Phys 100 2023

Lecture 7

Weds: Cover ~~2.4~~ 2.4 → 2.5

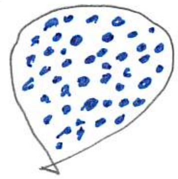
Fri: HW 2 due by 5pm

Atomic picture and gases

We can consider the properties of a gas, such as a balloon of Helium. We aim to explain these using an atomic picture.

Actual

→ Model



→

* Gas consists of a large number of individual atoms
* Atoms are very small
* There are significant gaps between atoms (most of the gas is empty space)
* Molecules do not interact except briefly when they collide with each other and the container.
* Behavior can be analyzed using (classical) physics of solid pointlike particles

The physics in this model predicts that

> The higher the temperature of the gas, the larger the speed of the atoms,

DEMO: PhET Gas Properties → One molecule

EXPLORE Tab - push inwards → Many molecules.

DEMO: Fire Syringe Demonstration.

DEMO: Fowler 1D Atom Gas

Consider the reverse process, where a gas expands.

Quiz 1 100%

Quiz 2 95%

The pressure of the gas describes the force (per area) that the gas exerts on its walls. In the atomic model of a gas

Pressure increases as rate and/or force of collisions of molecules with walls increases

DEMO: Previous PhET - compress / observe collisions / rate.

Quiz 3 Done one pass very mixed

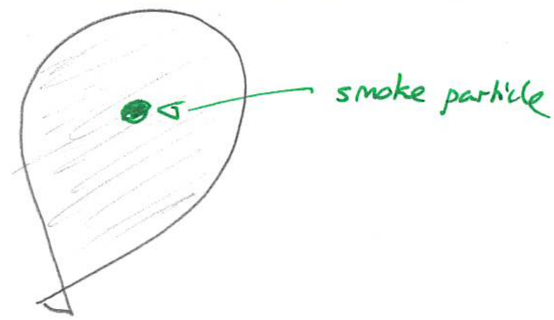
DEMO: Boiling water / bottle / balloon demo

The explanation is:

1) steam is a gas
2) steam condenses → removes gas molecules (like atoms)
3) much lower rate of collision with sides
4) pressure decreases

Brownian motion

The fact that an atomic picture could describe the overall behavior of gases was not conclusive evidence for its correctness. Other models could also do this. The evidence eventually came from the motion of small microscopically visible particles in a gas.



Quiz 4

The actual motion had been observed by Robert Brown (1827) and is now called Brownian motion

DEMO: PhET Gas ~~Molecules~~ Properties

- 1 large many small

DEMO: IOP Youtube video

The exact description of this motion was provided by Einstein (1905) and it produced predictions distinct from any continuous fluid model. These predictions match the observations

Measurements and units

Physics often deals with mathematical relationships of measurable (number) quantities. This requires

- describing how measurements are done
- the units used.

Example: Measure the width of a letter sheet page. The results are either

8.5 inches

or

21.6 centimeters

These clearly mean the same length. However, the numbers are different because the units used are different. Thus when describing the result of a measurement, we need

(some number) AND (units used)

In physics the preferred units are the metric (SI) units. The basic metric units are:

quantity	unit	abbreviation
time	second	s
length	meter	m
mass	kilogram	kg

Thus for some person

height = 1.75 meters = 1.75 m

weight (mass) = 70 kilograms = 70 kg

These basic units are not always convenient. For example we need to measure lengths on scales from

atomic → microscopic → typical objects → planet size → galaxy size.

The metric system has a standard way for derived units (analogous to inches, yards, miles, ...). This involves adding prefixes to basic units:

Example: $1000\ m = 1000$ meters $= 1$ kilometer $= 1\ km$

(kilo: prefix; meter: basic)

$1000\ g = 1000$ grams $= 1$ kilogram $= 1\ kg$

Demo: Secret worlds
- do manual toggle.

Some examples for distance are:

$$1000\,m = 1\,km = 1 \text{ kilometer}$$

$$0.01\,m = \frac{1}{100}\,m = 1\,cm = 1 \text{ centimeter}$$

$$0.001\,m = \frac{1}{1000}\,m = 1\,mm = 1 \text{ millimeter}$$