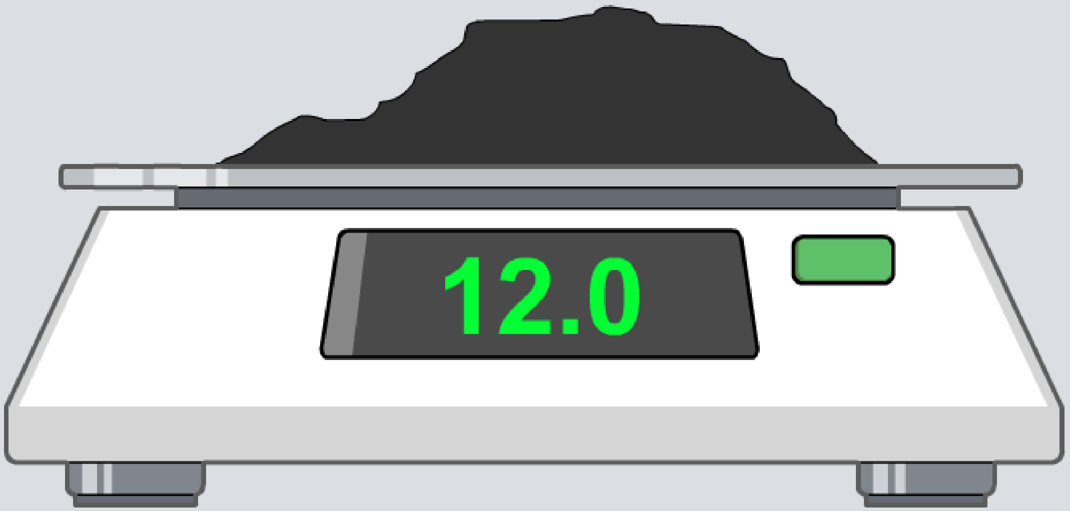
# What are Moles?



# How many particles?

Scientists often need to know how many particles of a substance they are dealing with.

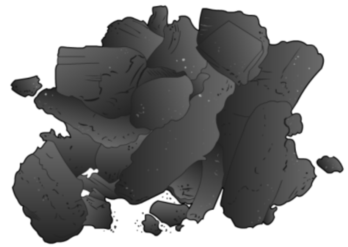
Unfortunately, atoms and molecules are tiny and it is impossible to count them directly.

Instead of counting, scientists use the relative masses of different atoms and molecules to measure how many are present in a given sample.

# How many particles?

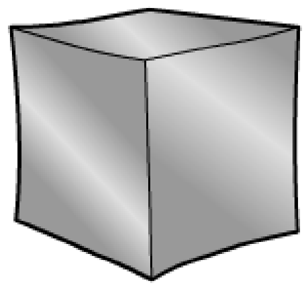
**For example:**


One carbon atom has a relative atomic mass of 12.



The quantity of atoms in 24 g of pure graphite can be calculated as $\frac{24}{12} = 2$


One magnesium atom has a relative atomic mass of 24.



The quantity of atoms in 24 g of pure magnesium can be calculated as $\frac{24}{24} = 1$

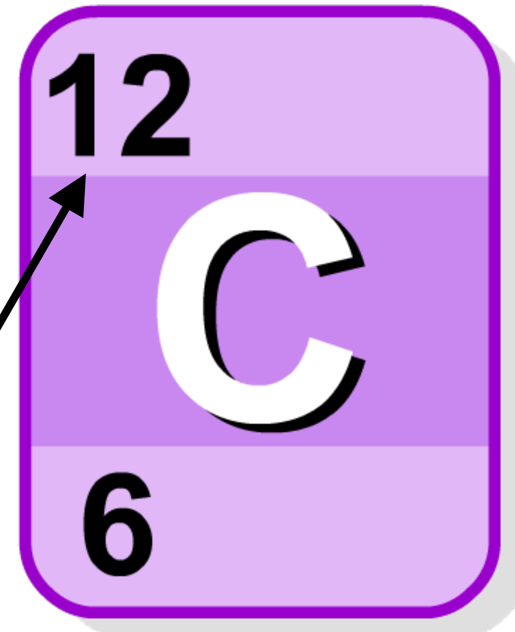
So, 24 g of carbon contains twice as many atoms as 24 g of magnesium, because magnesium atoms are twice as heavy. The unit for these results is called a **mole**.

