Chemistry 101 Name(s):

Exercise 1: A chemical and mathematical overview

You may work on these exercises individually or in groups; they may also be turned in individually or in groups, but, if you work in groups, you may wish to keep a copy for yourself for use on exams (no sharing of exercises during exams!).

Chemical overview

In this part of the exercise, you will use a set of simplified rules for bonding between atoms in molecules. Obtain a molecular model kit from the cart.

The **rules**:
- Yellow represents hydrogen
- Red represents oxygen
- Black represents carbon
- Blue represents nitrogen (some of these blue balls have five holes but use only **three adjacent holes**)
- Sticks and springs represent chemical bonds (which are merely a pair of shared electrons between atoms); length doesn't matter
- For a molecule to be "happy" (i.e., have all of its bonding requirements satisfied), all holes must be filled with bonds

1. So a nitrogen atom can only bond to three other atoms **maximum** (because you can only use three holes). What is the maximum number of atoms that **carbon** could bond to (hint: count holes)? That **oxygen** could bond to? That **hydrogen** could bond to?

2. Create the following molecules: water (H_2O), ammonia (NH_3) and methane (CH_4). What are the shapes of these molecules? Don't just draw the molecules; **describe** their shapes! Possible shape choices: **linear**, **bent**, **pyramidal**, **tetrahedral**.

3. By writing the chemical formula CH_4, what information about methane are you losing (so always keep this loss of information in mind)?

4. Create the molecule CO_2 (carbon dioxide). What type of bonds need to be used to fulfill the "fill every hole rule" (hint: you will need springs)? Is there more than one way to do this? The correct structure will not have any oxygen-oxygen bonds. What is the shape of carbon dioxide?

More rules: Oxygen and nitrogen have a slight negative charge (even when the atoms are neutral)
Carbon and hydrogen have a slight positive charge (even when the atoms are neutral)
A molecule is called **polar** if the distribution of positive and negative charges is asymmetric (not symmetrical).
A molecule is called **non-polar** if the distribution of positive and negative charges is symmetric.

5. So, for instance, ammonia is a polar molecule but carbon dioxide is non-polar. What about methane and water?

6. At room (Earth) temperatures, what phase (solid, liquid or gas) are water, ammonia, carbon dioxide and methane?

7. Another basic rule is that "**like dissolves like**"; in other words, polar gases dissolve in polar liquids and non-polar gases dissolve in non-polar liquids. Given this rule, of the four compounds you've made, which **gases** will **dissolve** in which **liquids**?

Mathematical overview
Perform the following calculations, giving the result with the proper number of significant figures.

8. a. In future, we will be using a unit called "the **mole**". One mole of any thing is 6.022×10^{23} of that thing (like a dozen of a thing is 12 of that thing). **How many iron atoms** are in exactly six moles of iron? Be careful about **significant figures**.

b. Each iron atom weighs 9.274×10^{-23} grams. How much does exactly one mole of iron **weigh**? Be careful about **units**.

9. a. In a capillary, blood flows at a rate of 0.300 cm/s. The typical capillary is 1.0 mm long; what is the length of **time** blood takes to traverse a typical capillary? (Source: www.mas.ncl.ac.uk/~sbrooks/book/nish.mit.edu/2006/Textbook/Nodes/chap09/node22.html)

b. All of the capillaries in the human body have a total cross-sectional area of 2.5×10^3 cm^2. Given that volume = cross-sectional area times length, what is the blood flow **rate** through the capillaries in cm^3/s?

c. Given that the typical adult human has 6.0 L of blood, on average, how **long** does it take to cycle all of the body's blood supply through the capillaries? You might have to look up a conversion factor here.

10. From Fraknoi, Morrison and Wolff, *Voyages to the Planets*, 2nd ed. (2001):

mass of the Earth = 5.977×10^{24} kg

radius of the Earth = 6.378×10^{6} m

a. Calculate the density of the Earth in kg/m^3. You may find the formula for the volume of a sphere to be useful: $V = 4\pi r^3/3$. Be careful about **significant figures**.

b. Convert your answer to part a into g/cm^3, using **conversion factors**.