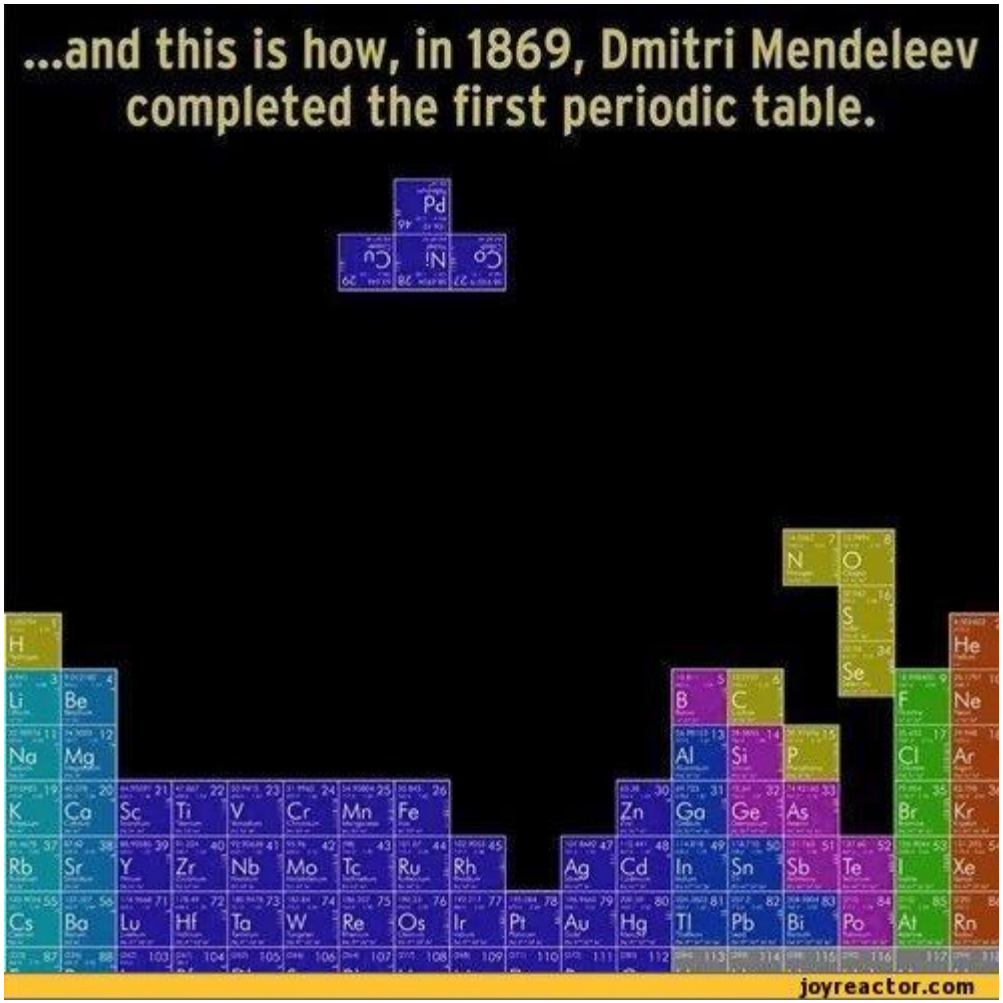
Sec 4
Science and Technology

WE'RE GETTING THERE…



Review: Periodic Table

Periodic Table

- A means of **organizing** chemical elements
  - A visual representation
- Elements are organized:
  - 1) according to the number of **electron shells** they possess (or **Periods**)
  - 2) according to the number of **valence electrons** they possess (or **Groups**)

Groups? Periods?

Groups

Periods

Periodic Table of the Elements

Atomic Number
Symbol
Name
Atomic Mass

1 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 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 H Hydrogen 1.008																	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 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 47.867	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 84.468	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 112.411	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 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	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 [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Fl Flerovium [289]	115 Uup Ununpentium unknown	116 Lv Livermorium [298]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown

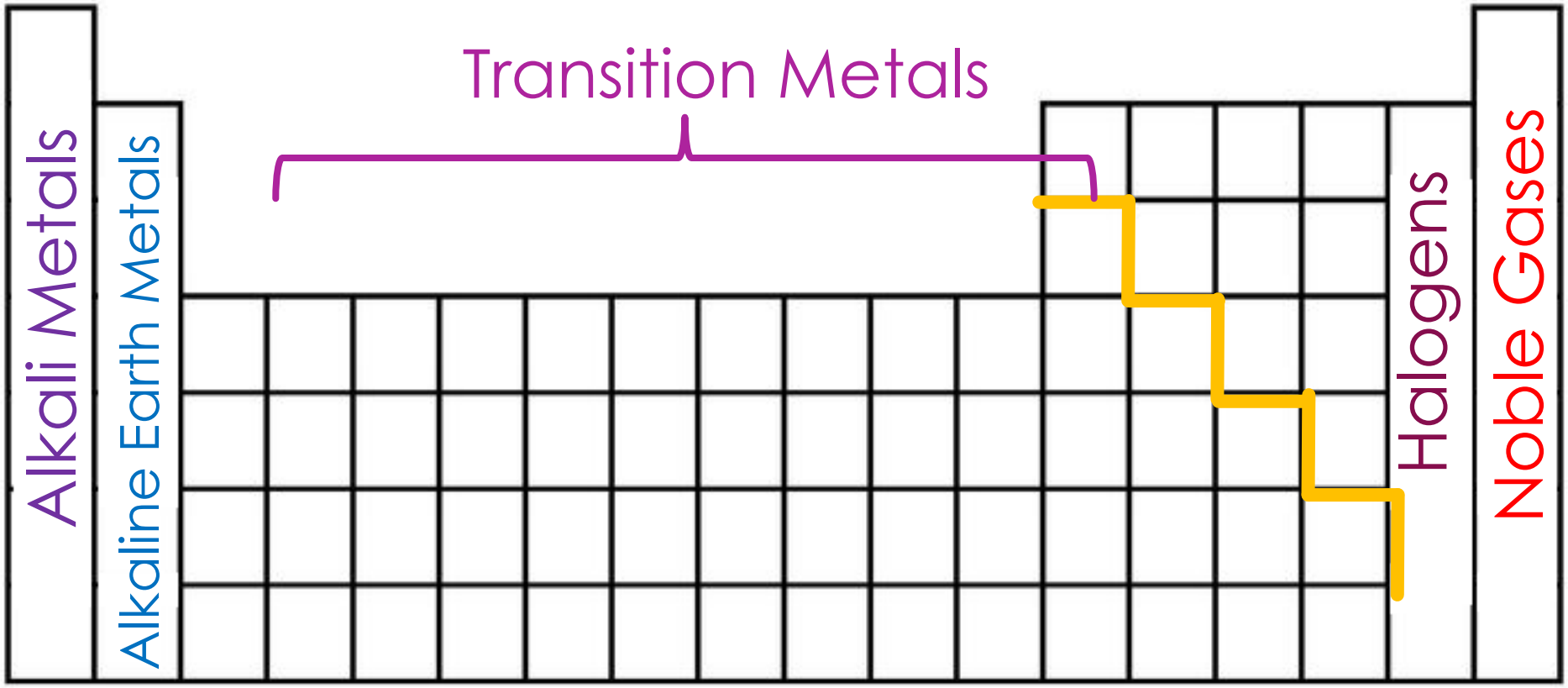
Lanthanide Series	57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69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

Alkali Metal | Alkaline Earth | Transition Metal | Basic Metal | Semimetal | Nonmetal | Halogen | Noble Gas | Lanthanide | Actinide

Groups vs Periods

- **Groups (Families):**
  - **Columns** (vertical)
  - The elements share similar **characteristics** due to the fact that they have the **same number of valence electrons**
    - **Valence electrons**: electrons in **outermost energy shell**

Group names & characteristics



Families (Groups)

Alkali metals:

