Chemistry: *<u>Introduction to Chemistry</u>*

Pure Science vs. Applied Science

pure science = **"science"** *the search for facts about the natural world.*

In science, we often try to establish a <u>cause-effect</u> relationship.

What drives pure scientists? *curiosity; the need to know, to explore, to conquer something new.*

applied science = **"technology"**

the practical application of scientific discoveries or using science to improve our lives.

EXAMPLE

pure science: *discovering the chemical structure of ibuprofen and acetaminophen.*

applied science: *using these chemicals to reduce pain and fever.*

What are some pros and cons of our present-day technology?

great potential for good and great risk for harm (mixed blessing).

Science has a moral component. *What we search for and how we use technology depend on our system of values.*

The Science of Chemistry

chemistry = *the study of matter, its structure, properties, and composition, and the changes that matter undergoes.*

alchemy = the quest for the Philosopher's Stone, a liquid that would change cheap metals into gold…practiced during the Middle Ages (~500 A.D. to ~1300 A.D.).

Alchemists were the forerunners of modern chemists.

Chemistry is concerned with **chemicals** = *any substance formed by, or used in, a chemical reaction.*

All matter IS chemicals: *water (H_2O), oxygen (O_2), iron (Fe),*

rust (Fe_2O_3).

Usually the term "chemicals" brings to mind dangerous or toxic substances.

Chemistry studies the properties of chemicals.

melting point, boiling point, flammability, conductivity, ductility

Because chemicals are all around us…

chemistry is all around us.

e.g. *swimming pool, photography, gasoline, motor oils,*

inks and dyes, preservatives, perfumes, farming

Everyone needs some background in chemistry.

Areas of Chemistry

Organic – study of carbon-containing compounds

living creatures, petroleum (plastics, oils, fuels)

Inorganic – study of all substances that DON'T contain carbon

reactions involving metals

Analytical – measuring quantities very carefully with highly-sensitive instruments

Physical – calculating values *At what temperature does gold melt? How much "energy" is in Wheaties?*

Biochemistry – the chemical reactions that occur inside living creatures *photosynthesis, respiration*

A Career in the Field of Chemistry – What do chemists do?

<u>research chemists</u> discover new products and materials

For every new pharmaceutical drug that makes it to market, 10,000 other compounds don't!

a new drug requires, on average, 10 years of R & D.

<u>chemists who work in development</u> design large-scale production equipment and facilities for the manufacture of products and materials

<u>production chemists and technicians</u> monitor production processes to ensure that manufactured products meet quality standards

<u>other jobs for chemists</u>:

chemical sales, software engineering, patent law, teaching, banking and finance.

The Scope of Chemistry

The **chemical industry** has a large effect on our lives.

bulk chemical manufacturing:

strong acids, cleaning agents, fertilizers

synthetic fibers: *polyester, rayon, nylon*

petroleum products: *plastics, fuels, oils, lubricants*

pharmaceuticals: *prescription medications*

All fields of endeavor are affected by chemistry:

agriculture, environmental occupations, law, industry, insurance, food service, office products.

Government Regulation of Chemicals

The government regulates chemicals to reduce the risk to the…

<u>consumer</u>: *FDA, USDA, Consumer Product Safety Commission*

Thalidomide (only two cases in US)

<u>worker</u>: *OSHA*

<u>environment</u>: *EPA*

Safety in the Science Classroom

The Science Safety Contract must be followed. Violations are intolerable.

Common sense should dictate what behaviors are appropriate. You are responsible for each item on the Safety Contract, especially…

wear goggles

no horseplay

handle chemicals, glassware, and equipment with care and respect

stay out of all chemical storage areas

ask your teacher how to properly dispose of chemicals

In case of accident or emergency, remain calm and notify your teacher immediately.

Equipment you should be familiar with: *fire extinguisher, fire blanket, emergency shower, fume hood*

Material Safety Data Sheet (MSDS)

Federal law requires that every chemical have a Material Safety Data Sheet (MSDS).

The MSDS contains important information about the chemical…

description, properties, emergency phone number, precautions to take when using, emergency procedures, disclaimer

Using Units in Chemistry

Unlike in math, in chemistry we never use numbers by themselves. This is because chemistry involves actual, physical quantities of matter and energy that can be measured.

measurement = *a number followed by a unit*

Examples: *24 km, 10.56 m, 4.8 g, 2.11 L*

In chemistry, you must use units.

The International System (SI System) of Units

The SI system is the system adopted as the worldwide standard system of measurement.

This is the system we will use in chemistry. We will never use English system units such as the pound, tablespoon, or ^{o}Fahrenheit. The **base units** for the SI system that you should know are:

Quantity	***Base Unit***	***Symbol***
length	*meter*	*m*
mass	*kilogram*	*kg*
time	*second*	*s*
amount of substance	*mole*	*mol*
temperature	*Kelvin*	*K*

Once you are familiar with it, the SI system is easy to use because it is based on multiples of *10*.

SI prefixes are commonly used to make the "number" part of the measurement more understandable.

Examples: *use 70 kg instead of 70,000 g*

use 2 mg instead of 2×10^{-3} *g*

The SI prefixes you should know are:

kilo- = 1000 *(k)*

centi- = 1/100th *(c)*

milli- = 1/1000th *(m)*

For the quantity of length…

1 km = 1000 m, 1 m = 100 cm, 1 m = 1000 mm

Scientific Notation

Scientific notation is often used in chemistry to handle very small numbers and very large numbers. Numbers in scientific notation are expressed in the form:

$$BASE \times 10^{exponent}$$

The BASE is a number between 1 and 10

The exponent can be any number – positive, zero, or negative.

Examples: Write the following numbers in scientific notation.

