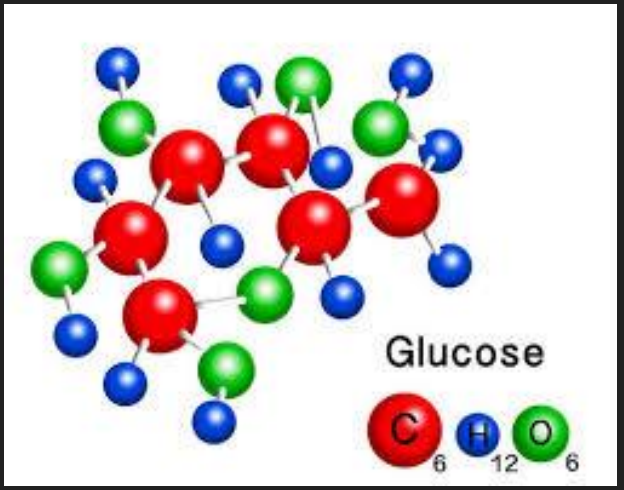
Elements are the Building Blocks of Matter

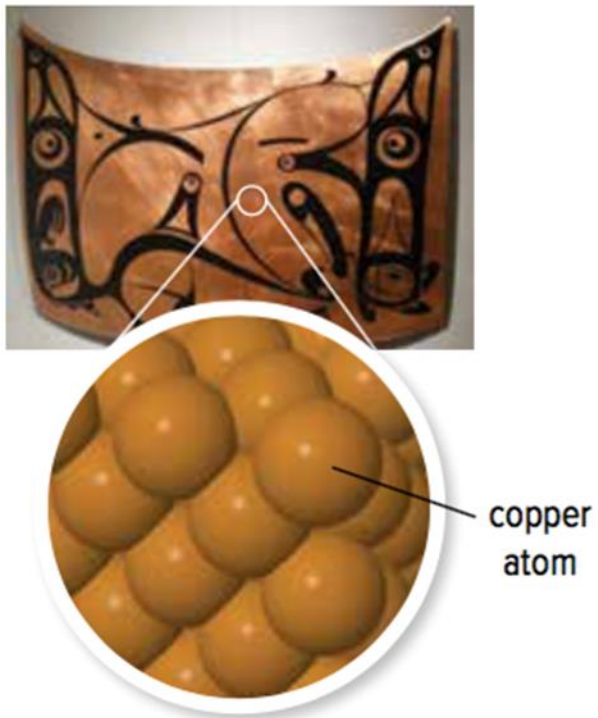


Elements

Elements:

- The basic building blocks of matter
- Made up of one type of atom (cannot be broken down further)
- About 90 elements occur naturally (carbon, silver, oxygen)
- Some elements are synthesized in labs
- Have varying properties

Figure 2.6: Copper is made up of one type of atom, and cannot be broken down further.



Copper (Cu) is shiny and malleable. This means it can be hammered into thin sheets such as the copper leaf used on this car hood by B.C. artist Michael Nicoll Yahgulanaas. This piece is part of a series called *Coppers from the Hood*.

Element Names and Symbols

Each element has a

- **Chemical name**
  - Based on Latin words, countries, names of famous scientists
- **Chemical symbol**
  - One or two letters (first letter is capitalized)

Table 2.2 Symbols and Names of Selected Elements

Name of Element	Element Symbol	Origin of Symbol or Name
carbon	C	*Carbo* = Latin for coal and charcoal. Carbon in the form of soot and charcoal has been known to humans for many thousands of years. 
copper	Cu	*Cuprum* = Latin for cyprium, meaning metal of Cyprus, an island country near Greece. The ancient Romans obtained much of their copper from mines on Cyprus. 
francium	Fr	*France* = Marguerite Perey discovered this element in France in 1939. 
lead	Pb	*Plumbum* = Latin for lead. This element's name has the same root as "plumbing" because the ancient Romans used lead in their plumbing systems. Unfortunately, lead is toxic and their pipes poisoned their water. 
sulfur	S	*Sulphuium* = Latin for sulfur. In Canada, the United States, and Great Britain, there has been some switching back and forth of the name of this element from sulfur to sulphur. The spelling "sulfur" is now considered standard. 

Examples:

- Carbon: C
- Oxygen: O
- Aluminum: Al
- Gold: Au
- Polonium: Po

Elements can be organized by their properties

1860s: Dmitri Mendeleev

- Russian teacher and chemist
- Looked at different ways to organize the elements
- Wrote properties of elements on cards so that he could rearrange them and compare properties ("chemical solitaire")
- Properties included atomic mass (average mass of an atom of an element), density, and melting point

