


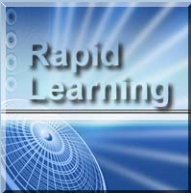
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 **Atoms and Molecules**

CLEP Chemistry Rapid Learning Series

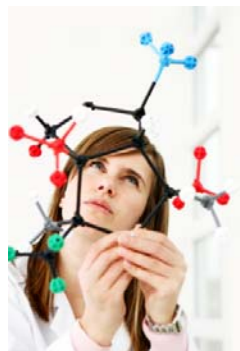
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Learning Objectives

By completing this tutorial, you will learn:



- What atoms are made of
- How ions are formed
- What information is found in an element symbol
- What isotopes are & how their properties are different
- How atoms, elements and molecules are related

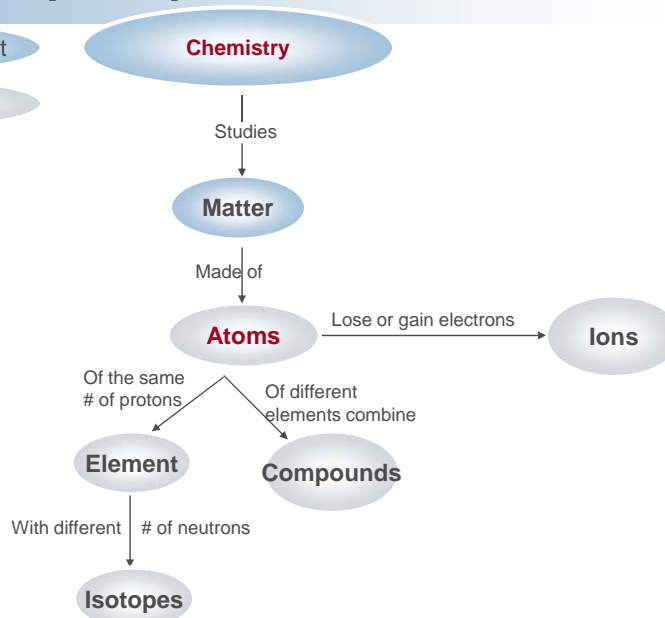
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Concept Map


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What is an Atom?




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Definition: Atom

Atom – The smallest piece of matter that has the chemical properties of the element.

Often called the
“Building Block of Matter”



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What's in an Atom?

An atom is made of three sub-atomic particles.

Particle	Location	Mass	Charge
Proton	Nucleus	1 amu = 1.67×10^{-27} kg	+1
Neutron	Nucleus	1 amu = 1.67×10^{-27} kg	0
Electron	Outside the nucleus	0.00055 amu 9.10×10^{-31} kg	-1

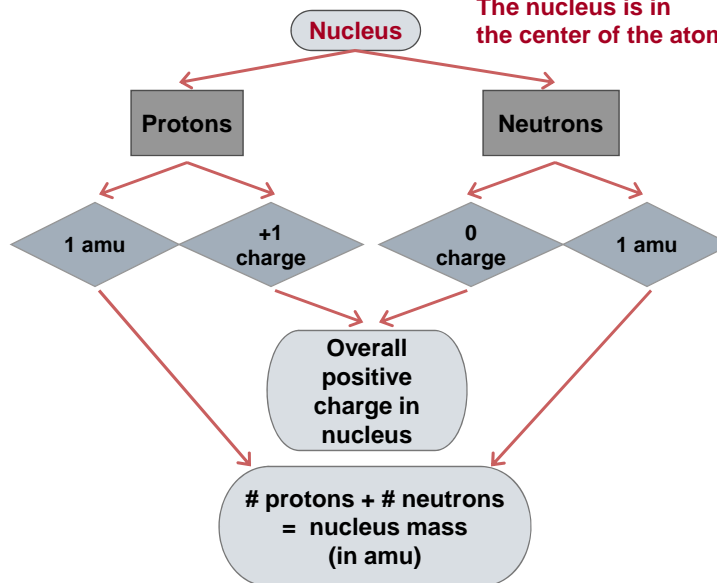
1 amu ("atomic mass unit") = 1.66×10^{-27} kg

