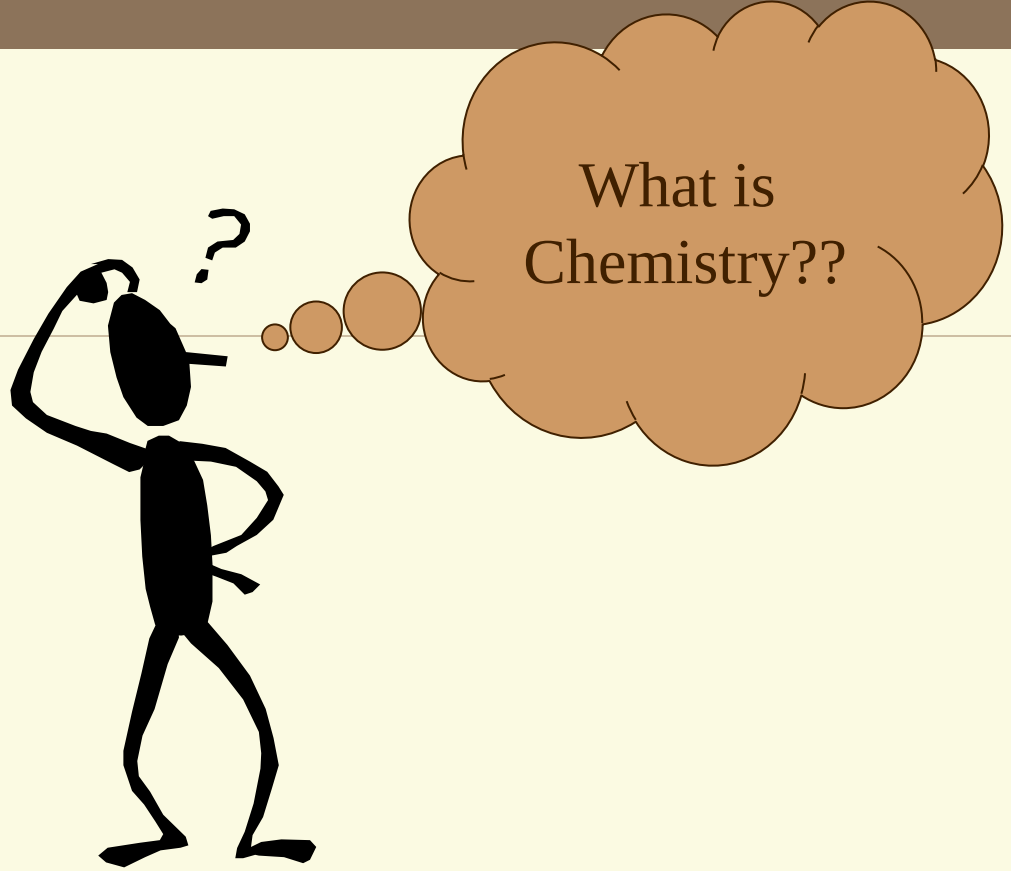
MATTER & MEASUREMENT

CHEMISTRY

The Central Science



The Study of the composition, structure, and properties of matter and of the reactions by which one form of matter may be produced from or converted into other forms.

The rapid progress true Science now makes occasions my regretting sometimes that I was born so soon. It is impossible to imagine the heights to which may be carried, in a thousand years, the power of man over matter. O that moral Science were in as fair a way of improvement, that men would cease to be wolves to one another, and that human beings would at length learn what they now improperly call humanity.

BENJAMIN FRANKLIN, 8 FEBRUARY 1780

The Elements

A fundamental substance which cannot be chemically changed nor broken down.

THE ELEMENTS

- 92 naturally occurring
- 24 produced artificially by nuclear chemists
- The atom is the basic stable elemental particle
- Arranged in the modern **Periodic Table** according to atomic number (number of protons)
    - Periods - horizontal rows
    - Groups(families) - vertical columns
    - Elements within a given group have similar chemical properties
    - Main groups
    - Transition metals
    - Inner transition metals

CHEMICAL PROPERTIES OF THE ELEMENTS

Intensive properties :

Possess values independent of amount of sample

Extensive properties:

Possess values dependent on amount of sample

Physical Properties

- Characteristics that do not involve a change in the chemical identity of the matter.
  - color
  - hardness
  - melting point
  - boiling point
  - physical state
  - electrical conductivity

Chemical Properties

- Characteristics involving the way one kind of matter is transformed into another kind of matter.
  - Heat of combustion (Enthalpy)
  - oxidation
  - reduction
  - chemical activity
  - pH (acid or base)

MATTER

Anything occupying space and having mass

Law of Conservation of Matter

During a physical or chemical change, there is no detectable increase or decrease in the total quantity of matter from that initially present.

