1 Cognitive reasoning in the chemical sciences 4.3

1. Please suggest two or three things around you whose chemical composition you are uncertain of. If we are doing this exercise in class, please ask me what the material is made out of. If doing this exercise in the dorm, please find the answer on the internet.

2. Please answer the questions.

   (a) For an electron in a box. If λ doubles and L halves, what happens to v, the velocity?

   (b) For effusion. If one doubles n, keeps V constant, doubles m and doubles T, what happens to the rate of effusion?

   (c) For shielding. Be in its ground state is $(1s)^2(2s)^2$. In one of its excited states it is $(1s)^2(2s)^1(3p)^1$. Does the shielding for the remaining $2s$ electron change?

   (d) For shielding. Be in its ground state is $(1s)^2(2s)^2$. In one of its excited states it is $(1s)^2(2s)^1(3p)^1$. Does the shielding for the $1s$ electron change by a smaller or greater factor than the shielding for the $2s$ electron?

   (e) For effusion. If one keeps n constant, doubles V, halves m and keeps T constant, what happens to the rate of effusion?

   (f) For an electron in a box. If one doubles L and doubles λ, what happens to the number of positions inside the box where the electron has zero probability of being located?

3. The questions given below are proportionality questions. Some of these questions will require your powers of estimation. Please answer all questions to either to one or two significant figures.

   (a) A soccer ball is three-quarters air and one-quarter organic material. Consider now a soccer ball exactly the same size as a regular soccer ball, but made out of lead. Air is eight hundred times less dense than water while lead is eleven times as dense as water. Organic material has a density roughly the same as water's. How many times more heavy is the lead soccer ball than a regular soccer ball?

   (b) Rubber is organic. How many times more heavy is a solid rubber ball which is one-yard-across than a solid rubber ball which is six-inches-across?

   (c) In the movie *Titanic*, the movie producers built a ship which was of the right shape but of $5/6$ the length of the original *Titanic*. What is the ratio in weight of this smaller Titanic and the weight of a Titanic which the movie producers could have produced at the true full-scale?

   (d) Assume human babies have exactly the same shape as human adults. Assume a human baby boy typically weighs nine pounds, while an adult human male weighs 180 pounds. Based on these numbers, if an adult human male is six feet tall, how tall is a typical human baby boy?

(e) The average kinetic energy of molecules in an ideal gas is proportional to the temperature of the gas, as long as the temperature is measured in degrees Kevin, K. Oxygen molecules travel at around 350 m/s. If the temperature of an ideal oxygen gas triples from 300 K to 900 K, calculate the root-mean-square average speed of the oxygen molecules.

(f) Helium is eight times lighter than oxygen molecules, O_2. How fast does helium travel at 900 K?

(g) To the correct order of magnitude how many ping-pong balls fill an airplane which typically seats 200 people?