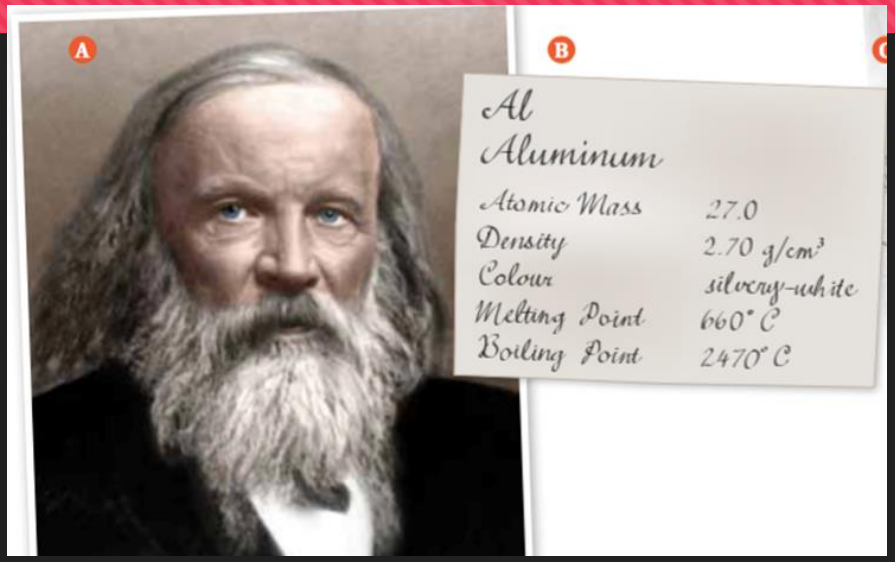
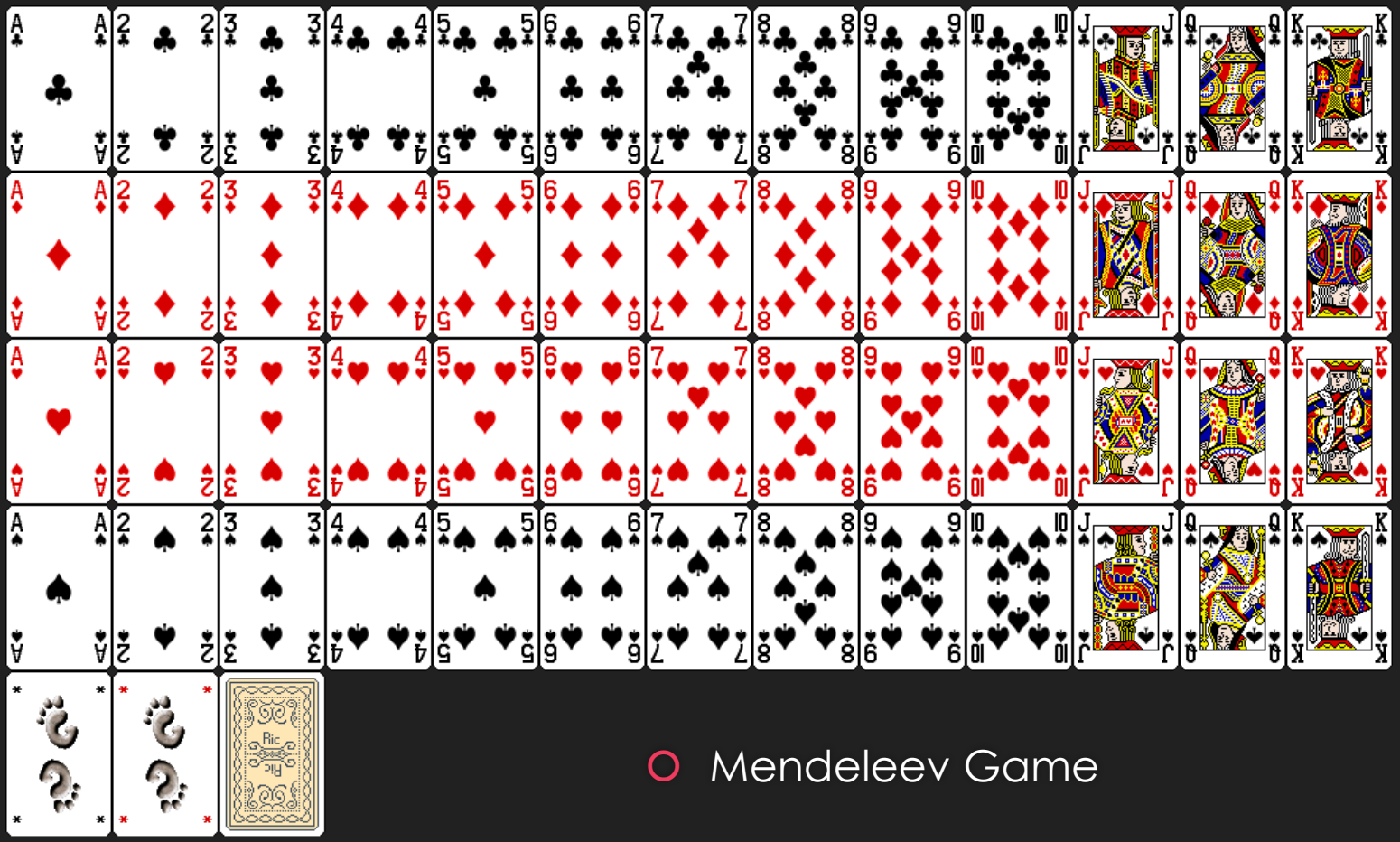


Figure 2.7: A) Dmitri Mendeleev B) Mendeleev wrote the properties of elements on cards like this one so he could rearrange them and compare properties.

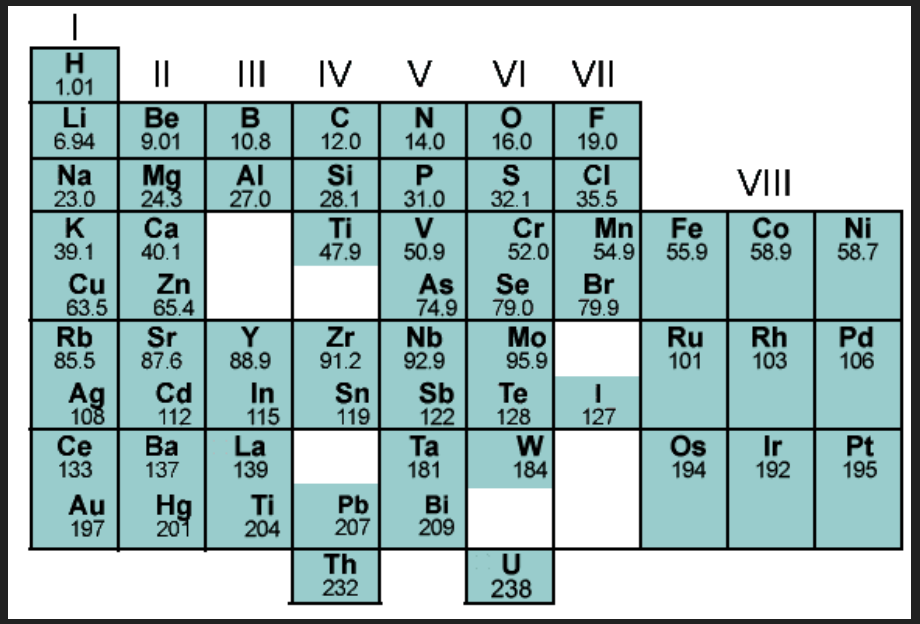
Dmitri Mendeleev



- Mendeleev Game

The Predictive Power of Mendeleev's Table

- Mendeleev's periodic table:
  - Ordered the elements by increasing atomic mass
  - Grouped elements into "families" based on similar properties (density, melting point)
  - Left gaps in his periodic table to predict the existence of elements not yet found yet
  - These missing elements would have properties similar to other elements in the same families



