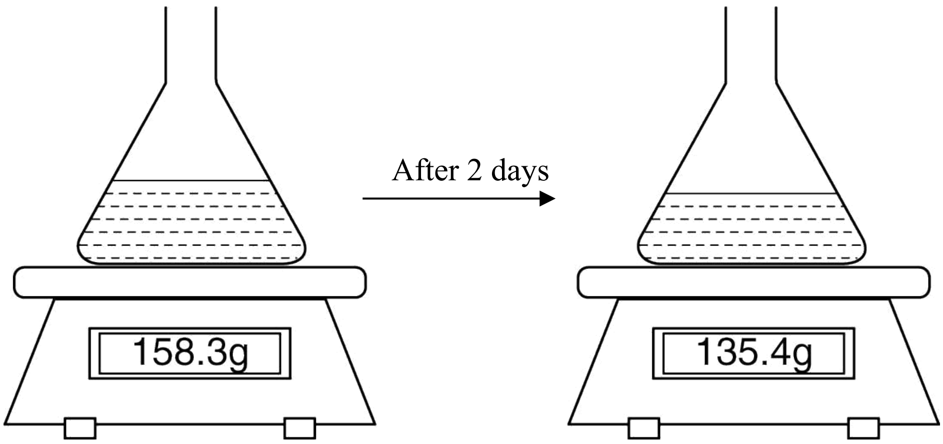
Chemistry: Chapter 15 Concentration of solutions

Combined Science (Chemistry Part): Chapter 15 Concentration of solutions

Sections 15.1−15.2

|!|ELB041515001O|!|

Pauline has prepared 150 cm^3 aqueous solution of 1 M $MgSO_4$. She left the flask unstoppered and noticed that there was a weight loss in the flask. The weight of the flask changed as follows:



(a) What was the cause of the weight loss?

(b) Would the resultant solution become concentrated or diluted after two days? Explain your answer.

(c) What was the molarity of the solution after two days? (Given: Density of water = 1 g cm^{-3})

[5M]

##

(a) It was due to the evaporation of water. [1]

(b) The solution would become concentrated as the amount of $MgSO_4$ remained the same but there was less solvent. [2]

(c) Let X be the new molarity,

Volume of water evaporated = $\frac{(158.3-135.4)}{1}$ = 22.9 cm^3 [1]

Since the number of moles of $MgSO_4$ remained the same before and after evaporation of water,

$$1 \times \frac{150}{1000} = X \times \frac{(150-22.9)}{1000}$$

X = 1.18 [1]

The molarity of the solution after two days is 1.18 M.

##

|!|ELB0415150002O|!|

The compositions of two brands of Hi-Ca milk are listed below:

Brand	**Volume of milk per box**	**Mass of $CaCl_2$**	**Mass of $Ca_3(PO_4)_2$**
X	0.88L	1.32 g	0.30 g
Y	1L	1.86 g	0.08 g

(1 L = 1 dm^3)

(a) What is the molarity of calcium ion in milk X?

(b) What is the molarity of calcium ion in milk Y?

(c) For one standard box of milk, which brand is richer in calcium?

[7M]

##

(a) Number of moles of Ca^{2+} in milk *X*

= Number of moles of Ca^{2+} in 1.32 g $CaCl_2$ + Number of moles of Ca^{2+} in 0.30 g of $Ca_3(PO_4)_2$

$= (\frac{1.32}{40.1 + 35.5 \times 2}) + (\frac{0.30}{40.1 \times 3 + 31.0 \times 2 + 16.0 \times 8} \times 3)$ [1]

= 0.0119 + 0.0029

= 0.0148 mol [1]

Molarity of Ca^{2+} in milk *X*

$= \frac{0.0148}{0.88}$ M

= 0.0168 M [1]

(b) Number of moles of Ca^{2+} in milk *Y*

= Number of moles of Ca^{2+} in 1.86 g $CaCl_2$ + Number of moles of Ca^{2+} in 0.08 g of $Ca_3(PO_4)_2$

$= (\frac{1.86}{40.1 + 35.5 \times 2}) + (\frac{0.08}{40.1 \times 3 + 31.0 \times 2 + 16.0 \times 8} \times 3)$ [1]

$= 0.0167 + 7.74 \times 10^{-4}$

= 0.0175 mol [1]

Molarity of Ca^{2+} in milk *Y*

$= \frac{0.0175}{1}$ M

= 0.0175 M [1]

(c) Milk *Y* [1]

##

|!|ELB041515003O|!|

Alvin is helping his father to prepare a fertilizer solution for a large potted plant. He is given a bottle of 0.5 M NH_4NO_3 and a bottle of 0.5 M KCl. His father reminds him that the fertilizer solution should have the following composition:

	Amount needed
Nitrogen	2 g
Potassium	1 g
Volume of solution	250 cm^3

Alvin plans to mix X cm^3 of 0.5 M NH_4NO_3, Y cm^3 of 0.5 M KCl and Z cm^3 of water to make up the fertilizer solution.

