Unit 5

On completion of the unit you should be able to:

1. write the number of particles in a mole.
2. calculate the formula (or molecular) mass of compounds.
3. solve problems involving conversions between the mass, the number of moles, the number of formula units and the volume (for gaseous substances at standard temperature and pressure).
4. given the formula of a compound calculate the percent composition.
5. given the composition of a compound calculate the empirical formula.
6. given the composition and molecular mass of a molecular compound calculate the molecular formula.
7. express solution concentration in moles/liter.
8. do calculations involving solutions which have concentrations expressed in moles/liter.
9. solve dilution calculation.

THE MOLE CONCEPT
5.1 **Mole concept**
Reading: Hebden – page 78
5.2 **Formula mass**
5.3 **Information in chemical formulae**
5.4 **From amu to gram**
5.5 **Molar mass**
Reading: Hebden – page 79
5.6 **Calculations involving Avogadro's number**
Reading: Hebden – page 81-88
5.7 **Molar volume of a gas**
Reading: Hebden – page 82
5.8 **Percent composition of compounds**
Reading: Hebden – page 90
5.9 **Empirical formula**
Reading: Hebden – page 91-95
5.10 **Molarity and solution preparation**
Reading: Hebden – page 96-98
5.11 **Solution dilution**
Reading: Hebden – page 99

Mole Concept

A ‘mole’ is a unit. We write it behind a numerical value.

