Unit 2 Marathon Review Problems

NaCl(aq)

1. A student is given the task of determining the Cl^- content in a 50.0 mL sample of aqueous sodium chloride solution. The student measures 25.0 mL of the sample into an empty flask.

NaCl(aq)

   (a) Which of the following solutions should be added to the flask in excess to isolate the Cl^- ions: $AgNO_3(aq)$, $K_2SO_4(aq)$, or $CaBr_2(aq)$? Explain your reasoning.

$AgNO_3(aq)$ should be added since the $Ag^+(aq)$ ions will cause the $Cl^-(aq)$ ions to precipitate out of solution in the form of $AgCl(s)$. $K_2SO_4(aq)$ and $CaBr_2(aq)$ will not cause a precipitate of Cl because $K^+_{(aq)}$ and $Ca^{2+}(aq)$ are both soluble with $Cl^-(aq)$ ions.

(b) Write a balanced, net-ionic equation for the reaction that takes place when the chosen solution in (a) is added to the flask.

$$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$$

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The student adds the solution from (a) in excess to the flask. A precipitate forms, which is then filtered, washed, and dried. The data from the experiment are shown in the table below.

Mass of thoroughly dried filter paper	1.324 g
Mass of filter paper + precipitate after first drying	1.941 g
Mass of filter paper + precipitate after second drying	1.867 g
Mass of filter paper + precipitate after third drying	1.866 g

(c) Calculate the moles of precipitate that is produced in the experiment.

mass of precipitate $AgCl_{(s)}$ = 1.866 g − 1.324 g = 0.542 g $AgCl_{(s)}$

$$\frac{0.542 \text{ g AgCl}}{} \left| \frac{1 \text{ mol AgCl}}{143.32 \text{ g AgCl}} \right. = \boxed{0.00378 \text{ mol AgCl}}$$

(d) Calculate the mass of Cl^- in the 50.0 mL sodium chloride solution.

$$\frac{0.00378 \text{ mol AgCl}}{} \left| \frac{1 \text{ mol } Cl^-}{1 \text{ mol AgCl}} \right| \frac{35.45 \text{ g } Cl^-}{1 \text{ mol } Cl^-} = 0.134 \text{ g } Cl^- \text{ in } AgCl_{(s)}$$

The $AgCl_{(s)}$ was made using 25.0 mL of $NaCl_{(aq)}$, thus the mass of Cl^- in the 50.0 mL $NaCl_{(aq)}$ is twice that of the 25.0 mL sample.

∴ mass of Cl^- in 50.0 mL $NaCl_{(aq)}$ is

$$0.134 \text{ g } Cl^- \times 2 = \boxed{0.268 \text{ g } Cl^-}$$

(e) Which chemical species are present in the filtrate solution?

Filtrate is the solution that is not captured by the filter paper, meaning that the filtrate consists of everything except $AgCl_{(s)}$.

$$\underset{LR}{\cancel{NaCl_{(aq)}}} + \underset{Excess}{AgNO_{3(aq)}} \rightarrow \underset{Filter\ paper}{\cancel{AgCl_{(s)}}} + NaNO_{3(aq)}$$

∴ The filtrate soln consists of $Na^+_{(aq)}$, $Ag^+_{(aq)}$, and $NO_3^-{}_{(aq)}$.

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2. A student is to prepare 1.0 L of a 3.0 M LiCl solution using solid LiCl and distilled water.

   (a) Explain how to prepare the solution. Include appropriate calculations and lab equipment.

$$3.0\ M\ LiCl = \frac{mol\ LiCl}{1.0\ L}$$

$\therefore$ 3.0 mol LiCl needed

$$\frac{3.0\ mol\ LiCl \mid 42.39\ g\ LiCl}{\mid 1\ mol\ LiCl} = 127.17\ g = 130\ g\ LiCl$$

To make the solution:

1) Measure 130 g $LiCl_{(s)}$ on a balance
2) Place the 130 g $LiCl_{(s)}$ into a 1.0L Volumetric flask.
3) Add distilled water to dissolve $LiCl_{(s)}$
4) Swirl/mix
5) Add distilled water to 1.0 L mark on the Volumetric flask.
6) cap the flask and invert to mix thoroughly

