A few more math with significant figures examples:

$\underset{5}{15047} \times \underset{2}{11} \times \underset{4}{0.9876} = 163464.5892$ → **160000**

Placeholder zeros, even though they aren't SIGNIFICANT, still need to be included, so we know how big the number is!

| | |
|---|---|
| 147.3 | ± 0.1 |
| 2432 | ± 1 |
| 0.97 | ± 0.01 |
| + 111.6 | ± 0.1 |
| 2691.87 | |

**2692**

DENSITY CALCULATION

$\frac{14.70668 \text{ g (6)}}{2.7 \text{ mL (2)}} = 5.446962963 \text{ g/mL}$

**5.4 g/mL**

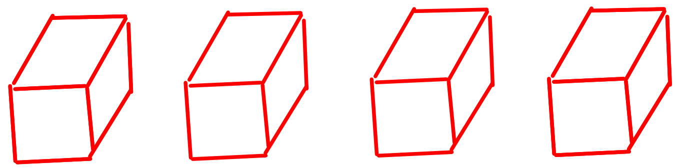
To improve the quality of the density, we must improve the precision of the volume measurements, since the volume measurements are limiting our final answer.

(We could even use a less precise balance if necessary for this measurement with no loss in quality, as long as it gave us at least two significant figures for our mass!)

# Exact Numbers

- Some numbers do not have any uncertainty. In other words, they weren't measured!

1) Numbers that were determined by COUNTING!



How many blocks are to the left?

exactly 4!

2) Numbers that arise from DEFINITIONS, often involving relationships between units

12 in = 1 ft

Km = $10^3$ m

* All metric prefixes are exact!

- Treat exact numbers as if they have INFINITE significant figures!

# Example

You'll need to round the answer to the right number of significant figures!
Convert 4.45 m to in, assuming that 2.54 cm = 1 in *

$$\text{cm} = 10^{-2}\,\text{m} \qquad 2.54\ \text{cm} = 1\ \text{in}$$

$$4.45\ \text{m} \times \frac{\text{cm}}{10^{-2}\ \text{m}} \times \frac{1\ \text{in}}{2.54\ \text{cm}} = 175.1968504\ \text{in}$$

3 ↑ (4.45); ∞ ↑ ($10^{-2}$); ∞ ↑ (2.54)

$$= \boxed{175\ \text{in}}$$

*An inch is defined as EXACTLY 2.54 cm !

When merely converting the units of a measurement, you almost always have the same number of significant figures in the answer as you did in the original measurement. (EXCEPTION: Temperature conversions, since they involve addition and subtraction)

# Scientific Notation

-a way to represent large and small numbers

-a way to indicate significant figures

Form:

$a.aaa.... \times 10^{a}$

(always ONE nonzero digit before the decimal)

$3.6 \times 10^{4}$

means

$3.6 \times 10 \times 10 \times 10 \times 10$

OR

36000

$6.21 \times 10^{-3}$

means

$6.21 \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}$

OR

0.00621

Scientific notation removes the need for placeholder zeros, and that's good when you're dealing with very large and very small numbers!

$$4.70 \times 10^{-6} = 0.00000470$$

Scientific notation indicates significant figures without extra decimal points or lines. All numbers in front of the power of ten are significant!

$$3\bar{7}00 = 3.70 \times 10^{3}$$

To write a number in scientific notation, move the decimal point so that it is behind the first nonzero number. The power of ten will be the number of places you moved the decimal. If the number is less than 1, the power of ten is negative. If it's greater than one, the power of ten is positive.

$$0.00765$$

3

$$7.65 \times 10^{-3}$$

$$14\,0\bar{0}0$$

4

$$1.400 \times 10^{4}$$

$6.38 \times 10^5$ ← Big number!

6.38000000000

**638000**

$4.20 \times 10^{-6}$ ← Small number!

000000000004.20

**0.00000420**

Using scientific notation on a calculator:

$6.38 \times 10^5$

on a TI-8x:

enter

6.38 [EE] 5

calculator displays:

6.38E5 — this E means "x10 raised to"

$4.20 \times 10^{-6}$

enter:

4.20 [EE] [(-)] 6

calculator displays:

4.2E⁻6 — means "$\times 10^{-6}$"

# Matter

- anything that takes up space and can be perceived!

What about the structure of matter? Matter as atoms!

small particles that are the building blocks of matter

## THE PHASES OF MATTER

### SOLIDS

* Rigid: Fixed shape AND fixed volume
* Dense: contain much mass in a given volume!

### LIQUIDS

* Variable shape ("fluid")
* Fixed volume
* Dense

usually less dense than solid!

exception: water!