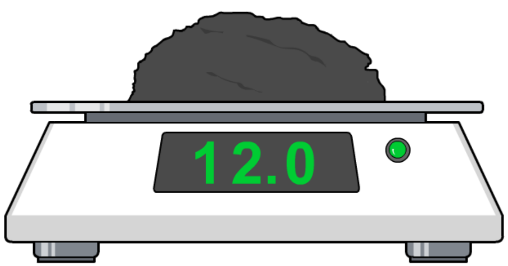
# What are moles?

The term **mole** is used to describe how many atoms or molecules of a substance are present in a sample.

**One mole** of a substance is equal to its relative atomic mass, or relative formula mass, in **grams**.

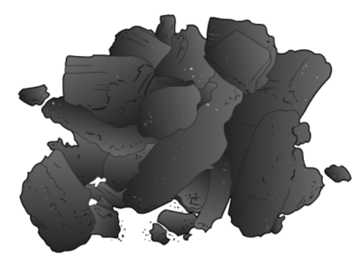
**relative atomic mass**



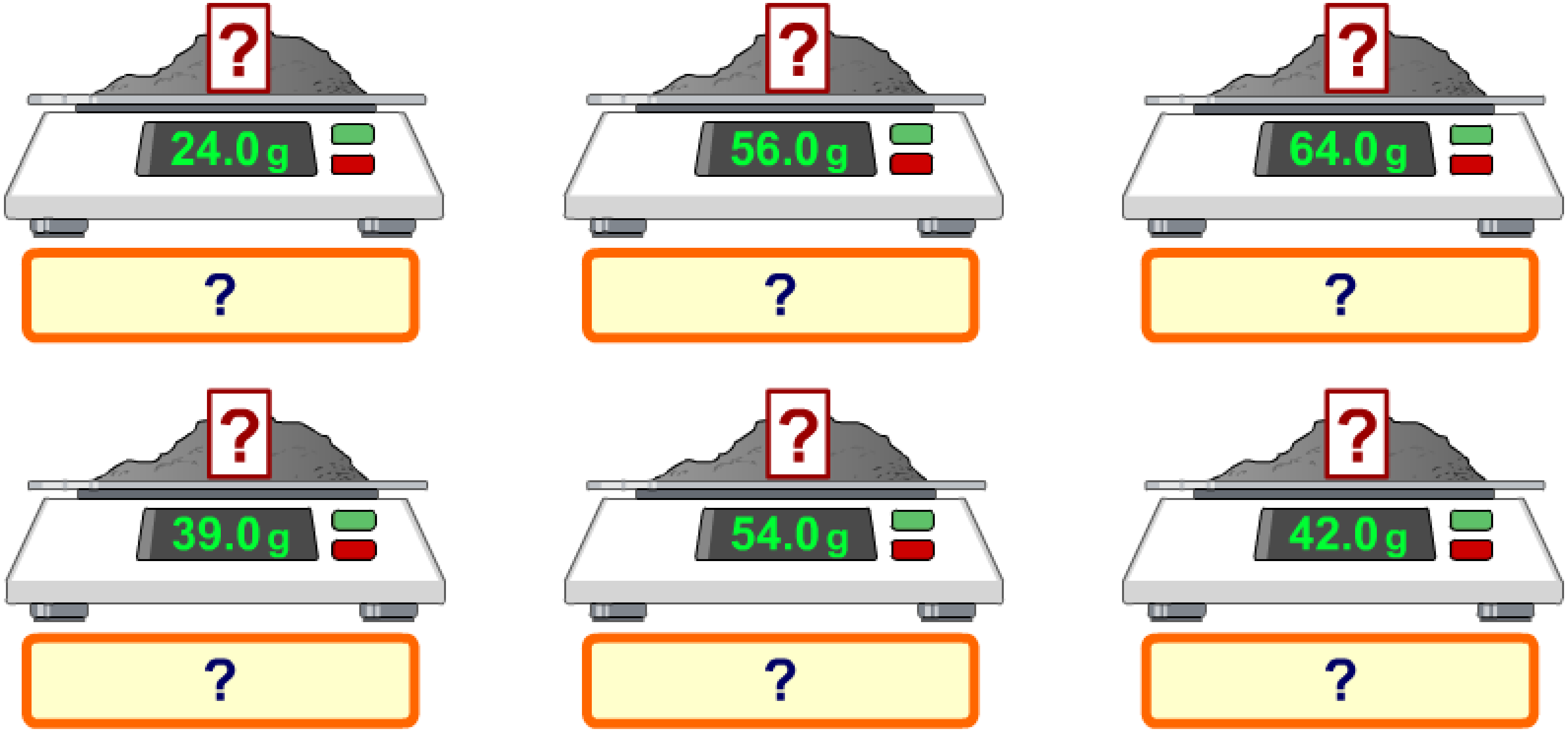




For example, the relative atomic mass of carbon is 12, so **one mole of carbon atoms weighs 12 g**.

24 g of pure graphite therefore contains 2 **moles** of carbon atoms.