Mass

The amount of matter in an object.

Physical States of Matter

- Solid
  - Possesses a definite shape and has a volume nearly independent of changes in temperature and pressure
- Liquid
  - Posses an indefinite shape and is only slightly compressible

Physical States of Matter

- Gas
  - Very fluid; possesses both an indefinite shape and indefinite volume resulting in gases being readily compressible and capable of infinite expansion
- Plasma
  - Extremely high energy state consisting of a mixture of free electrons and highly ionized nuclei

Le Système International d'Unités

International System of Units

(SI System)

SI System

- Developed in France in 1791
- Used in the US since 1964
- A decimal measurement system
- Seven fundamental units

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Experimentation and Measurement in Chemistry

SYSTÈME INTERNATIONALE D´UNITÉS (SI)

TABLE 0.1 The Seven Fundamental SI Units of Measure

Physical Quantity	Name of Unit	Abbreviation
Mass	kilogram	kg
Length	meter	m
Temperature	kelvin	K
Amount of substance	mole	mol
Time	second	s
Electric current	ampere	A
Luminous intensity	candela	cd

ALL OTHER UNITS ARE DERIVED FROM THESE FUNDAMENTAL UNITS.

Experimentation and Measurement in Chemistry

TABLE 0.2 Some Prefixes for Multiples of SI Units

Factor	Prefix	Symbol	Example
$1{,}000{,}000{,}000{,}000 = 10^{12}$	tera	T	1 teragram (Tg) $= 10^{12}$ g
$1{,}000{,}000{,}000 = 10^{9}$	giga	G	1 gigameter (Gm) $= 10^{9}$ m
$1{,}000{,}000 = 10^{6}$	mega	M	1 megameter (Mm) $= 10^{6}$ m
$1{,}000 = 10^{3}$	kilo	k	1 kilogram (kg) $= 10^{3}$ g
$100 = 10^{2}$	hecto	h	1 hectogram (hg) $= 100$ g
$10 = 10^{1}$	deka	da	1 dekagram (dag) $= 10$ g
$0.1 = 10^{-1}$	deci	d	1 decimeter (dm) $= 0.1$ m
$0.01 = 10^{-2}$	centi	c	1 centimeter (cm) $= 0.01$ m
$0.001 = 10^{-3}$	milli	m	1 milligram (mg) $= 0.001$ g
$*0.000\,001 = 10^{-6}$	micro	μ	1 micrometer (μm) $= 10^{-6}$ m
$*0.000\,000\,001 = 10^{-9}$	nano	n	1 nanosecond (ns) $= 10^{-9}$ s
$*0.000\,000\,000\,001 = 10^{-12}$	pico	p	1 picosecond (ps) $= 10^{-12}$ s
$*0.000\,000\,000\,000\,001 = 10^{-15}$	femto	f	1 femtomole (fmol) $= 10^{-15}$ mol

*It is becoming common in scientific work to leave a thin space every three digits to the right of the decimal point in very small numbers, analogous to the comma placed every three digits to the left of the decimal point in large numbers.

