Dimensional analysis Problem 1 (Easy):

A researcher wants to know how much mercury is in a fish caught from San Francisco Bay. They digest (dissolve) 0.2g of fish tissue into a total volume of 40mL of acid. The mercury analyzer that the researcher is using can measure aqueous samples with concentrations of 0.1ng/L to 100ng/L Hg. In order to have the digested sample concentration within the machine's limit, based on similar fish samples, they dilute the sample by adding 0.8mL of sample into 39.2mL of water. The analysis of the diluted sample is 50ng/L, what is the concentration (mg/kg) of mercury in the fish?

Dimensional analysis Problem 2 (Little more difficult):

A researcher wants to know how much mercury is in sediment collected from the New Idria mercury mine in San Benito County, CA. They digest (dissolve) 0.2g of sediment into a total volume of 40mL of acid. The mercury analyzer that the researcher is using can measure aqueous samples with concentrations of 0.1ng/L to 100ng/L. In order to have the digested sample concentration within the machine's limit the sample was diluted twice. Initially the 0.4mL of sample was added to 39.6mL of water. This diluted sample was again diluted by taking 0.04mL of diluted sample added to 39.96mL of water. The analysis on second diluted sample was 24.1ng/L, what is the concentration (mg/kg) of mercury in the sediment?

Problem 1:

Answer: 0.5 mg/kg Hg

Solution:

1) Find dilution factor (DF) for sample.

   DF = 0.8mL (sample)/(0.8mL + 39.2mL) = 0.02 or 1:50

2) Divide concentration from analysis by DF.

   50ng/L / 0.02 * (1μg/1,000ng) = 2.5μg/L
   (This is the concentration in the original vial)

3) Multiply concentration from part 2 to find total Hg in solution.

   2.5μg/L * 40mL *(1L/1,000mL) = 0.1μg Hg
   (Assume all Hg came from fish dissolved. This can be done because a reagent blank is also run to make sure there is no addition of Hg from the chemicals used in the analysis.)

4) Divide total Hg in vial by the amount of fish dissolved.

   0.1μg / 0.2g * (1,000g/1kg) * (1μg/1,000mg) = 0.5mg/kg

To simplify you can just say a 1:100 dilution was done instead of making the students calculate the dilution factor.

Problem 2:

Answer: 482mg/kg

Solution:

1) Find the two dilution factors (DF1 and DF2) for the sample.

   DF1 = 0.4mL (sample) / (0.4mL + 39.6mL) = 0.01 or 1:100

   DF2 = 0.04mL (diluted sample) / (0.04mL + 39.96mL) = 0.001 or 1:1,000

2) Multiply DF1 by DF2 to find total dilution (DF3) then divide concentration from analysis by DF3

   DF3 = DF1 * DF2 = 0.01 * 0.001 = 0.00001 or 1:100,000

24.1ng/L / 0.00001 = 2,410,000ng/L * (1μg/1,000ng) * (1mg/1,000μg) = 2.41mg/L

or

Divide concentration from analysis by DF2 then divide that result by DF1

24.1ng/L / 0.001 = 24,100 ng/L * (1μg/1,000ng) = 24.1μg/L

24.1μg/L / 0.01 = 2,410μg/L * (1mg/1,000μg) = 2.41mg/L

3) Multiply concentration from part 2 to find total Hg in solution.

   2.41mg/L * 40mL * (1L/1,000mL) = 0.0964mg

4) Divide by mass digested for total concentration.

   0.0964mg / 0.2g * (1,000g/1kg) = 482mg/kg

Only difference between Problem 1 and 2 is the addition of an extra dilution factor. Problems can easily be answered without a calculator.