Concentration of Solutions and the Concentration/Volume Relationship

CONCENTRATION

Amount of a Substance
in a unit
Amount of Solution

WEIGHT Per Unit VOLUME

OR

WEIGHT / VOLUME

GRAMS / LITER
or
Milligrams / Liter

mg/L

CONCENTRATION

WEIGHT / VOLUME

Weight per Unit Volume

Times

Number of Units of Volume

Equals

Total Weight of Substance in Total Volume of Solution

OR

Concentration X Volume = Weight

One liter of a solution contains 100 mg of phosphorus. How much (Wt.) phosphorus would be in 50 mL of this solution?

Conc. (mg/L) X Volume (L) = Weight

$$100\ \text{mg/L} \times 50\ \text{mL} \times \frac{1\ \text{L}}{1000\ \text{mL}} = \text{Wt.}$$

$$\frac{100\ \text{mg}}{\text{L}} \times \frac{50}{1000}\ \text{L} = \text{Wt.}$$

5.0 mg = Wt.

How much phosphorus would be in a solution made by adding enough water to this 50 mL to dilute it to one liter?

The amount (Wt.) of phosphorus would not change.

5.0 mg of phosphorus would be in the solution.

What would be the concentration of the new solution?

Concentration = Wt./Vol. = mg/L

Concentration = 5.0 mg/L

Conc. (mg/L) X Volume (L) = Weight (mg)

Abbreviated

C x V = W

When Making a Dilution

Two Solutions

Before and After Adding Water

Conc. (mg/L) X Volume (L) = Weight (mg)

When Making a Dilution

Let the Subscript 1 refer to the solution Before dilution

and

Let the Subscript 2 refer to the solution After dilution

then

$$C_1 \times V_1 = W_1$$

and

$$C_2 \times V_2 = W_2$$

BUT

Weight before dilution = Weight after dilution

OR

$$W_1 = W_2$$

THEREFORE

$$C_1 \times V_1 = W_1 = W_2 = C_2 \times V_2$$

and

$$C_1 \times V_1 = C_2 \times V_2$$

EXAMPLE 1

What would be the final concentration of a solution made by diluting 50 mL of a 100 mg/L phosphorus solution to one Liter?

$$C_1 \quad X \quad V_1 \quad = \quad C_2 \quad X \quad V_2$$

C_1 = Initial Concentration (mg/L or N)

V_1 = Initial Volume (mL or Liter)

C_2 = Final Concentration (mg/L or N)

V_2 = Final Volume (mL or Liter)

Note that the terms tell if the value is a Volume or a Concentration

Liter or mL – always Volume (V)

mg/L or Normality (N) – always Concentration (C)

EXAMPLE 1

What would be the final concentration of a solution made by diluting 50 mL of a 100 mg/L phosphorus solution to one Liter?

$$C_1 \quad X \quad V_1 \quad = \quad C_2 \quad X \quad V_2$$

C_1 = Initial Concentration (mg/L or N)
V_1 = Initial Volume (mL or Liter)
C_2 = Final Concentration (mg/L or N)
V_2 = Final Volume (mL or Liter)

Note that the terms tell if the value is a Volume or a Concentration

<u>of</u> – links a Concentration with a Volume (Either C_1 and V_1 or C_2 and V_2)

<u>to</u> – indicates initial (1) and final (2)

water was added <u>to</u> V_1
OR
V_1 was diluted <u>to</u> V_2

EXAMPLE 1

What would be the final concentration of a solution made by diluting 50 mL of a 100 mg/L phosphorus solution to one Liter?

$$C_1 \quad X \quad V_1 \quad = \quad C_2 \quad X \quad V_2$$

C_1 = Initial Concentration (mg/L or N) = 100 mg/L

V_1 = Initial Volume (mL or Liter) = 50 mL

C_2 = Final Concentration (mg/L or N) = ?

