1 Cognitive reasoning in the chemical sciences 2.2

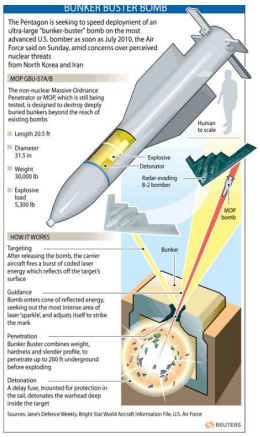
1. The following are six proportionality problems.

A bronze copy of the Statue of Liberty reduces its volume from its original volume of 4100 m^3 to 2 m^3. The original mass is 3 x 10^7 kg. Assuming this French copy has the same density as the original statue, what is the mass of the French copy?

Jardin du Luxembourg

each MK82 bomb has 89 kg lbs TNT and delivers 4.1 x 10^5 kJ

To one significant figure, how much energy does the new bunker buster deliver?



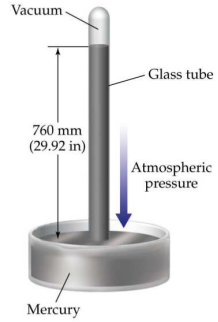
Robert runs a mile in 4.0 minutes. A mile is 1.6 kilometers. At the same speed, how fast does he run a kilometer?

Atmospheric pressure is the same pressure as the pressure under 760 mm of Hg.

This means a column of Hg 760 mm tall exerts one atmosphere of downward pressure.

The density of mercury is 13.5 g/mL. How tall does a column of water have to be to exert a downward pressure of 1.0 atmosphere?

The density of seawater is 1.03 g/mL. A submarine 300 m under the surface experiences what pressure from the water on top of it.



mass	velocity
200 grams	100 mph
50 grams	200 mph
5000 grams	20 mph

The numbers on the left give the maximum speed and typical mass of a baseball, a golfball, and a bowling ball.

Please suggest a proportionality law which accounts for the relation between ball mass and speed.

mass kg	heartbeat (hb) min^{-1}
0.8 kg	300 min^{-1}
60 kg	70 min^{-1}
20,000 kg	10 min^{-1}

The numbers on the left give the mass and heart-beat of a Guinea pig, a human (represented by Enrico Fermi), and a humpback whale.

Please suggest a an approximate proportionality law which accounts for the relation between heart-beat and mass.

2. Cows have nine times the mass of goats and move one-third as fast.

   (a) Cows and goats share a fenced-in pasture with a small open gate to the outside. If the pasture initially consists of 50% cows and 50% goats, initially what percentage of the animals leaving the pasture are goats? What percentage are cows?

   (b) The pasture is now twice as big as before, but the number of cows and goats in the pasture remains the same. Does the number of cows leaving the pasture change? If so, by how much? Does the ratio of cows and goats leaving the pasture change?

   (c) If the pasture initially consists of 75% cows and 25% goats, initially what percentage of the animals leaving the pasture are goats? What percentage are cows?

   (d) It's a hot day. Cows are moving 25% faster but goats are moving 50% faster. If the pasture initially consists of 75% cows and 25% goats, initially what percentage of the animals leaving the pasture are goats? What percentage are cows?

   (e) There are two equal-sized pastures, both fenced-in. There is a small gate which connects the two pastures. The first pasture contains only cows, while the second contains only goats. Initially, there are two times as many cows in the first pasture as there are goats in the second pasture. If after a short time the first pasture contains 97% cows and 3% goats, at this instant in time, to three significant figures, what is the ratio of the total number of animals in the first pasture compared to the total number of animals in the second pasture?