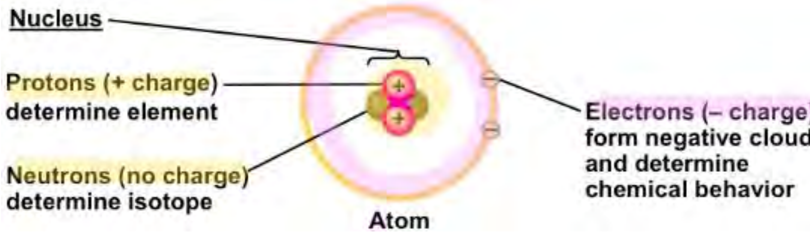
Element	Symbol	Percentage of Body Mass (including water)	
Oxygen	O	65.0%	96.3%
Carbon	C	18.5%	
Hydrogen	H	9.5%	
Nitrogen	N	3.3%	
Calcium	Ca	1.5%	3.7%
Phosphorus	P	1.0%	
Potassium	K	0.4%	
Sulfur	S	0.3%	
Sodium	Na	0.2%	
Chlorine	Cl	0.2%	
Magnesium	Mg	0.1%	

Trace elements (less than 0.01% of mass): Boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), zinc (Zn)

Trace elements (required in small quantities)

Atomic structure:



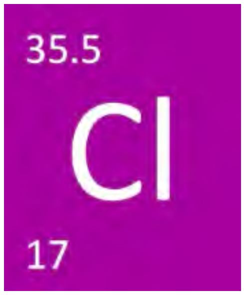
Mass of the atom: protons + neutrons

Mass number (A): the total number of proteins and neutrons in an atom. Giv mass of element compared to Carbon 12

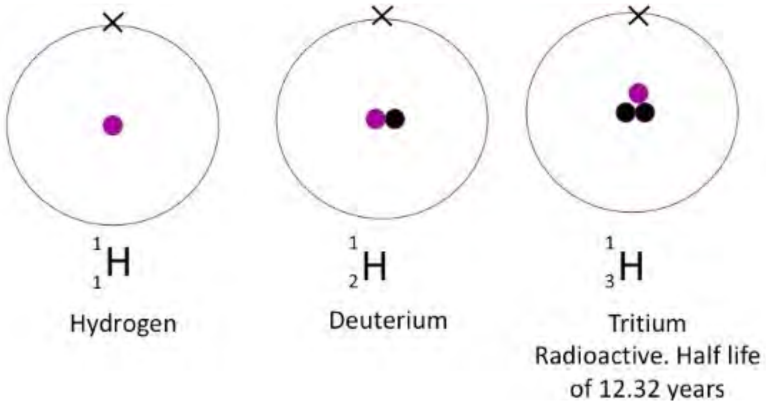
Atomic number (Z): the number of protons in the nucleus. By default in a neu atom, this is also the number of electrons as the charges between protons ar electrons will cancel each other out.

Atomic number:
Protons = 3
Electrons = 3
Mass of the atom: 7 - 3 = 4 neutrons

Isotopes: atoms with the same number of protons but **a different number of neutrons**
The mass number of some elements isn't an integer. The mass number is an average of the different isotopes of the element. Ex. Cl35 (75% abundance) and Cl37 (25% abundance)



Isotopes have the same chemical properties but different physical properties, unstable isotopes are radioactive, they decay and give off particles and energy.