V_2 = Final Volume (mL or Liter) = 1 Liter = 1000 mL

$$\frac{100 \text{ mg/L} \quad X \quad 50 \cancel{\text{ mL}}}{1000 \cancel{\text{ mL}}} = \frac{C_2 \quad X \quad \cancel{1000 \text{ mL}}}{\cancel{1000 \text{ mL}}}$$

$$\frac{100 \text{ X } 50}{1000} \text{ mg/L} = C_2$$

$$\boxed{5.0 \text{ mg/L} = C_2}$$

EXAMPLE 2

What would be the final concentration of a solution made by diluting 10 mL of a 250 mg/L phosphorus solution to one Liter?

$$C_1 \quad X \quad V_1 \quad = \quad C_2 \quad X \quad V_2$$

C_1 = Initial Concentration (mg/L or N) = 250 mg/L

V_1 = Initial Volume (mL or Liter) = 10 mL

C_2 = Final Concentration (mg/L or N) = ?

V_2 = Final Volume (mL or Liter) = 1 Liter = 1000 mL

$$\frac{250 \text{ mg/L} \quad X \quad 10 \cancel{\text{ mL}}}{1000 \cancel{\text{ mL}}} = \frac{C_2 \quad X \quad \cancel{1000 \text{ mL}}}{\cancel{1000 \text{ mL}}}$$

$$\frac{250 \text{ X } 10}{1000} \text{ mg/L} = C_2$$

$$\boxed{2.5 \text{ mg/L} = C_2}$$

EXAMPLE 3

What would be the final concentration of a solution made by diluting 100 mL of a 24.0 mg/L phosphorus solution with 500 ml of distilled water?

$$C_1 \quad X \quad V_1 \quad = \quad C_2 \quad X \quad V_2$$

C_1 = Initial Concentration (mg/L or N) = 24.0 mg/L

V_1 = Initial Volume (mL or Liter) = 100 mL

C_2 = Final Concentration (mg/L or N) = ?

V_2 = Final Volume (mL or Liter) = 500 mL + 100 mL = 600 mL

$$\frac{24.0 \text{ mg/L} \quad X \quad 100 \cancel{\text{ mL}}}{600 \cancel{\text{ mL}}} = \frac{C_2 \quad X \quad \cancel{600 \text{ mL}}}{\cancel{600 \text{ mL}}}$$

$$\frac{24.0 \text{ X } 100}{600} \text{ mg/L} = C_2$$

$$\boxed{4.0 \text{ mg/L} = C_2}$$

EXAMPLE 4

How many milliliters of a 50 mg/L phosphorus solution would be needed to make 50 mL of a 2.0 mg/L solution?

$$C_1 \quad X \quad V_1 \quad = \quad C_2 \quad X \quad V_2$$

C_1 = Initial Concentration (mg/L or N) = 50 mg/L

V_1 = Initial Volume (mL or Liter) = ?

C_2 = Final Concentration (mg/L or N) = 2.0 mg/L

V_2 = Final Volume (mL or Liter) = 50 mL

$$\frac{\cancel{50\ mg/L} \quad X \quad V_1}{\cancel{50\ mg/L}} = \frac{2.0\ \cancel{mg/L} \quad X \quad 50\ mL}{50\ \cancel{mg/L}}$$

$$V_1 = \frac{2.0\ X\ 50}{50}\ mL$$

$$\boxed{V_1 = 2.0\ mL}$$

Practice Problems

1. What would be the concentration of a solution made up by diluting 5 mL of a 250 mg/L solution to 100 mL?

2. 100 mL of a 25 mg/L stock zinc solution is diluted to one Liter. What is the concentration of zinc in the final solution?

3. How many mL of a 500 mg/L solution are needed to make one liter of a 25 mg/L solution?

4. 4 mL of a sample was diluted to 100 mL in a volumetric flask. The diluted solution was analyzed and found to have a concentration of 2.0 mg/L. What was the concentration of the original sample?

5. To dilute 100 mL of a 50 mg/L solution to get a 20 mg/L solution, how much water must be added?

6. How many milliliters of distilled water must be added to 950 mL of 0.01295 N sodium thiosulfate to get a solution with a concentration of 0.0125 N sodium thiosulfate?

Work Calculations on Separate Paper

Answers Given on Next Slides

1. **What would be the concentration of a solution made up by diluting 5 mL of a 250 mg/L solution to 100 mL?**

$$C_1 \times V_1 = C_2 \times V_2$$

$C_1 =$ 250 mg/L

$V_1 =$ 5 mL

$C_2 =$?

