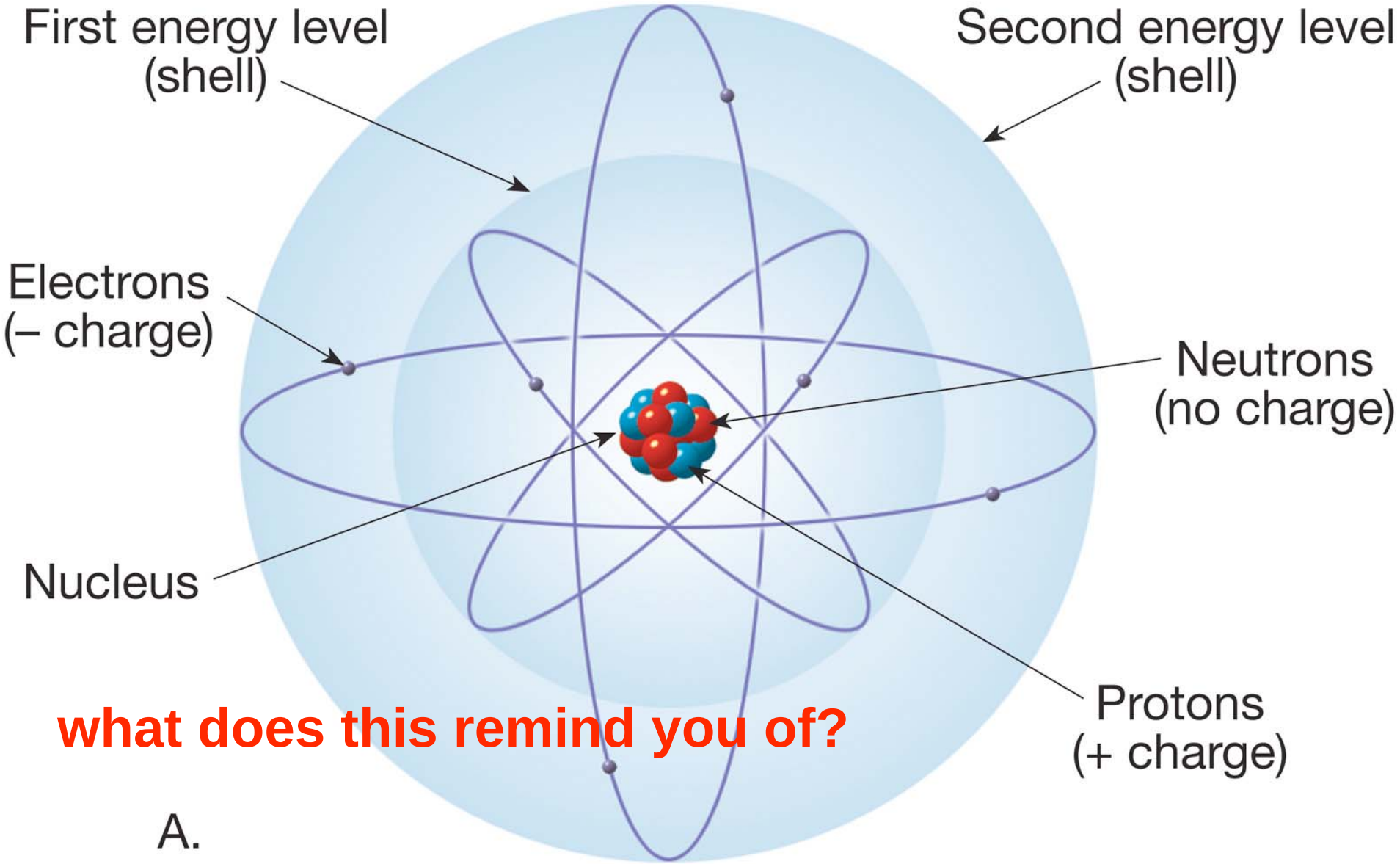
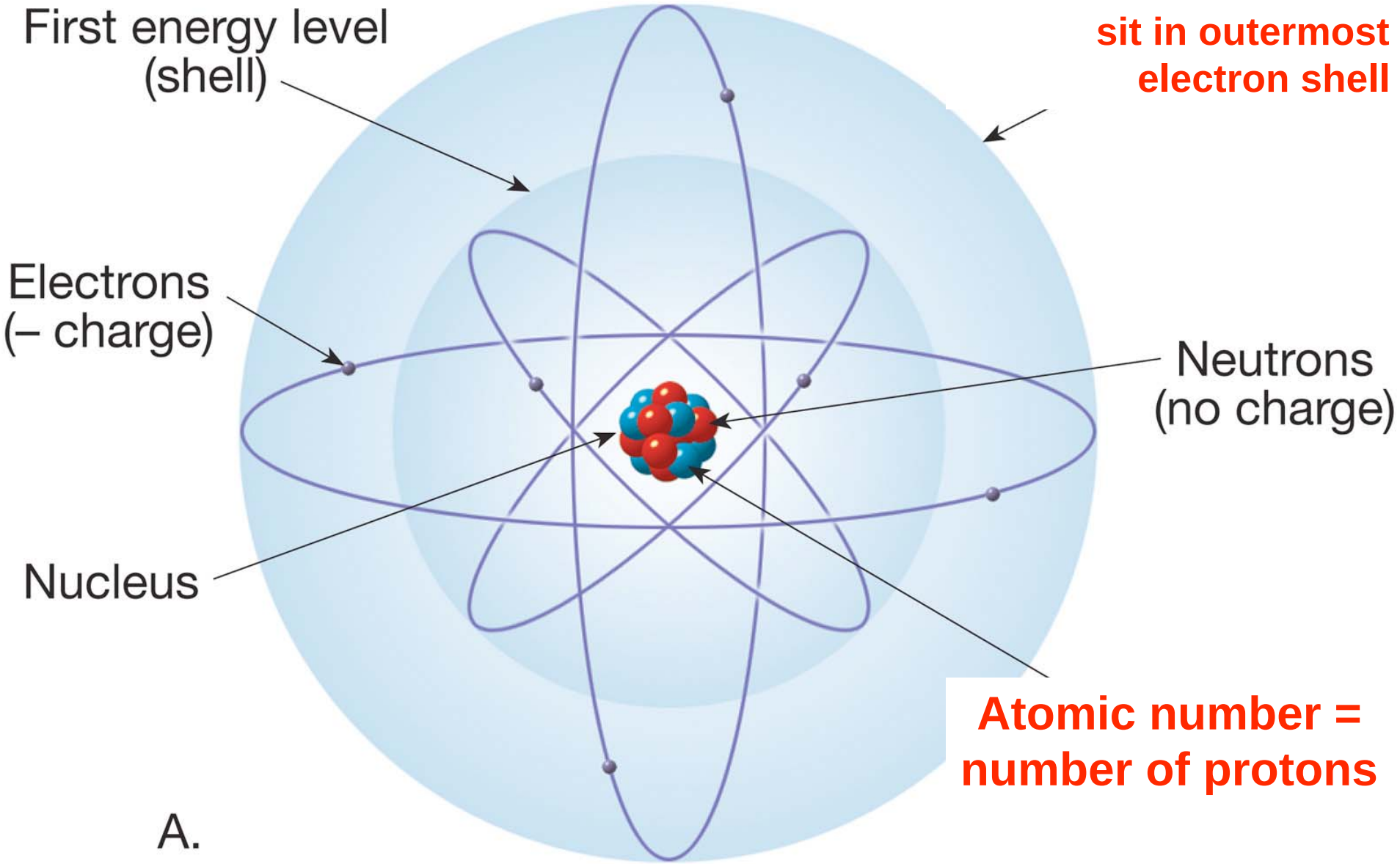
smallest possible particle of a chemical element that retains that element's chemical properties

smallest possible particle of a chemical element that retains its chemical properties = ATOM



what does this remind you of?

Valence electrons
sit in outermost electron shell

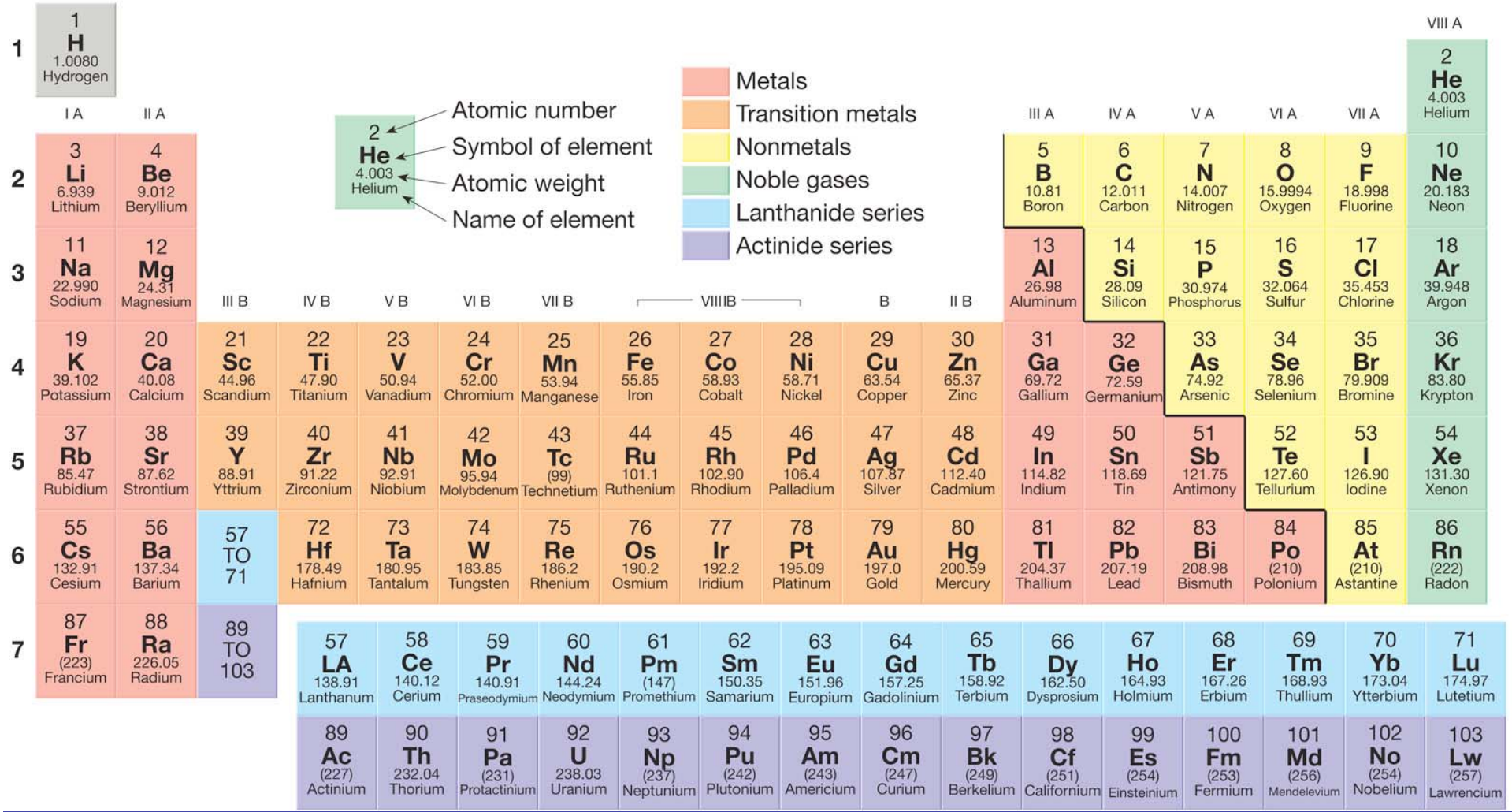


Atomic number = number of protons

particle — smallest possible particle of a chemical element that retains that element's chemical properties
=
ATOM

substance — a substance that cannot be decomposed or transformed into other chemical substances by ordinary chemical processes
=
?

a substance that cannot be decomposed or transformed into other chemical substances by ordinary chemical processes = ELEMENT

