Introductory Chemistry 1111

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What is Chemistry?

Chemistry is the study of substances in terms of

Composition of Matter

What a material it made of

Structure of Matter

How the elementary particles are put and held together

Properties of Matter

The characteristics of the material

Reactions of Matter

The behavior with other substances

Properties of Matter

- **What is matter?**

  anything that has both mass & volume.

  What is weight and how does it compare to mass?
- **Properties:**

  describe or identify matter.

  - **Intensive Properties:**

    do not depend on amount.

    melting temperature, boiling temperature, density
  - **Extensive Properties:**

    do depend on amount.

    heat of melting, volume, mass

Physical Properties:

can be determined without changing the chemical makeup of the sample.

Some typical physical properties are:

melting point, boiling point, density, mass, temperature, size, color, hardness, conductivity.

Some typical physical changes are:

melting, freezing, boiling, condensation, evaporation, dissolving.

Chemical Properties:

properties that ***do*** change the chemical makeup of the sample

Some typical chemical properties are:

burning, cooking, rusting of iron nails, souring of milk, ripening of fruit, digesting food.

Homogeneous matter:
has the same appearance, composition, and properties throughout.

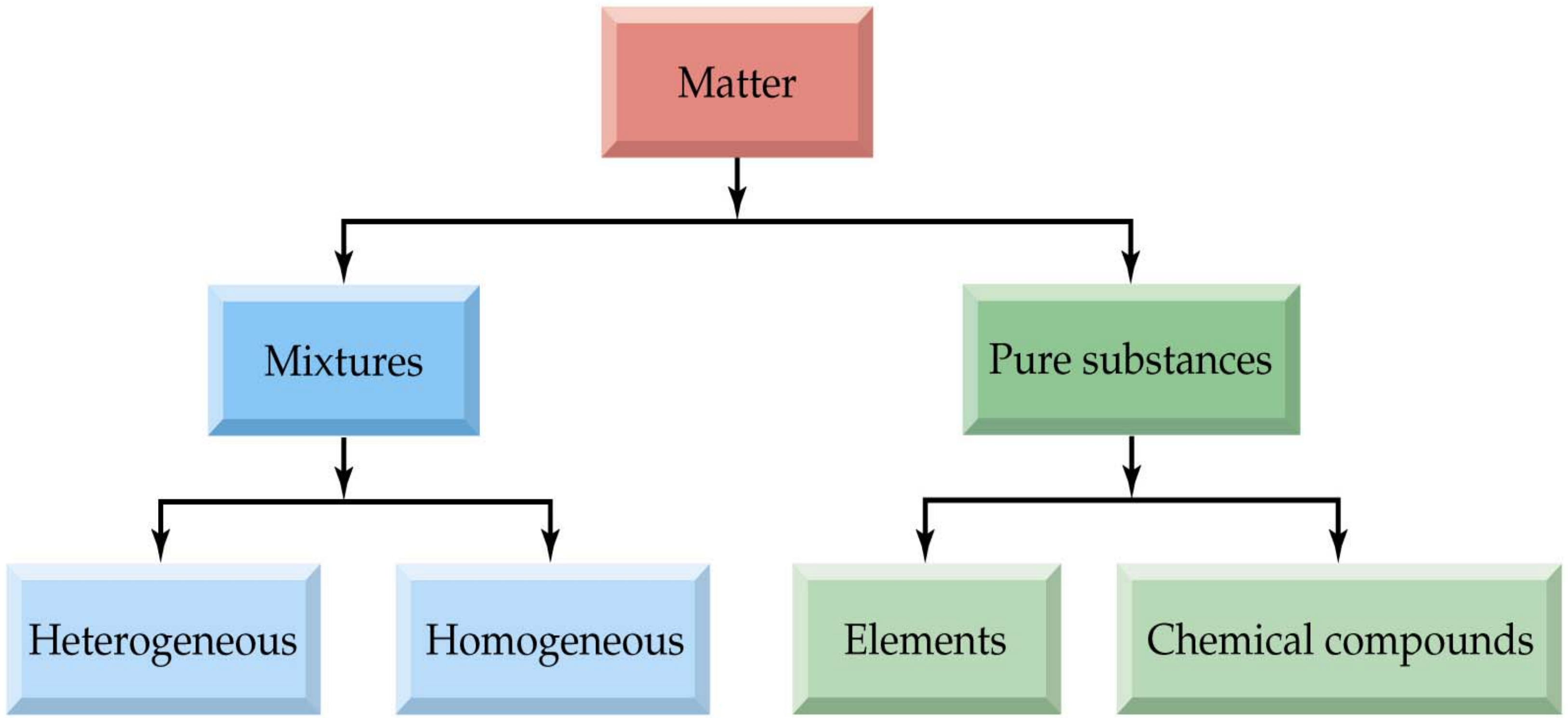
Heterogeneous matter:
has visibly different phases which can be seen, or properties that vary through the substance.

Pure substances:
have a distinct set of physical and chemical properties and cannot be separated by physical changes.

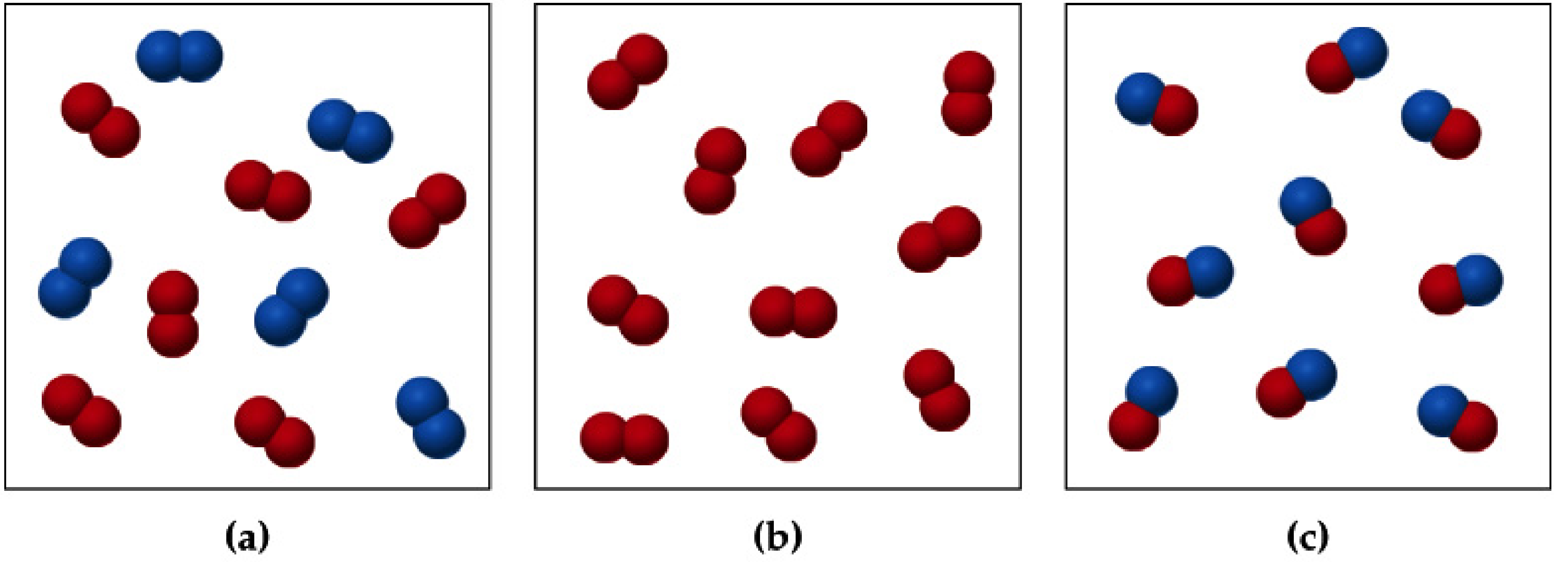
Impure substance or mixture:
two or more pure substances that can be separated by physical changes.