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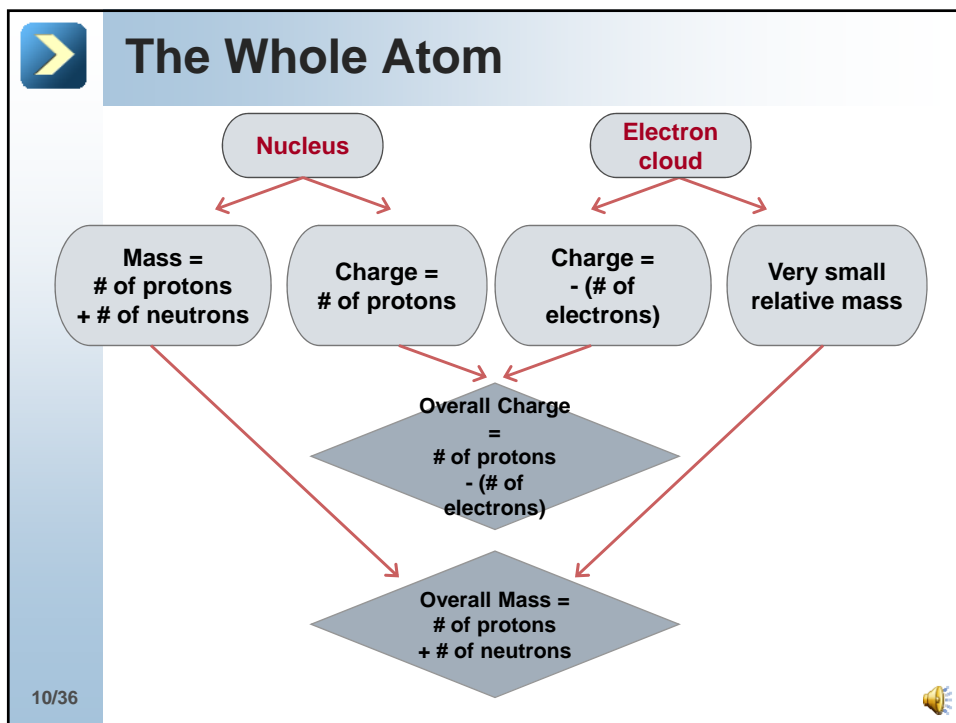
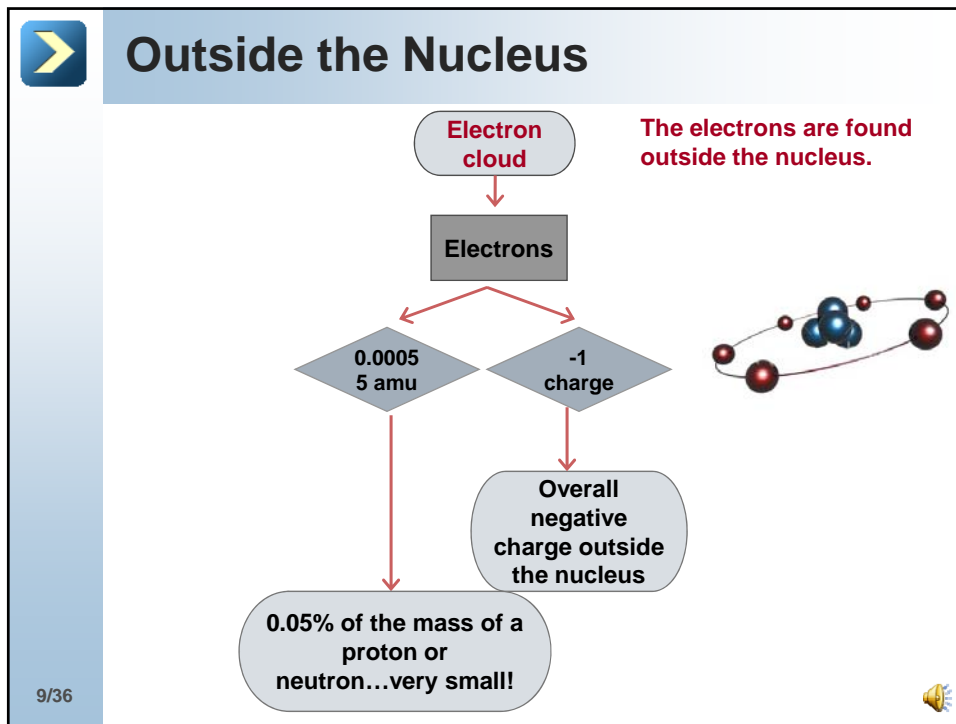
Inside the Nucleus