Can you match the molar quantities to their masses?




1 mole of Fe

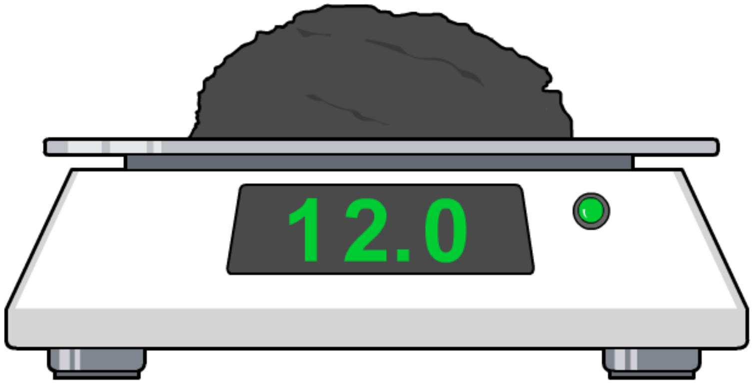
?

C

solve

# How much is in a mole?

Scientists have calculated that one mole of **any substance** contains 602,000,000,000,000, 000,000,000 ($6.02 \times 10^{23}$) particles.




One mole of carbon weighs 12 g, so 12 g of carbon contains $6.02 \times 10^{23}$ carbon atoms.

One mole of sodium weighs 23 g, so 23 g of sodium contains $6.02 \times 10^{23}$ sodium atoms.

One mole of water weighs 18 g, so 18 g of water contains $6.02 \times 10^{23}$ water molecules.