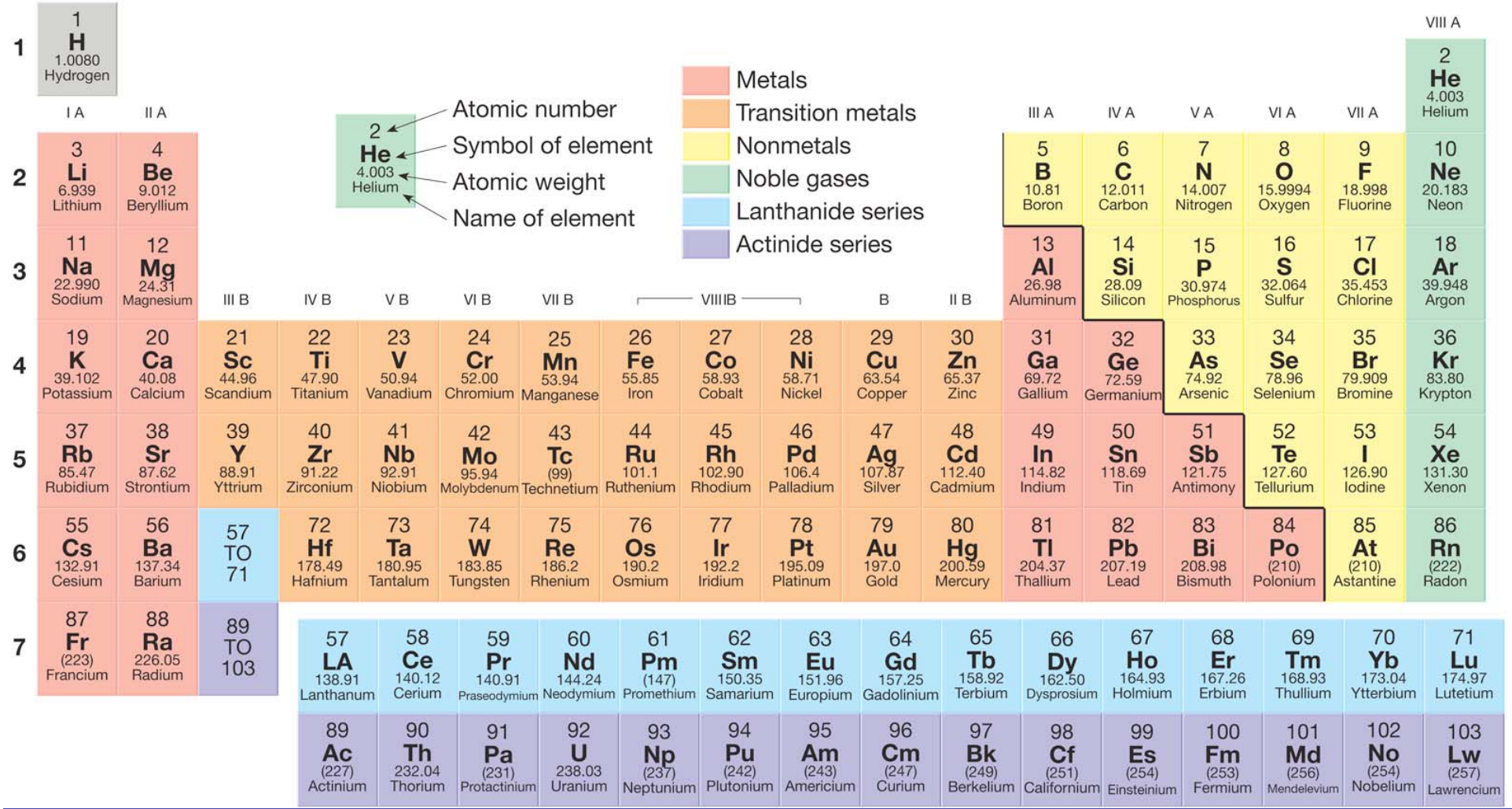


	I A	II A	III B	IV B	V B	VI B	VII B	VIII B			B	II B	III A	IV A	V A	VI A	VII A	VIII A
1	1 H 1.0080 Hydrogen																	2 He 4.003 Helium
2	3 Li 6.939 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.9994 Oxygen	9 F 18.998 Fluorine	10 Ne 20.183 Neon
3	11 Na 22.990 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminum	14 Si 28.09 Silicon	15 P 30.974 Phosphorus	16 S 32.064 Sulfur	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
4	19 K 39.102 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.90 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 53.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.71 Nickel	29 Cu 63.54 Copper	30 Zn 65.37 Zinc	31 Ga 69.72 Gallium	32 Ge 72.59 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.909 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 95.94 Molybdenum	43 Tc (99) Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.90 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.87 Silver	48 Cd 112.40 Cadmium	49 In 114.82 Indium	50 Sn 118.69 Tin	51 Sb 121.75 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine	54 Xe 131.30 Xenon
6	55 Cs 132.91 Cesium	56 Ba 137.34 Barium	57 TO 71	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.85 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.09 Platinum	79 Au 197.0 Gold	80 Hg 200.59 Mercury	81 Tl 204.37 Thallium	82 Pb 207.19 Lead	83 Bi 208.98 Bismuth	84 Po (210) Polonium	85 At (210) Astantine	86 Rn (222) Radon
7	87 Fr (223) Francium	88 Ra 226.05 Radium	89 TO 103															

57 LA 138.91 Lanthanum	58 Ce 140.12 Cerium	59 Pr 140.91 Praseodymium	60 Nd 144.24 Neodymium	61 Pm (147) Promethium	62 Sm 150.35 Samarium	63 Eu 151.96 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.93 Holmium	68 Er 167.26 Erbium	69 Tm 168.93 Thullium	70 Yb 173.04 Ytterbium	71 Lu 174.97 Lutetium
89 Ac (227) Actinium	90 Th 232.04 Thorium	91 Pa (231) Protactinium	92 U 238.03 Uranium	93 Np (237) Neptunium	94 Pu (242) Plutonium	95 Am (243) Americium	96 Cm (247) Curium	97 Bk (249) Berkelium	98 Cf (251) Californium	99 Es (254) Einsteinium	100 Fm (253) Fermium	101 Md (256) Mendelevium	102 No (254) Nobelium	103 Lw (257) Lawrencium

Periodic Table first created in 1869 by the Russian chemist Dmitri Mendeleev

Organized by: 1) atomic number / atomic weight



	I A	II A	III B	IV B	V B	VI B	VII B	VIII B			B	II B	III A	IV A	V A	VI A	VII A	VIII A
1	1 H 1.0080 Hydrogen																	2 He 4.003 Helium
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How are these related?

Organized by: 2) rows – indicate how many electron shells total

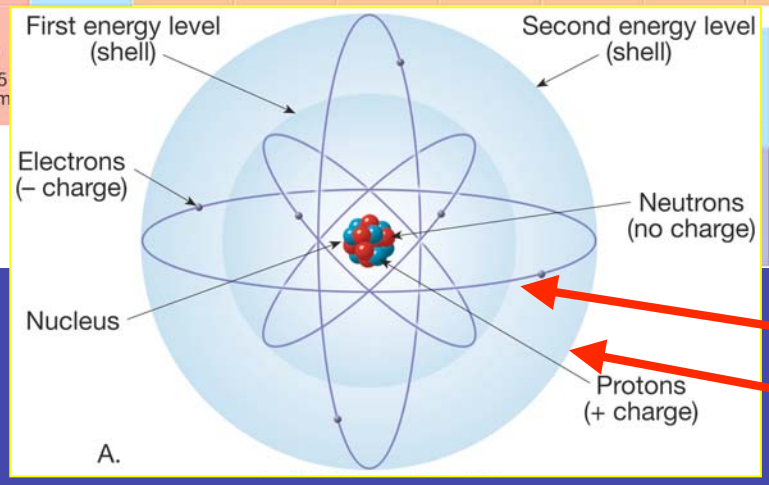
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7	87 Fr (223) Francium	88 Ra 226.05 Radium																

2 He 4.003 Helium

- Atomic number
- Symbol of element
- Atomic weight
- Name of element

- Metals
- Transition metals
- Nonmetals
- Noble gases
- Lanthanide series
- Actinide series

63 Eu 151.96 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.92 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.93 Holmium	68 Er 167.26 Erbium	69 Tm 168.93 Thullium	70 Yb 173.04 Ytterbium	71 Lu 174.97 Lutetium
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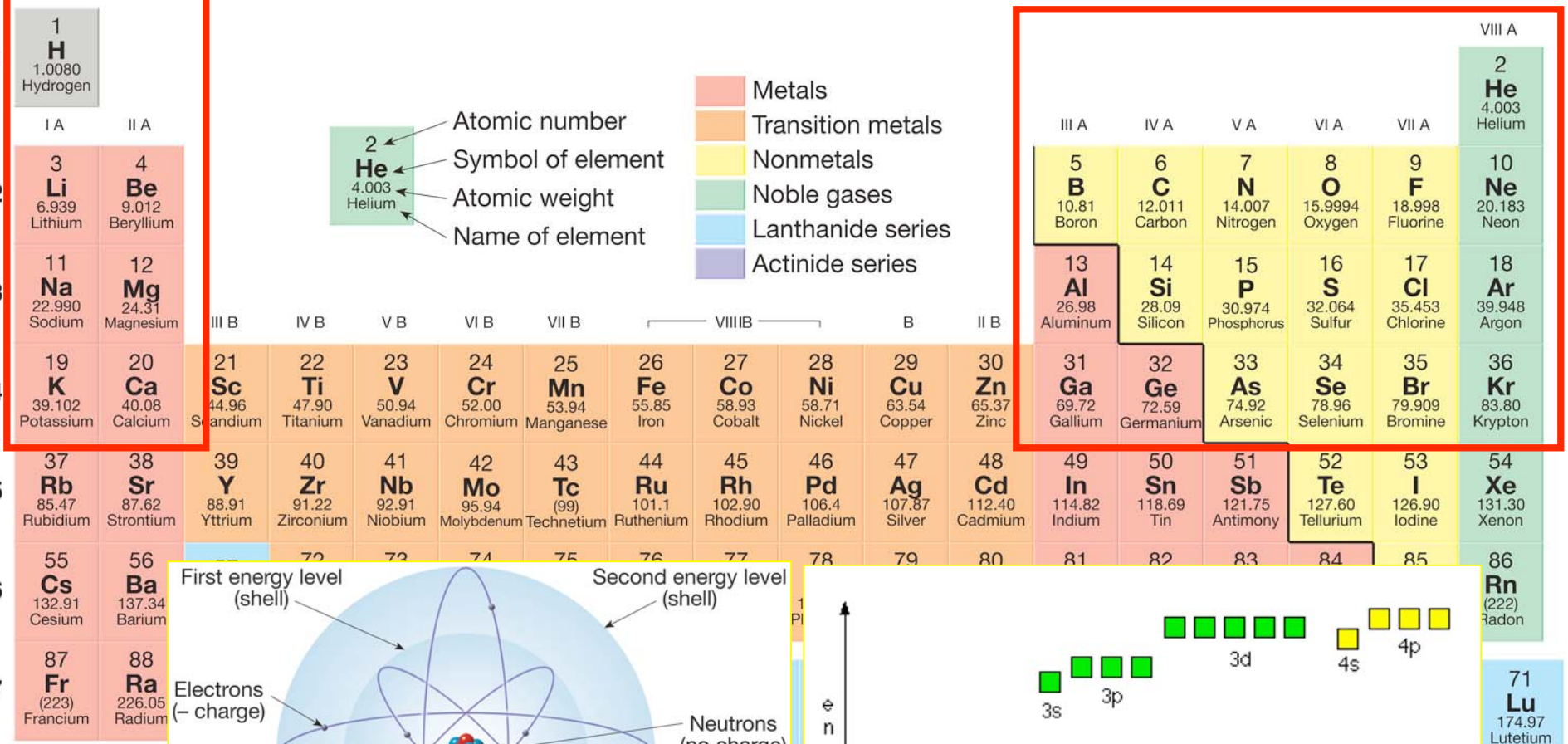


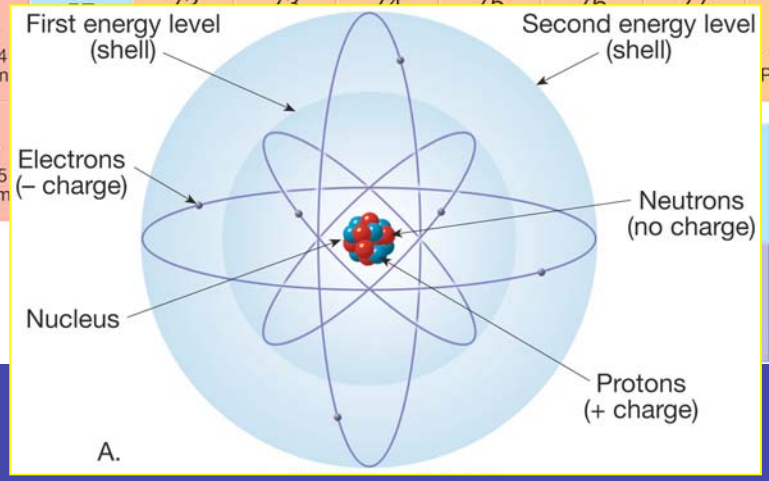
shell one

shell two (valance shell)

Organized by: 3) columns – # of electrons in the outermost shell

1 2 3 4 5 6 7 8



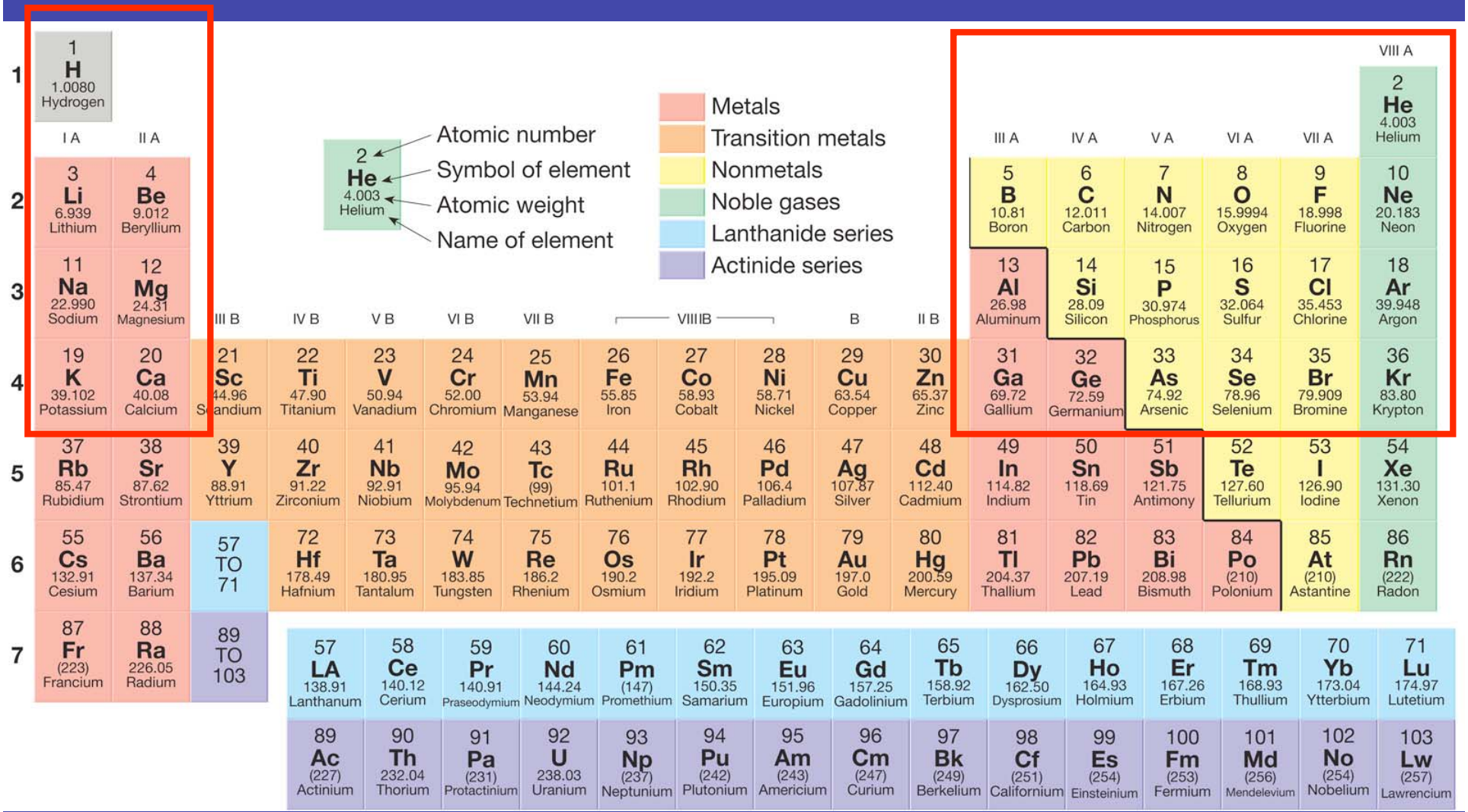




Starts out simple, then gets complicated!

