An Introduction to Chemistry

Chapter 1

Version 1.0

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1.1 What is a Science?

The observation, identification, description, experimental investigation, and theoretical explanation of natural phenomena.

"*the study in which humans attempt to organize and explain, in a sytematic and logical manner, knowledge about themselves and their surroundings"*

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SCIENTIFIC DISCIPLINES

PHYSICAL SCIENCES:
Astronomy, Geology, Physics, Chemistry

BIOLOGICAL SCIENCES:
Botany, Zoology

***TODAY*:**
Biochemistry, Molecular Biology

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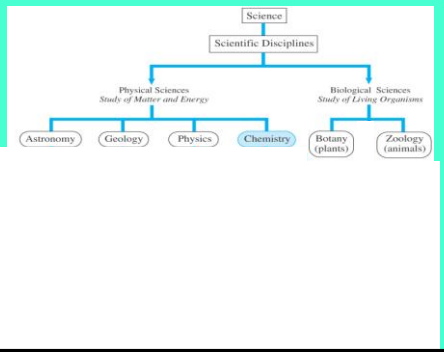

- Chemistry is sometimes describes as the study of the structure and behavior of matter.

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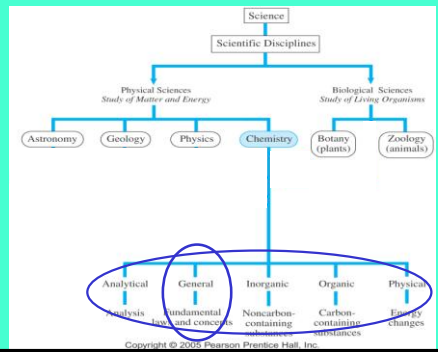

CHEMISTRY DISCIPLINES

Analytical – ***what and how much (analysis)***

General – ***fundamental laws and concepts***

Inorganic – ***substances that are not organic***

Organic – ***carbon and hydrogen containing compounds***

Physical – ***energy changes in chemical reactions, theoretical***

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1.3 How chemists discover things - The Scientic Method

The observation, identification, description, experimental investigation, and theoretical explanation of natural phenomena.

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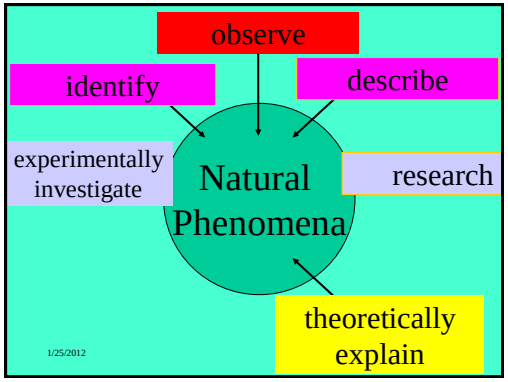

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SCIENTIFIC METHOD

1. Observation
2. Literature research
3. Hypothesis
4. Experiment
5. Theory

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Definitions

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Hypothesis: A tentative *explanation* of certain facts (observation) that can be tested through experimentation.

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Experiment: is conducting a controlled test to *collect data* to support or negate a hypothesis.

- Data from experiments are called FACTS
- Experiments must be conducted under carefully controlled conditions so that they can be reproduced over and over. This separates science from pseudo science.

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Theory: a statement which explains what is observed that is supported with experimental evidence and is used to make predictions. (*Mathematical models are frequently derived from a theory. At any time, a new experiment may be done that invalidates the theory.)*

Law: Statement of natural phenomena to which no exceptions are known under the given conditions. A law is not an explanation.

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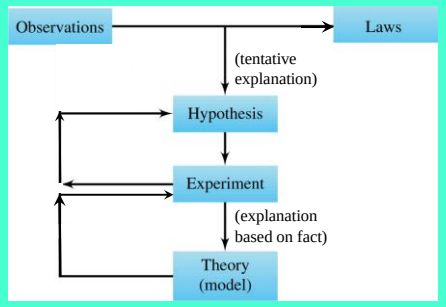

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CH. 1.4 –MEASUREMENT and UNITS

Measurements are the data obtained from an experiment

MEASUREMENT (cont)

What's wrong with this measurement?

55.5

Always include a numerical value *and* a unit

55.5 km makes more sense!

Measurements used in chemistry

length, volume, mass, time, temperature, pressure, concentration

The Metric System of Units

Used in scientific work, even in the US

Table 1.1
SI Units (standard metric units)

Quantity	Symbol	Base Unit	Abbrev
Length	*l*	meter	m
Mass	*m*	kilogram	kg
Time	*t*	second	s
Temp	*T*	kelvin	K
Amount	*n*	mole	mol

SI Unit Prefixes

Prefix	Symbol	Factor
giga-	G	10^{9}
mega-	M	10^{6}
kilo-	k	10^{3}
BASE UNIT	---	10^{0}
deci-	d	10^{-1}
centi-	c	10^{-2}
milli-	m	10^{-3}
micro-	μ	10^{-6}
nano-	n	10^{-9}
pico-	p	10^{-12}

GREATER THAN ONE →
← LESS THAN ONE

LENGTH (m)

- Meter is both the standard and base metric unit
- Other common length measurement:

1 mm → 10^{-3} m → 0.001 m (1000 mm / 1 m)
1 cm → 10^{-2} m → 0.01 m (100 cm / 1 m)
1 km → 10^{3} m → 1000 m (0.001 km / 1 m)

Volume

- Combination of base units.
  (e.g., length × length × length)
- Standard unit is m^3
- Base unit is L
- Other common units: cm^3, dL, mL, μL
- Other facts:

1 cm^3 = 1 mL
1 dm^3 = 1 L

1000 L = 1 m^3

Mass

- Mass is the total quantity of matter in something.
- Determined by *weight*

what is weight????

