AIM 01: What is chemistry?

Chemistry – the study of matter and the change the matter undergoes.

There are 2 types of Chemistry research:

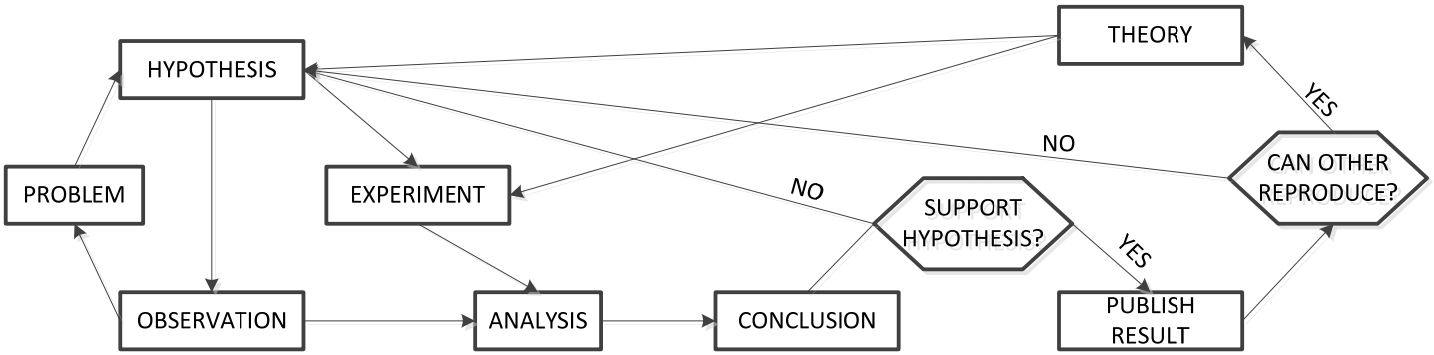
1. Pure chemistry – chemistry done for the purpose of gaining knowledge
2. Applied chemistry – chemistry done for a specific purpose and applying existing knowledge. No new science principals are being discovered.

There are 5 major divisions of Chemistry:

- Analytical chemistry – the study of composition of substances. Normally used in research and forensics
- Biochemistry – the study of composition and the changes in composition of matter, which makes up living things.
- Inorganic Chemistry – the study of compounds that do not contain carbon
- Organic Chemistry – the study of compounds that are carbon-based
- Physical Chemistry – the study of the physical structures and their behaviors.

Scientific Method

1. Definition – a series of steps followed to conduct scientific research. It is not a series of exact steps. It is a strategy for producing solid conclusions
2. Steps – see map below



<u>Main 6 steps:</u>

1) Observations
   a) What one sees.
   b) Can happen at different stages in the scientific method process.
      i) Before identifying a problem. Example: a paper bag.
      ii) During an experiment. Example: The item inside the bag is rigid.
   c) Can be qualitative or quantitative
      i) Qualitative - can be observed but not measurable
      ii) Quantitative - can be observed and is measurable
   d) Details are important
2) Problem –The questions or problems trying to resolve.
3) Hypothesis
   a) Educated guess.
   b) Try to predict the outcome.

c) Must be testable
d) Common format: If…then…because
   i) Example: If the item in the bag is rigid with a sharp end, then the bag must hold a boat, because a boat has a sharp end.

4) Experiment
   a) The steps for testing the hypothesis
   b) Identify all the variables (factors) that may affect the experiment
   c) Controlled Experiment - Each variable should be tested separately. In other words, to be a valid experiment, only one independent variable (variable that is changing; also known as the controlled variable) and the other variables should be dependent (not changing).
5) Analysis
   a) What happened?
      i) Understand the observations collected from the experiment
      ii) Explain what happens
6) Conclusion
   a) The result. Either support or not support the hypothesis.