- has all the characteristics of **metals** (lustre, ductility, malleability, etc)
- **most reactive** family because has only **1 ve** (valence electron)
- **H is not part of the family**
  - put there because it has 1 ve but is a **non-metal**

Families

Alkaline Earth metals:

- Basically the same as the **alkali metals** **BUT** **less reactive** because they have **2 ve**

Families

Halogens:

- **Non-metals**
- Halogen + metal = **salt**
- Used as **antiseptics** (to disinfect/kill bacteria)
  - Think about putting chlorine in a pool

Families

Noble/Inert gases:

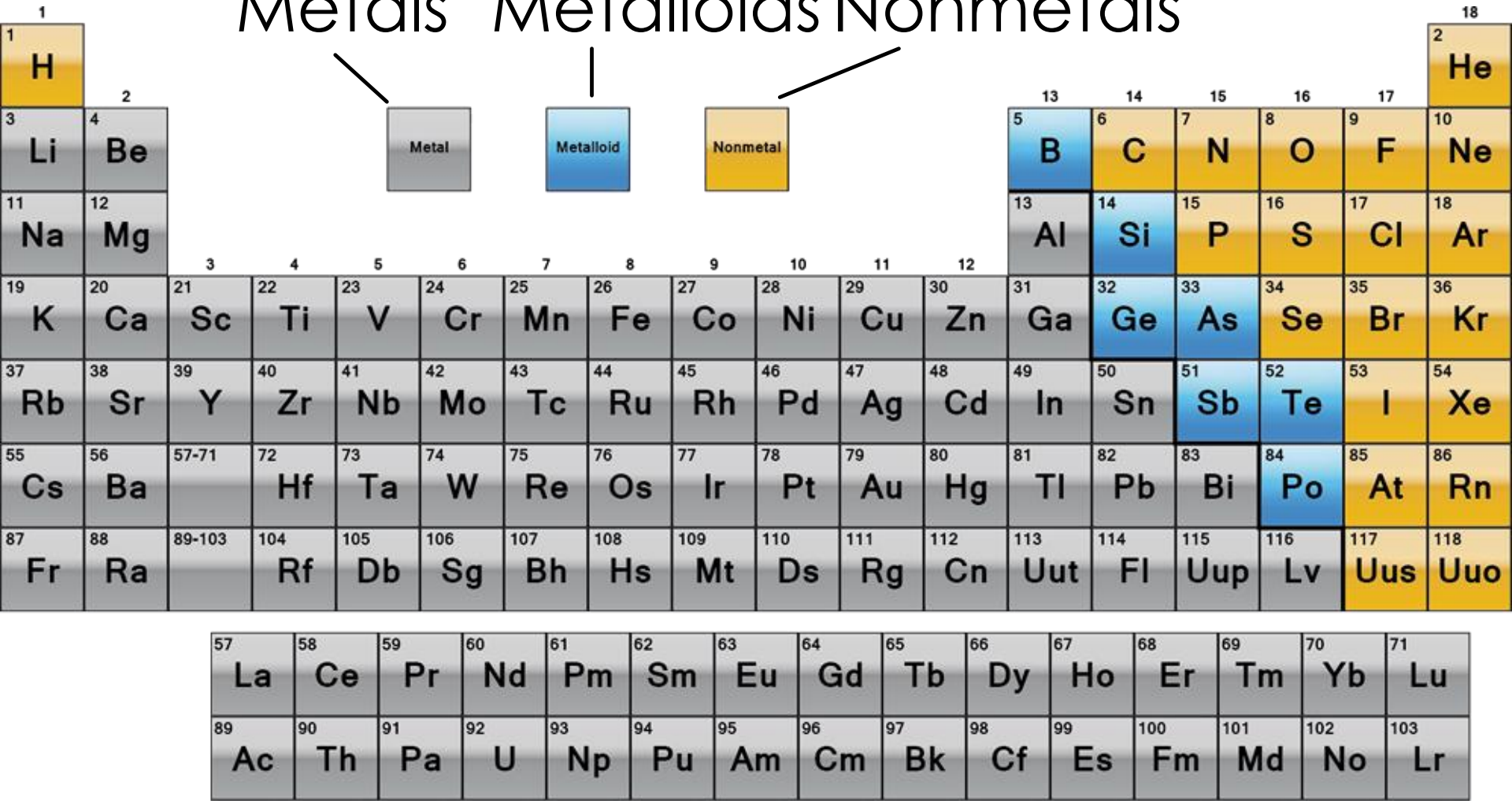
- Produce a **bright light** when electricity is passed through them
  - Neon signs
- **Outermost electron shell is full**
  - Do **NOT react** at all (do not give or receive electrons)
    - Means they are **stable**

Groups vs Periods

- **Periods (orbits, shells, energy levels):**
  - **Rows** (horizontal)
  - The elements share the same **number of total electron shells**

Period 1 1 shell	Hydrogen H	**Group 2A**	**Group 3A**	**Group 4A**	**Group 5A**	**Group 6A**	**Group 7A**	Helium He
Period 2 2 shells	Lithium Li	Beryllium Be	Boron B	Carbon C	Nitrogen N	Oxygen O	Fluorine F	Neon Ne
Period 3 3 shells	Sodium Na	Magnesium Mg	Aluminum Al	Silicon Si	Phosphorus P	Sulfur S	Chlorine Cl	Argon Ar

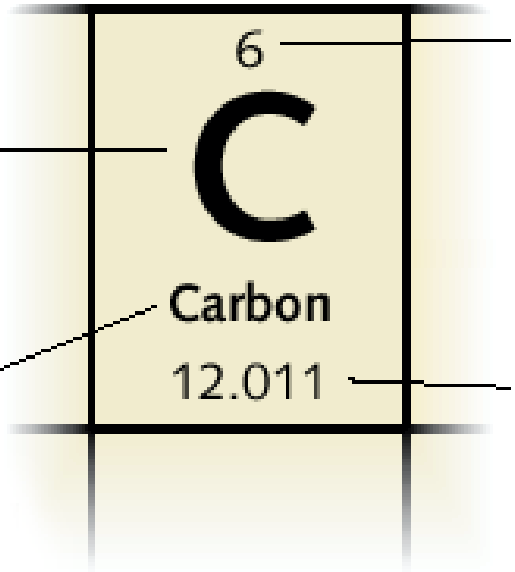
Metals Metalloids Nonmetals



Reading the Periodic Table

Symbol
A one- or two-letter abbreviation derived from the element's English or Latin name.

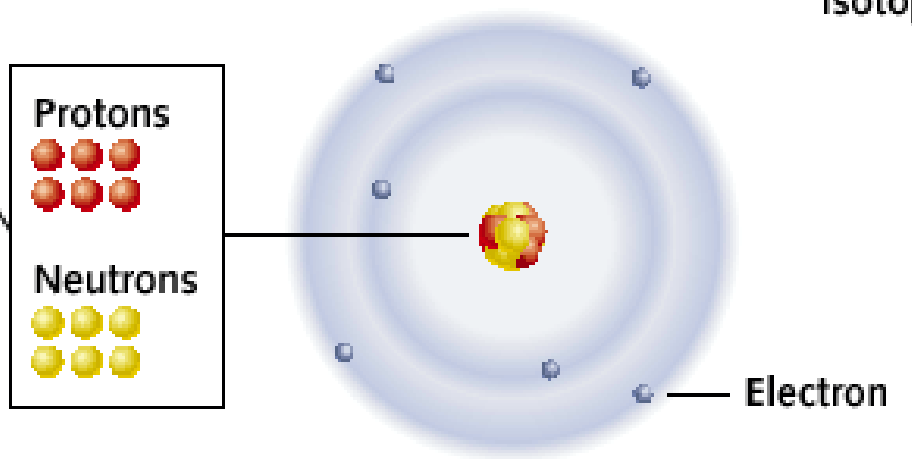
Name
Element's common name.



Atomic Number
Equal to the number of protons in the nucleus, as well as the number of electrons in the electron cloud.

