

Periodic Table of the Elements

1 H Hydrogen 1.01																	2 He Helium 4.00
3 Li Lithium 6.94	4 Be Beryllium 9.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.95
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.88	23 V Vanadium 50.94	24 Cr Chromium 51.99	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.63	33 As Arsenic 74.92	34 Se Selenium 78.97	35 Br Bromine 79.90	36 Kr Krypton 83.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.95	43 Tc Technetium 98.91	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90	54 Xe Xenon 131.29
55 Cs Cesium 132.91	56 Ba Barium 137.33	57-71 Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.85	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.20	83 Bi Bismuth 208.98	84 Po Polonium [208.98]	85 At Astatine 209.98	86 Rn Radon 222.02
87 Fr Francium 223.02	88 Ra Radium 226.03	89-103 Actinides	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [277]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [282]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]

General Chemistry

202-SN1-RE

with Olivia Bibollet-Bahena

Office: 5th floor

57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium 144.91	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.06	71 Lu Lutetium 174.97
89 Ac Actinium 227.03	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium 237.05	94 Pu Plutonium 244.06	95 Am Americium 243.06	96 Cm Curium 247.07	97 Bk Berkelium 247.07	98 Cf Californium 251.08	99 Es Einsteinium [254]	100 Fm Fermium 257.10	101 Md Mendelevium 258.10	102 No Nobelium 259.10	103 Lr Lawrencium [262]

- Alkali Metal
- Alkaline Earth
- Transition Metal
- Basic Metal
- Metalloid
- Nonmetal
- Halogen
- Noble Gas
- Lanthanide
- Actinide

Exercises in Teams – Dimensional Analyses

You'll have to know that:

$$1 \text{ cm}^3 = 1 \text{ mL}$$

$$1 \text{ dm}^3 = 1 \text{ L}$$

Try the following:

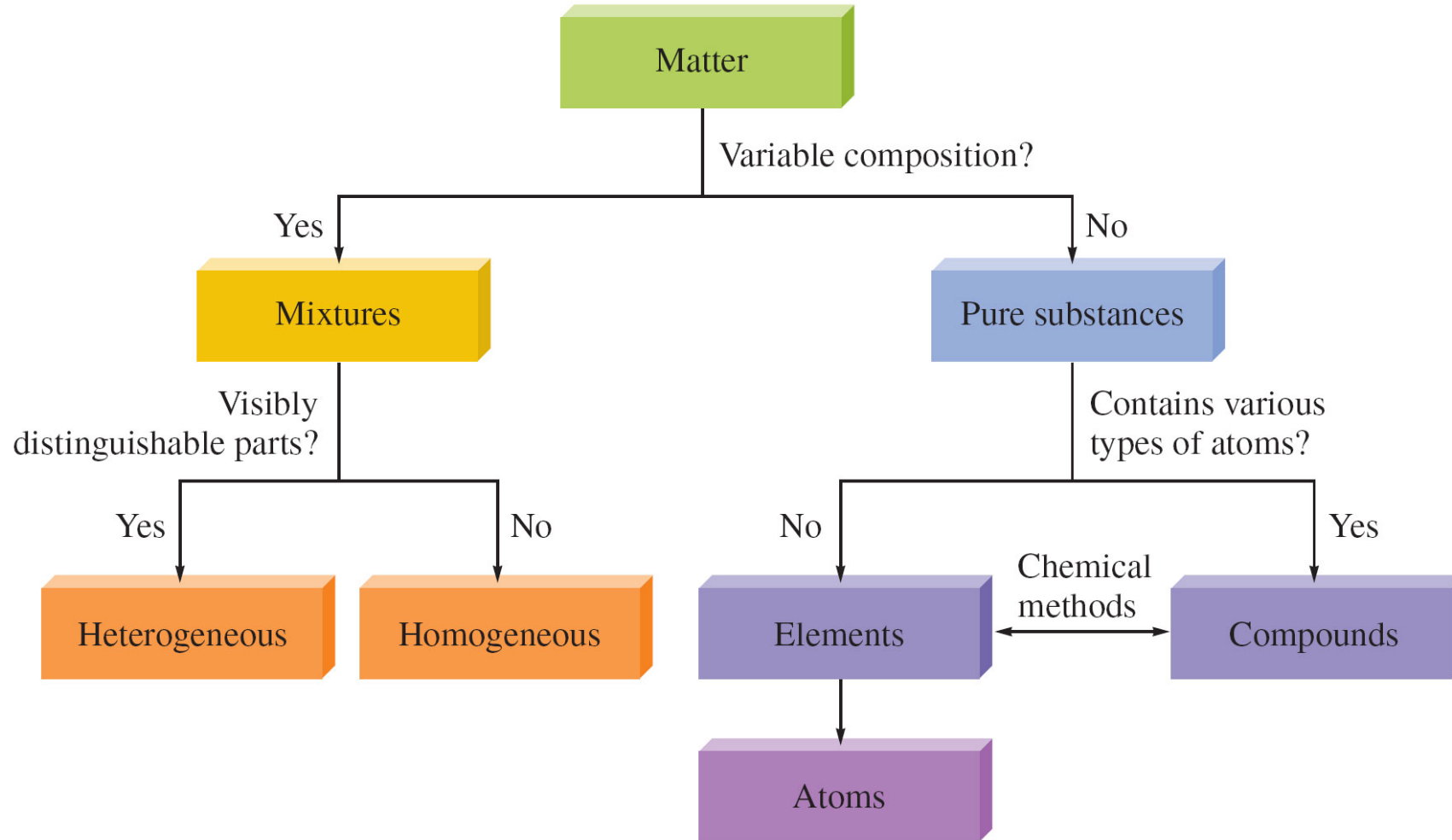
Conversion 1	1.886 cm ³ /day to dL/week
Conversion 2	10.2 kg/cm ² to mg/m ²
Conversion 3	0.26458 mg/mL to ng/mm ³
Conversion 4	455 km ² /h to m ² /s
Conversion 5	1.0009 L/h to m ³ /day

What is Chemistry?

- Chemistry is the study of **matter** and its **transformations**.
 - Matter is anything and everything around us as long as it occupies space and has a mass.
- Chemistry is the '**central science**'.
 - It bridges other natural sciences like physics and biology with each other.



Classification of Matter



Some Common Groups of Elements and Their Properties

- **Intensive Properties:** Independent of sample size
 - Temperature
 - Melting point
- **Extensive Properties:** Dependent on sample size
 - Length
 - Volume

Some Common Groups of Elements and Their Properties

- **Physical Properties:** Characteristics that **do not** involve a change in a sample's chemical makeup
- **Chemical Properties:** Characteristics that **do** involve a change in a sample's chemical makeup

Physical Properties

Temperature

Color

Melting point

Electrical conductivity

Amount

Odor

Solubility

Hardness

Chemical Properties

Rusting (of iron)

Combustion (of gasoline)

Tarnishing (of silver)

Cooking (of an egg)

Table 2.3 Some Examples of Physical and Chemical Properties

Exercises

Physical or Chemical Transformation?

Boiling water to make a coffee

Roasting a marshmallow over a campfire

A zamboni going over the ice between hockey periods

The movement of a gas-engine car

Car rust

Air drying clothes after washing them

Lighting a candle for a nice romantic dinner

What is an Atom?

- Smallest recognized division of a **chemical element**

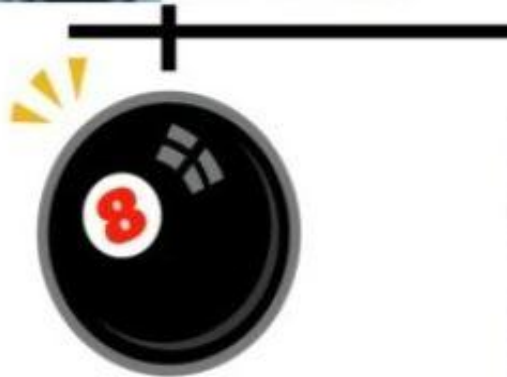
OR

- The smallest particle that still displays the chemical properties of the elements in the Periodic Table.