The nucleus is in the center of the atom.



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Protons Versus Electrons

Protons	Electrons
+ Charge	- Charge
Contributes to mass of atom	Does not contribute significantly to mass of atom
Found in nucleus	Found outside nucleus
# determines the "identity" of the atom	# and configuration determine how the atom will react
<u>Cannot</u> be lost or gained without changing which element it is (nuclear reaction)	<u>Can</u> be lost or gained—results in an atom with a charge (ion)
The ratio of protons to electrons determines the charge on the atom	

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Density of the Nucleus


Since the majority of the mass of the atom is contained in the nucleus, it is **very dense**.

The electron cloud has very little mass and a lot of empty space—it has a very **low density**.




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Ions




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Definition: Ion

Ion – An atom with a charge (uneven # of protons and electrons).



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How Are Ions Formed?

Anion - Atom with a negative charge (less protons than electrons).

Before	Change	After	Charge
Oxygen atom 8 protons 8 neutrons	Add 2 electrons	Oxygen anion 8 protons 10 electrons	O^{2-}

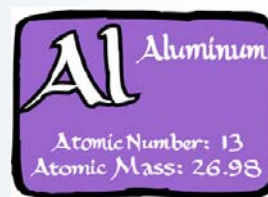
Cation - Atom with a positive charge (more protons than electrons).

Sodium atom 11 protons 11 electrons	Loses 1 electron	Sodium cation 11 protons 10 electrons	Na^+
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Chemical Symbology



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The Periodic Table

The periodic table organizes the elements.

Periodic Table of the Elements																																																																																																						
Representative (main group) elements										Transition metals								Representative (main group) elements																																																																																				
IA		IIA												IIIA		IVA		VA		VIA		VIIA		VIII																																																																														
1 H 1.0079	2 He 4.003	3 Li 6.941	4 Be 9.012	5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180	11 Na 22.990	12 Mg 24.305	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948	19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.8	37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc 98	44 Ru 101.07	45 Rh 101.07	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.905	54 Xe 131.29	55 Cs 132.905	56 Ba 137.327	57 La 138.905	58 Ce 140.908	59 Pr 140.908	60 Nd 144.24	61 Pm 145	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.925	66 Dy 162.5	67 Ho 164.93	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po 209	85 At 210	86 Rn 222	87 Fr 223	88 Ra 226.025	89 Ac 227.038	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	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	103 Lr 262
Rare earth elements																																																																																																						
Lanthanides																																																																																																						
Actinides																																																																																																						

The element symbols are one or two letters—the first is always capitalized.

e.g. O = Oxygen; Cl = Chlorine; Cu = Copper

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The Periodic Table Organization

Elements are organized by increasing atomic number.

The atomic number = # of protons

Each element has a different atomic #...

Therefore, each element has a different # of protons...

That's what makes an element that element - the # of protons.