I	II	III	IV	V	VI	VII	VIII		
H 1.01									
Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0			
Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5			
K 39.1	Ca 40.1		Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9	Co 58.9	Ni 58.7
Cu 63.5	Zn 65.4			As 74.9	Se 79.0	Br 79.9			
Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9		Ru 101	Rh 103	Pd 106
Ag 108	Cd 112	In 115	Sn 119	Sb 122	Te 128	I 127			
Ce 133	Ba 137	La 139		Ta 181	W 184		Os 194	Ir 192	Pt 195
Au 197	Hg 201	Ti 204	Pb 207	Bi 209					
			Th 232		U 238				

The Predictive Power of Mendeleev's Table

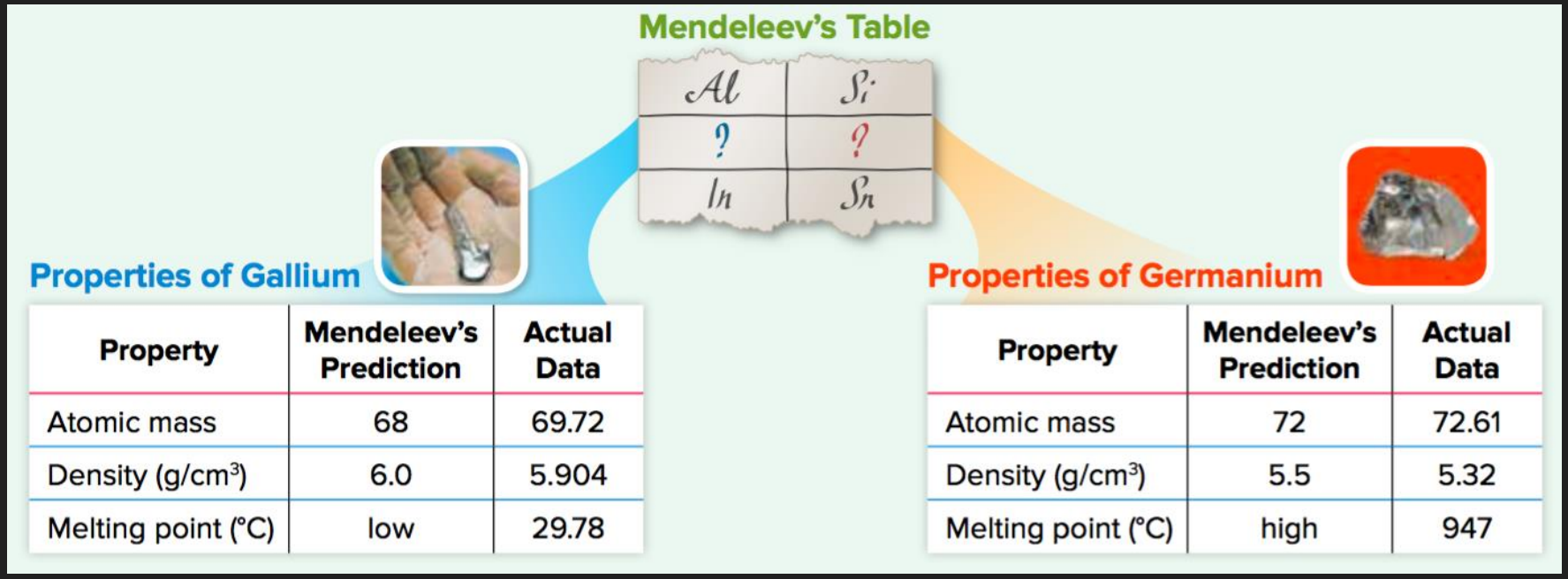


Figure 2.8: The gaps in Mendeleev's table predicted the existence of yet-to-be-discovered elements. Mendeleev used the properties of other elements in the same families to predict the properties of these elements.

Discussion Questions

1. Why did Mendeleev leave gaps in his periodic table?

2. How was Mendeleev able to predict the properties of gallium and germanium?

Modern Periodic Table

Mendeleev's periodic table was ordered by increasing atomic mass:

- Did not work perfectly – some elements were out of order so they would fit in a family that had similar properties

Modern periodic table is ordered by increasing **atomic number**:

- Henry Moseley: scientist that determined an element's atomic number (the number of protons in an atom)
- When elements are arranged according to increasing atomic number, the elements fit perfectly and do not require re-ordering

The modern periodic table consists of

- **Groups** (1-18): A vertical column of elements; also called a *family*
  - Elements of common properties
- **Periods** (1-7): A horizontal row of elements
  - Mass increasing from left to right