Atomic Mass
Weighted average of the masses of all the element's isotopes. Rounding the atomic mass to the nearest whole number yields the mass number of the most common isotope.

Mass Number
The sum of the numbers of protons and neutrons in a specific isotope.



Carbon Atom

Examples

- Give me the period # and group name for each of the following elements:
  - Helium Period 1, noble gases
  - Magnesium Period 3, alkaline earth met.
  - Potassium Period 4, alkali metals
  - Chlorine Period 3, halogens
  - Sulfur Period 3, oxygen family

Examples

- Name the element:
  - 4 valence electrons, period 2

    Carbon (C)
  - Alkaline earth metal, 3 electron shells

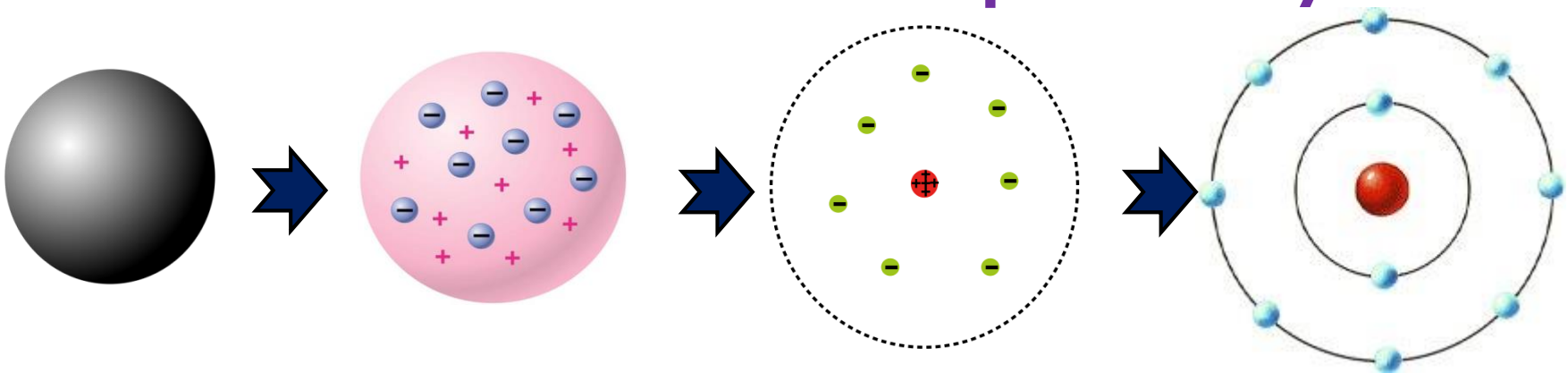
    Magnesium (Mg)
  - 2 energy levels, 7 valence electrons

    Fluorine (F)

Review: Atomic Models

Atomic Models Through History

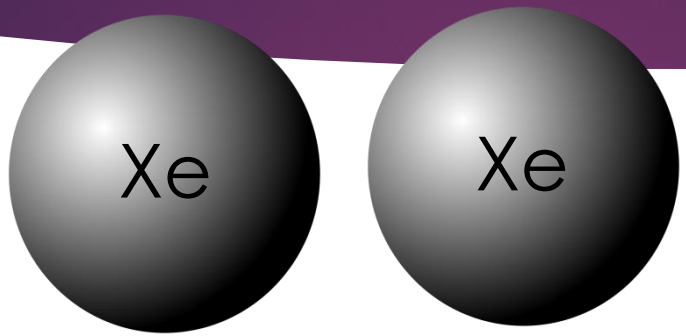
- Dalton's model – **solid sphere**
- Thomson's model – **plum pudding**
- Rutherford's model – **mostly empty space**
- Rutherford-Bohr model – **planetary atom**



Dalton's Atomic Model
1803

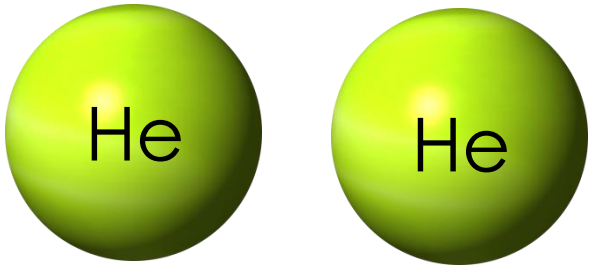
- Matter is composed of **tiny indivisible particles** called atoms.
  - **Atoms** are the **smallest units of matter**; they cannot be broken up further
- All atoms of a **single element** are **identical**
  - All He atoms are identical; all Xe atoms are identical, etc
- The atoms of **different elements** are **different**
  - He atoms are different from Xe atoms

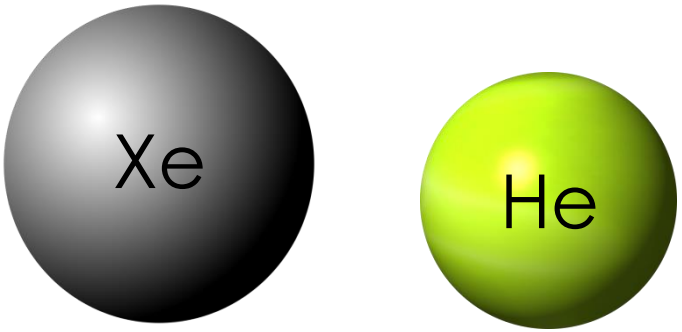
Dalton's Atomic Model
1803



Identical

Identical



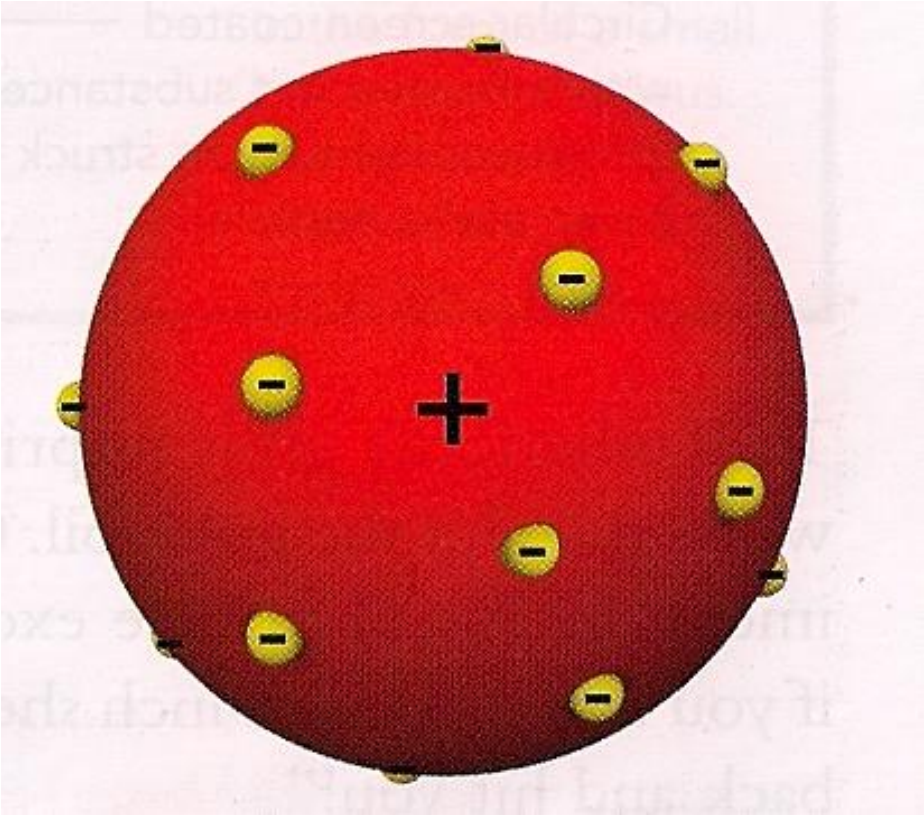


Different

Thomson's Atomic Model
1897

- The atom is a **positively (+) charged sphere** with **negatively (-) charged electrons** imbedded in it
  - Like raisins in plum pudding or chocolate chips in a cookie
- The positive and negative charges cancel out, making it **neutral**
- Atoms are **divisible**
  - Atoms can be broken down