$V_2 =$ 100 mL

$$\frac{250 \text{ mg/L} \times 5 \cancel{\text{ mL}}}{100 \cancel{\text{ mL}}} = \frac{C_2 \times \cancel{100 \text{ mL}}}{\cancel{100 \text{ mL}}}$$

$$\frac{250 \times 5}{100} \text{ mg/L} = C_2$$

$$\boxed{12.5 \text{ mg/L} = C_2}$$

2. 100 mL of a 25 mg/L stock zinc solution is diluted to one Liter. What is the concentration of zinc in the final solution?

$$C_1 \times V_1 = C_2 \times V_2$$

$C_1 =$ 25 mg/L

$V_1 =$ 100 mL

$C_2 =$?

$V_2 =$ 1 L = 1000 mL

$$\frac{25 \text{ mg/L} \times 100 \text{ mL}}{1000 \text{ mL}} = \frac{C_2 \times 1000 \text{ mL}}{1000 \text{ mL}}$$

$$\frac{25 \times 100}{1000} \text{ mg/L} = C_2$$

$$2.5 \text{ mg/L} = C_2$$

3. How many mL of a 500 mg/L solution are needed to make one liter of a 25 mg/L solution?

$$C_1 \times V_1 = C_2 \times V_2$$

$C_1 =$ 500 mg/L

$V_1 =$?

$C_2 =$ 25 mg/L

$V_2 =$ 1 Liter = 1000 mL

$$\frac{500 \text{ mg/L} \times V_1}{500 \text{ mg/L}} = \frac{25 \text{ mg/L} \times 1000 \text{ mL}}{500 \text{ mg/L}}$$

$$V_1 = \frac{25 \times 1000}{500} \text{ mL}$$

$$\boxed{V_1 = 50 \text{ mL}}$$

4. 4 mL of a sample was diluted to 100 mL in a volumetric flask. The diluted solution was analyzed and found to have a concentration of 2.0 mg/L. What was the concentration of the original sample?

$$C_1 \times V_1 = C_2 \times V_2$$

$C_1 = ?$

$V_1 = 4$ mL

$C_2 = 2.0$ mg/L

$V_2 = 100$ mL

$$\frac{C_1 \times 4 \text{ mL}}{4 \text{ mL}} = \frac{2.0 \text{ mg/L} \times 100 \text{ mL}}{4 \text{ mL}}$$

$$C_1 = \frac{2.0 \times 100}{4} \text{ mg/L}$$

$$50.0 \text{ mg/L} = C_1$$

5. To dilute 100 mL of a 50 mg/L solution to get a 20 mg/L solution, how much water must be added?

$$C_1 \times V_1 = C_2 \times V_2$$

$C_1 = 50$ mg/L

$V_1 = 100$ mL

$C_2 = 20$ mg/L

$V_2 = ?$

$$\frac{50 \text{ mg/L} \times 100 \text{ mL}}{20 \text{ mg/L}} = \frac{20 \text{ mg/L} \times V_2}{20 \text{ mg/L}}$$

$$\frac{50 \times 100}{20} \text{ mL} = V_2$$

$$250 \text{ mL} = V_2$$

5. To dilute 100 mL of a 50 mg/L solution to get a 20 mg/L solution, how much water must be added?

$$C_1 \times V_1 = C_2 \times V_2$$

$C_1 =$ 50 mg/L

$V_1 =$ 100 mL

$C_2 =$ 20 mg/L

$V_2 =$?

$$250 \text{ mL} = V_2$$

$$- 100 \text{ mL}$$

150 mL Water to be Added

6. How many milliliters of distilled water must be added to 950 mL of 0.01295 N sodium thiosulfate to get a solution with a concentration of 0.0125 N sodium thiosulfate?

$$N_1 \times V_1 = N_2 \times V_2$$

$$\frac{0.01295\ N \times 950\ mL}{0.0125\ N} = \frac{0.0125\ N \times V_2}{0.0125\ N}$$

$$\frac{0.01295 \times 950}{0.0125}\ mL = V_2$$

$$984.2\ mL = V_2$$

$$-\ 950.0\ mL$$

$$34.2\ mL$$ Water to be Added

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