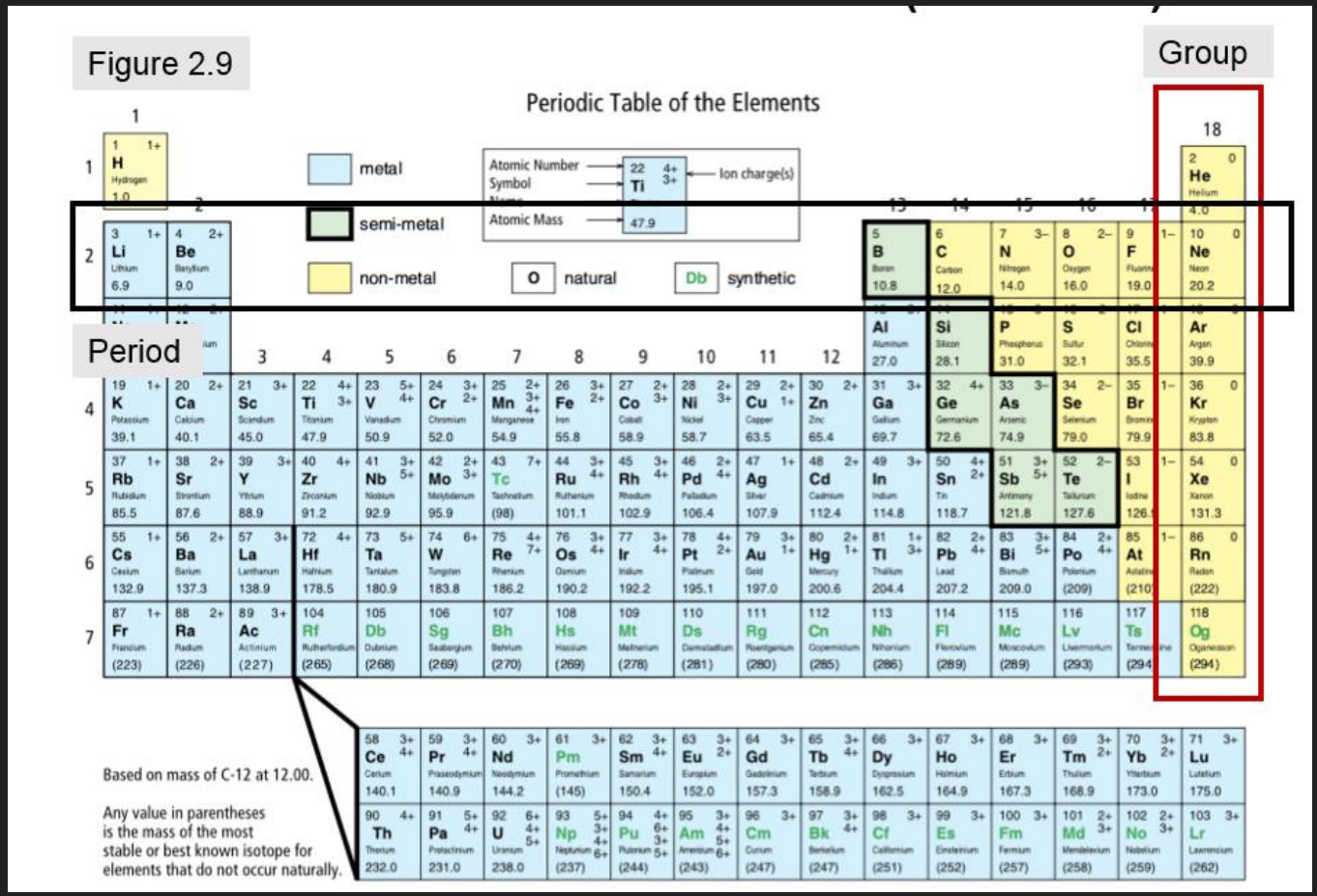
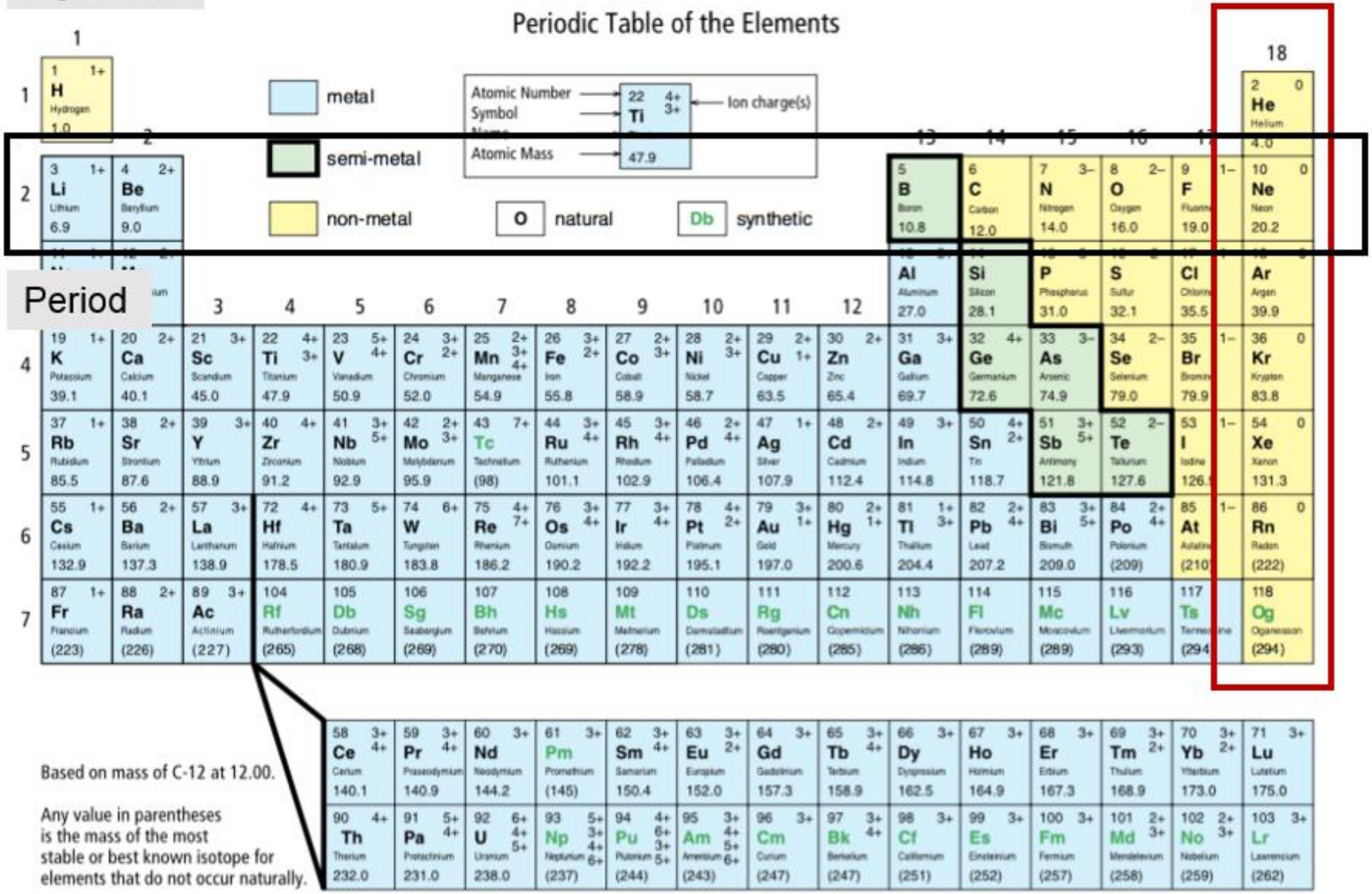