- **An element:**
- a pure substance with its own set of physical and chemical properties under ambient conditions that cannot be decomposed into simpler chemical substances.

- **Compound:**
- is a pure substance that can be decomposed by a chemical change into two or more elements.

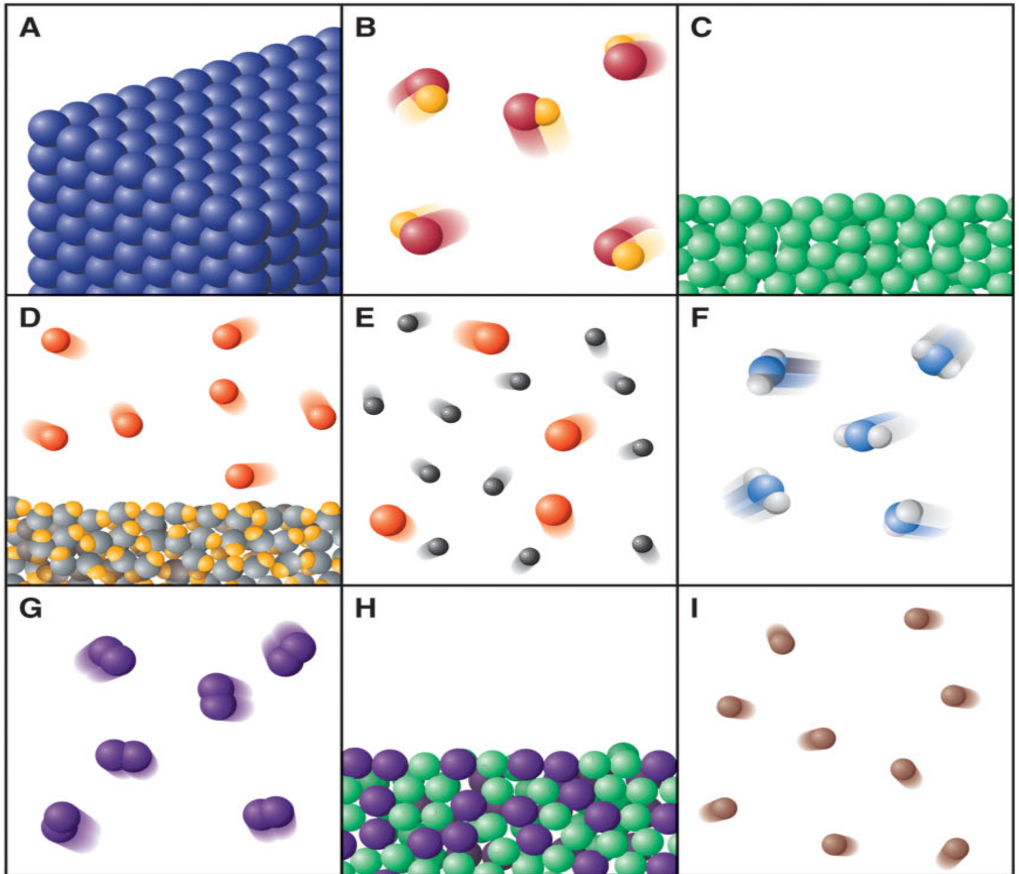

Matter
Mixtures
Pure substances
Heterogeneous
Homogeneous
Elements
Chemical compounds

•Which of the following represents a mixture, an element, a compound?



2.127 Scenes A–I depict various types of matter on the atomic scale. Choose the correct scene(s) for each of the following:

(a) A mixture that fills its container
(b) A substance that cannot be broken down into simpler ones
(c) An element with a very high resistance to flow
(d) A homogeneous mixture
(e) An element that fills its container but displays a surface
(f) A gas consisting of diatomic particles
(g) A gas that can be broken down into simpler substances
(h) A substance with a 2:1 number ratio of its component atoms
(i) Matter that can be separated into its component substances by physical means
(j) A heterogeneous mixture
(k) Matter that obeys the law of definite composition



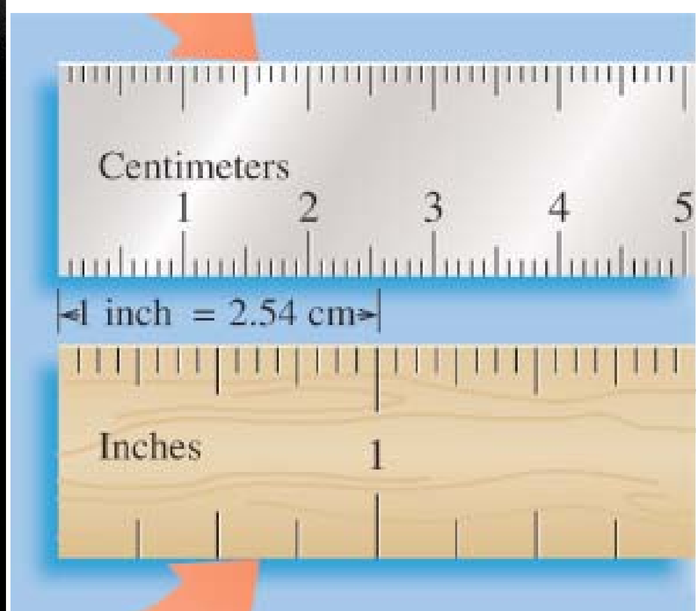
- **Scientific notation** is used to write very large or very small numbers
- the width of a human hair (0.000 008 m) is written
- 8×10^{-6} m
- a large number such as 4 500 000 s is written
- 4.5×10^{6} s

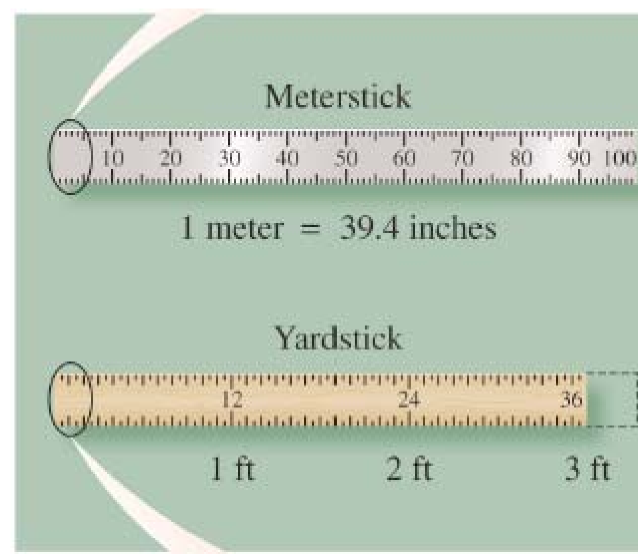
- A number in scientific notation contains a coefficient and a power of 10.
- ***coefficient power of ten coefficient power of ten***
- 1.5×10^{2} 7.35×10^{-4}
- To write a number in scientific notation, the decimal point is placed after the first digit.
- The spaces moved are shown as a power of ten.
- $52\,000. = 5.2 \times 10^{4}$ $0.00378 = 3.78 \times 10^{-3}$
-
- *4 spaces left* *3 spaces right*