(a) How many moles of nitrogen are needed in the fertilizer solution?

(b) How many moles of potassium are needed in the fertilizer solution?

(c) Determine X, Y and Z for Alvin.

[5M]

##

(a) Number of moles of nitrogen needed = $\frac{2}{14}$ mol = 0.14 mol [1]

(b) Number of moles of potassium needed = $\frac{1}{39.1}$ mol = 0.026 mol [1]

(c) Number of moles of nitrogen needed = number of moles of N in X cm^3 of 0.5 M NH_4NO_3,

$\frac{X}{1000} \times 0.5 \times 2 = 0.1429$

$X = 143$ [1]

Number of moles of potassium needed = number of moles of K in Y cm^3 of 0.5 M KCl,

$\frac{Y}{1000} \times 0.5 = 0.0256$

$Y = 51.2$ [1]

Since $X + Y + Z = 250$

$Z = 55.8$ [1]

##

|!|ELA0415150004O|!|

3.78 g of ethanedioic acid crystals $(COOH)_2 \cdot 2H_2O$ was dissolved in water and the solution made up to 250.0 cm^3 in a volumetric flask. Calculate the concentration of this standard solution expressed in

(a) g dm^{-3}.

____

(b) molarity.

____

[2M]

##

(a) Concentration of $(COOH)_2 \cdot 2H_2O$ standard solution

$= \dfrac{3.78}{\frac{250.0}{1000}}$ g dm^{-3}

$= 15.12$ g dm^{-3} [1]

(b) Molar mass of $(COOH)_2 \cdot 2H_2O = 126.0$ g mol^{-1}

From (a), concentration of $(COOH)_2 \cdot 2H_2O$ standard solution is 15.12 g dm^{-3}, the molarity (in mol dm^{-3}) of the solution

$= \frac{15.12}{126.0}$ M

= 0.12 M [1]

##

|!|ELA041515005O|!|

(a) What volume of water should be added to 25.0 cm^3 of 1.0 M sodium hydroxide solution to make it 0.2 M?

(b) What volume of water has to be evaporated away from 50.0 cm^3 of 0.1 M sodium chloride solution in order to concentrate it to 0.4 M?

[4M]

##

(a) (Number of moles of NaOH) $_{\text{before dilution}}$ = (Number of moles of NaOH) $_{\text{after dilution}}$

$(MV)_{\text{before dilution}} = (MV)_{\text{after dilution}}$

$$1.0 \times \frac{25.0}{1000} = 0.2 \times \frac{V}{1000}$$

V = 125.0 cm^3 [1]

The volume of water should be added

= (125.0 – 25.0) cm^3

= 100.0 cm^3 [1]

(b) (Number of moles of NaCl) $_{\text{before concentrated}}$ = (Number of moles of NaCl) $_{\text{after concentrated}}$

$(MV)_{\text{before concentrated}} = (MV)_{\text{after concentrated}}$

$$0.1 \times \frac{50.0}{1000} = 0.4 \times \frac{V}{1000}$$

$V = 12.5\ cm^3$ [1]

The volume of water should be evaporated

$= (50.0 - 12.5)\ cm^3$

$= 37.5\ cm^3$ [1]

##

|!|ELA041515006O|!|

Calculate the mass of solute needed to prepare each of the following solutions.

(a) $1.0\ dm^3$ of 0.05 M Na_2CO_3

(b) $250.0\ cm^3$ of 0.2 M $(COOH)_2$

(c) $500.0\ cm^3$ of 0.1 M $AgNO_3$

[6M]

##

(a) Number of moles of Na_2CO_3 needed

$= 0.05 \times 1.0$ mol

$= 0.05$ mol [1]

Molar mass of Na_2CO_3

$= (23.0 \times 2 + 12.0 + 16.0 \times 3)$ g mol^{-1}

$= 106.0$ g mol^{-1}

Mass of Na_2CO_3 needed

$= 0.05 \times 106.0$ g

$= 5.3$ g [1]

(b) Number of moles of $(COOH)_2$ needed

$= 0.2 \times \frac{250.0}{1000}$ mol

$= 0.05$ mol [1]

Molar mass of $(COOH)_2$

$= (12.0 + 16.0 \times 2 + 1.0) \times 2$ g mol^{-1}

$= 90.0$ g mol^{-1}

Mass of $(COOH)_2$ needed

$= 0.05 \times 90.0$ g

$= 4.5$ g [1]

(c) Number of moles of $AgNO_3$ needed

$= 0.1 \times \frac{500.0}{1000}$ mol

$= 0.05$ mol [1]

Molar mass of $AgNO_3$

$= (107.9 + 14.0 + 16.0 \times 3)$ g mol^{-1}

$= 169.9$ g mol^{-1}

Mass of $AgNO_3$ needed

$= 0.05 \times 169.9$ g

$= 8.5$ g [1]

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