- Standard unit is kg
- Base unit is g
- Other common units μg, mg, kg

Temperature

- A measure of the intensity of heat.
- It does not depend on the size of the system.

Temperature Measurement

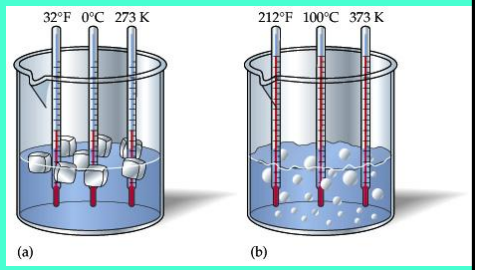
- There are three temperature scales:
  - ❑Kelvin, Celsius and Fahrenheit.
- The SI unit of temperature is the Kelvin.
- In the laboratory, temperature is commonly measured with a thermometer in Celsius.

Degree Symbols

Kelvin (absolute) = K

degrees Celsius = ^{o}C

degrees Fahrenheit = ^{o}F



1.5 Reporting Values from Measurements

Exact and inexact numbers

- Exact numbers are "counting" numbers
  7 days per week
  12 equals one dozen
  "*there are 32 students in this room*"
- Measurements are always inexact

Inexact Numbers (measurements) contain **ERROR**

- Systematic – controllable (faulty equipment)
- Random - uncontrollable (noise)

Accuracy and Precision

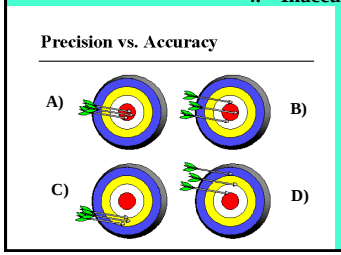
- Accuracy - how close a measurement is to the accepted value
- Precision - how close a series of measurements are to each other

ACCURATE = CORRECT

PRECISE = CONSISTENT

Choose an answer

1. **Accurate/precise**
2. **Accurate/imprecise**
3. **Inaccurate/precise**
4. **Inaccurate/imprecise**



Choose an answer

1. **Accurate/precise**
2. **Accurate/imprecise**
3. **Inaccurate/precise**
4. **Inaccurate/imprecise**

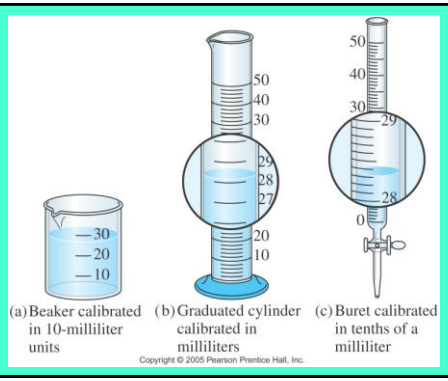
A)	B)
55.3 kg 55.4 kg 55.5 kg	54.9 kg 54.8 kg 55.0 kg
AVG = 55.4 kg	*AVG = 54.9 kg*
C)	**D)**
54.7 kg 55.6 kg 55.9 kg	54.2 kg 54.7 kg 55.5 kg
AVG = 55.4 kg	*AVG = 54.8 kg*

Uncertainty in measurement

- **Every measurement has error associated with it.**
- **The more precise the measurement the less error.**
- **Error in a measurement is indicated by the number of significant figures in the number**

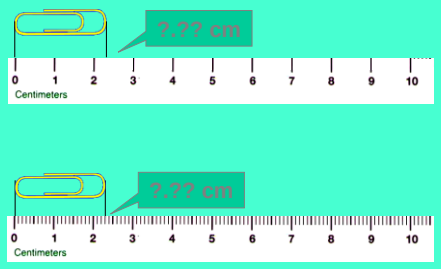
- **Which measurement has less error?**
- **Which measurement is more precise?**
- **Which measurement has more significant figures?**

29.2°C or 29.25°C



Significant Figures

- Indicate precision of a measurement.
  Sig. figs. do not apply to exact numbers
- Recording Sig Figs
  - Sig figs in a measurement include the known digits plus a final estimated digit



Uncertainty in measurements

- Unless otherwise stated the last digit.
- Determined from the smallest division.
- Stated on the device. E.g.: ± 1, ± 0.2, etc.
- The last digit in a digital display.
- Determined from the data set.

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Counting Sig Figs

- **Count all numbers EXCEPT:**
  - **Leading zeros -- 0.0025**
  - **Trailing zeros without a decimal point -- 2,500**

Counting Sig Fig Examples

1. 23.50 — 4 sig figs
2. 402 — 3 sig figs
3. 5,280 — 3 sig figs
4. 0.080 — 2 sig figs