0.820 mole NaCl

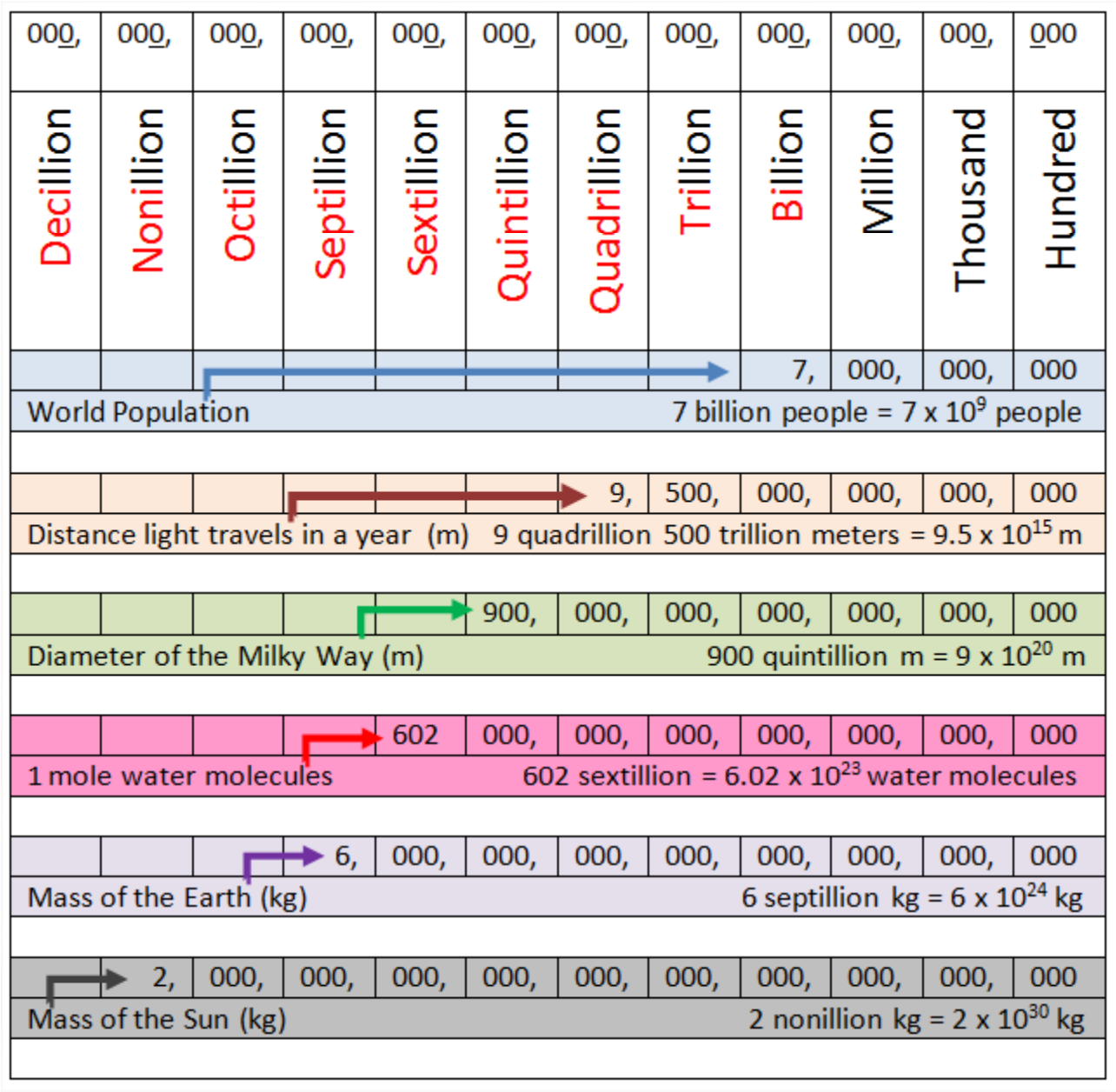
0.230 mole H_2O

Equivalence:

= 48.0 grams of NaCl ⟷ (Mass quantity) = 4.14 grams of H_2O

= 4.94 x 10^{23} Na^+ ions ⟷ (Counting quantity) = 2.77 x 10^{23} H^+ ions

How big is the mole?



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The **mole unit** is used to express:

1. A mass quantity
2. A counting quantity

Mole: Mass Quantity

What is this mass unit?

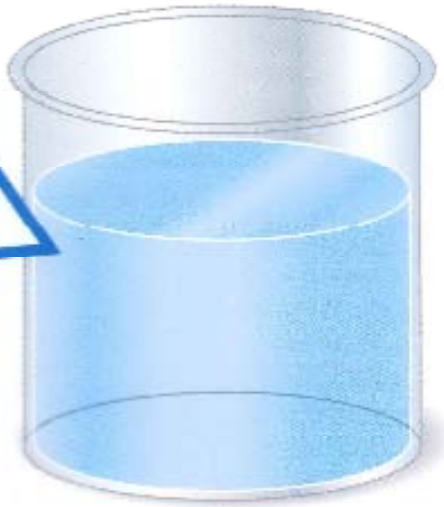
1.008	15.999
H	O
1	8

Atomic mass

Single molecule

1 molecule H_2O

Laboratory-sized sample



(1.008x2)+15.999 = 18.015 amu

18.015 amu is the mass of 1 molecule of H_2O.

Chemistry: The Central Science, 9e
by Theodore L. Brown, H. Eugene LeMay, Jr., Bruce E. Bursten

amu = atomic mass unit

$$18.015 \frac{\text{amu}}{\text{molecule of } H_2O}$$

Mole: Mass Quantity

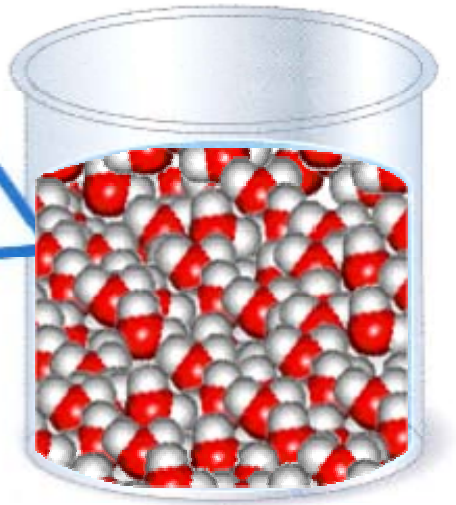
Mass unit is amu

1.008	15.999
H	O
1	8

Atomic mass

What is this mass unit?

