**Recitation, Week 3, Fall 2020** -- SOLUTIONS

I. We mentioned in class that the noble gases (the far right-hand column of the periodic table) are special in that they are not very reactive (in other words, they are "inert"). We will exploit that observation in class tomorrow (Wednesday) but for now, let's consider this special group of elements that exist in nature as atoms.

A. For each of the following noble gases, assume that the mass number of the most common isotope is the whole number closest to the average atomic mass. For example, for krypton the average atomic mass is 83.80, so we would assume that the mass number for the most common isotope is 84. Now give the number of protons and neutrons for that isotope.

1. helium number of protons **2** number of neutrons 4 – 2 = **2**

The atomic number (Z) of helium is 2, so a helium atom has 2 protons. A – Z = # neutrons; 4 – 2 = 2

2. neon number of protons **10** number of neutrons 20 – 10 = **10**

3. argon number of protons **18** number of neutrons 40 – 18 = **22**

4. krypton number of protons **36** number of neutrons 84 – 36 = **48**

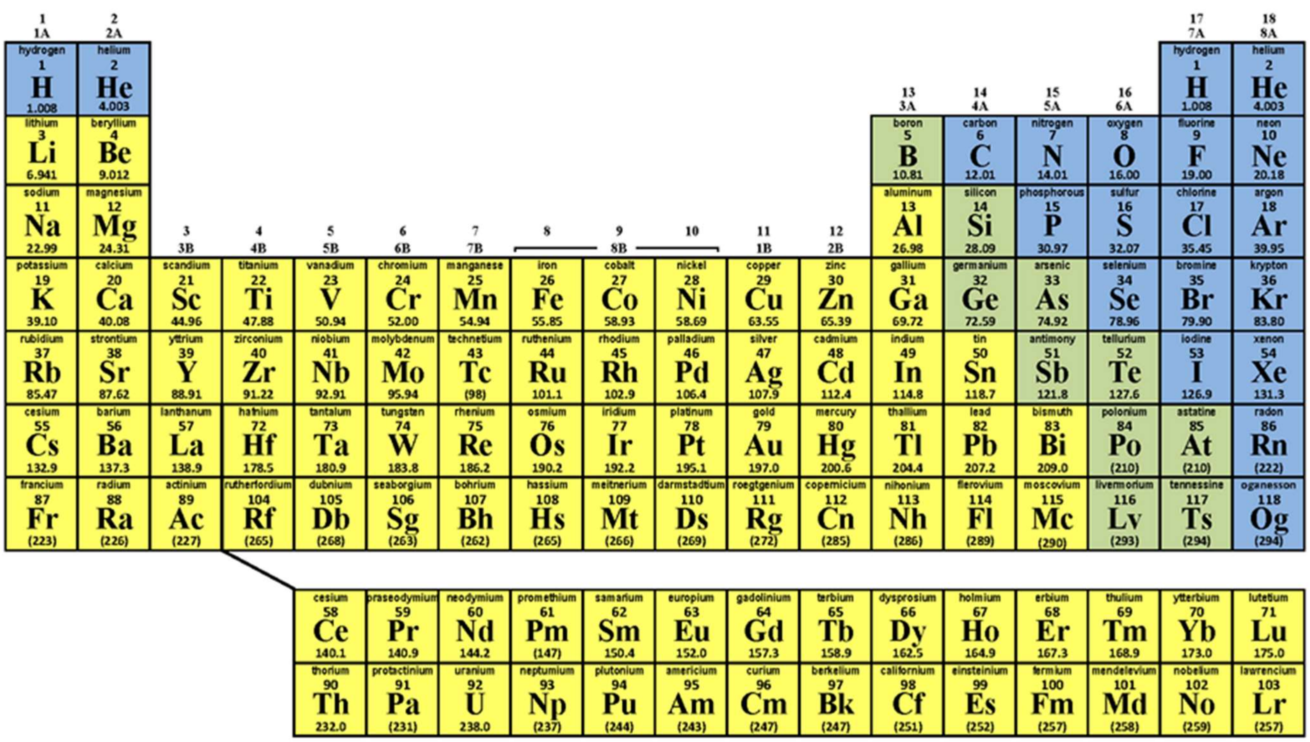
5. xenon number of protons **54** number of neutrons 131 – 54 = **77**

B. As you look over your answers to Part A, you should notice a trend (other than the obvious trends that the mass number, the number of protons, and the number of neutrons all increase as you go down the periodic table). Describe any other trend(s) you notice, and suggest an explanation for that trend.

As we go down the periodic table, the number of neutrons increases faster that the number of protons. For helium and neon, the number of protons and neutrons are equal, but there are increasingly more neutrons than protons as you go down from neon, with xenon having 40 percent more neutrons in the nucleus than protons.

C. Are there any circumstances where the mass number of the most common isotope ***would not be*** the whole number closest to the average atomic mass? If so, explain.

As you increase the number of protons in the nucleus, you need increasingly more neutrons to "dilute" the repulsive force of all those positively charged particles in such a small space.



II. What is the difference between sulfur-32 and sulfur-34 in terms of physical and/or chemical properties? In other words, what measurable difference(s) would you expect to observe between sulfur-32 and sulfur-34 and their compounds?

Sulfur-32 and sulfur-34 are isotopes. The have the same number of protons, so both are sulfur, and they should exhibit the same chemical properties. But sulfur-34 has two more neutrons than sulfur-32, so sulfur-34 atoms will be a little heavier, and compounds containing $^{34}S$ will be a little heavier and more dense than the same compound containing $^{32}S$.