Temperature

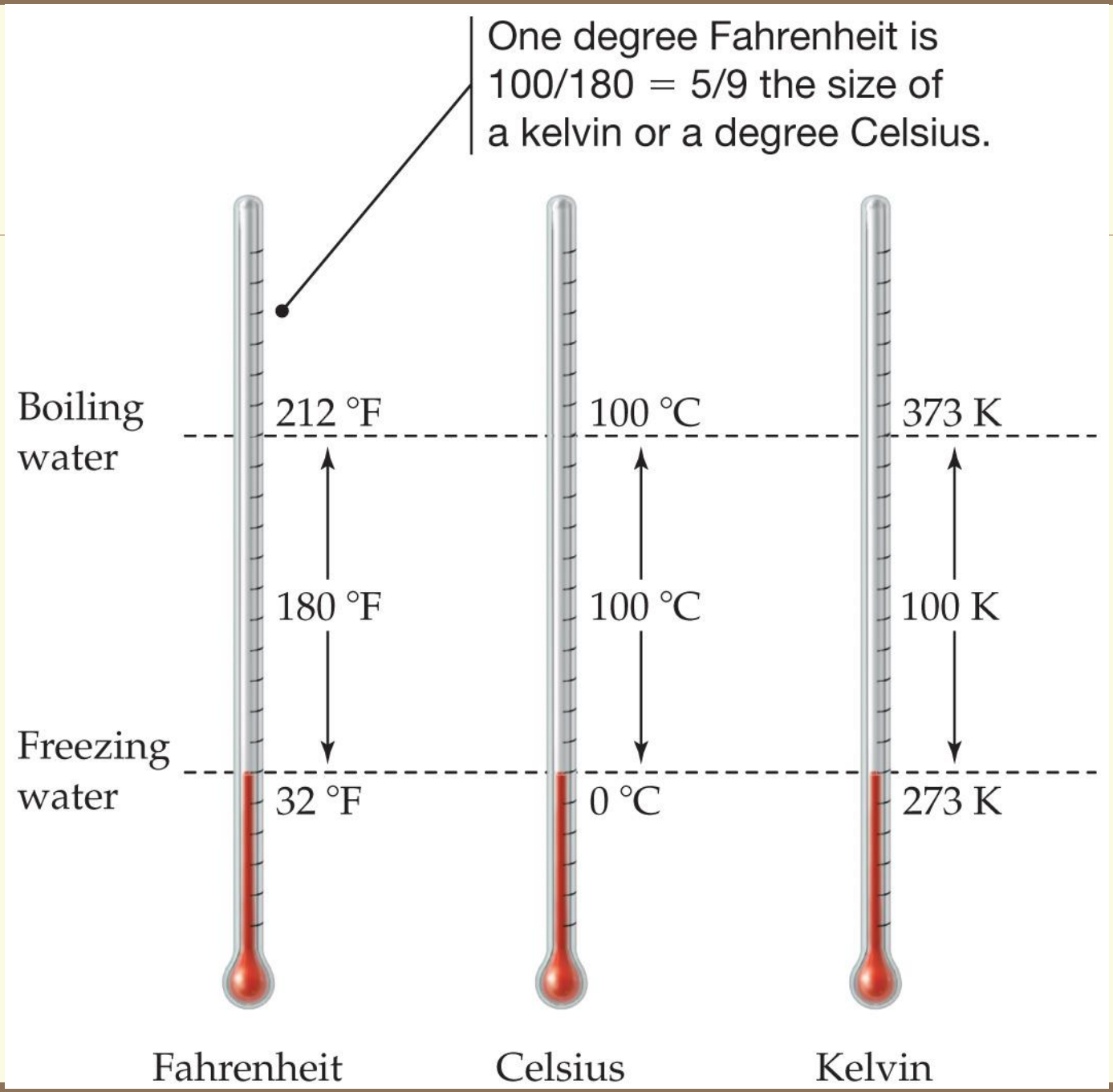
Three distinct scales

- Celsius
- Fahrenheit

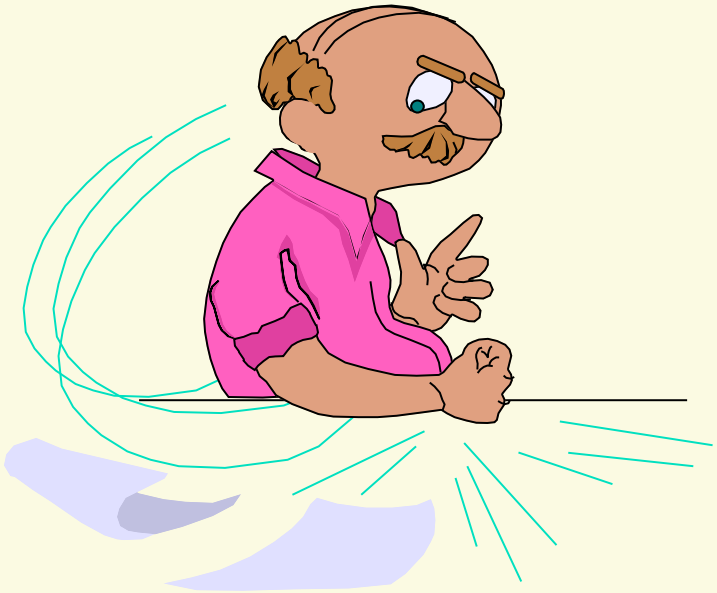
$$\frac{^oC}{100} = \frac{^oF - 32}{180}$$