Laboratory-sized sample



Single molecule

1 molecule H_2O

$$18.015 \frac{\text{amu}}{\text{molecule of } H_2O}$$

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SI mass unit is gram

Mass Quantity conversion factor:

1 gram = 6.02×10^{23} amu

amu = atomic mass unit

Mole: Mass Quantity

Mass unit is amu

1.008	15.999
H	O
1	8

Atomic mass

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amu = atomic mass unit

Conversion Factor:

1 gram = 6.02×10^{23} amu

Q: How many grams does 1 molecule of water weigh?

Dimensional Analysis:

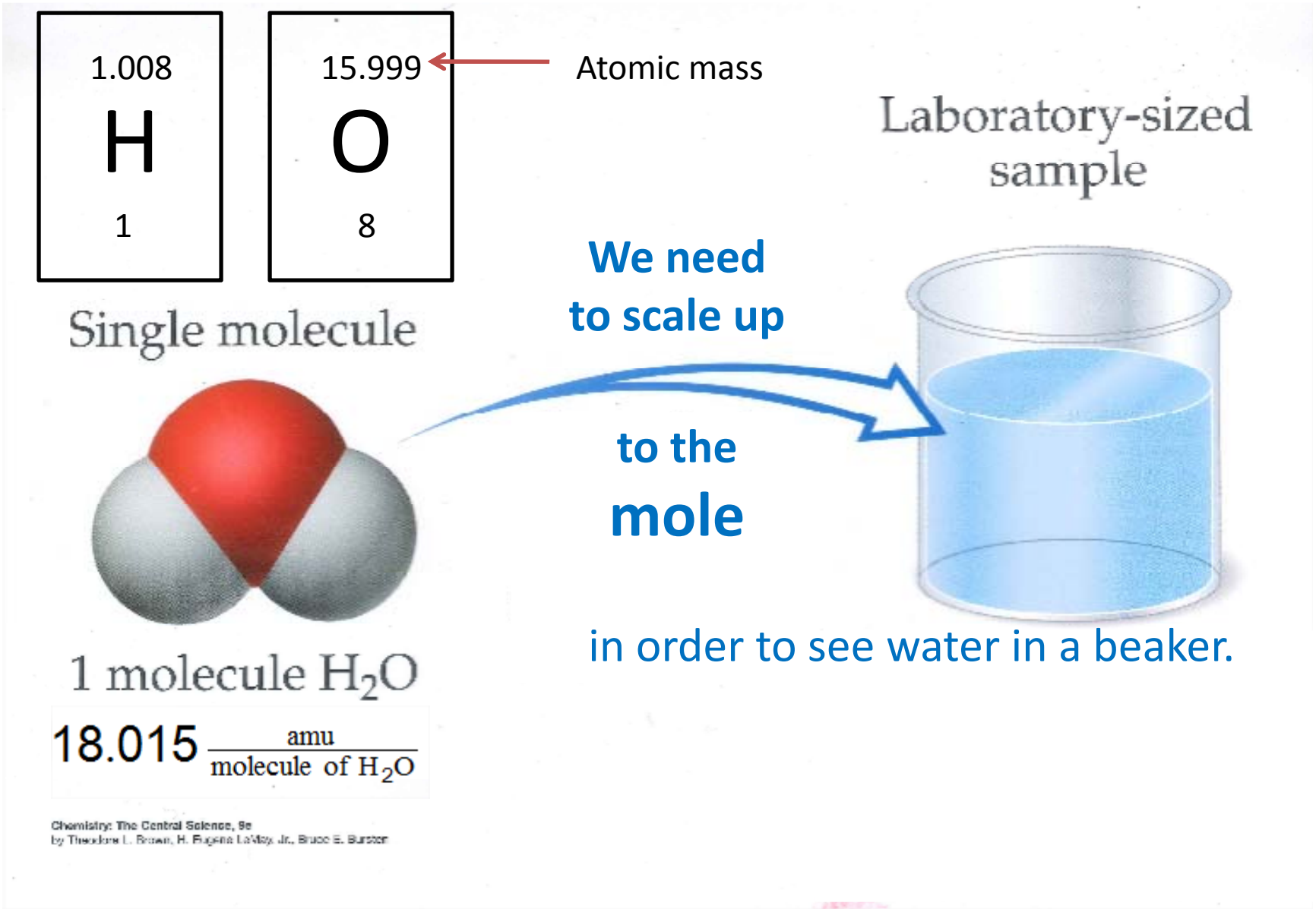
Unit given x *conversion factor(s)* = *unit sought*

