through the body. If the liquid does not travel in the correct path, the doctor will know where the problem is located! Most of the time doctors use **Technetium-99** ("teck-net-ee-um") as the isotope used as a tracer.



These are just a few of the ways that radiation is used in our everyday lives! You could spend hours reading about how we use the power of the atom to improve our way of life…and I hope you will!

Nuclear science is a really cool field to study!

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

2. radioactive isotope most commonly used as a tracer
4. radioactive isotope used in small lights found on appliances
5. radioactive isotope used in smoke detectors
6. most common use of radioactive isotopes by doctors; once inside the body, tracers can be detected with x-rays

DOWN

1. radioactive isotope used in the long, skinny light bulbs
3. radioactive isotope used to clean the tools doctors use in surgery

Use the definitions to fill in the missing letters.

1. _ oba _ _ - _ _ _
2. _ _ _ c _ r
3. t _ or _ _ m _ _ 2 _ _
4. _ e _ hn _ _ _ um _ _ _
5. kr _ p _ _ _ _ _ 5 _
6. am _ ric _ _ m _ _ _ _ _

1. radioactive isotope used to clean the tools doctors use in surgery
2. most common use of radioactive isotopes by doctors; once inside the body, tracers can be detected with x-rays
3. radioactive isotope used in the long, skinny light bulbs
4. radioactive isotope most commonly used as a tracer
5. radioactive isotope used in small lights found on appliances
6. radioactive isotope used in smoke detectors

Use the definitions to unscramble the words below.

1. aterrc ______________________________
2. icae1mrmiu42 ______________________________
3. h9tec9nemtiu ______________________________
4. 9iorumth22 ______________________________
5. p5ortkyn8 ______________________________
6. oltc6ba0 ______________________________

1. most common use of radioactive isotopes by doctors; once inside the body, tracers can be detected with x-rays
2. radioactive isotope used in smoke detectors
3. radioactive isotope most commonly used as a tracer
4. radioactive isotope used in the long, skinny light bulbs
5. radioactive isotope used in small lights found on appliances
6. radioactive isotope used to clean the tools doctors use in surgery

Why do small amounts of radioactive particles not harm us, but large amounts can?

Unit 4 Review

Use the definitions to unscramble the words below.

1. cnrictnioaaeh ______________
2. naunicerlocreat ______________
3. uavrspneo ______________
4. aium4m1ric2e ______________
5. iprtmou ______________
6. urmaiun ______________
7. snsoifi ______________
8. creatr ______________
9. tmreeuudi ______________
10. lt6bco0a ______________
11. hmei4ul ______________
12. 2mor2i9uht ______________
13. reebtcapltai ______________
14. ntimlopuu ______________
15. ipaocremtialtsc ______________
16. rcappiahteall ______________
17. sfonui ______________
18. not8kry5p ______________
19. 9eumth9ntcie ______________
20. odatraangmmaii ______________
21. ralcnufueel ______________
22. iitidyraatovc ______________
23. sampal ______________
24. ehmu3il ______________
25. uosfin ______________

1. a process in which one neutron sets off a huge amount of fission reactions
2. a reaction involving a change in the nucleus of an atom; examples include fission and fusion
3. a star that has blown up
4. radioactive isotope used in smoke detectors
5. an isotope of hydrogen that is made up of only one proton and no neutrons
6. one of several radioactive elements; an isotope of this element (U-235) is commonly used as a nuclear fuel
7. process of splitting the nucleus of an element by striking it with a moving neutron
8. most common use of radioactive isotopes by doctors; once inside the body, tracers can be detected with x-rays
9. an isotope of hydrogen with one proton and one neutron
10. radioactive isotope used to clean the tools doctors use in surgery
11. an isotope of helium with two protons and two neutrons

12. radioactive isotope used in the long, skinny light bulbs
13. one of three atomic particles; a super fast electron created from a nuclear reaction
14. one of several radioactive elements; an isotope of this element (Pu-239) is commonly used as a nuclear fuel
15. three different "pieces" of matter that fall off of isotopes that are radioactive
16. one of three atomic particles; made up of two protons and two neutrons
17. the process of creating heavier atoms by joining two smaller nuclei
18. radioactive isotope used in small lights found on appliances
19. radioactive isotope most commonly used as a tracer
20. one of three atomic particles; the energy that is given off during a nuclear reaction
21. different isotopes of elements that can be broken apart through fission
22. the release of energy and atomic particles during a nuclear reaction
23. the fourth state of matter which is made of a mixture of free electrons and nuclei
24. an isotope of helium with two protons and one neutron
25. the process of creating heavier atoms by joining two smaller nuclei

Be certain to go over your definitions for the test!!!

Chapter 17

You have been working very hard on understanding the nucleus of an atom. Now it's time to start looking at what is spinning around the nucleus. That's right! We are going to be studying...

Electrons!

It's time for a quick review! Electrons are always moving around the nucleus of an atom. This means they have a lot of energy as they are moving around! The smaller atoms, like Hydrogen, only have one electron spinning around its nucleus. However, the larger the atom, the more electrons it will have!

You learned in an earlier unit that electrons have a negative charge (-) and protons have a positive charge (+). Most of the time...

Atoms tend to have no charge at all!

Therefore, there has to be a way for an atom to balance out the positive and negative charges. So how does it happen? If you guessed that there are an equal number of protons and electrons in an atom you are correct! For example, an atom of Nitrogen has 7 protons in its nucleus and 7 electrons spinning around its nucleus! An atom with an equal number of protons and electrons is called a **neutral atom.**

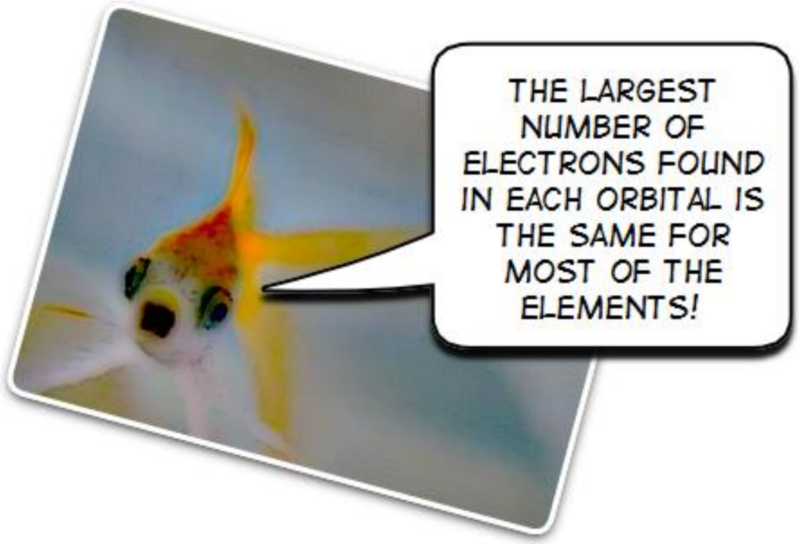
Every element has a different number of electrons that spin around its nucleus. But, even though different elements have different amounts of electrons spinning around them, there is one really cool thing that makes them all the same...

Orbitals

("or-bit-uls")

An **orbital** is a **layer** of electrons that spins around the nucleus. Think of orbitals like the layers of an onion. If you cut that onion in half, the nucleus would be in the center of the onion and layers of electrons could be found surrounding it in every direction!

All atoms have one or more orbitals of electrons that are in motion. But what is so cool about orbitals? Well...



Let's go back to our story about the onion. The first layer that surrounds the center of your onion is just like the first orbital of an atom. If you look inside this first orbital, you would not find any more than two electrons! If you look inside the second orbital, you would not find any more than 8 electrons. The third orbital can contain no more than 8 electrons too. And so on.

The amount of electrons in each of the orbitals stay the same for the elements in the periodic table:	The first orbital can hold two electrons. The second orbital can hold eight electrons. and The third orbital can hold another eight electrons.

The layers of our onion (orbitals) move away from its center (nucleus). This means if you are an electron in the first orbital, you are closer to the nucleus than if you were in the second orbital. Scientists call the number of electrons in the last orbital of each element the **valence electrons** ("vay-luns"). The valence electrons determine how elements bond together!

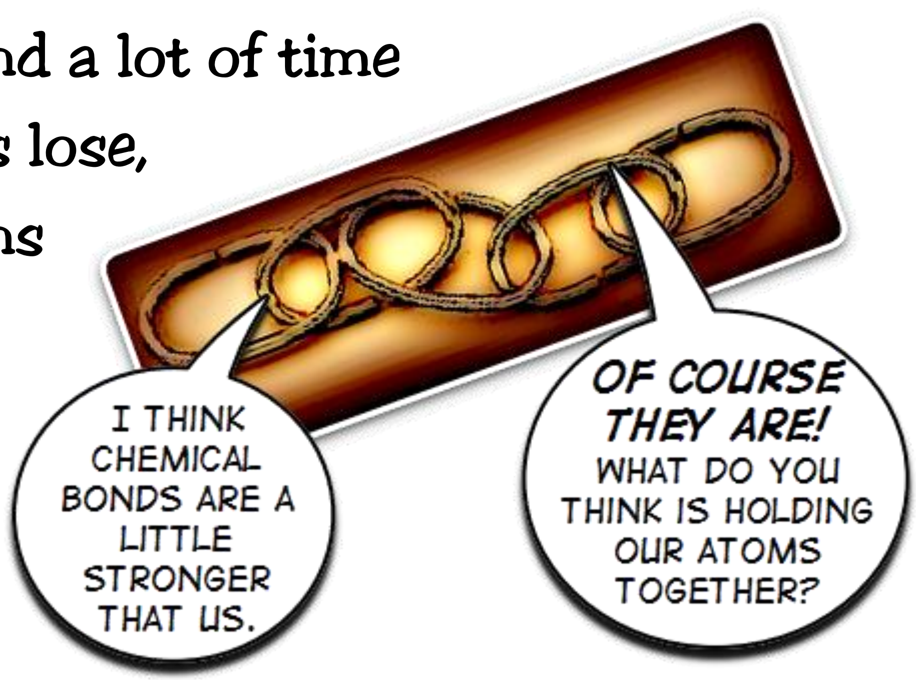
Valence electrons are so important that scientists have placed them in special areas on the periodic table. If you remember, each column on the periodic table is known as a family. Each family has its own number of valence electrons:

Family 1 (Alkali Metals)	One valence electron
Family 2 (Alkaline Metals)	Two valence electrons
Families 3-12 (Transition Metals)	(These elements don't follow the rules very well...)
Family 13 (Metals and Metalloids)	Three valence electrons
Family 14 (Metals, Metalloids and Nonmetals)	Four valence electrons
Family 15 (Metals, Metalloids and Nonmetals)	Five valence electrons
Family 16 (Metalloids and Nonmetals)	Six valence electrons
Family 17 (Halogens)	Seven valence electrons
Family 18 (Noble Gases)	Eight valence electrons (* except for Helium!)

From this table you can see that an element can have one to eight valence electrons. In nature, most atoms are stable when they cannot fit any more electrons in their last orbital. This means they do not lose, share or gain any electrons from other elements. Take a look at the noble gases. They have eight valence electrons. That means they have filled their first orbital with two electrons and their second orbital with eight more electrons! This means they are not very reactive at all!

Some atoms, like carbon and oxygen and hydrogen do not have their last orbital filled with electrons. This means they can react, or join together chemically with other atoms. When this happens, scientists call the force that holds the two atoms together a **chemical bond.** (You read about this force in an earlier chapter. It was called "chemical energy". They are both the same thing!)

You are going to spend a lot of time looking at how atoms lose, share or gain electrons in the next chapters. Stay tuned!



Match the definitions with the correct words

1. ______________________ an atom with an equal number of protons and electrons

2. ______________________ layer of electrons that spins around the nucleus

3. ______________________ the number of electrons in the last orbital of each element

4. ______________________ the force that holds two atoms together; also known as "chemical energy"

Orbital Chemical bond

Neutral atom Valence electrons

Circle the hidden words from below:

f	i	p	e	v	y	b	s	k	z	h	l	z	c	t	v	v	b	n	r
a	g	w	h	a	u	n	k	q	u	n	r	n	p	b	l	k	n	v	x
x	n	k	q	l	j	o	m	b	n	m	d	d	c	q	a	s	a	c	e
t	c	p	q	e	f	d	l	h	e	r	n	v	n	c	f	j	n	s	w
f	h	t	x	n	x	o	u	s	u	u	d	m	n	x	f	d	e	k	r
f	e	c	l	c	i	c	z	p	t	v	e	o	r	b	i	t	a	l	l
o	m	f	e	e	z	g	i	u	r	n	s	a	m	n	y	x	k	c	g
f	i	b	u	e	l	x	n	b	a	x	c	o	o	c	r	l	b	h	h
n	c	l	k	l	g	r	y	k	l	g	d	p	n	r	p	e	e	u	n
c	a	t	p	e	t	o	x	m	a	i	k	z	r	n	n	t	h	f	b
h	l	h	n	c	r	h	z	l	t	z	k	t	d	k	b	r	d	b	f
a	b	a	f	t	v	h	b	p	o	d	d	o	j	j	b	y	x	v	r
m	o	h	w	r	b	b	s	o	m	j	f	f	h	t	p	t	t	l	m
l	n	c	i	o	l	d	l	g	s	b	p	i	i	z	w	t	s	i	l
g	d	p	v	n	v	w	z	f	i	s	p	f	h	e	h	w	d	i	c
b	w	k	e	s	f	u	y	b	i	j	s	k	h	n	h	u	i	c	l

orbital

neutral atom

valence electrons

chemical bond

Draw the nucleus of an atom and at least three orbitals that surrounds the nucleus. Be certain to label each orbital with the total number of electrons it can hold.

Chapter 18

You learned from the last chapter that 1) a neutral atom has an equal number of protons and electrons; 2) atoms can lose, share or gain electrons; and, 3) **a lot about electrons.**

Let's add a few things to these three topics…

FIRST…

…when a neutral atom loses, shares or gains and electron it no longer has a neutral charge! If it gains an electron it now has a negative charge! This is because it has more electrons (-) than protons (+). Scientists call this atom a **negative ion** ("i-ahn").

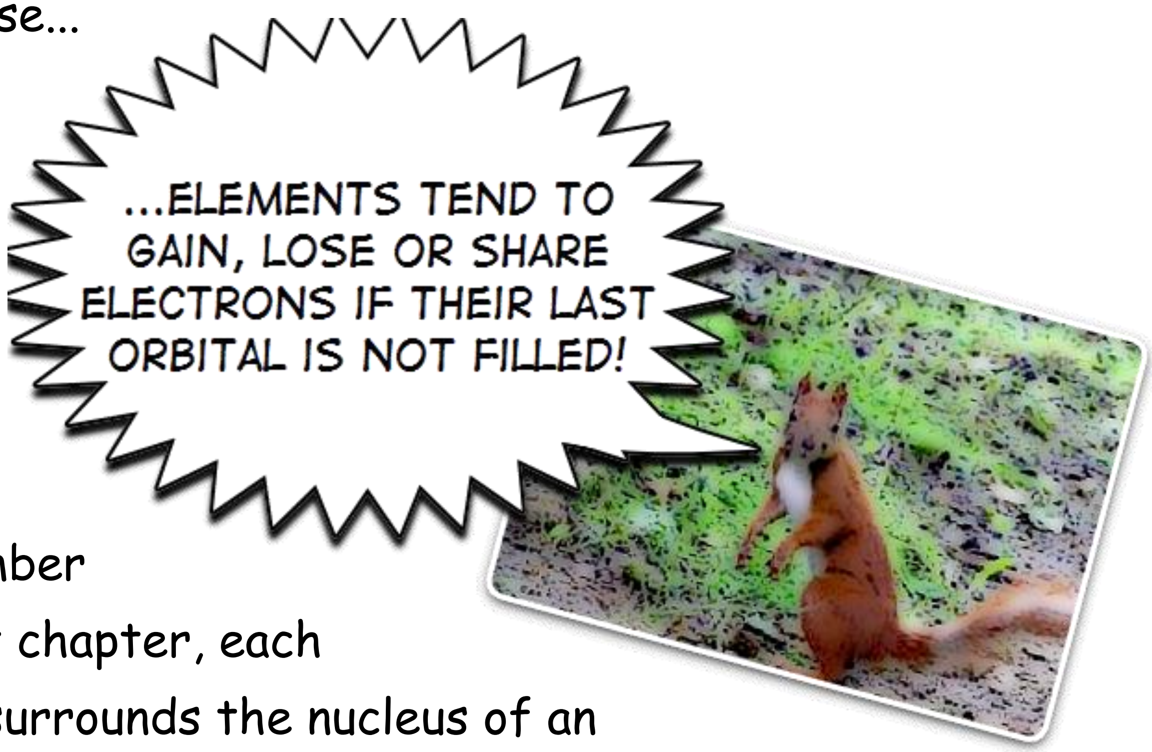
The opposite happens when an atom loses an electron. Since it has less negative charge (from the missing electron) it has a positive charge. Therefore, scientists call this atom a **positive ion.**

SECOND…

…negative ions tend to be attracted to positive ions. When this happens, the two ions join together to form an **ionic bond** ("i-ahn-ick").

But what causes the atoms to gain or lose electrons?

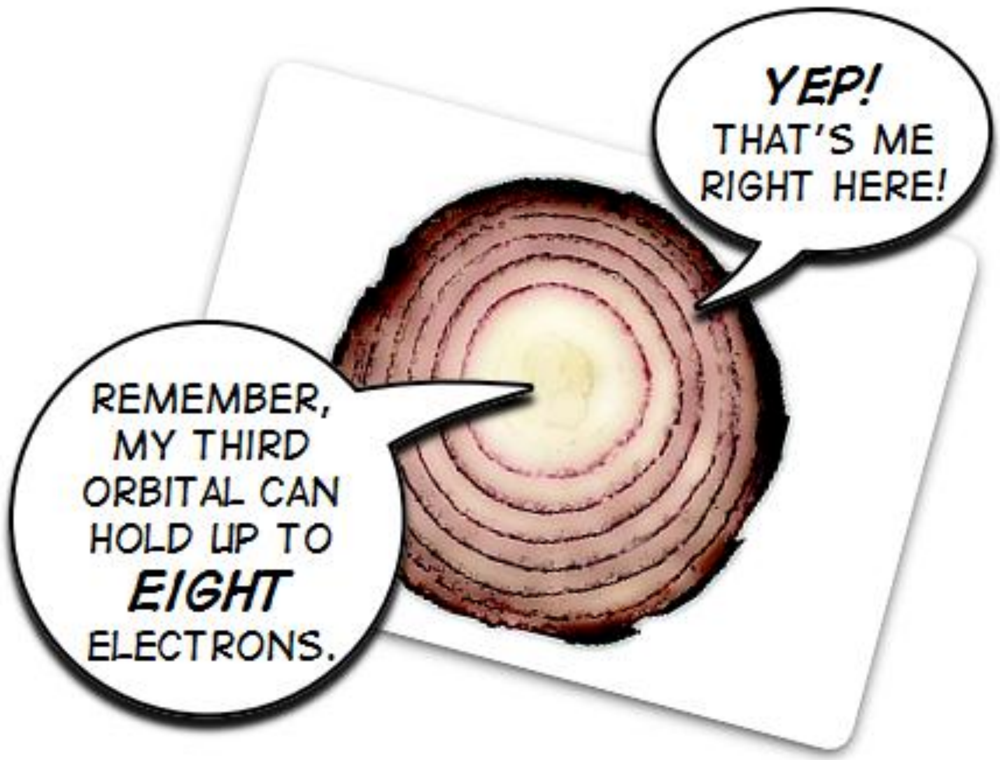
Well, in order to answer that question, we have to go back to something we learned about in the last chapter. The reason why atoms tend to gain or lose electrons has to do with the number of valence electrons in the last orbital of the element! This is because...



If you remember from the last chapter, each orbital that surrounds the nucleus of an atom can only hold so many electrons:

The first orbital can hold two electrons.
The second orbital can hold eight electrons.
and
The third orbital can hold another eight electrons.

So if the last orbital of an element is not filled up with electrons, the atom is likely to borrow, share or give away its valence electrons.



How about an example? Let's look at the first two families on the periodic chart first...

Sodium (Na) is in the first family. It has 11 total electrons so it can fill up its first orbital with two electrons. It can fill up its second orbital as well with eight more electrons. This leaves only one valence electron in its last orbital! What do you think would be easier for this atom?

Should the atom try to find seven more electrons to borrow or should it try to give away only one electron?

If you said "give away one electron" you are correct! It would be much easier to simply give one thing away than to try to get seven things, right? When it gives away an electron, it will become a positive ion! This is what happens with all of the atoms in the first family because...

...they all have one valence electron!

The same thing happens with elements in the second family as well! Magnesium ("mag-neez-ee-um") is in the second family and it has twelve electrons. So, it can fill up its first and second orbitals with ten electrons and have two more valence electrons in the third orbital. And just like with the first family, it would be much easier to give away two electrons than it would be to get six electrons! This is why the elements in the first two families become positive ions very easily!

Now let's look at the other side of the periodic table!

Chlorine ("klor-een") has a total of 17 electrons. So, its first two orbitals are filled with ten electrons and its third orbital has seven valence electrons.

Remember! The third orbital can hold up to eight electrons! This means chlorine needs one more electron in its third orbital. What do you think would be easier? Should it try to find one more electron or should it simply give away all seven of these electrons?

That's right! It would be much easier to find one electron!

But where could it find a single electron? Hmm... How about from sodium?

Great idea!

By giving away an electron, sodium becomes a positive ion. And, by taking one electron, chlorine becomes a negative ion.

And what do we know about positive and negative ions?

They form an ionic bond and stick together!

In this case, when you bond sodium with chlorine, you get table salt! Yep! The stuff you put on your fries! This ionic bond forms a new **ionic compound!**

(Remember – a compound is a group of two or more different atoms!)