The Atomic Structure

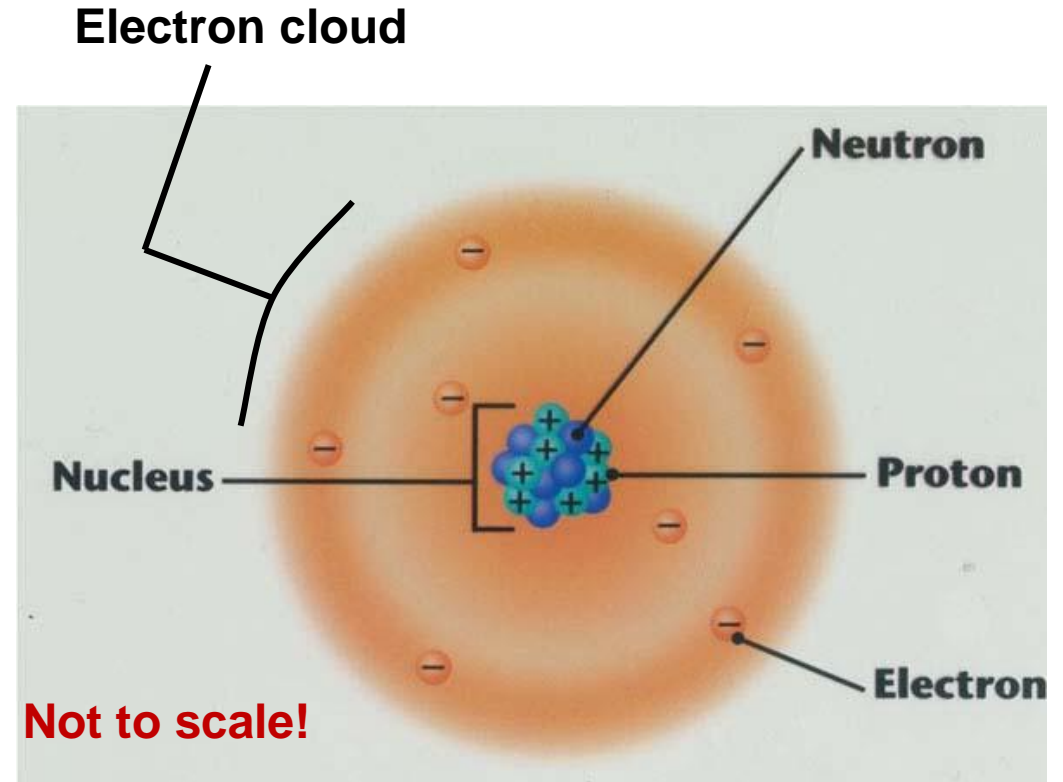
History of the Atom Timeline

Democritus 460 BC
and Dalton 1803 AD



The Modern View of Atomic Structure

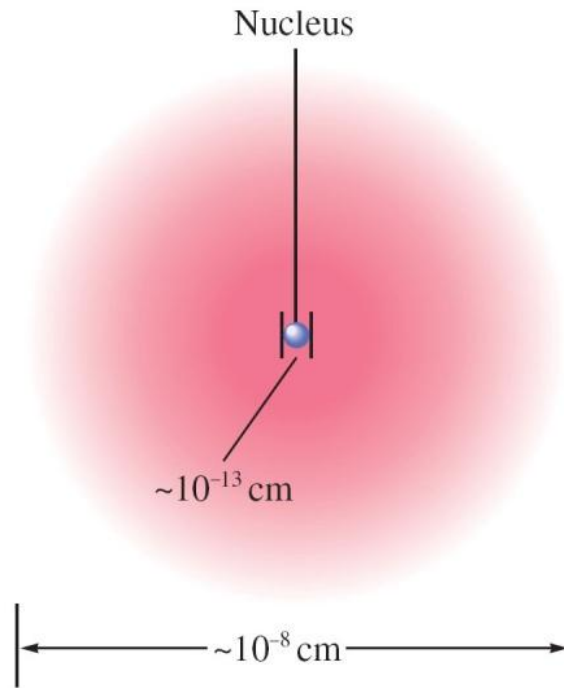
- The atom contains:
 - **Electrons (e^-)** – found outside the nucleus (in the electron cloud); negatively charged.
 - **Protons (p^+)** – found in the nucleus; positive charge equal in magnitude to the electron's negative charge.
 - **Neutrons (n^0)** – found in the nucleus; no charge; virtually same mass as a proton.



burro.cwru.edu/.../Astr201/MatterEnergy/atom.jpg

Particle	Mass	Charge*
Electron	9.109×10^{-31} kg	1-
Proton	1.673×10^{-27} kg	1+
Neutron	1.675×10^{-27} kg	None

Modern View of Atomic Structure



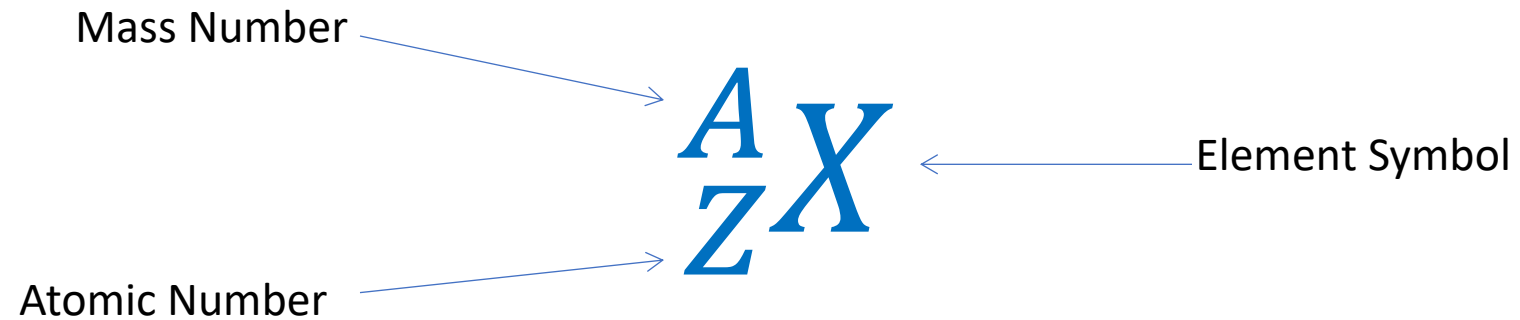
Bean = Nucleus
Stadium = Atom

If all atoms are composed of the same 3 parts (electrons, protons, and neutrons), why do different atoms have different chemical properties?

Chemistry of an Atom

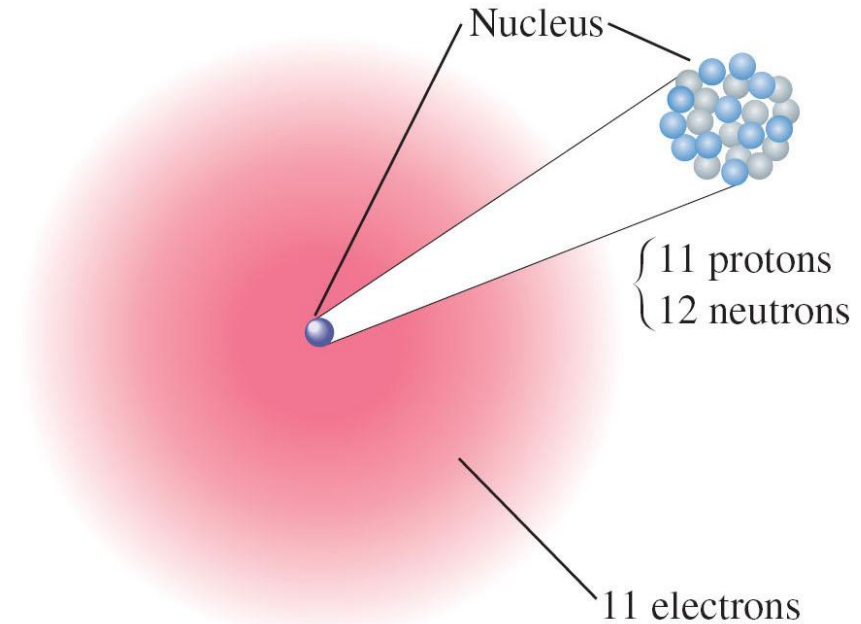
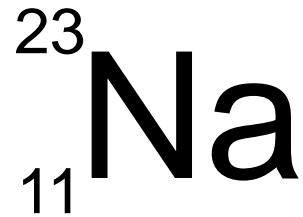
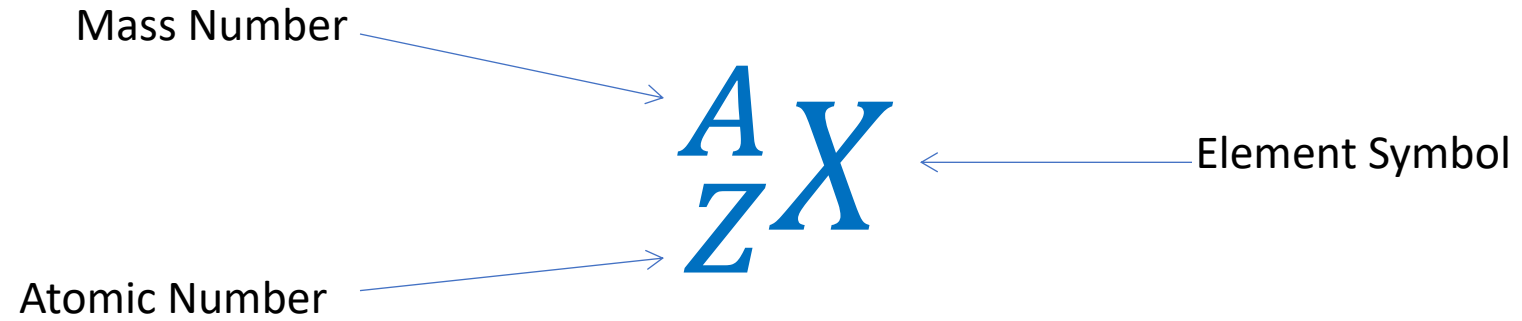
- Most chemistry involves interactions of electrons (exception being nuclear)
- Different elements have unique numbers of protons and electrons, which give different chemical behavior