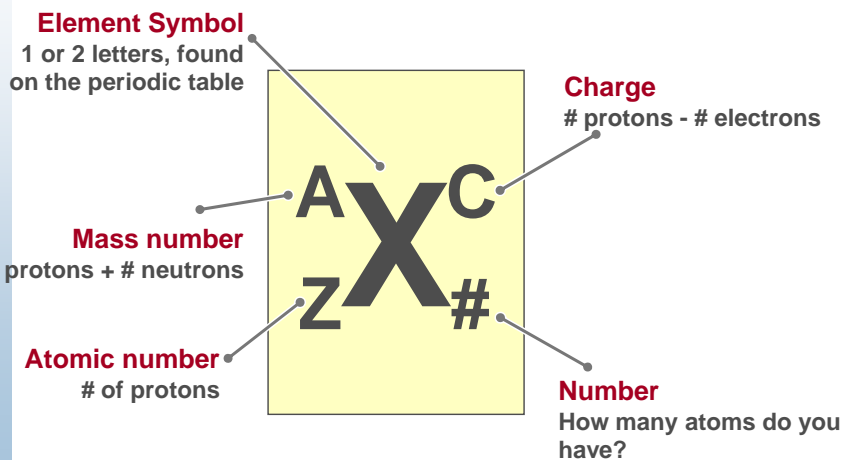
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Element Symbols

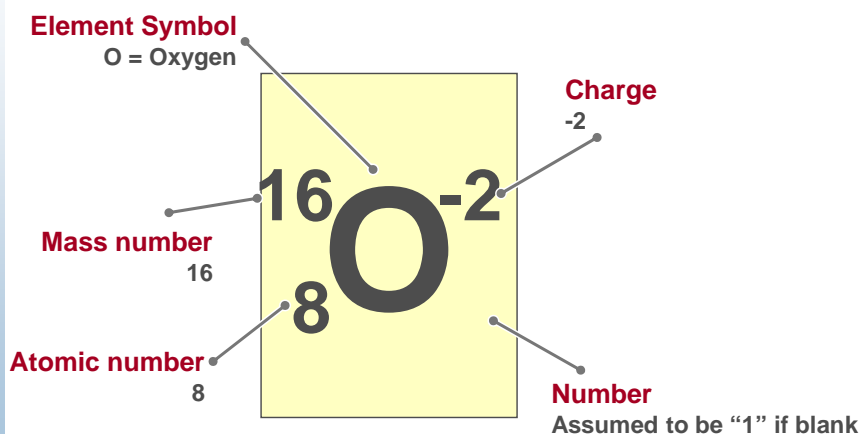
A lot of information can be displayed with an element's symbol.



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Example: Element Symbols




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Isotopes




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Definition: Isotopes

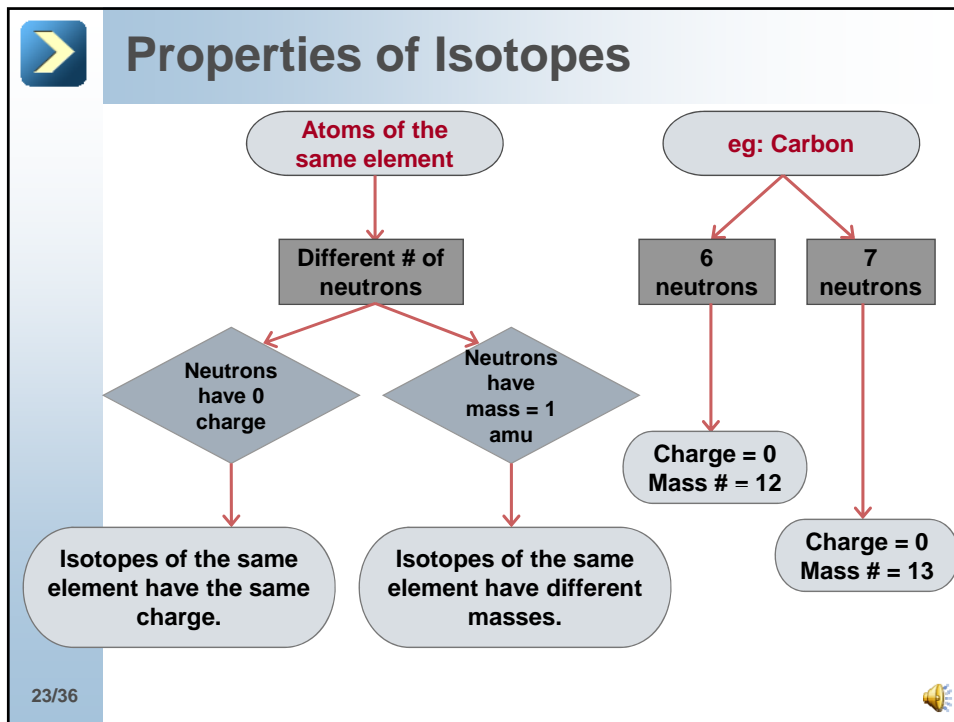
Isotopes - Atoms of the same element (therefore having the same number of protons) with a different number of neutrons.