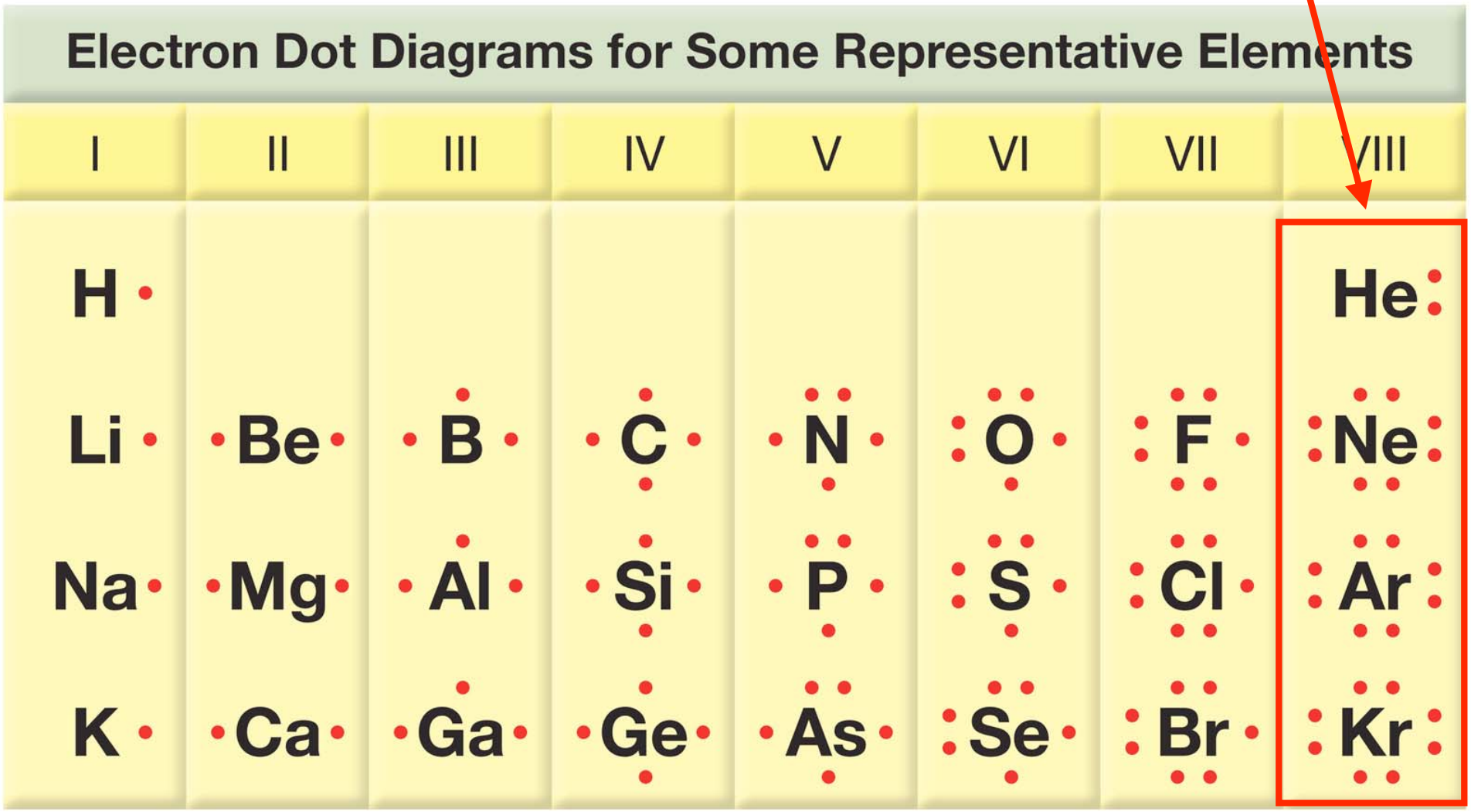
Which of these elements are the most STABLE?

1 2 3 4 5 6 7 8



stable configuration: valence shell contains maximum electrons

noble gases

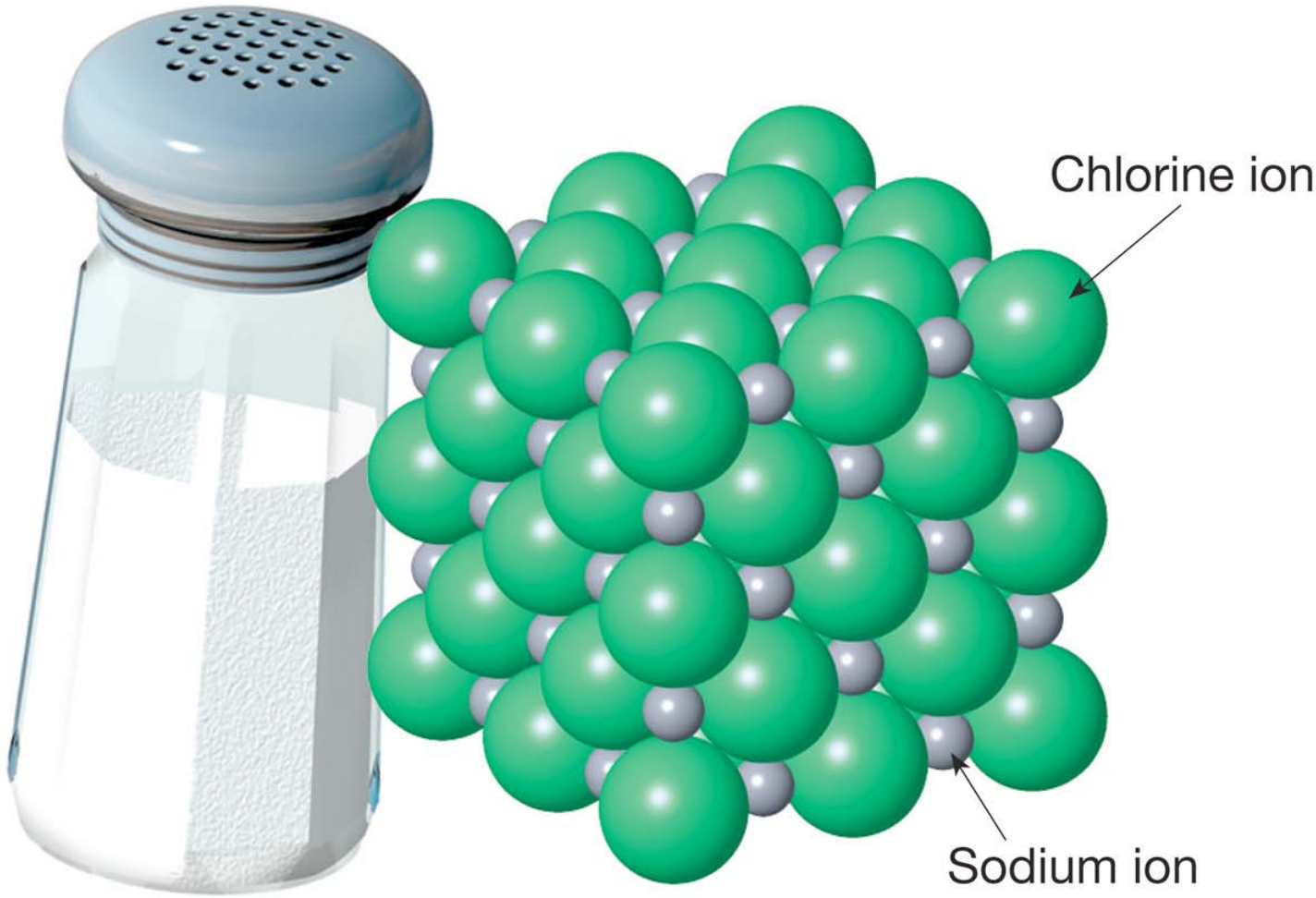


how do <u>other</u> elements <u>gain</u> stability?

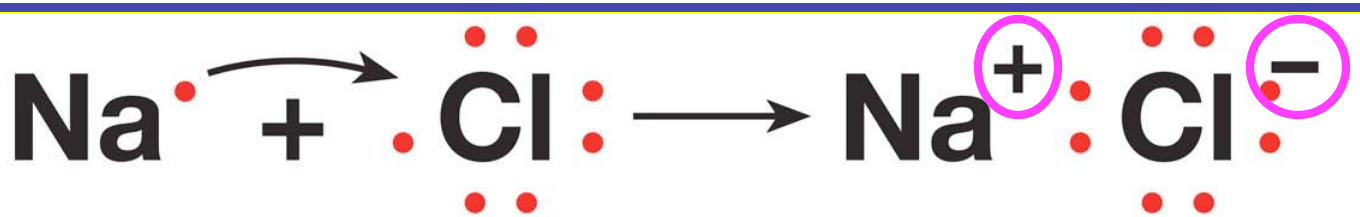
A.



B.



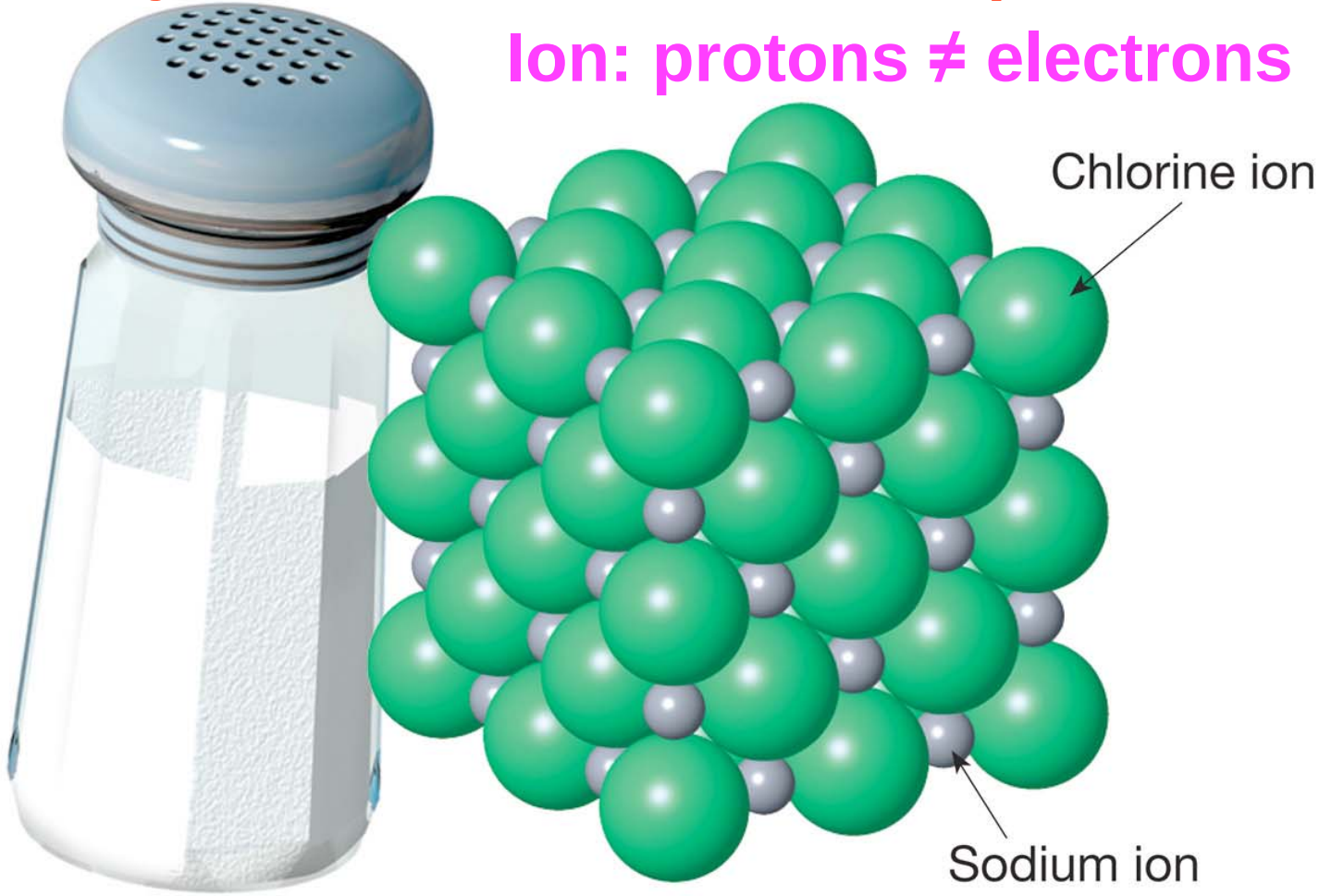
A.



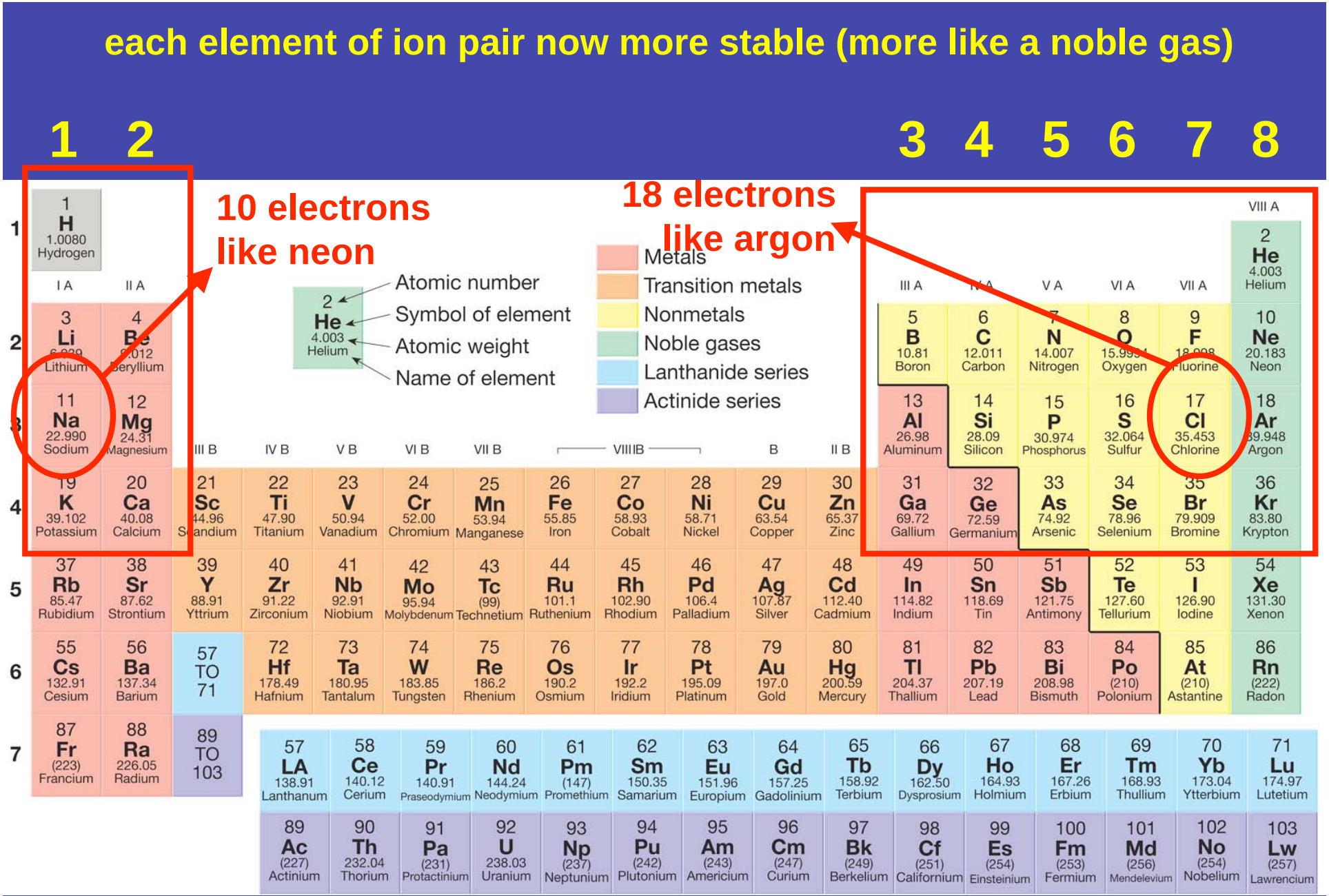
Ionic bond: electrons transferred (usually from metal to non-metal)

Ion: protons ≠ electrons

B.