Symbols for Atoms



- For an element of symbol X :
 - The **mass number (A)** indicates the total number of protons and neutrons (written as a superscript)
 - The **atomic number (Z)** indicates the number of protons in an element (written as a subscript)

Symbols for Atoms (example)



Chemistry and the Elements

Element	Symbol	Element	Symbol
Aluminum	Al	Manganese	Mn
Argon	Ar	Nitrogen	N
Barium	Ba	Oxygen	O
Boron	B	Phosphorus	P
Bromine	Br	Silicon	Si
Calcium	Ca	Sulfur	S
Carbon	C	Zinc	Zn
Chlorine	Cl	Copper (cuprum)	Cu
Fluorine	F	Iron (ferrum)	Fe
Helium	He	Lead (plumbum)	Pb
Hydrogen	H	Mercury (hydrargyrum)	Hg
Iodine	I	Potassium (kalium)	K
Lithium	Li	Silver (argentum)	Ag
Magnesium	Mg	Sodium (natrium)	Na

Table 2.1 Names and Symbols of Some Common Elements. Latin names from which the symbols of some elements are derived are shown in parentheses.

Exercise

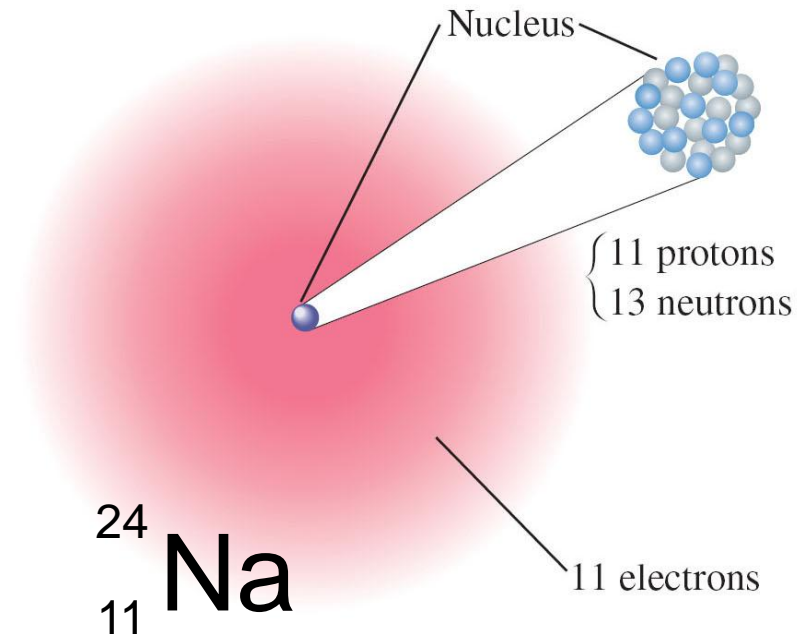
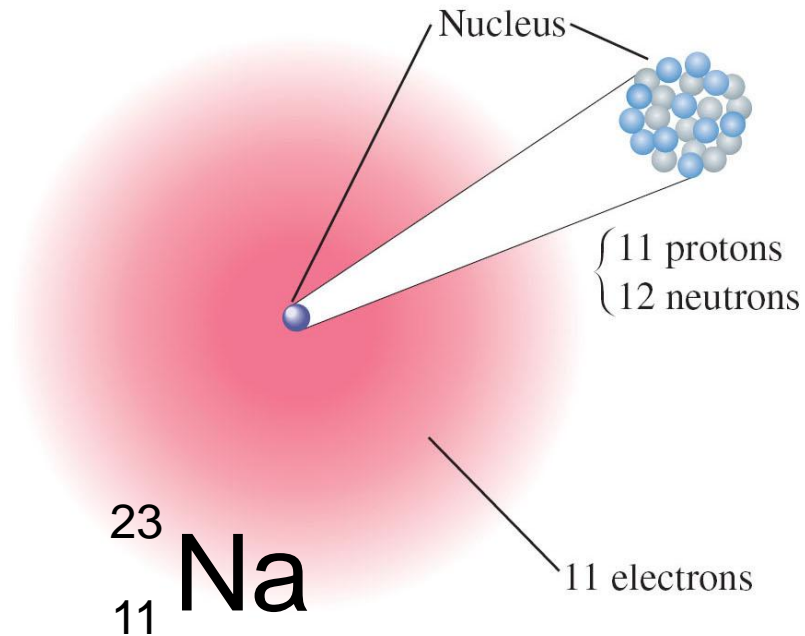
- For the following atoms, provide the number of protons, neutrons and electrons:

	Protons	Neutrons	Electrons
⁷⁹ Br ₃₅	<input type="text"/>	<input type="text"/>	<input type="text"/>
⁴⁰ Ca ₂₀	<input type="text"/>	<input type="text"/>	<input type="text"/>
⁵⁹ Co ₂₇	<input type="text"/>	<input type="text"/>	<input type="text"/>

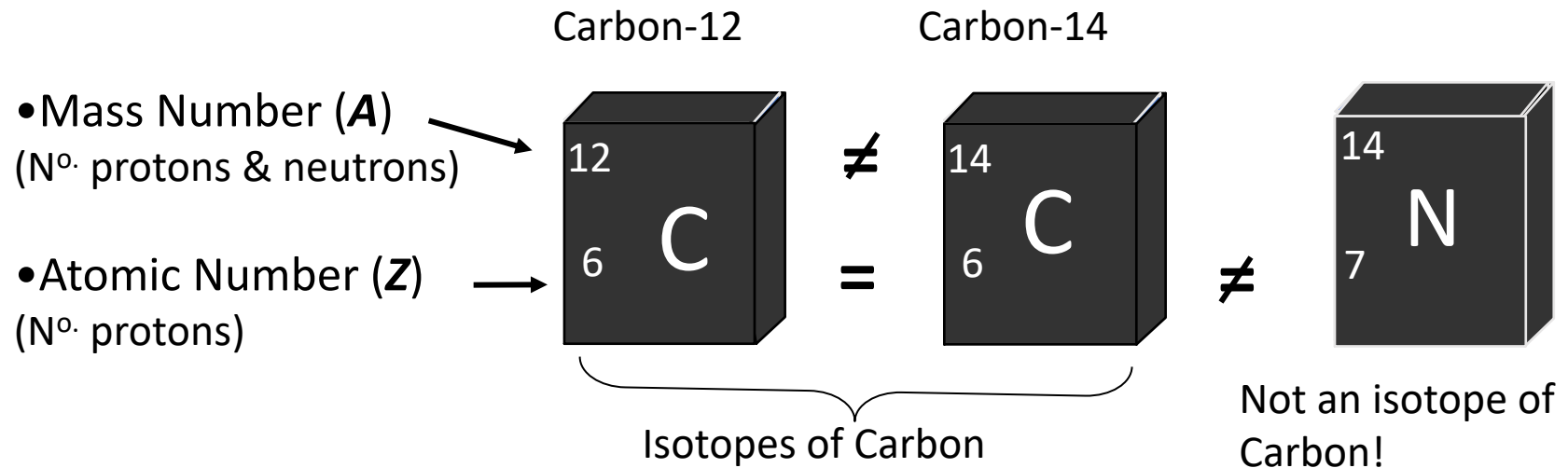
Isotopes

“Iso” means “same” and
“topos” means “identity”

- Atoms of the **same element** with the same number of protons, but not neutrons
- Ex:



Isotopes (Example)



Exercise

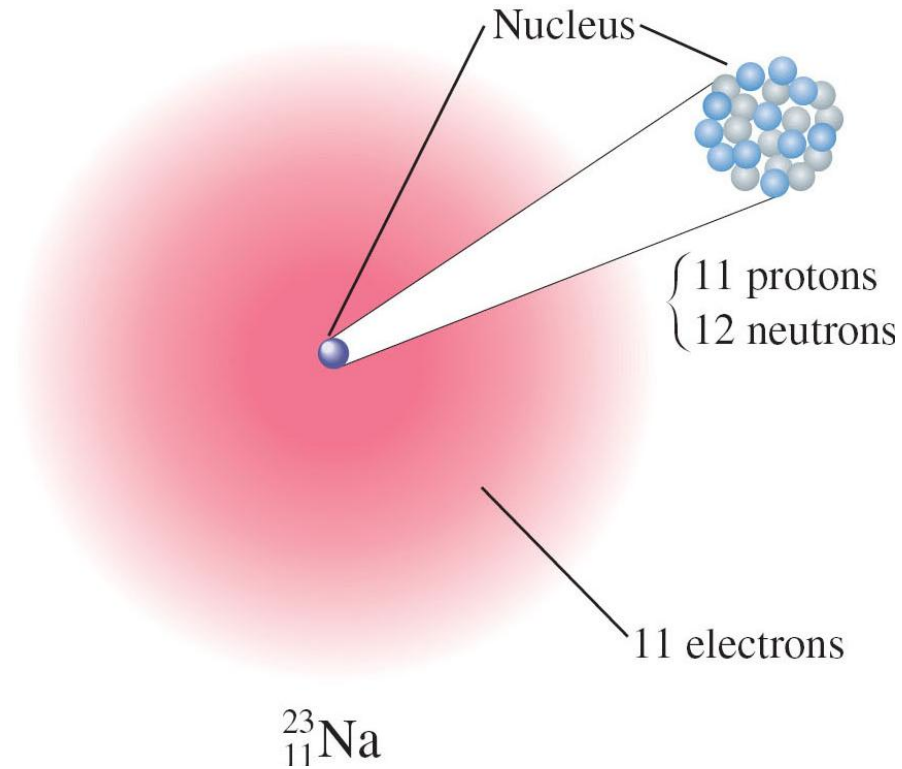
A certain isotope X contains 23 protons and 28 neutrons.