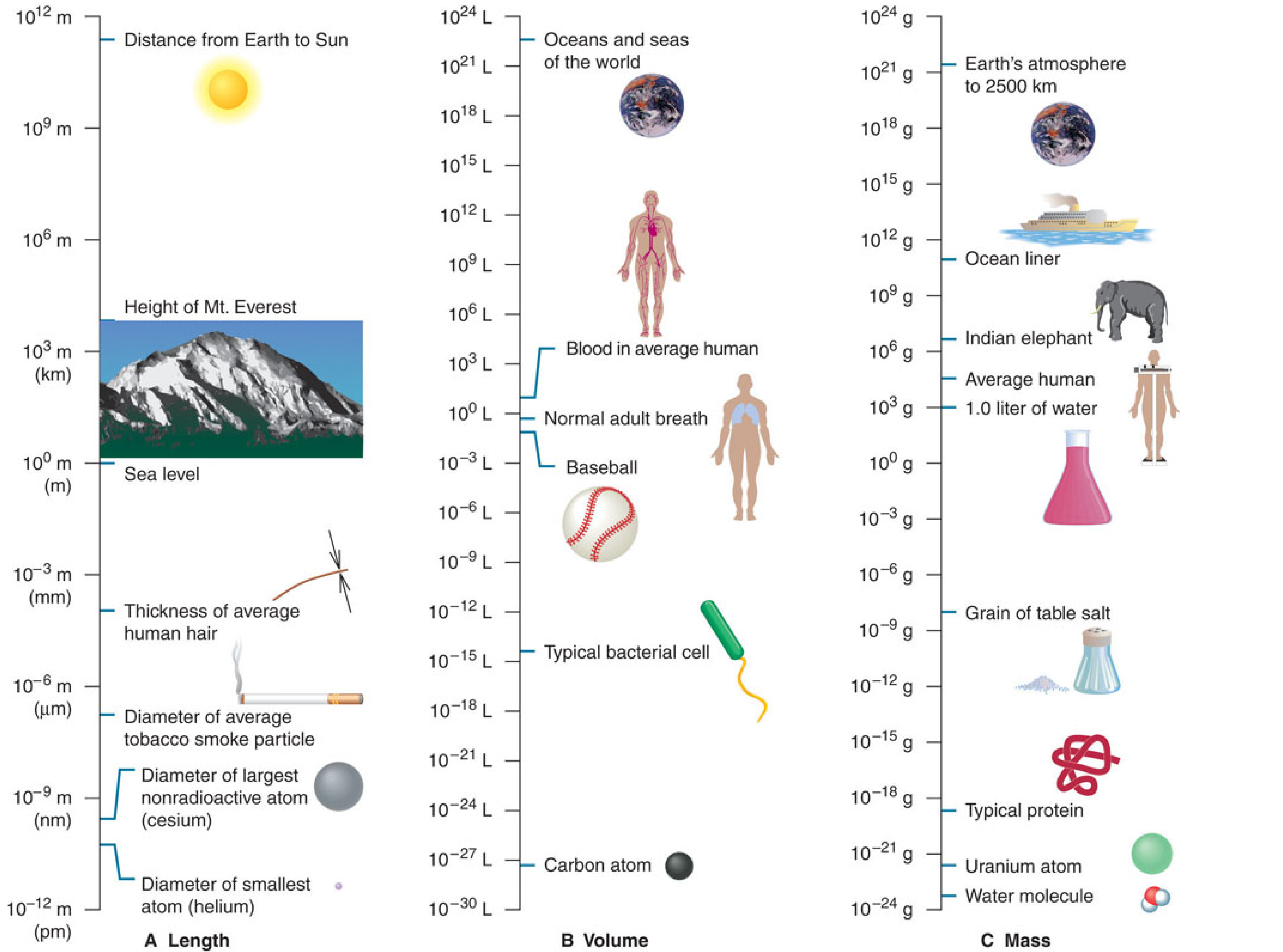
Some Prefixes for Multiples of SI Units.

Factor	Prefix	Symbol
$1,000,000,000 = 10^{9}$	giga	G
$1,000,000 = 10^{6}$	mega	M
$1,000 = 10^{3}$	kilo	k
$100 = 10^{2}$	hecto	h
$10 = 10^{1}$	deka	da
$0.1 = 10^{-1}$	deci	d
$0.01 = 10^{-2}$	centi	c
$0.001 = 10^{-3}$	milli	m
$0.000,001 = 10^{-6}$	micro	μ
$0.000,000,001 = 10^{-9}$	nano	n
$0.000,000,000,001 = 10^{-12}$	pico	p

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







10¹² m
Distance from Earth to Sun
10⁹ m
10⁶ m
Height of Mt. Everest
10³ m (km)
10⁰ m (m)
Sea level
10⁻³ m (mm)
Thickness of average human hair
10⁻⁶ m (µm)
Diameter of average tobacco smoke particle
10⁻⁹ m (nm)
Diameter of largest nonradioactive atom (cesium)
Diameter of smallest atom (helium)
10⁻¹² m (pm)
A Length
10²⁴ L
Oceans and seas of the world
10²¹ L
10¹⁸ L
10¹⁵ L
10¹² L
10⁹ L
10⁶ L
Blood in average human
10³ L
10⁰ L
Normal adult breath
Baseball
10⁻³ L
10⁻⁶ L
10⁻⁹ L
10⁻¹² L
Typical bacterial cell
10⁻¹⁵ L
10⁻¹⁸ L
10⁻²¹ L
10⁻²⁴ L
10⁻²⁷ L
Carbon atom
10⁻³⁰ L
B Volume
10²⁴ g
10²¹ g
Earth's atmosphere to 2500 km
10¹⁸ g
10¹⁵ g
10¹² g
Ocean liner
10⁹ g
Indian elephant
10⁶ g
Average human
10³ g
1.0 liter of water
10⁰ g
10⁻³ g
10⁻⁶ g
Grain of table salt
10⁻⁹ g
10⁻¹² g
10⁻¹⁵ g
10⁻¹⁸ g
Typical protein
10⁻²¹ g
Uranium atom
Water molecule
10⁻²⁴ g
C Mass

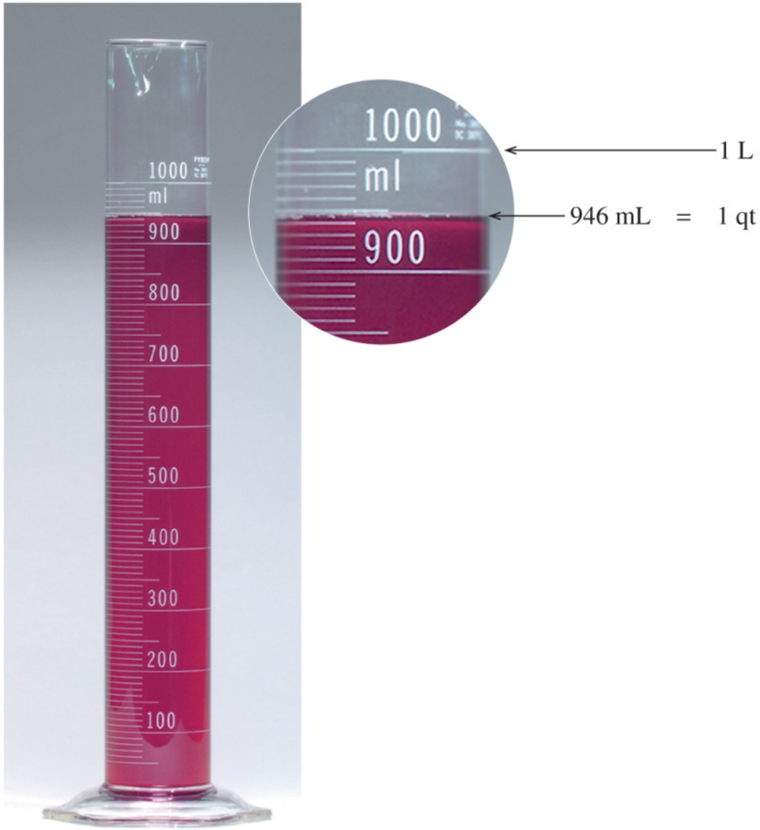
Derived Quantities

Quantity	Definition	Derived Unit (Name)
Area	Length times length	m^2
Volume	Area times length	m^3
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)