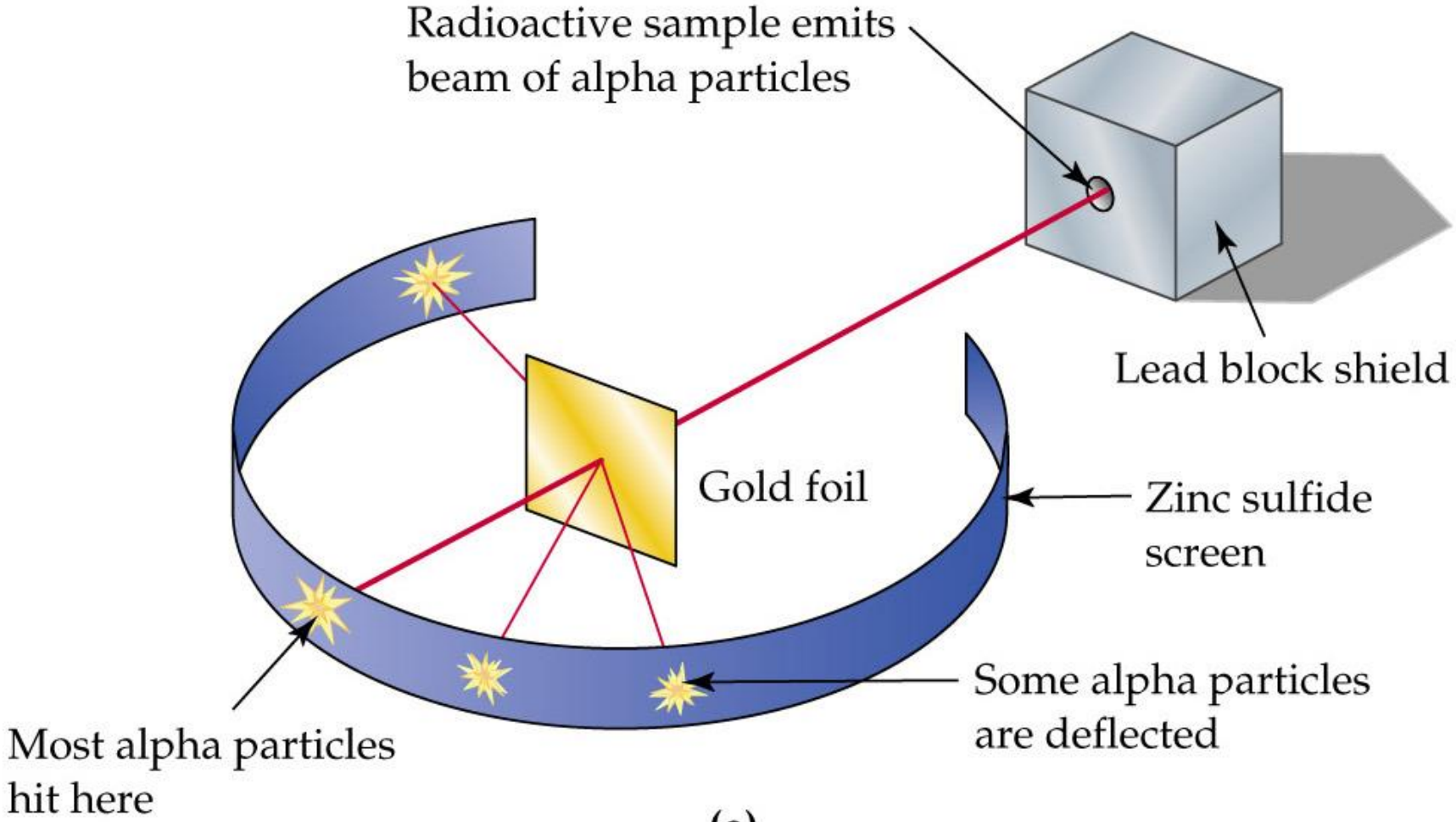
Thomson's Atomic Model
1897



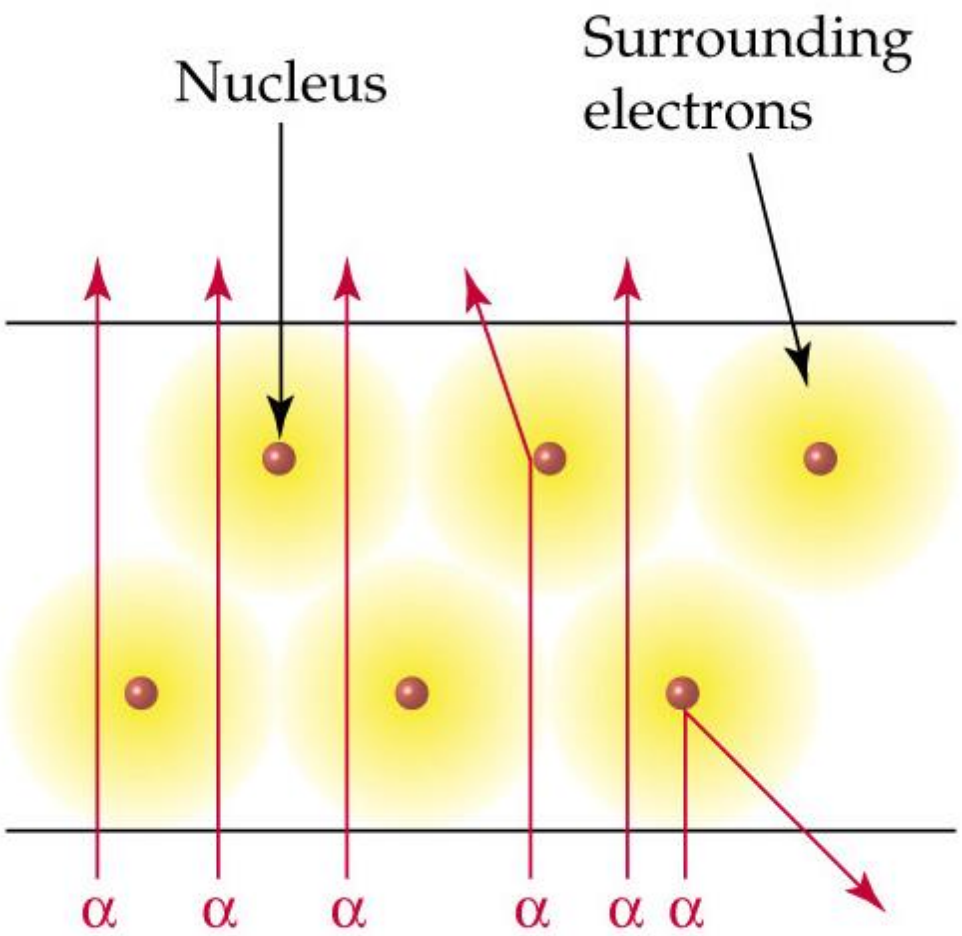
Gold Foil Experiment

Fun fact: Rutherford worked at McGill!