- What is the **mass number** of this isotope?
- Identify the **element**.

Exercise

Which of the following statements is/are true?

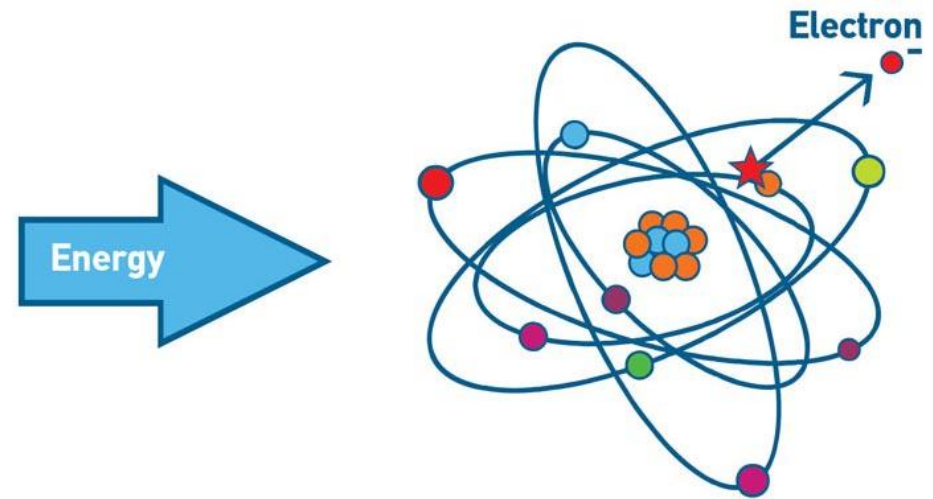
- I. The number of protons is the same for all neutral atoms of an element.
- II. The number of electrons is the same for all neutral atoms of an element.
- III. The number of neutrons is the same for all neutral atoms of an element.



When the number of electrons and protons are equal, the atom is **neutral**.

But what if they are not equal?

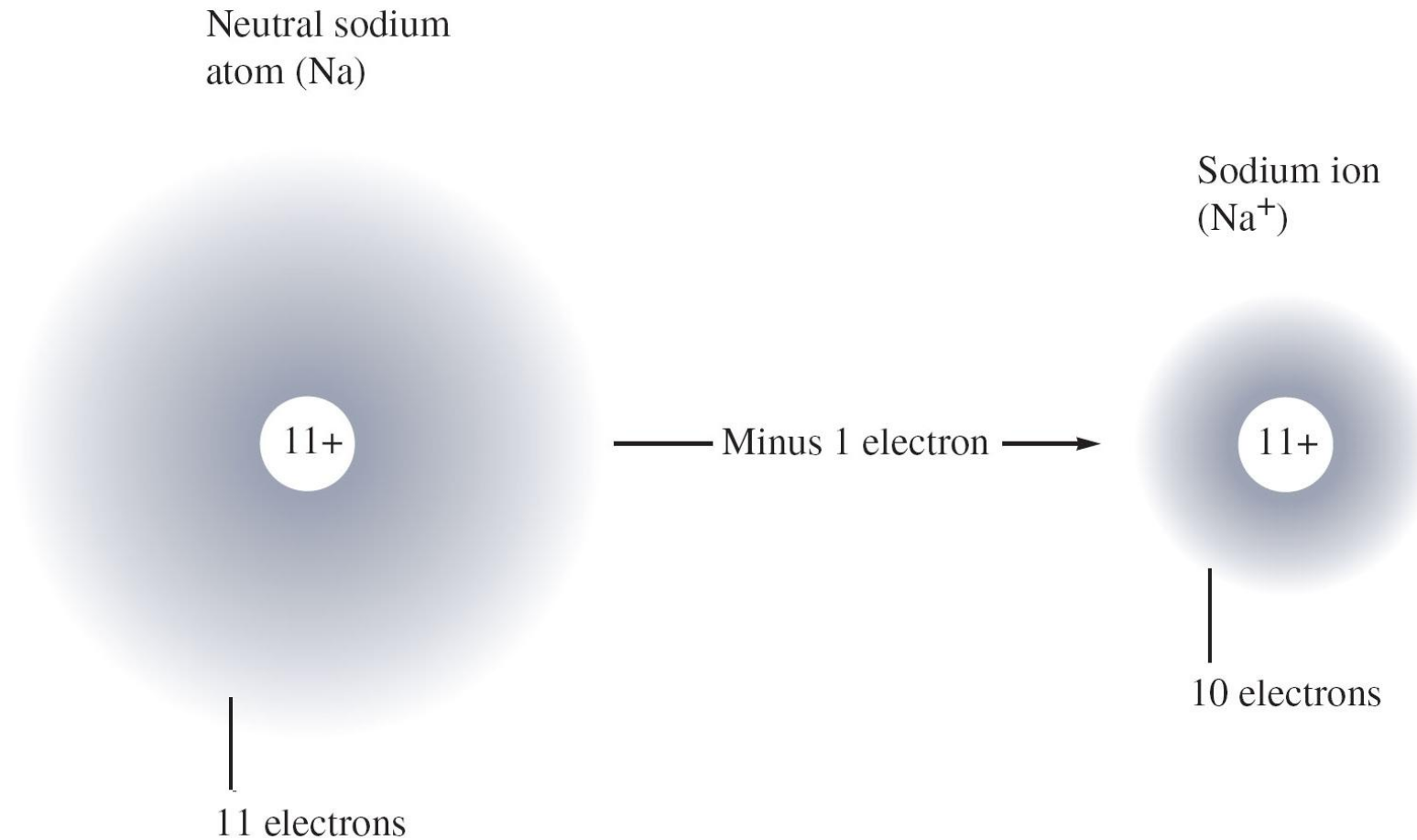
Ions



Ions

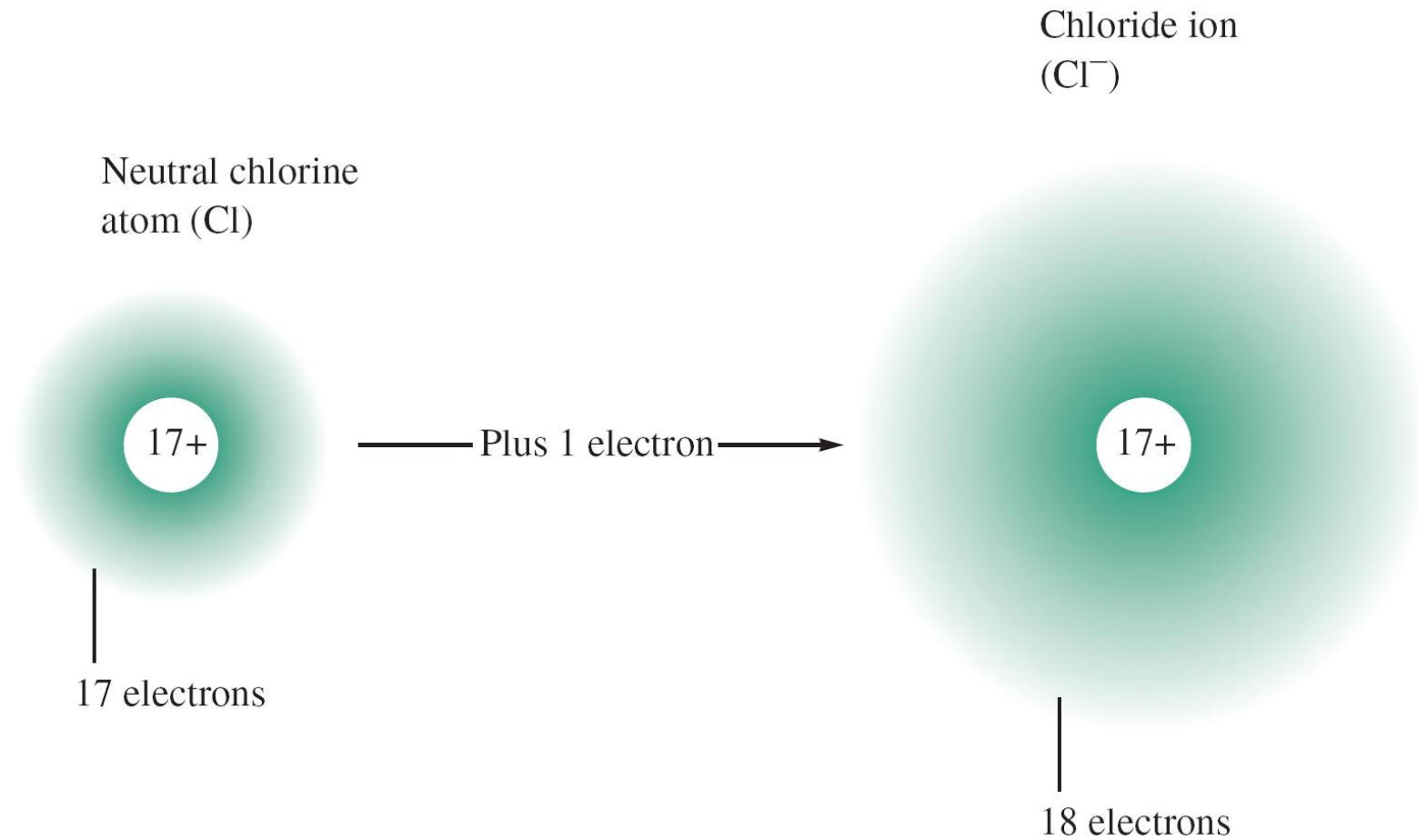
- An atom or group of atoms that has a net positive or negative charge is called an **ion**.
 - If losing electrons, it is a **cation** (positive charge)
 - If gaining electrons, it is an **anion** (negative charge)