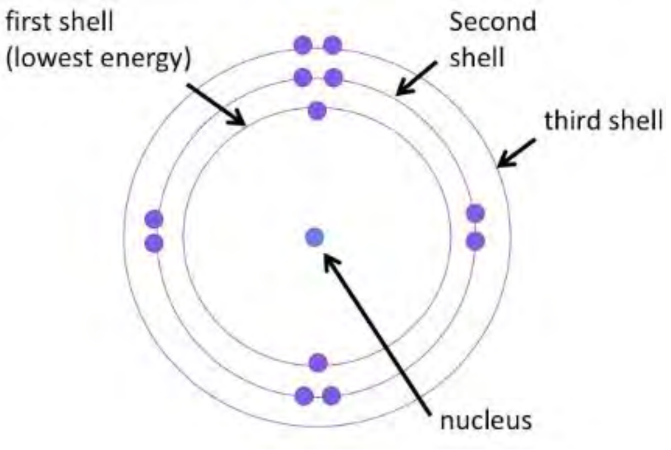
Use of radioactive tracers:
- Diagnostic tools in medicine
- To track atoms through metabolism
- In combination with sophisticated imaging instruments

Ex. PET scans: radioactive tracers may be combined into molecules like sugars, proteins or hormones and using the imaging machine, it's possible to work out where particular processes take place in the body. It's useful specifically for Alzheimer's, cancer or heart disease.

PET (Positron Emission Tomography) scan:
1. A fresh batch of tracers is prepared before each scan for the patient

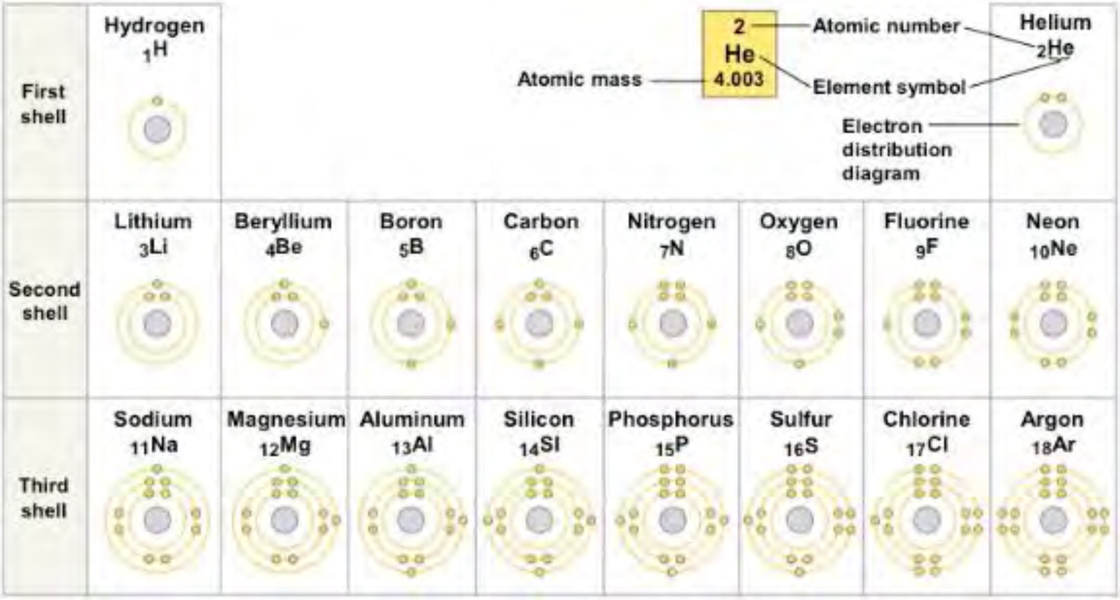
2. A radioactivity is produced using cyclotron, which smashes particles into ordinary atoms turning them into radioactive atoms, which doesn't last long
3. A biological molecule needs to be synthesised from the atoms' radioactivity
4. This biological molecule can be synthesised to be any type of molecule, depending on what the aim of the scan is
5. Then the biological molecule is purified as it passes through quality control, and its functioning is checked
6. Tracer is ready
7. It's injected into the patient's blood stream
8. The radioactive atom on the tracer uses its radioactivity to give off a positron, and as soon as it hits an electron at the right speed, they combine and destroy each other
9. The energy is released as 2 gamma rays being released to the external environment which is captured by the PET scan

Electron configuration: an orbital (shells) is the 3D space where an electron is found 90% of the time. The first shell can only accommodate 2 electrons, while the rest of the shells - 8.