Ionic compounds have a few rules:

- Ionic compounds form between metals (like sodium) and nonmetals (like chlorine).
- Ionic compounds are always called with their metal named first! (In this case, you have created sodium chlorine).
- Ionic compounds form a crystal at room temperature. (i.e. salt crystals)
- Ionic compounds can be dissolved very well in water. (i.e. saltwater)

Ionic bonds explain how atoms can gain or lose electrons. What about their ability to **share** electrons? Well, that is a different kind of bond that you are going to learn about in the next chapter! Here we go!

List all four rules about ionic compounds.

1. ______________________________________

____

2. ______________________________________

____

3. ______________________________________

____

4. ______________________________________

____

Use the definitions to fill in the missing letters.

---

1. _ _ _ a _ _ _ _ ion _
2. i _ _ i _ _ _ _ _ _ und
3. p _ s _ t _ v _ _ _ _ n _
4. _ o _ _ _ _ _ on _

1. an atom with more electrons (-) than protons (+)
2. a compound formed by an ionic bond between positive and negative ions
3. an atom with fewer electrons (-) than protons (+)
4. the bonding of a positive and negative ion by the gaining and releasing of electrons

Use the definitions to unscramble the words below.

1. cbiodnion ______________________________
2. eistionpoiv ______________________________
3. eiogtinnaev ______________________________
4. nicoicnmooupd ______________________________

1. the bonding of a positive and negative ion by the gaining and releasing of electrons
2. an atom with fewer electrons (-) than protons (+)
3. an atom with more electrons (-) than protons (+)
4. a compound formed by an ionic bond between positive and negative ions

Chapter 19

Let's look at a very important sentence from the last chapter:

If the last orbital of an element is not filled up with electrons, the atom is likely to borrow, share or give away its valence electrons.

So far, you have explored how an element can gain or lose electrons while making an ionic bond.

But how do atoms SHARE electrons?

That is what we are going to study this week! Our first stop is with the oxygen atom.

Oxygen has a total of eight electrons. This means it can fill its first orbital (with two electrons) and has six more electrons in its second orbital.

With only six electrons in its outer orbital, oxygen has room for two more electrons! Where is it going to get these electrons?

It has three options:

#1 It can get rid of all six electrons in its outer orbital - but that would take way too much effort;

#2 It could gain two electrons and form an ionic bond; or,

#3 It could share two electrons from one or more atoms.

Whenever an atom shares electrons with another atom, the two nuclei get stuck together by forming a **covalent bond** ("koe-vale-ent"). When two atoms form a covalent bond neither atom loses or gains an electron. This is because the positive charge of each nuclei keeps the shared electron spinning around both of them!

The number of covalent bonds an atom can have depends on its number of valence electrons.

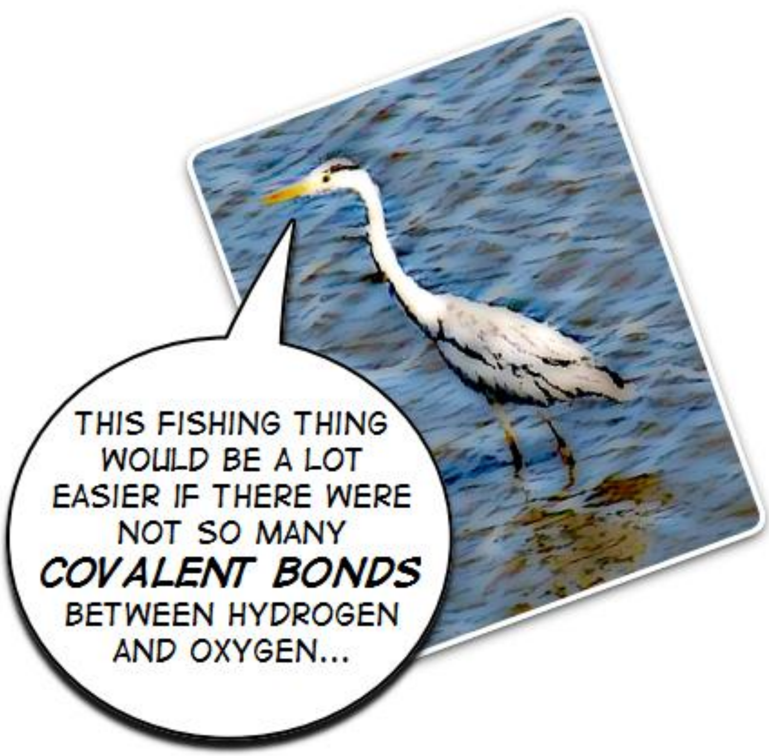
Let's look again at oxygen:

Oxygen has six valence electrons. Its outer orbital can hold up to eight electrons - so there is room for two more electrons!

(Remember – valence electrons are the number of electrons in the outer orbital)

Since there is room for two more electrons, oxygen can have up to two covalent bonds. This is what happens with oxygen bonds with hydrogen.

Hydrogen has only one electron in its first orbital. So this means it can share its electron with other elements. Since oxygen needs two electrons, it can form covalent bonds with two hydrogen atoms. When this happens, we get H_2O, which we normally call...



WATER!

Of course, oxygen cannot form a covalent bond with hydrogen if there are no hydrogen atoms around! What if there are no atoms other than oxygen in an area? Well...

Oxygen will bond to itself!

That's right! The number of covalent bonds an atom can have depends on its number of valence electrons. Since oxygen needs two more electrons, it can share **both** of them with another oxygen atom. This is called a **double bond!**

The double bond that is formed between two oxygen atoms give us O_2, which we call oxygen gas! You owe your life to this gas as O_2 is what our bodies need to survive!

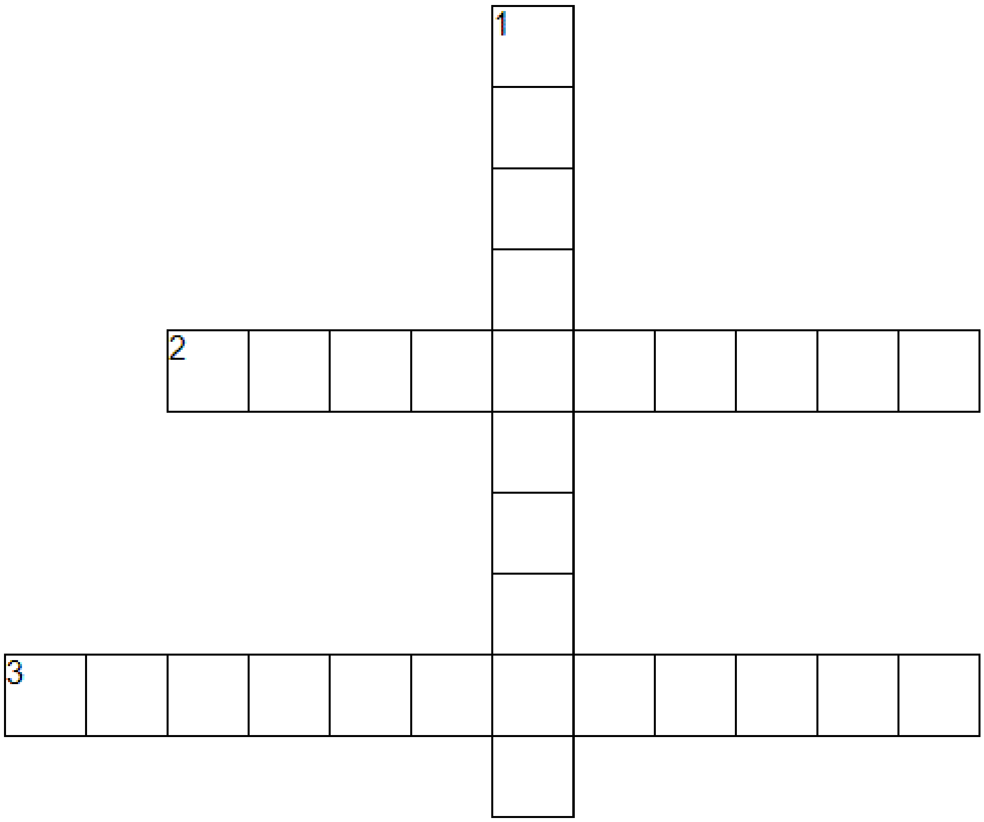
It is possible to have a **triple bond** too! This happens with two atoms share three electrons!

One of the most important things for you to know is this...

...most compounds (groups of two or more different atoms) are made up of both ionic and covalent bonds!

For example, the compound called sodium hydroxide ("sow-dee-um hi-drox-eyed") is made up of a sodium atom that has an **ionic bond** with an oxygen atom. The oxygen atom also has a **covalent bond** with hydrogen.

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

2. covalent bond in which two electrons are shared between atoms
3. a bond shared between atoms that shares electrons with each other

DOWN

1. covalent bond in which three electrons are shared between atoms

Match the definitions with the correct words

1. ________________ covalent bond in which two electrons are shared between atoms

2. ________________ a bond shared between atoms that shares electrons with each other

3. ________________ covalent bond in which three electrons are shared between atoms

Triple bond

Covalent bond

Double bond

If an atom has five electrons in its second orbital, is it likely to get rid of, share or gain electrons in order to make a bond?

Chapter 20

We have spent a lot of time talking about how atoms bond together to form molecules (two or more similar atoms) and compounds (two or more different atoms). The two bonds we have studied so far are ionic (electrons are gained or lost) and covalent (electrons are shared).

Now it is time to learn about a different kind of bond...

The Hydrogen bond!

Hydrogen bonds take place between (you guessed it) hydrogen atoms and a handful of atoms that love to gain electrons from other atoms. These "handful of atoms" tend to be the following elements:

Nitrogen, Oxygen, Fluorine and Carbon

Now I'm not saying you create a hydrogen bond by simply binding a couple of hydrogen atoms with oxygen! It's a little trickier that that!

Hydrogen bonds need another "connection" to take place. The hydrogen that binds to nitrogen, oxygen, fluorine or carbon atoms needs to be bound to another atom!

Another way to say this is...

A compound that contains a hydrogen atom can form a hydrogen bond with a nitrogen, oxygen, fluorine or carbon atom in another molecule.

You learned in the last chapter that oxygen can form covalent bonds with two hydrogen atoms creating water. But how do water molecules "stick together" when they are solid (ice) or liquid? That is a good question and the answer is...

...because hydrogen bonds help the molecules stick to each other!

Water is known as a **polar** molecule. This means the electrons that are shared between the hydrogen atoms and the oxygen atom are not evenly shared. Because these two atoms do not share their electrons evenly, the oxygen atom has a small negative charge and the hydrogen atoms have a small positive charge.

What do you think is going to happen when we put a whole bunch of water molecules together, each with negatively-charged oxygen atoms and positively-charged hydrogen atoms? That's right!

They are going to bind together!

The reason why water molecules stay in a liquid state is because the hydrogen bonds between them hold them together! You could say that hydrogen bonds make water "sticky"! You can always break these hydrogen bonds if you add enough energy!

And we all know what happens when you add enough heat energy to liquid water...

The molecules of water split apart from each other and go flying all over the room as a gas!

Another way to say this is...

The heat energy added to the liquid water has a greater force than the energy in the hydrogen bonds holding the water molecules together.

Hydrogen bonds give water another really cool property...

Surface tension is a term used by scientists to explain how "sticky" water can be. Think of it this way, in a glass of water you may have millions and millions of water molecules. Almost all of the oxygen atoms in these molecules are bound to hydrogen atoms in every possible direction. If a hydrogen atom is pulling up on oxygen atom, the oxygen atom is pulling the hydrogen atom down. If the hydrogen is pulling left, the oxygen is pulling right...

It's a tug of war all the time!

But what about the layer of water molecules on the top of your glass? Is anything pulling up on the molecules? No way!

There are no water molecules above the water level in your glass! So what does this mean?

Well, if you are very careful, and you slowly pour water into your glass, you can probably see something pretty cool happen...

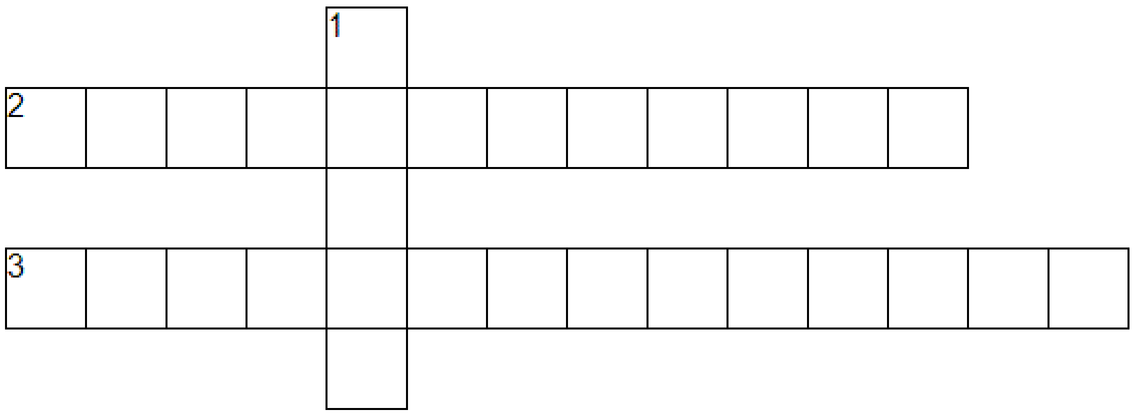
You can create a "dome" of water over the top of your glass!

Remember, water is sticky. Its molecules hold on to each other with hydrogen bonds. And each molecule is being pulled by another molecule – except at the top of the water level. There is no force pulling on the water molecules at the water level. So, as you add more and more water molecules into the glass, they keep holding onto each other because nothing is pulling them in the opposite direction. This allows you to add more water than the glass would be able to hold! This extra water forms a "dome" over the top of your water glass.

I know you want to go try this right now!

So what are you waiting for?!?!

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

2. bonds take place between hydrogen atoms and a handful of atoms that can gain electrons from other atoms
3. the "stickiness" of water; created by hydrogen bonds between water molecules

DOWN

1. uneven sharing of electrons within molecules which cause some of its atoms to have a positive charge and others to have a negative charge

Use the definitions to fill in the missing letters.

1. p _ l _ _
2. _ _ _ _ _ ce _ _ ns _ o _
3. _ _ _ _ o _ en _ _ o _ d

1. uneven sharing of electrons within molecules which cause some of its atoms to have a positive charge and others to have a negative charge
2. the "stickiness" of water; created by hydrogen bonds between water molecules
3. bonds take place between hydrogen atoms and a handful of atoms that can gain electrons from other atoms

Use the definitions to unscramble the words below.

1. aplro ______________________________
2. groondnbdehy ______________________________
3. rtasuesiofcenn ______________________________

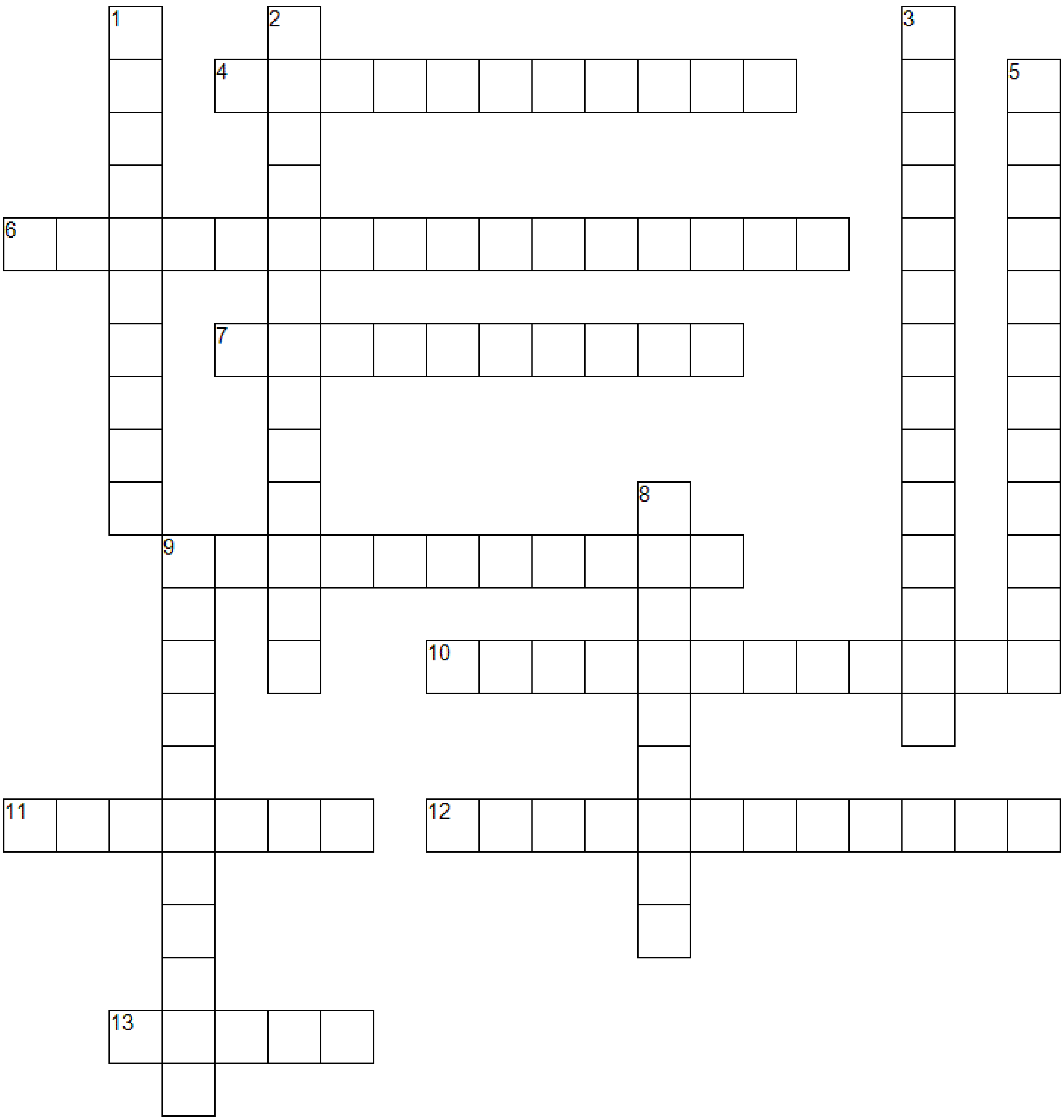
1. uneven sharing of electrons within molecules which cause some of its atoms to have a positive charge and others to have a negative charge

2. bonds take place between hydrogen atoms and a handful of atoms that can gain electrons from other atoms

3. the "stickiness" of water; created by hydrogen bonds between water molecules

Unit 5 Review

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

4. an atom with fewer electrons (-) than protons (+)
6. the number of electrons in the last orbital of each element
7. covalent bond in which two electrons are shared between atoms
9. an atom with an equal number of protons and electrons
10. the force that holds two atoms together; also known as "chemical energy"
11. layer of electrons that spins around the nucleus
12. bonds take place between hydrogen atoms and a handful of atoms that can gain electrons from other atoms
13. uneven sharing of electrons within molecules which cause some of its atoms to have a positive charge and others to have a negative charge

DOWN

1. covalent bond in which three electrons are shared between atoms
2. a compound formed by an ionic bond between positive and negative ions
3. the "stickiness" of water; created by hydrogen bonds between water molecules
5. a bond shared between atoms that shares electrons with each other
8. the bonding of a positive and negative ion by the gaining and releasing of electrons
9. an atom with more electrons (-) than protons (+)

Be certain to go over your definitions for the test!!!

Chapter 21

It's time to start applying all of your knowledge about ions, elements, bonding and molecules!

You learned in the last unit that table salt is made up of one sodium atom and one chloride atom. Table salt is known as an ionic compound because the sodium atom gives away one electron to chlorine to fill up its outer orbital. By giving away an electron, sodium becomes a positive ion. And, by taking one electron, chlorine becomes a negative ion.

The sodium and chlorine ions can then form an ionic bond and stick together!

Okay, let's look at an important rule about ionic compounds:

Ionic compounds can be dissolved very well in water.

Whenever you add an ionic compound with water, the water molecules surround each ion and separate the ions from each other.

For example, water contains large oxygen atoms which are negatively charged. When you place an ionic compound, like table salt, into water a huge tug-of-war starts to happen! The large negatively charged oxygen ions surround the positive sodium ion in one molecule of table salt. As they surround the sodium ion, the force of all the oxygen ions pulling on the sodium ion is so great...

...the sodium ion is pulled away from its partner,

the chloride ion!

This kind of tug-of-war goes on all the time with ionic compounds. However...

When covalent compounds are dissolved in water, the covalent bonds that hold each ion together are **not** broken apart!

For example, table sugar is a covalent compound. This means all of the carbon, hydrogen and oxygen ions inside one sugar molecule share all of their electrons. When you put table sugar in water, the water molecules completely surround one **entire** sugar molecule and separate this molecule from the other sugar molecule.

Does this make sense? I certainly hope so! Because now it is time to...

...start talking like a scientist!

First of all, not everything you mix together can be dissolved! You should know that, right? It doesn't matter how much you stir together a handful of rocks in water, they are not going to dissolve! Adding together two items that do not dissolve into each other is called **mixture!**

However, when one of the two items can dissolve, there are a whole bunch of different words you need to know...

Whenever you add two different molecules together, scientists tend to call each of the ingredients a different name. This helps them when they start talking about mixing all kinds of different molecules together. Here we go...

A molecule (like table salt) is known as a **solute** ("sahl-oot") when it is dissolved in another molecule (like water). The molecule that is doing the dissolving (in this example it would be water) would be called the **solvent** ("sahl-vent"). Together, when a solute mixes together so well that you cannot see it anymore in the solvent, you have a **solution** ("sow-loo-shun").

But what if not all of a solute dissolves in a solvent?

This happens all the time! Sometimes, the molecules of a solute are really just a large group of different molecules stuck together. Milk is a good example of this – it is made up of many different molecules that are bonded together. Some of these molecules can be dissolved in a solvent, but not all of them! Scientists call this kind of mixture a **colloid** ("kahl-oyd").

