1 Cognitive reasoning in the chemical sciences 3.1

1. A person carries two genes which determine their blood type. And these genes come in three flavors: A, B, and O. People with AA genes have A blood, AO genes A blood, BO genes B blood, BB genes B blood, AB genes AB blood, and OO genes O blood. Each parent gives a single one of their two genes to their children.

   I have A blood and my elder daughter has AB blood. There are six gene scenarios (AA, AO, BB, BO, OO, and AB). Determine the probabilities for each of these six possibilities for my daughter's mother. (Assume, for the sake of simplicity, that each gene type has by itself equal frequency.)

2. All metal atoms at the same temperature have roughly the same kinetic energy. To one significant figure how many times slower are the Pb atoms in a piece of lead moving than the Fe atoms in a piece of iron, assuming that both pieces of metal are at the same temperature?

3. A tree starts off with a single trunk. The following year the trunk splits into three branches. The following year each of the branches splits into three new branches and so forth. After five years how many tips are there on the tree?

4. You may have noticed that I have difficulty dressing myself. It could be worse. I could put left shoes on my right foot. I could put my undershirt on backwards and over my dress shirt. Assuming I wear one pair of shoes, underpants, pants, shirts, and undershirts, how many ways are there for me to get dressed?

5. The ratio in size between an atom and its nucleus is the same as between a golf ball and the Dallas Cowboys Stadium. The golf ball is 4 cm in diameter while the stadium is 400 meters in diameter. Strangely, almost all the weight of the atom is in its nucleus. And the density of the neutrons is roughly the same as the protons.

   Astronomers tell us that there are stars, neutron stars, where all the electrons have been pushed out, and the entire volume is filled with neutrons. Think of the Dallas Cowboy Stadium completely filled with golf balls. Estimate to one significant figure how many times more dense a neutron star is then an atom.

6. You are asked to place a paperback book in the corner of a room so that one corner of the book fits exactly into the corner of the room. How many ways are there of placing the book. (If the book is oriented in a different way, then it is a different way of placing the book.)

7. Place three cities, A, B, and C, at any point you wish on the surface of the Earth. You are required to go the shortest possible way visiting each city at least once, You wish to place the cities so that the trip as long as possible. Demonstrate that in order to make the trip as long as possible, no two cities can lie at the opposite ends of the Earth to another of the cities.

8. Ten adult clowns can fit into a VW Beetle. Estimate to within a factor of two how many liters of water a VW Beetle can contain.

9. In different countries, red-yellow-green traffic lights could follow different conventions. They could be horizontal instead of vertical. Yellow could be at the bottom. How many different conventions could any one country follow?

10. A train goes 500 miles along a straight track without stopping, completing the trip with an average speed of exactly 50 miles per hour. It travels, however, at different speeds along the way. It seems plausible that nowhere along the 500 miles of track is there a a segment of 50 miles that the train traverses in precisely one hour.