How many carbon atoms are in 6 g of carbon? **$3.01 \times 10^{23}$**

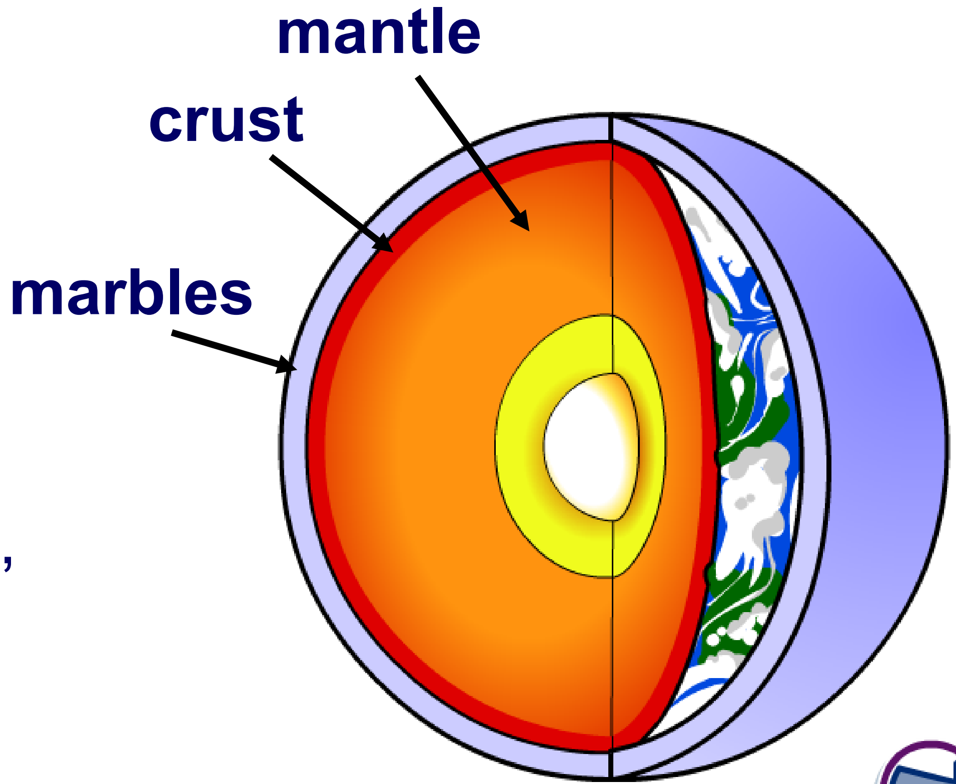
# Avogadro's number

The number of particles in one mole is called **Avogadro's number**.

It is named after Amedeo Avogadro, an Italian scientist working in the early 19th century.

$6.02 \times 10^{23}$ really is a staggeringly large number of particles.

If you collected $6.02 \times 10^{23}$ marbles and spread them over the surface of the Earth, they would form a layer of marbles 50 miles thick!



# Calculating moles

The number of moles in a sample is calculated using this equation:

$$\text{number of moles} = \frac{\text{mass of substance}}{\text{molar mass}}$$

**Remember:**

- mass of substance is measured in grams.
- some elements exist as molecules (for example, O2). You will need to use the molecular rather than atomic mass for these.
- for compounds, the molar mass is the sum of the relative atomic masses (RAM) of all the atoms in the formula.

## Calculating molar mass (relative formula mass)

**Substance** ____________________

Click an element to add an atom.
Click again to add more than one.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 H 1 | | | | | | | | | | | | | | | | | 4.0 He 2 |
| 6.9 Li 3 | 9.0 Be 4 | | | | | | | | | | | 10.8 B 5 | 12.0 C 6 | 14.0 N 7 | 16.0 O 8 | 19.0 F 9 | 20.2 Ne 10 |
| 23.0 Na 11 | 24.3 Mg 12 | | | | | | | | | | | 27.0 Al 13 | 28.1 Si 14 | 31.0 P 15 | 32.1 S 16 | 35.5 Cl 17 | 39.9 Ar 18 |
| 39.1 K 19 | 40.1 Ca 20 | 45.0 Sc 21 | 47.9 Ti 22 | 50.9 V 23 | 52.0 Cr 24 | 54.9 Mn 25 | 55.8 Fe 26 | 58.9 Co 27 | 58.7 Ni 28 | 63.5 Cu 29 | 65.4 Zn 30 | 69.7 Ga 31 | 72.6 Ge 32 | 74.9 As 33 | 79.0 Se 34 | 79.9 Br 35 | 83.8 Kr 36 |
| 85.5 Rb 37 | 87.6 Sr 38 | 88.9 Y 39 | 91.2 Zr 40 | 92.9 Nb 41 | 96.0 Mo 42 | [98] Tc 43 | 101.1 Ru 44 | 102.9 Rh 45 | 106.4 Pd 46 | 107.9 Ag 47 | 112.4 Cd 48 | 114.8 In 49 | 118.7 Sn 50 | 121.8 Sb 51 | 127.6 Te 52 | 126.9 I 53 | 131.3 Xe 54 |
| 132.9 Cs 55 | 137.3 Ba 56 | 138.9 La 57 | 178.5 Hf 72 | 180.9 Ta 73 | 183.8 W 74 | 186.2 Re 75 | 190.2 Os 76 | 192.2 Ir 77 | 195.1 Pt 78 | 197.0 Au 79 | 200.6 Hg 80 | 204.4 Tl 81 | 207.2 Pb 82 | 208.9 Bi 83 | [209] Po 84 | [210] At 85 | [222] Rn 86 |
| [223] Fr 87 | [226] Ra 88 | [227] Ac 89 | [267] Rf 104 | [268] Db 105 | [271] Sg 106 | [272] Bh 107 | [270] Hs 108 | [276] Mt 109 | [281] Ds 110 | [280] Rg 111 | | | | | | | |