Whenever you add a little milk to water, the water becomes cloudy. This is because the colloid you have created contains several large molecules that are not dissolved by the water. They just keep floating around in the water!

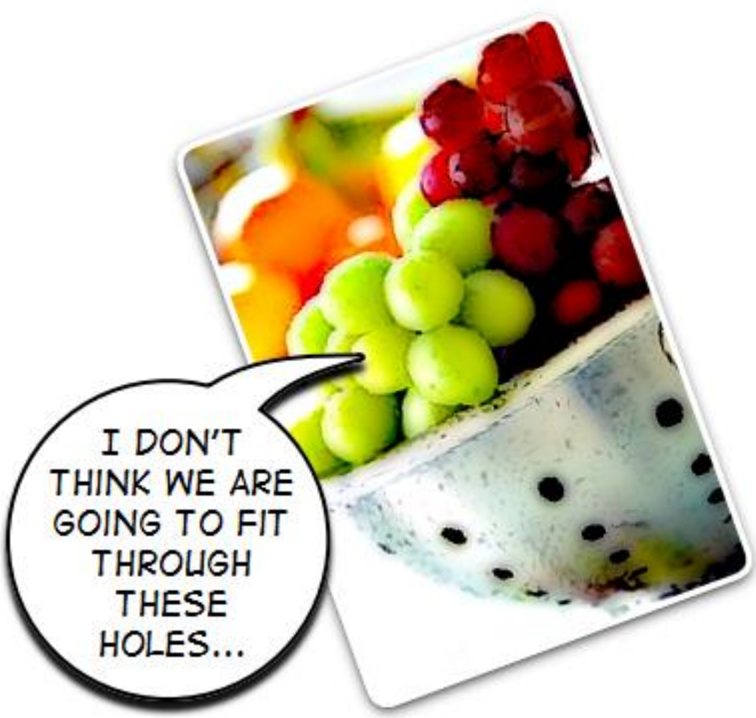
The molecules in a colloid may be larger than water...

...but they are still way too small to be seen!

In fact, it would be difficult to remove all of these larger molecules from a colloid. Try to imagine trying to get all of the white particles out of a glass of milk. It can be done, but not very easily!

It is much easier to remove the parts of a different kind of mixture which is called a **suspension** ("suh-spen-shun"). Think of orange juice filled with pulp as a suspension. The particles in a suspension are large enough to be easily seen (and removed) from the mixture.

All you need to remove pulp from orange juice is a strainer! Simply pour the orange juice through the strainer and all of that pulp will be removed. You can't do that very easily with our milk colloid, huh?



Solutes can do something else that is pretty cool!

They can change the freezing and boiling points of solvents!

Think of it this way... in order for a solvent (like water) to become a solid, it needs to freeze, right? And when a liquid freezes, its molecules create a "fixed" shape by lining up and stopping their movement. But when you add a solute to the water, the water molecules can't line up as easily. The solute gets in the way! This means that solutes lower the freezing point of a solvent! Pure water may freeze at 0°, but salt water will freeze at a lower temperature because the solute (salt) causes the ice to work harder to form solid ice!

Solutes change the boiling point of solvents too! Pure water boils at 100°, but the solutes (like sodium and chloride) that are attached to the solvent molecules (like water) will not allow them to break apart and turn into a gas. More energy is needed for the solvent molecules to change from a liquid to a gas. So, solutes raise the boiling point of liquids! Cool, huh?

Excellent work! In the next chapter, you are going to take a closer look into all kinds of solutions! See you soon!

Use the definitions to fill in the missing letters.

1. _ u _ _ _ _ sio _
2. _ _ lve _ _
3. _ _ lu _ i _ _
4. _ _ lu _ _
5. _ ixt _ _ _
6. c _ l _ _ _ d

1. a mixture in which some of the particles are large enough to be easily seen (and removed)
2. a molecule that is dissolving the solute in a solution
3. when a solute mixes together so well that you cannot see it anymore in the solvent
4. a molecule that is dissolved by the solvent in a solution
5. adding together two items that do not dissolve into each other
6. a mixture in which not all of the solute can be dissolved by the solvent; the undissolved solute is still very small

Circle the hidden words from below:

g	a	o	s	h	a	j	w	e	s	u	s	p	e	n	s	i	o	n	n
r	u	g	b	e	h	y	u	r	f	k	a	k	s	a	a	f	l	s	q
n	d	z	x	t	n	o	e	c	h	d	a	e	n	i	b	j	e	a	h
c	a	u	k	n	o	v	p	l	o	t	l	k	l	z	d	c	g	j	a
y	p	q	c	d	f	v	d	p	e	d	x	n	b	s	l	x	w	l	a
n	c	o	l	l	o	i	d	l	r	t	a	w	v	f	h	n	r	m	e
z	g	e	h	s	o	l	u	t	e	m	s	e	e	j	v	z	s	z	f
b	v	v	k	q	f	t	o	n	q	p	a	l	f	a	p	m	c	o	l
r	l	a	c	c	j	s	x	q	z	m	m	s	h	e	o	p	f	w	h
e	k	o	m	u	c	o	g	o	k	c	w	o	z	n	u	z	j	m	y
u	l	a	c	g	p	l	e	a	q	k	h	l	l	d	n	j	h	w	x
p	o	c	d	i	g	u	q	c	a	u	o	v	w	n	i	e	t	v	t
g	w	t	j	k	q	t	c	q	v	s	y	e	e	i	d	e	a	j	t
m	b	q	t	e	a	i	t	r	u	g	e	n	m	l	c	j	a	v	k
j	n	e	h	j	q	o	o	d	v	m	r	t	x	k	d	l	p	u	f
e	z	z	q	y	t	n	q	a	c	r	m	i	x	t	u	r	e	z	w

mixture

solute

solvent

solution

colloid

suspension

What happens when covalent compounds dissolve in water? How is this different from ionic compounds when they dissolve in water?

Chapter 22

In the last chapter you learned that a solution is a combination of dissolved solutes inside a solvent. Most of the time, the solvent you are studying is water. This is not only because water is a very simple compound for scientists to use! Water is known as the **universal solvent** because it can dissolve more solutes than any other liquid!

One thing we didn't look at in the last chapter is this fact:

You can always change the amount of solute you dissolve in a solvent!

Scientists have special names for solutions with different amounts of solutes.

A **dilute solution** only has a small amount of solute dissolved by its solvent. In fact, a dilute solution can easily dissolve more solute! If you have ever made fruit juice by opening a can, pouring it into a pitcher and then adding water...

...you just made a dilute solution!

And if you look carefully at your juice can, you may have seen the words "from concentrate" ("kon-sen-trate") on the label.

Concentrated solution

A **concentrated solution** contains a lot of solute that is dissolved by a solvent. The juice inside that can probably doesn't taste very good to you because it is concentrated. You can make the juice more dilute if you add too much solvent (but that wouldn't taste very good!). And you can keep the juice more concentrated if you don't add enough solvent (but that wouldn't taste very good either!)

There is a point when you cannot dissolve any more solute inside a certain amount of solvent. This is known as a **saturated solution** ("sa-ture-a-ted"). This means that there are not enough solvent ions to surround any more solute ions. What happens if you add more solute at this time? Well, it will probably sink to the bottom of the solvent!

Until this solution becomes saturated, scientists call it an **unsaturated solution** ("un-sa-ture-a-ted").

Scientists have a name for describing how much solute can dissolve in a solvent...

Solubility

("sahl-yoo-bill-itee")

Why do you need to know this? Well, solubility is a physical property of all molecules. For example, it is a fact that you can dissolve more sugar in a cup of water than salt. Because scientists have figured this out by running experiments, we can say that sugar is **more soluble** that salt!

The solubility of matter is affected by two things:

Pressure and Temperature

Whenever you change the pressure of a solution, its solubility is changed too. For example, you wouldn't shake up a can of soda and then open it up in front of your face, would you? It may look funny to someone else, but I doubt you would be laughing as soda is dripping off of your face!

The reason all that soda starts shooting out of that can is because of a change in pressure! Let me explain...

When a can of soda is created, a machine pumps a lot of extra gas into the liquid before the can is sealed up! This is because more gas (solute) can dissolve into the soda (solvent) at a higher pressure than normal. By "normal" I mean the normal air pressure that is around us every day!

But when you start to shake up that can of soda, a lot of the gas escapes from the liquid and starts to press against the sides of the can even more!

Once you open up that can, the high pressure inside the can forces all of the gas and liquid out of the can and into the low pressure in the air!

A simple rule in science is this:

Everything moves from an area of high concentration to an area of low concentration!

And another rule is this:

Don't ever look over a can of shaken soda when you open it!

Temperature also affects the solubility of solutions! You should remember what happens to molecules when you heat them up, right? **That's right!** They move around a lot faster!

When you heat up a solvent, you are adding a lot more energy into the solution. In fact, you can add so much energy that the solvent can dissolve more solute than normal. When this happens, you have created a **supersaturated solution**. This doesn't mean the solution starts to wear a mask and a cape and goes out to fight crime...

...it just has more solute than normal!

Supersaturated solutions are very important in making several kinds of candy that you like to eat! Some kinds of candy are made by heating a solvent with large amounts of sugar. As you increase the temperature of the solvent, you can increase the amount of sugar that can be added!

There is still so much for you to learn about solutions! Hang on!

Compare and Contrast the following vocabulary words:

Concentrated solution

Saturated solution

How are they the same? (Compare)

1. ______________________________

   ____

2. ______________________________

   ____

How are they different? (Contrast)

1. ______________________________

   ____

2. ______________________________

   ____

Use the definitions to unscramble the words below.

1. ilsotyubli ____________________________
2. veorsalunntislve ____________________________
3. uedrunsaoiotlutatsn ____________________________
4. uaesardtitutsolon ____________________________
5. tedsuralusuptionsatero ____________________________
6. encordnolctutisonate ____________________________
7. iondutilleutso ____________________________

1. a measurement of how much solute can dissolve in a solvent
2. water
3. any solution that can still dissolve more solute
4. a point when you cannot dissolve any more solute inside a certain amount of solvent
5. a solution which contains more solute than can normally be dissolved; usually formed by increasing the temperature of a solvent
6. a solution that contains a lot of dissolved solute
7. a solution that can easily dissolve more solute

Match the definitions with the correct words

1. ____________________ a solution that contains a lot of dissolved solute

2. ____________________ any solution that can still dissolve more solute

3. ____________________ water

4. ____________________ a point when you cannot dissolve any more solute inside a certain amount of solvent

5. ____________________ a solution which contains more solute than can normally be dissolved; usually formed by increasing the temperature of a solvent

6. ____________________________ a measurement of how much solute can dissolve in a solvent

7. ____________________________ a solution that can easily dissolve more solute

Solubility

Saturated solution

Supersaturated solution

Universal solvent

Unsaturated solution

Concentrated solution

Dilute solution

Chapter 23

Okay! Time for a pop quiz!

What happens to an ionic compound when you place it in water?

If you said that the ions that are bonded together are split apart as they are dissolved in water... **you are correct!**

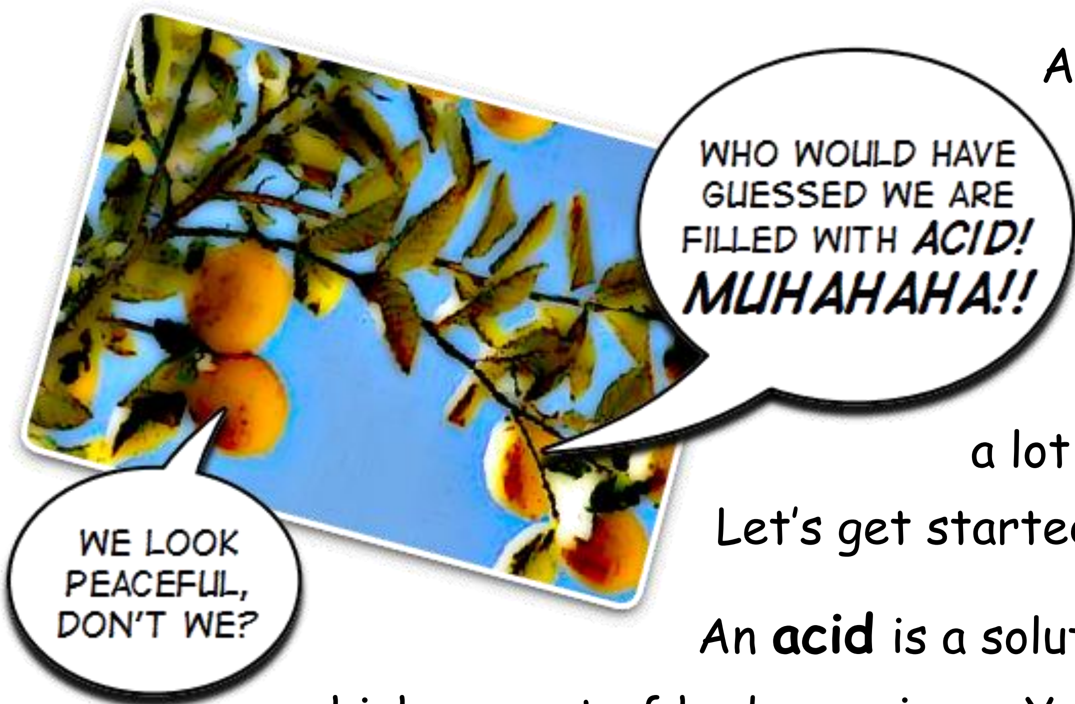
The ions that are stuck together by an ionic bond are surrounded by water molecules and pulled apart from each other!

If one of the ions that are dissolved in water happens to be hydrogen, your solution is called an...

Acid

However, if one of the ions that are dissolved is made up of hydrogen AND an oxygen atom stuck together, the solution is called a...

Base



Acids and bases have some very cool properties! We are going to be studying them a lot in this chapter. Let's get started!

An **acid** is a solution that contains a high amount of hydrogen ions. You can taste the acid in many different foods such as pickles, soda and several different kinds of fruit like lemons or grapefruit. Acids taste sour, and if you have ever tasted a raw lemon before you know what I mean!

Some acids are not safe to put inside your body!

For example, batteries contain acids and so do **fertilizers** ("fur-till-eyes-erz") which are chemicals used to help plants grow! You should never play with either of these things! The acids in batteries and fertilizers are very dangerous!

WHY ARE THEY SO DANGEROUS?

Well, if you remember, a hydrogen ion is an atom of hydrogen that has lost its electron. Since it has not filled up its outer orbital, it can easily react with many different ions that are willing to share or give away their electrons! This means that hydrogen ions are very reactive! In a **strong acid**, there are many hydrogen ions inside the solution so it is possible for this liquid to react with many different molecules! Scientists say acids are **corrosive** ("ko-row-siv") because they react with many different materials and can cause them to break apart very quickly!

But how do we know if we have a strong acid or a weak acid?

Good question! Scientists have created a way to measure the amount of hydrogen ions in a solution. It is called the **pH scale**. This scale is a range of numbers from 0 to 14. If a solution has a high amount of Hydrogen ions it is known as a strong acid and has a pH of 0. As the number of Hydrogen ions decreases in the solution, the pH scale starts to rise until it reaches a pH of 7. At this level, there are no extra Hydrogen ions floating around and the solution is called neutral. The water you drink out of the faucet (hopefully) has a pH of 7!

But what about the higher numbers on the pH scale?

Well, if you dissolve an ionic compound in water and you have a lot of extra **hydroxide ions** ("hi-drocks-eyed"), the solution is known as a **base**. A hydroxide ion is a combination of an oxygen and hydrogen atom which together has an extra electron.

Bases taste very bitter and feel slippery to the touch. Soap is a good example of a base. You all know how slippery soap can make things! And please don't try to taste any soap to prove that it is bitter! That could be dangerous! I'm not joking!

In addition to being used in soaps, bases are used in baking cookies and cakes. The chemical called baking soda is a base that is used to help make your cookies light and fluffy! Without this base, your cookies would look and feel like a hockey puck!

Strong bases are just as corrosive as strong acids. The only difference is that you would find a large amount of hydroxide ions in a strong base! Since a hydroxide ion has an extra electron to give away or share, it can react with a lot of different materials! And if you have a strong base, there are a lot of these ions ready to react!

On the pH scale, a strong base would have a pH of 14. As you dilute a strong base solution with water, the pH will start to decrease until you reach the neutral pH level of 7.

In review, solutions with extra hydrogen ions are called acids. Solutions with extra hydroxide ions are called bases. Both acids and bases can be strong or weak and are used in many different ways! That's **basically** it! (Ha ha!!!)

But here's something you may not have known...

Your body has all kinds of different pH solutions!

You are going to look at these solutions in our next chapter! See you then!

Match the definitions with the correct words

1. ______________ a solution that contains a high amount of hydroxide ions
2. ______________ a solution with a high amount of hydrogen ions
3. ______________ a solution with a high amount of hydroxide ions
4. ______________ an ion that is made up of an oxygen and hydrogen atom which holds onto one extra electron
5. ______________ description given to strong acids and/or bases as they can react with many different materials causing them to break apart very quickly
6. ______________ a solution that contains a high amount of hydrogen ions
7. ______________ chemicals used to help plants grow

Base
Corrosive
Strong acid
Acid
Strong base
Hydroxide ion
Fertilizers

Circle the hidden words from below:

w	v	y	k	u	j	s	b	t	s	c	z	j	h	q	u	x	d	b	x
k	f	f	m	s	c	f	r	x	t	c	x	v	m	o	s	d	n	w	t
i	j	i	v	e	s	s	o	m	l	o	l	q	o	n	c	q	z	g	b
h	m	o	y	m	u	t	h	b	t	o	p	m	i	i	u	k	i	f	w
s	o	e	e	t	h	r	y	i	f	o	y	e	j	h	n	i	c	l	w
t	b	c	j	x	y	o	x	w	h	o	t	d	e	x	z	e	k	q	v
r	j	t	b	i	d	n	d	b	a	s	e	a	t	z	d	i	d	e	p
o	a	x	c	n	r	g	z	w	r	p	v	f	d	x	z	s	h	c	w
n	y	x	o	i	o	a	h	v	i	b	c	p	p	z	p	o	l	f	s
g	z	c	r	t	x	c	t	a	w	f	h	b	g	s	e	m	c	d	c
b	f	h	r	o	i	i	g	b	i	x	y	w	m	b	b	e	y	w	g
a	z	m	o	r	d	d	s	x	b	e	y	l	y	b	y	r	y	m	q
s	v	x	s	k	e	m	q	o	i	j	o	a	c	i	d	l	d	t	g
e	f	n	i	z	i	q	c	f	f	e	r	t	i	l	i	z	e	r	s
c	s	s	v	w	o	p	b	f	w	p	l	g	p	g	l	t	w	i	s
o	r	f	e	g	n	o	d	y	z	t	p	r	p	x	h	f	o	l	t

fertilizers

acid

base

hydroxide ion

corrosive

strong base

strong acid

Why are strong acids and bases so dangerous?

Chapter 24

We are going to look at two solutions that every single one of you is carrying it around right now! You may not see these solutions very often (and that is a very good thing), but without them you would not live very long. This week, we are going to take a look at...

Stomach acid and Blood

("stum-ak")

Everything you eat must be broken down into smaller, easy-to-dissolve pieces that your body can use to survive. This process is known as **digestion** ("di-jest-shun").

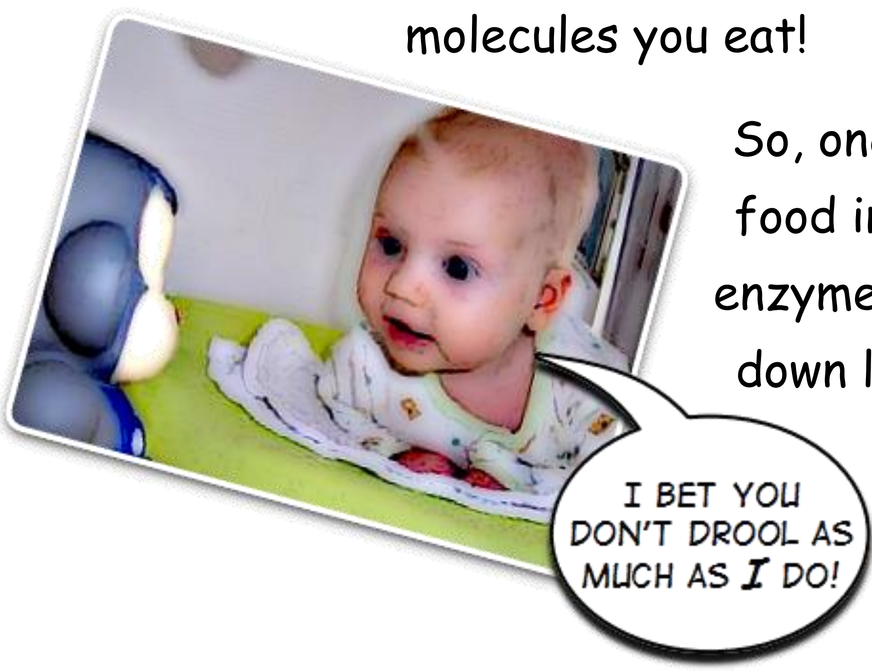
Let's imagine you are eating your favorite kind of pizza. Like everything in the universe, your pizza is made up of different compounds! Many of these compounds are way too large for your body to be able to use! So, once that pizza gets in your mouth your teeth get to work. They grind your pizza into smaller and smaller pieces. By doing this, your teeth start to break down a lot of the large compounds into smaller molecules!

But the molecules that make up your pizza still need to get smaller!

This is when your body starts to attack your food with chemicals called **enzymes** ("en-zimes"). Enzymes are chemicals made by your body to do all kinds of cool things. Some enzymes are made to help break down the large molecules in your food! But one thing is very true...

...most enzymes can only work at certain temperatures and pH!

Some enzymes work in areas of your body where the pH is close to neutral (pH 7). A good example of this is in your mouth. The **saliva** ("sah-live-ah") in your mouth (some people call it "spit") has an enzyme in it that breaks down some of the large sugar molecules you eat!