Principal quantum number (n)	shell	Maximum number of electrons
1	First	2
2	Second	8
3	Third	18
4	Fourth	32

First shell has the lowest amount of energy, the second shell has a bit more, and the third shell has more energy than the second shell.

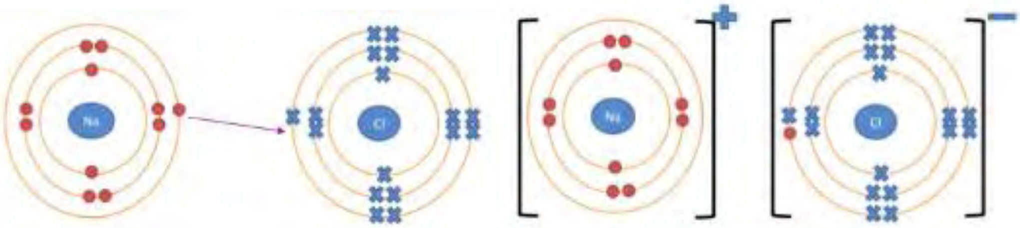


Elements in the same group (column) will have similar properties to each other, because they all have the same number of electrons in their outer shell. Last column on the right, the noble gases, have a full outer shell, meaning they're stable and unreactive

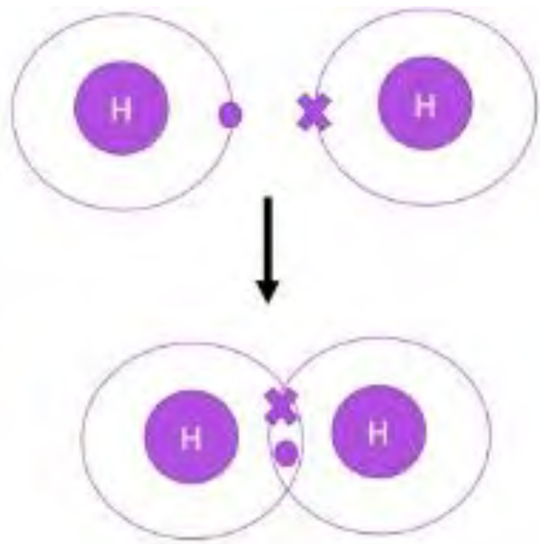
Chemical properties of an element are determined by the distribution of electrons in electron shells.
Valence shell: the outermost electron shell
Valence electrons: electrons in the outermost shell, which are the ones involved in reactions

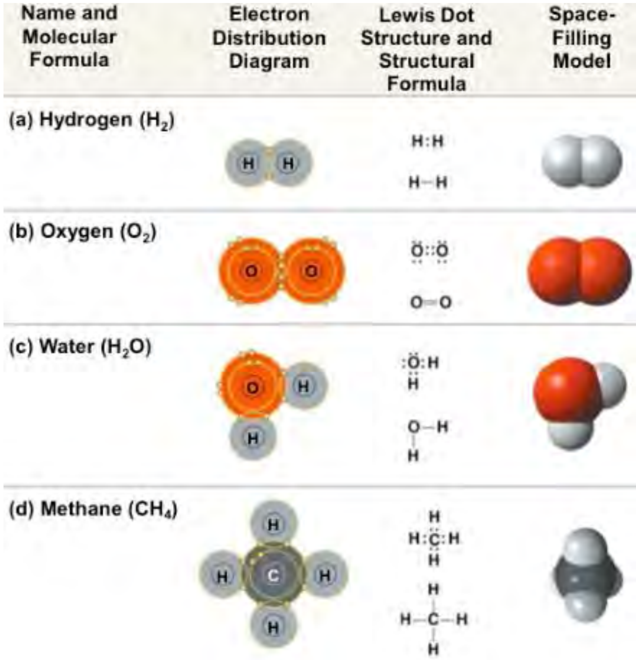
Intramolecular bonds:

1. Ionic bonds (between a metal and a nonmetal). In this case sodium will donate an electron to chlorine. Sodium will become positively charged because it lost an electron, while chlorine will become negatively charged because it gained an electron. These two elements are now oppositely charged ions bonded by an electrostatic attraction. A giant ionic lattice is when many elements are bonded ionically and form one big structure.