Some isotopes are radioactive - but not all...many are quite stable!



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Identifying Isotopes

Isotopes can be differentiated by their different mass numbers in the element symbol.

^{12}C
 ↓
Carbon-12

^{13}C
 ↓
Carbon-13

Or by the mass number following their name.

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Mass Number Vs Atomic Mass

Mass Number	Atomic Mass
# of protons + # of neutrons	Average of actual masses
Always a whole number	Not a whole number
For one specific isotope only	Weighted average of all isotopes found in nature
Is <u>not</u> found on the periodic table	Is found on the periodic table

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Calculating Average Atomic Mass

Average atomic mass is a weighted average (it takes into account how often each isotope occurs).

$$\text{Average atomic mass} = \sum \left(\underbrace{\text{Abundance of isotope}}_{\substack{\text{"Sum of"} \\ \text{What fraction of the time is that} \\ \text{isotope present?}}} \times \underbrace{\text{Mass of isotope}}_{\substack{\text{Actual mass} \\ \text{(not mass} \\ \text{number)}}} \right)$$

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Example: Atomic Mass

Example: Find the atomic mass of chlorine if Chlorine-35 has a mass of 34.969 amu and Chlorine-37 has a mass of 36.966 amu and is present 24.22% of the time.

Step	Write down
K	$^{35}\text{Cl} = 34.969 \text{ amu}$
	$^{37}\text{Cl} = 36.966 \text{ amu}$
	$^{37}\text{Cl} = 24.22\%$ therefore $^{35}\text{Cl} = 75.78\%$
U	Avg Atomic mass = ? amu
D	Atomic mass = Σ [(abundance of isotope) × (mass of isotope)]
O	Atomic mass = $(0.7578)(34.969 \text{ amu}) + (0.2422)(36.966 \text{ amu})$ Atomic mass = 35.45 amu
S	This is the average atomic mass found for chlorine on the periodic table. Therefore, the answer is correct.

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Atoms, Elements & Compounds



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Definition: Molecule & Compound

Molecule - At least two atoms combined (can be same or different element) to form a new “unit.”

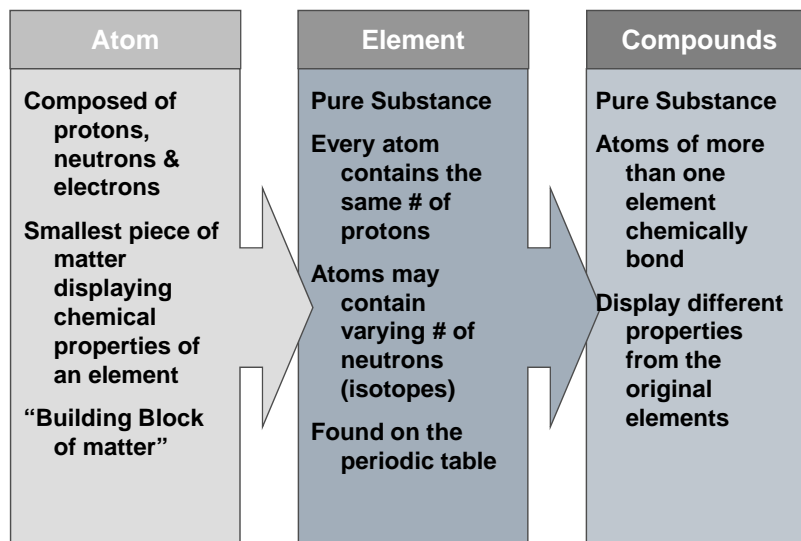
Compound - Atoms of two different elements combined to form a new “unit.”