So, once your teeth grind your food into smaller pieces and enzymes in your mouth break down large sugar molecules, where does the food go?

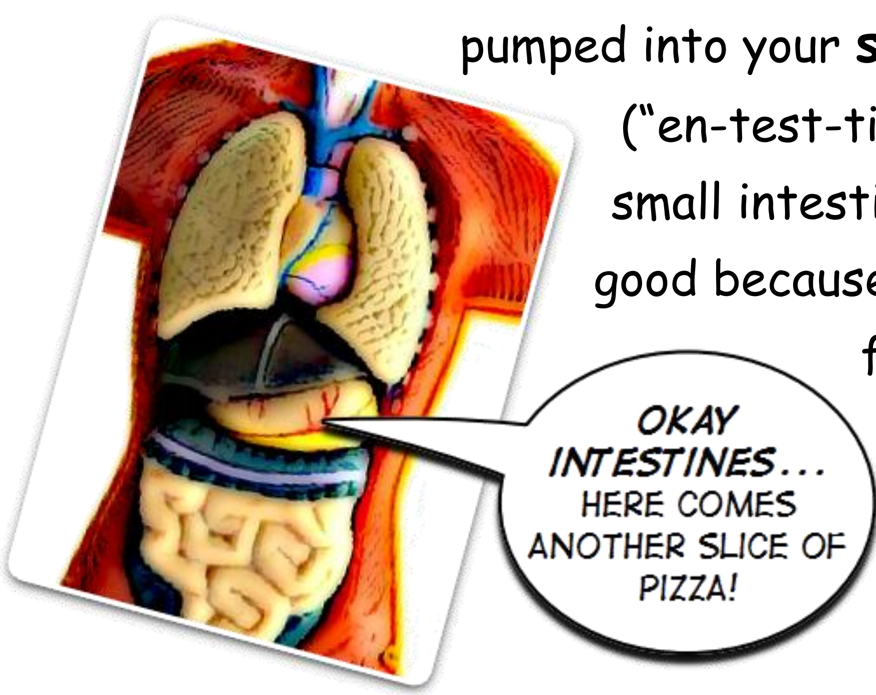
That's right! It goes down your throat and into your stomach!

This is where it gets really cool! You see, your stomach contains a very strong acid (pH2) that does a very good job at killing anything that may still be living in your food. This is a very good thing! You do not want any extra bacteria swimming around your body.

But your stomach acid is not alone!

Inside this acid you will find another enzyme that is very good at breaking down large molecules! However, you will never find these enzymes inside your mouth. They need a pH of 2 in order to live!

Once your stomach acid and its enzymes gets done with your pizza (after around 4 hours or so), what is left of your food is pumped into your **small intestines** ("en-test-tinz"). The pH of your small intestines is around 8. This is good because it is here where your food is small enough to pass into your **blood!**



Here's comes some more cool stuff!

Your blood needs to stay between a pH of 7.2-7.6. If it gets too high or too low, your brain cannot work very well and you can get very sick! Luckily, our bodies have a way of keeping our blood in a safe pH range. To do this, it needs three things:

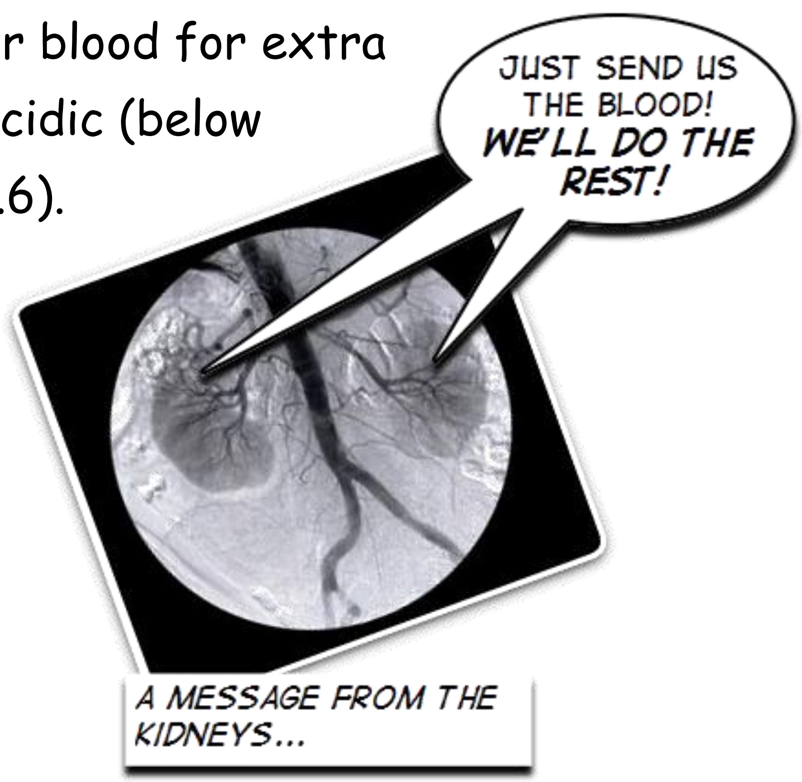
Buffers, Lungs, and Kidneys

Buffers are a group of many different compounds that float around in our blood. If our blood has a low pH, it has too many hydrogen ions floating around in this solution. This means our blood pH is too low! When this happens, the buffers react with the extra hydrogen ions and bind to them. This removes a lot of extra ions in the blood and helps it increase its pH between 7.2-7.6. Don't worry! Buffers do the same thing if there are too many hydroxide ions in our blood too! If our pH is too high, buffers are very good at binding to these ions and lowering our pH!

Unfortunately, buffers can only change our blood pH a little bit before they are used up! This is when our lungs help us out!

You should know that oxygen gas is what our bodies need to survive. When we breathe in, we take oxygen gas from the air into our lungs and into our blood! At the same time, our lungs help to remove a waste product from our blood – **carbon dioxide gas (CO_2).** CO_2 has a bad habit of binding with extra hydrogen ions in our blood to make a weak acid! So, every time you exhale, you are removing a gas that makes your blood acidic!

In addition to your lungs helping your blood pH, your kidneys come to your rescue too! Both of your kidneys do an outstanding job of filtering your blood for extra ions that make your blood too acidic (below pH7.2) or too basic (above pH7.6). These extra ions are removed from your body by your urine!



Buffers, lungs and kidneys work all day long to make certain your blood pH stays in a safe range! You can thank them by not making them work harder. This can be done by getting plenty of fruits and vegetables in your diet and staying away from smoking and other bad habits as well!

You see… the same rules you have been learning about chemistry can be used to understand your own body!

Cool, huh?

Use the definitions to fill in the missing letters.

1. _ u _ f _ r _
2. _ a _ i _ _
3. _ _ z _ _ es
4. b _ _ _ d
5. _ ig _ s _ _ _ n
6. _ a _ b _ n _ i _ x _ _ e _ _ _ _
7. _ _ _ ll _ _ _ t _ _ _ i _ es
8. s _ _ _ _ _ _ aci _

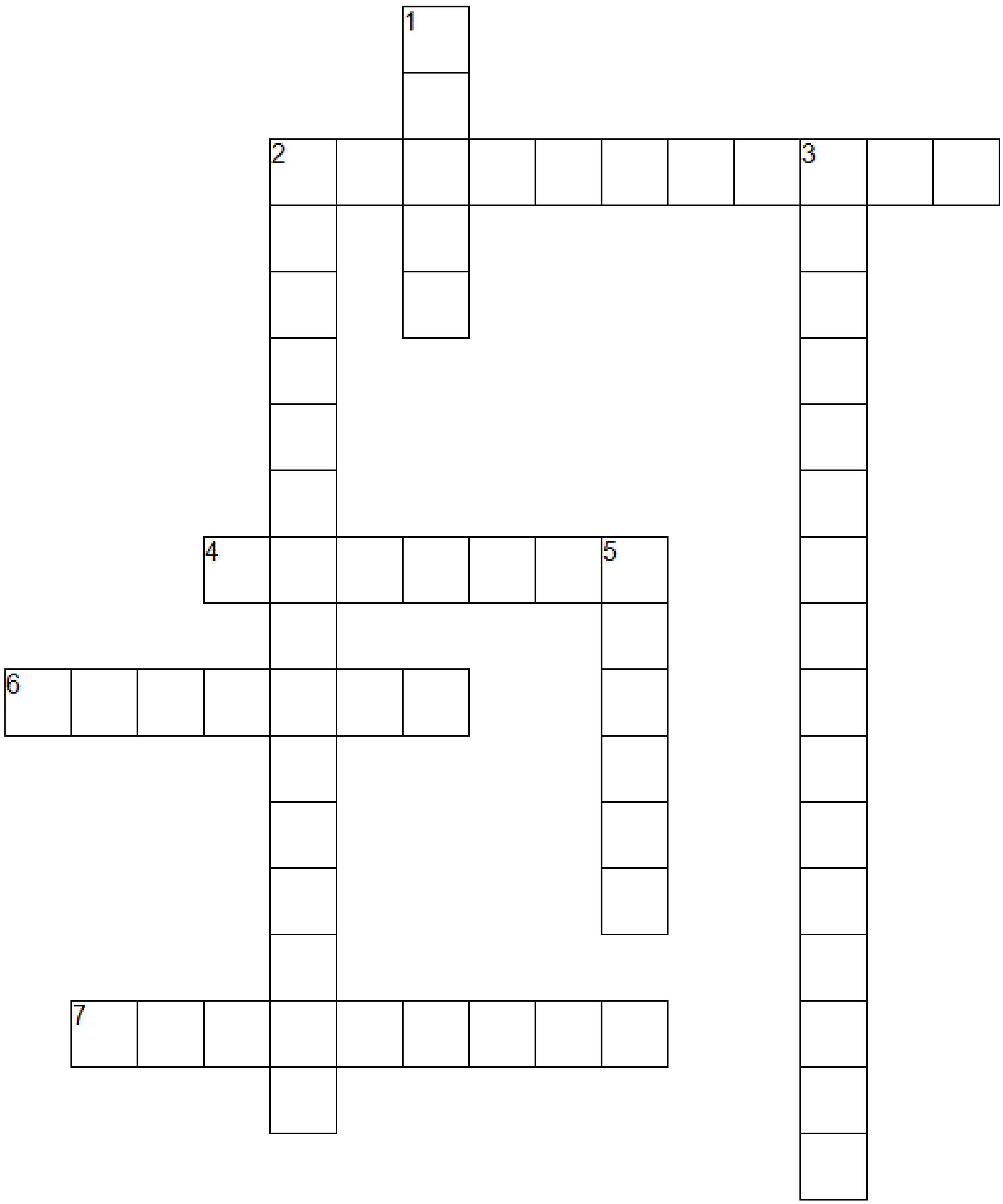
1. a group of many different compounds that float around in the blood and help to keep its pH between 7.2 and 7.6
2. fluid in your mouth; also known as "spit"
3. chemicals made by the body to help in chemical reactions
4. a solution of several compounds responsible for life to exist
5. the process of breaking down food into smaller, easy-to-dissolve pieces that your body can use to survive
6. waste product of human bodies
7. location in the body where food is small enough to pass into the blood
8. a strong acid in the stomach that helps to remove bacteria from the food we eat

Use the definitions to unscramble the words below.

1. lvaisa ______________________________
2. odlob ______________________________
3. chmstacidoa ______________________________
4. ursffbe ______________________________
5. esznmey ______________________________
6. cexibariodgasond ______________________________
7. digionets ______________________________
8. ltiemsinsnaltes ______________________________

1. fluid in your mouth; also known as "spit"
2. a solution of several compounds responsible for life to exist
3. a strong acid in the stomach that helps to remove bacteria from the food we eat
4. a group of many different compounds that float around in the blood and help to keep its pH between 7.2 and 7.6
5. chemicals made by the body to help in chemical reactions
6. waste product of human bodies
7. the process of breaking down food into smaller, easy-to-dissolve pieces that your body can use to survive
8. location in the body where food is small enough to pass into the blood

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

2. a strong acid in the stomach that helps to remove bacteria from the food we eat
4. chemicals made by the body to help in chemical reactions
6. a group of many different compounds that float around in the blood and help to keep its pH between 7.2 and 7.6
7. the process of breaking down food into smaller, easy-to-dissolve pieces that your body can use to survive

DOWN

1. a solution of several compounds responsible for life to exist
2. location in the body where food is small enough to pass into the blood
3. waste product of human bodies
5. fluid in your mouth; also known as "spit"

Unit 6 Review

Use the definitions to unscramble the words below.

1. nliessteltminas ______________
2. esirrelzift ______________
3. osericovr ______________
4. iacd ______________
5. iaomdthccsa ______________
6. bgasoesnrt ______________
7. stuole ______________
8. abse ______________
9. oblod ______________
10. clloodi ______________
11. mznyese ______________
12. ixmreut ______________
13. ognsietid ______________
14. ohidxiyneodr ______________
15. luoltbisiy ______________
16. avlsai ______________
17. sitlnouo ______________
18. tteusioliolndu ______________
19. rgoasitcnd ______________
20. refbfus ______________
21. uonpissnes ______________
22. soentlv ______________

1. location in the body where food is small enough to pass into the blood
2. chemicals used to help plants grow
3. description given to strong acids and/or bases as they can react with many different materials causing them to break apart very quickly
4. a solution that contains a high amount of hydrogen ions
5. a strong acid in the stomach that helps to remove bacteria from the food we eat
6. a solution with a high amount of hydroxide ions
7. a molecule that is dissolved by the solvent in a solution
8. a solution that contains a high amount of hydroxide ions
9. a solution of several compounds responsible for life to exist
10. a mixture in which not all of the solute can be dissolved by the solvent; the undissolved solute is still very small
11. chemicals made by the body to help in chemical reactions
12. adding together two items that do not dissolve into each other
13. the process of breaking down food into smaller, easy-to-dissolve pieces that your body can use to survive
14. an ion that is made up of an oxygen and hydrogen atom which holds onto one extra electron

15. a measurement of how much solute can dissolve in a solvent
16. fluid in your mouth; also known as "spit"
17. when a solute mixes together so well that you cannot see it anymore in the solvent
18. a solution that can easily dissolve more solute
19. a solution with a high amount of hydrogen ions
20. a group of many different compounds that float around in the blood and help to keep its pH between 7.2 and 7.6
21. a mixture in which some of the particles are large enough to be easily seen (and removed)
22. a molecule that is dissolving the solute in a solution

Be certain to go over your definitions for the test!!!

Chapter 25

We've talked a lot about how atoms, molecules and ions can bind together in the past few chapters. You have learned that reactivity is the ability and speed that atoms (or ions or molecules) have in bonding with each other. Whenever two or more atoms, ions or molecules interact with each other, something happens which is known as a **reaction**.

You should understand that there are many different kinds of ions, atoms and molecules in the universe. Because there are so many of them…

…the total number of reactions which can take place are impossible to count!

There may be a huge number of reactions that can take place, but there are a few rules they all have to follow. We are going to look at two of them this week:

Rule #1 - Reactions take place between ions, atoms and/or molecules. (You already know this one!)

Rule #2 - A reaction must produce a different form of matter.

This rule is very important! In fact, a chemical reaction is also known as a chemical change! You should know that a chemical change creates a new kind of matter with brand new properties from the atoms that are reacting together. If you have ever mixed baking soda with vinegar before, you probably know what happens...

...lot's of cool foamy bubbles!

Well, those bubbles are filled with carbon dioxide gas. You can look as hard as you can at that baking soda and vinegar, but you will never find bubbles of carbon dioxide hiding in them! This gas was created by a chemical reaction between the baking soda and vinegar.

Scientists call the two items you mix together (for example, the baking soda and the vinegar) **reactants** ("ree-act-ants"). The new molecule that is created from the chemical reaction is called the **product**. In this example, the carbon dioxide gas would be the product!

Scientists use a cool way of describing a chemical reaction...

Chemical equations and Chemical formula

You have been reading about **chemical formulas** throughout this book. For example, the formula for hydrogen gas is H_2, oxygen gas is O_2 and water's chemical formula is H_2O.

So how do chemical equations work?

Think of an addition problem. You can add two numbers together to get a brand new number, right? This is how chemical formulas work too! What scientists do is place chemical formulas in order so that the reactants (when added together) equal the products. Let's look at a simple example...

$$2H_2 + O_2 \rightarrow 2H_2O$$

In this example, two molecules of hydrogen gas ($2H_2$) are added to one oxygen gas molecule (O_2) to create two molecules of water ($2H_2O$).

You must never forget the most important rule about chemical equations...

All of the atoms within the reactants must be found somewhere in the products!

Why does this have to happen? Well, scientists have discovered a very important fact about chemical reactions. This "fact" is known as the **Law of Conservation** and it is described in the following sentence:

Matter cannot be created or destroyed, only changed!

Let's look back at our chemical formula for water:

$$2H_2 + O_2 \rightarrow 2H_2O$$

Within the reactants, there are a total of four atoms of hydrogen. How did I figure that out? Well, if you can imagine each hydrogen atom as a building block, you would need two of them to make one hydrogen gas molecule right? Yep! And, since you have two molecules of hydrogen gas, how many building blocks would you have? That's right! You would need four!

The products of this chemical reaction are two molecules of water. How many hydrogen atoms do you need to make two molecules of water? Each water molecule has two hydrogen atoms, right? And if you have two water molecules, how many hydrogen atoms would you have? If you said four, you are correct!

Four hydrogen atoms (reactants) = Four hydrogen atoms (products)

What about the oxygen?

Well, you have two oxygen atoms as reactants and two more oxygen atoms inside the water molecules. So...

Two oxygen atoms (reactants) = Two oxygen atoms (products)

This means that the chemical equation is balanced! We have not created or destroyed any matter. We only changed how the atoms were stuck together!

You just looked at two different rules about chemical reactions. But there are still many more to learn! You are going to spend some time on these rules next week! Stay tuned!

Match the definitions with the correct words

1. ______________ any new ion or molecule that is created as a result from a chemical reaction

2. ______________ the two atoms, ions or molecules that interact during a chemical reaction

3. ______________ the interaction of two or more ions, atoms or molecules

4. ______________ a law that states that matter cannot be created or destroyed, only changed

5. ______________ a way for scientists to identify chemical reactions which involve chemical formula in the form of reactants and products

6. ______________ the chemical symbols for ions, atoms or molecules

Chemical formulas	Products
Chemical equation	Reactants
Law of Conservation	Reaction

Circle the hidden words from below:

g	s	q	s	w	g	v	p	y	j	b	p	x	p	g	n	v	u	w	c
n	q	k	f	i	h	o	t	u	o	y	g	o	x	h	j	y	p	u	h
g	g	c	d	v	d	v	h	t	i	t	f	f	q	w	a	l	b	k	e
e	b	j	l	i	v	r	z	s	v	k	w	v	n	r	i	a	k	m	m
n	x	v	p	m	i	t	l	i	f	i	g	k	h	e	s	h	e	h	i
l	i	r	y	a	b	l	d	g	j	t	v	o	h	n	a	s	x	t	c
n	u	h	c	i	h	d	n	d	t	i	p	d	h	s	u	v	q	k	a
w	q	c	h	e	m	i	c	a	l	e	q	u	a	t	i	o	n	r	l
j	z	x	d	h	l	i	w	d	s	f	n	q	b	v	z	p	j	e	f
n	a	j	w	w	w	p	r	o	d	u	c	t	s	p	x	t	m	a	o
f	d	f	p	l	a	f	i	n	f	n	y	g	s	i	v	x	w	c	r
p	l	a	w	o	f	c	o	n	s	e	r	v	a	t	i	o	n	t	m
w	o	w	a	u	m	e	a	c	v	r	e	y	p	q	r	n	w	a	u
e	g	l	f	w	f	s	k	r	t	l	l	c	n	l	o	k	o	n	l
n	z	o	g	h	i	v	t	f	t	d	k	x	c	h	t	o	g	t	a
t	o	s	c	l	d	k	e	x	r	e	a	c	t	i	o	n	u	s	s

reaction

reactants

products

chemical formulas

law of conservation

chemical equation

What are two rules that all reactions have to follow?

1. ____

____

2. ____

____

Chapter 26

In the last chapter, you began looking at chemical reactions and two of the rules they follow:

Rule #1 Reactions take place between ions, atoms and/or molecules.

Rule #2 A reaction must produce a different form of matter.

Now it's time to look at a few more rules that chemical reactions follow. Here we go...

Rule #3 All chemical reactions need some energy to get started.

If you think about it, all of the reactants in a chemical reaction have chemical bonds holding them together. They are going to need some energy to split them apart so that they can make new products! This energy is known as **activation energy** ("ack-tih-vay-shun").

You learned in a previous chapter that chemical reactions can be either exothermic or endothermic.

Exothermic reactions give off a lot of heat energy while endothermic reactions create products that absorb heat energy.