Ions: Cations



Cation is **SMALLER** than the neutral atom!

Ions: Anions



Anion is **LARGER** than neutral atom!

Exercise

The ${}^{40}_{20}\text{Ca}^{2+}$ ion has:

- a) 20 protons, 20 neutrons, and 18 electrons.
- b) 22 protons, 20 neutrons, and 20 electrons.
- c) 20 protons, 22 neutrons, and 18 electrons.
- d) 22 protons, 18 neutrons, and 18 electrons.
- e) 20 protons, 20 neutrons, and 22 electrons.

The Periodic Table of Elements

Elements

- What is an **element**?
 - A fundamental substance consisting of atoms which all have the same number of protons - i.e. the **same atomic number (Z)**.
 - Can't be chemically changed or broken down into anything simpler while retaining the properties of that element.

Elements

- Every element known to man is represented in the periodic table.
 - There are 90 naturally occurring elements, and 28 have been produced artificially
 - Only 83 of the 90 naturally occurring elements are found in appreciable abundance (the rest are unstable radioactive elements)

Elements

Figure It Out

Question

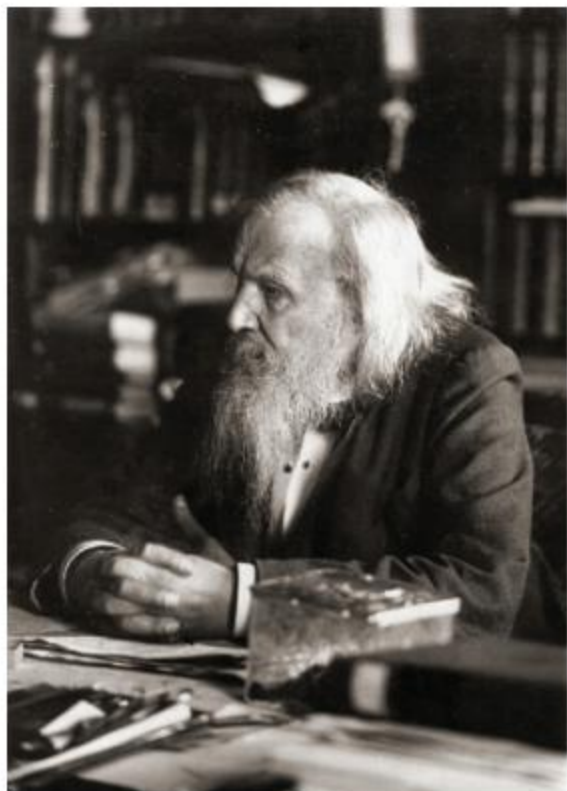
What is the most abundant element in both the Earth's crust and the human body?

What is the second most abundant element in (a) the Earth's crust and (b) the human body?

Elements

Which of the following statements about elements is false?

- a) Elements cannot be chemically changed or broken down into anything simpler and still be the same element.
- b) All naturally occurring elements are stable and nonradioactive.
- c) Elements exist in widely varying amounts on Earth.
- d) Elements are represented using one- or two-letter symbols that are often derived from the element's Latin name.



(a)

Reihen	Gruppo I. — R ⁰	Gruppo II. — RO	Gruppo III. — R ⁰ ³	Gruppo IV. RH ⁴ RO ²	Gruppo V. RH ⁵ R ⁰ ⁵	Gruppo VI. RH ⁶ RO ³	Gruppo VII. RH R ⁰ ⁷	Gruppo VIII. — RO ⁴
1	II=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	So=78	Br=80	
6	Rb=86	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	—	—	—	— — — —
9	(~)	—	—	—	—	—	—	
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	
12	—	—	—	Th=231	—	U=240	—	— — — —

(b)

FIGURE 2.25 (a) Dimitri Mendeleev is widely credited with creating (b) the first periodic table of the elements. (credit a: modification of work by Serge Lachinov; credit b: modification of work by “Den fjättrade ankan”/Wikimedia Commons)

Periodic Classification of Elements



Dimitri
Ivanovitch
Mendeleev



Table 2.2 A Comparison of Predicted and Observed Properties for Gallium (*eka*-Aluminum) and Germanium (*eka*-Silicon)

Element	Property	Mendeleev's Prediction	Observed Property
Gallium	Relative mass	68	69.7
	Density	5.9 g/cm ³	5.91 g/cm ³
	Melting point	Low	29.8 °C
Germanium	Relative mass	72	72.6
	Density	5.5 g/cm ³	5.35 g/cm ³
	Color	Dark gray	Light gray

Terminology

The periodic table is color-coded to show the classification of elements:

- Metals (Blue):** Elements on the left side of the table, including groups 1A through 10B.
- Nonmetals (Red):** Elements on the right side of the table, including groups 13A through 18A.
- Semimetals (Purple):** Elements located between the metals and nonmetals, including groups 11B through 12A.

1 IA 1A H Hydrogen 1.008	2 IIA 2A He Helium 4.003											13 IIIA 3A B Boron 10.811	14 IVA 4A C Carbon 12.011	15 VA 5A N Nitrogen 14.007	16 VIA 6A O Oxygen 15.999	17 VIIA 7A F Fluorine 18.998	18 VIIIA 8A Ne Neon 20.180
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8 VIII 8	9 VIII 8	10 VIII 8	11 IB 1B	12 IIB 2B	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 84.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.294
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [278]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]

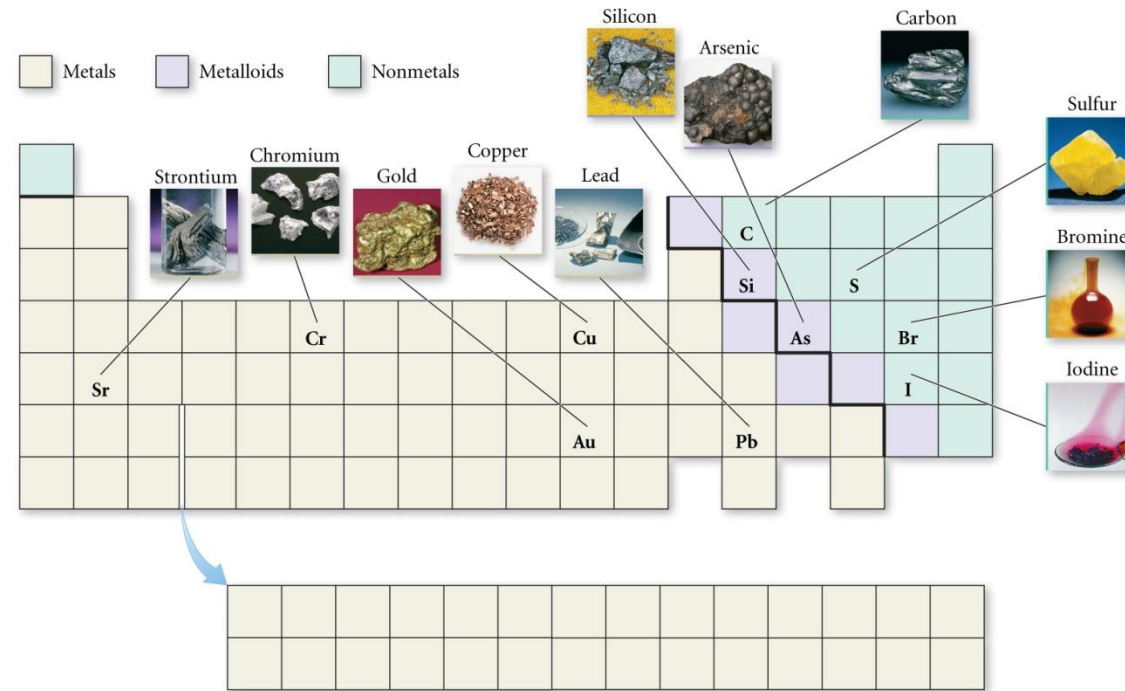
Lanthanide Series

57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
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Actinide Series

89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]
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Metals, Nonmetals & Metalloids



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Metals – Good conductors of heat and electricity, can be pounded into flat sheets (malleable); can be drawn into wires (ductile); often shiny; **lose** electrons when they undergo chemical changes to form cations.