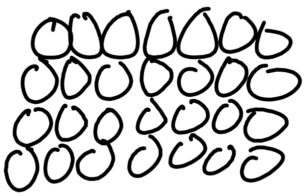
### GASES

* Variable shape ("fluid")
* Variable volume
* Not dense ("diffuse")

# An atomic picture of the phases of matter

## Solids:

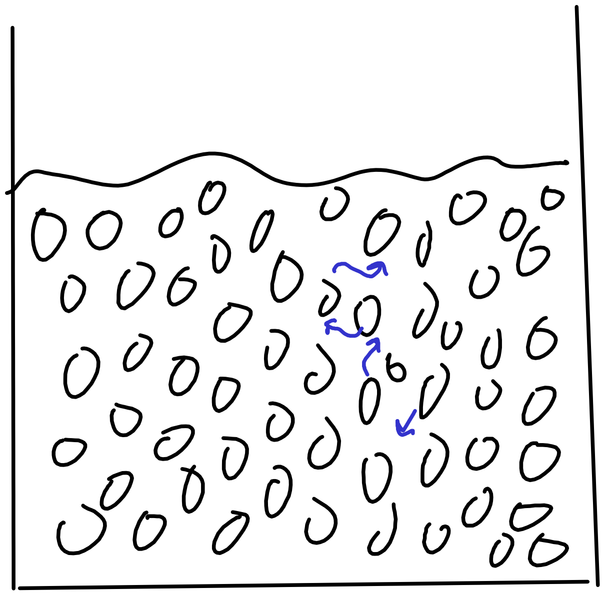
- fixed shape, dense, fixed volume



- Atoms closely packed
- Atoms are arranged in a regular structure (a CRYSTAL), giving the solid rigidity
- Atoms are strongly attracted to each other, keeping the solid together
- Atoms do not move about freely, but there is some vibration

# Liquids:

- variable shape, dense, fixed volume



- Atoms still very close to each other, but usually a little farther apart than in solid phase

  An exception: water.

- Atoms are not arranged in an overall order and can slide past and around one another

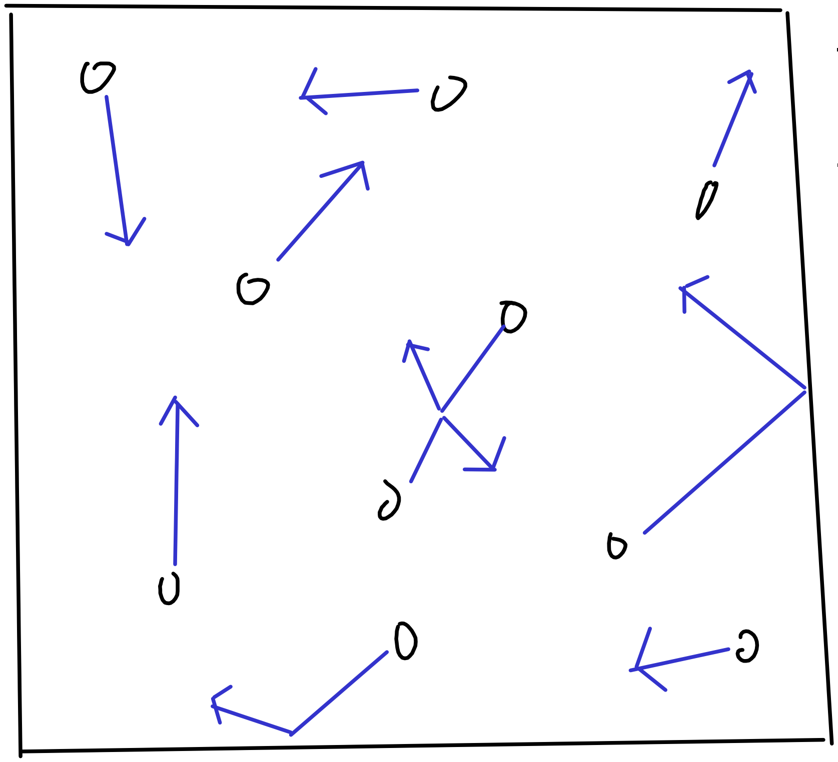
- Atoms are still strongly attracted to each other, keeping the liquid together

- Atoms move around each other constantly

Evidence: DIFFUSION - a drop of food coloring in a glass of water will eventually spread throughout the glass, even if the glass is NOT stirred.

