Key → SCAN

Unit 3 - Part 3 – Solution Chemistry Calculations Review:

Finding individual ion concentrations:

Example 1: You have a 2.0M solution of $Fe(NO_3)_3$. Find the $[Fe^{3+}]$ and the $[NO_3^-]$.

Write dissociation equation: $Fe(NO_3)_{3(s)} \rightarrow Fe^{3+}_{(aq)} + 3\,NO_3^-{}_{(aq)}$

$$[Fe^{3+}] = 2.0M\ Fe(NO_3)_3 \times \frac{1MFe^{3+}}{1MFe(NO_3)_3} = \mathbf{2.0M}$$

$$[NO_3^-] = 2.0M\ Fe(NO_3)_3 \times \frac{3MNO_3^-}{1MFe(NO_3)_3} = \mathbf{6.0M}$$

Coefficient ratios can apply to moles or M. Also remember that $M = \frac{mol}{L}$

Example 2: The $[Na^+]$ in 2.0 L of a solution of Na_3PO_4 is 1.5M. Find the $[PO_4^{3-}]$

Since $[Na^+]$ and $[PO_4^{3-}]$ are both in Molarity (M), the 2.0L volume is NOT needed in the calculation.

$Na_3PO_{4(s)} \rightarrow 3\,Na^+_{(aq)} + PO_4^{3-}{}_{(aq)}$

$$[PO_4^{3-}] = 1.5M\ Na^+ \times \frac{1MPO_4^{3-}}{3MNa^+} = \mathbf{0.50M}$$

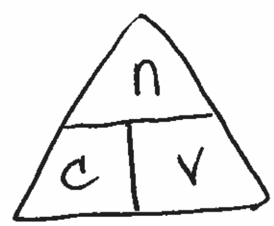
But sometimes you DO need to use the volume!

Example 3: 2.0 mol of Li_2SO_4 are dissolved in 8.0 L of solution. Find the $[Li^+]$.

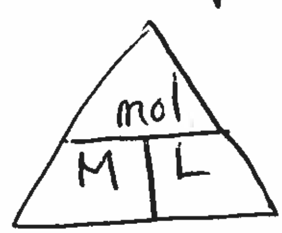
$Li_2SO_{4(s)} \rightarrow 2\,Li^+_{(aq)} + SO_4^{2-}{}_{(aq)}$

$$[Li_2SO_4] = \frac{2.0mol}{8.0L} = 0.25M$$

$c = \frac{n}{V}$



$$[Li^+] = 0.25M\ Li_2SO_4 \times \frac{2MLi^+}{1MLi_2SO_4} = \mathbf{0.50M}$$



n = mol
c = mol/L (M
V = volume (L

Do #18 (a,b,c) on p. 81 of Hebden

Dilution Formula:

$$C_{dil} \times V_{dil} = C_{conc} \times V_{conc}$$

OR

$$Cdil = \frac{Cconc \times Vconc}{Vdil}$$

Cdil = concentration diluted (final)
Vdil = volume diluted (final)
Cconc = Concentration concentrated
Vconc = volume concentrated

Example 1: 250.0 mL of water are added to 350.0 mL of 0.40M $Ca(NO_3)_2$. Find the final concentrations of both ions.

$$Cdil = \frac{Cconc \times Vconc}{Vdil}$$

$$\text{Diluted } [Ca(NO_3)_2] = 0.40M \times \frac{350.0mL}{600.0mL} = 0.233M$$

$$Ca(NO_3)_{2(s)} \rightarrow Ca^{2+}_{(aq)} + 2\,NO_3^-{}_{(aq)}$$

$$[Ca^{2+}] = 0.233M\ Ca(NO_3)_2 \times \frac{1MCa^{2+}}{1MCa(NO_3)_2} = \mathbf{0.23M}$$

$$[NO_3^-] = 0.233M\ Ca(NO_3)_2 \times \frac{2MNO_3^-}{1MCa(NO_3)_2} = \mathbf{0.47M}$$

Mixing Solutions Without Common Ions

When two solutions are mixed, they don't react with each other, and there are no common ions, each solution "see's" the other solution as if it was water.

Example 1: 20.0 mL of 0.20M NaCl is mixed with 30.0 mL of 0.15M $Ca(NO_3)_2$. Calculate the final concentrations of all four ions. ← They dilute eachother!