- Kelvin

$$K = 273.15 + ^oC$$


One degree Fahrenheit is
100/180 = 5/9 the size of
a kelvin or a degree Celsius.
Boiling
water
212 °F
100 °C
373 K
180 °F
100 °C
100 K
Freezing
water
32 °F
0 °C
273 K
Fahrenheit
Celsius
Kelvin

Units are Important



Never use a number representing a measurement without including the corresponding measurement units

Derived Units: Measuring Volume

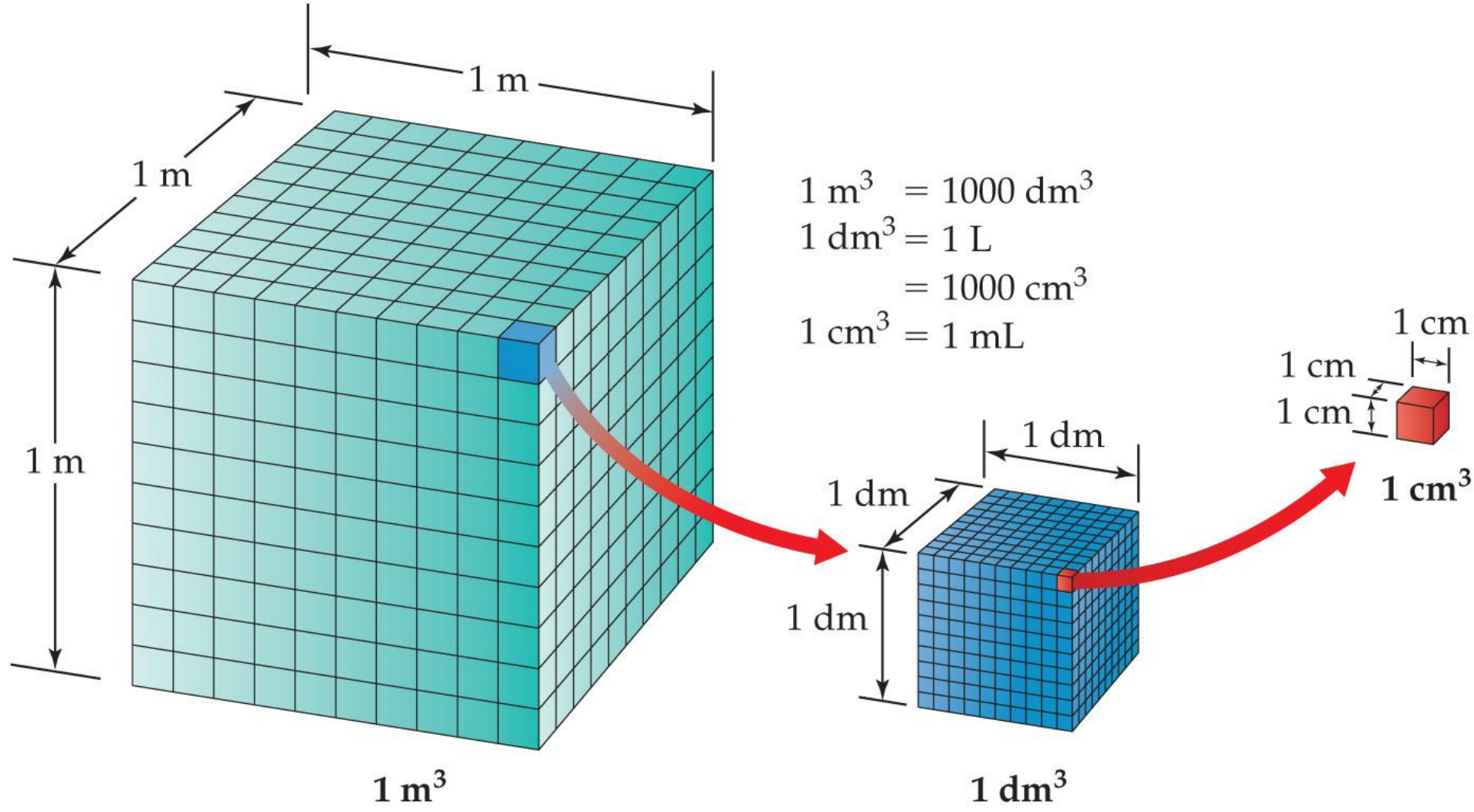
TABLE 0.3 Some Derived Units and the Quantities They Measure