- Rutherford bombarded gold foil with alpha (+) particles
- Noticed that **most** of the particles went through in a **straight line**
- But **some** were **deflected**
  - This meant they were **hitting something** more massive than themselves
- **Conclusion:** atom must be made up **mostly of empty space**, with small electrons floating around and a more **massive central positive (+) nucleus**


Radioactive sample emits beam of alpha particles
Lead block shield
Gold foil
Zinc sulfide screen
Some alpha particles are deflected
Most alpha particles hit here

(a)



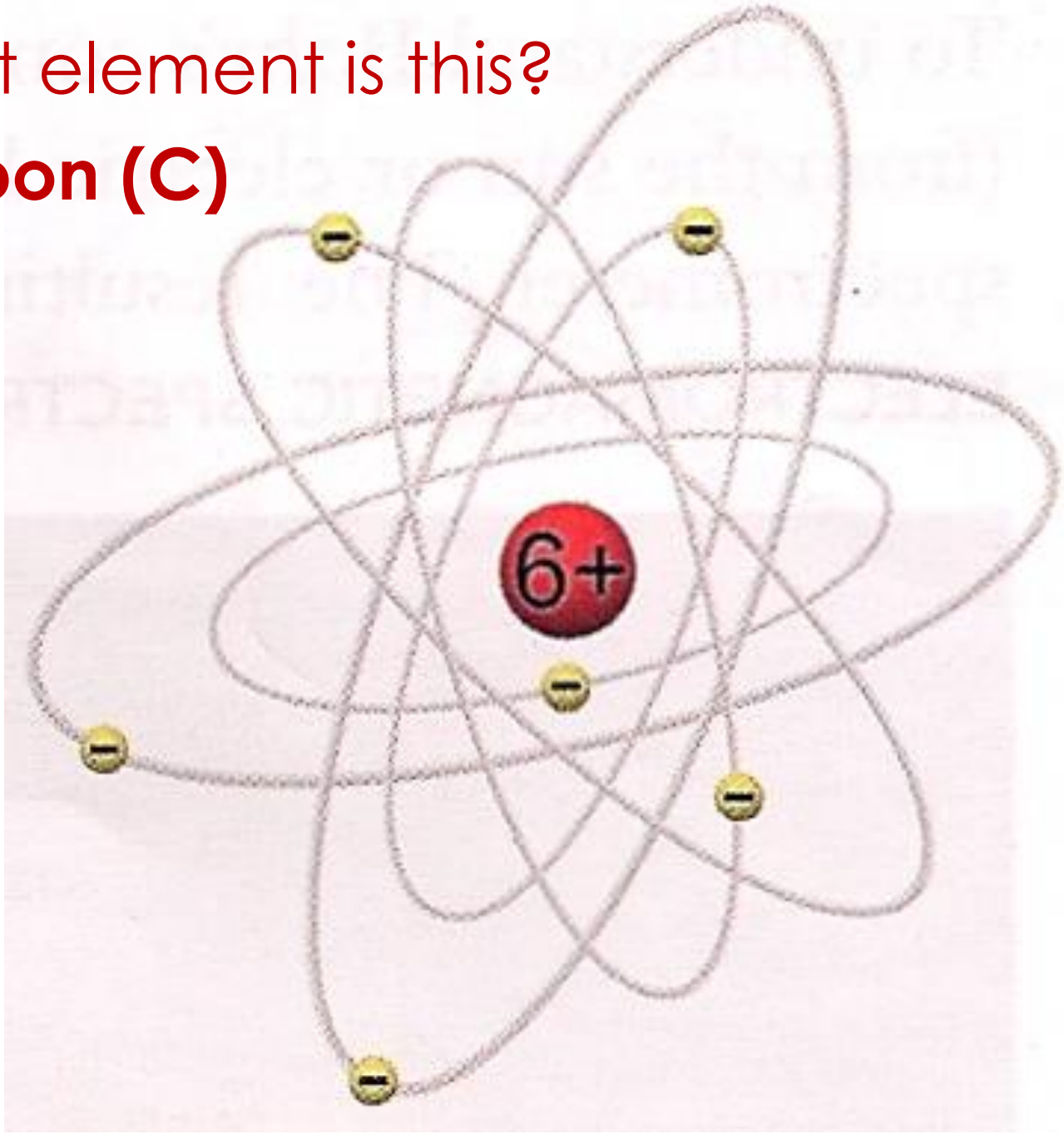
Source of particles

Rutherford's Atomic Model
1911

- The atom is **mostly empty space**
- There is a **dense structure in middle *(nucleus)*** which contains the **positive charge**
  - Positive charge particles = ***Protons***
- An equal number of ***electrons*** circle the nucleus, so the overall charge is neutral

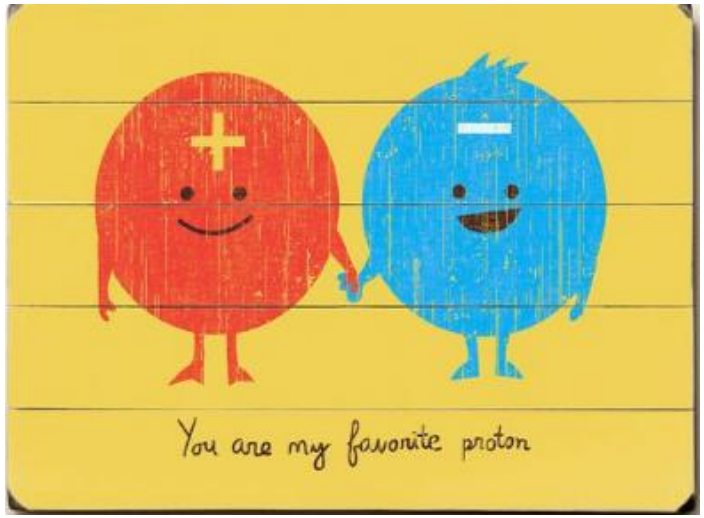
What element is this?

Carbon (C)



Problems with Rutherford's Model

- Since opposite charges attract each other; wouldn't the atom collapse?
- What prevents the (-) electrons from crashing into the (+) protons?