Figure 2.9

Group

Period



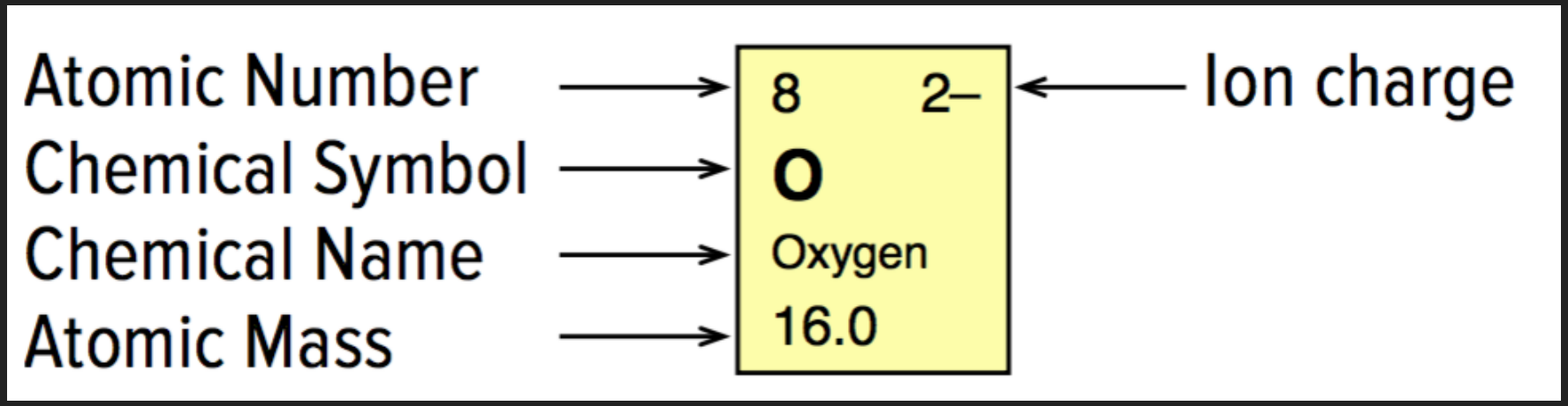


Figure 2.10: A typical box from the periodic table tells you the element's name, symbol, atomic number, and atomic mass. The symbol's font tells you the element's state.

Discussion Questions

1. What was Moseley's contribution to the periodic table and what problem did it resolve?

2. Give the symbol and atomic number for each of the following elements:
   a) manganese
   b) magnesium
   c) arsenic
   d) astatine

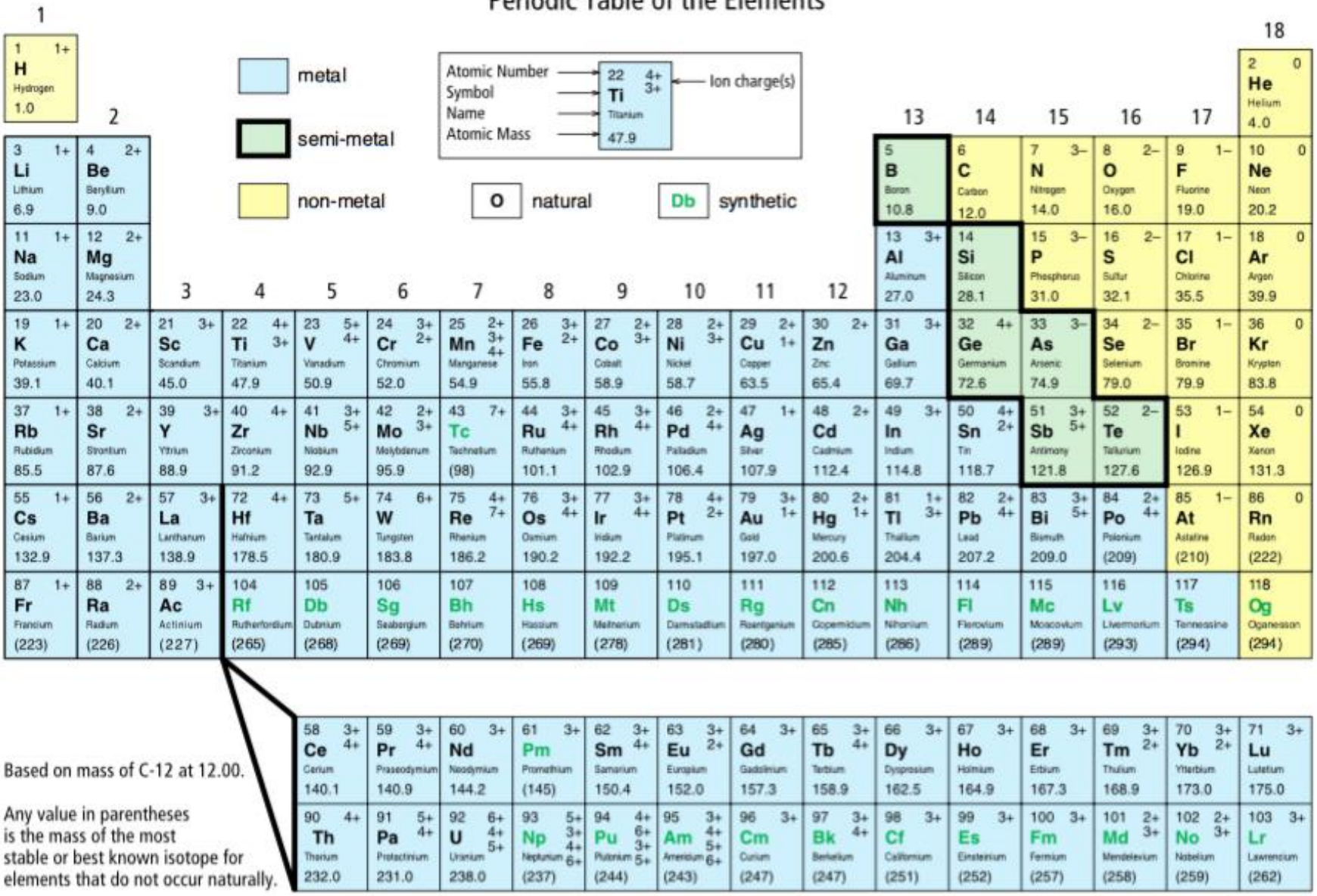
Elements are classified as metals, non-metals, or semi-metals.