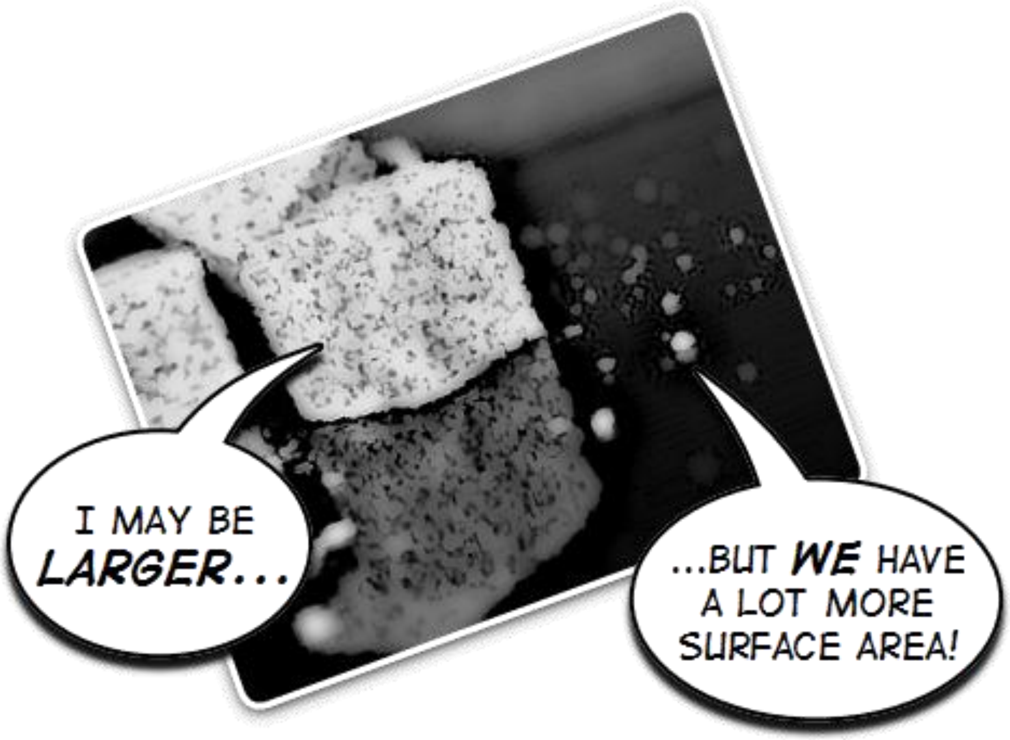
> *Endothermic reactions are like cooking bacon on the stove. You need the stove to stay on in order for the bacon to keep cooking! The bacon is not making its own heat energy as it cooks! However, once you set a piece of wood on fire, it continues to burn because the wood produces its own heat energy. Burning wood is a good example of an exothermic reaction.*

It's time to start looking at another rule about chemical reactions:

Rule #4

The rate of a chemical reaction can be controlled by the surface area of the reactants.

What does "rate of a chemical reaction" and "surface area of the reactants" mean?



Well, the rate of a chemical reaction is a measurement of how fast the chemical reaction takes place. The **surface area** of the reactants has to do with the size of the reactants. Another way to define surface area is the measurement of how much an object's surface is showing. For example, imagine a whole cookie sitting on your table. It is taking up a small amount of space on the table, right? Now imagine taking your hand and crushing that cooking into a lot of little pieces (please don't waste a perfectly good cookie like this!) Would all those pieces take up more or less space on your table than the whole cookie? If you said "more space" you are correct!

Now instead of a cookie, imagine you have a reactant that is a large group of molecules bonded together into a solid. The surface of this solid object can react with another reactant to form a new product. But, what if that solid object was crushed into smaller groups of molecules? Would there be more surfaces on the crushed object to react with the second reactant? Oh yes! And, since the "surface area" of this crushed object has increased...

Excellent job! Now it's time to look at the next rule of chemical reactions.

Rule #5

The rate of a chemical reaction can be controlled by the temperature of the reactants.

This rule should make sense to you. What happens when you increase the temperature of an atom? Does it speed up or slow down? Well, as you add heat energy to an atom it absorbs this energy and starts to move faster!

Since a chemical reaction depends on reactants bouncing into each other, what do you think will happen if you start moving them around a lot faster?

That's right! They are going to bounce into each other a lot faster. This will increase the rate of the chemical reaction!

You can slow down the rate of reactions too! All you have to do is take heat energy away from the reactants. Yes, it's that easy... Just cool down the reactants and they will not bounce into each other as fast!

So how else can you increase the rate of a chemical reaction? Well...

Rule #6

The rate of a chemical reaction can be controlled by the concentration of the reactants.

When scientists use the word **concentration** ("kon-sen-tray-shun") they don't mean that the reactants are "thinking really hard!" The concentration of reactants means the amount of reactants added to the chemical reaction.

You learned in the last chapter that if you add 1 cup of baking soda and 1 cup of vinegar together (reactants) you create a lot of foamy bubbles filled with carbon dioxide gas (product). If you follow Rule #6, you can increase the rate of this chemical reaction if you increase the concentration of baking soda (3 cups) to 1 cup of vinegar. By adding more baking soda to the vinegar there are more reactants reacting with each other at once!

Great job! Now you know some simple rules about chemical reactions! In the next chapter, you are going to look at what happens when the rate of a certain reaction is sped up really really fast!

Describe how the rate of a reaction can be changed. Use the following words in your answer:

Temperature
Surface area
Concentration

Match the definitions with the correct words

1. ______________________ energy required to start a chemical reaction

2. ______________________ the amount of reactants added to the chemical reaction

3. ______________________ measurement of how much an object's surface is showing

Activation energy

Concentration

Surface area

Use the definitions to unscramble the words below.

1. aticeconntrno ______________________
2. eeasaarcurf ______________________
3. ttanacioneivergy ______________________

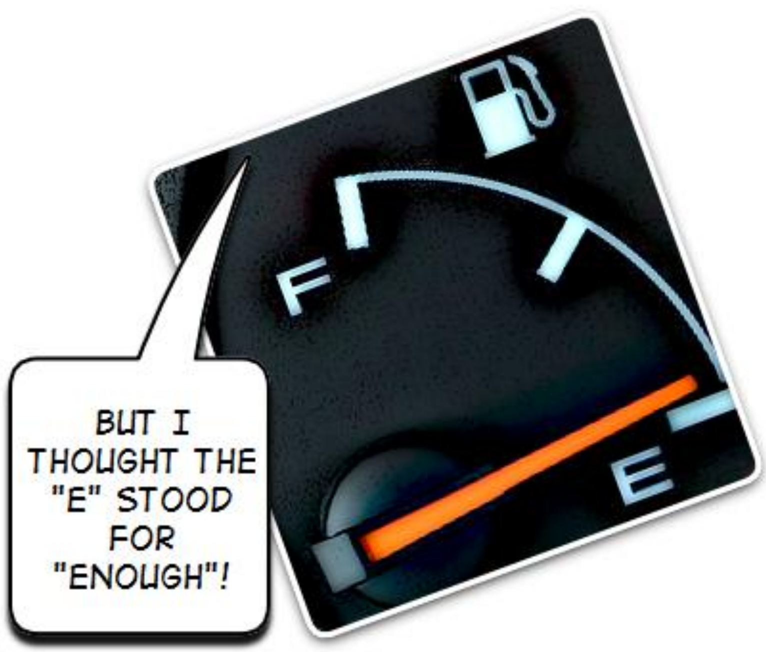
1. the amount of reactants added to the chemical reaction
2. measurement of how much an object's surface is showing
3. energy required to start a chemical reaction

Chapter 27

The rate of a chemical reaction can be sped up by increasing the reactant's...

Surface area, Temperature and Concentration

In this chapter you are going to look at a very fast reaction between oxygen and a **fuel**. A fuel is matter that gives off energy when it burns. You have learned about a fuel in the last chapter – wood! Burning wood is an exothermic reaction because it releases heat energy! Other fuels include oils and gasoline!



The very fast chemical reaction that takes place between oxygen and a fuel is known as **combustion** ("kom-bust-shun").

Fire is caused by combustion between these two reactants!

IT ONLY TAKES ONE SPARK...

Besides oxygen and a fuel, what else do all chemical reactions need? That's right!

Activation energy!

The **activation energy** that is needed to create fire is in the form of heat. This heat can come from a lot of different places. A match, an electric spark and **friction** ("frick-shun"; heat from two objects rubbing together) are three common forms of heat! All of these things can provide the activation energy needed to start a fire.

Once the activation energy starts to pull apart the atoms inside the reactants, a fire will continue to burn as long as there is fuel and oxygen.

Most of you have watched someone start a wood fire before. Did the wood burst into flames as soon as a match was brought close to it? Of course not! It takes a little time for the wood to absorb enough heat energy to start splitting apart its molecules.

Here is the chemical equation for **heating up** a piece of wood:

$$6C_{10}H_{15}O_7 + \text{Heat} \longrightarrow C_{50}H_{10}O + 10CH_2O$$

Wood — Charred wood — Smoke

(There are a lot of atoms inside one molecule of wood, huh?)

Once you add enough heat to wood it turns the wood black and starts to smoke, right? If you keep adding just enough heat to the wood to turn it completely black, it will stop smoking and form...

Charcoal!

That's right! The **charcoal** you use to make BBQ is really just wood that has been heated up so much that it does not have any more smoke to give off! That is why a charcoal fire does not give off a lot of smoke!

Cool, huh?

But what would happen if you heated up that charred wood/charcoal a little more?

In order to answer that question, we have to look at the smoke (CH_2O) we have created along with the charcoal ($C_{50}H_{10}O$).

When smoke gets heated, its atoms start to split apart and begin to react with the oxygen in our air! Here is the chemical formula...

$$\underset{\text{Smoke}}{CH_2O} + \underset{\text{Oxygen}}{O_2} \longrightarrow \underset{\text{Water}}{H_2O} + \underset{\text{Carbon Dioxide}}{CO_2}$$

When smoke is heated, it reacts with oxygen to form water, carbon dioxide...

...and a lot of heat!

This heat helps to keep the smoke reacting with the oxygen to produce even **more** heat! And you should know by now that the rate of a chemical reaction can be increased if you increase the temperature of the reactants!

So… are you saying the smoke is the real fuel during combustion? Yes it is!

The carbon in the charred wood can also react with the oxygen in the air. But this is a much slower reaction. It still can produce a lot of heat – which is why we use it in our BBQ grills! That is why the charcoal will turn bright orange after it is done burning for awhile. When they turn this color, the carbon inside the charcoal is reacting very well with oxygen and is very hot! But since it is a slower reaction, it sends off a lot of heat over a long time. This is very helpful when you are using charcoal to cook your food!

Only some compounds can be broken down to produce a lot of heat during combustion. As you know, not everything in the world will burn. For example, you cannot boil water and watch the steam burst into flames! Although it would be really cool!

The compounds that go through combustion very well contain carbon and hydrogen. Compounds with these two elements can be broken apart and mixed together very easily with oxygen to form the products of combustion (carbon dioxide and water) very easily! Gasoline burns very well because it is a **hydrocarbon**, which is a compound made with only carbon and hydrogen atoms.

Use the definitions to fill in the missing letters.

1. _ _ dr _ c _ _ _ o _
2. f _ _ l
3. _ _ _ c _ i _ n
4. _ _ _ _ _ at _ _ n _ _ er _ y
5. c _ _ r _ o _ _
6. _ om _ _ _ _ io _

1. a compound made with only carbon and hydrogen atoms
2. matter that gives off energy when it burns
3. heat from two objects rubbing together
4. energy required to start a chemical reaction
5. wood that has been heated up so much that it does not have any more smoke to give off
6. a very fast chemical reaction that takes place between oxygen and a fuel

Circle the hidden words from below:

y	h	q	s	o	q	f	d	x	w	f	p	r	h	v	h	a	e	q	w
x	f	w	i	x	c	s	p	h	r	a	v	g	y	a	m	k	q	x	e
n	w	p	e	q	e	x	y	i	n	d	x	a	y	j	o	a	g	s	w
h	f	j	w	g	r	d	a	i	t	a	k	n	r	z	o	f	h	i	e
y	r	w	g	z	z	l	u	y	l	y	w	g	h	k	m	q	q	z	f
d	i	e	z	j	d	o	c	v	j	u	w	i	w	o	t	f	u	e	l
r	c	e	z	i	n	z	h	i	c	u	o	w	i	d	q	m	b	f	x
o	t	n	p	x	e	w	a	i	y	w	r	r	q	o	i	r	x	d	n
c	i	i	m	z	q	o	r	n	f	k	e	f	q	u	i	a	o	d	a
a	o	u	b	q	y	g	c	j	c	o	m	b	u	s	t	i	o	n	u
r	n	m	x	r	k	g	o	x	y	u	l	l	i	c	u	e	h	w	n
b	a	s	b	x	e	m	a	d	q	k	z	l	r	n	h	x	k	d	c
o	v	z	s	n	b	v	l	w	l	m	k	u	t	n	n	b	h	b	l
n	r	q	t	o	h	j	c	d	t	m	k	o	w	e	k	n	k	t	p
a	c	t	i	v	a	t	i	o	n	e	n	e	r	g	y	p	i	s	p
d	k	m	q	j	x	u	q	q	o	x	h	y	z	q	j	a	a	x	m

fuel

friction

combustion

charcoal

activation energy

hydrocarbon

What three things are needed for combustion to take place?

1. ______________________________

2. ______________________________

3. ______________________________

Chapter 28

In the last chapter, you learned what happens to the atoms inside wood when it burns! This takes place in two different chemical formulas.

This first describes what happens to wood when it is heated up:

$$6C_{10}H_{15}O_7 + \text{Heat} \rightarrow C_{50}H_{10}O + 10CH_2O$$

Wood — Charred wood — Smoke

One of the products of this reaction is smoke. When smoke gets heated, its atoms start to split apart and begin to react with the oxygen in our air! Here is the chemical formula...

$$CH_2O + O_2 \rightarrow H_2O + CO_2$$

Smoke — Oxygen — Water — Carbon Dioxide

When this reaction is taking place, you can see the wood start to burn! And, of course, you start to feel a lot of heat from this reaction at this time too!

These two reactions are known as **complete combustion** ("kom-bust-shun"). You learned in the last chapter that combustion is a very fast chemical reaction that takes place between oxygen and a fuel. "Complete" combustion means that the reaction has plenty of oxygen to produce water and carbon dioxide.

But what if you don't have enough oxygen?

Good question!

When this happens, the reaction is known as incomplete combustion.

Incomplete combustion takes place in (almost) every fire on Earth. It is almost impossible to have enough oxygen atoms in the air around a fire to react with the fuel (smoke) to produce carbon dioxide and water. So this means that complete combustion rarely ever happens in real life.

Without enough oxygen to react with the fuel, the products of incomplete combustion are a little different. Carbon dioxide and water can be produced, but so can another compound...

Carbon monoxide (CO)

(Pure carbon and a bunch of other compounds can be produced as well from incomplete combustion. It all depends on the kind of fuel that is burning!)

Carbon monoxide is a gas that is made up of one carbon atom bonded with one oxygen atom. This compound has no color or smell and is very dangerous to living organisms! Carbon monoxide is almost always produced when there is not enough oxygen in the air during combustion. Almost **any** fuel that contains carbon atoms can produce carbon monoxide gas during incomplete combustion!

So why is carbon monoxide dangerous?

Well, your body needs oxygen gas to keep itself going all day long! This gas is carried by your blood throughout your body. Every time you take a breath, oxygen gas fills up inside your **lungs**. Think of your lungs as "gas tanks" inside your body. The really cool thing about this compound is that it is so small, it can easily pass from your lungs into your blood!

This is a good thing!

Because the same time your lungs are putting oxygen gas into your blood, something else is happening too…

…carbon dioxide gas leaves your blood and fills up your lungs!

So what does this have to do with carbon monoxide? Well, carbon monoxide is even smaller than oxygen! This means that carbon monoxide can pass into your blood very easily if the air you breathe is filled with this gas.

The bad thing is this...

...your body cannot use carbon monoxide to stay alive!

And, if your blood is filled up with carbon monoxide, it will not have enough room to carry any oxygen! So if you breathe too much carbon monoxide you can get hurt very badly! This is why you never run your car (or any other gas-powered engine) or start a fire inside your home (unless it is inside a fireplace with an open chimney!) Not only can you damage your home with fire, the products of incomplete combustion can hurt you too!

Fireplaces and gas-powered stoves, furnaces and water heaters are common places in homes which can produce carbon monoxide. But there is another location that you may not know about...

...the meat in your refrigerator!

What?!? There's no burning meat in my refrigerator!

That is true! But if you package up beef, pork or fish with carbon monoxide gas, the gas keeps the meat looking red and fresh! Butchers (people who prepare meat for the grocery stores) have known about this trick for a long time! They learned from scientists that carbon monoxide gas bonds with blood to produce a bright red color.

But isn't all blood red? Why do we need to use carbon monoxide to keep the meat looking red?

Another great question! You see, all blood will turn into a brownish color after a few days. However, scientists have discovered if the blood is filled with carbon monoxide gas, it does not turn brown as quickly!

This means that grocery stores can keep their meat for sale a little longer before they have to get rid of it.

But is it safe?

To be honest, we don't really know. Some scientists say it is but others say it's not. Scientists are still working on this question. The best way to be safe is to make certain you always cook your meat well! The warmer your steak or pork chops are, the better the chance of all those compounds splitting apart into smaller (and safer) atoms!

Match the definitions with the correct words

1. ______________________ the "gas tanks" of your body

2. ______________________ a gas without smell or color which is made up of one carbon atom bonded with one oxygen atom; this gas is very dangerous to living organisms

3. ______________________ a very fast chemical reaction that takes place between oxygen and a fuel in which there is not enough oxygen to produce water and carbon dioxide

4. ______________________ a very fast chemical reaction that takes place between oxygen and a fuel in which there is plenty of oxygen to produce water and carbon dioxide

Lungs
Incomplete combustion
Complete combustion
Carbon monoxide

Use the definitions to fill in the missing letters.

1. c _ _ bo _ m _ _ _ _ _ _ e _
2. _ _ ng _
3. _ n _ o _ p _ _ _ _ _ c _ _ _ us _ io _
4. c _ _ p _ _ te _ _ _ _ _ st _ o _

1. a gas without smell or color which is made up of one carbon atom bonded with one oxygen atom; this gas is very dangerous to living organisms
2. the "gas tanks" of your body
3. a very fast chemical reaction that takes place between oxygen and a fuel in which there is not enough oxygen to produce water and carbon dioxide
4. a very fast chemical reaction that takes place between oxygen and a fuel in which there is plenty of oxygen to produce water and carbon dioxide

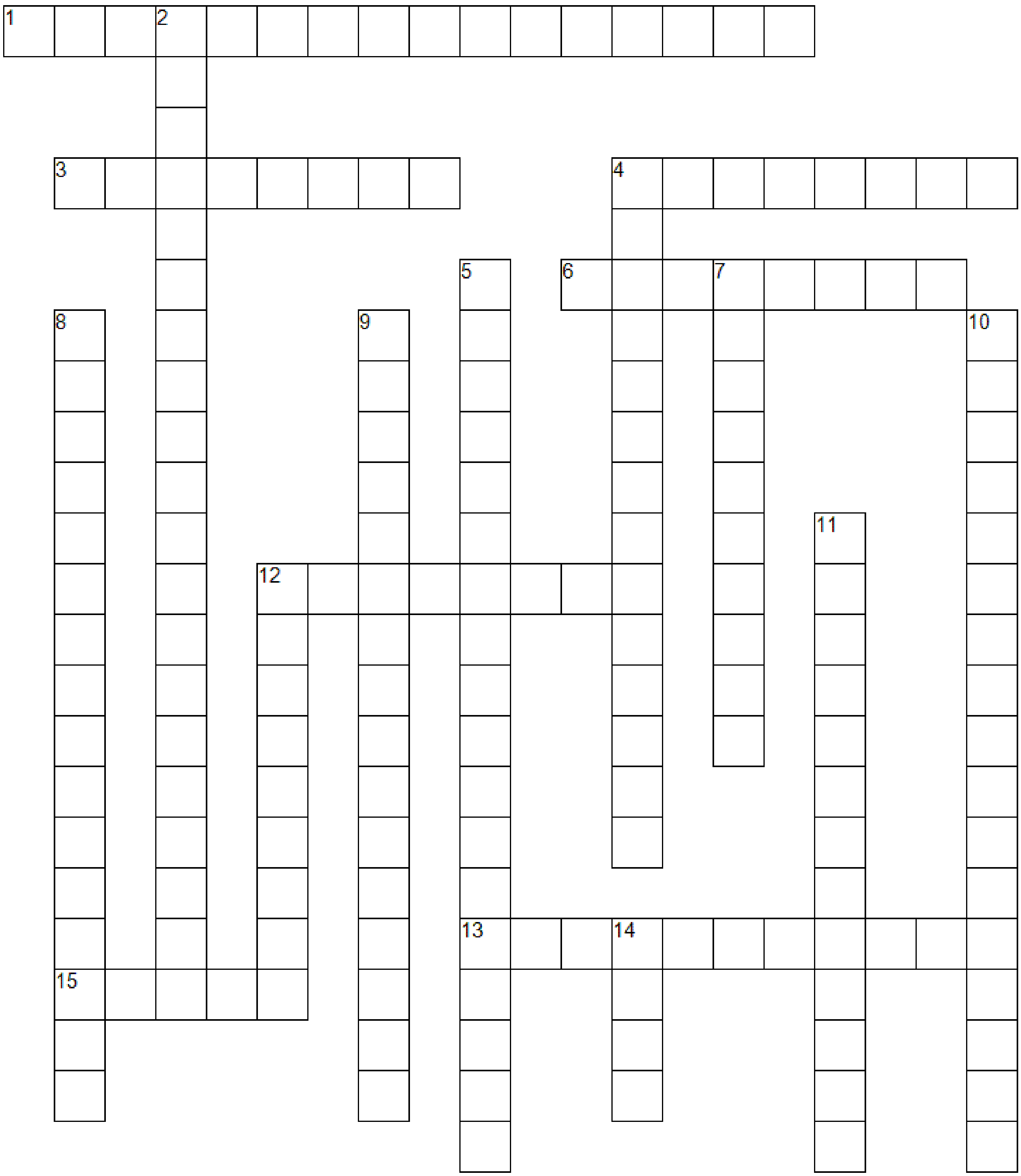
Which of the following compounds act as fuel for combustion reaction? What does this fuel need in order to cause something to burn?

$$6C_{10}H_{15}O_7 + \text{Heat} \longrightarrow C_{50}H_{10}O + 10CH_2O$$

Wood — Charred wood — Smoke

Unit 7 Review

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

1. energy required to start a chemical reaction
3. any new ion or molecule that is created as a result from a chemical reaction
4. wood that has been heated up so much that it does not have any more smoke to give off
6. heat from two objects rubbing together
12. the interaction of two or more ions, atoms or molecules
13. measurement of how much an object's surface is showing
15. the "gas tanks" of your body

DOWN

2. a very fast chemical reaction that takes place between oxygen and a fuel in which there is not enough oxygen to produce water and carbon dioxide
4. a gas without smell or color which is made up of one carbon atom bonded with one oxygen atom; this gas is very dangerous to living organisms
5. a very fast chemical reaction that takes place between oxygen and a fuel in which there is plenty of oxygen to produce water and carbon dioxide
7. a very fast chemical reaction that takes place between oxygen and a fuel
8. the chemical symbols for ions, atoms or molecules
9. energy required to start a chemical reaction
10. a law that states that matter cannot be created or destroyed, only changed
11. the amount of reactants added to the chemical reaction
12. the two atoms, ions or molecules that interact during a chemical reaction
14. matter that gives off energy when it burns

Be certain to go over your definitions for the test!!!