Quantity	Definition	Derived Unit (Name)
Area	Length times length	m^2
Volume	Area times length	m^3 (Liter, L)
Density	Mass per unit volume	kg/m^3
Speed	Distance per unit time	m/s
Acceleration	Change in speed per unit time	m/s^2
Force	Mass times acceleration	$(kg \cdot m)/s^2$ (newton, N)
Pressure	Force per unit area	$kg/(m \cdot s^2)$ (pascal, Pa)
Energy	Force times distance	$(kg \cdot m^2)/s^2$ (joule, J)

The Liter

- Volume is cubic length
- V = l X w X h
- 1L = 1 dm^3
- 1mL = 1 cm^3 or cc

Derived Units: Measuring Volume



Each **cubic meter** contains 1000 **cubic decimeters** (liters).

Each **cubic decimeter** contains 1000 **cubic centimeters** (milliliters).

Mass & Force (weight)

- Mass is measured in kg in the SI system
- Weight is a force
  - Force is a derived unit; F = m X a
  - Force is measured in newtons (N)
  - The acceleration of gravity on a body's mass
- Balance: Instrument used to compare the mass of an object with other objects of known mass
  - Tribeam balance
  - Electronic balance

Density

The mass of a unit volume of substance

$$D = m/V$$

ENERGY

The Capacity for doing work

Types of Energy

- Potential Energy (V):
  - Possesses the potential to do work based on position, condition, or composition.
- Kinetic Energy(E_k):
  - Energy due to the motion of a body.