Three broad categories of elements shown on the periodic table

- Metals (blue)
- Non-metals (yellow)
- Semi-metals (metalloids) (green)

- Elements of Groups 1, 2, and 13 to 18 are called *main-group elements* or *representative elements*
- Elements in Groups 3 to 12 are called *transition elements*

Periodic Table of the Elements



Based on mass of C-12 at 12.00.

Any value in parentheses is the mass of the most stable or best known isotope for elements that do not occur naturally.

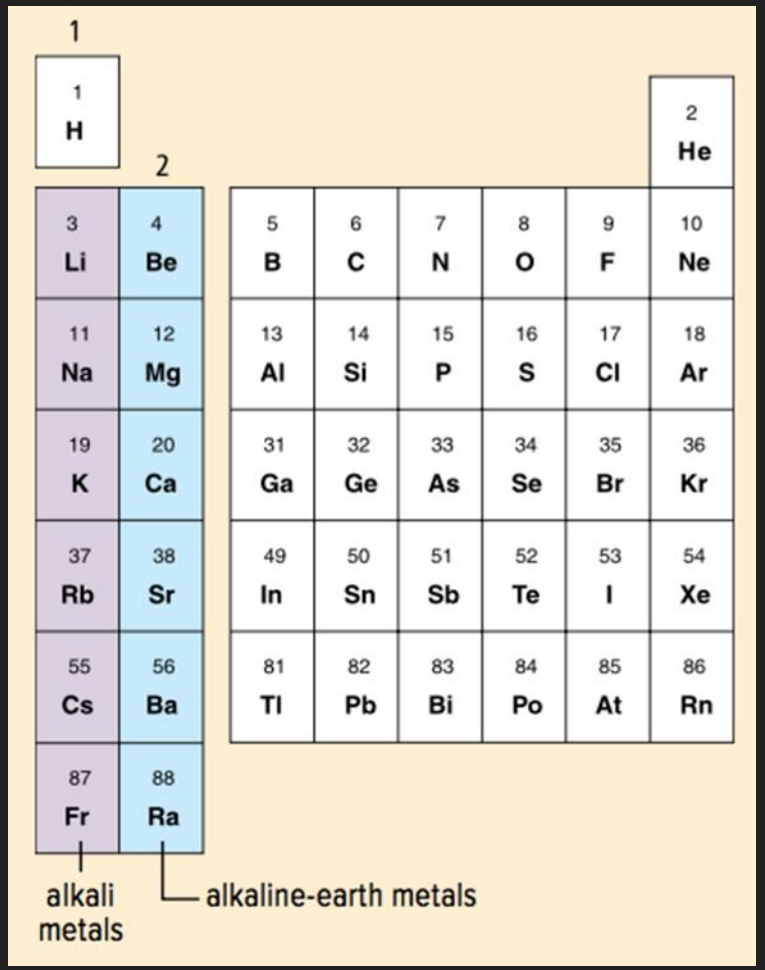
Metals

- Shiny and hard (typically)
- Malleable and ductile (can be made into sheets and drawn out into wires)
- Conducts electricity and heat
- Typically solid at room temperature
- Found to the left of the zigzag line on the periodic table

Alkali Metals

Alkali metals:

- Found in Group 1 (all elements, except hydrogen)
- Shiny and soft
- Highly reactive with water and oxygen (often stored in a non-reactive liquid such as oil)



Metals: Alkaline-earth Metals

Alkaline-earth metals:

- Found in Group 2
- Shiny and soft (but not as soft as alkali metals)
- Highly reactive (but not as reactive as alkali metals)