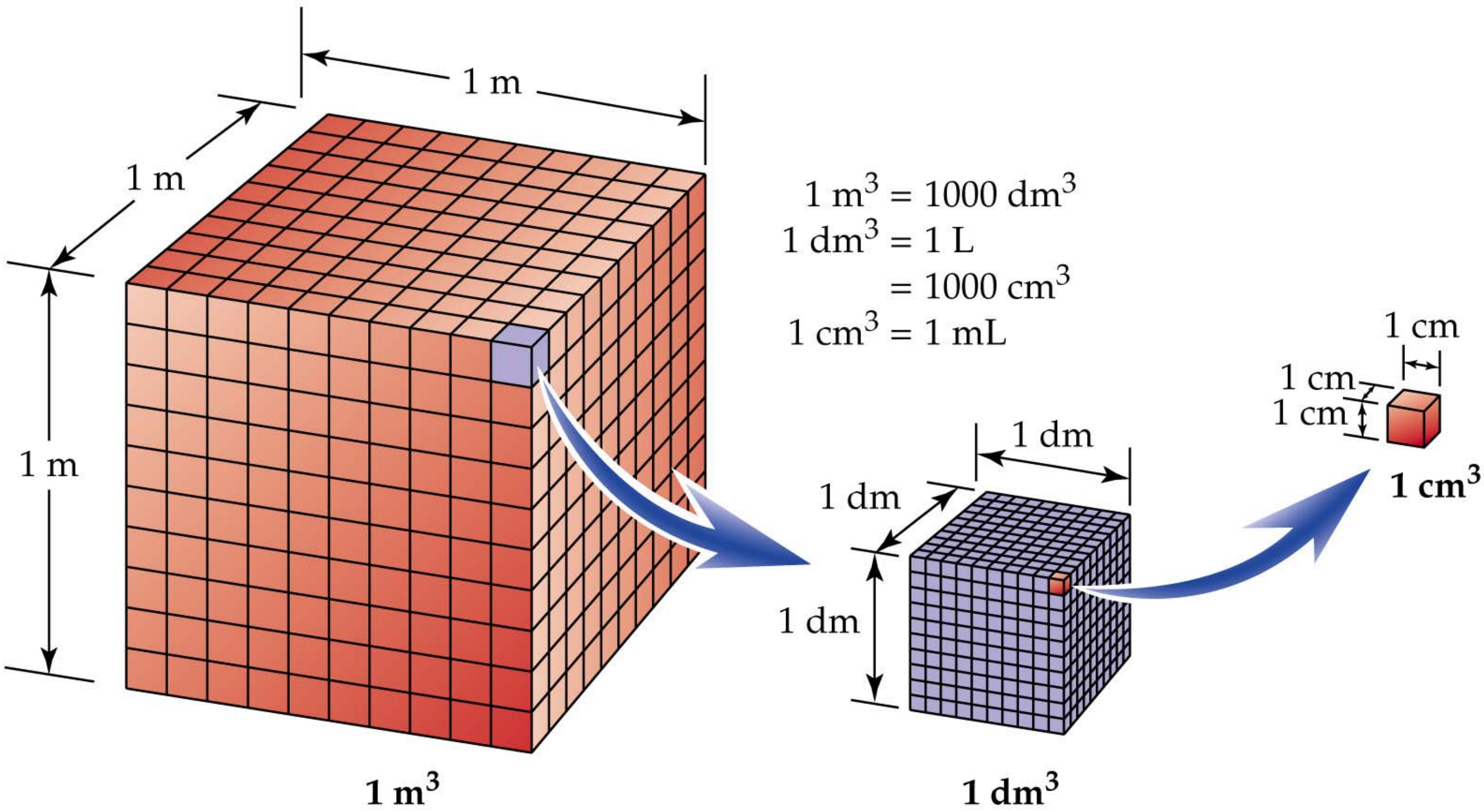
Volume

is the space occupied
by a substance;
the unit of volume is the **liter**
(L); in the metric system
1 L = 1.06 qt

