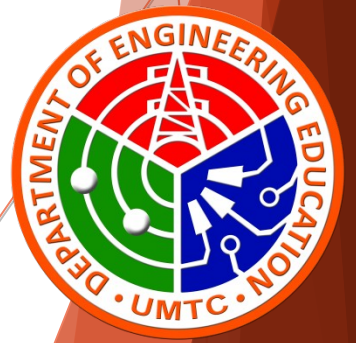
Introduction to Chemistry for Engineers

Lecture 1-1 BCHE 111L – Chemistry for Engineers



Engineering Students often ask:

"Why is another chemistry course required for non-chemical engineers?"

Chemistry

- the study of the composition of “matter” – (matter is anything with mass and occupies space), its composition, properties, and the changes it undergoes.
- the science that deals with the materials of the universe and the changes that these materials undergo
- the branch of science that deals with elements, and elements are building block of everything.

Chemistry

6 Major Areas:

1. **Analytical Chemistry** - concerned with the composition of substances.
2. **Inorganic Chemistry** - primarily deals with substances without carbon
3. **Organic Chemistry** - essentially all substances containing carbon
4. **Biochemistry** - Chemistry of living things
5. **Physical Chemistry** - describes the behavior of chemicals (ex. stretching); involves lots of math!
6. **Nuclear Chemistry** - dealing with radioactivity, nuclear processes and nuclear properties

The boundaries of these areas are not firm – they overlap and interact

Chemistry

Classifications:

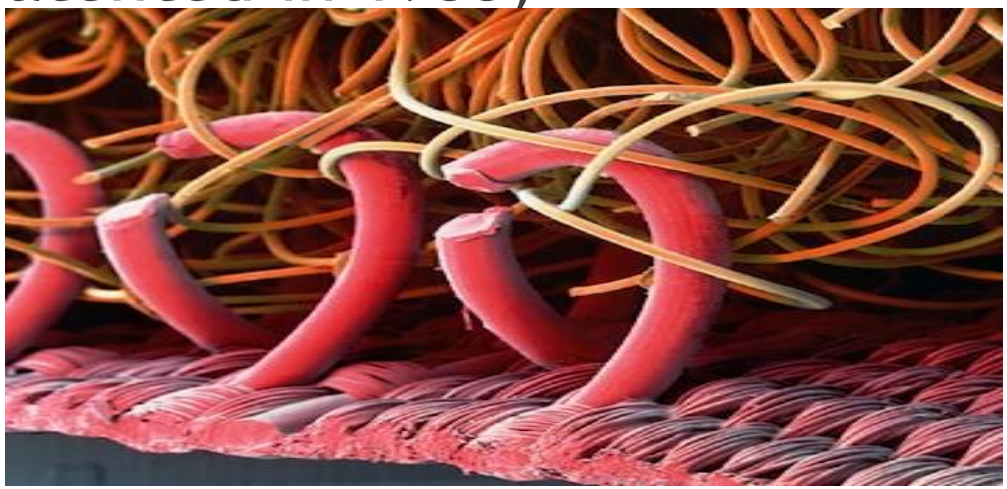
- **Pure Chemistry**
  - Gathers knowledge for the sake of knowledge
- **Applied Chemistry**
  - using chemistry to attain certain goals, in fields like medicine, agriculture, engineering, and manufacturing – leads to an application
  - e.g. Nylon or Aspirin ($C_9H_8O_4$) - to relieve pain

Importance of Chemistry

- **Everyone** and **everything** around us involves chemistry – explains our world
- Helps one make choices; helps make you a better informed citizen
- A possible career for your future
- Used to attain a specific goal

Applications of Chemistry

- Chemists design materials to fit specific needs – velcro (Patented in 1955)



- perfume, steel, ceramics, plastics, rubber, paints, nonstick cooking utensils, polyester fibers

A Quick Question:

Why use helium? Why not hydrogen?
Both “float” in air?