First calculate final [NaCl] (*consider the $Ca(NO_3)_2$ solution like adding water.*)

$$\text{Final [NaCl]} = 0.20M \times \frac{20.0mL}{50.0mL} = 0.080M$$

Find the $[Na^+]$ and $[Cl^-]$: $NaCl_{(s)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$

Since all coefficients are 1, $\mathbf{[Na^+] = 0.080M}$

$\mathbf{[Cl^-] = 0.080M}$

$$\text{Now, find final } [Ca(NO_3)_2] = 0.15M \times \frac{30.0mL}{50.0mL} = 0.090M$$

Now find $[Ca^{2+}]$ and $[NO_3^-]$: $Ca(NO_3)_{2(s)} \rightarrow Ca^{2+}_{(aq)} + 2\,NO_3^-{}_{(aq)}$

$[Ca^{2+}] = [Ca(NO_3)_2] = \mathbf{0.090M}$

$$[NO_3^-] = 0.090M\ Ca(NO_3)_2 \times \frac{2MNO_3^-}{1MCa(NO_3)_2} = \mathbf{0.18M}$$

Do # 20 (d & e) on p. 81 of Hebden

Mixtures With Common Ions

Example 1: 50.0 mL of 0.20M KCl is mixed with 60.0 mL of 0.30M $MgCl_2$. Find the final concentrations of all three ions.

$$\text{Final [KCl]} = 0.20M \times \frac{50.0mL}{110.0mL} = 0.0909M$$

$KCl_{(s)} \rightarrow K^+_{(aq)} + Cl^-_{(aq)}$

$[K^+] = [KCl] = 0.91M$

$[Cl^-]$ (*from KCl*) $= [KCl] = 0.091M$

$$\text{Final } [MgCl_2] = 0.30M \times \frac{60.0mL}{110.0mL} = 0.1636M$$

$MgCl_{2(s)} \rightarrow Mg^{2+}_{(aq)} + 2Cl^-_{(aq)}$

$[Mg^{2+}] = [MgCl_2] = 0.16M$

$$[Cl^-] \text{ (from } MgCl_2) = 0.1636M\ MgCl_2 \times \frac{2MCl^-}{1MMgCl_2} = 0.3273M$$

Final $[K^+]$ = **0.91M**

Final $[Mg^{2+}]$ = **0.16M**

Final $[Cl^-]$ = 0.0909M + 0.3273M = **0.42M** ← add any common ion concentrations at the end.

From KCl (0.0909M)

From $MgCl_2$ (0.3273M)

Total $[Cl^-]$ rounded to 2 SD's (0.42M)

Do #20 (f & g) on p. 81 of Hebden

Do **Solubility Calculations** practice - attached

Chemistry 12—Worksheet on Solubility Calculations

This worksheet covers material from class notes and SW for Unit 3.

↗ 0.7500 L

1. 5.62 grams of Na_2SO_4 is dissolved in enough water to make 750.0 mL of solution.

   a) Calculate the $[Na_2SO_4]$

$$5.62g \times \frac{1mol}{142.1g} = 0.0396\,mol \qquad [Na_2SO_4] = \frac{0.0396\,mol}{0.750L}$$

$$[Na_2SO_4] = 0.0527M$$

   b) Calculate the $[Na^+]$

$$Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-}$$

$$[Na^+] = \frac{0.0527\,mol\,Na_2SO_4}{L} \times \frac{2\,mol\,Na^+}{1\,mol\,Na_2SO_4} = 0.105M = [Na^+]$$

2. 250.0 mL of water are added to 600.0 mL of a 6.0 M HCl solution. Calculate the final [HCl].

$$C_{DIL} = \frac{6.0M \times 600.0\,mL}{250.0\,mL} = 4.2M$$

3. Calculate the mass of K_2CrO_4 needed to make 3.00 L of a 0.0200 M solution.

$$n = c \times V$$

$$= 0.0200\,\frac{mol}{L} \times 3.00L = 0.0600\,mol$$

$$mass = 0.0600\,mol \times \frac{194.2g}{mol} = 11.7g$$

4. 150.0 mL of a 0.400 M solution of $Mg(NO_3)_2$ is diluted to a volume of 500.0 mL by adding water. Calculate the final nitrate ion concentration.

$$C_{DIL} = \frac{0.400M \times 150.0\,mL}{500.0\,mL} = 0.120M$$

$$Mg(NO_3)_2 \rightarrow Mg^{2+} + 2NO_3^-$$

$$[NO_3^-] = 0.120M\,Mg(NO_3)_2 \times \frac{2\,mol\,NO_3^-}{1\,mol\,Mg(NO_3)_2} = 0.240M = [NO_3^-]$$