KINETIC ENERGY

$$E = E_k + V$$

TOTAL ENERGY

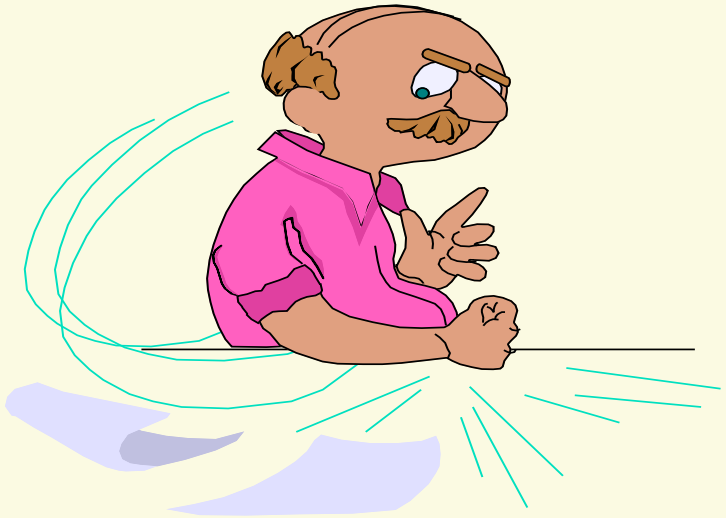
POTENTIAL ENERGY

Forms of Energy

- Electromagnetic
- Chemical
- Mechanical
- Nuclear
- Thermal

Law of Conservation of Energy

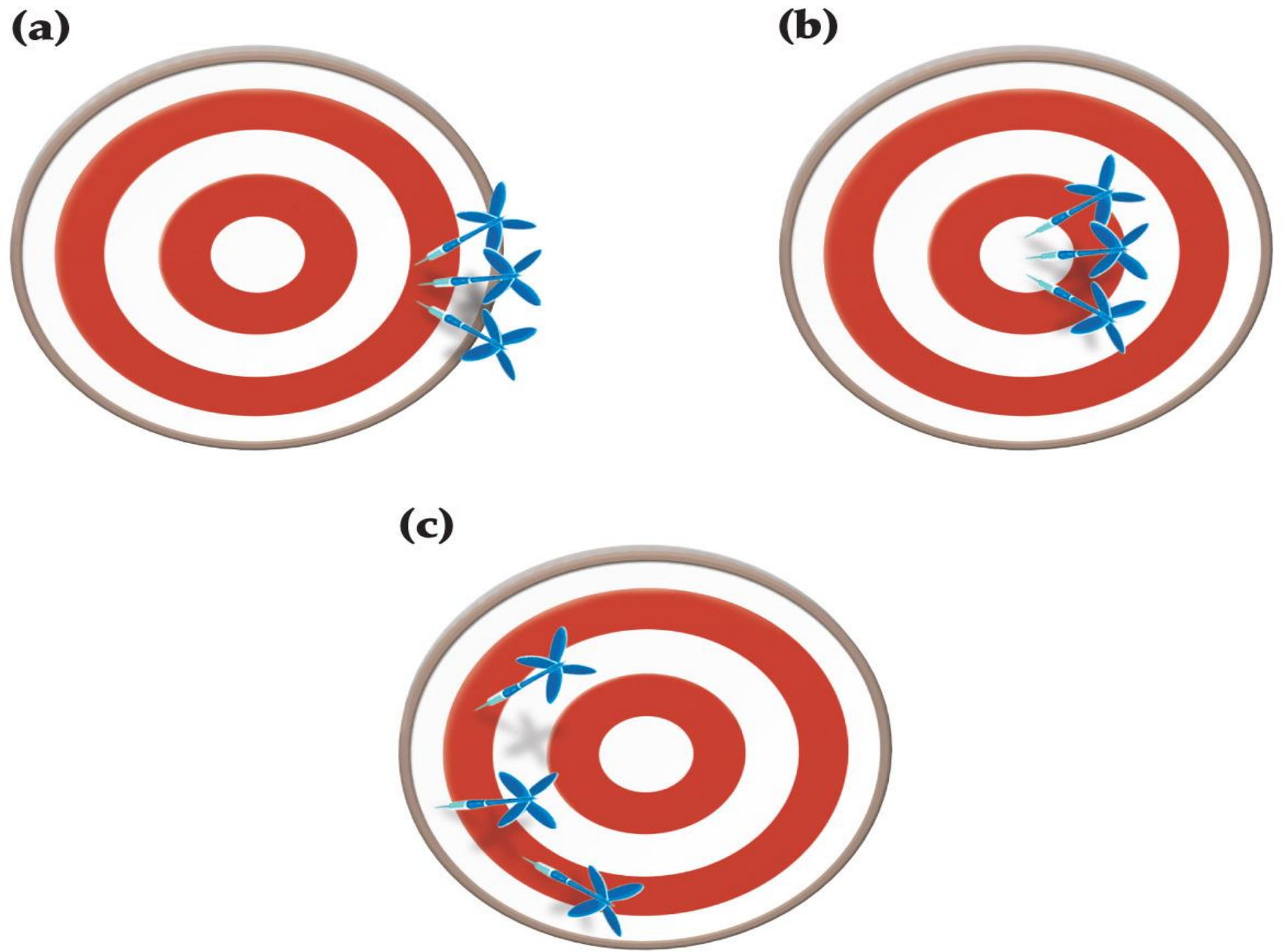
During a physical or chemical change, energy can be neither created nor destroyed; it only changes form.



Accuracy, Precision, and Significant Figures in Measurement

Accuracy: how close to the true value a given measurement is.

Precision: how well a number of independent measurements agree with each other.


(a)
(b)
(c)

Accuracy, Precision, and Significant Figures in Measurement

Significant figures: the total number of digits recorded for a measurement or calculated quantity. All digits but the last are certain.

The last digit is an estimate. An error of plus or minus one (±1) is assumed.