Nonmetals – Poor conductors of heat and electricity; tend to **gain** electrons when they undergo chemical changes to form anions

Metalloids – Divides metals and nonmetals; also known as semiconductors or semimetals; intermediate electrical conductivity that is highly temperature dependent

Main-Group and Transition Elements

Main-group elements		Transition elements										Main-group elements								
1A		2A												3A 4A 5A 6A 7A					8A	
Periods	Group number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1		H																		He
2		Li	Be											B	C	N	O	F	Ne	
3		Na	Mg											Al	Si	P	S	Cl	Ar	
4		K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
5		Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
6		Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
7		Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg			114		116			

Main group elements

- Properties largely predictable based on their position; labeled with a number and letter 'A'.

Transition elements

- Properties *less* predictable based simply on their position; labeled with a number and letter 'B'.

Transition Metals, Lanthanides, Actinides

1 IA 1A																		18 VIII 8A																	
1 H Hydrogen 1.008	2 IIA 2A																		2 He Helium 4.003																
3 Li Lithium 6.941	4 Be Beryllium 9.012																		5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180											
11 Na Sodium 22.990	12 Mg Magnesium 24.305																		13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 Ar Argon 39.948											
19 K Potassium 39.098	20 Ca Calcium 40.078	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948	19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 84.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.294	55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinide Series	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [278]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]	119 Ac Actinium 227.028	120 Th Thorium 232.038	121 Pa Protactinium 231.036	122 U Uranium 238.029	123 Np Neptunium 237.048	124 Pu Plutonium 244.064	125 Am Americium 243.061	126 Cm Curium 247.070	127 Bk Berkelium 247.070	128 Cf Californium 251.080	129 Es Einsteinium [254]	130 Fm Fermium 257.095	131 Md Mendelevium 258.1	132 No Nobelium 259.101	133 Lr Lawrencium [262]			

Terminology

The image shows a periodic table with a callout box for Carbon (C). The callout box contains the following information:

- Atomic Number:** 6
- Symbol:** C
- Name:** Carbon
- Atomic Mass:** 12.011

The periodic table is organized into groups and periods. The groups are labeled as follows:

- 1 IA 1A
- 2 IIA 2A
- 3 IIIB 3B
- 4 IVB 4B
- 5 VB 5B
- 6 VIB 6B
- 7 VIIB 7B
- 8 VIII 8
- 9 VIII 8
- 10 VIII 8
- 11 IB 1B
- 12 IIB 2B
- 13 IIIB 3A
- 14 IVA 4A
- 15 VA 5A
- 16 VIA 6A
- 17 VIIA 7A
- 18 VIIIA 8A


The periods are labeled as follows:

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18

The Lanthanide Series (57-71) and Actinide Series (89-103) are shown below the main table.

Group 1: Alkali Metals

1 IA 1A																	18 VIII A 8A	
1 H Hydrogen 1.008	2 IIA 2A																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012																	
11 Na Sodium 22.990	12 Mg Magnesium 24.305																	
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996													
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95													
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018	
87 Fr Francium 223.020	88	89-103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	



- Soft shiny silvery metals
- Typically found as a compound because of their reactivity (stored in oil)
- Low melting and boiling points (*vs. other metals*)
- Low densities (*Li, Na, and K float on water*)

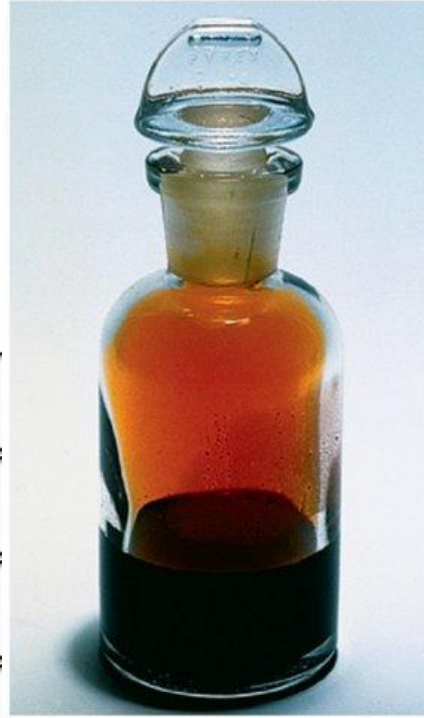
Alkali Metals

All very reactive metals;
reacts **violently** with water; readily form 1+ ions
(eg. Na^+ , K^+).




Group 7A: Halogens

1 IA 1A																	18 VIIIA 8A																																						
1 H Hydrogen 1.008	2 IIA 2A													5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180																																				
3 Li Lithium 6.941	4 Be Beryllium 9.012													11 IB 1B	12 IIB 2B	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948																																		
11 Na Sodium 22.990	12 Mg Magnesium 24.305	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B									19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996			37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95			55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85			87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	Bohrium [264]	Hassium [269]	Mitnerium [268]	Darmstadtium [278]	Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]



- Liquids and gases at room temperature - low melting and boiling points
- Not found naturally in their pure state - reactive
- Brittle when solid
- Poor conductors

Group 8A: Noble (Rare) Gases



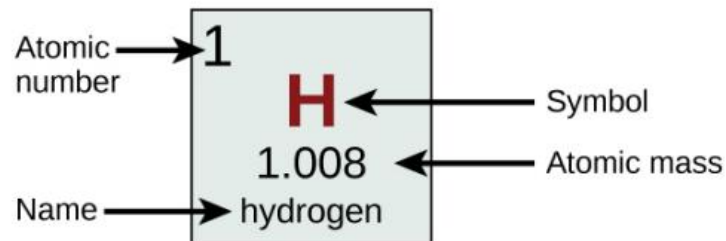
1 IA 1A	2 IIA 2A											13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A	
1 H Hydrogen 1.008	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	2 He Helium 4.003	
3 Li Lithium 6.941	11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	10 Ne Neon 20.180
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956											31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	18 Ar Argon 39.948
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906											49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	36 Kr Krypton 84.798
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71											81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	36 Kr Krypton 84.798
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [278]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	54 Xe Xenon 131.294	
			Hafnium 178.49	Tantalum 180.948	Tungsten 183.85	Rhenium 186.207	Osmium 190.23	Iridium 192.22	Platinum 195.08	Gold 196.967	Mercury 200.59						86 Rn Radon 222.018	
																	86 Rn Radon 222.018	
																	118 Og Oganesson [294]	

- Odourless, colourless, and nonreactive
- Low boiling pts (gases at room temperature)