<u>Other steps:</u>

7) Support Hypothesis
   a) Did the conclusion support the hypothesis?
      i) If yes, then the scientist may repeat the experiment a few more time to validate the results
      ii) If not, then the scientist have two options
         (1) Redo the experiment to validate that the hypothesis was wrong
         (2) Come up with another hypothesis
8) Publish Result
   a) If the conclusion has been validated, then share the result with other. Sharing can be done through journal articles.
9) Can other reproduce
   a) Others may reproduce the experiment to see if the experiment is reproducible.
10) Theory
   a) If the hypothesis can stand the test from others, then the hypothesis may become a theory.
   b) Well-tested explanation of observation.
   c) Theory can be disproved. Theory can never be completely proven.

Law

- A statement or mathematical expression that reliably describes a behavior of the natural world.
- Law describes the event while theory tries to explain the cause of the event.

Model

- Represents an object, a system, a process or an idea.
- It is a simplified representation

Scientific Knowledge

- knowledge gathered through the scientific method
- subject to change based on new observations
- it is limiting since not all questions are observable

AIM 2a: What types of measurement do we use in chemistry?
AIM 2b: What is accuracy and precision?

Measurement

- a collection of quantitative data
- subject to errors and limitations
    - depending upon the measuring tools
- include three pieces of information
    - magnitude
    - unit
    - uncertainty

Accuracy and Precision

In chemistry, scientists want accuracy and precision

- accuracy = how close the measurement is to the true or actual value
- precision
    - exactness of a measurement
    - how close several measurements are to one another

Examples of Accuracy vs. Precision
True value of a = 4.02 cm
Measurements (all in cm)

Students	1st time	2nd time	3rd time	4th time
Bill	4.00	4.45	3.89	3.90
Jane	4.20	4.21	4.23	4.22
Walt	4.10	4.07	4.39	4.20
Sam	3.80	4.10	4.23	4.01

<u>Determining Accuracy</u>
Difference Value = True Value – Measurement Value
NOTE: the one with the smallest Difference Value is the most accurate.
Most accurate: Sam's 4th time (reason: closest to the true value)
Least accurate: Bill's 2nd time

Determining Precision

Step 1: Determine the average of the measurement value
Step 2: Determine the difference of each measurement value from the average value
Step 3: Square each differences
Step 4: Take the average of the differences (this is known as variance)
Step 5: Take the square root of the variance

Example (for Bill):

Step 1:

Average = (4.00 + 4.45 + 3.89 + 3.90)/4
Average = 4.06

Step 2:

D1 = 4.06 – 4.00 = 0.06
D2 = 4.06 – 4.45 = -0.39 = 0.39 (we only want the absolute difference)
D3 = 4.06 – 3.89 = 0.17
D4 = 4.06 – 3.90 = 0.16

Step 3:

$$\frac{(0.06^2+0.39^2+0.17^2+0.16^2)}{4}$$

Variance = 0.05255

Step 4: Square root of 0.5255 = 0.22923

Students	Average	D1	D2	D3	D4	Variance	Standard Deviation
Bill	4.0600000	0.0600000	0.3900000	0.1700000	0.1600000	0.0525500	0.2292379
Jane	4.2150000	0.0150000	0.0050000	0.0150000	-0.0050000	0.0001250	0.0111803
Walt	4.1725000	0.0725000	0.1725000	0.2175000	0.0275000	0.0207688	0.1441137
Sam	4.0350000	0.2350000	0.0650000	0.1950000	0.0250000	0.0245250	0.1566046

Most precise: Jane (reason: lowest standard deviation value)
Least precise: Bill (reason: highest standard deviation value)

Precision	Accuracy
reproducibility	correctness
check by repeating measurements	check by using a different method
poor precision results from poor technique	poor accuracy results from procedural or equipment flaws
poor precision is associated with 'random errors' - error has random sign and varying magnitude. Small errors more likely than large errors.	poor accuracy is associated with 'systematic errors' - error has a reproducible sign and magnitude.