Applications of Chemistry

- Medicine and Biotechnology-
  - Supply materials doctors use to treat patients
  - vitamin C, penicillin, aspirin ($C_9H_8O_4$)
  - materials for artery transplants and hipbones
  - bacteria producing insulin

Applications of Chemistry

- Energy – we constantly have greater demands
  - We can conserve it; use wisely
  - We can try to produce more; oil from soybeans to make biodiesel
  - fossil fuels, solar, batteries (that store energy – rechargeable?), nuclear (don't forget pollution!)

Applications of Chemistry

- Agriculture
  - Produce the world's food supply
  - Use chemistry for better productivity – soil, water, weeds
  - plant growth hormones
  - ways to protect crops; insecticides
  - disease resistant plants

Applications of Chemistry

- The Environment
  - both risks and benefits involved in discoveries
  - Pollutants need to be 1) identified and 2) prevented
  - Lead paint was prohibited in 1978; Leaded gasoline? Drinking water?
  - carbon dioxide, ozone, global warming

Applications of Chemistry

- The Universe
  - Need to gather data from afar, and analyze matter brought back to Earth
  - composition of the planets
  - analyze moon rocks
  - planet atmospheres
  - life on other planets?

A Quick History

- The word **chemistry** comes from **alchemy** – practiced in China and India since 400 B.C.
  - Alchemy – developed the tools and techniques for working with chemicals
- Alchemy has two sides:
  - Practical: techniques for working with metals, glass, dyes, etc.
  - Mystical: concepts like perfection – gold was a perfect metal

A Quick History

- In the 1500s, a shift started from alchemy to science – King Charles II was a supporter of the sciences
- “Royal Society of London for the Promotion of Natural Knowledge”
- Encouraged scientists to use more experimental evidence, and not philosophical debates

A Quick History

- Experimental Evidence
  - Recognize the problem (observation)
  - Propose possible solutions or explanations (hypothesize)
  - Decide which solution is best (performing experiments)

A Quick History

- In the late 1700s, **Antoine Lavoisier** helped transform chemistry from a science of *observation* to the science of *measurement* – still used today
- He settled a long-standing debate about burning, which was…
  - **Oxygen** was required!

The Scientific Method

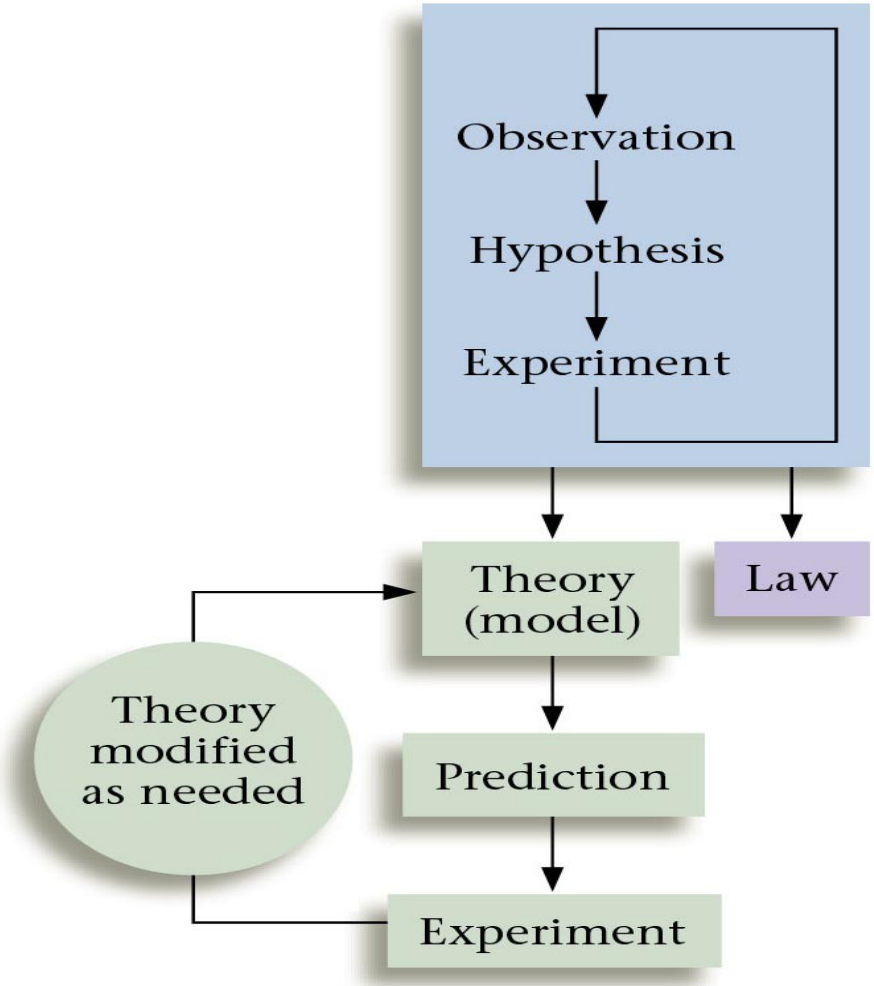
- A logical approach to solving problems or answering questions.
- Starts with observation- noting and recording information and facts
- hypothesis- a proposed explanation for the observation; must be tested by an experiment

