1. (3 points) Although there is only one naturally occurring isotope of gold, $^{197}\text{Au}$, the atomic mass of gold given in the modern periodic table is 196.96655, but not 197. Explain.

$^{197}\text{Au}$ is the mass number which is an exact number. It is defined as the sum of the numbers of protons and neutrons in the nucleus of one atom of the isotope.

196.96655, the number given below the element’s symbol in the periodic table, is the atomic weight of gold in amu which is a measured number. In case of gold, 196.96655 amu is also the mass of individual gold atoms as there is only one naturally occurring isotope of gold in nature.

2. (3 points) On the old atomic mass scale used by physicists, the mass of oxygen-16 atom was assigned to be exactly 16 amu. What would be the mass of one atom of gold on that scale? Show work.

\[
\frac{^{16}\text{O}}{107} = \frac{196.96655 \text{ amu}}{15.994915 \text{ amu}} = \frac{^{16}\text{O}}{16} = \frac{X \text{ amu}}{16 \text{ (exactly) amu}}
\]

\[
X = \frac{196.96655 \text{ amu} \times 16 \text{ amu}}{15.994915 \text{ amu}} = 197.029168 \text{ amu}
\]

3. (3 points) How many different types of CO$_2$ molecule exist in nature? Explain.

CO$_2$ is a linear molecule with the following arrangements of atoms: O=C=O. In nature, there are three isotopes of oxygen ($^{16}\text{O}$, $^{17}\text{O}$, and $^{18}\text{O}$) and two isotopes of carbon ($^{12}\text{C}$ and $^{13}\text{C}$). There could be 6 pairwise combinations for oxygen atoms ($^{16}\text{O}^{16}\text{O}$, $^{17}\text{O}^{17}\text{O}$, $^{18}\text{O}^{18}\text{O}$, $^{16}\text{O}^{17}\text{O}$, $^{16}\text{O}^{18}\text{O}$, and $^{17}\text{O}^{18}\text{O}$). Each of the six pairs can be combined an atom of either of the two isotopes of carbon. That gives the total $6 \times 2 = 12$ possible combinations of the three atoms.

What is the mass of the most common of those molecules?  43.9898 amu

What is the mass of the heaviest of those molecules?  49.0017 amu

What is the average mass of all those molecules?  44.0095 amu
4. (3 points) In the periodic table of elements, atomic weights for some elements are given with very many significant digits whereas for some other elements with considerably fewer.

(a) What kind of elements are those with the largest numbers of significant digits in their atomic weights?

Those that have a single isotope in nature.

(b) What kind of elements are those with the smallest numbers of significant digits in their atomic weights?

Those that have more than one isotope in nature and for which the relative abundance of atoms of different isotope varies significantly from one location in the Earth’s crust to another.

5. (3 points)

(a) Fill the blanks.

\[ \text{1 km} = \underline{10^5} \text{ cm} \quad \text{1 km}^2 = \underline{10^{10}} \text{ cm}^2 \quad \text{1 km}^3 = \underline{10^{15}} \text{ cm}^3 \]

(b) What is the edge of a cube in millimeters if the volume of that cube is \(1.25 \times 10^8 \text{ nm}^3\)?

Show work.

\[ V_{\text{cube}} = a^3 \]
\[ a = \sqrt[3]{V_{\text{cube}}} = \sqrt[3]{125 \times 10^6 \text{ nm}^3} = 5.00 \times 10^2 \text{ nm} \]
\[ 5.00 \times 10^2 \text{ nm} = 5.00 \times 10^{2-6} \text{ mm} = 5.00 \times 10^{-4} \text{ mm} \]