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Atoms, Elements & Compounds



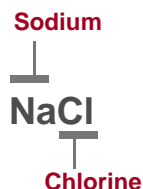
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Molecular Formulas

Just as there are symbols for the elements, those symbols are joined together to show the composition of a molecule.



NaCl (table salt) is made from a chemical bond between two elements.

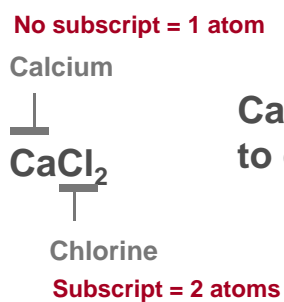
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Subscripts in Molecular Formulas

Element symbols are used to show which type of atom.

Subscripts are used to show how many of each type.



Calcium chloride is used to de-ice roads.

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More on Molecular Formulas

Usually, the most metallic element (closest to the far left column on the periodic table) is written first.



Organic molecules are an exception to this rule—they are often written in the order the atoms are bonded in.



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Learning Summary

Isotopes are atoms of the same element with a different # of neutrons.

All matter is made of atoms.


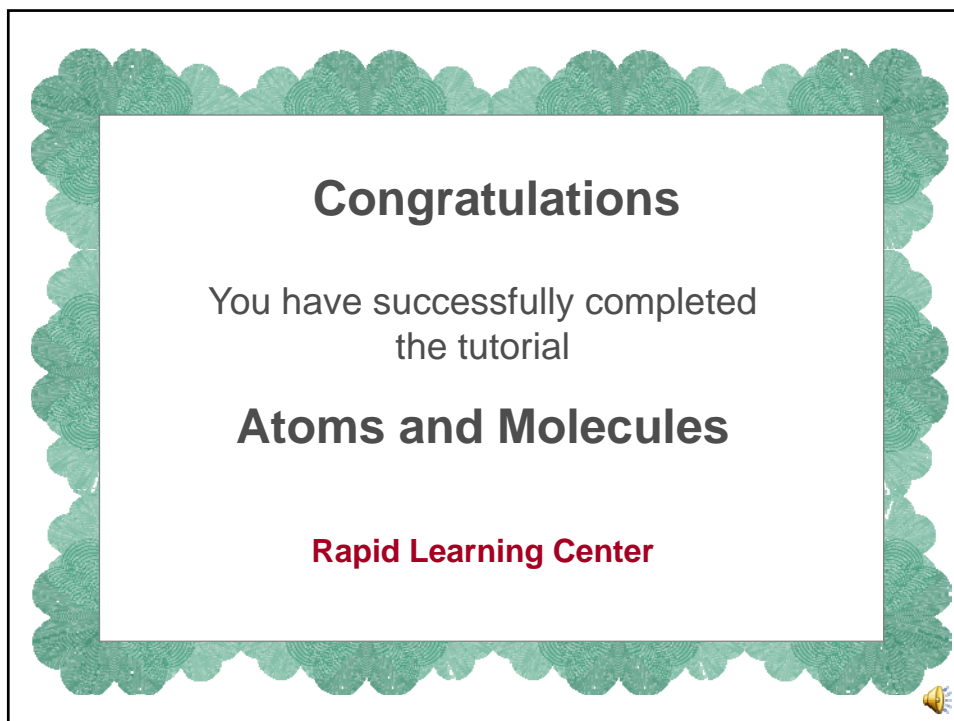
Atoms of the same type make up elements, while atoms of different elements combine to form compounds.

Atoms are made of protons, neutrons & electrons.


Element symbols can give information about the components of the atom.

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What's Next ...

Step 1: Concepts – Core Tutorial (Just Completed)
→ Step 2: Practice – Interactive Problem Drill
Step 3: Recap – Super Review Cheat Sheet

Go for it!



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