Chapter 29

By far, one of the most important elements on the periodic chart is carbon. Why is carbon so important?

Carbon is found in all living things!

Carbon has the ability to bond with many different elements in many different ways. This is because carbon has four valence electrons. (If you remember, valence electrons are the number of electrons in the last orbital of each element.) This means that carbon can form four bonds with other elements.

Scientists call a compound that contains carbon an **organic compound** ("ore-gan-ick"). One of the most important organic compounds in the world is sugar ($C_6H_{12}O_6$). You may not know this, but sugar is made by plants during a chemical reaction called **photosynthesis** ("foto-sinth-ee-sis"). I'm sorry to tell you that humans cannot go through photosynthesis and make our own sugar...

But wouldn't that be cool?!?!?!

During photosynthesis, carbon dioxide (CO_2) reacts with water (H_2O) thanks to a little activation energy from the sun (or other lights). The products of this reaction are sugar ($C_6H_{12}O_6$) and oxygen gas (O_2). The chemical equation looks like this:

$$\text{Light} + 6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

Light	$6CO_2$	$6H_2O$	$C_6H_{12}O_6$	$6O_2$
Activation energy	Carbon dioxide	Water	Sugar	Oxygen

You can thank plants for this amazing reaction that gives us all our sweets!

Nearly every organism in the world uses the sugar created by plants to go through a different chemical reaction called **respiration** ("ress-pur-ay-shun"). Respiration is the opposite of photosynthesis...

...this reaction breaks down sugar into different products!

Once we start eating sugar, our bodies start to break down the sugar and use it for energy. (By the way, it's not just animals that go through respiration. Plants do this too! They need energy to grow and live as well!) The breakdown of sugar into energy is known as respiration.

During respiration, sugar and oxygen react together to produce carbon dioxide and water...

$$C_6H_{12}O_6 + 6O_2 \longrightarrow \text{Energy} + 6CO_2 + H_2O$$

Sugar | Oxygen | Carbon dioxide | Water

The energy that is created from respiration is what humans (and plants) use to grow, move, dance, play and eat pizza! As you can see, sugar is a very important organic compound for us!

So where do you find sugar in your food? The first thing you should learn is this...

SUGARS ARE FOUND IN MANY OF THE FOODS YOU EAT!

Since there are many different kinds of sugars, scientists call **all** sugars by different name, **carbohydrates** ("kar-bow-hi-drates"). Carbohydrates are organic compounds that are made of carbon, hydrogen and oxygen.

Don't forget! The carbon that is found in carbohydrates can form four bonds with other elements! Because of this fact, it is very easy for long chains of carbohydrates to bind together. Most of the foods you eat are really long chains of carbohydrates!

Some of these chains can have hundreds of sugar molecules bound together! This long chain is also known as...

Starch!

You can find **starch** in potatoes, pasta and cereals. That's right! These foods that come from plants are full of long chains of sugars. Plants store large amounts of starch as a food source to be used for respiration. In fact, a lot of the white part inside a potato (the part we make into mashed potatoes – yum!) is actually starch! Cool, huh?

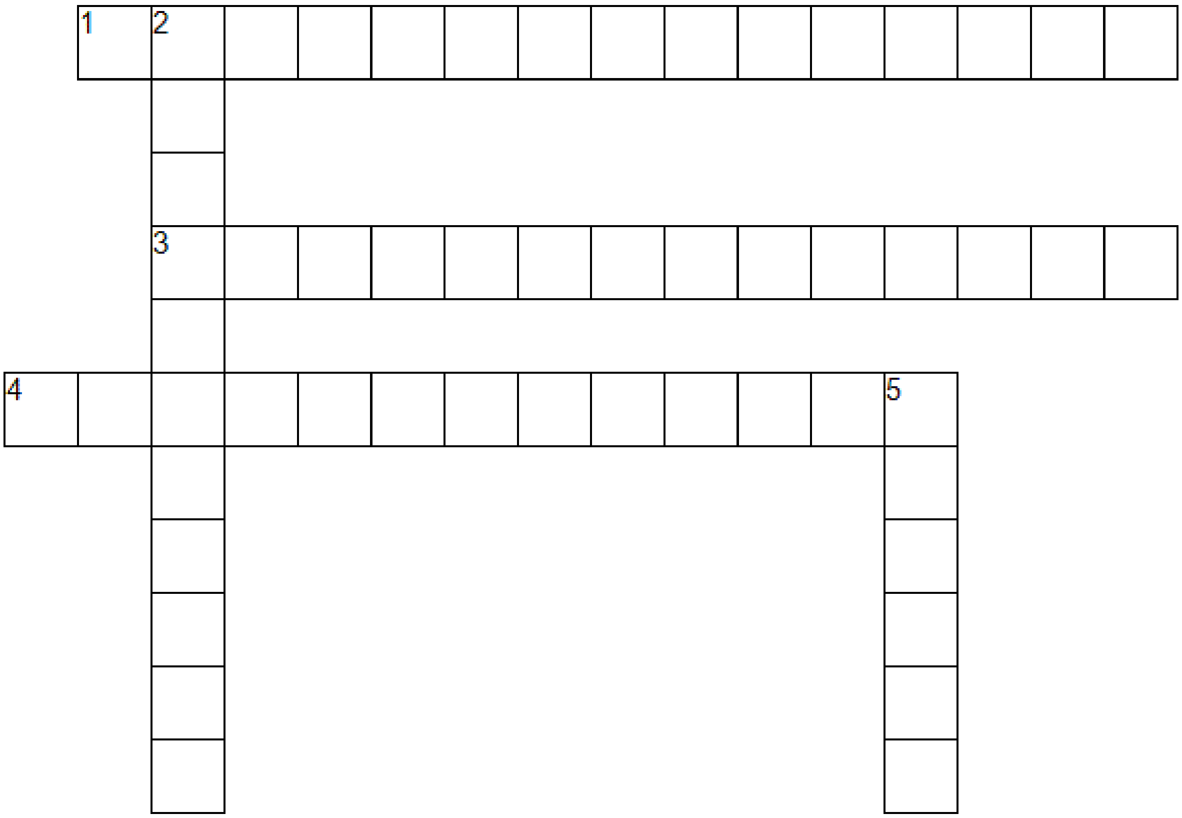
You may be asking yourself, "How are potatoes and pastas full of sugar, but they don't taste sweet?"

That is a good question! The individual organic compounds of sugar (like $C_6H_{12}O_6$) taste sweet. However, when these compounds are bound together into long chains of starch, our tongues cannot taste the sweetness of these sugars!

As your body breaks down starches in your food, the long chains are broken down into individual sugar molecules. Once these chains are split apart, your body can use the sugar molecules to go through respiration and create energy!

Carbohydrates are one of four organic compounds that most organisms need in order to survive! Next week, we are going to look at another organic compound that is just as important!

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

1. a compound that contains carbon
3. a chemical reaction in plants which produces sugar
4. organic compounds that are made of carbon, hydrogen and oxygen

DOWN

2. a chemical reaction in plants and animals in which sugar is broken down into energy
5. long chains of sugar molecules bound together

Use the definitions to fill in the missing letters.

1. _ t _ r _ _
2. p _ ot _ _ _ _ t _ es _ _
3. re _ _ _ _ _ _ i _ n
4. or _ _ n _ _ _ co _ p _ _ _ _
5. _ _ _ boh _ d _ _ _ e _

1. long chains of sugar molecules bound together
2. a chemical reaction in plants which produces sugar
3. a chemical reaction in plants and animals in which sugar is broken down into energy
4. a compound that contains carbon
5. organic compounds that are made of carbon, hydrogen and oxygen

Compare and Contrast the following vocabulary words:

Photosynthesis
Respiration

How are they the same? (Compare)

1. ____

____

2. ____

____

How are they different? (Contrast)

1. ____

____

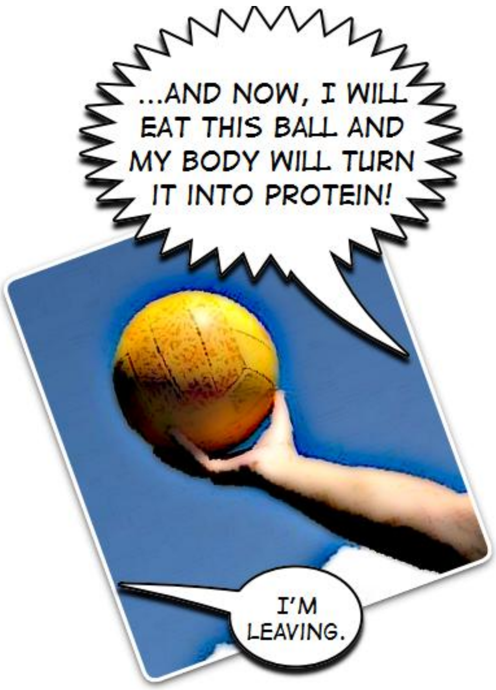
2. ____

____

Chapter 30

If you were to take all of the solids out of the cells in your body, half of all those solids would be a very important organic compound...

Protein!



There are thousands of different kinds of **protein** ("proh-teen") in the world! It is found in every living organism in the world! Plants can make their own protein from the carbon, hydrogen, oxygen, nitrogen (and sometimes sulfur, phosphorus and iron) in the ground and the air. We make our protein too! Every time you eat something, your body turns some of those compounds into new protein. So which compounds do our bodies use to make new protein?

Well, are only twenty different compounds that are used in the world to make protein and they are called **amino acids** ("ah-mee-no"). Amino acids bind together to make long chains.

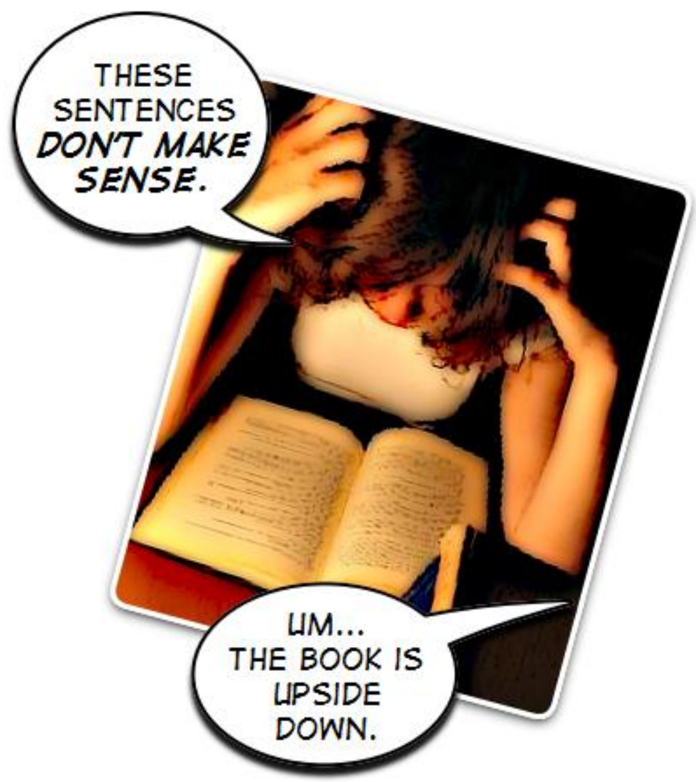
You may be asking yourself, "How can 20 different compounds make so many different proteins?"

I'll answer your question if you look at this sentence:

Proteins are made up of 50 to 3000 amino acids bonded together in a chain.

Would this sentence make sense if I rearranged the words to say...

50 proteins are made up of 3000 acids bonded together in to a amino chain.



I could rearrange the words in this sentence hundreds of times! And every sentence would say something different! This is how proteins work too! The function of a protein depends on the order of their amino acids!

But what are the functions of proteins?

Great question! There are many functions of proteins. Some of the most important ones are used to:

Allow our muscles to stretch

These kinds of proteins are called **contractile proteins** ("kon-tract-till") and are used in our muscles to the help them move!

Defend our body from diseases

Your body has an amazing set of proteins in your blood called **antibodies**. These proteins float around in your blood and if they find something that doesn't exist, they get rid of it! They also are very good at sealing up any cuts you have on your skin. That's right! These proteins help you to form scab! If you could not form a scab, you would not be able to stop bleeding.

(And I don't think I have to explain how bad that would be…)

You owe your life to these proteins!

Control chemical reactions

You learned in an earlier chapter that enzymes are created and used by your body to control chemical reactions. What you did not know is that these enzymes are a form of proteins! The really cool thing about enzymes is this... Once they get involved in a chemical reaction (as a reactant) they do not get broken down! This means they can keep reacting with other compounds without being used up! Cool, huh? Scientists call all compounds that can control a chemical reaction without being broken down a **catalyst** ("kat-ah-list").

Supply our bodies with food

Some proteins can be digested by our bodies to give us the food we need to survive. This is typically how a baby receives food from his or her mother before they are born!

Provide structure to our cells

Every time you run a brush through your hair, you are really just moving around long chains of protein! That's right! Your hair is made up of proteins! So are your fingernails! In fact, you would not be able to run a brush through your hair without another group of proteins known as **tendons**. Tendons are tough bands of proteins (like rubber bands) that connect your muscles to bones. Without tendons, you would be nothing more than a sack of muscles and bones and could not move at all!

Transport molecules throughout the body

Proteins are used as messengers throughout your body. One example of this is the protein **hemoglobin** ("he-mo-glow-bin"). This protein is found inside your red blood cells and is used to carry oxygen gas throughout your blood.

Proteins and carbohydrates are very important to your survival. But there are two more organic compounds that are just as important! Next week, you are going to learn about one of these important compounds!

Match the definitions with the correct words

1. ______________________ proteins used in our muscles to the help them move

2. ______________________ protein found inside red blood cells which is used to carry oxygen gas throughout the blood

3. ______________________ building blocks of protein which attach to themselves in long chains

4. ______________________ compounds that can control a chemical reaction without being broken down

5. ______________________ tough bands of proteins (like rubber bands) that connect your muscles to bones

6. ______________________ proteins in our blood which are used to defend us against disease

7. ______________________ long chains of amino acids found in all living things that is responsible for most functions of survival

Antibodies
Tendons
Protein
Hemoglobin
Catalyst
Amino acid
Contractile proteins

Use the definitions to unscramble the words below.

1. gobliemnho ______________________________
2. dnteons ______________________________
3. rctileactneinotospr ______________________________
4. tpeiron ______________________________
5. inoacimad ______________________________
6. tcysaatl ______________________________
7. ianstdbieo ______________________________

1. protein found inside red blood cells which is used to carry oxygen gas throughout the blood
2. tough bands of proteins (like rubber bands) that connect your muscles to bones
3. proteins used in our muscles to the help them move
4. long chains of amino acids found in all living things that is responsible for most functions of survival
5. building blocks of protein which attach to themselves in long chains
6. compounds that can control a chemical reaction without being broken down
7. proteins in our blood which are used to defend us against disease

Circle the hidden words from below:

j	x	o	v	j	x	o	u	w	b	w	e	c	c	n	a	j	g	o	p
t	v	t	e	n	d	o	n	s	o	l	u	i	r	m	s	q	u	k	n
p	c	o	n	t	r	a	c	t	i	l	e	p	r	o	t	e	i	n	s
y	i	a	s	c	q	b	f	c	d	c	j	v	p	g	x	q	b	b	u
e	d	c	h	f	u	h	g	u	z	b	m	z	d	a	s	e	c	q	m
i	j	p	k	d	i	u	u	j	z	h	g	o	v	p	h	w	d	a	m
i	o	q	o	p	o	m	m	m	e	z	p	g	c	w	e	m	d	t	s
x	b	r	x	o	q	o	t	b	i	z	r	b	a	m	m	j	k	m	k
a	n	t	i	b	o	d	i	e	s	d	o	t	t	z	o	p	s	p	o
o	a	o	j	l	r	s	v	m	n	o	t	i	a	e	g	h	b	u	d
k	x	x	b	f	f	f	v	g	g	r	e	a	l	d	l	o	m	r	b
g	b	d	i	r	h	h	o	c	a	c	i	g	y	y	o	y	e	v	a
l	u	t	c	a	d	v	s	r	s	y	n	l	s	t	b	z	v	y	z
a	m	i	n	o	a	c	i	d	l	j	t	p	t	u	i	w	y	c	h
t	k	s	p	k	z	s	q	i	d	m	v	q	v	a	n	o	l	m	x
v	d	i	c	h	b	c	i	h	h	t	n	p	c	n	r	u	w	k	t

protein

amino acid

contractile proteins

antibodies

catalyst

tendons

hemoglobin

Chapter 31

You learned in the first chapter of this unit that carbohydrates can be used as fuel to create energy for our bodies. Now it is time for you to learn about an even more powerful fuel...

Lipids!

Lipid is the scientific word for "fat". Like all organic compounds, fat is made up of carbon, hydrogen and oxygen! Our bodies store fat as a fuel to be used when we need energy. Before you explore how your body breaks down lipids, you should understand where we can find lipids in our food!

All of the oils we use in our foods are made up of lipids, so are the meats and dairy products too! Have you ever looked at a package of bacon before? If you have, you should be able to see that part of the meat is white. Well, that is a solid piece of fat that the pig had stored for extra fuel!

The butter you use to put on your pancakes is nothing more than fat that has been removed from cream or vegetables. That's right! Vegetables have fat in them too! Most of the seeds and nuts that you love to eat are filled with lipids! If you press these nuts, it is possible to remove their oils.

(By the way, oil and fat are the same things! The only difference is that at room temperature, an oil is liquid while fat is a solid.)

Most of the time, you hear about two different kinds of fats:

Saturated and **Unsaturated**

("satch-ur-ay-ted")

Saturated fat is different in several ways from **unsaturated fat.** However, the most important difference is this...

Saturated fats are solid at room temperature and unsaturated fats are liquid at room temperature.

So, the cooking oil you use is (mostly) an unsaturated fat. And the solid white matter that is attached to your uncooked piece of bacon is a saturated fat! You should know, however, that many of the foods we purchase are a mixture of both saturated and unsaturated fats! There are many reasons for this that we do not have time to study here!

But what is fat made of?

Great question! Fat is made up of two different compounds:

Fatty acids

and

Glycerol

("gliss-er-all")

Fatty acids are long chains of hydrocarbons (compounds made up of carbon and hydrogen atoms). **Glycerol** is a type of carbohydrate that is used to bind fatty acid chains together.

It takes three fatty acid chains bound together with glycerol to form one fat molecule, which is also known as a **triglyceride** ("try-gliss-ur-eyed"). The type of fatty acid chain (and there are a lot of different kinds!) allows the triglyceride to have different properties! (For example, what the fat will look like, or if it is going to be a liquid at room temperature, etc.)

You probably have heard a lot of bad things about fat, but the truth is...

Now I'm not saying it is okay to eat as much fatty foods as you can! But a little fat in your food is a good thing. Here's why...

1) Triglycerides (fat) help our bodies absorb important **vitamins** ("vite-ah-minz") into our blood. Vitamins are organic compounds that are used in small amounts to keep organisms healthy.
2) Triglycerides are needed in order to make new cell membranes for our bodies. (That's right! Our cells are covered in a thin layer of fat!)
3) Triglycerides can be stored in the body and broken down when there is a need for extra energy!

Fat gives our bodies twice as much energy as carbohydrates!

Again, I'm not saying that eating mountains of french fries are good for you!

It's not!

You only need a small amount of fat each day to keep your body running. All of the extra fat you eat gets stored in your body. And it will stay in your body until you need to use more energy. So don't go crazy with the fries!

Only one more organic compound to go! Next week, we look into the control center of a cell to see what chemicals our bodies need to survive!

Use the definitions to fill in the missing letters.

1. l _ _ _ d
2. u _ _ at _ r _ _ _ _ _ f _ t
3. g _ y _ _ _ _ l
4. _ _ _ t _ ac _ _ _
5. _ r _ _ _ y _ e _ id _
6. _ ita _ _ _ _
7. _ _ tur _ _ _ d _ f _ _

1. one of four organic compounds all living organisms need to survive; also known as fat
2. a fat which is liquid at room temperature
3. a type of carbohydrate that is used to bind fatty acid chains together
4. long chains of hydrocarbons bound to glycerol to make lipids
5. one lipid molecule which is made up of three fatty acids and one glycerol
6. organic compounds used in small amounts to keep organisms healthy
7. a fat which is solid at room temperature

Use the definitions to unscramble the words below.