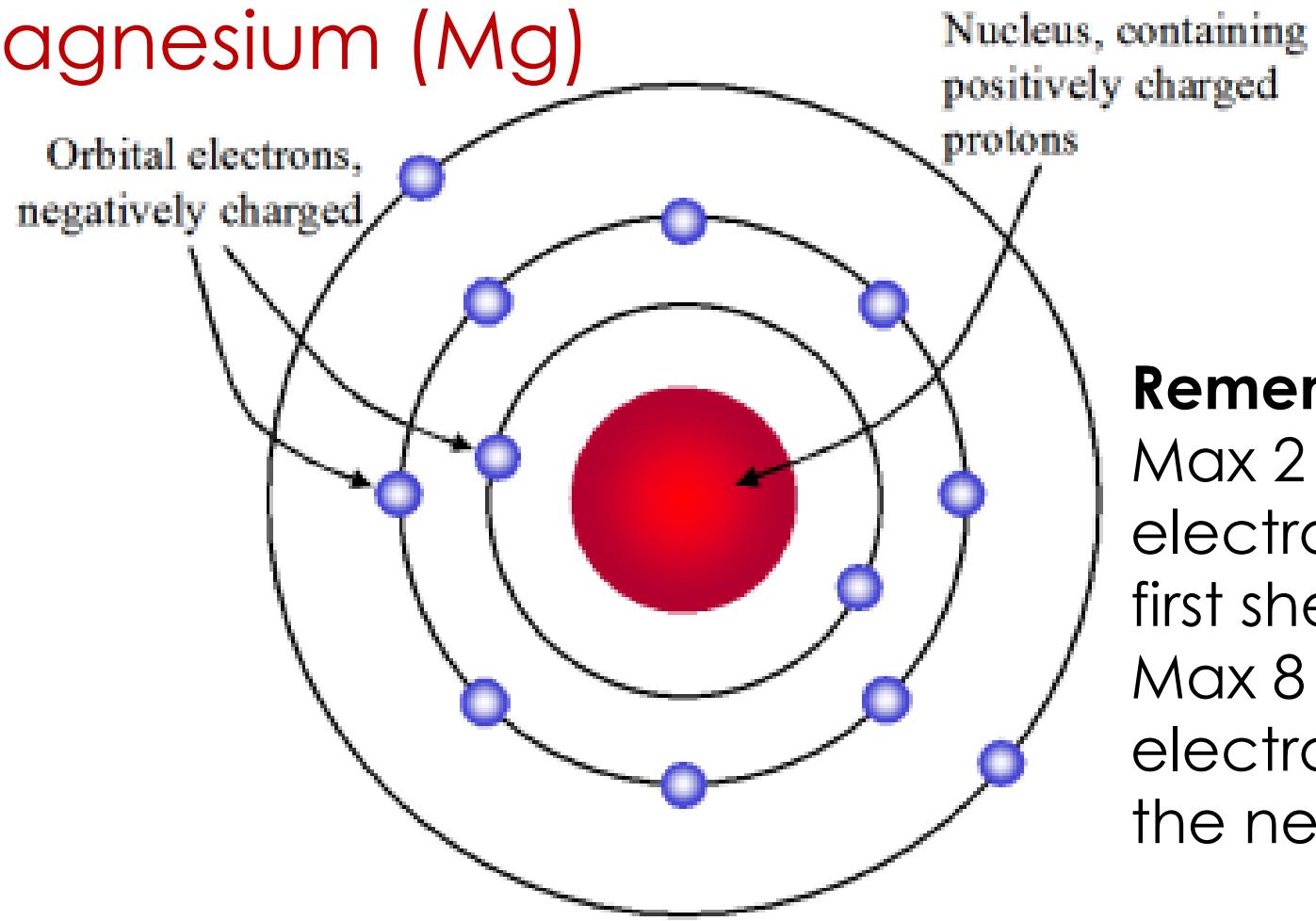


Rutherford-Bohr Atomic Model 1913

- Bohr discovered that electrons must be in **specific orbitals** around nucleus
- Electrons closer to the nucleus are harder to remove (stronger attraction)
- Electrons further away from the nucleus are easier to remove (weaker attraction)

Assuming a neutral atom, what element is this?

Magnesium (Mg)

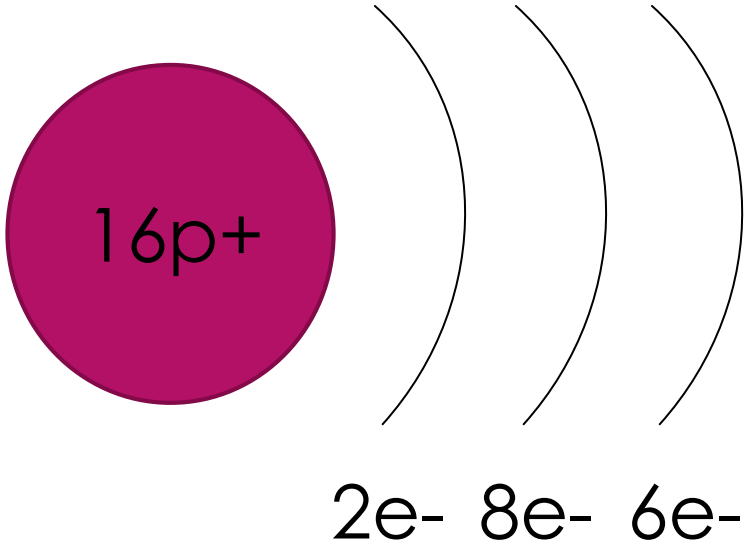


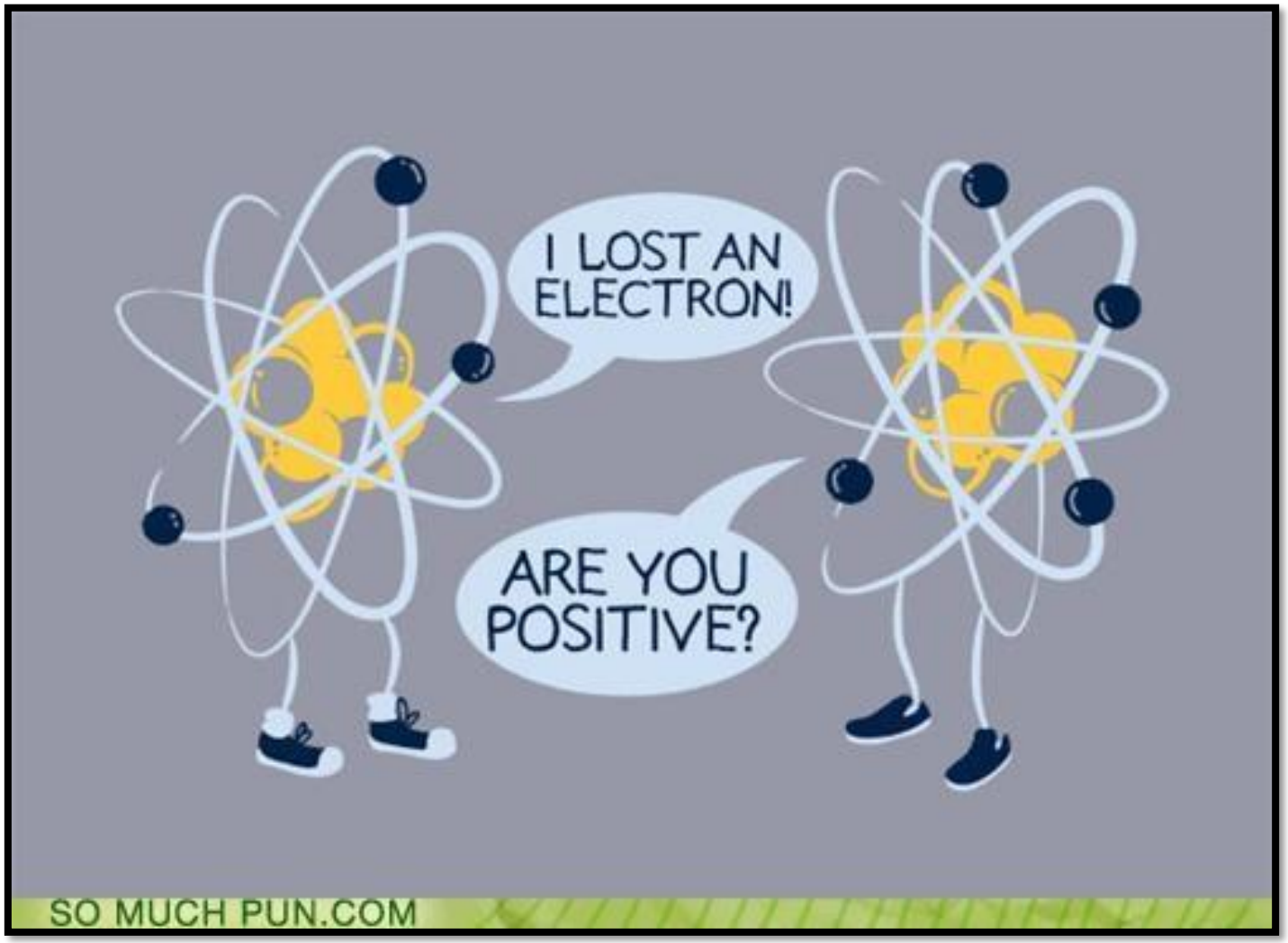
Remember:
Max 2 electrons in first shell
Max 8 electrons in the next ones

"The Planetary Model"

Example

Let's draw the Rutherford-Bohr model of Sulfur





Ions

Ions

- *What is an ion?*
  - An atom that has a **charge** because it either **gained or lost** one or more **electrons**
  - If it **gained** an electron its charge will be…
    - **Negative!**
  - If it **lost** an electron its charge will be…
    - **Positive!**