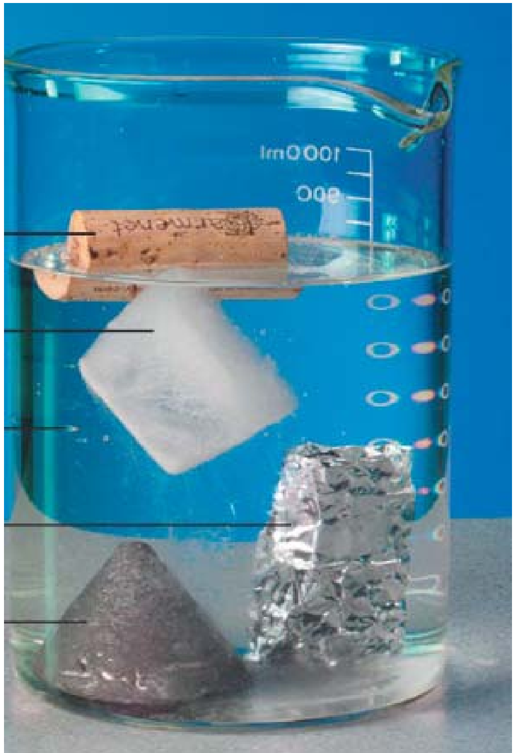
1 mL = 1 cm^3



dm^3 = decimeter = 1/100 m^3



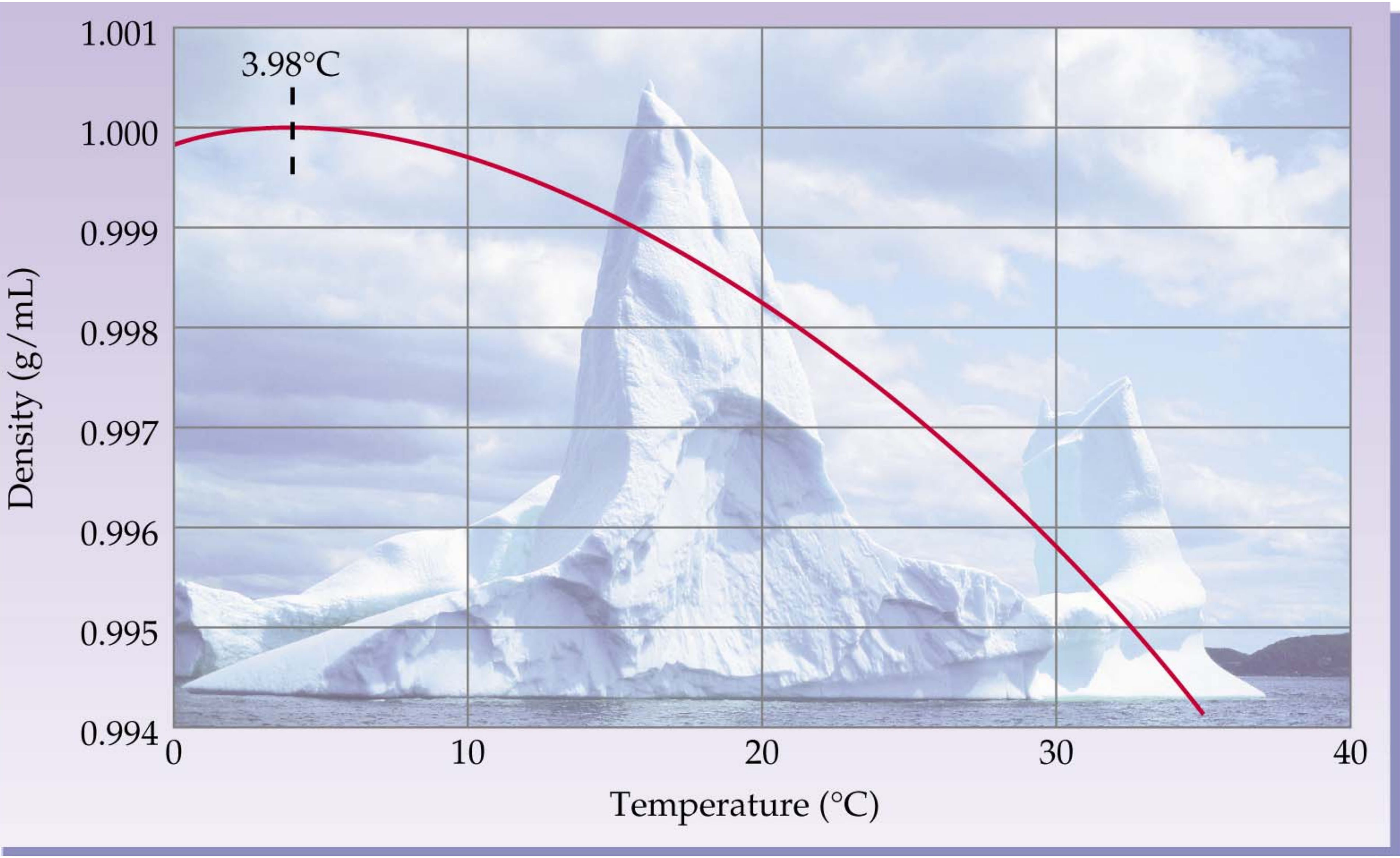
- **Density:** relates the mass of an object to its volume.
- Density decreases as a substance is heated because the substance's volume usually increases. Knowing the density of a substance allows measurements of volume to be related to mass or measurements of mass to be related to volume.



Density is the mass of a substance divided by its volume

Density expression:

$$D = \frac{\text{mass}}{\text{volume}} = \frac{g}{mL} \text{ or } \frac{g}{cm^3} = g/cm^3$$

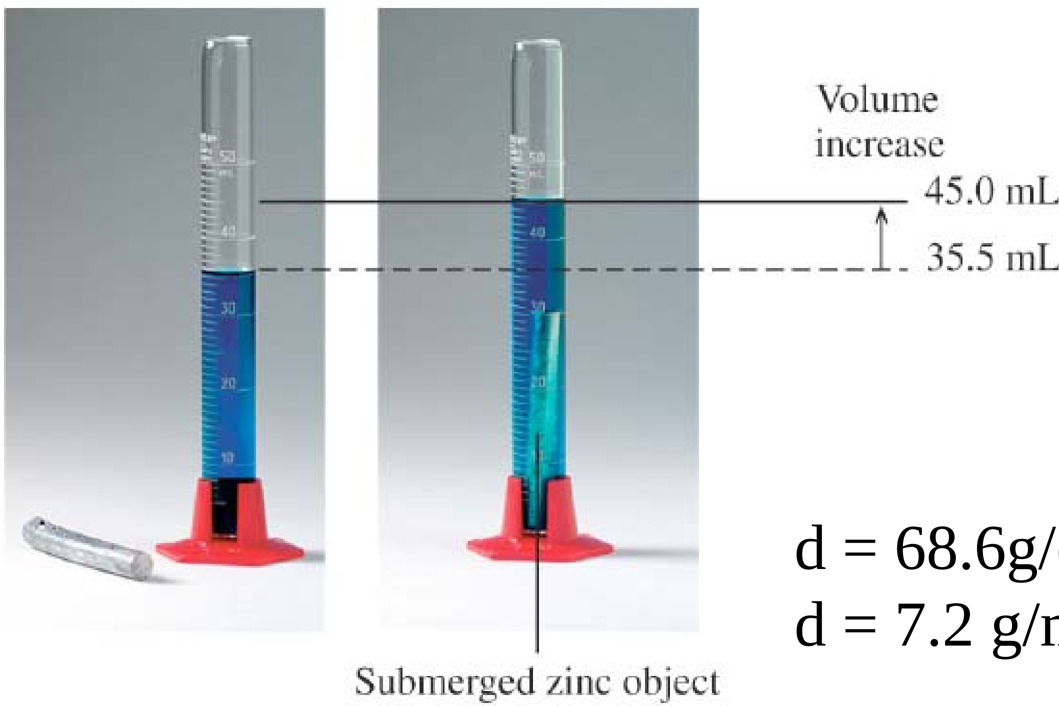

3.98°C
1.001
1.000
0.999
0.998
0.997
0.996
0.995
0.994
Density (g/mL)
0
10
20
30
40
Temperature (°C)

Densities of Some Common Materials.

Substance	Density (g/cm^3)	Substance	Density (g/cm^3)
Ice (0.0°C)	0.917	Human Fat	0.94
Water (4.0°C)	1.0000	Cork	0.22–0.26
Gold	19.31	Table Sugar	1.59
Helium (25.0°C)	0.000164	Balsa Wood	0.12
Air (25.0°C)	0.001185	Earth	5.54

- Density

- The density of the zinc object can be
- calculated from its mass and volume.



d = 68.6g/(45.0-35.5)mL;   68.6g/9.5 mL
d = 7.2 g/mL

Some Density Calculations

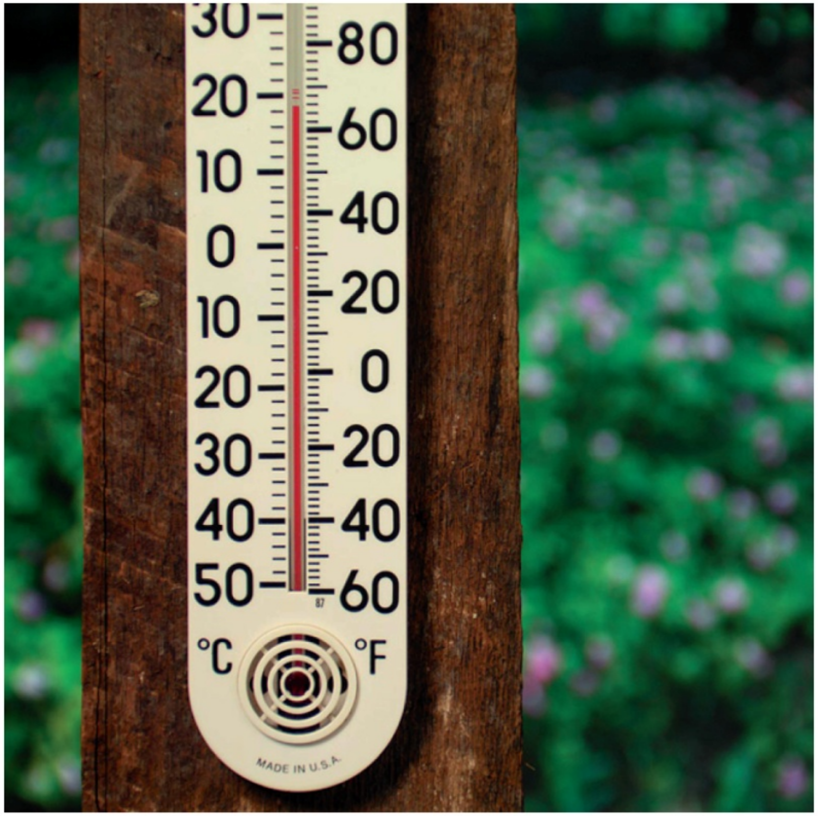
- Density = m/V
- density is usually given in g/mL or g /cm^3 we will treat 1 mL = 1 cm^3
- What is the density of glass (in grams per cubic centimeter) if a sample weighing 26.43 g has a volume of 12.40 cm^3?