$$18.015 \frac{\cancel{\text{amu}}}{\text{molecule of } H_2O} \times \frac{1\,\text{g}}{6.02 \times 10^{23}\ \cancel{\text{amu}}} = ? \frac{\text{g}}{\text{molecule of } H_2O}$$

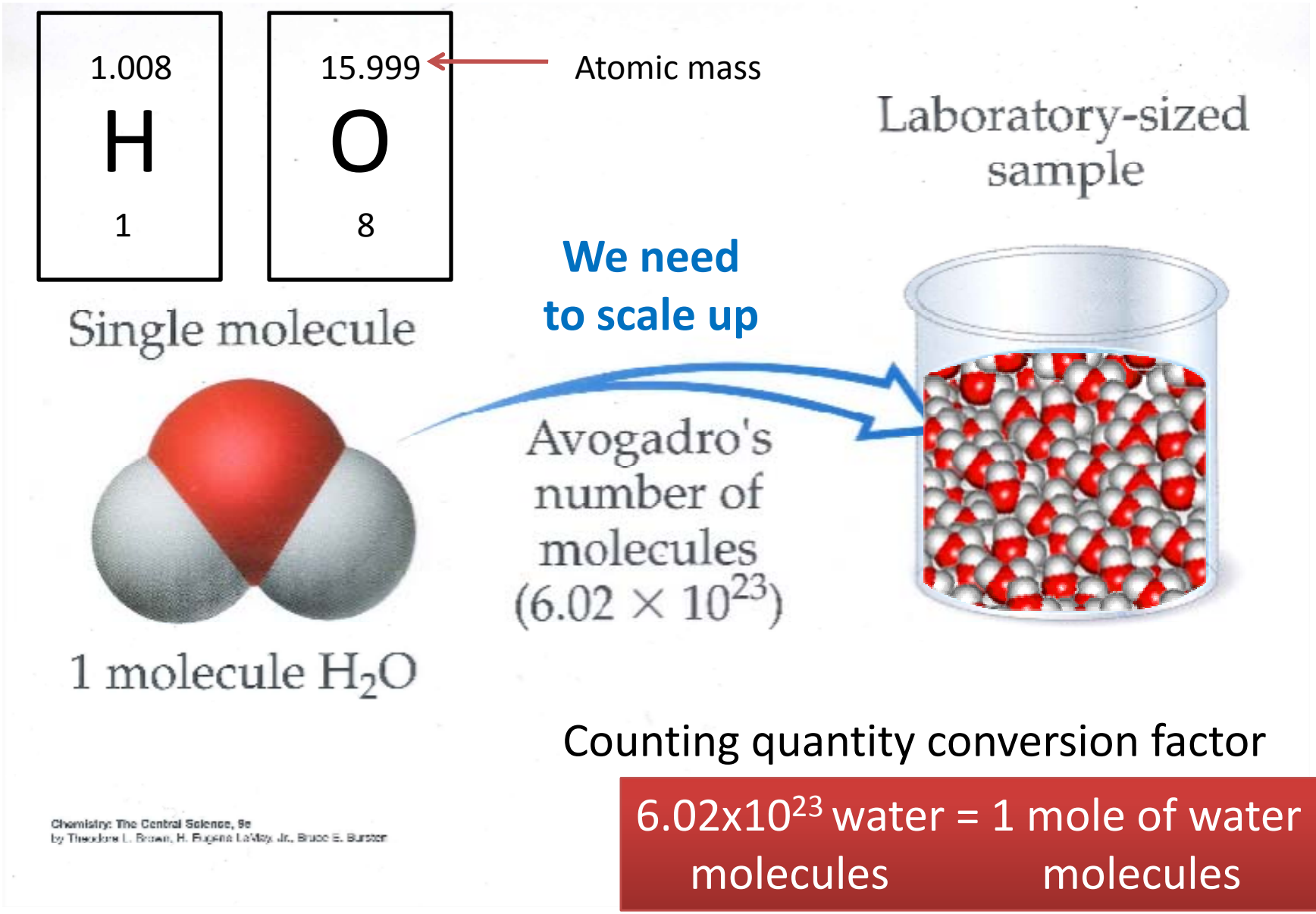
Answer: $= 2.99 \times 10^{-23} \frac{\text{g}}{\text{molecule of } H_2O}$