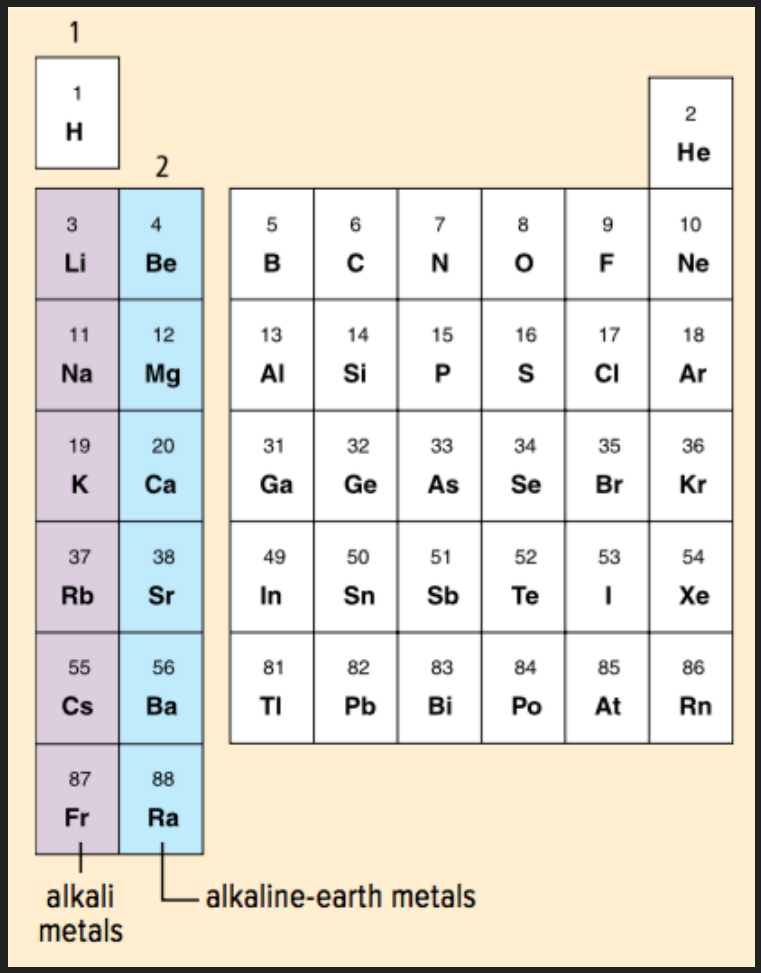


Figure 2.12: Magnesium (left) burns easily in air when ignited.

Non Metals

- Not shiny, malleable, or ductile
- Poor conductor of electricity and heat
- Found to the right of the zigzag line on the periodic table
- Generally gases or brittle, dull solids

Non-metals: Hydrogen

Hydrogen:

- Usually on the left side of the periodic table
- Lightest element
- Colourless, odourless, tasteless
- Highly flammable
- Makes up over 90% of atoms in the universe
- On Earth: Most hydrogen is found combined with oxygen as water

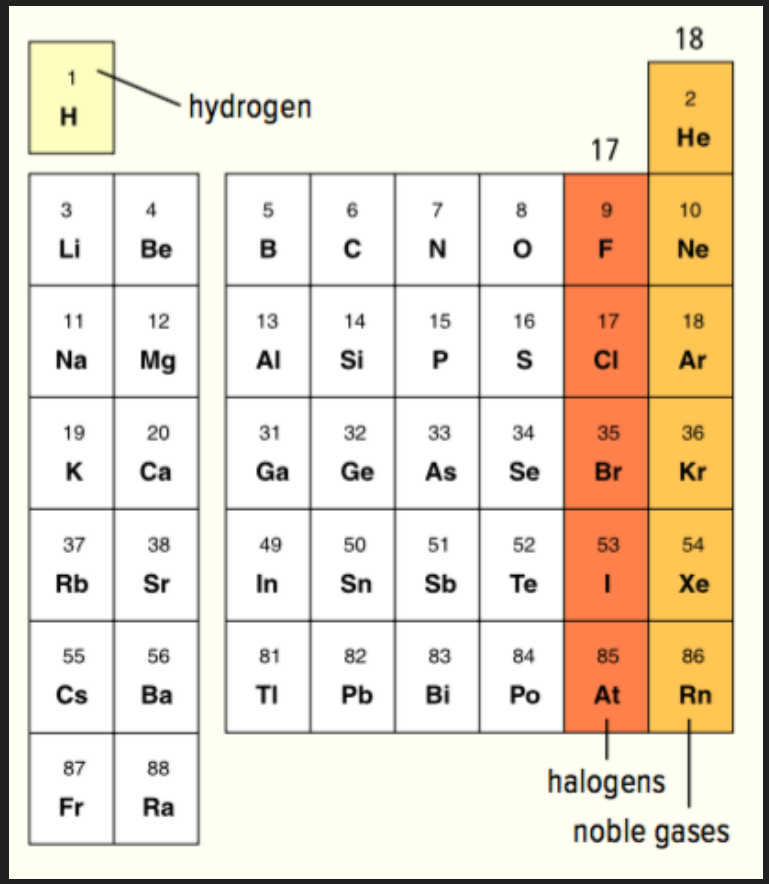


Figure 2.13

Non-metals: Halogens

Halogens:

- Found in Group 17
- Highly reactive (therefore usually found in nature as part of compounds)

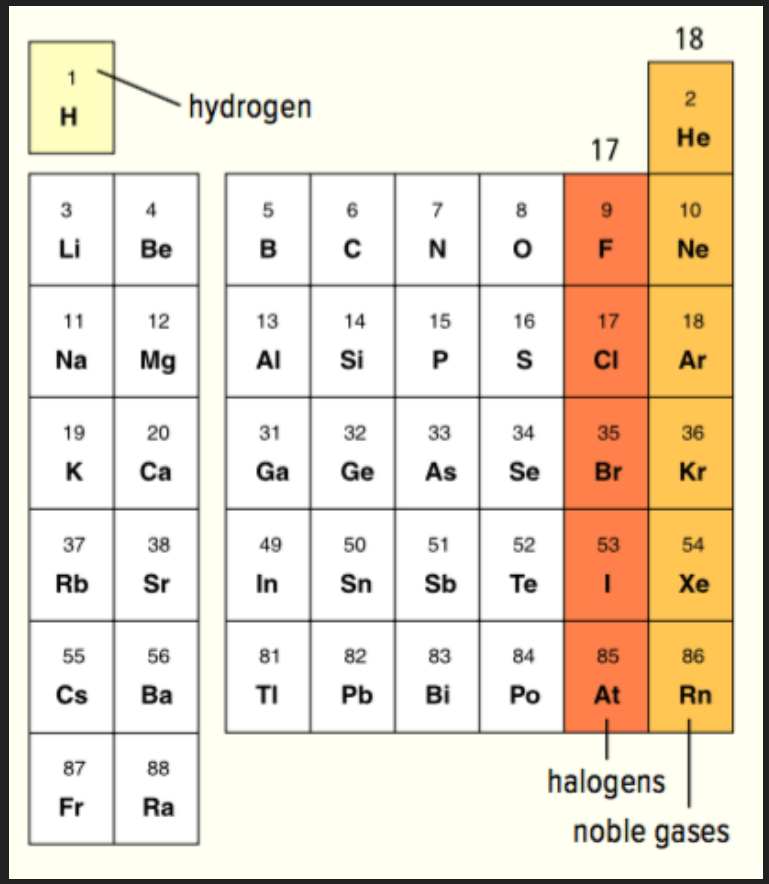


Figure 2.13

Non-metals: Noble Gases

Noble gases:

