Counting Units: Popcorn, Socks and Atoms

- How many kernels are in a popcorn counting unit (PCU)?
- And what is a counting unit, anyway?

Link to class data sheet

- The popcorn counting unit (PCU) is different from the other units we've been talking about. It measures how many items you have, rather than measuring a property of the items.
- For instance:
  - You measure the **mass** of popcorn using **grams**.
  - You could measure the **volume** of popcorn in **mL or cm^3**
  - You could measure the number of kernels of popcorn in **popcorn counting units**

Counting Units: Popcorn, Socks and Atoms

- We use some counting units in our everyday lives…

- A *pair* is a counting unit that contains *2* items.

- A *dozen* is a counting unit that contains *12* items.

Counting Units: Popcorn, Socks and Atoms

- There are others that are used less commonly but are useful in certain contexts.
- A *gross* is a counting unit that contains *144* items.

- A *sagan* is a counting unit that contains *4 billion* items.

Counting Units: Popcorn, Socks and Atoms

- A counting unit, once defined, is not limited to a single type of item.

- Each of these groups contains a dozen items.

Counting Units: Popcorn, Socks and Atoms

- We use counting units to make things easier for ourselves.

- How many fun socks are these folks wearing?
- How many pairs of fun socks are there?

Counting Units: Popcorn, Socks and Atoms

- We use counting units to make things easier for ourselves.

$$\frac{10 \text{ socks} \mid 1 \text{ pair of socks}}{\mid 2 \text{ socks}} = 5 \text{ pair of socks}$$

This number can be more useful because we wear socks in groups of two. This number tells us how many people can wear these socks at a time!

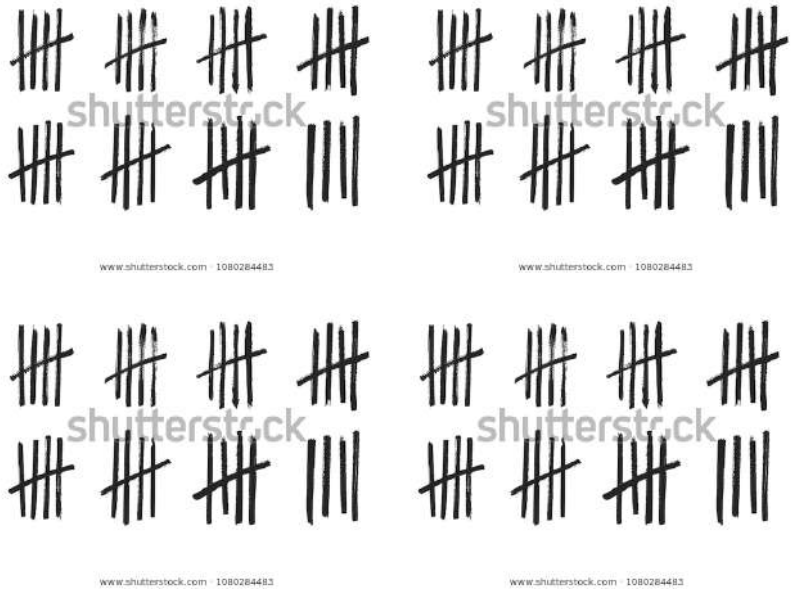
Counting Units: Popcorn, Socks and Atoms

- We use counting units to make things easier for ourselves.

$$\frac{120 \text{ bagels}}{\frac{1 \text{ dozen bagels}}{12 \text{ bagels}}} = ?$$

Why might this be more useful?

Counting Units: Popcorn, Socks and Atoms



Is a PCU a useful counting unit?

Go to polleverywhere/kmahone182
And answer the question.

The PCU is most useful when you know how much a PCU of a certain substance weighs and can use that to avoid actually counting out a PCU of items!

Counting lentils, beans, and popcorn kernels can get tedious.

Luckily, once we count out a PCU of a certain item once, we can use the mass as part of an equivalence statement:

1 PCU popcorn = 100 kernels = 25.0g

$$150\text{g popcorn} \times \frac{1\text{ PCU popcorn}}{25.0\text{g popcorn}} \times \frac{100\text{ kernels popcorn}}{1\text{ PCU popcorn}}$$

= 600 kernels of popcorn

How many kernels are in this pile?
Using our PCU equivalence statement,
we can just weigh it to find out.

What about atoms?

How many atoms of gold are in this 1kg pure gold bar?

- Technically, we could use our PCU to figure it out, but 100 atoms would weigh so little that we couldn't measure the mass very well.

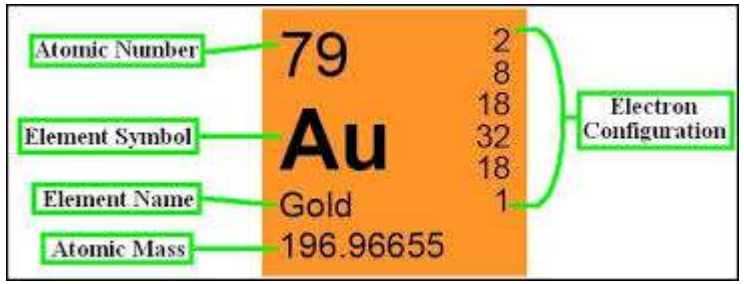
- Instead, we use a counting unit called the **mole.**
  - A *pair* is a counting unit that contains *2* items.
  - A *dozen* is a counting unit that contains *12* items.
  - **A *mole* is a counting unit that contains *6.02 x 10^{23}* items.**

What about atoms?