The Scientific Method

Steps:

1. Observations (uses your senses)
   a. quantitative involves numbers = 95°F
   b. qualitative is word description = hot
2. Formulating hypotheses (ideas)
   - possible explanation for the observation, or "educated" guess
3. Performing experiments (the test)
   - gathers new information to help decide whether the hypothesis is valid

The Scientific Method



The Scientific Method

We deal with **variables**, or factors that can change.

Two types:

1. Manipulated variable (or independent variable) is the one that we change
2. Responding variable (or dependent variable) is the one observed or measured during the experiment

For results to be accepted, the experiment needs to always produce the same result

The Scientific Method

- “controlled” experiment- designed to test the hypothesis
- Recall IF…..AND….THEN
- IF… (statement of what we believe to be true based on our background knowledge)
- AND … (what we are doing experimentally)
- THEN… what we predict will be the outcome
  - only two possible answers:
    - hypothesis is right
    - hypothesis is wrong
  - We gather data and observations by doing the experiment
  - Modify hypothesis - repeat the cycle

The Scientific Method

Outcomes:

- Theory (Model)
  - A set of well-tested hypotheses that give an overall explanation of some natural
  - A theory (model) is an attempt to explain **why** it happened – this changes as new information is gathered.
  - **Big Bang Theory**
- Natural Law (or Scientific Law)
  - The same observation applies to many different systems; summarizes results
  - A law summarizes **what** has happened.
  - **Newton's Law of Gravitation**

Engineering

- Is an Applied Science
- Engineering is the knowledge required, and the process applied, to conceive, design, make build, operate, sustain, recycle or retire, something of significant technical content for a specified purpose; a model, a product, a device, a process, a system, a technology.
- Engineering involves the knowledge of mathematical and natural sciences gained by study, experience, and practice, applied with judgement and creativity to develop ways to utilize the materials and forces of nature for the benefit of mankind.

Chemistry in Engineering

- There is some element of engineering in virtually everything we use:
- from the clothes we wear and the food we eat to the transport we use; from the micro components in modern electronics devices to the structures in the largest civil engineering projects.
- Therefore, an Engineer will not be worth if has no knowledge about matter's building blocks.

Chemistry in Engineering

- An aeronautical engineer must have to think about a material which is lighter yet stronger so that it can fly easily in space, hence alloys are developed.
- A civil engineer must know about the nature of soil, rocks, concrete, steel for stability.
- An electronic or electrical engineer has to know about electrons, conduction, magnetic nature, etc.
- A mechanical engineer has to have idea about materials and fuels for better efficiency.

Chemistry in Engineering

- Energy
- Electrochemical Energy
- Nuclear Chemistry
- Fuels
- Engineering Materials
- Air Chemistry
- Water Chemistry
- Soil Chemistry
- Chemical Safety