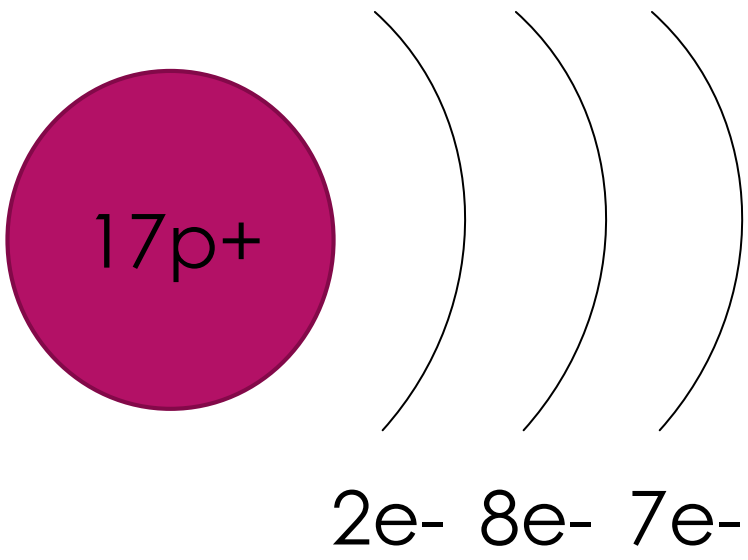
Ions

- An atom that does not satisfy the **octet rule** (full outer shell) is unstable
  - **It wants to stabilize!**
- Each element will either lose or gain electrons in order to achieve this stability
  - Ion most likely to form is the one that allows for the **easiest transition to a full outer shell**

+1	+2						+3	+4 -4	-3	-2	-1	0
IA	IIA						IIIA	IVA	VA	VIA	VIIA	VIIIA
1 H											1 H	2 He
3 Li	4 Be						5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg						13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti		29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr		47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf		79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf		111	112		114		116		118

Example

Let's draw the Rutherford-Bohr model of neutral Chlorine

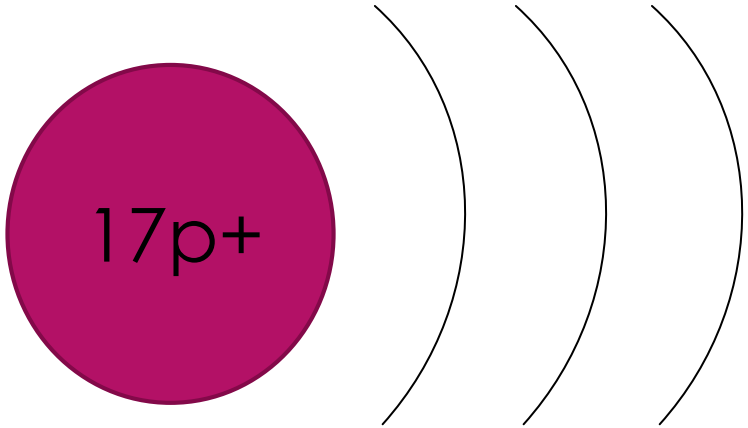


FYI This is the simplified model

Example

Let's draw the Rutherford-Bohr model of Cl^{-1}

Means has an extra e-

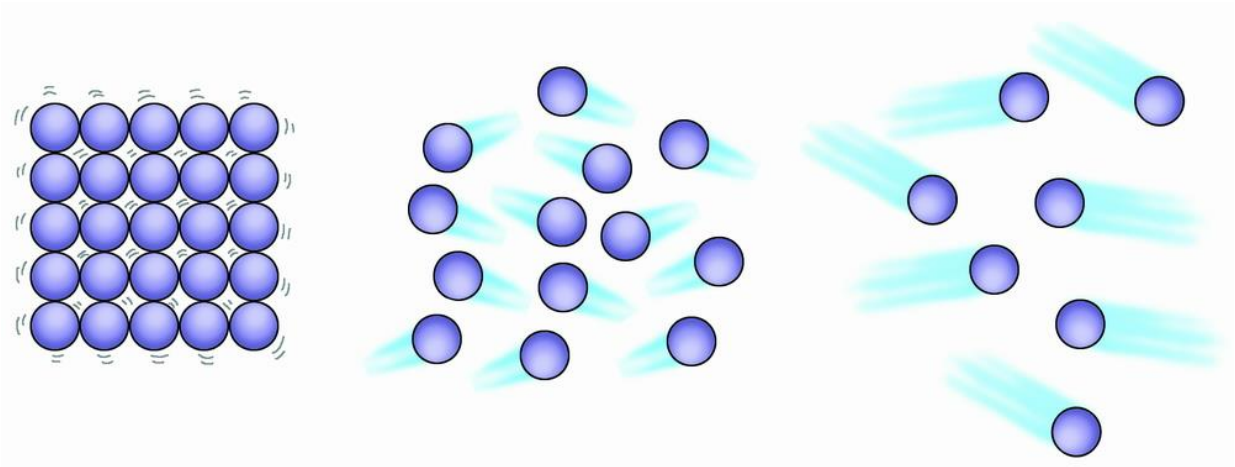


17p+
18e- → -1

Particle Model and Balancing Equations

Particle Model

- You've done this since sec 1
  - Used for the different phases of matter



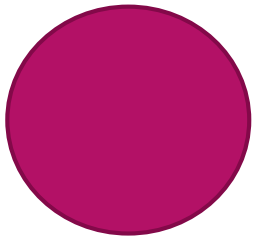
- We use shapes (often circles/spheres) to represent an atom of a particular element

Rules for Chemical Equations

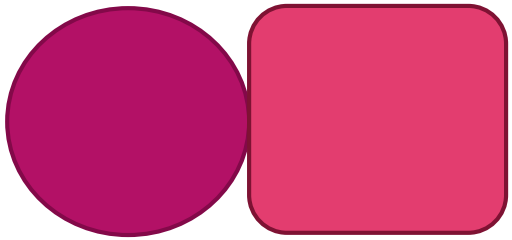
- 1) Look for **capital (uppercase) letters** to determine how many different elements are present
- 2) within a particular molecule, use different shapes to represent different elements
- 3) **subscript** numbers tell you how many **atoms** of each element are present in **1 molecule**
- 4) stoichiometric coefficient (**numbers in front)** tell you how many **total molecules** there are

How would you represent the following molecules/atoms using the particle model?

Na



NaCl

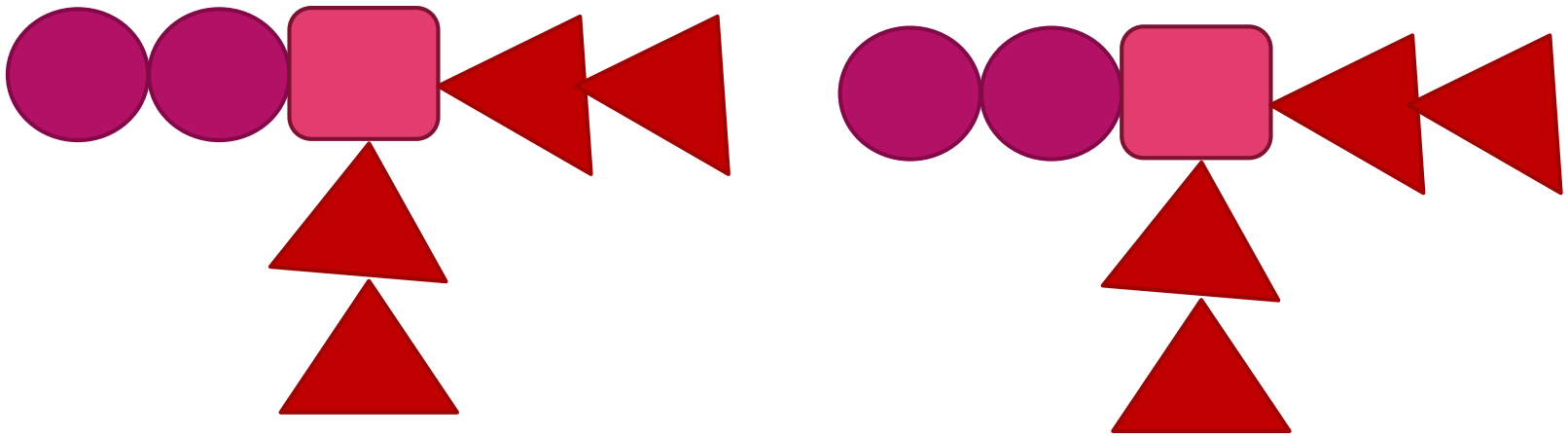


H_2O

Remember: Every time you see a capital letter, it's a new element. The subscript tells you how many of each element there is.