68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

Periodic Table of the Elements

Period	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
1	1 H 1.008 hydrogen																	2 He 4.003 helium
2	3 Li 6.94 lithium	4 Be 9.012 beryllium											5 B 10.81 boron	6 C 12.01 carbon	7 N 14.01 nitrogen	8 O 16.00 oxygen	9 F 19.00 fluorine	10 Ne 20.18 neon
3	11 Na 22.99 sodium	12 Mg 24.31 magnesium											13 Al 26.98 aluminum	14 Si 28.09 silicon	15 P 30.97 phosphorus	16 S 32.06 sulfur	17 Cl 35.45 chlorine	18 Ar 39.95 argon
4	19 K 39.10 potassium	20 Ca 40.08 calcium	21 Sc 44.96 scandium	22 Ti 47.87 titanium	23 V 50.94 vanadium	24 Cr 52.00 chromium	25 Mn 54.94 manganese	26 Fe 55.85 iron	27 Co 58.93 cobalt	28 Ni 58.69 nickel	29 Cu 63.55 copper	30 Zn 65.38 zinc	31 Ga 69.72 gallium	32 Ge 72.63 germanium	33 As 74.92 arsenic	34 Se 78.97 selenium	35 Br 79.90 bromine	36 Kr 83.80 krypton
5	37 Rb 85.47 rubidium	38 Sr 87.62 strontium	39 Y 88.91 yttrium	40 Zr 91.22 zirconium	41 Nb 92.91 niobium	42 Mo 95.95 molybdenum	43 Tc [97] technetium	44 Ru 101.1 ruthenium	45 Rh 102.9 rhodium	46 Pd 106.4 palladium	47 Ag 107.9 silver	48 Cd 112.4 cadmium	49 In 114.8 indium	50 Sn 118.7 tin	51 Sb 121.8 antimony	52 Te 127.6 tellurium	53 I 126.9 iodine	54 Xe 131.3 xenon
6	55 Cs 132.9 cesium	56 Ba 137.3 barium	57-71 La-Lu *	72 Hf 178.5 hafnium	73 Ta 180.9 tantalum	74 W 183.8 tungsten	75 Re 186.2 rhenium	76 Os 190.2 osmium	77 Ir 192.2 iridium	78 Pt 195.1 platinum	79 Au 197.0 gold	80 Hg 200.6 mercury	81 Tl 204.4 thallium	82 Pb 207.2 lead	83 Bi 209.0 bismuth	84 Po [209] polonium	85 At [210] astatine	86 Rn [222] radon
7	87 Fr [223] francium	88 Ra [226] radium	89-103 Ac-Lr **	104 Rf [267] rutherfordium	105 Db [270] dubnium	106 Sg [271] seaborgium	107 Bh [270] bohrium	108 Hs [277] hassium	109 Mt [276] meitnerium	110 Ds [281] darmstadtium	111 Rg [282] roentgenium	112 Cn [285] copernicium	113 Nh [285] nihonium	114 Fl [289] flerovium	115 Mc [288] moscovium	116 Lv [293] livermorium	117 Ts [294] tennessine	118 Og [294] oganesson
			* 57 La 138.9 lanthanum	58 Ce 140.1 cerium	59 Pr 140.9 praseodymium	60 Nd 144.2 neodymium	61 Pm [145] promethium	62 Sm 150.4 samarium	63 Eu 152.0 europium	64 Gd 157.3 gadolinium	65 Tb 158.9 terbium	66 Dy 162.5 dysprosium	67 Ho 164.9 holmium	68 Er 167.3 erbium	69 Tm 168.9 thulium	70 Yb 173.1 ytterbium	71 Lu 175.0 lutetium	
			** 89 Ac [227] actinium	90 Th 232.0 thorium	91 Pa 231.0 protactinium	92 U 238.0 uranium	93 Np [237] neptunium	94 Pu [244] plutonium	95 Am [243] americium	96 Cm [247] curium	97 Bk [247] berkelium	98 Cf [251] californium	99 Es [252] einsteinium	100 Fm [257] fermium	101 Md [258] mendelevium	102 No [259] nobelium	103 Lr [262] lawrencium	



Color Code	
 Metal	Solid
 Metalloid	Liquid
 Nonmetal	Gas

FIGURE 2.26 Elements in the periodic table are organized according to their properties.

The Periodic Table of Elements

- Chemical properties vary greatly across a period; however, remain similar within a group

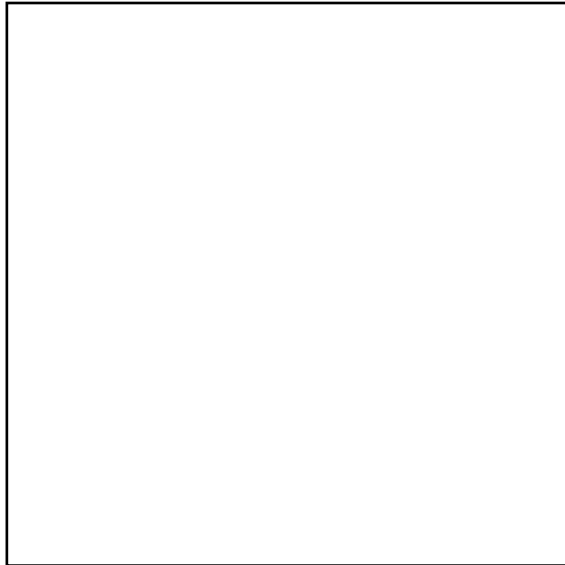
1 H	2 He											13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	3	4	5	6	7	8	9	10	11	12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 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
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
87 Fr	88 Ra	89 Ac†	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup			118 Uuo

- Due to elements in the same group having the same **number of valence electrons**

*Lanthanides	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
†Actinides	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

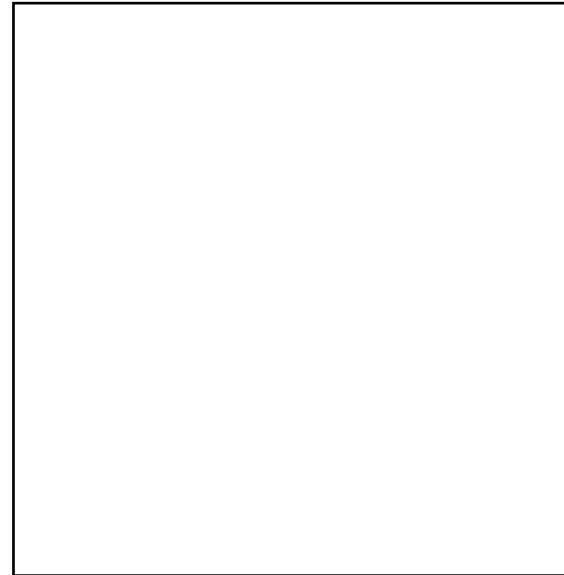
The Mystery Element A

- A very shiny solid.
- It reacts violently in water.
- In the same period as copper.



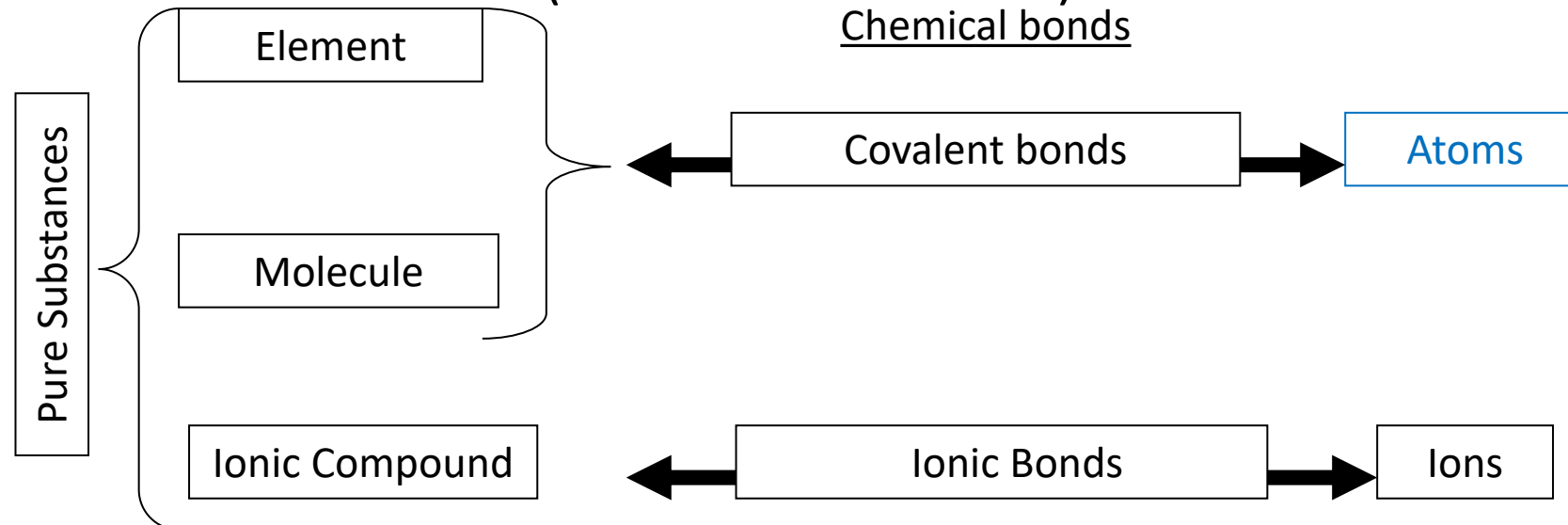
The Mystery Element B

- A gas with a pungent odor.
- It is very reactive.
- In the same period as magnesium.



