

Electrons

- What are electrons?
- Where are electrons located?
- the electron has a charge of -1.60×10^{19} C
- the electron has a mass of 9.1×10^{-28} g

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Subatomic Particle	Mass g	Mass amu	Location in atom	Charge	Symbol
Proton	1.67262×10^{-24}	1.00727	nucleus	+1	p, p ⁺ , H ⁺
Electron	0.00091×10^{-24}	0.00055	empty space	-1	e, e ⁻
Neutron	1.67493×10^{-24}	1.00866	nucleus	0	n, n ⁰

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Elements

- What differentiates one element from another?

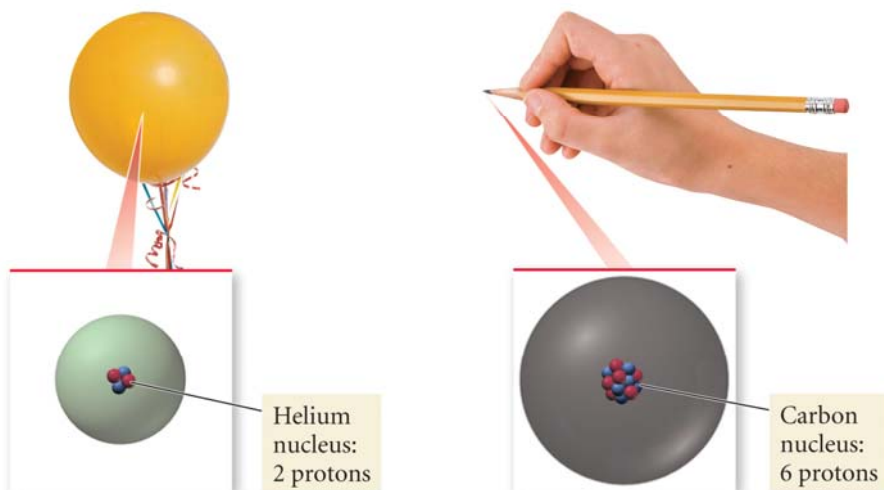
What subatomic particles are typically involved in benchtop chemistry? Why?

- Atomic number:

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The Number of Protons Defines the Element



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The Periodic Table of Elements

Atomic number (Z)

Chemical symbol

Name

1 H hydrogen																	2 He helium																												
3 Li lithium	4 Be beryllium											5 B boron	6 C carbon	7 N nitrogen	8 O oxygen	9 F fluorine	10 Ne neon																												
11 Na sodium	12 Mg magnesium											13 Al aluminum	14 Si silicon	15 P phosphorus	16 S sulfur	17 Cl chlorine	18 Ar argon																												
19 K potassium	20 Ca calcium	21 Sc scandium	22 Ti titanium	23 V vanadium	24 Cr chromium	25 Mn manganese	26 Fe iron	27 Co cobalt	28 Ni nickel	29 Cu copper	30 Zn zinc	31 Ga gallium	32 Ge germanium	33 As arsenic	34 Se selenium	35 Br bromine	36 Kr krypton																												
37 Rb rubidium	38 Sr strontium	39 Y yttrium	40 Zr zirconium	41 Nb niobium	42 Mo molybdenum	43 Tc technetium	44 Ru ruthenium	45 Rh rhodium	46 Pd palladium	47 Ag silver	48 Cd cadmium	49 In indium	50 Sn tin	51 Sb antimony	52 Te tellurium	53 I iodine	54 Xe xenon																												
55 Cs cesium	56 Ba barium	57 La lanthanum	72 Hf hafnium	73 Ta tantalum	74 W tungsten	75 Re rhenium	76 Os osmium	77 Ir iridium	78 Pt platinum	79 Au gold	80 Hg mercury	81 Tl thallium	82 Pb lead	83 Bi bismuth	84 Po polonium	85 At astatine	86 Rn radon																												
87 Fr francium	88 Ra radium	89 Ac actinium	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 **	114 **	116 **																																
<table border="1"> <tbody> <tr> <td>58 Ce cerium</td> <td>59 Pr praseodymium</td> <td>60 Nd neodymium</td> <td>61 Pm promethium</td> <td>62 Sm samarium</td> <td>63 Eu europium</td> <td>64 Gd gadolinium</td> <td>65 Tb terbium</td> <td>66 Dy dysprosium</td> <td>67 Ho holmium</td> <td>68 Er erbium</td> <td>69 Tm thulium</td> <td>70 Yb ytterbium</td> <td>71 Lu lutetium</td> </tr> <tr> <td>90 Th thorium</td> <td>91 Pa protactinium</td> <td>92 U uranium</td> <td>93 Np neptunium</td> <td>94 Pu plutonium</td> <td>95 Am americium</td> <td>96 Cm curium</td> <td>97 Bk berkelium</td> <td>98 Cf californium</td> <td>99 Es einsteinium</td> <td>100 Fm fermium</td> <td>101 Md mendelevium</td> <td>102 No nobelium</td> <td>103 Lr lawrencium</td> </tr> </tbody> </table>																		58 Ce cerium	59 Pr praseodymium	60 Nd neodymium	61 Pm promethium	62 Sm samarium	63 Eu europium	64 Gd gadolinium	65 Tb terbium	66 Dy dysprosium	67 Ho holmium	68 Er erbium	69 Tm thulium	70 Yb ytterbium	71 Lu lutetium	90 Th thorium	91 Pa protactinium	92 U uranium	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium
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Structure of the Nucleus

- Isotopes
- Natural Abundance
- What is average atomic mass?

