Chapter 1

The Process of Science

Question

What ?
How much?

Direct observation or measurement

Repeated observation
Generate natural laws by summary
These are the facts, the scientific truth

How?
Why?

Requires model for explanation

Generate hypothesis
Test hypothesis
May become theory

Use theory to predict new outcomes

Test theory repeatedly
Explains related phenomena but never established as absolute truth

Measurement, an explicit part of the process of science

Direct measurements, based on standards

length - meter
mass - gram
time - seconds

Derived measurements

volume
temperature

SI units

A number without a unit is meaningless.
Become accustomed to writing units with numbers.

Exponential notation

You must use exponential (or scientific) notation in all of your quantitative work.
You must know metric prefixes
Advantages of metric prefixes

- Easy to write
- Easy estimate of magnitude after arithmetic operation
- Easy log use
- Clear expression of significant figures

Significant figures

Limitation of measurements based on experimental uncertainty

Random error

- Precision
- Standard deviation

Systematic error

- Accuracy
- % error

Unit conversions

Conversion factors
Multiple conversions
Dimensional analysis
Match units when doing arithmetic

Density and specific gravity

Density = d = mass/volume
You must know this relationship.

Specific gravity is the comparison of the density of a substance with that of water.

Specific gravity = density of substance/density of water
The units cancel. Comparison at 20 °C, density of water = 1.00 g/mL

Energy - The capacity to do work

Kinetic energy is energy of motion.
Kinetic energy = KE = 1/2mv2 =3/2kT, T = K

Potential energy is stored energy or energy of position.
Chemical energy is potential energy.
Energy can be converted from one form to another.
The sum of kinetic and potential energy is the total energy.
Energy is conserved; it is not created or destroyed.
This observation is expressed as the “law of conservation of energy”.

Heat – a form of energy

Common units are calories (cal) and Joules (J).
1 cal = 4.184 J, J = kg m^2/s^2
The specific heat is the amount of heat required to raise the temperature of 1 g of any substance by 1 °C.

Heat change = s x m x ($T_2 - T_1$)

- Exothermic
- Endothermic

Matter – has mass and occupies space

Substances
- Elements
- Compounds

Mixtures
- Homogeneous
- Heterogeneous

Chemical properties, relate to chemical change and formation of a different substance

Physical properties, relate to physical differences and no change in substance identity.

States of matter - Change of physical state is a physical change.

Physical states of matter
- Solid
- Liquid
- Gas

Change from one to another by adding or removing energy.