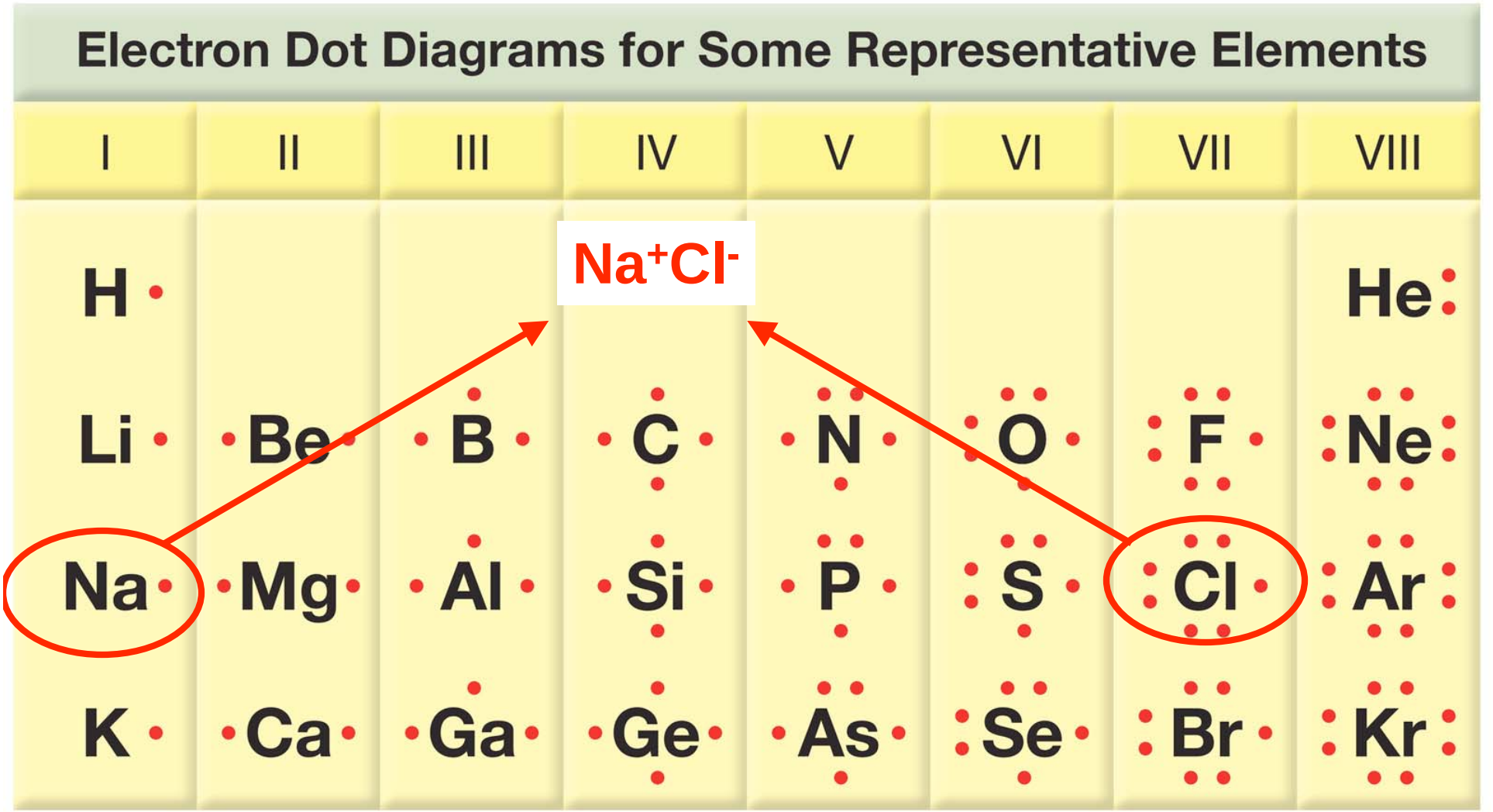


each element of ion pair now more stable (more like a noble gas)



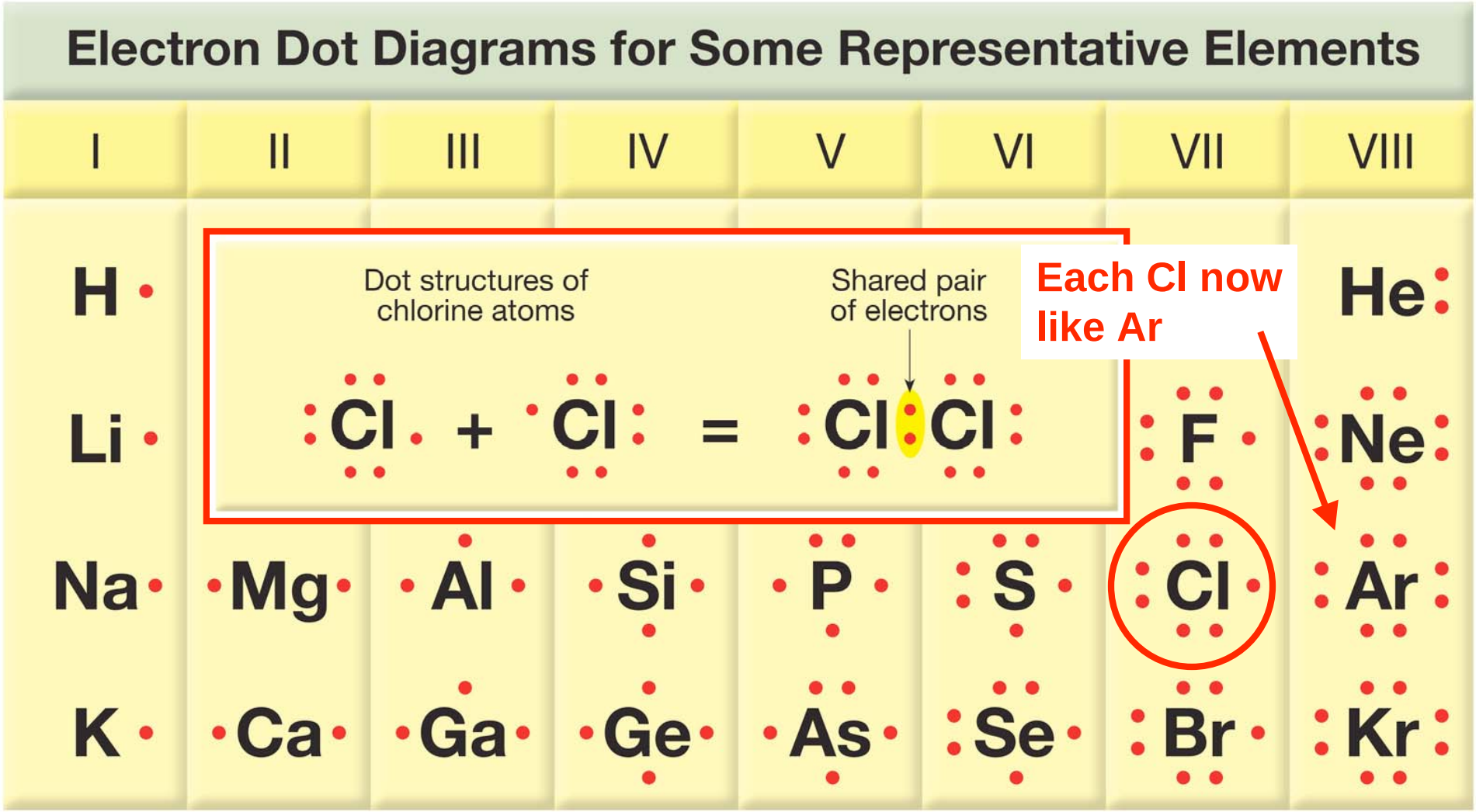
stable configuration: valence shell contains maximum electrons

1. **ionic bonding…electron transfer**
2. **_____**



stable configuration: valence shell contains maximum electrons

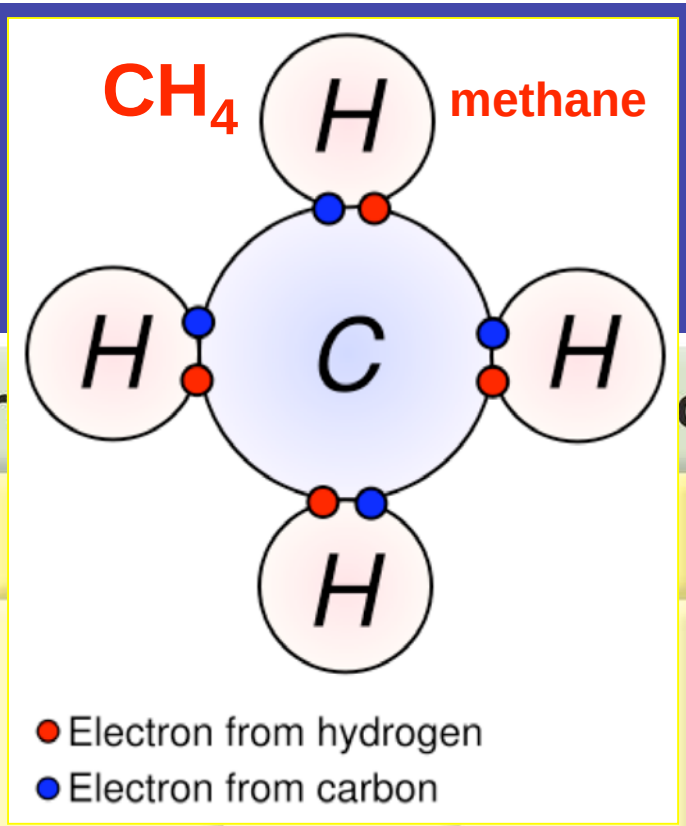
2. covalent bonding…electron sharing



no charge change

stable configuration: valence shell contains maximum electrons

covalent bonding…electron sharing



Electr ome Representative Elements

I	V	VI	VII	VIII
H				He
Li	N	O	F	Ne
Na	P	S	Cl	Ar
K	As	Se	Br	Kr
	Be	B	C	Mg	Al	Si	Ca	Ga	Ge

Each H now like He
Each C now like Ne

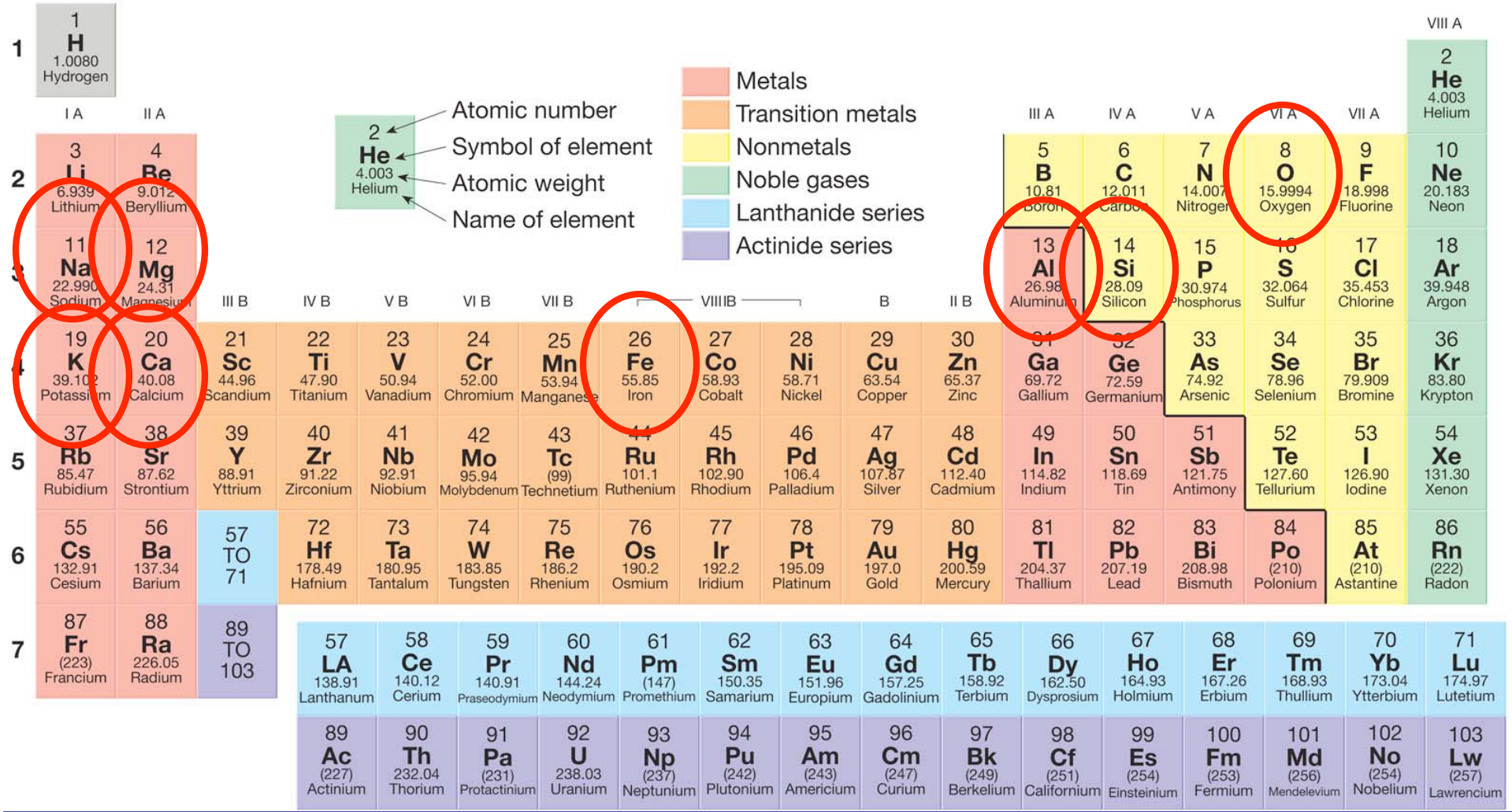
Take-home message:

Most of Earth's elements PREFER (chemically) to exist in combination with other elements

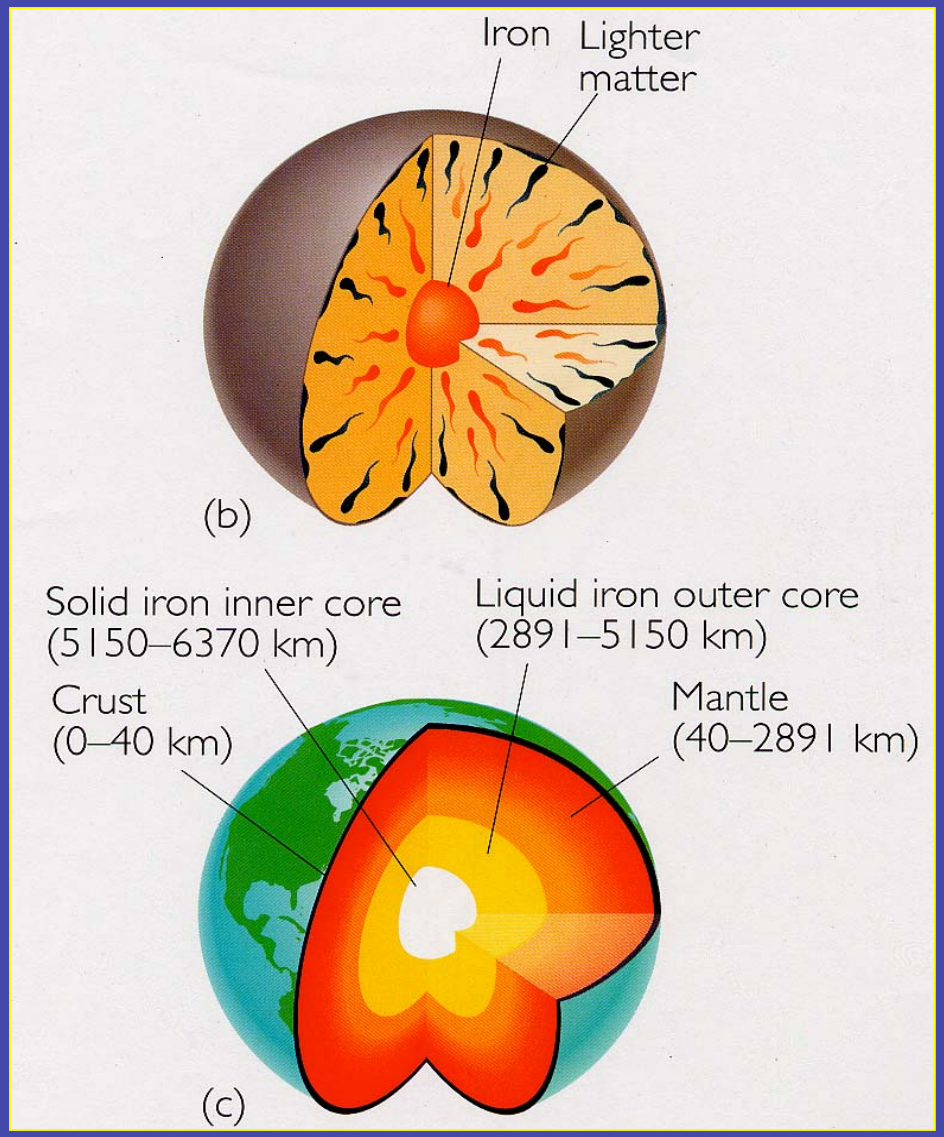
~

accomplished via electrostatic bonding
(ionic, covalent, and many other types)

only eight elements make up
98% of Earth's crust
(by weight)



Lightest element most abundant

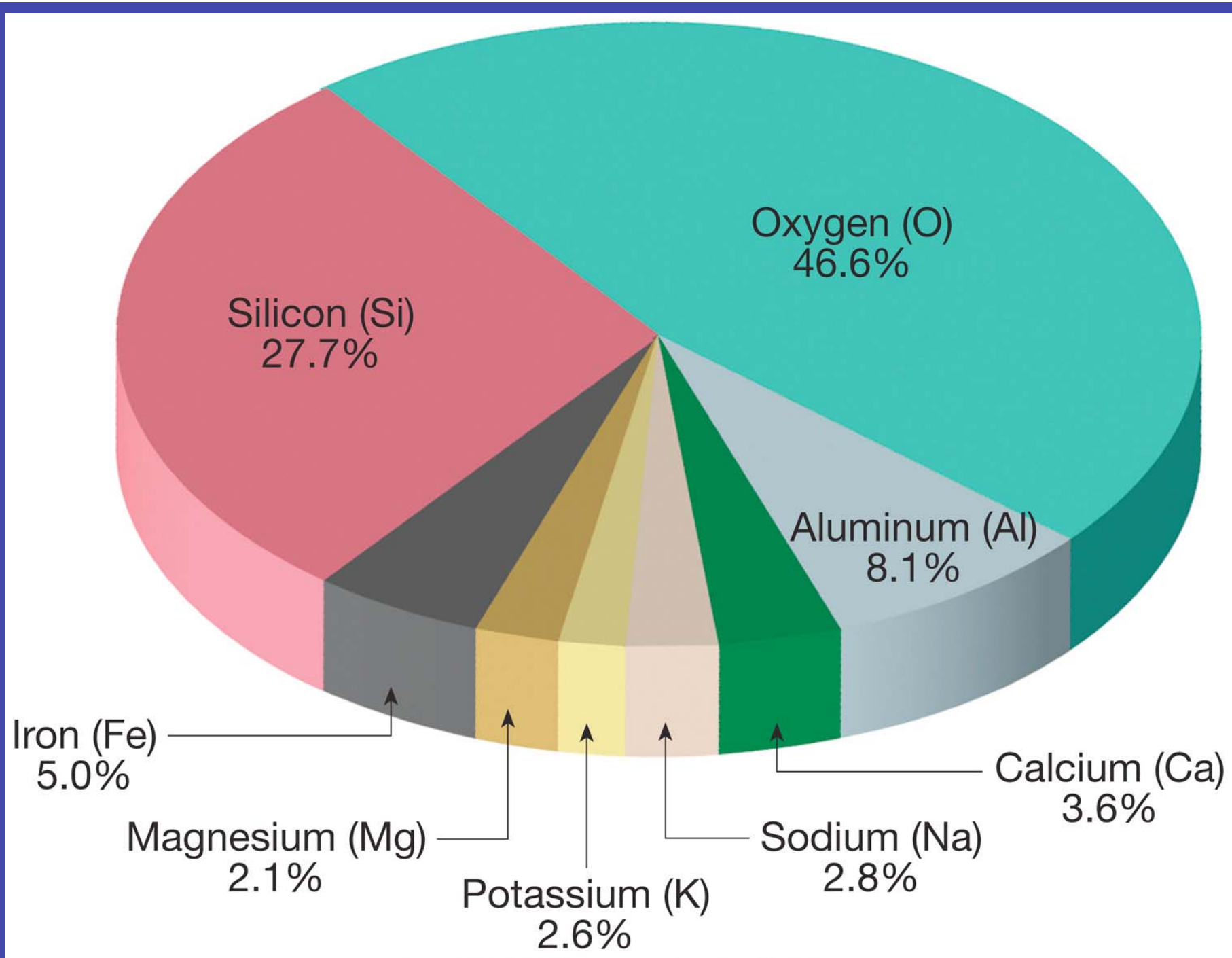


"Iron Catastrophe"

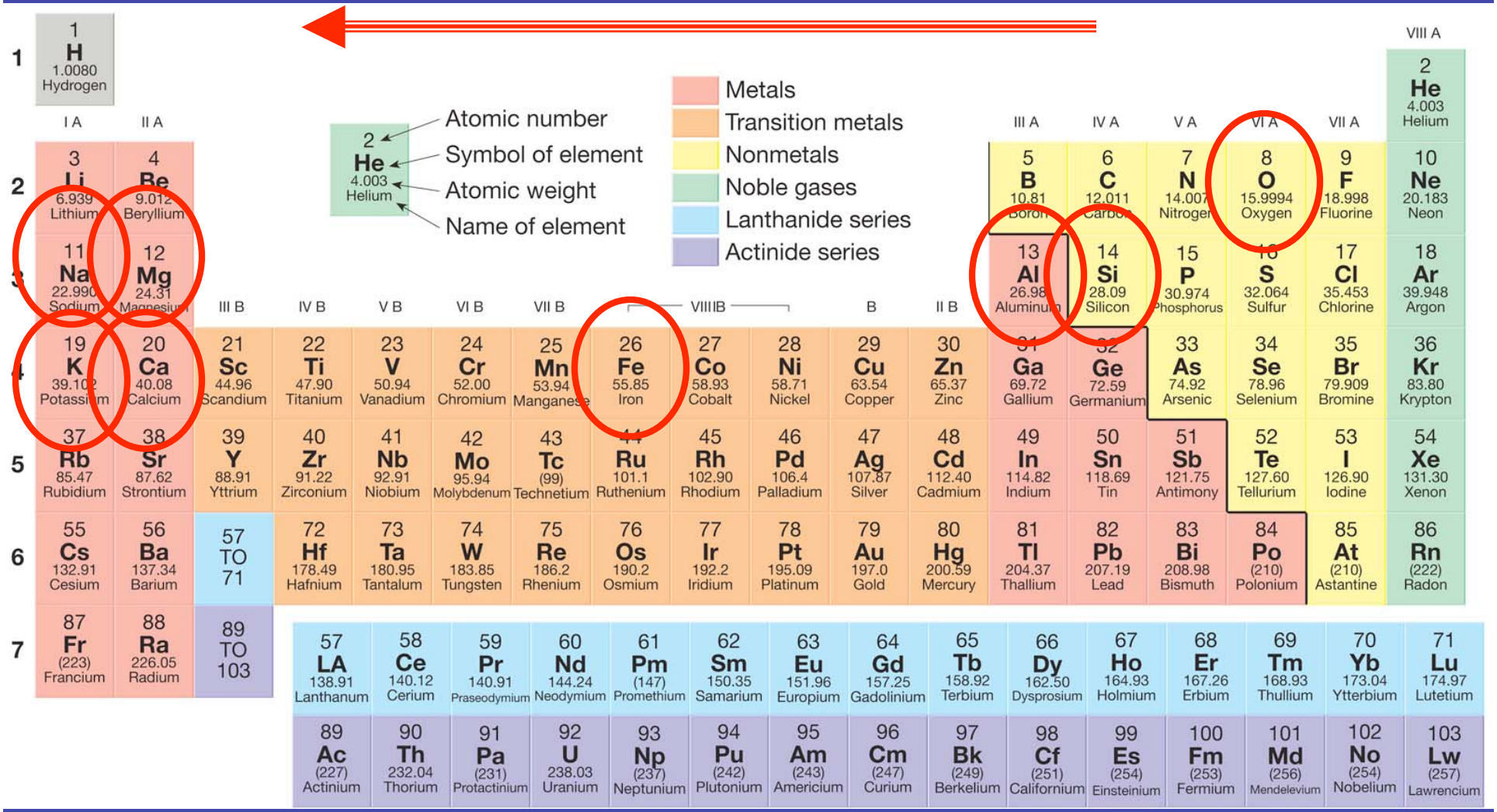
Planet became chemically differentiated

Increasing Fe/Mg toward core

Increasing Si/O toward crust

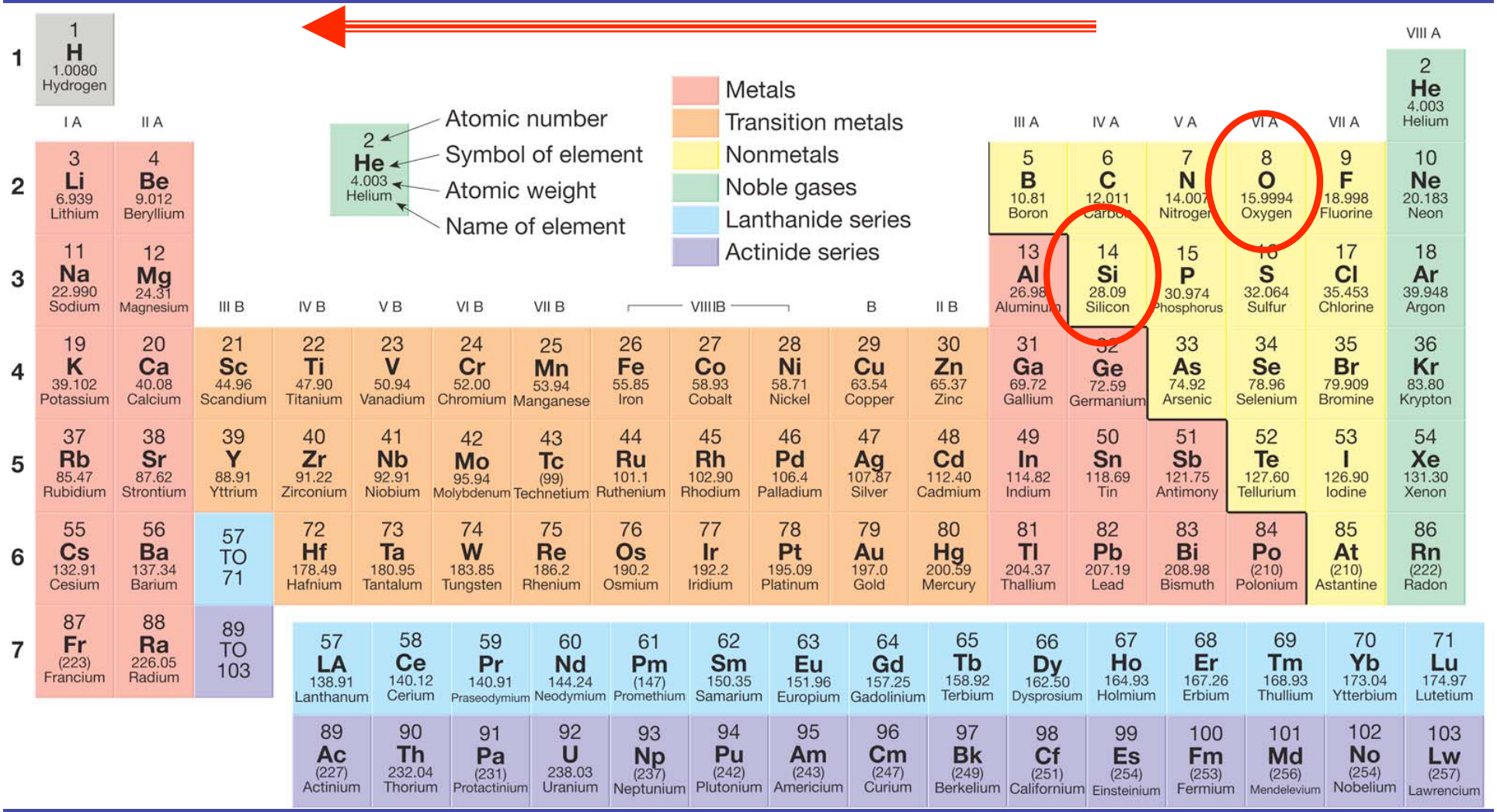

Oxygen (O)
46.6%
Silicon (Si)
27.7%
Aluminum (Al)
8.1%
Iron (Fe)
5.0%
Magnesium (Mg)
2.1%
Potassium (K)
2.6%
Sodium (Na)
2.8%
Calcium (Ca)
3.6%

less abundant most abundant



What is most common mineral group going to be made up of?

less abundant most abundant



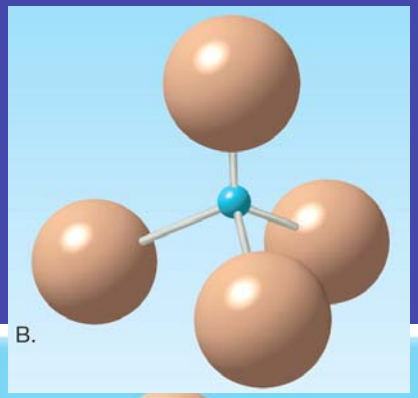
What is most common mineral group going to be made up of?