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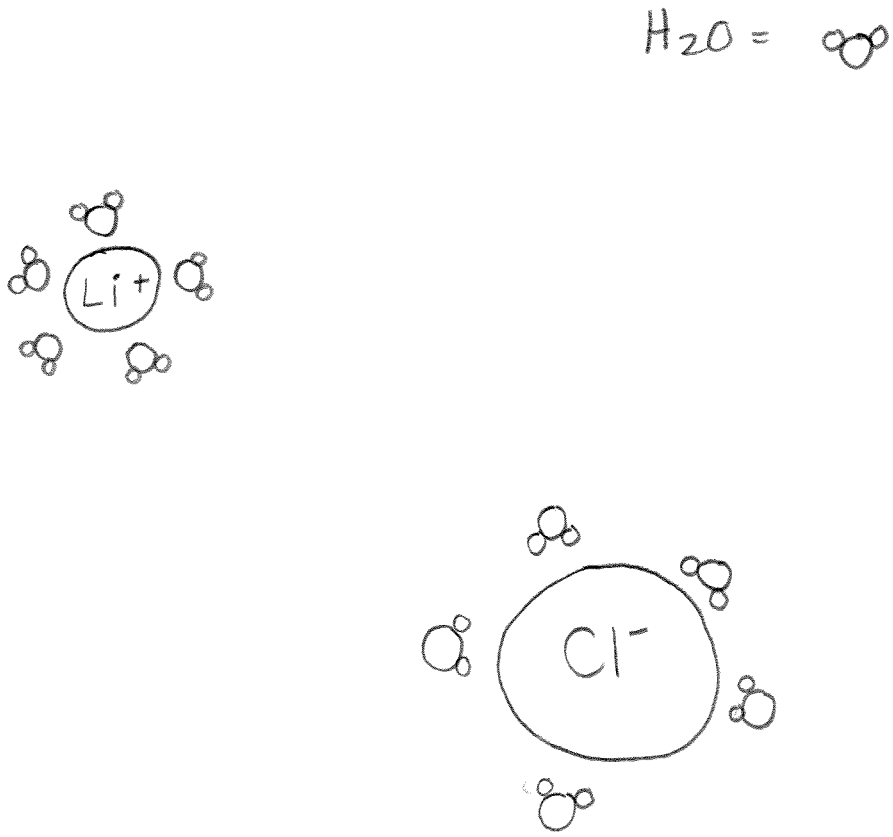
(b) Draw the particle interactions in the LiCl(aq) solution. Include only one formula unit of LiCl and no more than ten molecules of water. Include the identity of ions (symbol and charge) and the arrangement and proper orientation of the particles in the solution.



(c) The student then needs to prepare 2.0 L of a 0.60 M LiCl solution from the 3.0 M LiCl solution. Explain how to prepare the 0.60 M LiCl solution. Include appropriate calculations and lab equipment.

$$(3.0\ M\ LiCl)(V_1) = (0.60\ M\ LiCl)(2.0\ L)$$

$$V_1 = 0.40\ L$$

To prepare the solution:

1) Measure 0.40 L of the 3.0 M LiCl(aq) using a pipet
2) Place the 0.40 L of 3.0 M LiCl(aq) into a 2.0L volumetric flask.
3) Add distilled water to the flask to the 2.0L mark.
4) Cap the flask and invert to thoroughly mix

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(d) The student then measures 20. mL of the 3.0 M LiCl solution into an empty beaker. 50. mL of the 0.60 M LiCl solution is then measured and added to the same beaker. Assuming volumes are additive, calculate the concentration of Cl^- ions in the resulting solution.

Soln 1: (3.0 M LiCl)(0.020 L) = 0.060 mol LiCl = mol Cl^-

Soln 2: (0.60 M LiCl)(0.050 L) = 0.030 mol LiCl = mol Cl^-

Total moles of Cl^- in the beaker

= 0.060 mol Cl^- + 0.030 mol Cl^- = 0.090 mol Cl^-

$$[Cl^-] = \frac{0.090 \text{ mol } Cl^-}{0.070 \text{ L}} = \boxed{1.3 \text{ M } Cl^-}$$