SOLUTION STOICHIOMETRY

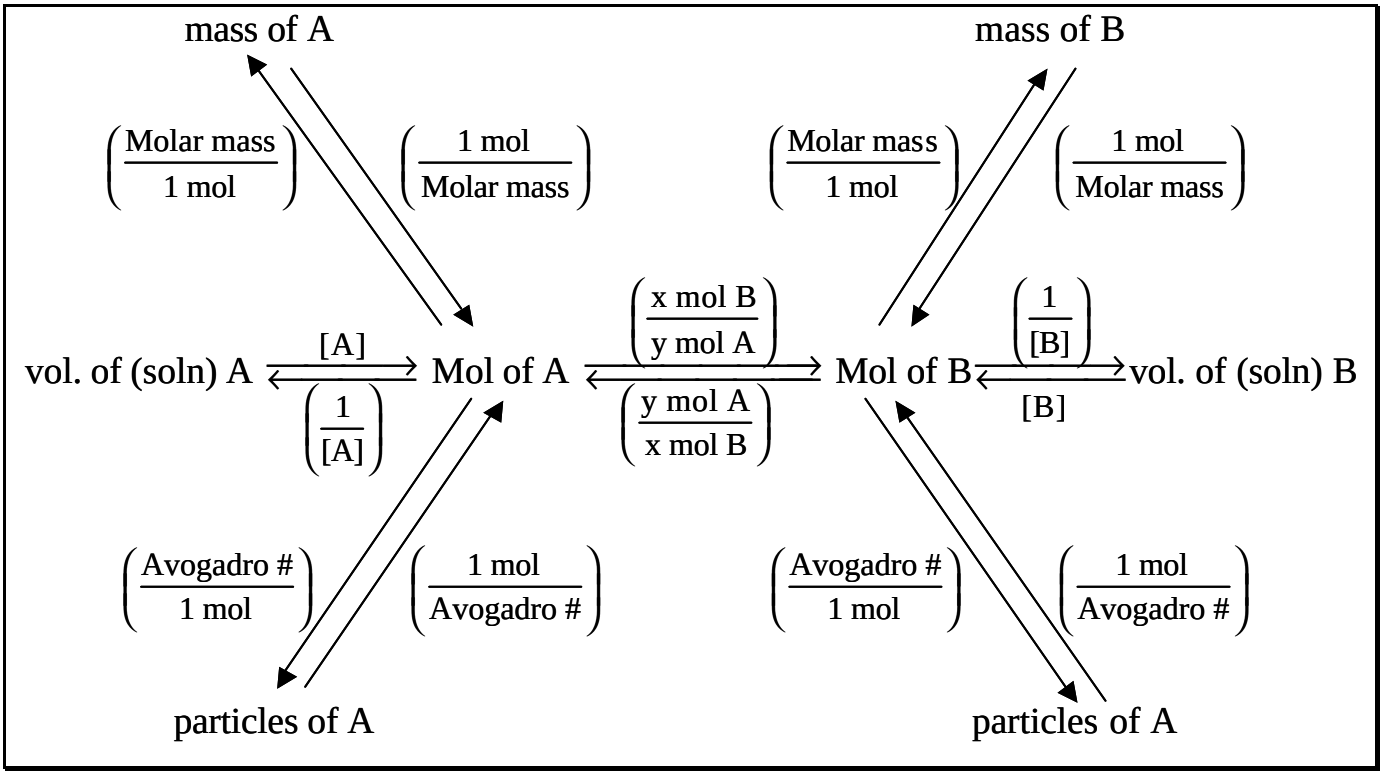
Solving solution-reaction problems

1. List initial species present in the combined solution before any reaction occurs, and decide what reaction will occur.
2. Write balanced molecular (or net ionic) equation for this reaction.
3. Calculate moles of reactants. (Use the volumes of the original solutions and their molarities.)
4. Determine limiting reactant where appropriate.
5. Calculate moles of required reactant/product.
6. Convert to grams or volume (of solution) or concentration as required.

Remember to follow the four-step strategy to problem-solving:

1. Analyze,
2. Plan an approach,
3. Execute the plan, and
4. Check the answer.

Scheme



Questions

1. What is the difference between 0.50 mol HCl and 0.50 M HCl?

Molarity and mass

2. (a) Calculate the molarity of a solution containing 0.0335 mol Na_2CrO_4 in 200 mL.
   (b) How many moles of HCl are present in 25.0 mL of a 12.0 M solution of hydrochloric acid?
   (c) How many millimeters of 2.00 M NaOH solution are needed to obtain 0.100 mol of NaOH?
3. (a) Calculate the molarity of a solution made by dissolving 0.0670 mol $NaHCO_3$ in enough water to form 250.0 mL of solution.
   (b) How many moles of $K_2Cr_2O_7$ are present in 50.0 mL of a 0.105 M solution?
   (c) How many milliliters of 9.0 M H_2SO_4 solution are required to obtain 0.050 mol of H_2SO_4?

4. Calculate the number of grams of solute present in each of the following solutions:
(a) 0.200 dm^3 of 0.125 M KBr (b) 250.0 mL of 0.0500 M $KBrO_3$ (d) 50.0 mL of 1.70 M $C_6H_{12}O_6$

5. Calculate the molar concentration of solute in each of the following solutions:
(a) 0.250 dm^3 containing 5.75 g of $NaNO_3$ (b) 100.0 mL containing 22.57 g of H_2SO_4 (c) 2.00 dm^3 containing 138 g of $NiCl_2 \cdot 6H_2O$

Concentration of components

6. (a) Determine the molar concentration of the cation in each of the solution given in question 5 above.
(b) Determine the molar concentration of the anion in each of the solution given in questions 5 above.
(c) Determine the total ion concentration in each of the solution in question 5 above.