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Isotopes

- How do isotopes differ?
- How are they the same?
- What are the three parts of a chemical symbol?
- X, M, A

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Neon



Symbol	Number of Protons	Number of Neutrons	A, Mass Number	Percent Natural Abundance
Ne-20 or ${}^{20}_{10}\text{Ne}$	10	10	20	90.48%
Ne-21 or ${}^{21}_{10}\text{Ne}$	10	11	21	0.27%
Ne-22 or ${}^{22}_{10}\text{Ne}$	10	12	22	9.25%

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Charged Atoms

- Ions
- Cations versus Anions
- Behavior of ions versus atoms
- Ionic symbols (X, M, A)

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Atomic Structures of Ions

- What species typically form anions?
- Naming anions

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Atomic Structures of Ions

- What species typically form cations?

- Naming cations

Mendeleev

- What observations did Mendeleev make? The “Periodic Law!”

- Arrangements of elements in a typical periodic table:

- Why do elements in the same column have the same general properties?

Periodic Pattern

A Simple Periodic Table

The Periodic Law

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
H	He	Li	Be	B	C	N	O	F	Ne	Na	Mg	Al	Si	P	S	Cl	Ar	K	Ca

Elements with similar properties recur in a regular pattern.

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francium	radium	act
K	Ca	

Elements with similar properties
fall into columns.

Yb	Lu
ytterbium	lutetium
No	Lr
nobelium	lawrencium

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Major Divisions of the Periodic Table

Metals	Metalloids	Nonmetals
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Metals

- Properties of Metals

Strontium



Location of metals in the periodic table:

Copper



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Nonmetals

- Properties of Nonmetals

Sulfur, S(*s*)



Bromine, Br₂(*l*)



- Location of Nonmetals in the Periodic Table:

Chlorine, Cl₂(*l*)



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Metalloids

- Properties of Metalloids:

- Location in the periodic table:

Silicon



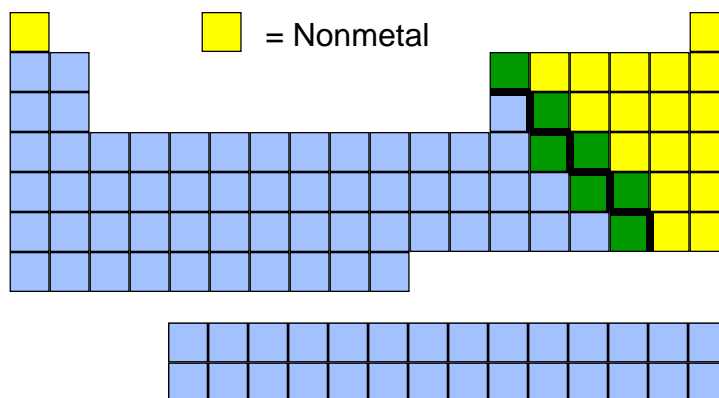
Properties of Silicon
 shiny
 conducts electricity
 does not conduct heat well
 brittle

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Patterns in Metallic Character

= Metal
 = Metalloid
 = Nonmetal



The Modern Periodic Table

- Vertical groups are called
- Horizontal groupings are called
- The “Main Group” is
- The “Transition Metals” are
- The “Rare Earth Elements” are

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		Main-group elements		Transition elements										Main-group elements						
		1A	2A											3A	4A	5A	6A	7A	8A	
		Group number																		
1		1 H																		2 He
2		3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
3		11 Na	12 Mg	3B	4B	5B	6B	7B	8B		1B	2B	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar		
4	Periods	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5		37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
6		55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	
7		87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112	114		116				

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Example 2.5 If copper is 69.17% Cu-63 with a mass of 62.9396 amu and the rest Cu-65 with a mass of 64.9278 amu, find copper's atomic mass

Given:	Cu-63 = 69.17%, 62.9396 amu Cu-65 = 100-69.17%, 64.9278 amu
Find:	atomic mass, amu
Concept Plan:	<div style="display: flex; align-items: center; justify-content: center;"> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; margin-right: 10px;">isotope masses, isotope fractions</div> → <div style="border: 1px solid black; border-radius: 15px; padding: 5px; margin-left: 10px;">avg. atomic mass</div> </div>
Relationships:	$\text{Atomic Mass} = \sum (\text{fractional abundance of isotope})_n \times (\text{mass of isotope})_n$
Solution:	$\begin{aligned} \text{Atomic Mass} &= (0.6917)(62.9396 \text{ amu}) \\ &\quad + (0.3083)(64.9278 \text{ amu}) \\ \text{Atomic Mass} &= 63.5525 = 63.55 \text{ amu} \end{aligned}$
Check:	the average is between the two masses, closer to the major isotope