1. cifaattyds ________________________
2. erglctridiye ________________________
3. uteatradfsat ________________________
4. ilidp ________________________
5. lygrolce ________________________
6. ivismtan ________________________
7. atatraufuntsde ________________________

1. long chains of hydrocarbons bound to glycerol to make lipids
2. one lipid molecule which is made up of three fatty acids and one glycerol
3. a fat which is solid at room temperature
4. one of four organic compounds all living organisms need to survive; also known as fat
5. a type of carbohydrate that is used to bind fatty acid chains together
6. organic compounds used in small amounts to keep organisms healthy
7. a fat which is liquid at room temperature

Circle the hidden words from below:

h	w	e	s	q	l	s	l	f	a	t	t	y	a	c	i	d	s	s	o
m	c	e	k	r	s	b	t	r	o	w	j	g	e	n	j	p	h	w	h
a	p	i	a	s	g	s	e	o	w	k	r	s	u	s	n	v	n	q	a
a	g	o	w	v	i	t	a	m	i	n	s	u	e	o	a	h	h	s	g
v	e	t	k	t	l	s	a	t	u	r	a	t	e	d	f	a	t	z	r
h	l	i	p	i	d	y	j	e	z	s	a	t	a	o	r	b	e	w	u
a	s	h	n	d	t	e	d	p	q	y	t	e	v	u	e	q	x	p	x
g	u	e	g	u	r	f	v	m	d	p	u	j	l	b	l	r	y	n	j
z	b	m	l	w	r	n	n	q	b	r	m	r	h	a	r	q	w	b	m
c	i	h	y	x	k	b	v	v	m	i	n	e	f	z	f	k	u	u	p
h	k	l	c	n	z	e	u	s	f	n	a	l	v	k	n	u	o	d	p
t	c	j	e	t	b	f	e	y	u	l	q	i	n	s	m	c	t	m	y
r	k	w	r	e	z	o	h	t	r	i	g	l	y	c	e	r	i	d	e
o	h	s	o	d	k	v	z	v	z	f	s	d	r	q	j	p	j	q	m
i	h	v	l	c	u	n	s	a	t	u	r	a	t	e	d	f	a	t	a
x	g	h	f	b	p	a	x	n	x	f	d	q	m	c	d	g	z	q	o

lipid

saturated fat

unsaturated fat

fatty acids

glycerol

triglyceride

vitamins

Chapter 32

Before we get started in this chapter, let's review the last three organic compounds you have studied so far:

Carbohydrates

Carbohydrates (also known as sugar) are used as fuel for a chemical reaction called respiration. During respiration, carbohydrates are broken down into energy which can be used by living organisms.

Proteins

Proteins are long chains of amino acids which help an organism complete many functions of life.

and

Lipids

Lipids are storage containers for chemical energy in living organisms and are used to build the membranes that surround cells.

Now it's time to learn about what controls all three of these organic compounds...

Nucleic acids!

("noo-klay-ick")

Nucleic acids are another type of organic compound that is found in all living organisms. These compounds are very large and are made up of carbon, oxygen, hydrogen, nitrogen and phosphorus. There are many different kinds of nucleic acids, but there is one that I'm certain all of you have heard about before...

I DON'T THINK NUCLEIC ACIDS ARE THAT DANGEROUS!

DNA

That's right! **DNA** is a nucleic acid! (That's what the "NA" stands for!)

All nucleic acids, including DNA, are made up of smaller compounds that are joined together to make this large organic compound. These smaller compounds are called **nucleotides** ("noo-klee-oh-tides").

There are four nucleotides that our bodies need in order to create DNA:

Thymine ("thy-meen")
Cytosine ("sigh-toe-seen")
Adenine ("add-neen")
and **Guanine** ("guah-neen")

Scientists have learned that these nucleotides only bind together in certain ways:

Adenine only binds with Thymine
and
Cytosine only binds with Guanine

Thousands of these nucleotides can bind together, forming long chains of DNA. That is very important! Why? Well, you have probably learned that your DNA is the "blueprints" or the "instruction book" of your cells. Both of those ideas are pretty true!

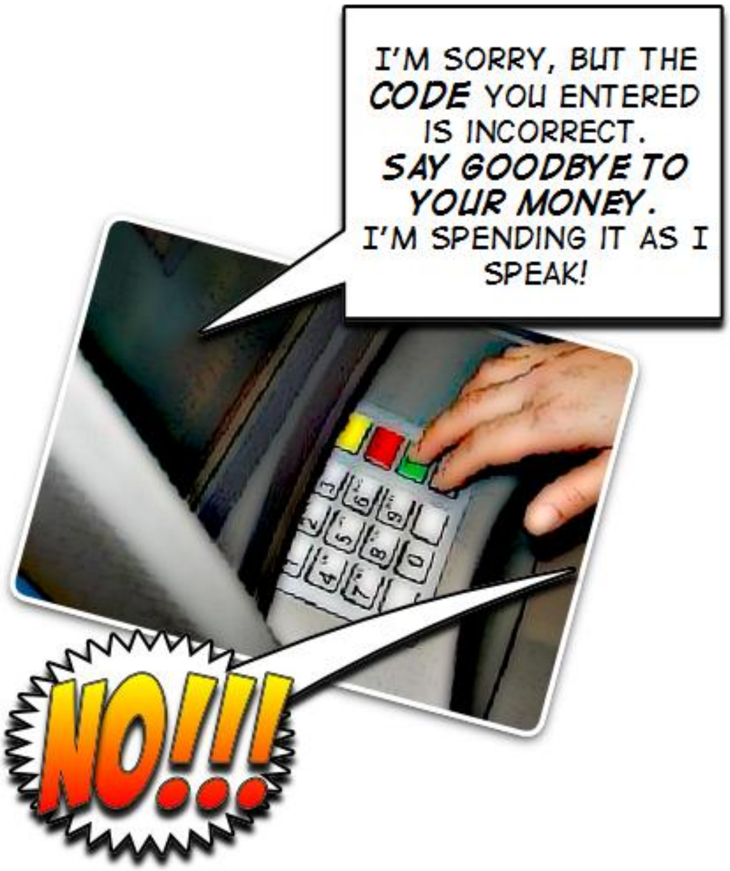
If DNA is a "blueprint" for how the cell is going to work, there needs to be a lot of information in this organic compound!

This is where it really gets cool!

If you remember, proteins have a lot of jobs inside organisms. They defend our cells from diseases, control chemical reactions, provide nutrition and structure to our cells and move compounds around our bodies. Each of these functions needs a different kind of protein, so...

It is the order of nucleotides in a DNA molecule that determines the order of amino acids in a protein!

This means our "blueprints" are really a code for what kind of protein a cell needs to make! Cool, huh?



But it keeps getting better! Every single organism on the planet has DNA. And many of these nucleic acids are very similar to each other! You and your mom and your dad all have an order of nucleotides that are very similar...

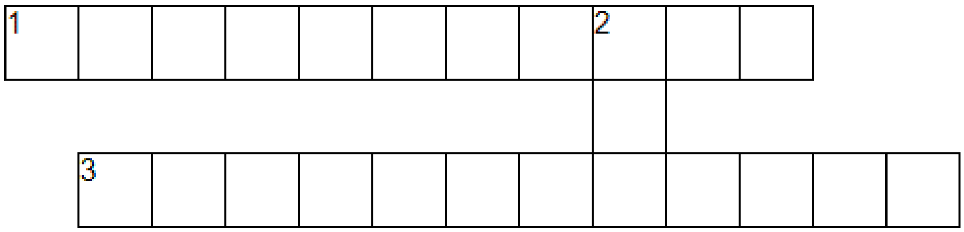
...but your order of nucleotides still has a few differences!

These differences keep you from being an identical twin to your parents!

Because of some really cool chemistry, a part of your DNA will be passed on to your children too! And their DNA will be a little different from yours!

Carbohydrates, proteins, lipids and nucleic acids are the four organic compounds that every living creature on the planet needs to survive! We may all look and act a little different, but it is our chemistry that makes us all connected to each other!

Place the answers to the following clues in the boxes below. Each box should contain one letter.



ACROSS

1. compounds that bind together to form long chains of nucleic acids; adenine, thymine, guanine and cytosine
3. organic compound found in all living organisms; created from long chains of nucleotides

DOWN

2. a type of nucleic acid; known as the "blueprint" or "instruction book" for a cell

Match the definitions with the correct words

1. ________________ organic compound found in all living organisms; created from long chains of nucleotides

2. ________________ compounds that bind together to form long chains of nucleic acids; adenine, thymine, guanine and cytosine

3. ________________ a type of nucleic acid; known as the "blueprint" or "instruction book" for a cell

Nucleic acids DNA

Nucleotides

Use the definitions to unscramble the words below.

1. otesclenidu ______________________________

2. nad ______________________________

3. uccnileidsac ______________________________

1. compounds that bind together to form long chains of nucleic acids; adenine, thymine, guanine and cytosine

2. a type of nucleic acid; known as the "blueprint" or "instruction book" for a cell

3. organic compound found in all living organisms; created from long chains of nucleotides

Unit 8 Review

Use the definitions to unscramble the words below.

1. itdtaayfcs ______________
2. ptoeirn ______________
3. eonlhogmbi ______________
4. teorradahcbys ______________
5. ineostirpra ______________
6. sotnldeiuec ______________
7. and ______________
8. tonpsyeoitsshh ______________
9. rylolecg ______________
10. dinaocaim ______________
11. yederlictigr ______________
12. ylatatsc ______________
13. tttufdasarea ______________
14. tenodsn ______________
15. mvsitain ______________
16. csarth ______________
17. tiaiobsedn ______________
18. ttsatarudfnaue ______________
19. iidpl ______________
20. enciuicdscla ______________
21. ouogccamndpnroi ______________

1. long chains of hydrocarbons bound to glycerol to make lipids
2. long chains of amino acids found in all living things that is responsible for most functions of survival
3. protein found inside red blood cells which is used to carry oxygen gas throughout the blood
4. organic compounds that are made of carbon, hydrogen and oxygen
5. a chemical reaction in plants and animals in which sugar is broken down into energy
6. compounds that bind together to form long chains of nucleic acids; adenine, thymine, guanine and cytosine
7. a type of nucleic acid; known as the "blueprint" or "instruction book" for a cell
8. a chemical reaction in plants which produces sugar
9. a type of carbohydrate that is used to bind fatty acid chains together
10. building blocks of protein which attach to themselves in long chains
11. one lipid molecule which is made up of three fatty acids and one glycerol
12. compounds that can control a chemical reaction without being broken down
13. a fat which is solid at room temperature
14. tough bands of proteins (like rubber bands) that connect your muscles to bones

15. organic compounds used in small amounts to keep organisms healthy
16. long chains of sugar molecules bound together
17. proteins in our blood which are used to defend us against disease
18. a fat which is liquid at room temperature
19. one of four organic compounds all living organisms need to survive; also known as fat
20. organic compound found in all living organisms; created from long chains of nucleotides
21. a compound that contains carbon

Be certain to go over your definitions for the test!!!

Chapter 33

In science, there are many ideas that are not completely understood by many people. Sometimes, people have a hard time understanding scientific concepts because they believe they are too difficult. At other times, people have a hard time letting go of old ideas and legends. But there is always one thing that is true...

Science is always changing as people discover new things about the universe!

In this unit we are going to look at some of these myths about chemistry! Here's the first one...

MYTH #1 Atoms can be seen with a microscope.

Sorry. But this is not true. Scientists do not have microscopes that are powerful enough to see atoms. Some of these microscopes can see a lot of cool things, but you need to know how large an atom really is...

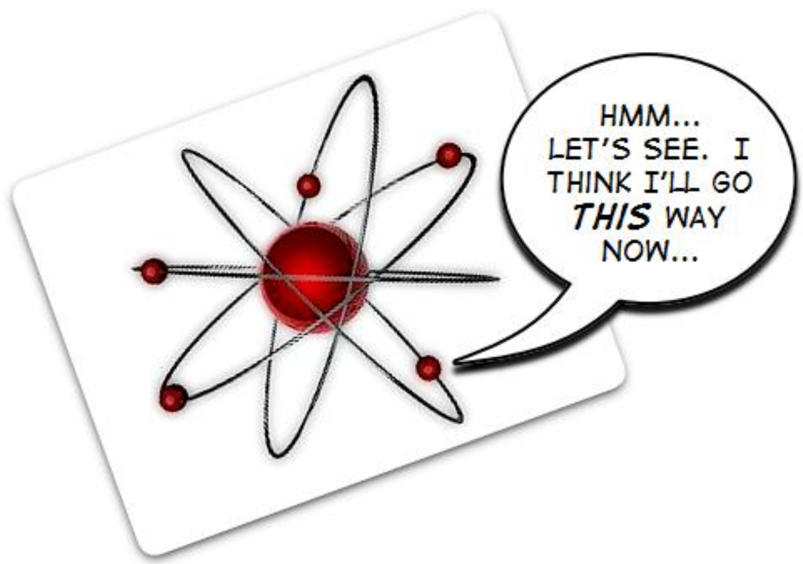
First of all, go to your bathroom and find a brush or comb. Can you see at least one hair? Good! It's pretty tiny, isn't it? Well…

…you could put over one million atoms next to each other and it would be just as wide as that hair!

That's right! 1,000,000 atoms!

MYTH #2 **Atoms have electrons circling them like planets around a star.**

First of all, electrons do not follow the same path around the nucleus. Scientists call an electron's path around the nucleus an orbital. This is because the electrons can be found anywhere inside



this area as they "orbit" the nucleus. This brings up another myth about electrons…

MYTH #3

Electrons never leave the nucleus they are orbiting.

Let's get something straight... the electrons that are in orbit around an oxygen nucleus are the same as the electrons that orbit a nitrogen nucleus, and a carbon nucleus, and so on...

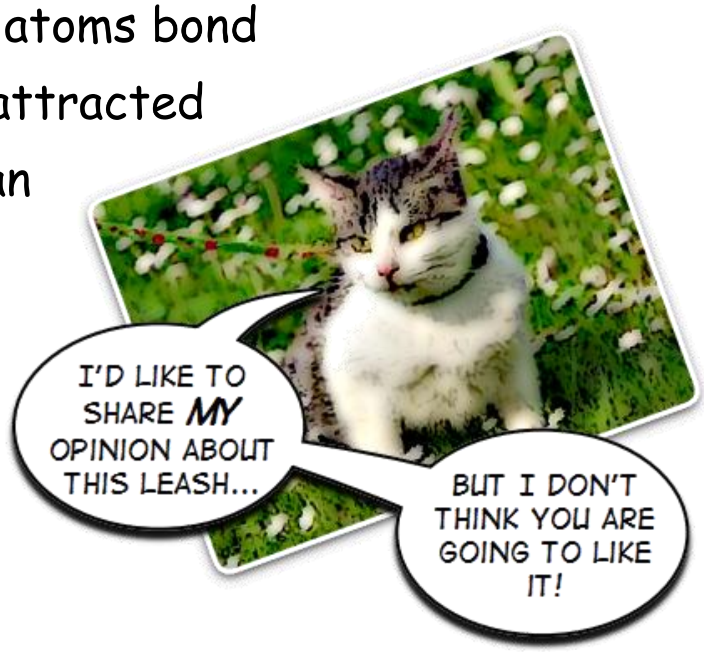
Electrons are the same for every element!

Not only are all electrons the same, but elements do not hold onto their electrons all of the time! As you learned in earlier chapters, electrons can be gained, shared or given away when atoms bond together.

MYTH #4

Electrons are equally shared in covalent bonds.

This is totally wrong! When some atoms bond together, electrons may be more attracted to one atom than another. This can happen if the size of the atoms in the compound is much different from each other.



For example, the size of an oxygen atom is much larger than hydrogen in a molecule of water. Because of this, when hydrogen atoms and oxygen share their electrons to make a water molecule, they tend to move towards the oxygen molecule. This makes the oxygen molecule have more of a negative charge as the electrons are found more around this atom.

Now here is another funny myth...

MYTH #5 Molecules of solids are larger than molecules of gases.

This myth is believed by people all the time! But you know better! Never forget that the shape, size and mass of a molecule does not change as matter changes between a solid, liquid and gas.

Just because you see a collection of molecules change from a solid to a liquid, does not mean that the atoms change too!

When you were learning how atoms can change their state, you were asked to imagine a bucket of tennis balls as atoms. Depending on how much energy you use to move the bucket, the "tennis balls" changed from a solid to a liquid and finally into a gas. But the big question is...

Did the tennis balls (atoms) ever grow larger?

No way!

The tennis balls may have moved their speed or location in the bucket, but the tennis balls never changed their shape! This is the same with atoms that make up solids, liquids and gases! If you remember, this fact is what makes up the Law of Conservation of Matter...

Matter cannot be created or destroyed, only changed!

I know that YOU understand all of this information. But not everyone is so lucky! Next week, we are going to look at a few more myths. This time, we will be studying myths about chemical reactions! Stay tuned!

All of these statements are completely false! Explain why they are so wrong!

Atoms can be seen with a microscope.

Atoms have electrons circling them like planets around a star.

Electrons never leave the nucleus they are orbiting.

Electrons are equally shared in covalent bonds.

Molecules of solids are larger than molecules of gases.

Chapter 34

You learned last week that there are many myths about atoms and molecules. There are myths about everything in science!

But if you keep studying, you can learn the difference between myths and truths!

In this chapter, you are going to look at myths about chemical reactions. But do not worry, if you study this chapter very hard you can help others understand the truths about chemical reactions. Let's get started!

MYTH #6 Chemical bonds store energy and breaking bonds release energy.

Chemical bonds do not **store** energy! Think about what it takes to form an ionic or covalent bond...

Electrons must be given away, taken or shared between atoms!

What is most important is that matter is not being created when bonds are being formed. So where would energy be stored? That's right... it's not!

Energy is released during an exothermic reaction (like when you burn wood). However...

...not all chemical reactions release energy!

During endothermic reactions, energy is absorbed! This takes place when you mix baking soda and vinegar together to make carbon dioxide gas. When the bonds of baking soda and vinegar are broken, energy is needed to produce the carbon dioxide gas! This energy (in the form of heat) is absorbed from the air and the container which holds the reactants.

I hope that makes sense because here's another myth:

MYTH #7 Energy is used up or created during chemical reactions.

It is a fact that energy cannot be created or destroyed, only changed. Does that sound familiar? It should! Because this is almost the same as the Law of Conservation of Matter! Not only is **matter** not created or destroyed, so is the amount of **energy** in our universe!

Cool, huh?

How can energy be changed?

Well, we use gasoline (chemical energy) burn a fuel (thermal energy) to run our cars (mechanical energy). During this process, some of this energy is released as heat (thermal energy) from the engine.

MYTH #8

Freezing and boiling are examples of chemical reactions.

The freezing and boiling of molecules are **physical** reactions and not **chemical** reactions. This goes back to our story of the tennis balls within the bucket. As you add energy to the bucket by shaking it, the tennis balls start to move around. This is the same as when heat is added to a solid which causes it to melt.

Did any of the tennis balls stick to each other? Or did they change into different shapes?

No way!

MYTH #9 Physical changes are reversible while chemical changes are not.

This myth is believed by many people! It is important you understand that both chemical and physical changes can be reversed!

You already know that physical changes can be reversed. I'm certain all of you know that you can freeze liquid water into ice, melt the ice into liquid water and refreeze it again.

But how are chemical changes reversed?

Let's use water as an example to answer this question. As you have already learned, water is a compound of two hydrogen atoms and one oxygen atom (H_2O).

The chemical equation for the creation of water is:

$$2H + O \longrightarrow H_2O$$

However, it is possible to split water back into its reactants. All you need to do is add a little activation energy (in the form of electricity) to the water to start the reaction!

$$H_2O \longrightarrow 2H + O$$

This is just one example of how chemical reactions can be reversed! Since we cannot create or destroy atoms, it is possible to reverse every chemical reaction.

(But it wouldn't be very easy for some of them. Can you imagine trying to reverse a chemical reaction that involves the burning of wood? That would be very hard!)

Great job! In the next chapter, you are going to explore a few more myths about chemistry. Stay tuned!

All of these statements are completely false! Explain why they are so wrong!

Chemical bonds store energy and breaking bonds release energy.

____

____

____

____

Energy is used up or created during chemical reactions.

____

____

____

____

Freezing and boiling are examples of chemical reactions.

Physical changes are reversible while chemical changes are not.

Chapter 35

Oh, we are not done yet! There are all kinds of myths out there about chemistry! Let's not waste any time...

MYTH #10 The reactants of a chemical reaction completely disappear.

First of all, can anything in the world completely disappear?

I hope you said NO!

You have learned several times throughout this book about the Law of Conservation. The reactants of a chemical reaction cannot disappear because...

Matter cannot be created or destroyed, only changed!

The reactants of a chemical reaction can be formed again from its products. **This is because chemical reactions can be reversed!**

Now it might take a lot of extra energy to break the new bonds in the products. And, it could take even more energy to form the bonds within these atoms to create reactants again...

...but it can be done!

Okay, on to our next myth:

MYTH #11 Gas molecules weigh less than solid molecules.

You may think this is true if you didn't know anything about atoms. It is very easy to see solids, right? They are everywhere! But it is not always so easy to see gases. Is this because the atoms that make up gases are invisible? **No way!**

Atoms are so tiny that we cannot see them at all! Just because you can't see something does not mean it's not there.

The atoms and molecules that make up gases are the same pieces of matter that can make up solids and liquids too! For example, we could take your car and heat it up so much that all of its atoms separate and turn into a gas!

That's right!

We could evaporate your car with enough heat!

Each of these floating atoms (that used to be your car) has the same weight as they did when they were a part of a solid. A change of state does not change the weight of a molecule.

There's another myth that a lot of people have that is very close to Myth #12...

MYTH #12 Molecules of solids are hard and molecules of gases are soft.

Are the floating atoms of your (former) car harder when they are bonded together? Of course not!

Think about our story about the bucket of tennis balls. When we shake the tennis balls so hard that they fly out of the bucket, do these balls get softer as they fly through the air?

Ha ha ha ha!!! No way!

You know that!

Okay, let's take a look at a myth about acid and bases...

MYTH #13

Molecules containing hydrogen (H) are acidic and molecules that contain oxygen-hydrogen (OH) are basic.

Many solutions contain hydrogen and OH but are not an acid or a base. For example, let's look at sugar. Have you ever looked at sugar very closely? It is made up of tiny pieces of white crystals. Each one of those crystals contains many molecules of sugar that are bonded together.

When you dissolve sugar in water, the water molecules pull an **entire** molecule of sugar ($C_6H_{12}O_6$) away from other sugar molecules.

$$\underset{\text{Sugar}}{C_6H_{12}O_6} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Sugar}}{C_6H_{12}O_6} + \underset{\text{Water}}{H_2O}$$

Do you see anything odd about this? That's right! The sugar does not break apart into hydrogen ($H+$) or hydroxide ($OH-$) ions! (A solution with extra hydrogen ions is an acid; while a solution with extra hydroxide ions is a base.)