  d = 26.43 g/ 12.4 mL = 2.131451613 How many figures after the decimal should we carry?

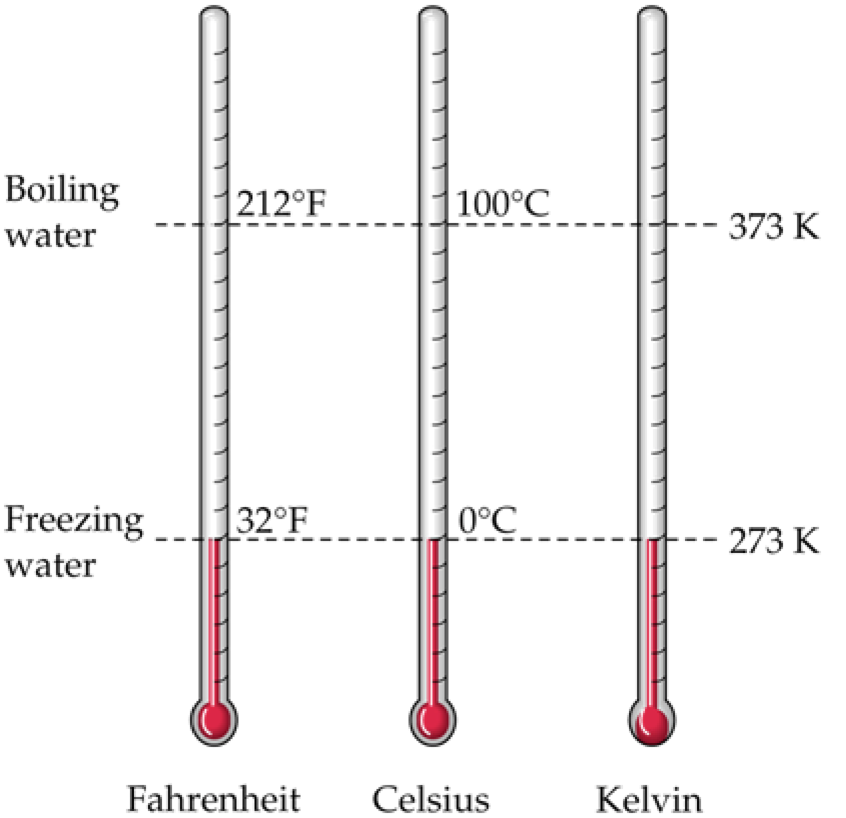
- Chloroform, a substance once used as an anesthetic, has a density of 1.483 g/mL at 20°C. How many mL would you use if you needed 9.37 g?
- d = 1.483 g/mL ; 1.483 = 9.37g/x mL ; solving for x:
- x = 9.37 g/1.483 g/mL = 6.318273769 mL
- x = 6.31mL

Temperature

- **What does temperature measure?**
  - **Temperature measures**
  - **motion; it is a measure of**
  - **the average kinetic energy**
  - **of molecules: $1/2mv^2$**
  - **where m is the mass of the**
  - **molecule and v is its velocity**



- **Temperature Conversions:**
- The Kelvin and Celsius degree are essentially the same because both are one hundredth of the interval between freezing and boiling points of water.



- How do you convert from ° C to K?

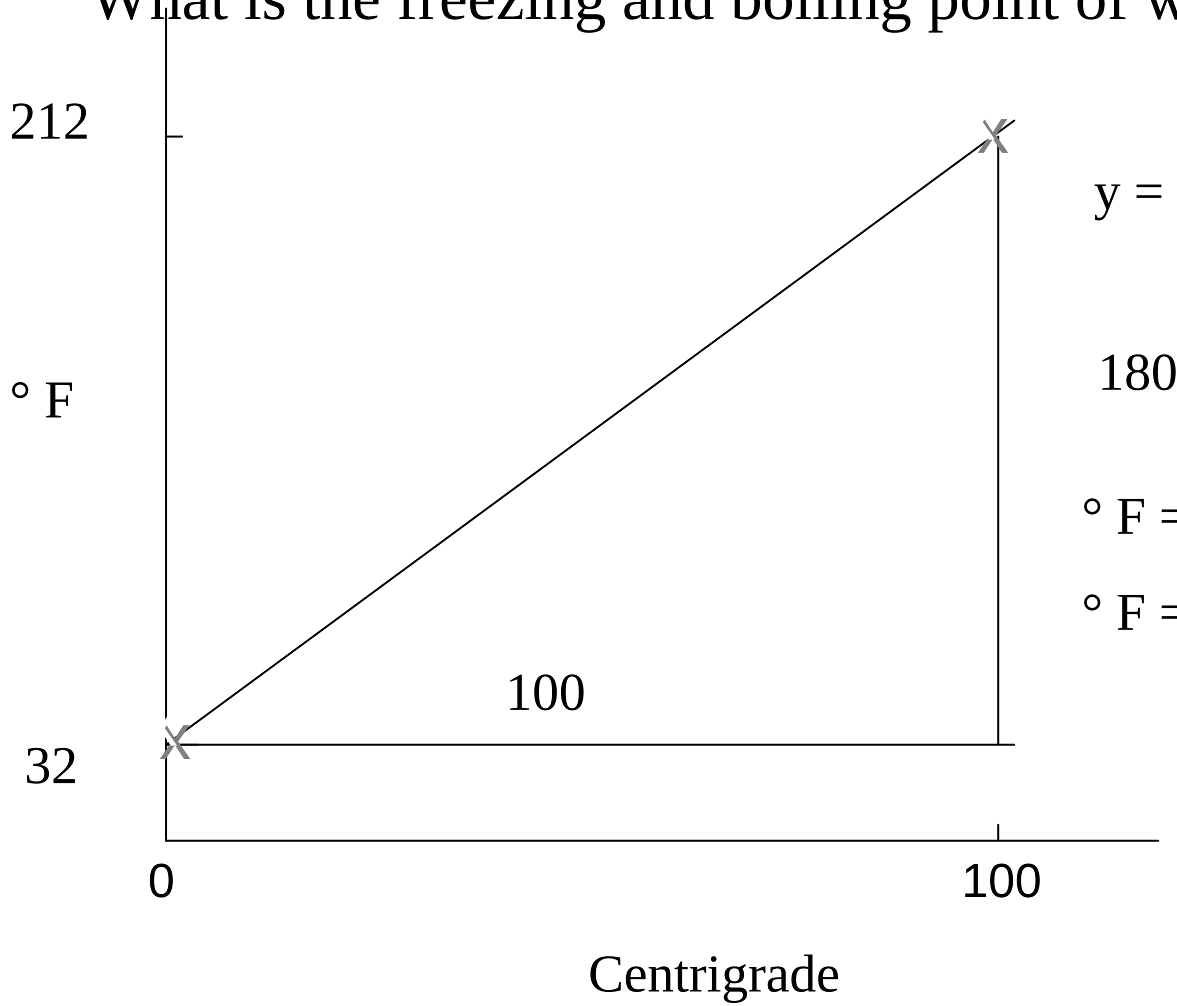
Celsius (°C) to Kelvin temperature conversion:

Kelvin (K) = °C + 273.15

Fahrenheit (°F) — Celsius temperature conversions:

What is the freezing point and boiling of water in °C?