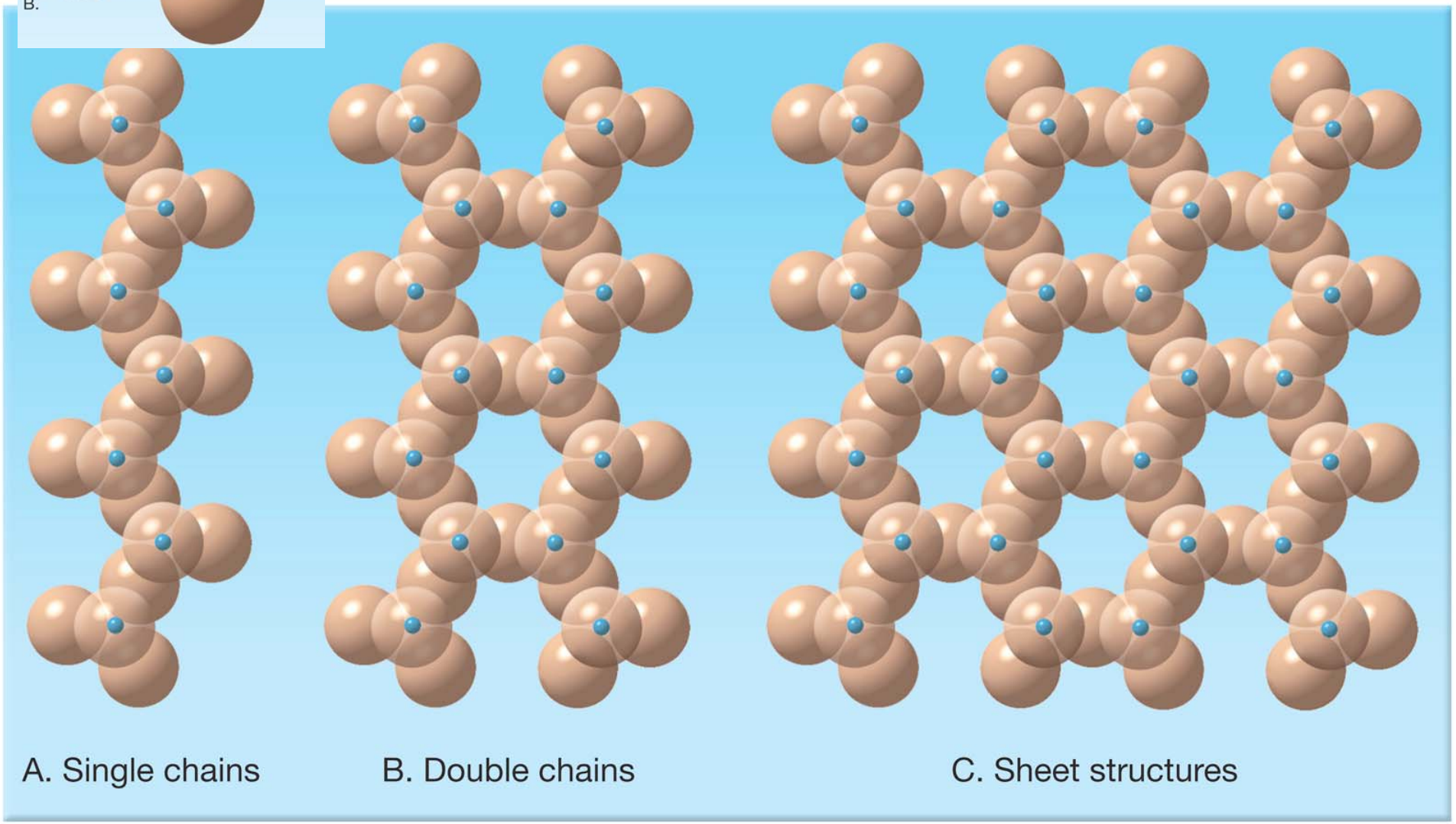
Oxygen, Silica – Silicates (90% of Earth's crust)

Ratio of oxygen to silica changes

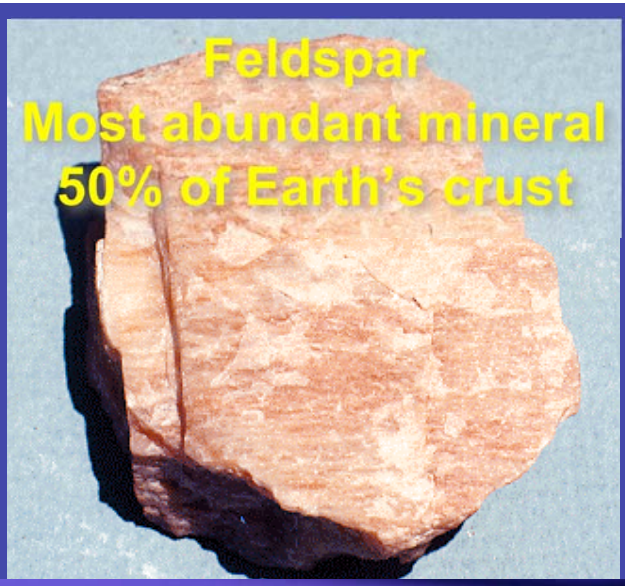
4:1, 3:1, (2:1)

% silica controls physical properties of magma





Mineral/Formula	Cleavage	Silicate Structure	Example
Olivine $(Mg, Fe)_2SiO_4$	None	Single tetrahedron	Olivine
Pyroxene group (Augite) $(Mg,Fe)SiO_3$	Two planes at right angles	Single chains	Augite
Amphibole group (Hornblende) $Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$	Two planes at 60° and 120°	Double chains	Hornblend
Micas: Biotite $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	One plane	Sheets	Biotite
Micas: Muscovite $KAl_2(AlSi_3O_{10})(OH)_2$	One plane	Sheets	Muscovite
Feldspars: Potassium feldspar (Orthoclase) $KAlSi_3O_8$	Two planes at 90°	Three-dimensional networks	Potassium feldspar
Feldspars: Plagioclase feldspar $(Ca,Na)AlSi_3O_8$	Two planes at 90°	Three-dimensional networks	
Quartz SiO_2	None	Three-dimensional networks	Quartz








2 cm



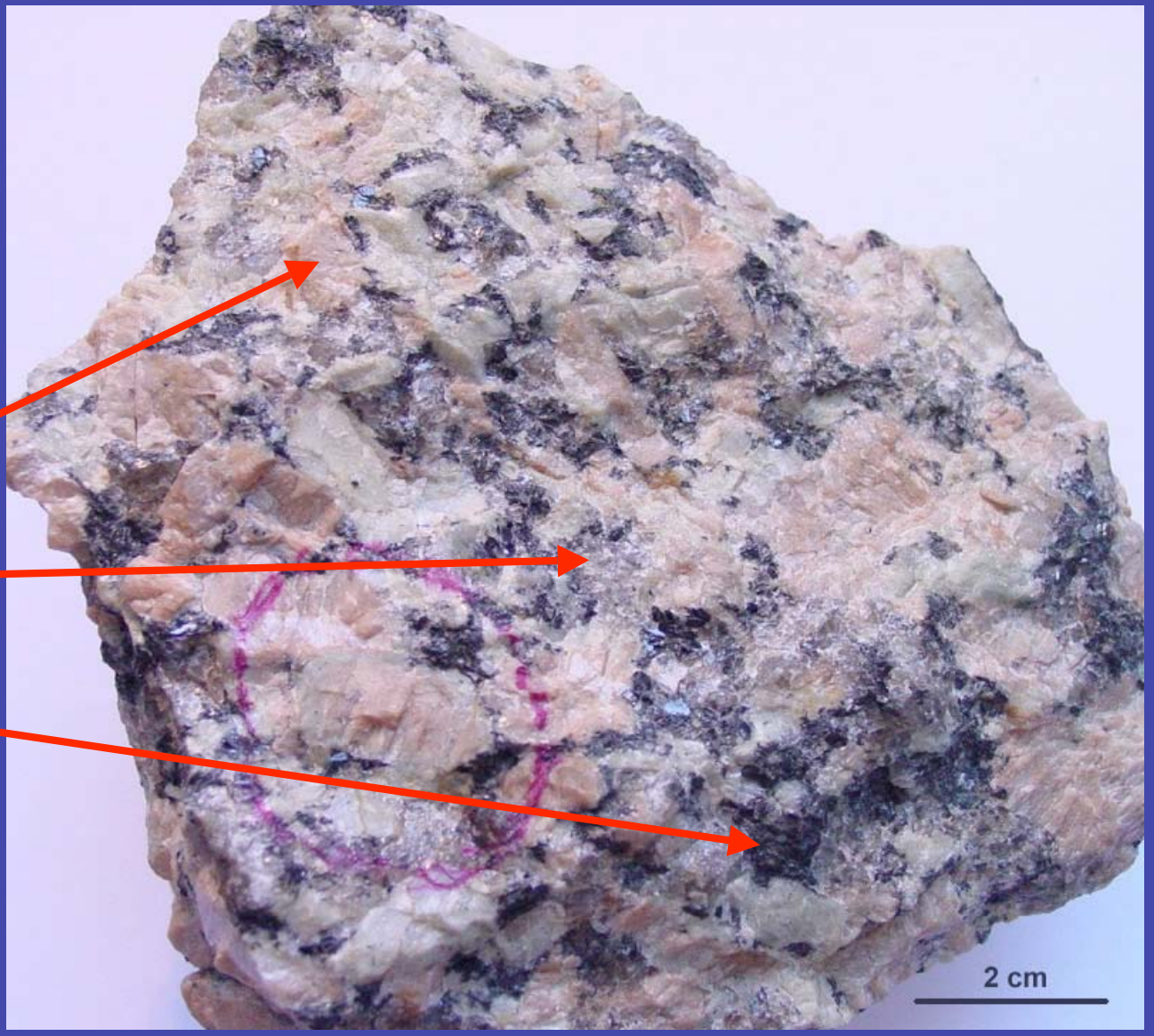
Granite

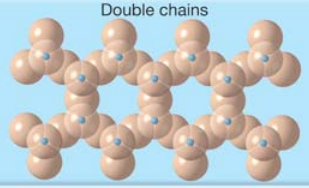
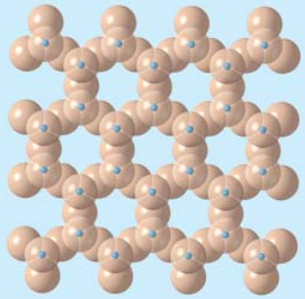
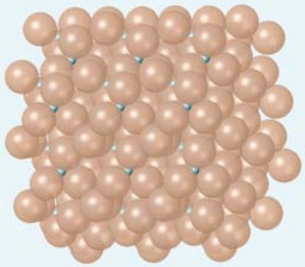
most common rock in continental crust

Feldspar

Quartz

Micas



Mineral/Formula		Cleavage	Silicate Structure	Example
Olivine $(Mg, Fe)_2SiO_4$		None	Single tetrahedron 	 Olivine
Pyroxene group (Augite) $(Mg,Fe)SiO_3$		Two planes at right angles	Single chains 	Augite 
Amphibole group (Hornblende) $Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$		Two planes at 60° and 120°	Double chains 	 Hornblend
Micas	Biotite $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	One plane	Sheets 	 Biotite
	Muscovite $KAl_2(AlSi_3O_{10})(OH)_2$			 Muscovite
Feldspars	Potassium feldspar (Orthoclase) $KAlSi_3O_8$	Two planes at 90°	Three-dimensional networks 	 Potassium feldspar
	Plagioclase feldspar $(Ca,Na)AlSi_3O_8$			
Quartz SiO_2		None		 Quartz

How is percent silica changing?

Mineral/Formula	Cleavage	Silicate Structure	Example
Olivine $(Mg, Fe)_2SiO_4$	None	Single tetrahedron	Olivine
Pyroxene group (Augite) $(Mg,Fe)SiO_3$	Two planes at right angles	Single chains	Augite
Amphibole group (Hornblende) $Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$	Two planes at 60° and 120°	Double chains	Hornblend
Micas: Biotite $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	One plane	Sheets	Biotite
Micas: Muscovite $KAl_2(AlSi_3O_{10})(OH)_2$	One plane	Sheets	Muscovite
Feldspars: Potassium feldspar (Orthoclase) $KAlSi_3O_8$	Two planes at 90°	Three-dimensional networks	Potassium feldspar
Feldspars: Plagioclase feldspar $(Ca,Na)AlSi_3O_8$	Two planes at 90°	Three-dimensional networks	
Quartz SiO_2	None	Three-dimensional networks	Quartz

Oxygen:Silica

4:1

How is percent silica changing?

3:1

2:1

Mineral/Formula	Cleavage	Silicate Structure	Example
Olivine $(Mg, Fe)_2SiO_4$	None	Single tetrahedron	Olivine
Pyroxene group (Augite) $(Mg,Fe)SiO_3$	Two planes at right angles	Single chains	Augite
Amphibole group (Hornblende) $Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$	Two planes at 60° and 120°	Double chains	Hornblend
Micas: Biotite $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	One plane	Sheets	Biotite
Micas: Muscovite $KAl_2(AlSi_3O_{10})(OH)_2$	One plane	Sheets	Muscovite
Feldspars: Potassium feldspar (Orthoclase) $KAlSi_3O_8$	Two planes at 90°	Three-dimensional networks	Potassium feldspar
Feldspars: Plagioclase feldspar $(Ca,Na)AlSi_3O_8$	Two planes at 90°	Three-dimensional networks	
Quartz SiO_2	None	Three-dimensional networks	Quartz

Oceanic Crust (dark silicates)

Which has more silica?