5. What volume of 0.250 M $NaNO_3$ solution needs to be evaporated in order to produce 68.0 grams of solid $NaNO_3$ residue?

$$68.0g\,NaNO_3 \times \frac{1\,mol}{85.0g} = 0.800\,mol$$

$$V = \frac{n}{c} = \frac{0.800\,mol}{0.250\,mol/L} = 3.20L$$

6. The concentration of chloride ion, $[Cl^-]$ in a solution of aluminum chloride is 0.99 M. Calculate the $[Al^{3+}]$ in the same solution.

$$AlCl_3 \rightarrow Al^{3+} + 3Cl^-$$

$$0.99M\,Cl^- \times \frac{1mol\,Al^{3+}}{3mol\,Cl^-} = 0.33M\,Al^{3+}$$

7. 400.0 mL of 0.200 M Li_3PO_4 is mixed with 200.0 mL of 0.250 M Na_2CO_3. Calculate the final concentrations of all four ions in the final mixture. Assume the solutions do not react with each other.

$C_{DIL}[Li_3PO_4] = \frac{0.200M \times 400.0mL}{600.0mL} = 0.133M$ $Li_3PO_4 \rightarrow 3Li^+ + PO$

$[Li^+] = 0.133M\ Li_3PO_4 \times \frac{3 mol\ Li^+}{1 mol\ Li_3PO_4} = 0.400M$

$[PO_4^{3-}] = [Li_3PO_4] = 0.133M$

$C_{DIL}[Na_2CO_3] = \frac{0.250M \times 200.0mL}{600.0mL} = 0.0833M$

$[Na^+] = 0.0833M \times \frac{2}{1} = 0.167M$

$[CO_3] = 0.0833M$

Answer $[Li^+]$ = 0.400M

Answer $[PO_4^{3-}]$ = 0.133M

Answer $[Na^+]$ = 0.167M

Answer $[CO_3^{2-}]$ = 0.0833M

8. 300.0 mL of 0.100 M Li_3PO_4 is mixed with 500.0 mL of 0.050 M Li_2CO_3. Calculate the final concentrations of all three ions in the final mixture. Assume the solutions do not react with each other.

$C_{DIL}[Li_3PO_4] = \frac{0.100M \times 300.0mL}{800.0mL} = 0.0375M$

$[Li^+] = 0.0375 \times 3 = 0.113M$

$[PO_4^{3-}] = 0.0375M$

$C_{DIL}[Li_2CO_3] = \frac{0.050M \times 500.0mL}{800.0mL} = 0.0313M$

$[CO_3] = 0.0313M$ $[Li^+] = 0.0313 \times 2 = 0.0625M$

Total $[Li^+] = 0.113 + 0.0625 = 0.175M$.

Answer $[Li^+]$ = 0.175M

Answer $[PO_4^{3-}]$ = 0.0375M

Answer $[CO_3^{2-}]$ = 0.031M

10. Calculate the volume of 12.0 M Na_2SO_3 which needs to be added to 500.0 mL of water in order to produce a solution in which $[Na^+]$ = 0.200 M. $C_{DIL}[Na_2SO_3] = 0.100M$.

$V_{conc} \Rightarrow x = \frac{(0.100M)(500.0mL + x)}{12.0M}$

$12.0x = 50 + 0.100x$

$11.9x = 50$

$x = \frac{50}{11.9} = 4.20$

Volume Na_2SO_3 12.0M = 4.20 mL

11. The molar solubility of calcium sulphate $CaSO_4$ is 8.43×10^{-3} M. Calculate the mass of solid $CaSO_4$ which can be evaporated from 250.0 mL of a saturated solution of $CaSO_4$.

$\frac{8.43 \times 10^{-3} mol}{1L} \times 0.2500L \times \frac{136.2g}{mol} = 0.287g$

12. It is found that 13.01g is the maximum mass of $PbCl_2$ which will dissolve in 3.0 L of solution. Use this information to calculate the solubility of $PbCl_2$ in moles/L.

$$\frac{13.0\,g}{3.0\,L} \times \frac{1\,mol}{278.2\,g} = 0.016\,\frac{mol}{L} = 0.016\,M$$

Answer 0.016M

13. The molar solubility of silver iodate ($AgIO_3$) is 1.79 x 10^{-4} M at 25°C. Calculate the maximum **mass** of silver iodate that can be dissolved in 650.0 mL of water at 25°C

$$\frac{1.79 \times 10^{-4}\,mol}{1\,L} \times 0.6500\,L \times \frac{282.8\,g}{1\,mol} = 0.0329\,g$$