What is the freezing and boiling point of water in °F?



y = m x + b

180

° F = 180/100 °C +32

° F = 1.8 °C +32

Carry out the following conversions

(a) $-78°C = ?\ K$

$273-78 = 195\ K$

(b) $158°C = ?\ °F$

$°F = 1.8°C+32$

$1.8(158)+32 = 316.4\ °F$

(c) $375\ K = ?\ °C$

$°C = 375-273 = 102\ K$

(d) $98.6°F = ?\ °C$

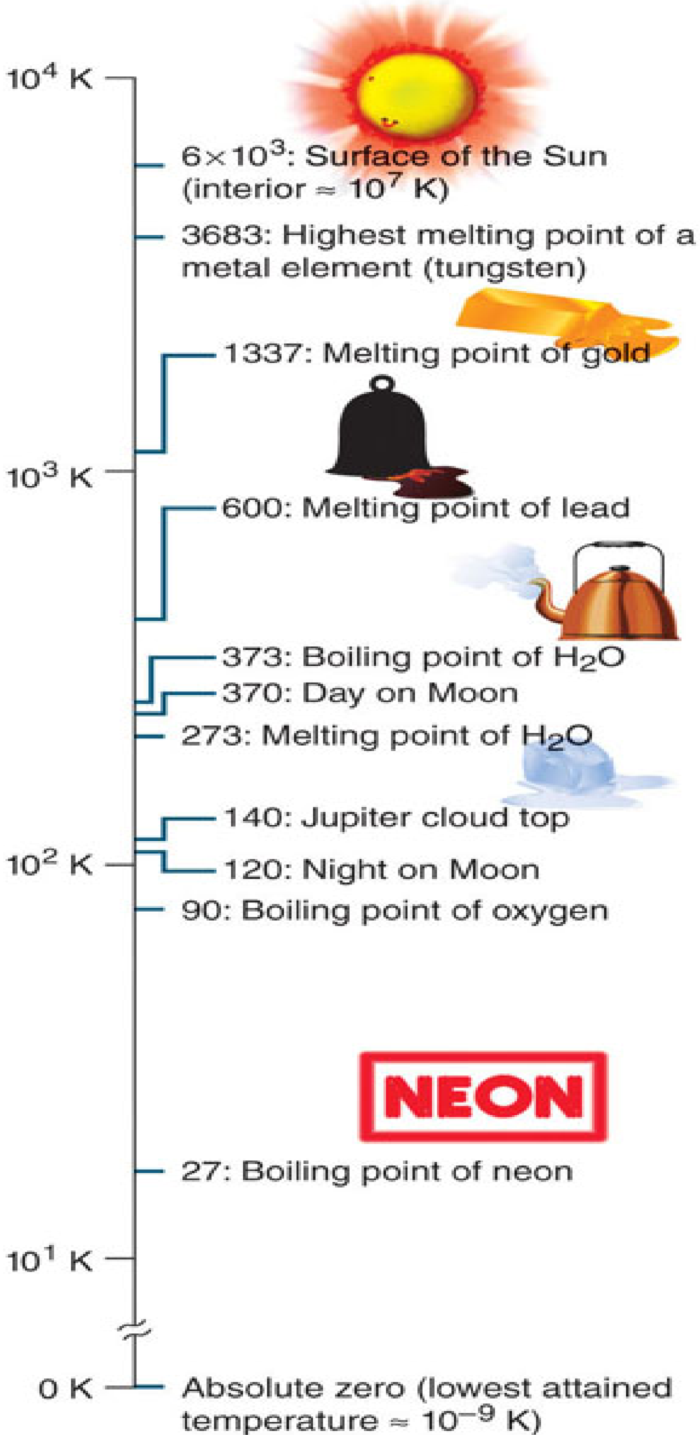
$°C = (°F - 32)/1.8$

$= (98.6-32)/1.8 = 37.000\ °C$

(e) $98.6°F = ?\ K$

$98.6°F = 37.0\ °C;$

$K = 273+37 = 310\ K$



A Range of Temperatures

Dimensional-Analysis:
The use of conversions factors to express the relationship between units.

- Express 2.5 kg in lbs: 1 kg = 2.205 lb

- 2.205 lb/1 kg =1 or 1kg/2.205 lb = 1
- 2.5 kg *2.205 lb/1kg or 2.5 kg*1 kg/2.205 lb
- 6.0 lb or 1.13 kg^2/lb

- An injured person loses 0.3 pints of blood; how many milliliters would that be?

1 qt = 2 pt	1 = 2pt/qt	1qt/2pt = 1
1qt = 946 mL	1 = 946 mL/qt	1qt/946 mL= 1

0.3 pt*1qt/2pt = 0.15 qts;

0.3 pt*2pt/qt = 0.6pt^2/qt

0.15 qt*946 mL/qt = 141.9 mL;

0.15 qts*1qts/946 mL = 1.59x10^{-4}qt^2/mL

Conversion Factors: 1 mi = 5280 ft; 1 in = 2.54 cm

1 ft = 12 in; 1 m = 100 cm

How many meters are there in a marathon race (26 miles and 385 yd)?

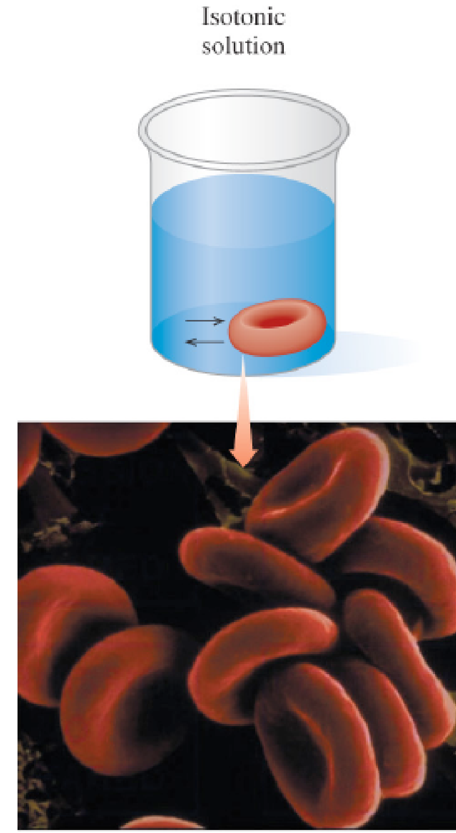
1 mi x 5280 ft/mi x 12 in/ft x 2.54 cm/in x 1m/100cm = 1609.3 m