Which is more dense?

Continental Crust (light silicates)

Mineral/Formula		Cleavage	Silicate Structure	Example
Olivine $(Mg, Fe)_2SiO_4$		None	Single tetrahedron	Olivine
Pyroxene group (Augite) $(Mg,Fe)SiO_3$		Two planes at right angles	Single chains	Augite
Amphibole group (Hornblende) $Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$		Two planes at 60° and 120°	Double chains	Hornblend
Micas	Biotite $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	One plane	Sheets	Biotite
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Feldspars	Potassium feldspar (Orthoclase) $KAlSi_3O_8$	Two planes at 90°	Three-dimensional networks	Potassium feldspar
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Quartz SiO_2		None	Three-dimensional networks	Quartz

Oceanic Crust

Less silica, but…

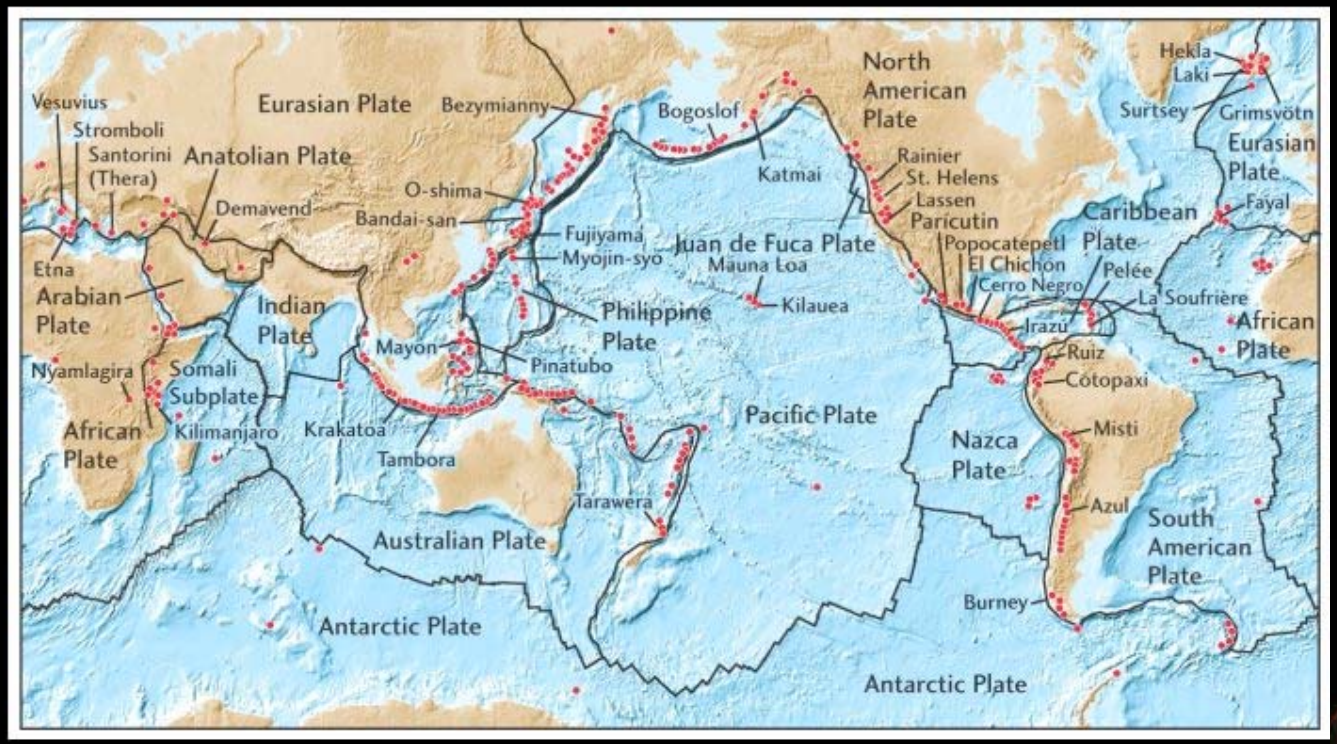
- **more dense due to accessory minerals: iron, magnesium**

Continental Crust

More silica, but…

- **less dense/less volume**
- **accessory minerals: calcium, sodium, potassium**

The World's Active Volcanoes



Silicates have volcanic origin

Plate tectonics controls lava chemistry



Summary

Silicates: 90% of Earth's Crust, volcanic origin

1) Continental crust

- **High silica but…low density**
- **Granite most common rock**
  - **Feldspars and quartz most common minerals (light silicates)**

2) Oceanic crust

- **Lower silica but…higher density**
- **Basalt most common rock**
  - **Olivine and pyroxene most common minerals (dark silicates)**

Non-silicates: <10% of Earth's crust





Non-silicates: Halides, Sulfates, Carbonates


gypsum


zinc

limestone




Great
Salt
Lake
OR
ID
CA
NV
Salt Lake
City
Bonneville
Salt Flats
UT
AZ

Salt flats







Gypsum $CaSO_4 \cdot 2H_2O$



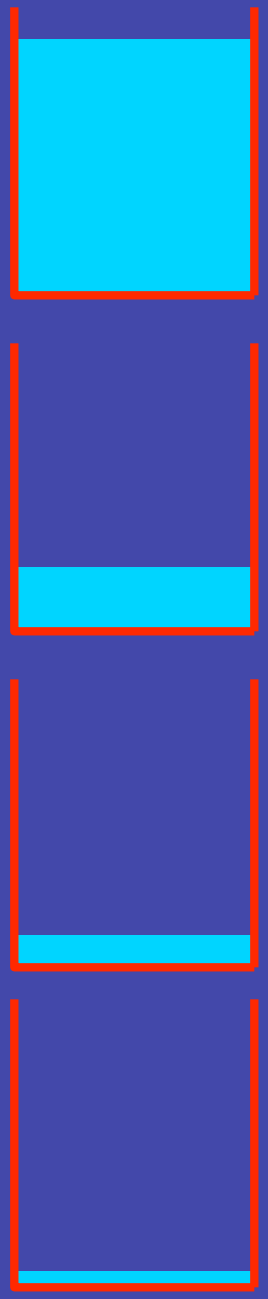
Chemical Sedimentary Rocks -

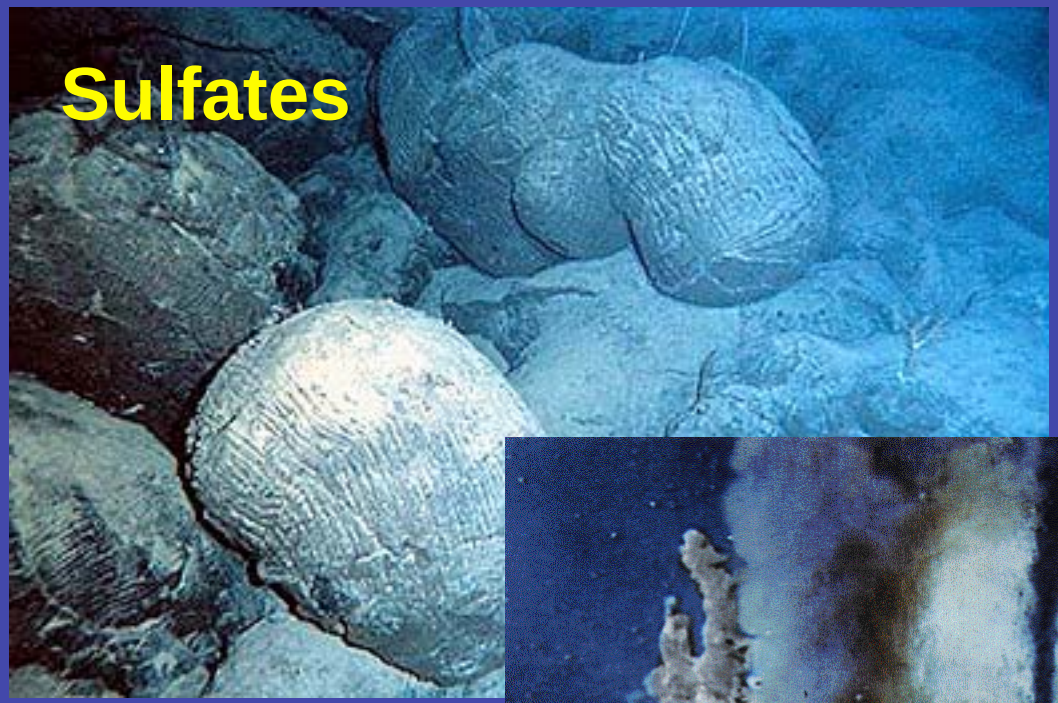
Evaporites











Before





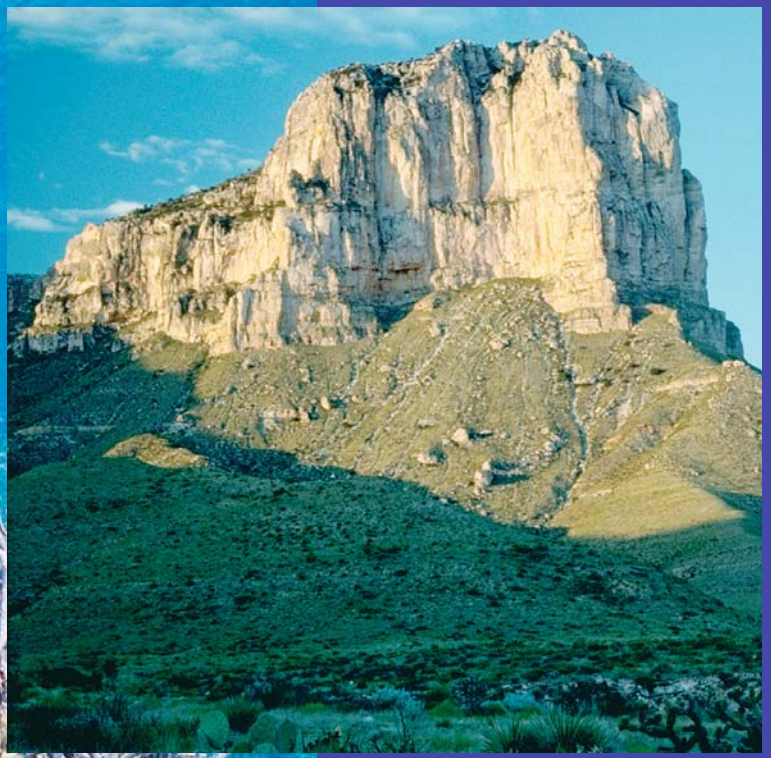
After

Where do you find these?



200,000 tons from 3,500-1,200 BC !





Carbonates

Former marine organisms

Non-silicates: Non-volcanic, commercially useful


Halide


Sulfate

Carbonate

Building blocks…

Made up of:	Description:
1. (Quarks, photons, neutrinos……	Subatomic)
2. Protons, neutrons, electrons……..	Atom
(Atoms: elements)	
3. Atom → molecule/compound……	Mineral

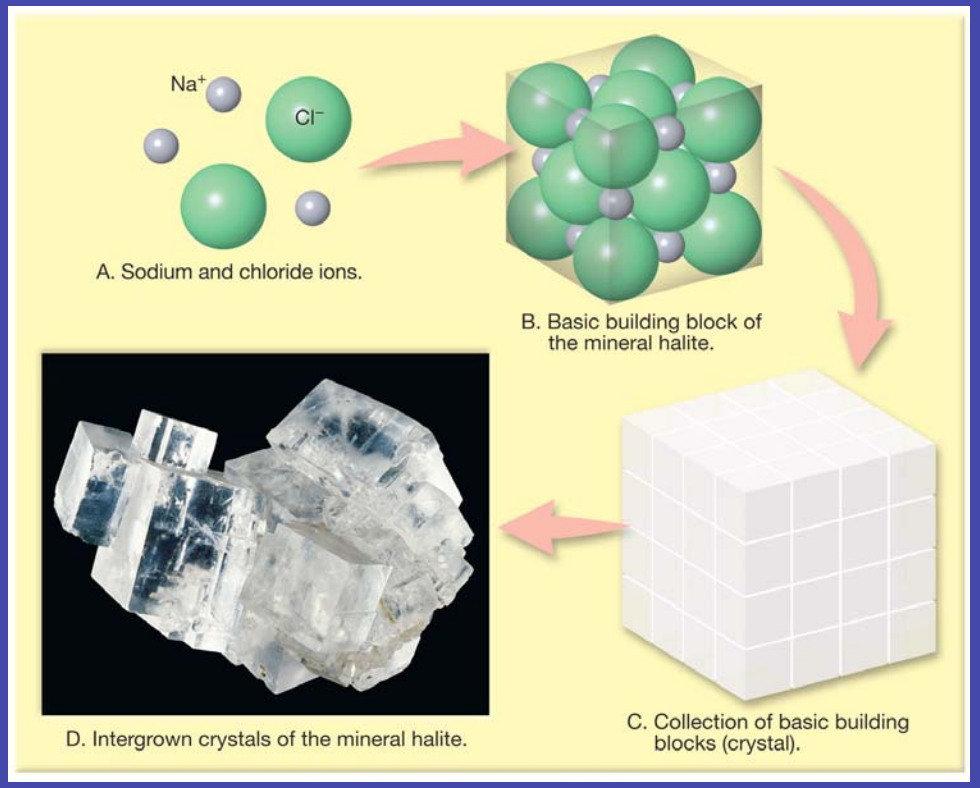


Increasing size, complexity

Geologists' definition of "mineral"…



1. Naturally occurring (no synthetics)
2. Solid substance (on Earth)
3. Orderly crystalline structure
4. Definite chemical composition
5. Generally inorganic



How do you identify a mineral?

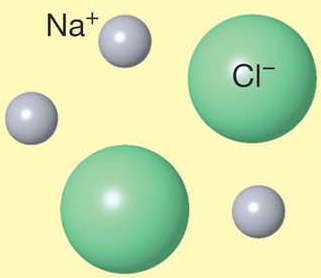
Physical properties of minerals

1. Crystal form
2. Luster
3. Color
4. Streak
5. Hardness
6. Cleavage
7. Fracture
8. Density/specific gravity
9. Other

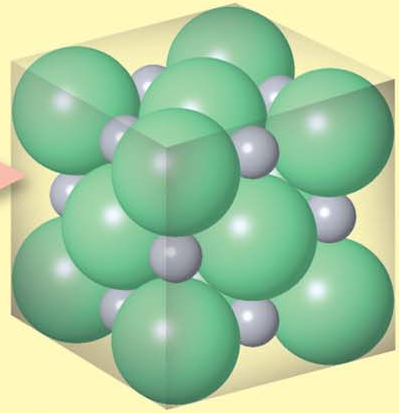
1. Crystal form.....