Exact numbers effectively have an infinite number of significant figures.

RULES FOR SIGNIFICANT FIGURES

- All nonzero digits are significant
- All zeros between two nonzero digits are significant
- Zeros to the right of a nonzero digit, but to the left of an understood decimal, are not significant. (unless specifically indicated)
- All zeros to the right of a decimal, but to the left of a nonzero digit are not significant.
- All zeros to the right of a decimal and to the right of a significant digit are significant.

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Operations with Significant Digits

Addition & Subtraction

Leftmost place of uncertainty

$$\begin{array}{r} 20.63\ cm \\ 6.6\ cm \\ +\ 3.786 cm \\ \hline 31.016 cm \end{array}$$

Rightmost significant figure in sum

Multiplication & Division

$$9.52m \times 0.52m \times 11.35m = 56.18704m^3$$

3 sig. figures

2 sig. figures

4 sig. figures

Multiplication & Division

$$9.52m \times 0.52m \times 11.35m = 56m^3$$

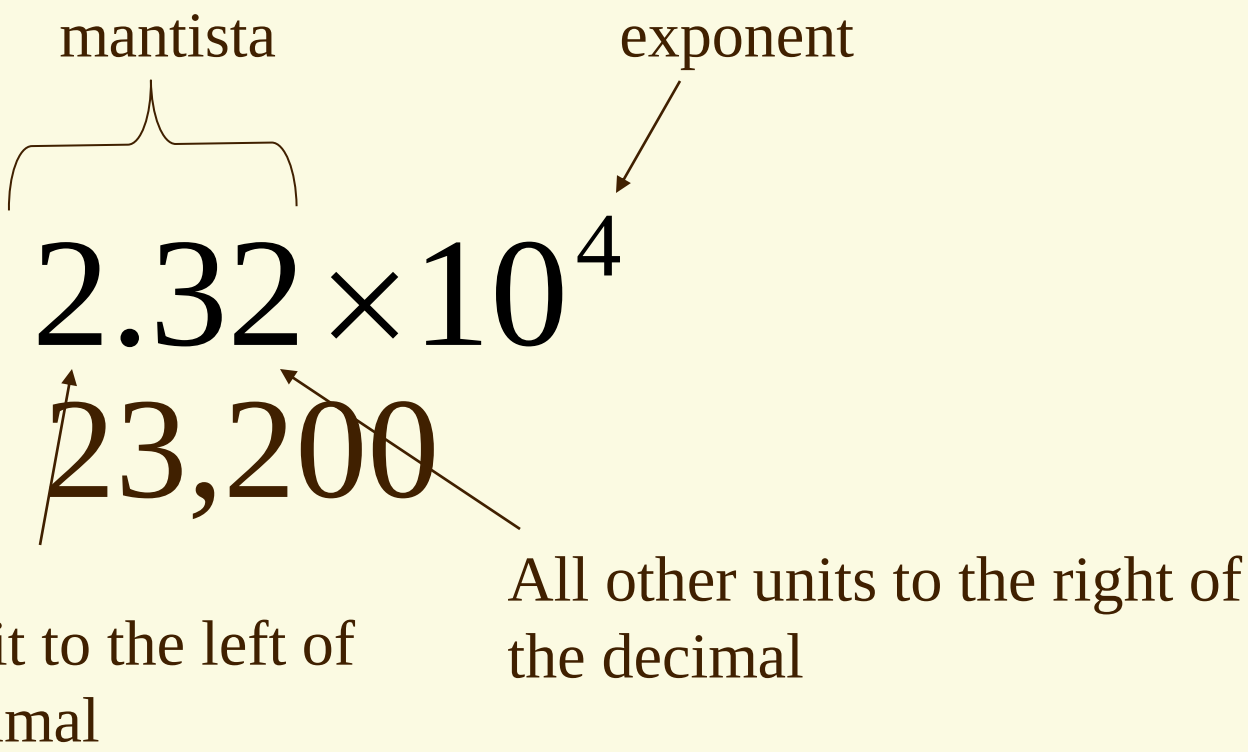
Dimensional Analysis

given

$$5m \times \frac{100.cm}{1.00m} = 500cm$$

Conversion factor

Exponential Notation

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