Dilution

7. Determine the concentration of the resulting solutions when:
(a) 50.0 mL of the following solution is diluted to 100.0 mL:
(i) 0.125 M KBr, (ii) 0.150 M Na_2SO_4, (iii) 0.0500 M $KBrO_3$, (iv) 1.70 M $C_6H_{12}O_6$
(b) 10.0 mL of the following solution is diluted to 100.0 mL:
(i) 0.125 M KBr, (ii) 0.150 M Na_2SO_4, (iii) 0.0500 M $KBrO_3$, (iv) 1.70 M $C_6H_{12}O_6$
(c) 5.0 mL of the solution from question 5a is diluted to 250.0 mL.
(d) the solutions given in question 5 are diluted 5 fold.

8. Determine the mass of the solute present in each of the solution in question 7 (a) and (b).

9. Determine the volume of 18.0 M solution of sulfuric acid required to prepare
(a) a 100.0 mL of 0.100 M solution. (b) a 250.0 mL of 2.00 M solution. (c) a 500.0 mL of 0.500 M solution.

10. Determine the concentration of a dilute solution of nitric acid prepared by the dilution of 12.00 M concentration solution in the following manner:
(a) 10.0 mL is made up to 500.0 mL; (b) 50.0 mL is made up to 1000.0 mL; (c) 25.0 mL is made up to 500.0 mL.

Aqueous Reaction Stoichiometry

Acid-Base reactions

11. a) Determine the concentration of a basic solution of sodium hydroxide if
i) 25.00 mL of it is neutralized by 40.00 mL of 0.500 M hydrochloric acid.
ii) 25.00 mL of it is neutralized by 40.00 mL of 0.500 M sulfuric acid.
b) Determine the concentration of barium hydroxide if 20.00 mL of hydrochloric acid of concentration 0.200 M was required to completely titrate a 25.00 mL sample.
c) Determine the concentration of ethanoic acid if 25.00 mL of sodium hydroxide of concentration 0.200 M was required to completely titrate a 20.00 mL sample.
d) Determine the volume of 0.200 M ammonia solution that would be required to completely neutralize a 30.00 mL of 0.100 M hydrochloric acid.
e) Determine the volume of 0.100 M barium hydroxide that would be required to completely neutralize 25.00 mL of 0.200 M ethanoic acid.

12. a) Determine the mass of sodium hydroxide dissolved in a solution if the solution required 30.00 mL of 1.00 M sulfuric acid to completely neutralize it.
b) Potassium dissolves in water to produce a solution of potassium hydroxide and hydrogen gas. If a solution obtained by dissolving potassium when titrated against a 1.00 M nitric acid required 20.00 mL of the acid, determine the mass of the original potassium dissolved in the solution.
c) When sodium oxide dissolves in water, it produces an alkaline solution of sodium hydroxide. A certain mass of the oxide is dissolved in water and made up to a 200.0 mL. If 25.00 mL of this solution required 35.00 mL of 0.250 M sulfuric acid to completely neutralize it, determine the mass of sodium oxide weighed out to prepare the 200.0 mL solution.
d) Determine the mass of barium hydroxide used in the preparation of a stock solution of 200.0 mL if

25.00 mL sample of this solution required 20.00 mL of hydrochloric acid.
e) Determine the mass of ethanoic acid in 300.0-mL vinegar if 5.00 mL sample of it completely reacted with 15.00 mL of 0.100 M sodium hydroxide solution.

13. a) Determine the total ion concentration in each of the solutions in question 11 after the reaction is complete. Assume volumes to be additive.
    b) Determine the total ion concentration in each of the following mixture of solutions:
        (i) 25.00 mL of 0.100 M barium hydroxide and 20.00 mL of 0.100 M HCl
        (ii) 25.00 mL of 0.100 M sodium hydroxide and 20.00 mL of 0.100 M sulfuric acid
        (iii) 25.00 mL of 0.100 M barium hydroxide and 20.00 mL of 0.100 M sulfuric acid.

Precipitation Reactions

14. When a solution of copper(II) sulfate and barium chloride is mixed, barium sulfate precipitates out leaving a solution of copper(II) chloride.
    a) Write a balanced chemical equation for the reaction.
    b) If 15.00 mL of 0.200 *M* copper sulfate is treated with a 0.150 *M* barium chloride solution, determine the volume of barium chloride solution that would be required for the complete precipitation of the sulfate ions.
    c) Determine the mass of barium sulfate that would be formed.

15. When a solution of calcium chloride is treated with silver nitrate, a precipitate of silver chloride and solution of calcium nitrate result.
    a) If 10.00 mL of 0.500 *M* calcium chloride solution required 15.00 mL of the silver nitrate solution, determine the concentration of the silver nitrate solution used.
    b) Determine the mass of silver chloride that would be produced.
    c) Determine the concentration of calcium nitrate in the final solution assuming the volumes are additive.

16. A 20.00 mL of 0.500 M lead(II) nitrate and 40.00 mL of 0.300 *M* sodium chloride solution is mixed in a beaker. The reaction produces a precipitate of lead(II) chloride and a solution of sodium nitrate.
    a) Write a balanced equation showing the reaction between the substances.
    b) Determine if all the chlorides are precipitated out by the amount of lead(II) nitrate added to the sodium chloride solution.
    c) Identify the excess reagent and determine the excess amount.
    d) Determine the theoretical yield (mass) of the precipitate.
    e) If only 0.90 gram of the solid was recovered from the reaction, determine the percent yield.
    f) Determine the concentration of cations in the final solution assuming the volumes are additive.
    g) Determine the concentration of anions in the final solution assuming the volumes are additive.
    h) Determine the total ion concentration in the final solution assuming the volumes are additive.