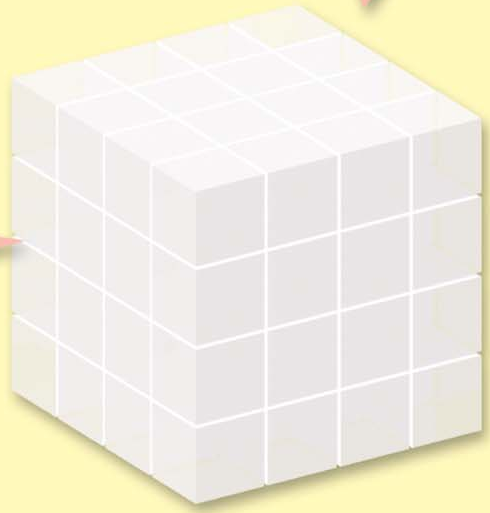




A. Sodium and chloride ions.



B. Basic building block of the mineral halite.



C. Collection of basic building blocks (crystal).



D. Intergrown crystals of the mineral halite.

2. Luster.....



3. Color.....



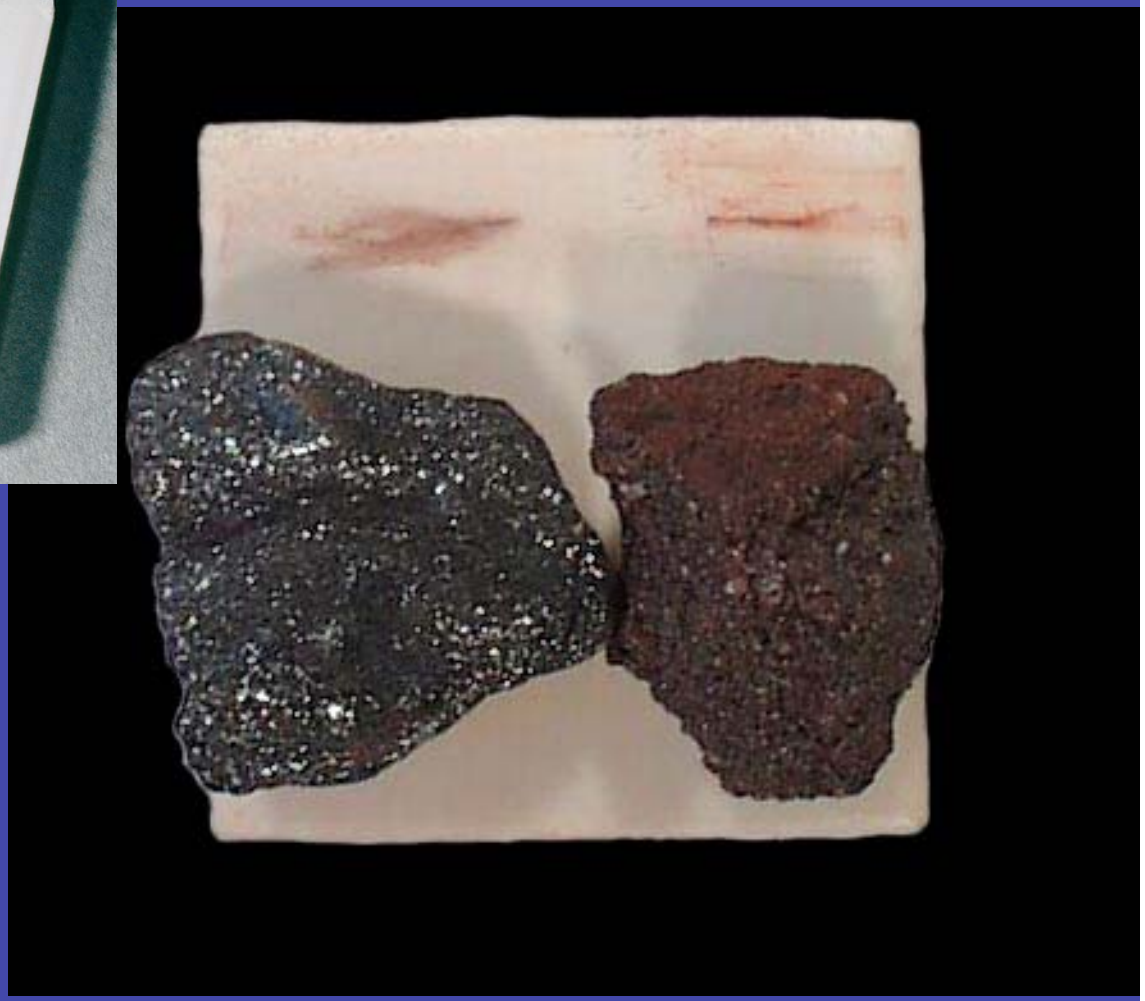






4. Streak.....



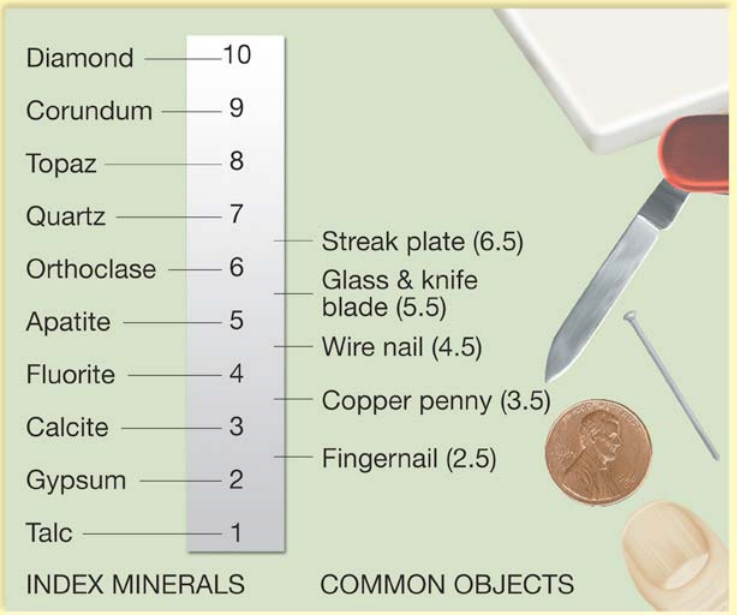


5. Hardness…

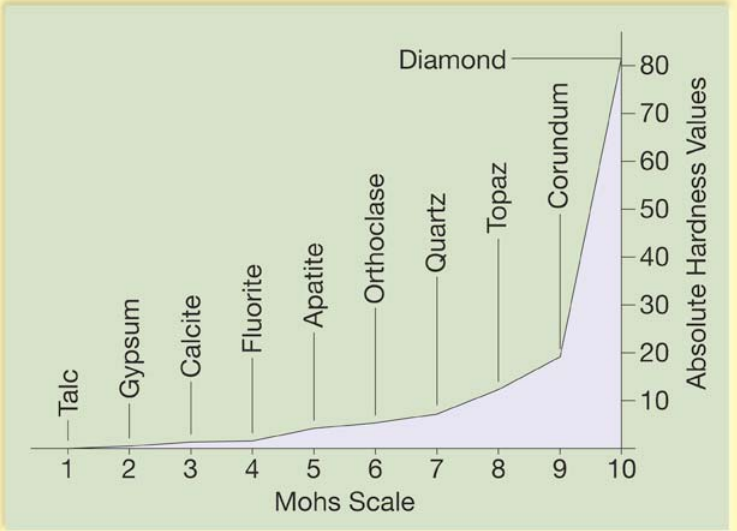




A. Mohs scale (Relative hardness)

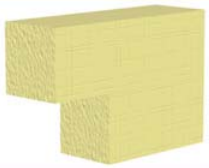
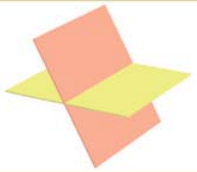
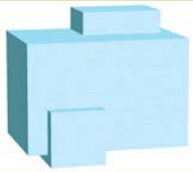


B. Comparison of Mohs scale and an absolute scale



6. Cleavage



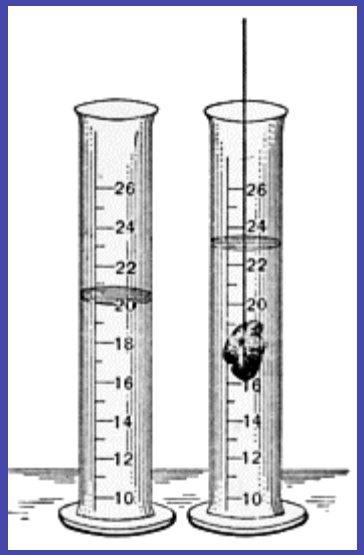
Number of Cleavage Directions	Shape	Sketch	Directions of Cleavage	Sample
1	Flat sheets			 Muscovite
	Elongated form with rectangle cross section (prism)			 Feldspar
	Elongated form with parallelogram cross section (prism)			 Hornblende
	Cube			 Halite
	Rhombohedron			 Calcite
4	Octahedron			 Fluorite

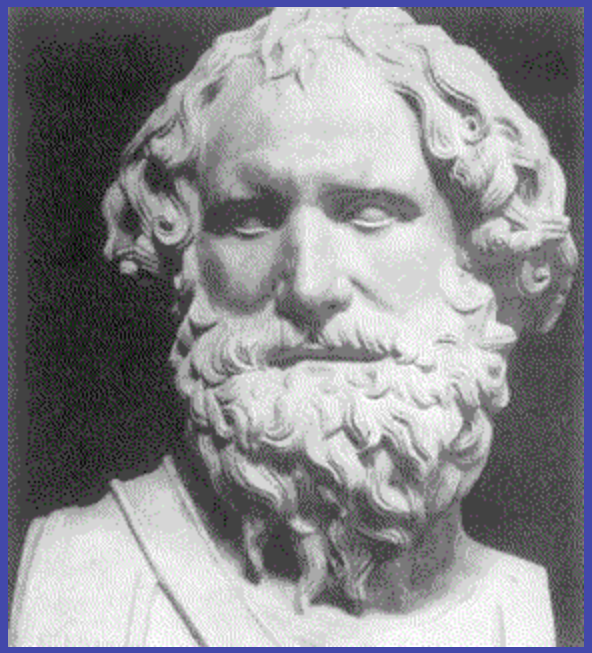
7. Fracture…





8. Specific gravity/density…





Asbestos = 2.45
Basalt = 3.01
Coral = 2.12
Granite = 2.69
Etc…

weight of mineral
vs.
weight of equal volume of water

9. Other…



Taste
Elasticity
Malleability
Feel (greasy, soapy)
Magnetism
Double refraction
Etc…

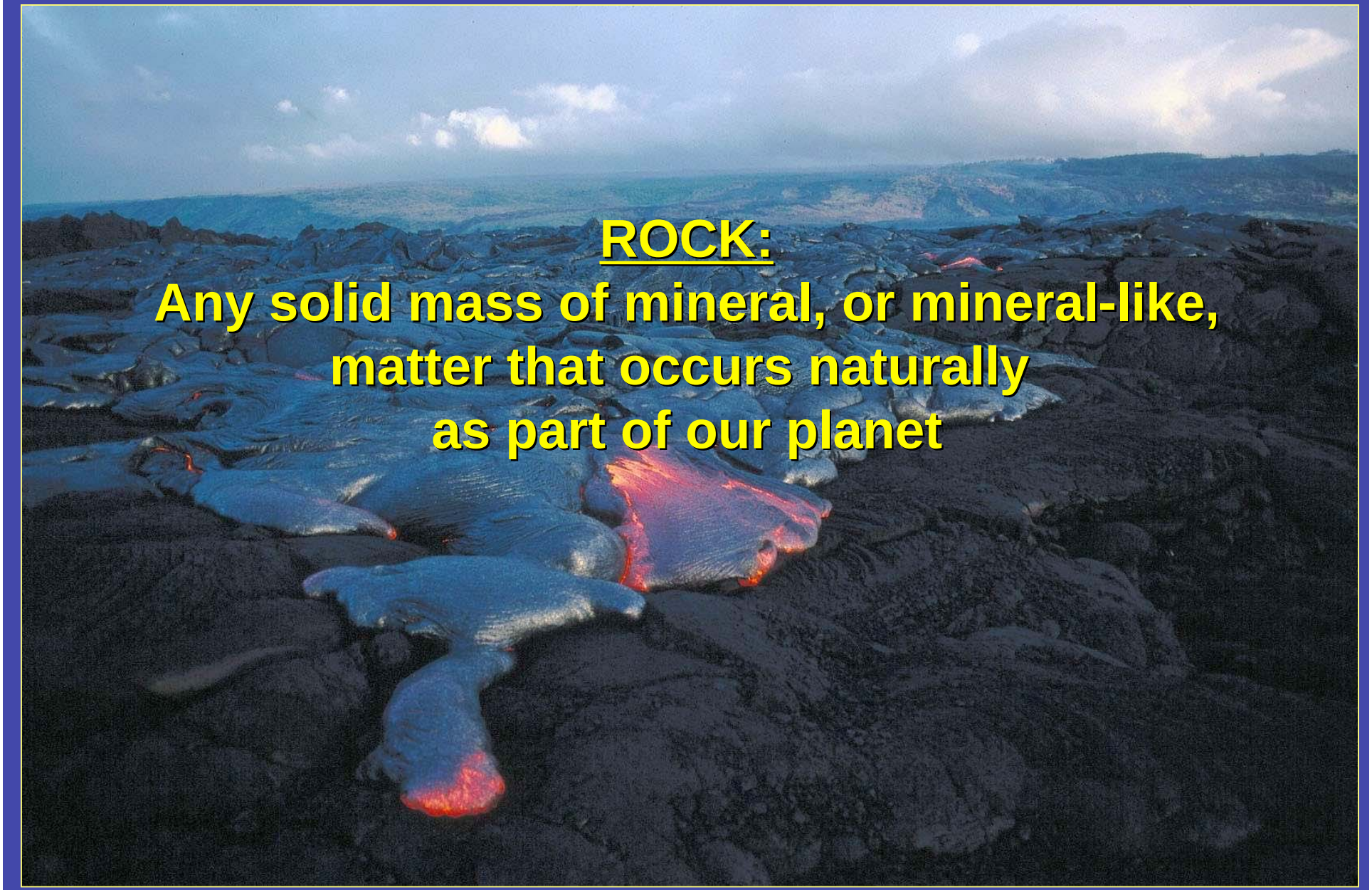
Take-home message:

Physical properties of minerals can be used in combination to determine mineral type

Building blocks…of ROCKS!

Made up of:	Description:
1. (Quarks, photons, neutrinos……	Subatomic)
2. Protons, neutrons, electrons……..	Atom
(Atoms: elements)	
3. Atom → molecule/compound……	Mineral
4. Minerals……..	Rock

Increasing size, complexity


ROCK:
Any solid mass of mineral, or mineral-like,
matter that occurs naturally
as part of our planet