2. Covalent bonds (between 2 nonmetals). In this case 2 hydrogen atoms both have 1 electron in their outer shell. As the first shell requires 2 electrons, the 2 hydrogen molecules share their electrons with each other.

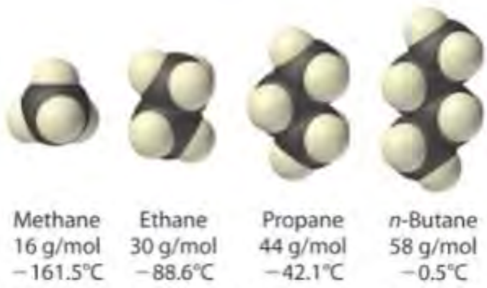




3. Electronegativity: the power of an atom within a molecule to attract bonding electrons to itself. 2 hydrogens are the same and therefore will exert equal force of attraction, meaning electrons will be shared equally. Whereas for hydrogen and chlorine, the latter is more electronegative; it will pull the electrons in its bonding pair towards itself. This means that chlorine will get a slightly negative charge and the hydrogen will have a slightly positive charge = polar bond.
   a. Non-polar covalent bonds have a difference in electronegativity of below 0.4
   b. Ionic bonds form between atoms and with a difference in electronegativity of above 1.7
   c. Anything in between 0.4-1.7 is considered to be a polar bond

Intermolecular bonds:

1. Van der Waals forces: electrons are always moving. At any particular moment electrons may not be evenly distributed around the molecule, which creates a temporary negative dipole. Van der Waals forces (in between atoms) are very weak compared to covalent and ionic bonding.

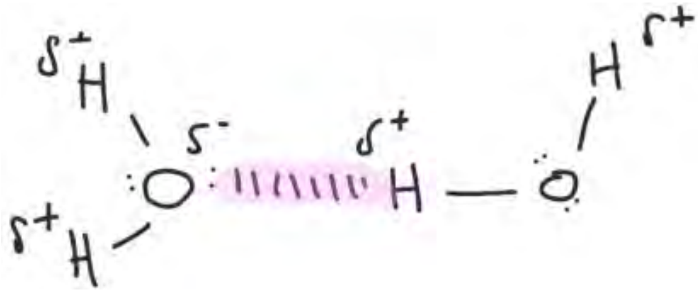


(a) Increasing mass and boiling point

Larger masses or large surface area increases boiling point because of the increased area for van der waals forces

2. Hydrogen bonding: a special type of dipole-dipole interaction formed when hydrogen is covalently bound to a highly electronegative atom like O2, nitrogen or fluorine.

A water molecule where oxygen is attracted to hydrogen which makes hydrogen molecules slightly positive and the oxygen molecule slightly negative when binding to one another. If another water molecule comes in, the oxygen will be attracted to the slightly positively charged hydrogen and it will form a hydrogen bond (purple), which is relatively weak.



Water is kept in a tight configuration, meaning each molecule is closer together in water than in ice. This is the reason for ice being less dense than water.

Hydrogen bonds in DNA: in the bases the hydrogen is covalently bonded to the electronegative nitrogen atom.
Hydrogen bonds in proteins formation: secondary structure which forms the alpha helical shape in place

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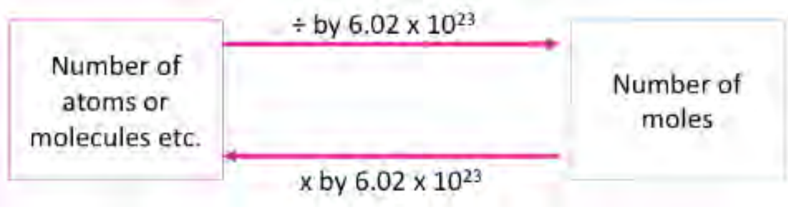
Chemical quantities

Dozen: 12
Gross: 144
Ream: 500

1 mole: 6.02 x 10^23 items (Avogadros' number). Small particles like atoms, molecules and ions are counted using the mole.