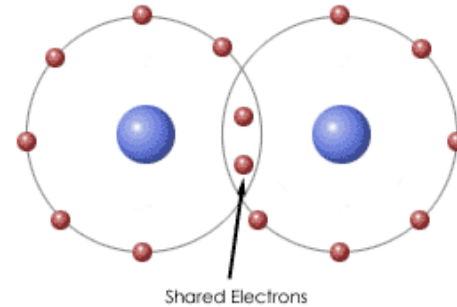
Molecules and Compounds

- Atoms and ions of the same or different types can form **molecules and compounds**
- These are held together by the following types of **chemical bonds**:
 - Covalent bonds (sharing of electrons)
 - Ionic bonds (transfer of electrons)



Covalent Bonds

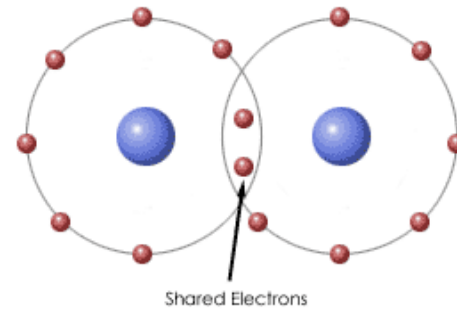
- Results when the electrons between two atoms are shared



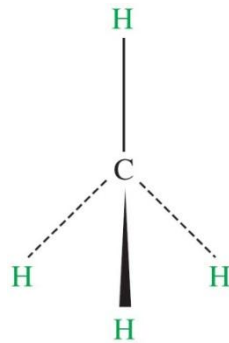
- Covalently bonded molecules can be represented several ways

Covalent Bonds

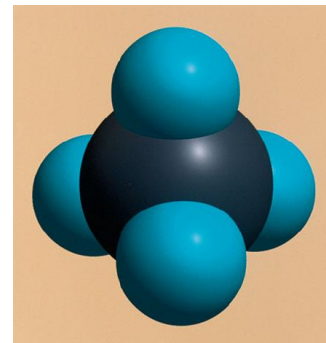
- Results when the electrons between two atoms are shared



Chemical
Formula



Methane
Structural
Formula



Space Filling
Model



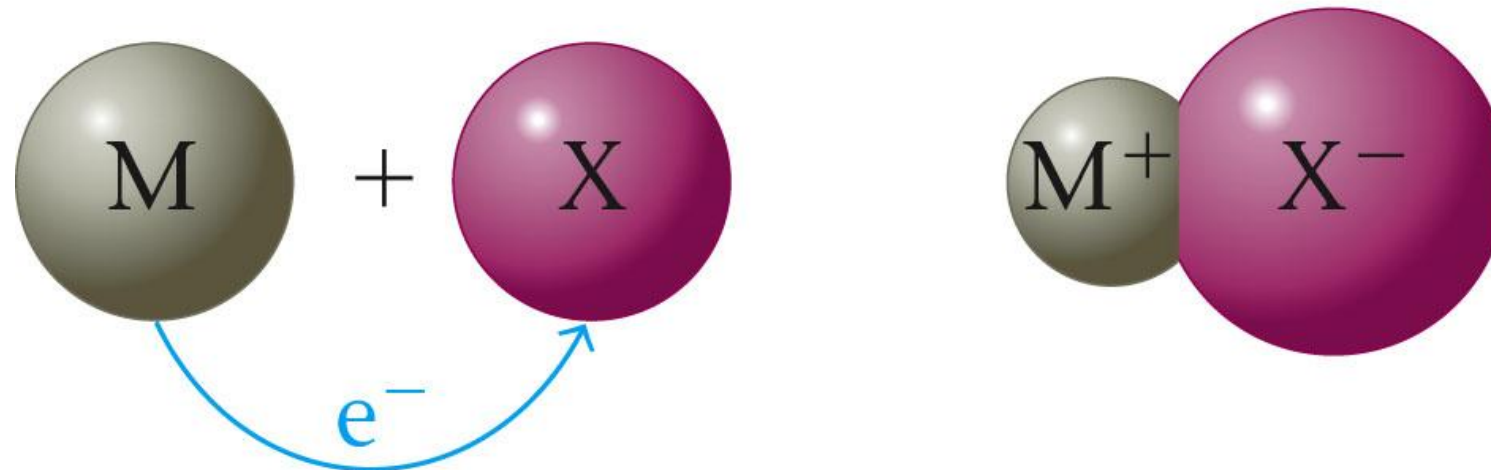
Ball-and-Stick
Model

Ionic Bonds

- Results from a force of attraction (electrostatic) between oppositely charged ions.

- Unlike Covalent bonds, electrons are not shared

Metal Nonmetal Ionic compound



Ionic Compounds and Ionic Bonds

Ionic compound formulas ALWAYS correspond to their empirical formula, because they form a large crystal structure.

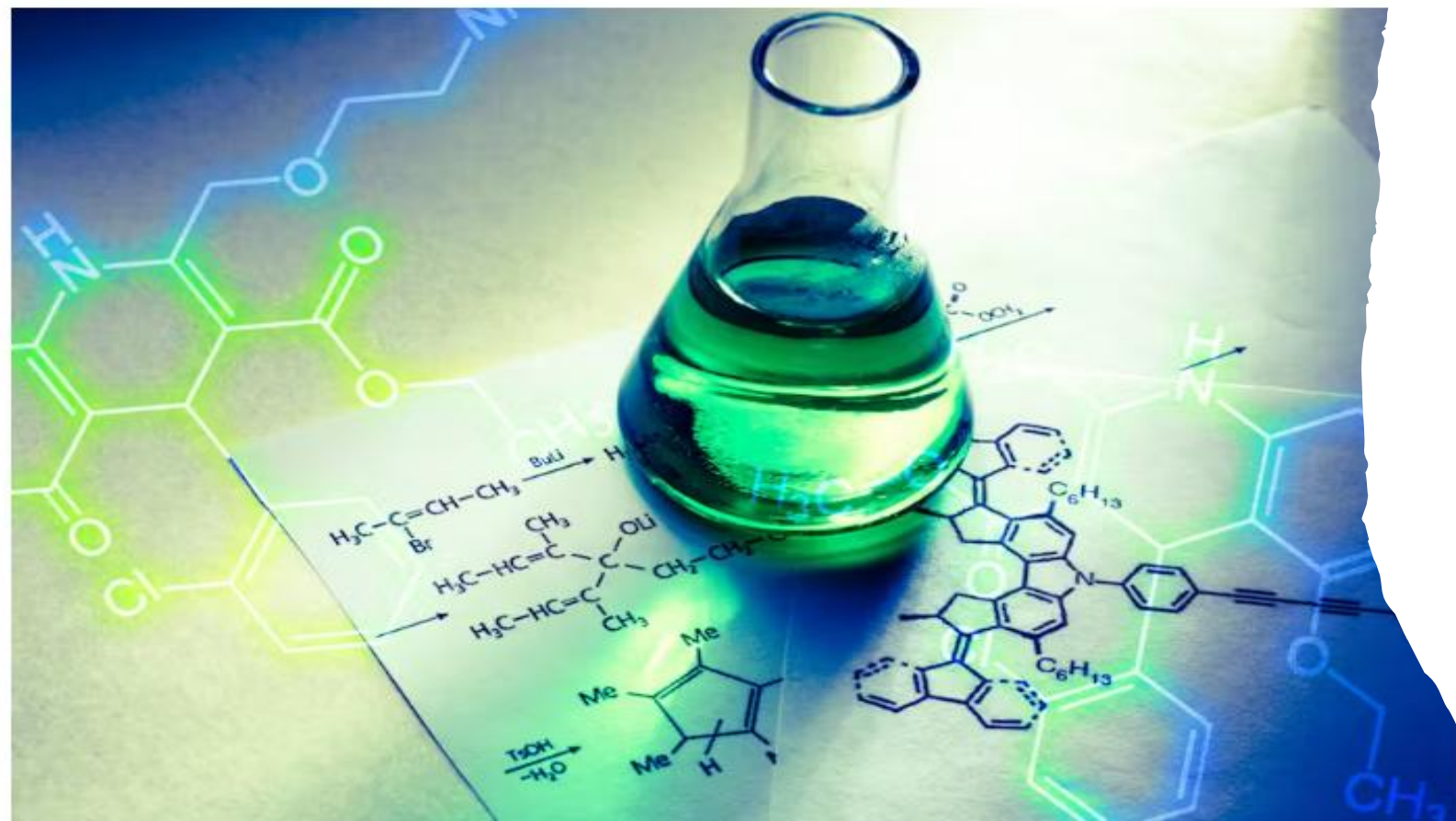


Example: Sodium chloride

One electron is transferred from the sodium atom to the chlorine atom.

Only 1% of chemical compounds have been discovered – here's how we search for others that could change the world

Published: October 17, 2023 12.42pm EDT



Only 1% of chemical compounds have been discovered – here's how we search for others that could change the world

- Give the chemical symbol for each of the following elements.

Magnesium		Iodine		Neon	
Oxygen		Aluminum		Calcium	
Carbon		Iron		Fluorine	
Nitrogen		Hydrogen		Bromine	
Copper		Sodium		Argon	

Example 1

The isotope ${}_{34}^{75}\text{Se}$ is used medically for the diagnosis of pancreatic disorders. How many protons, neutrons, and electrons does an atom of ${}_{34}^{75}\text{Se}$ have?

Example 2

Element X is toxic to humans in high concentration but is essential to life in low concentrations. Identify element X, whose atoms contain 24 protons, and write the symbol for the isotope of X that has 28 neutrons.

Example 3

What is expected:

If given the name, provide the chemical symbol, and relevant information

And vice versa

Symbol	Name	Z	A	#n ⁰	#e ⁻
<input type="text"/>	Carbon	<input type="text"/>	<input type="text"/>	7	<input type="text"/>
${}_{22}^{48}\text{Ti}$	<input type="text"/>	22	<input type="text"/>	<input type="text"/>	<input type="text"/>
${}_{12}^{24}\text{Mg}$	Magnesium	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>