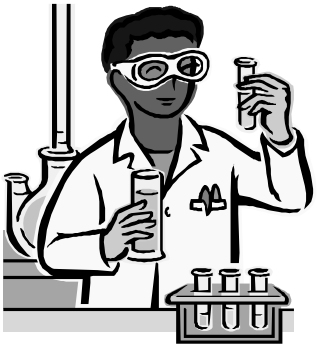

Measurements and Moles

- qualitative analysis - determination of chemical and physical properties
- quantitative analysis - determination of chemical amounts and composition

Measurements and Units

- measurements - quantitative observations
- units - standards used to compare measurements (yard→standard for comparison of length measurements)

2.1 The SI System

- Based on the metric system (France)
- SI base units

quantity = number × unit

5.5 seconds = 5.5 × 1 s

Table 2.1 SI base units

Quantity	Base unit
length	1 meter (1 m)
mass	1 kilogram (1 kg)
time	1 second (1 s)
electric current	1 ampere (1 A)
temperature	1 kelvin (1 K)
chemical amount	1 mole (1 mol)
luminous intensity	1 candela (1 cd)

2.2 Prefixes for Units

- Prefixes
  - denote powers of 10
  - can be used with any unit

1 mm = 10^{-3} × (1 m) = 10^{-3} m

1 MW = 10^{6} × (1 W) = 10^{6} W

1 μs = 10^{-6} × (1 s) = 10^{-6} s

1 ng = 10^{-9} × (1 g) = 10^{-9} g

Table 2.2 Common SI prefixes

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

2.3 Derived Units

- Derived from the base units
  - volume (V) → 1 m^3 = (1 m) × (1 m) × (1 m)

1 mL = 1 cm^3 = (1 cm)×(1 cm)×(1 cm) =
= (10^{-2} m)×(10^{-2} m)×(10^{-2} m) = (10^{-2}×10^{-2}×10^{-2}) m^3 = 10^{-6} m^3

  - density (d) → mass (m) per unit volume (V) → ($d = m/V$)

unit of *d* = (1 kg)/(1 m^3) = 1 kg/m^3

  - velocity (v) → distance (l) per unit time (t) → ($v = l/t$)

unit of *v* = (1 m)/(1 s) = 1 m/s

  - extensive properties - depend on sample size (mass, volume, length, ...)
  - intensive properties - independent of sample size (density, temperature, color, ...)

Examples:

- What is the density of an alloy, if **55 g** of it displace **9.1 mL** of water?

***d* = *m*/*V* = (55 g)/(9.1 mL) = 6.0 g/mL = 6.0 g/cm^3**

- What is the mass of 7.3 cm^3 of this alloy?

***m* = *V*×*d* = (7.3 cm^3)×(6.0 g/cm^3) = 44 g**

2.4 Unit Conversions

- Systems of units (metric, English, SI, ...)
- Equalities between units
  1 in = 2.54 cm
  1 km = 10^3 m
- Conversion factors - ratios between two equal or equivalent units (derived from equalities)
  [1 in/2.54 cm] or [2.54 cm/1 in]

- Unit conversions (old unit → new unit)
  – quantity remains the same; units change
  new unit = (old unit) × (conversion factor)
  conversion factor = (new unit)/(old unit)
  new unit = old unit × [new unit / old unit]
  – the old units cancel

Example:

- Convert **5.13 inches** in **centimeters**.

old unit → in **new unit → cm**

1 in = 2.54 cm → conversion factor = [2.54 cm/1 in]

5.13 in×[2.54 cm/1 in] = 5.13×2.54×(in·cm/in) = 13.0 cm

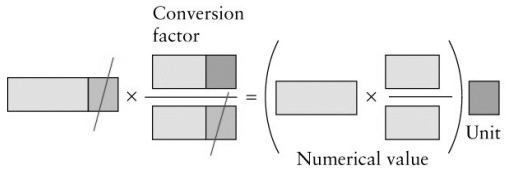

Fig. 2.4

Example:

- Two cities are **250 mi** apart. What is this distance in **km**?

1 km = 0.6214 mi

250 mi ×[1 km/0.6214 mi] = 402 km

Example:

- Convert the speed of sound, **332 m/s**, to **km/hr**.

⇒ need to convert both the numerator and denominator
m → km and s → hr

1 km = 10^3 m and 1 hr = 60 min = 3600 s

332 m/s ×[1 km/10^3 m]×[3600 s/1 hr] = 1195 km/hr

Example:

- Convert the density of gold, **19.3 g/cm^3**, to **kg/m^3**.

⇒ need to convert both the numerator and denominator
g → kg and $cm^3 \rightarrow m^3$

1 kg = 10^3 g

1 cm = 10^{-2} m ⇒ 1 cm^3 = $(10^{-2})^3$ m^3 = 10^{-6} m^3

19.3 g/cm^3×[1 kg/10^3 g]×[1 cm^3/10^{-6} m^3] =

= 19.3×10^3 kg/m^3