Do you think we can weigh this in the lab?

Mole: Counting Quantity



Mole: Counting Quantity



Counting quantity conversion factor

6.02×10^{23} water molecules = 1 mole of water molecules

What are these?

How do you buy nails?

In Chemistry, we count by weighing because we know each element by its exact mass!

1 Hydrogen atom weighs 1.008 amu.

1.008
H
1

$$1.008\ \text{amu} \times \frac{1\ \text{g}}{6.02\text{x}10^{23}\ \text{amu}} = 1.67\text{x}10^{-24}\ \text{g}$$

$$1.67\text{x}10^{-24}\ \frac{\text{g}}{\text{H atom}} \times \frac{6.02\text{x}10^{23}\ \text{H atom}}{1\ \text{mole H atoms}} = \frac{1.008\ \text{g}}{1\ \text{mole H atoms}}$$

1 mole Hydrogen atoms weighs 1.008 g.

1  H atom weighs 1.008 amu.

1 Hydrogen atom weighs 1.008 amu.

1.008
H
1

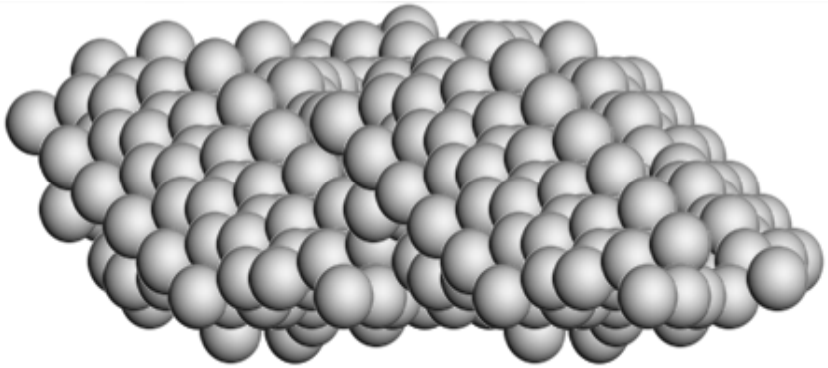
Atomic mass has two units:

$$\frac{\text{amu}}{\text{atom}}$$

1 gram = 6.02×10^{23} amu

$$\frac{\text{g}}{\text{mole of atoms}} = \frac{\text{g}}{\text{mole}}$$

1 mole Hydrogen atoms weighs 1.008 g.

1 mole  H atoms weighs 1.008 g.

Q1: How much does 1 molecule of water weigh, in amu?

$$18.015 \frac{\text{amu}}{\text{molecule of } H_2O}$$

Q2: How much does 1 mole of water weigh, in gram?

$$18.015 \frac{\text{g}}{\text{mole of } H_2O}$$

We can weigh this!!

If the density of water is 1.00 g/mL,
1 mole of water = 18.0 mL!!

Try some mole concept
practice problems in Maple TA.

Use Dimensional Analysis in your
calculations!!