Dilutions

In almost all laboratory and medical setting dilution of solutions of known concentrations are done. It is very important to be able to do them correctly.

Overview of this Lecture

- Review of Calculating Concentration of Solutions & Using Chemical Equations
- Introducing Dilution Calculations – Molarity
- Dilutions
  - %
  - g/ml
  - $M_dV_d=M_cV_c$
  - ppb
- Summary Calculations

Chemical Reaction and Molarity

- In our bodies we "burn" glucose to get energy.
- Burning glucose requires oxygen and produces carbon dioxide according to the following reaction

Concentrations and Reactions

- Nitrogen and hydrogen can react to form ammonia. The balance equation for this reaction is shown below.

$$3H_2 + N_2 \rightarrow 2NH_3$$

- How much Nitrogen will be used if 7.00 moles of H_2 react?

$$7.00 moles H_2 \left(\frac{1 mole N_2}{3 moles H_2} \right) = 2.333 moles N_2$$

Concentrations and Reactions

If all of the ammonia made in this reaction is trapped in 3.000 L of water, what is the molar concentration of the ammonia in the water?

- $3H_2 + N_2 \rightarrow 2NH_3$
- Calculate the # of moles NH_3 made.

$$7.00 moles H_2 \left(\frac{2 mole NH_3}{3 moles H_2} \right) = 4.666 moles NH_3$$

Concentrations and Reactions

- Calculate the Molarity of this solution

$$M\,NH_3 = \left(\frac{moles\,NH_3}{1\,Liter\,soultion} \right)$$

$$= \left(\frac{4.666\,moles\,NH_3}{3.000\,L} \right)$$

$$= 1.555\,M\,NH_3 = 1.56\,M\,NH_3$$

- (There are 3 Sig. Fig. in the final answer because …)

done

What is the % of the solution is Ammonia?

Known:

- In 1 L of the solution there is 1.56 moles NH_3.
- Assume that 1L of solution weighs 1000g.

Needed:

- $\%NH_3$ =(gNH_3/gSolution)

What is the % of the solution that is Ammonia?

1. Find the Mass of NH_3 in 1 liter

$$1\,Liter\,solution \left(\frac{1.56\,moles\,NH_3}{1\,Liter\,soultion} \right) \left(\frac{17.031\,g\,NH_3}{1\,mole\,NH_3} \right)$$

$$= 26.49 g\,NH_3$$

2. Determine the % by mass

$$\left(\frac{26.49\,g\,NH_3}{1000\,g\,solution} \right) \times 100\% = 2.649\% = 2.65\%$$

done

What would the concentration of a solution made with 5 ml of the 1.56M ammonia solution and 65ml of water be?

Needed:

- ? M dilute solution
  (moles NH3/1 L solution)

Known:

- 5ml Concentrated Solution
- 65ml added volume
- 1.56 M concentrated solution

1. Find Moles NH_3 used in the dilution

$$5\,ml\,solution\left(\frac{1L}{1000\,ml}\right)\left(\frac{1.56\,moles\,NH_3}{1L\,solution}\right)$$

$$=0.0078\,moles\,NH_3$$

2. Get the concentration of the dilute volume

$$\left(\frac{moles\,NH_3}{1L\,solution}\right)=\left(\frac{0.0078\,moles\,NH_3}{65ml+5ml}\right)\left(\frac{1000ml}{1L}\right)$$

$$=\left(\frac{0.111\,moles\,NH_3}{1L\,solution}\right)=0.111\,M\,NH_3$$

done

What would the concentration of a solution made with 5 g of a 2.65% ammonia solution and 65g water be?

Needed:

- ? % dilute solution
  (g NH_3/g solution)x100%

Known:

- 5g Concentrated Solution
- 65g H_2O added
- 2.65% NH_3 in the initial solution

How about the same calculation with % by mass

1. Calculate the mass of NH_3 used in the dilution

$$5\,g\,solution\left(\frac{26.5\,g\,NH_3}{100\,g\,solution}\right)=1.325\,g\,NH_3$$

2. Calculate its % of the total mass

$$\left(\frac{1.325\,g\,NH_3}{65g+5g}\right)\times 100\%=1.89\%$$

done

How about making the dilution

How much of a concentrated solution should you use to make a 30 ml solution with 10 mg A/ml? Your concentrated solution has 150mg A/ml.

1. Find the # of mg you need in the final solution.
2. Find the volume of the concentrated solution you need to get that many moles.

1. Find the # of mg you need in the final solution.

$$30ml\,dilute\,solution\left(\frac{10mgA}{1ml\,dilute\,solution}\right)=300mgA$$

2. Find the volume of the concentrated solution you need to get that many moles.

$$300mgA\left(\frac{1ml\,conc.\,solution}{150mgA}\right)=2ml\,conc.\,solution$$

done

Another way to look at this.

- # moles in dilute solution = # of moles in the concentrated solution

$$M_dV_d=M_cV_c$$

- For Molar Concentrations

$$\left(\frac{Moles\,Solute}{1L\,Dilute\,Solution}\right)\begin{pmatrix}Volume\\of\,(in\,L)\\Dilute\\Solution\end{pmatrix}=\left(\frac{Moles\,Solute}{1L\,Conc.Solution}\right)\begin{pmatrix}Volume\\of\,(in\,L)\\Conc.\\Solution\end{pmatrix}$$

Another Way - $M_dV_d=M_cV_c$

- Substituting from our earlier example

$$M_d(70ml)\left(\frac{1L}{1000ml}\right)=\left(\frac{1.56Moles\,NH_3}{1L\,Conc.\,Solution}\right)(5ml)\left(\frac{1000ml}{1L}\right)$$

$$M_d=\left(\frac{1.56Moles\,NH_3}{1L\,Conc.\,Solution}\right)\left(\frac{5ml}{70ml}\right)$$

$$=0.111\,M\,NH_3$$

Problems with $M_dV_d=M_cV_c$

- Substituting in the wrong concentrations and volumes
- Mistakes in algebra
- Applying it when $M_dV_d \neq M_cV_c$
- I can't recommend it unless you do a lot of dilution calculations. This is a simple equation that is attractive but dangerous.

ppb calculation

You have a patient who has been taking a tincture that has 15ppb Arsenic in it. The patient dilutes around 2 ml of the tincture in about 500ml water, and then drinks 400ml of this throughout the day. How much arsenic is the patient consuming?

Known:
15ppb As
2ml Tincture
500 ml dilution
400 ml dose
Molar mass As

Needed:
? g As
Intermediate
ppb dilution

ppb dilution->gAs (1g solution=1mlsolution)

1. Find g As in the dilute solution.

$$2g\ tincture\left(\frac{15gAs}{1{,}000{,}000{,}000g\ tincture}\right)=3\times10^{-8}gAs$$

2. Calculate ppb As in the dilute solution.

$$\left(\frac{3\times10^{-8}gAs}{500g\ dilute\ solution}\right)=\frac{6\times10^{-11}gAs}{1g\ dilute\ solution}$$

g As in daily dose

3. Calculate ppb As in the dilute solution.

$$400g\ dilute\ solution\left(\frac{6\times10^{-11}gAs}{1g\ dilute\ solution}\right)=2.4\times10^{-8}gAs$$

$$=2\times10^{-8}gAs$$

$$=2\times10^{-2}\mu gAs$$

done

Summary

- Concentration calculations can be combined with calculations using chemical equations
- Correctly determining the concentration diluted solutions is the same as other calculations.
- Correctly determining how to make a diluted solutions is the same as other calculations.
- The concepts that are part of dilution calculations can be extended to other circumstances
- Use $M_dV_d=M_cV_c$ with care.