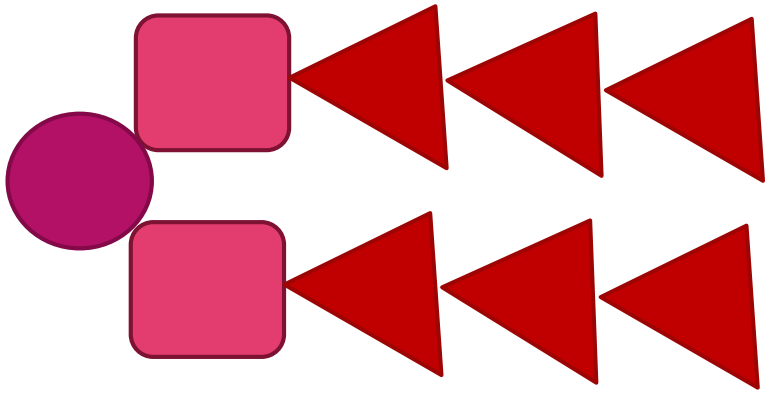
How would you represent the following molecules/atoms using the particle model?

$2\ H_2SO_4$



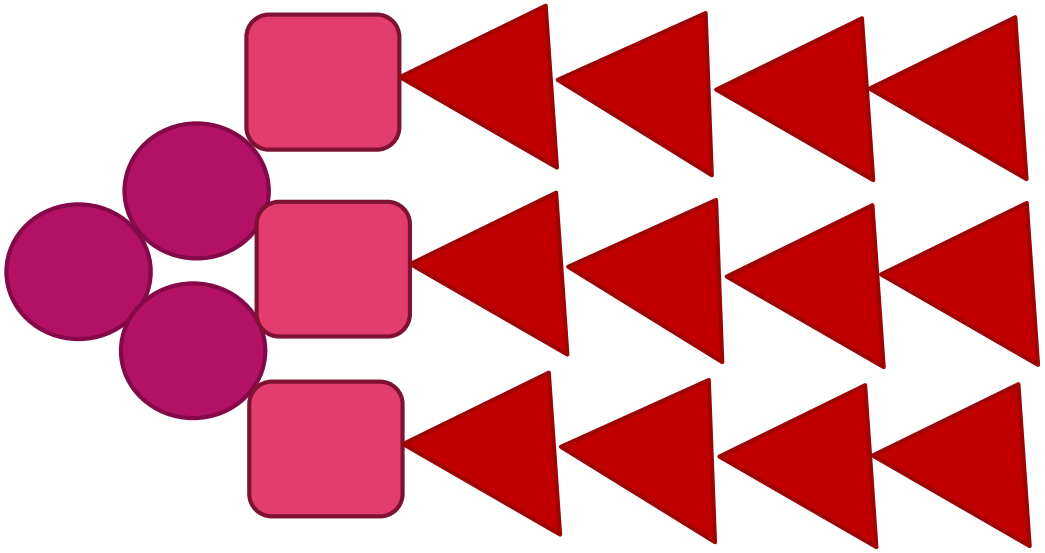
How would you represent the following molecules/atoms using the particle model?

$Cu(NO_3)_2$



How would you represent the following molecules/atoms using the particle model?

$Ca_3(PO_4)_3$



Balancing Equations

- All about the **conservation of matter**
- Rules:
  - 1) The **type of atoms** stays **constant** before and after the reaction
    - If you have Fe before, it has to be there after
  - 2) The **number of atoms of each element** stays **constant** before and after the reaction
    - If you had 3 Al before, you have to have 3 Al after
  - 3) The **total mass** of atoms stays **constant** before and after the reaction
    - If there was a total of 125g of matter before, there has to be 125g after

Examples

- 1) $2\,H_2 + O_2 \rightarrow 2\,H_2O$
- 2) $2\,N_2 + 5\,O_2 \rightarrow 2\,N_2O_5$
- 3) $2\,P + 3\,Cl_2 \rightarrow 2\,PCl_3$

Law of Conservation of Mass

- Steps to follow:
  - 1) Write out the reaction
  - 2) Figure out masses of reactants and products
  - 3) Calculate missing value(s)

Example

- You combined 80 g of 2 KOH with 100 g of H_2SO_4 to produce 120 g of K_2SO_4 and 2 H_2O. How much water was produced?

$$2\ KOH + H_2SO_4 \rightarrow K_2SO_4 + 2\ H_2O$$

80g 100g 120g Xg

$$180g = 120g + Xg$$

$$180g - 120g = Xg$$

$$60g = Xg$$

Let's see what you remember from part 1

Review Part 1

1. Oxygen forms an O^{2-} ion. Which of the following statements is correct?

A) The oxygen atom loses 2 protons to form its ion.

B) The oxygen atom loses 2 electrons to form its ion.

C) The oxygen atom gains 2 electrons to form its ion.

D) Oxygen neither gains nor loses electrons when forming its ion.

Review Part 1

2. What mass of ammonia (NH_3) is produced when 6 g of hydrogen gas (H_2) combines with 28 g of nitrogen gas (N_2)?

$$N_2 + 3\ H_2 \rightarrow 2\ NH_3$$

- A) 6 g
- B) 23 g
- C) 34 g
- D) 46 g

Review Part 1

3. The following model represents a balanced equation for a reaction involving a piece of magnesium metal and hydrochloric acid.

- Which of the following equations correctly represents this reaction?

A) $Mg + HCl \rightarrow H_2 + MgCl_2$

B) $Mg + H_2Cl_2 \rightarrow H_2 + MgCl_2$

C) $Mg + 2\,HCl \rightarrow 2\,H_2 + MgCl_2$

D) $Mg + H_2Cl_2 \rightarrow 2\,H_2 + 2\,MgCl_2$

Review Part 1

4. Which of the following equations is balanced?

A) $2\ Fe_2O_3 + 3\ C \rightarrow 3\ CO_2 + 2\ Fe$

B) $CH_4 + O_2 \rightarrow CO_2 + 2\ H_2O$

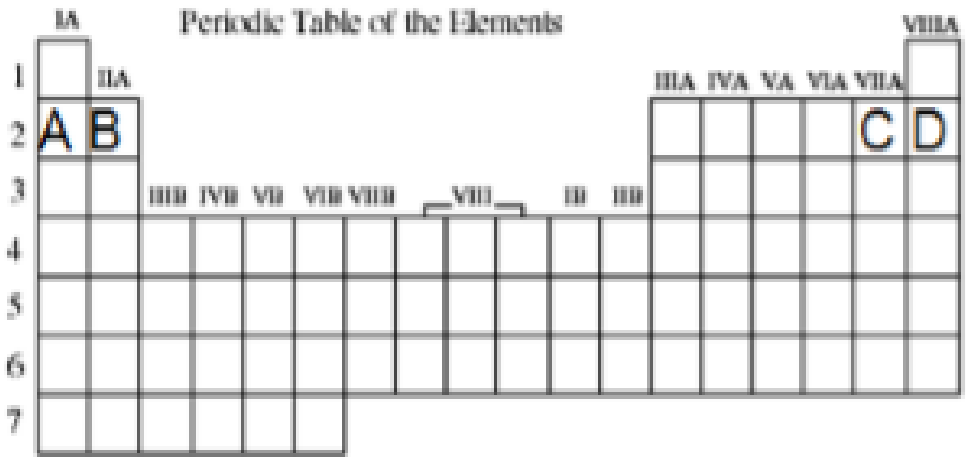
C) $Cu + 4\ HNO_3 \rightarrow Cu(NO_3)_2 + 4\ NO_2 + 2\ H_2O$

D) $4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O$

Review Part 1

5. An element is examined in the laboratory. Despite several attempts it doesn't seem to react with any other substance. It is a gas at room temperature. Which letter best represents where this element would be located in the periodic table?

- A
- B
- C
- D



Review Part 1

6. Which element below has the following properties?

- - Has electrons in 2 electron shells
- - Is completely non-reactive or is inactive

A) Li

B) F

C) He

D) Ne