26 mi x(1.6093×10^3)m/mi = 41.84×10^3 m

385 yd x 3 ft/yd x 12 in/ft x 2.54 cm/in x 1 m/100 cm = 352 m

41840 m +352 m = 42192 m

Volume of a cylinder; $V = \pi r^2 h$



How large, in cubic centimeters, is the volume of a red blood cell if the cell has a cylindrical shape with a diameter of 6.0×10^{-6} m and a height of 2.0×10^{-6} m? The volume of a cylinder is given by $V = \pi r^2 h$ where r = the radius and h is the height of the cylinder ($\pi = 3.1416$), so

$$V = 3.1416 \times [(6.0 \times 10^{-6} \text{ m} \times 100 \text{ cm/m})/2]^2 \times 2.0 \times 10^{-6} \text{ m} \times 100 \text{ cm/m}$$

$$V = 3.1416 \times [(3.0 \times 10^{-4} \text{ cm}]^2 \times 2.0 \times 10^{-4} \text{cm} = 5.65 \times 10^{-11} \text{cm}^3$$

$$V = 5.7 \times 10^{-11} \text{ cm}^3$$

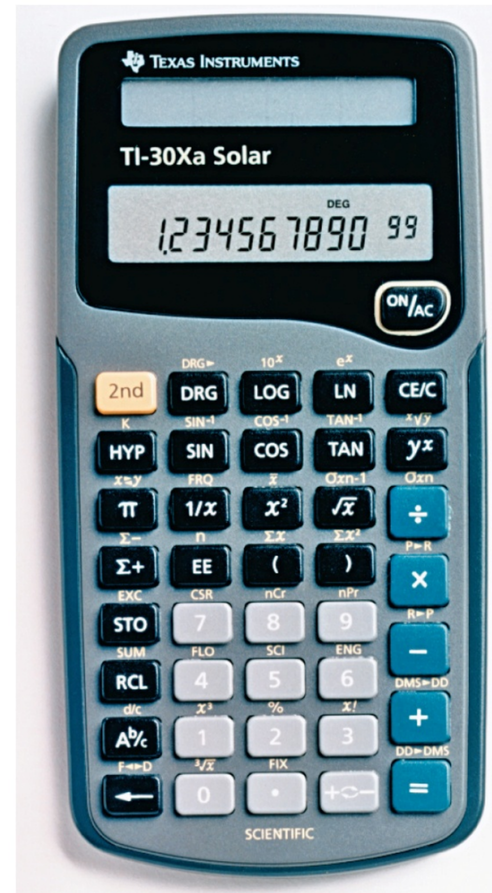
Accuracy, Precision, and Significant Figures in Measurement

Significant Figures:

include the number of digits in the measurement in which you have confidence plus an additional one which is an estimate.

The results of calculations are only as reliable as the least precise measurement.

Rules exist to govern the use of significant figures after the measurements have been made.



- ***Rules for Significant Figures:***
  - Zeros in the middle of a number are significant eg. 704
  - Zeros at the beginning of a number are not significant eg. 0.023
  - Zeros at the end of a number and following a period are significant eq. 230.0
  - Zeros at the end of a number and before a period are usually significant. 230.
  - Zeros at the end of a number without a period are usually not 230

How many significant figures in each of the following measurements?

(a) 0.036653 m

5

(a) 7.2100×10^{-3} g

3

(c) 72,100 km

3

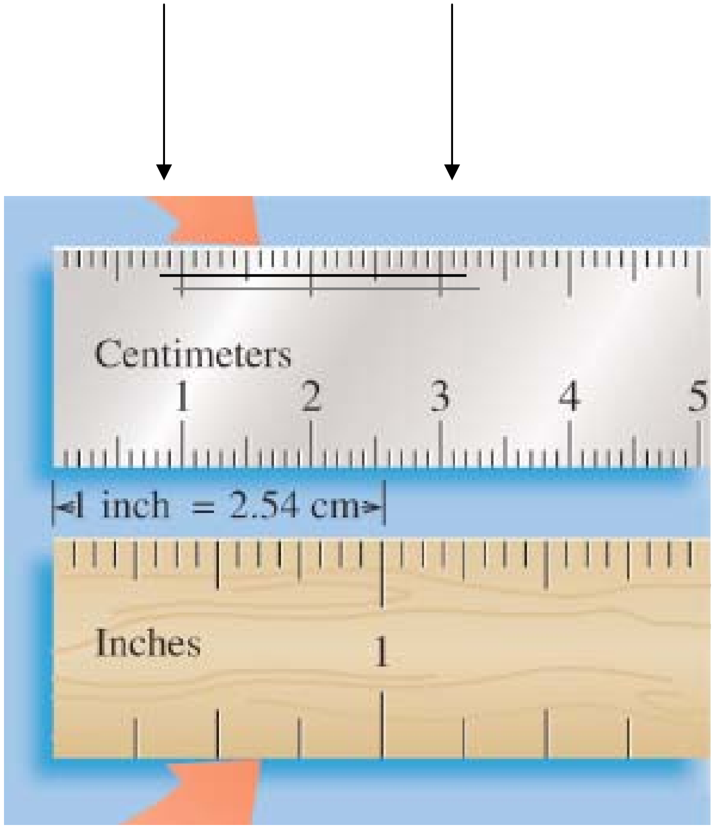
(d) $25.03

4

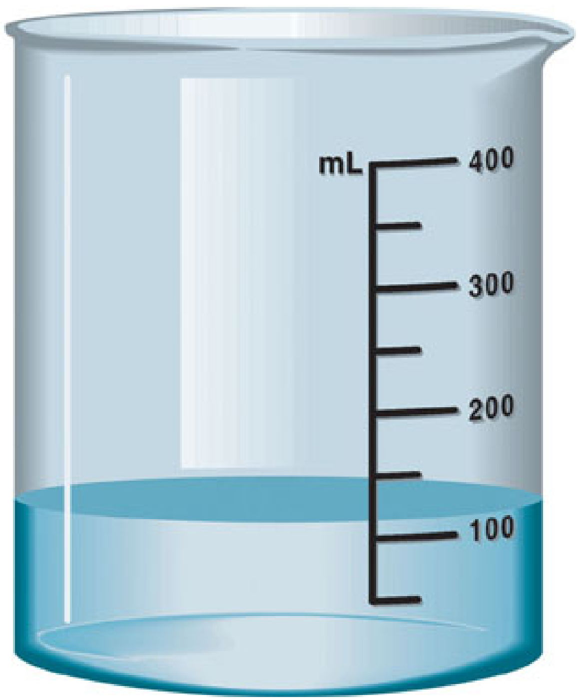
What is the length of the black line?

The length in cm is?

3.25
0.82
2.43 cm



1.71 What volume of liquid is shown in the beaker at right? Be sure to report your answer with the correct number of significant figures.



110 mL ?

120 mL ?

How many significant figures in 110:

2

Rules for significant figues in calculations

- During multiplication or division, the answer should not have more significant figures than the number with the least number of significant figures.
- During addition or subtraction, the answer should not have more digits to the right of the decimal point than any of the original numbers.

Rounding off in calculations

If the answer should have 3 significant figures:

– andthe last digit is 5 or greater, round to the next larger number: 2.545 = 2.55

– and the last digit is less than 5 - round down

– 2.544 = 2.54

- Express the result with the appropriate number of significant figures

- 12.453/2.3 = 5.414347826
- 12.453/2.3 = 5.4

- 12.453 +2.3 = 14.753
- 14.8

- 12.3567ft*12 in/ft =148.2804 in
- 148.2804 in

- 120./4.184 = 28.680688
- 28.7