Geologists at the University of Cincinnati used isotopes to track the distribution of sulfur in plants in the Caribbean island of Trinidad (*Applied Geochemistry* **2019**, 108). They found that the ratio of sulfur-34 to sulfur-32 tended to decrease as they moved inland and away from the ocean shore. Speculate on why this trend was observed.

Several possible explanations; here's one: The relative about of sulfur-34 in the plants decreased compared to sulfur-32 as you go inland, so sulfur compound taken up by the plants are blown in from the ocean or carried on sea mist, and the heavier sulfur-34 compounds to not drift as far inland before falling to the ground.

III. Concerns about vitamin D deficiency have received a great deal of attention over the last few years as it was discovered that a significant number of people are deficient in this important vitamin. Adults identified to have insufficient amounts of vitamin D are often recommended to take a daily supplement containing 2000 IU (International Units) of vitamin D, which corresponds to 50 $\mu$g. (The IU to mass conversion varies with different drugs and vitamins since the IU reflects the potency of the drug.)

> ***Note:*** Problem 14 is from Fall 2009. The assertion that "a significant number of people are deficient" in vitamin D has been challenged since then; see, for example:
> https://www.sciencealert.com/the-largest-ever-clinical-study-on-vitamin-d-shows-we-re-wrong-about-its-benefits

The annual production of vitamin D is roughly 10 ton per year. Assuming all of this vitamin D was used to manufacture pills containing 50 $\mu$g of the vitamin per pill, and that these pills are sold in bottles containing 100 pills per bottle, how many bottles could be produced in one year?

| 10 ton | 2000 lb | 453.6 g | $10^6$ $\mu$g | 1 pill | 1 bottle | $1.81... \times 10^9$ bottles |
|---|---|---|---|---|---|---|
| | ton | lb | g | 50 $\mu$g | 100 pills | |

=> $2 \times 10^9$ bottles

IV. (*Part 1, more fun with density*) The National Oceanic and Atmospheric Administration (NOAA) and its predecessor tried an experiment to weaken hurricanes by dropping silver iodide into the rainbands of the storms. Small particles of AgI are produced in combustion generators using a fuel such as acetone. These generators vaporize the AgI, and as the vapor cools, very small particles form with diameters around 0.01 mm to 0.1 mm. Let's assume 25 g of AgI was used to generate particles by this method. How many particles would be formed? (The density of silver iodide is 6.75 g/cm$^3$.)

First, let's calculate the mass of a "typical" AgI particle by assuming a size of 0.05 mm, assuming the particles to be spherical. You may have taken a different approach. That's okay, as long as your assumptions and approximations are reasonable.

$V = {}^4/_3\pi r^3 = {}^4/_3(3.14159)(0.05/2)^3 = 6._5 \times 10^{-5}\ mm^3 \times (1\ cm/10\ mm)^3 = 6._5 \times 10^{-8}\ cm^3$

Therefore, the mass of a typical sphere would be $6._5 \times 10^{-8}\ cm^3 \times (6.75\ g\ AgI/1\ cm^3)$

$= 4._4 \times 10^{-7}$ g AgI

So the number of particles would be 25 g AgI x (1 particle/$4._4 \times 10^{-7}$ g AgI) = **$5._7 \times 10^7$ particles**

## Selected Constants, Conversion Factors, Equations, and Other Data

| Prefix | Symbol | Factor | Example |
|---|---|---|---|
| femto | f | $10^{-15}$ | 1 femtosecond (fs) = $1 \times 10^{-15}$ s (0.000000000000001 s) |
| pico | p | $10^{-12}$ | 1 picometer (pm) = $1 \times 10^{-12}$ m (0.000000000001 m) |
| nano | n | $10^{-9}$ | 4 nanograms (ng) = $4 \times 10^{-9}$ g (0.000000004 g) |
| micro | μ | $10^{-6}$ | 1 microliter (μL) = $1 \times 10^{-6}$ L (0.000001 L) |
| milli | m | $10^{-3}$ | 2 millimoles (mmol) = $2 \times 10^{-3}$ mol (0.002 mol) |
| centi | c | $10^{-2}$ | 7 centimeters (cm) = $7 \times 10^{-2}$ m (0.07 m) |
| deci | d | $10^{-1}$ | 1 deciliter (dL) = $1 \times 10^{-1}$ L (0.1 L ) |
| kilo | k | $10^{3}$ | 1 kilometer (km) = $1 \times 10^{3}$ m(1000 m) |
| mega | M | $10^{6}$ | 3 megahertz (MHz) = $3 \times 10^{6}$ Hz (3,000,000 Hz) |
| giga | G | $10^{9}$ | 8 gigayears (Gyr) = $8 \times 10^{9}$ yr (8,000,000,000 Gyr) |
| tera | T | $10^{12}$ | 5 terawatts (TW) = $5 \times 10^{12}$ W (5,000,000,000,000 W) |

**mass**

1 lb = 453.6 g
1 amu = $1.66 \times 10^{-24}$ g
1 ton = 2000 lb

**length**

1 inch ≡ 2.54 cm (exact)
1 yard = 3 feet
1 angstrom (Å) = $1 \times 10^{-10}$ m
1 foot = 12 inches
1 mile = 1.609 km

**volume**

1 $cm^3$ = 1 mL
1 gallon = 3.785 L
1 $m^3$ = 1000 L
1 mL = 0.033814 fl oz
1 gallon = 4 quarts = 8 pints = 16 cups = 128 fl oz
1 $ft^3$ = 28.3168 L