1 Cognitive reasoning in the chemical sciences 1.2

1. Determine if the following pairs of statments are synonomous:

   (a) **ideal gases**

      i. p and V are constant and n is halved.

      ii. p and V are constant and T is doubled.

   (b) **solids**

      i. A sample of pure copper on a benchtop weighs three times as much as another sample of pure copper.

      ii. A sample of pure copper on a benchtop is three times more dense than another sample of pure copper.

   (c) **ideal gases**

      i. p and V are both doubled. n is constant.

      ii. T increases by a factor of 4. n is constant.

   (d) **solids**

      i. An alloy of Cu and Fe is 50% iron and 50% copper.

      ii. A copper-iron alloy's density is exactly the average of the density of copper and iron.

   (e) **ideal gases**

      i. p/T is doubled.

      ii. n/V is doubled.

2. Please decide whether the best way to solve the listed problems is through plug-and-chug automation or through proportionality reasoning. Without using a calculator, indicate how you would go about solving the individual problems.

   (a) p= 6.14 atm, V=39.4 L, and n= 3.73 moles. What is T?

   (b) p increases by 23.4%, V decreases by 45.8% and n increases by 78.2%. What is the percent change in T?

   (c) p=2 atm, V=44.8 L, and $n = 0.25$ moles. What is T?

   (d) p changes from 4.23 atm to 7.41 atm; V changes from 99.3 L to 17.3 L; and n goes from 3.55 moles to 8.22 moles. The initial temperature was 1443 K. What is the final temperature?

3. In the following problems state if the pair of quantities listed in the problem are proportional to one another. If they are, what is the proportionality constant relating the the two quantities called?

   (a) The distance from the pitcher mound to home plate and the time it takes for Justin Verlander's fastball to travel this distance:

In major league baseball, home plate is 60.0 feet and 6.0 inches from the pitcher. If a professional pitcher throws the baseball 90.0 mph, how long (in seconds) does it take for the baseball to travel from the pitcher to home plate? (Given: 1 mile = 5280 feet)

(b) The number of carats and the volume of a diamond:

Diamonds are measured in carats and 1 carat = 0.200 g. The density of diamond is 3.51 g/cm^3. What is the volume of a 5-carat diamond?

(c) The mass of the metal pellets and the increase in the water level volume:

A sample containing 33.42 g of metal pellets is poured into a graduated cylinder initially containing 12.7 mL of water, causing the water level in the cylinder to rise 21.6 mL. Calculate the density of the pellets' material. (Assume that the mixture of pellets and water contains no air.)

4. Effusion: Imagine there is a small circular hole, of radius R, in the wall of a sealed flask. A gas molecule will escape from the flask if the hole lies in the flight path of the molecule. The rate at which gas molecules leave through this small hole is the *rate of effusion* from the flask.

   (a) Suggest the proportionality relationship between effusion and V, the volume of the flask, assuming the n, T, and p values of the gas are constant.

   (b) Suggest the proportionality relationship between effusion and n assuming V, T, and p are constant.

   (c) Suggest the proportionality relationship between effusion and ρ, where ρ is the molar density, the number of molecules per unit volume, assuming T is constant.

   (d) Suggest the proportionality relationship between effusion and r, where the gas is composed of monoatomic atoms, which are hard spheres with radius r. Assume n, T and V, and the mass of the particles are constant.

   (e) Suggest the mathematical proportionality relationship between effusion and T assuming n, V, r, and p are constant.

   (f) Suggest the proportionality relationship between effusion and m, where the gas is composed of monoatomic atoms, with variable molecular masses, m, but with constant n, T r, and V.

   (g) Suggest the proportionality relationship between effusion and R.

   (h) Give a formula for effusion of an ideal gas in terms of n, m, V, r, R and T

   (i) Give a formula for the effusion of an ideal gas in terms of n, m, V, r, R, and T. Express this formula as a proportionality relation.

   (j) Give a formula for the effusion of an ideal gas in terms of n, m, V, r, R, and T. Express this formula as an equation, using a proportionality constant c.