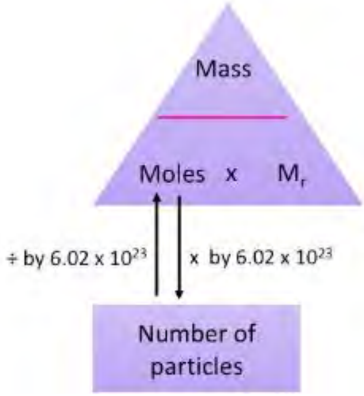
Example: how many NaOH molecules are in 3.2 moles of NaOH?
3.2 x (6.02 x 10^23) = 1.93 x 10^24

Molar mass: the relative atomic mass in grams of any element contains one mole of atoms. Carbon has an atomic mass of 12.01 meaning 1 mole of carbon atoms = 12.01g of carbon atoms

Relative formula mass (Mw): is the mass of 1 mole of a substance. The relative formula mass is calculated by adding together the atomic mass of each atom in the molecule.

Compound formulas:
1. CaCl2: the number after the symbol shows the number of atoms = 1 calcium and 2 chlorines
2. Al(NO3)3: bracket multiply everything in the brackets by the number outside it = 1 aluminium, 3 nitrogens and 9 oxygens

Example: calculate the molar mass of lithium carbonate, Li2CO3, used to treat bipolar disorder.
Li = 2 atoms x 7 mass = 14
C = 1 atom x 12 mass = 12
O = 3 atoms x 16 mass = 48
48 + 12 + 14 = **74g/mol**



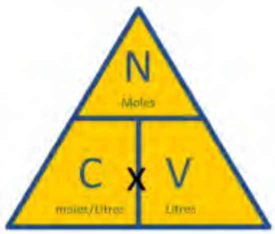
To work out how many moles of atoms are in a particular mass of substance:
Number of moles = mass (g) / mass of one mole (g)

Example: calculate the number of moles of 5.5g of ethanol (C2H5OH)
C = 2 x 12 = 24
H = 5 x 1 = 5
O = 1 x 16 = 16
H = 1 x 1 = 1

1 + 16 + 5 + 24 = 46g of one mole of ethanol
5.5g = mass
5.5 / 46 = **0.12 moles**

Example: calculate the number of molecules of nitric acid, HNO3 (formula mass = 63) in 10mg.
10gm = 0.01g
Number of moles = 0.01 / 63 = 0.00015873 or 1.6 x 10^-4 moles
Number of molecules = (0.1.6 x 10^-4) x (6.02 x 10^23) = **9.6 x 10^19 molecules**

Concentration: the amount of substance in a defined volume. A common way to express solution concentration is molarity (M) or mol/L = moles (mol) / volume (L)
1L = 1dm^3
1mL = 1cm^3
mL / 1000 = L
L x 1000 = mL



Example: what is the concentration of a 450mL NaCl solution containing 1.3 moles of NaCl.
1.3 / (450 / 1000) = **2.89mol/L**

Example: If you need 4L of a 0.2M sodium chloride solution (NaCl), what mass of sodium chloride must you use?
0.2 = ? / 4L
? = 0.8 = moles

Mass = moles x formula mass = (23 + 35.5) x 0.8 = **46.8g**

Dilution: a solution can be diluted by adding ONLY solvent. The concentration decreases, but the moles don't change. Molarity of the new solution can be determined from the equation: C1 x V1 = C2 x V2 where C1 and C2 are the molarity of the concentrated and dilute solutions, respectively, and where V1 and V2 are the volumes of the solutions.
Number of moles doesn't change because in both solutions the equation will be the same = concentration x volume