3000 m

14500000 kg

0.007 L

0.00000004302 cm

Graphs

Often, a large amount of information is more easily conveyed by using a graph. There are 3 main types of graphs.

Line Graph: *used to show trends or continuous change (the hourly temperature reading in the chemistry classroom for a week).*

Bar Graph: *used to display information collected by counting (how many students earned each letter grade in Chemistry).*

Pie Graph: *used to show how some fixed quantity is broken down into parts (% of chemistry budget spent on chemicals, glassware, equipment).*

How Does Scientific Knowledge Advance?

1. Sometimes, we set out with a specific goal in mind.

   discovery of economical method for purifying aluminum

   – Charles Martin Hall, 1886

2. People make an observation and then get curious.

   astronomer working late nights; rate of cricket chirps with air temperature

3. We also learn by experience.

   some plants made you feel better, others harmed you

4. Discovery by accident

   Alexander Fleming, 1920's – *moldy oranges, no bacteria around mold, penicillin* safety glass – *material left in test tube prevented shattering*

shoe protectant – *spilled chemical on one shoe; months later, it looks brand new*

The Scientific Method

The scientific method is an organized, logical procedure used by scientists to advance scientific knowledge.

Basic Steps of the Scientific Method

1. **observe** – *state the problem and gather all available information on it*
2. propose a **hypothesis** – *a testable, reasonable explanation of an event, an educated guess.*

A hypothesis is often in the "If – Then" format –

If the temperature in the balloon increases, then the volume of the balloon will increase.

3. test the hypothesis by conducting controlled experiments

variable – any factor that could influence the outcome of an event

referee, crowd, amount of oxygen available, temperature, wind

In a **controlled experiment**, the variables are altered one at a time.

After each variable is changed, scientists note the effect that particular variable is having on the results of the experiment.

experiments require **data** – *the results of the experiment; a collection of measurements*

Experiments must be repeated many times before scientists have confidence in their data.

4. draw a valid conclusion – *follows from results of the experiments, not personal prejudices*

Conclusions must be supported by data in order to be valid.

Theory vs. Law

A hypothesis that withstands repeated testing may become part of a theory.

theory – *an explanation of an observation based on many experiments and logic tries to explain WHY something happens* based on all evidence available at the time.

Theories undergo revision, and are occasionally thrown out altogether:

Atomic theory, Cell theory, Theory of Gravity, Theory of Evolution, Theory of Relativity

Explaining observed facts of nature with theories involves using models.

Models help us simplify what we are trying to study

Separate the important from the unimportant, and concentrate on the important.

Understanding and clarity require simplification.

(What did you do today?)

A **law** of nature states what happens

"Nature is THIS way…"

we do not revise laws

we have never observed a single instance in which a law of nature has been violated

Law of Gravity, Law of Conservation of Mass and Energy, Charles' Gas Law

EXAMPLE: the phlogiston theory of burning

How is a burning candle explained by the phlogiston theory?

all that burned believed to contain ph, given off when burned, dephlogisticated matter; when air was full of ph, no more burning; O_2 *had less ph than ordinary air*

How did Lavoisier disprove the phlogiston theory?

theory of over 100 years; Priestley disc. O_2 *in 1774; 1778, used sci. method, burned P, Sn, Pb ox., red Hg ox; oxides always weighed more*

Some Basic Concepts in Chemistry

In chemistry, we will study chemical reactions.

chemical reaction = *when the smallest particles of substances (atoms) are rearranged so that "what we end up with" has different properties from "what we started with"*

Chemical reactions have two main parts:

reactants and products.

reactants = *what we start with; always on the left side of the equation*

products = *what we end up with; always on the right side of the equation*

Example reaction:

sodium + water → hydrogen + sodium oxide

2 Na (s) + H_2O (l) → H_2 (g) + Na_2O (s)

Let's visualize what's happening at the "particle level"…

What happens to the **particles** during a chemical reaction?

they are NOT created or destroyed

they are merely rearranged

Is there a **change in energy** associated with a chemical reaction? *yes; heat, light, sound*

(perhaps not easily noticed)

The Law of Conservation of Mass:

total mass of reactants = total mass of products

During chemical reactions, no measurable change in total mass occurs.

BLACK SNAKE DEMO

The Law of Conservation of Mass is one of the fundamental cornerstones of chemistry. Remember it.

Chemical Reactions in Industry

Chemical reactions involving large quantities of substances occur every day in industrial processes. The results of these reactions are the many products we take for granted. Most of these products are NOT produced in a single chemical reaction, but are the result of many reactions, one after the other. Consider, for example, aspirin:

At a large-scale production plant, many factors must be considered: *equipment durability, waste products from chemical reactions, worker safety, supply and storage of reactants*

INDUSTRIAL PROCESSES TRANSPARENCIES

How to Succeed in Learning Chemistry

1. Learn the language. Take time to learn new vocabulary by going over the new terms several times.
2. Use the illustrations in the textbook.
3. Review your notes frequently. What was complete nonsense the first time around may become clear on the 4^{th} or 5^{th} try.
4. Work as many problems as possible for practice.
5. Do NOT cram for exams. For best results, keep up with your work.

A General Procedure for Solving Problems

In this class, we will often combine our knowledge of chemistry concepts with math to solve simulated, real-world problems. Although no single method of solving problems will work in all situations, you should attempt to follow the "recipe" included below.

1. Read the problem carefully and make a list of "knowns" and "unknowns."
2. Look up any other information you may need. Your lecture outline will have most of the formulas and constants you will use, and you will learn to refer often to the Periodic Table as well.
3. Solve the problem on paper, writing down all relevant information and taking care NOT to skip steps.
4. Check your work. Be sure the units are correct, and ask yourself if the answer seems reasonable.
5. Do as many problems as you can. Repetition builds understanding and confidence.