As you can see, not every solution that has hydrogen atoms or oxygen-hydrogen atoms are acids or bases!

All of these statements are completely false! Explain why they are so wrong!

The reactants of a chemical reaction completely disappear.

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Gas molecules weigh less than solid molecules.

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Molecules of solids are hard and molecules of gases are soft.

Molecules containing hydrogen (H) are acidic and molecules that contain oxygen-hydrogen (OH) are basic.

Chapter 36

In this last chapter, we are going to look at five more myths about chemistry. You have been doing an excellent job so far! You should be proud of yourself!

I hope you are ready. Here we go!

MYTH #14 Boiling points are the same for all elements and molecules.

In order to crush this myth, you need to remember this...

1. The boiling point of elements is the temperature in which a liquid starts to turn into a gas.
2. The atoms of elements form bonds between each other very well.
3. The liquid must be heated enough to break the bonds between the atoms in order to form a gas.

But why does each element have a different boiling point? Well, the boiling point is a measure of how strong the atoms are held together! Molecules that are held together more strongly will need more heat energy to break their bonds and begin to boil. The boiling point of the compound table salt (NaCl) is different from its individual atoms of sodium (Na) and Chloride (Cl).

MYTH #15 Bubbles in boiling water contain air, oxygen or nothing at all.

If you have ever watched water boil before, you should have seen bubbles moving through the water. Many people do not understand what are inside these bubbles. Some people think these bubbles are filled with oxygen gas, others may say the bubbles are filled with "air" or even nothing at all! But none of these people are correct!

So what is found inside those bubbles? **More water!**

Actually, it is water that is in the form of a gas! As the liquid heats up, the water molecules vibrate so much they break the hydrogen bonds that bind the molecules together. As the molecules move away from the liquid, they begin to form a bubble of gas. This gas floats to the top of the water where the molecules escape into the air!

Since we are talking about gases, let's look at another myth about gas...

MYTH #16 The molecules of gas always spread out and fill up its container.

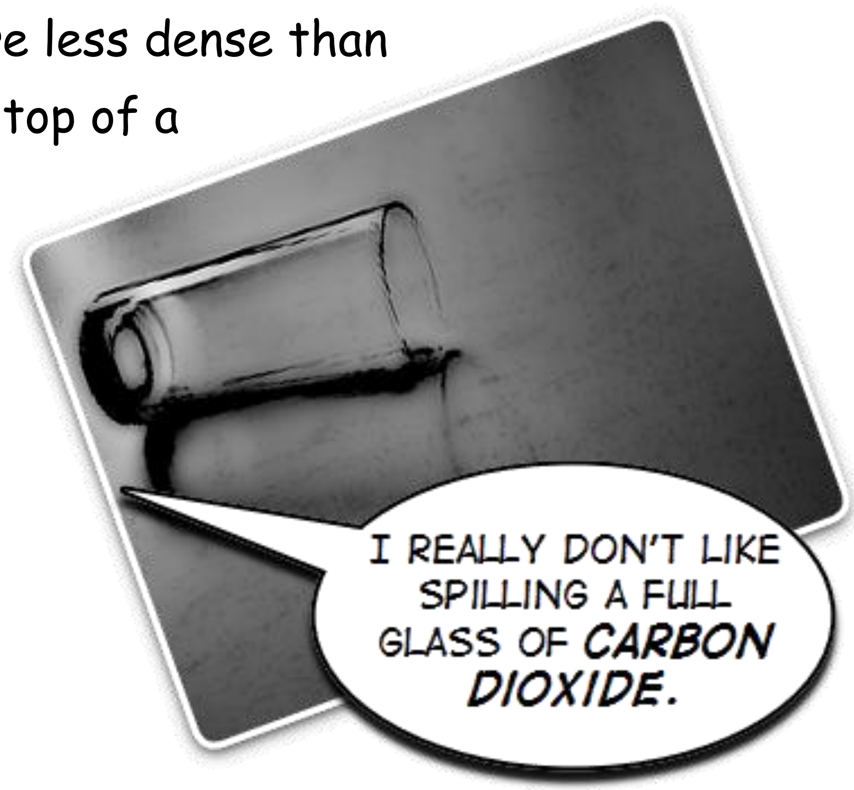
Gases are made up of fast-moving atoms, but many of them have some of the same properties of liquids. Some gases (like carbon dioxide) have a greater density than the air.

(Density is the amount of atoms that can be found in an object. In this case, the "object" is the bubble of gas.)

Because of its high density, carbon dioxide can be poured into a container (just like pouring water from a glass!) Once inside the container, the gas will settle towards the bottom.

Other gases (like helium) are less dense than the air and will float to the top of a container.

So you see, not all gases will spread out to fill up a container!



Density can be used to solve another myth about atoms...

MYTH #17 Objects float in water because they are lighter than water.

There are lots of ways you can prove this myth is wrong. The problem with this myth is the use of the word "lighter". Objects that float (or sink) in water have nothing to do with their weight. If that was the case, every large ship on the ocean would sink to the bottom all the time!

Let's think about the bubbles of gas that is created in our pot of boiling water. As the bubbles were formed, did they stay within the pot? Nope! They started to move towards the top of the liquid! This is because the density of the gas bubble was less than the density of the liquid water.

This should make sense to you!

Think about it! The molecules that make up liquid water are the same as those in the gas. Since the bubble of gas contains water molecules that are more spread out than is found in the liquid water, the bubble's density is lower. Since its density is lower, it floats to the surface of the water.

The study of chemistry is a very important job for many people around the world! Atoms and molecules affect everything in our lives and the scientists that understand these tiny pieces of matter have a very important job! Maybe you can be a chemist too someday. I hope you will! We always need good chemists! Take care!

All of these statements are completely false! Explain why they are so wrong!

Boiling points are the same for all elements and molecules.

Bubbles in boiling water contain air, oxygen or nothing at all.

The molecules of gas always spread out and fill up its container.

Objects float in water because they are lighter than water.

Unit 9 Review

Which one is right? Circle the correct answer.

1. Which of the following is true:
   a. Electrons orbit the nucleus of an atom
   b. Electrons follow the same path around the nucleus of an atom
   c. Electrons stay with the same nucleus all the time

2. Which of the following take place when a molecule changes from a solid to a liquid:
   a. The size and shape of molecules change
   b. The shape and mass of molecules change
   c. The size, shape and mass do not change at all

3. ___________ cannot be created or destroyed, only changed.
   a. Energy
   b. Matter
   c. Matter and energy

4. Gas molecules weigh _________ compared to solid molecules.
   a. More
   b. Less
   c. The same

5. The bubbles inside boiling water contain ______________.
   a. Air
   b. Oxygen
   c. Water (gas)

Glossary

Acid	a solution that contains a high amount of Hydrogen ions
Activation energy	("ack-tih-vay-shun"); energy required to start a chemical reaction
Activation energy	energy required to start a chemical reaction
Alkali metals	("al-kah-lie"); metals in the first family of the periodic table (except for hydrogen) which are shiny, malleable and have high reactivity

Alkaline metals	("al-kah-line"); metals in the second family of the periodic table which are grey or white in color, not very malleable at all and have a lower reactivity than the first family of metals
Alloy	("al-oi"); a combination of two or more metals (or other elements) together to form a different kind of metal
Alpha particle	one of three atomic particles; made up of two protons and two neutrons
Americium-241	("ah-mare-eh-see-um"); radioactive isotope used in smoke detectors
Amino acid	("ah-mee-no"); bind together to form long chains; building blocks of protein

Antibodies	proteins in our blood which are used to defend us against disease
Atom	the building blocks of the universe
Atomic mass	average mass of the protons and neutrons for an element and all its isotopes
Atomic number	the number of protons in the nucleus of an atom
Atomic particles	three different "pieces" of matter that fall off of isotopes that are radioactive
Base	a solution that contains a high amount of Hydroxide ions
Beta particle	one of three atomic particles; a super fast electron created from a nuclear reaction

Blood	a solution of several compounds responsible for life to exist
Brass	alloy of the elements copper and zinc
Bronze	alloy of the elements copper and tin
Buffers	a group of many different compounds that float around in the blood and help to keep its pH between 7.2 and 7.6
Burning	a chemical change in which elements inside wood combine with oxygen to form ashes and smoke
Carbohydrates	("kar-bow-hi-drates"); organic compounds that are made of carbon, hydrogen and oxygen; used as fuel for respiration

Carbon	("kar-bon"); a nonmetal in family 14 that gains or shares four electrons during a reaction
Carbon dioxide gas (CO_2)	waste product of human bodies
Carbon monoxide	a gas without smell or color which is made up of one carbon atom bonded with one oxygen atom; this gas is very dangerous to living organisms
Catalyst	("kat-ah-list"); compounds that can control a chemical reaction without being broken down
Chain reaction	a process in which one neutron sets off a huge amount of fission reactions

Charcoal	wood that has been heated up so much that it does not have any more smoke to give off
Chemical bond	another name for "chemical energy"
Chemical bond	the force that holds two atoms together; also known as "chemical energy"
Chemical change	a change in matter in which a new kind of matter, with brand new properties, is formed
Chemical energy	the energy that holds two or more atoms together
Chemical equation	a way for scientists to identify chemical reactions which involve chemical formula in the form of reactants and products

Chemical formulas	the chemical symbols for ions, atoms or molecules
Chemical properties	the characteristics of objects that can change such as through burning or rusting
Chemical symbol	one or two letters in the alphabet that identifies one element in the periodic table
Chemistry	("kem-iss-tree"); the study of matter and how it changes
Chromium	("kroh-me-um"; Atomic Number 24); used in the making of stainless steel as it prevents iron from turning into rust
Cobalt-60	("ko-balt"); radioactive isotope used to clean the tools doctors use in surgery

Colloid	("kahl-oyd"); a mixture in which not all of the solute can be dissolved by the solvent; the undissolved solute is still very small
Combustion	("kom-bust-shun"); a very fast chemical reaction that takes place between Oxygen and a fuel
Complete combustion	("kom-bust-shun"); a very fast chemical reaction that takes place between oxygen and a fuel in which there is plenty of oxygen to produce water and carbon dioxide
Compound	("kom-pownd"); two or more different atoms joined together

Concentrated solution	("kon-sen-tray-ted"); a solution that contains a lot of dissolved solute
Concentration	("kon-sen-tray-shun"); the amount of reactants added to the chemical reaction
Condensation	("kon-den-say-shun"); the process in which a gas turns back into a liquid
Conductive	("kon-duck-tiv"); a physical property of solids that can transfer electricity, heat or sound very easily
Contractile proteins	("kon-tract-till"); proteins used in our muscles to the help them move

Corrosive	("ko-row-siv"); description given to strong acids and/or bases as they can react with many different materials causing them to break apart very quickly
Covalent bond	("koe-vale-ent"); a bond shared between atoms that shares electrons with each other
Density	("den-city"); the amount of atoms that can be found in an object
Deuterium	("doo-teer-ee-um"); an isotope of hydrogen with one proton and one neutron

Digestion	("di-jest-shun"); the process of breaking down food into smaller, easy-to-dissolve pieces that your body can use to survive
Dilute solution	a solution that can easily dissolve more solute
DNA	a type of nucleic acid; known as the "blueprint" or "instruction book" for a cell
Double bond	covalent bond in which two electrons are shared between atoms
Ductile	("duck-tull"); physical property of solids that can be pulled into the shape of a wire

Electron	("ee-leck-trahnz"); small piece of an atom with a negative charge that sits inside the nucleus
Elements	("ell-uh-ments"); a single atom or groups of atoms with the same number of protons in their nucleus
Endothermic reaction	("en-doh-thur-mik"); a chemical reaction in which thermal energy is being absorbed by the new form of matter
Energy	the ability to do work, or move things around
Enzymes	("en-zimes"); proteins made by the body to help in chemical reactions

Exothermic reaction	("ex-oh-thur-mik"); a chemical reaction in which thermal energy is being released by the new form of matter
Family	a column of elements on the periodic table; each contains similar chemical and physical properties of elements
Fatty acids	long chains of hydrocarbons bound to glycerol to make lipids
Fertilizers	("fur-till-eyes-erz"); chemicals used to help plants grow!
Fission	("fizz-shun"); process of splitting the nucleus of an element by striking it with a moving neutron

Freezing point	temperature at which liquids turn into solids
Friction	("frick-shun"); heat from two objects rubbing together
Fuel	matter that gives off energy when it burns or is broken down
Fusion	("fewz-shun"); the process of creating heavier atoms by joining two smaller nuclei
Gamma radiation	one of three atomic particles; the energy that is given off during a nuclear reaction
Gas	a group of atoms that have no fixed volume or shape
Glycerol	("gliss-er-all"); a type of carbohydrate that is used to bind fatty acid chains together

Gram	unit of measurement for weight and mass
Gravity	a force that pulls objects towards each other
Halogens	("hal-oh-gens"); nonmetal elements in family 17 (Fluorine, Chlorine, Bromine, Iodine and Astatine) that gains or shares one electron during a reaction
Helium	("hee-lee-um"); a gas which is less dense than air
Helium-3	an isotope of helium with two protons and one neutron
Helium-4	an isotope of helium with two protons and two neutrons

Hemoglobin	("he-mo-glow-bin"); protein found inside red blood cells which is used to carry oxygen gas throughout the blood
Hydrocarbon	a compound made with only carbon and hydrogen atoms
Hydrogen	("hi-droe-jen"); an element with only one proton in its nucleus
Hydrogen bond	bonds take place between hydrogen atoms and a handful of atoms that can gain electrons from other atoms
Hydroxide ion	an ion that is made up of an Oxygen and Hydrogen atom which holds onto one extra electron

Incomplete combustion	a very fast chemical reaction that takes place between oxygen and a fuel in which there is not enough oxygen to produce water and carbon dioxide
Ionic bond	("i-ahn-ick"); the bonding of a positive and negative ion by the gaining and releasing of electrons
Ionic compound	a compound formed by an ionic bond between positive and negative ions
Iron	a transition metal (Atomic Number = 26) that has is magnetic and is used to create the alloy called steel

Isotopes	atoms with the same number of protons but a different number of neutrons
Krypton-85	(“krip-tawn”); radioactive isotope used in small lights found on appliances
Law of Conservation	a law that states that matter cannot be created or destroyed, only changed
Light energy	light
Lipid	one of four organic compounds all living organisms need to survive; also known as fat
Liquid	a group of atoms that have a fixed volume but its shape changes with the shape of its container
Lungs	the “gas tanks” of your body

Malleable	(“mal-ee-uh-bull”); a physical property of solids that can be hammered or rolled into a flat sheet
Mass	the measurement of how much matter there is in an object
Matter	the name for all of the solids, liquids and gases in the universe
Melting point	temperature at which solids turn into liquids
Metalloids	(“met-ahl-oidz”); elements that have chemical and physical properties of both metals and nonmetals; these elements conduct electricity only at certain temperatures or in certain amounts of light

Metallurgists	("meh-tall-ur-jists"); scientists who study new ways to mix metals together
Mixture	a group of two or more substances that are mixed together
Mixture	adding together two items that do not dissolve into each other
Molecule	("maul-ee-koo-el"); two or more atoms joined together
Negative ion	("i-ahn"); an atom with more electrons (-) than protons (+)
Neutral atom	an atom with an equal number of protons and electrons
Neutron	("noo-trahn"); small piece of an atom that no charge and sits inside the nucleus

Nitrogen	(“nigh-trow-gen”); a nonmetal in family 15 that gains or shares three electrons during a reaction
Noble gases	Nonmetal elements in family 18 that do not react with any other elements in the periodic table
Nonmetals	elements that have the opposite physical and chemical properties of metals; most are gases; solid nonmetals are dull, brittle and not conductive
Nuclear energy	(“nuke-lee-er”); the amount of energy that holds an atom together
Nuclear fuel	different isotopes of elements that can be broken apart through fission

Nuclear reaction	a reaction involving a change in the nucleus of an atom; examples include fission and fusion
Nucleic acids	(“noo-klay-ick”); organic compound found in all living organisms; created from long chains of nucleotides
Nucleotides	(“noo-klee-oh-tides”); compounds that bind together to form long chains of nucleic acids; adenine, thymine, guanine and cytosine
Nucleus	(“new-klee-us”); combination of protons and neutrons within every atom
Orbital	(“or-bit-uls”); a layer of electrons that spins around the nucleus

Organic compound	("ore-gan-ick"); a compound that contains carbon
Oxygen	("ox-ee-jen"); an element with six protons in its nucleus
Oxygen	("ox-ee-gen"); a nonmetal in family 16 that gains or shares two electrons during a reaction
Periodic table	an arrangement of all the elements that have been discovered
Phosphorus	("foss-for-us"); a nonmetal in family 15 that gains or shares three electrons during a reaction
Photosynthesis	("foto-sinth-ee-sis"); a chemical reaction in plants which produces sugar

Physical change	the act of changing the state of matter; a reversible change in matter
Physical properties	("fizz-eh-kull"); the characteristics of objects that stay the same such as color, shape and size
Plasma	("plaz-mah"); the fourth state of matter which is made of a mixture of free electrons and nuclei
Plutonium	("plew-tone-ee-um"); one of several radioactive elements; an isotope of this element (Pu-239) is commonly used as a nuclear fuel

Polar	uneven sharing of electrons within molecules which cause some of its atoms to have a positive charge and others to have a negative charge
Positive ion	("i-ahn"); an atom with fewer electrons (-) than protons (+)
Pressure	the measurement of how hard atoms of gas push on the walls of its container
Products	any new ion or molecule that is created as a result from a chemical reaction
Protein	("proh-teen"); long chains of amino acids found in all living things that is responsible for most functions of survival

Protium	("pro-tee-um"); an isotope of hydrogen that is made up of only one proton and no neutrons
Proton	("pro-tahn"); small piece of an atom with a positive charge that sits inside the nucleus
Radioactivity	("ray-dee-oh-ack-tiv-eh-tee"); the release of energy and atomic particles during a nuclear reaction
Reactants	("ree-act-ants"); the two atoms, ions or molecules that interact during a chemical reaction
Reaction	the interaction of two or more ions, atoms or molecules
Reactivity	the ability and speed that atoms have in bonding with other atoms

Respiration	("ress-pur-ay-shun"); a chemical reaction in plants and animals in which sugar is broken down into energy
Room temperature	the normal temperature of the air that we, as humans, are used to
Saliva	("sah-live-ah"); fluid in your mouth; also known as "spit"
Saturated fat	("satch-ur-ay-ted"); a fat which is solid at room temperature
Saturated solution	("sa-ture-a-ted"); a point when you cannot dissolve any more solute inside a certain amount of solvent

Selenium	("seh-len-ee-um") ; a nonmetal in family 16 that gains or shares two electrons during a reaction
Semiconductors	the ability of metalloids to conduct electricity only at certain temperatures or in certain amounts of light
Small intestines	("en-test-tinz"); location in the body where food is small enough to pass into the blood
Solid	a group of atoms that have a fixed shape and a fixed volume
Solubility	("sahl-yoo-bill-itee"); a measurement of how much solute can dissolve in a solvent
Solute	("sahl-oot"); a molecule that is dissolved by the solvent in a solution

Solution	("sow-loo-shun"); when a solute mixes together so well that you cannot see it anymore in the solvent
Solvent	("sahl-vent"); a molecule that is dissolving the solute in a solution
Stainless steel	alloy of the elements iron and chromium
Starch	long chains of sugar molecules bound together
States of matter	a solid, liquid, gas or plasma
Steel	alloy of the elements iron and carbon or chromium
Stomach acid	("stum-ak"); a strong acid in the stomach that helps to remove bacteria from the food we eat

Strong acid	a solution with a high amount of Hydrogen ions
Strong base	a solution with a high amount of Hydroxide ions
Sulfur	("sull-fur") ; a nonmetal in family 16 that gains or shares two electrons during a reaction
Supernova	a star that has blown up
Supersaturated solution	a solution which contains more solute than can normally be dissolved; usually formed by increasing the temperature of a solvent
Surface area	measurement of how much an object's surface is showing

Surface tension	the "stickiness" of water; created by hydrogen bonds between water molecules
Suspension	("suh-spen-shun"); a mixture in which some of the particles are large enough to be easily seen (and removed)
Technetium-99	("teck-net-ee-um"); radioactive isotope most commonly used as a tracer
Temperature	("tem-pur-ah-chur"); the measurement of the motion of atoms
Tendons	tough bands of proteins (like rubber bands) that connect your muscles to bones

Theory	("thee-or-ee"); a statement about some scientific event that has been tested many times and have all had the same results
Thermal energy	measurement of the amount of energy given off by atoms in motion; felt as heat on our bodies
Thermal energy	("thur-mull"); heat
Thorium-229	("thor-ee-um"); radioactive isotope used in the long, skinny light bulbs
Tracer	most common use of radioactive isotopes by doctors; once inside the body, tracers can be detected with x-rays

Transition metals	("tranz-ish-shun"); metals in the 3rd-12th families of the periodic table which are normally very shiny, hard and conductive, with poor reactivity
Triglyceride	("try-gliss-ur-eyed"); one lipid molecule which is made up of three fatty acids and one glycerol
Triple bond	covalent bond in which three electrons are shared between atoms
Universal solvent	water
Unsaturated fat	a fat which is liquid at room temperature
Unsaturated solution	any solution that can still dissolve more solute

Uranium	(“yoo-rain-ee-um”) one of several radioactive elements; an isotope of this element (U-235) is commonly used as a nuclear fuel
Valence electrons	(“vay-luns”); the number of electrons in the last orbital of each element
Vaporization	(“vay-puhr-ih-zay-shun”); the process by which a liquid turns into a gas
Vitamins	(“vite-ah-minz”); organic compounds used to keep organisms healthy
Volume	the amount of space that an object takes up
Weight	(“wayt”); measurement of the force of gravity on an object

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