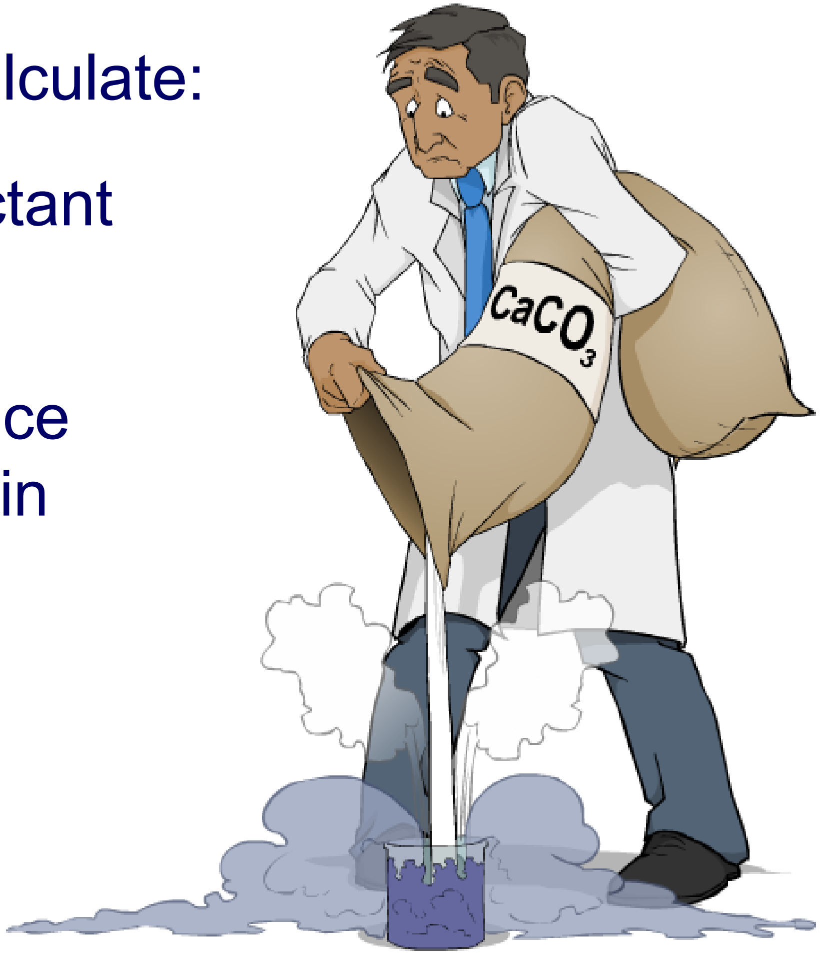
( $)_2$ $)_3$ $)_4$

# Using moles in calculations

Moles are very useful when reacting substances together. They provide us with a quick way of calculating how many particles of each substance are present.

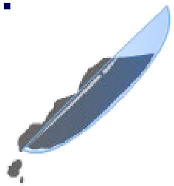
Chemists use moles to calculate:

- how much of each reactant they will need
- how much of a substance they are likely to make in the end.



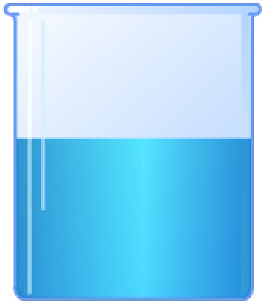
# Using moles

If you reacted 56 g of iron with excess copper sulfate solution, what mass of copper would you expect to make?



**Step 1**: Write a balanced equation for the reaction:

$$\mathbf{Fe + CuSO_4 \rightarrow Cu + FeSO_4}$$



**Step 2**: Turn the mass of iron into moles of iron:

$$\text{moles} = \frac{\text{mass}}{\text{molar mass}} = \frac{56}{56} = 1 \text{ mole of iron}$$

**Step 3**: Use the balanced equation to determine how many moles of copper you should make:

**1 mole of Fe makes 1 mole of Cu**

**Step 4**: Turn moles of copper into mass of copper:

$$\text{mass} = \text{moles} \times \text{RAM} = 1 \times 63.5 = 63.5\text{ g of Cu}$$

**Can you solve these calculations using moles?**

Calculate the answer to each of the following questions using the formula:

$$\text{number of moles} = \frac{\text{mass of substance}}{\text{molar mass}}$$

Click "**start**" to begin.

start

?

show