- Found in Group 18
- Odourless, colourless gases
- Least reactive of all of the elements
  - Helium and neon never form compounds
  - Other noble gases form compounds with great difficulty

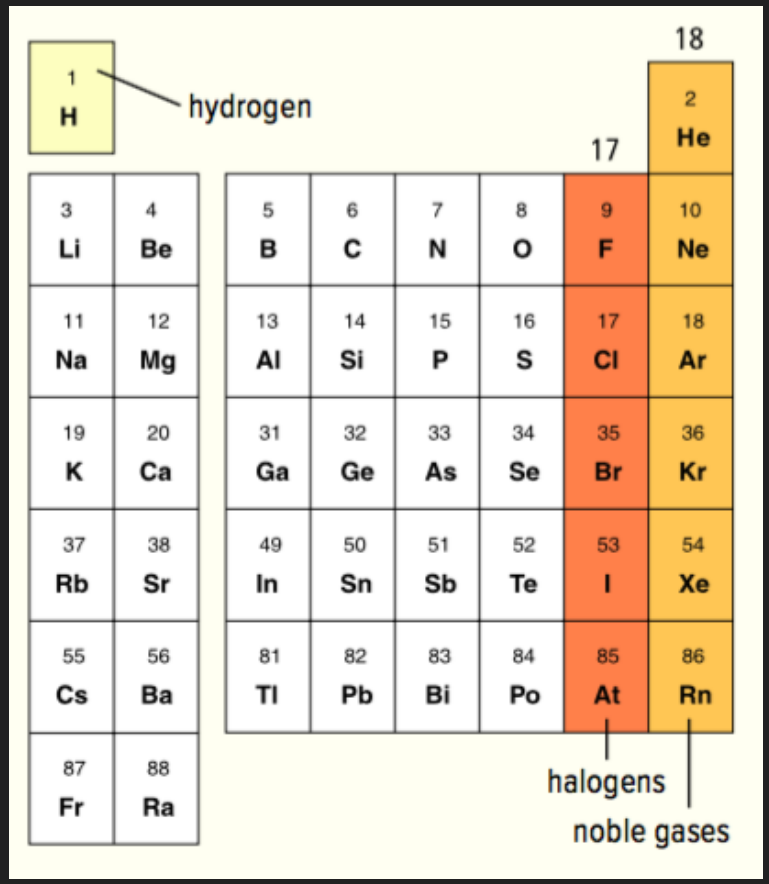


Figure 2.13

Semi-metals

- Also known as *metalloids*
- Found in the green boxes in a staircase shape
- Have physical and chemical properties of both metals and non-metals
  - Shiny (like metals)
  - Brittle and not ductile (like non-metals)
  - Poor conductors of heat and electricity (like non-metals)

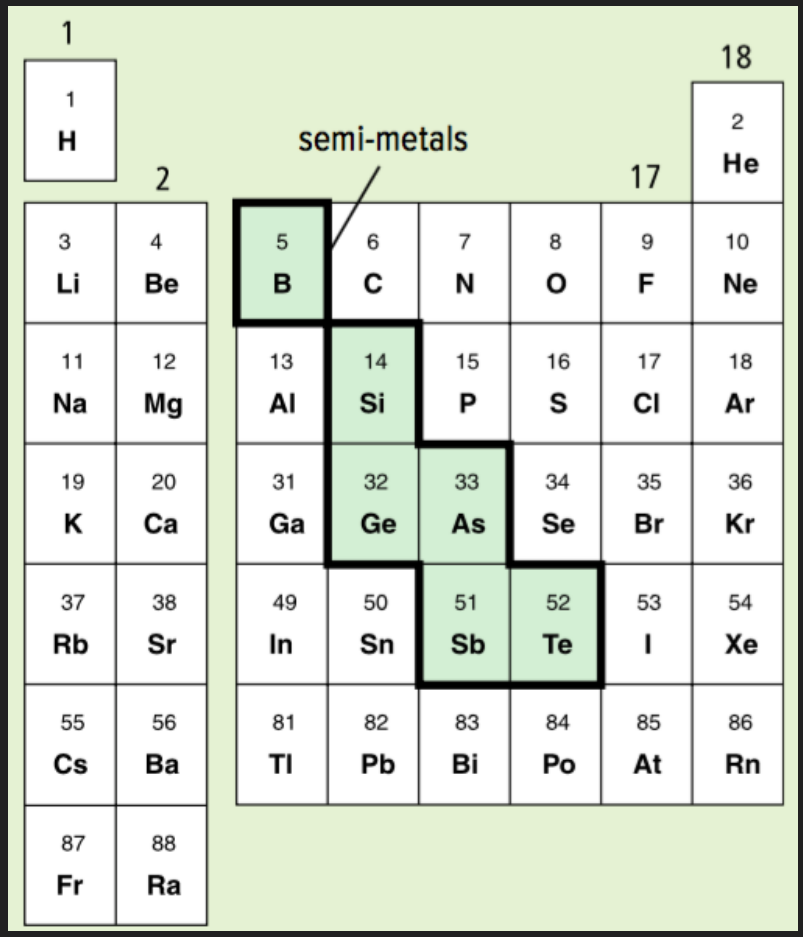


Figure 2.14

Semi-metals: Silicon

Silicon:

- Second-most abundant element in Earth's crust (after oxygen)
- Used in many electronic devices (computers, smartphones)
- Used to make silicone (material used in cookware, contact lenses, prosthetics)

Discussion Questions

1. Make a table to summarize the characteristic properties of metals, non-metals, and semi-metals.

2. What makes hydrogen an unusual element?

3. What characteristics define semi-metals?

	State at Room Temperature	Appearance	Conductivity	Malleability and Ductility
Metals	• solid except for mercury (a liquid)	• shiny lustre	• good conductors of heat and electricity	• malleable • ductile
Non-metals	• some gases • some solids • only bromine is a liquid	• not very shiny	• poor conductors of heat and electricity	• brittle • not ductile
Metalloids	• solids	• can be shiny or dull	• may conduct electricity • poor conductors of heat	• brittle • not ductile