# Gases:

- variable shape, diffuse (not dense), variable volume



- Atoms are spread far apart

- No structure

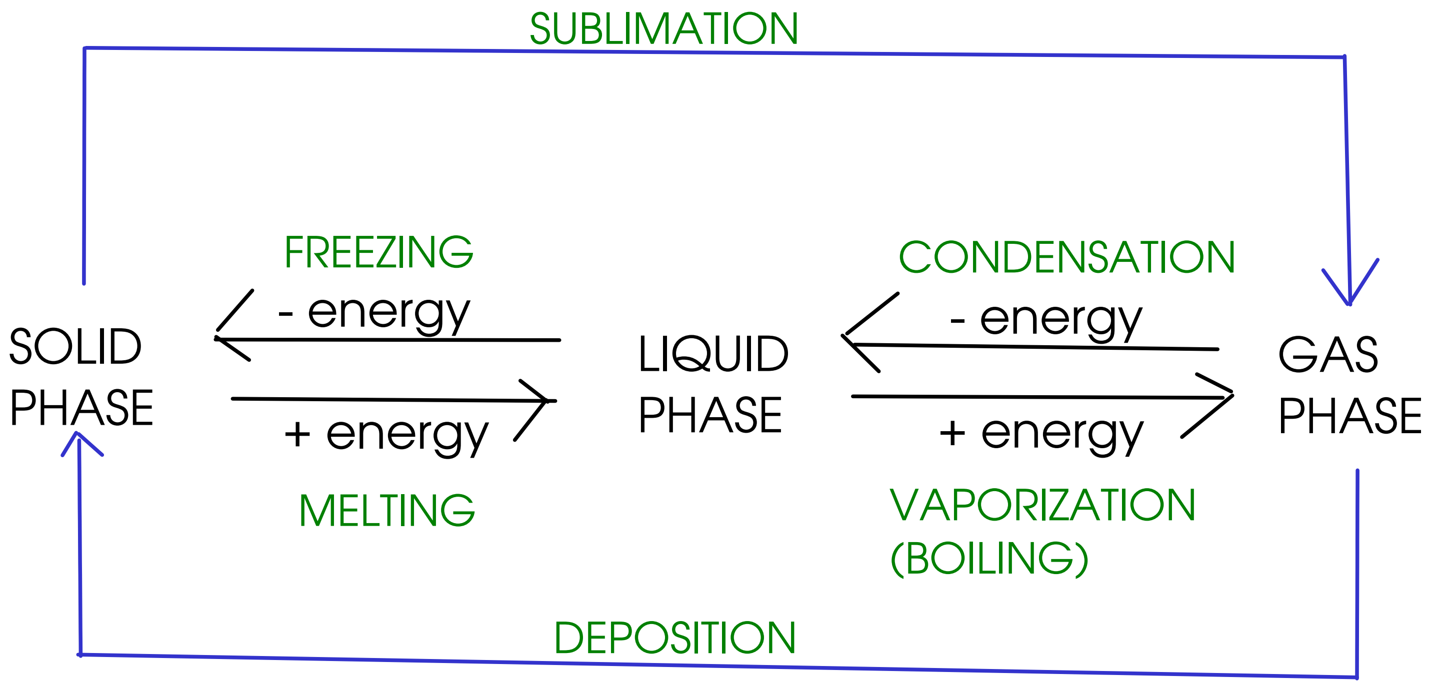
- Atoms are NOT strongly attracted to each other. They don't interact much at all, unless they happen to collide.

- Atoms in constant, rapid motion. The speed of the atoms increases as temperature increases.

Gases take the shape of their containers. Collision of atoms/molecule of gas with the walls of their containers create the effect we call PRESSURE.

# Kinetic theory

- describes matter in terms of atomic/molecular MOTION
- the energy of the molecules relates to atomic/molecular motion, and temperature




You can speed up the molecules (add energy) by heating!
You can slow down the molecules (remove energy) by cooling!

# Physical and Chemical

- We classify changes in matter according to whether the identity of matter changes during the process.

## PHYSICAL CHANGE

- A change in the form or appearance of matter WITHOUT a change in identity

Examples:

- Melting, freezing (all phase changes) are physical changes
- Breaking, cutting, etc. are also physical changes

## CHEMICAL CHANGE

- A change in the identity of matter
- also called "chemical reactions"

Examples:

- Burning, rusting, metabolism

We classify PROPERTIES of substances by whether or not you must change the identity of a substance to obtain information about the property

PHYSICAL PROPERTIES

- can be determined without changing the identity of matter

Examples:

- size, shape, color, mass, hardness
- melting point, boiling point, density, etc.

CHEMICAL PROPERTIES

- can only be determined by changing the identity of matter

Examples:

- flammability, reactivity with acids, temperature at which thermal decomposition occurs