How many atoms of gold are in this 1kg pure gold bar?

1 mole = ***6.02 x 10^{23}*** atoms of gold = ???g

- For any element in the periodic table, the equivalence unit is known! It is called the **atomic mass**.



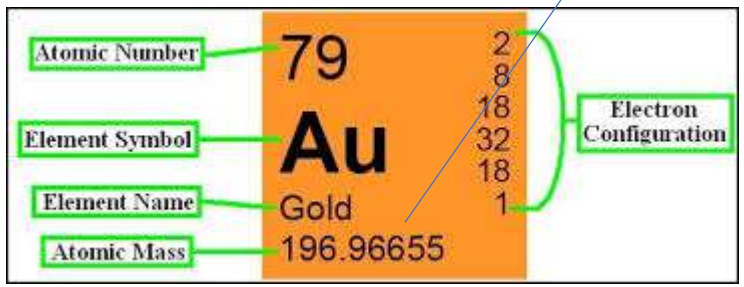
- Atomic mass: The mass, in grams, of *6.02 x 10^{23}* atoms (1 mole) of an element.

What about atoms?

How many atoms of gold are in this 1kg pure gold bar?

1 mole = ***6.02 x 10^{23}*** atoms of gold = 197.0g

- For any element in the periodic table, the equivalence unit is known! It is called the **atomic mass**.



What about atoms?

How many atoms of gold are in this 1kg pure gold bar?

1 mole = ***6.02 x 10^{23}*** atoms of gold = 197.0g

1 kg Au	1000g Au	1 mole Au	6.02 x 10^{23} atoms Au
	1kg Au	197.0g Au	1 mole Au

= 3 x 10^{24} atoms Au

We can calculate the number of atoms in a sample of a monatomic element just by knowing its mass (by weighing the sample) and its atomic mass (from the periodic table).

The same principle applies for compounds:

Table salt, NaCl

1 mole NaCl = 6.02 x 10^{23} **formula units** NaCl = 58.5 g NaCl

For a compound, this is called the **molar mass**.

This is reason #1 why chemists are so obsessed with the periodic table. We use it. All. The. Time.

1 H 1.00794												13	14	15	16	17	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050	3	4	5	6	7	8	9	10	11	12	13 Al 26.581538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6534	29 Cu 63.545	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.504	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 196.56655	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	71 Lu 174.967	72 Hf 178.49	73 Ta 180.94.79	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.56655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.58038	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	103 Lr (262)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Ds (269)	111 Rg (272)	112 Cn (277)	113 Uut (277)	114 Uuq (277)	115 Uup (277)	116 Uuh (277)		118 Uuo (277)

57 La 138.9055	58 Ce 140.116	59 Pr 140.50765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04
89 Ac 232.0381	90 Th 232.0381	91 Pa 231.035888	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)

The same principle applies for compounds:

Table salt, NaCl

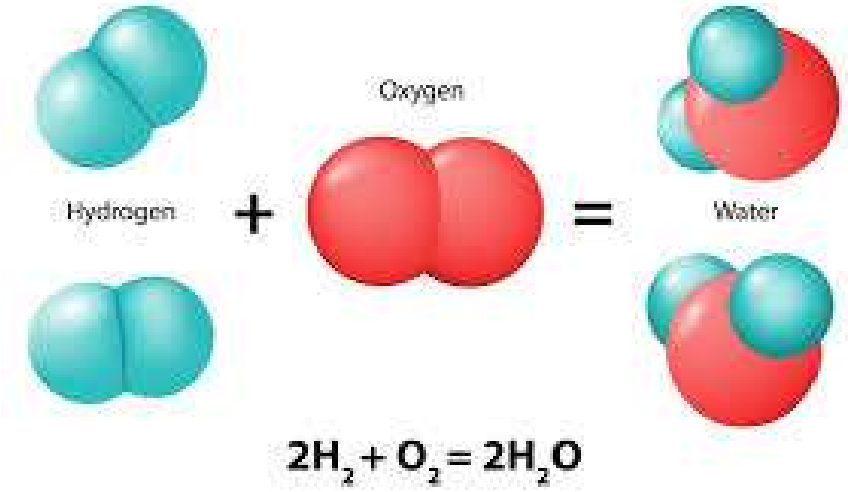
1 mole NaCl = 6.02×10^{23} **formula units** NaCl = 58.5 g NaCl

How many formula units of salt are in 120g NaCl?

$$120\text{g NaCl} \times \frac{\text{mole NaCl}}{\text{g NaCl}} \times \frac{\text{FU NaCl}}{\text{mole NaCl}}$$

$= 1.2 \times 10^{24}$ atoms NaCl

Why do we care how many atoms are in a sample?



- Because when elements and compounds react with each other, they do it on an atom-by-atom basis, and not a gram-by-gram basis. When you are calculating how much of each "ingredient" you need for your chemical reaction, you better not assume that 1g of oxygen is equivalent to 1g of hydrogen.

- Many times we do mass-to-mole conversions and don't need to do the last step (moles to atoms or molecules) because we compare amounts on a mole basis. More on this later.

NOTE: Only mole is abbrieviated as *mol*. Molecule is just written as *molecule*.