Chemistry 20 Final Review

Solutions Checklist

Have you mastered the concepts, applications, and skills associated with the following items? Check them off when you are confident in your understanding.

Knowledge

- explain the nature of solutions and the dissolving process
- illustrate how dissolving substances in water is often a prerequisite for chemical change
- differentiate between electrolytes and nonelectrolytes
- explain dissolving as an endothermic or an exothermic process with regard to breaking and forming of bonds
- express concentration in various ways
- perform calculations involving concentration, chemical amount, volume and/or mass
- use dissociation equations to calculate ion concentration
- describe the procedures and calculations required for preparing solutions from a pure solid and by dilution
- define solubility and identify the factors that affect it
- explain a saturated solution in terms of equilibrium

Key Terms

solution	dissociation	solute
ionization	solvent	electrolyte
nonelectrolyte	concentration	standard solution
molar concentration	stock solution	saturated solution
solubility	primary standard	secondary standard
dynamic equilibrium		

Solutions

1. Define the following
    a. Solute
    Solute is the substance that gets dissolved.
    b. Solvent
    Solvent is the substance that does the dissolving.
    c. Saturated solution
    A solution that contains the maximum amount of solute at a given temperature.
    d. Miscible
    A liquid that will form a solution with another liquid (they will have very similar or the same type of intermolecular forces) in all proportions.
    e. Immiscible
    A liquid that will not form a solution with another liquid in any proportion.
    f. Endothermic reaction
    A reaction that absorbs energy.
    g. Exothermic reaction
    A reaction that releases energy.
    h. Solubility Equilibrium
    A solubility equilibrium exists when the rate of precipitation is equal to the rate of dissolving, or dissociation. You know you have a solubility equilibrium when you see a solution with a precipitate present on the bottom of the solution.

2. What is the difference between gases and solids in terms of temperature and solubility?
   Generally, as the temperature increases, solids increase in solubility, because the solvent particles move more quickly and can surround each solute with fewer solvent particles. However, as the temperature increases, gases become less soluble, because they have more energy to move together (coalesce) and form a bubble and leave the solvent.

3. What are the units for solubility?
   Solubility is measured in g/100 mL solution at a given temperature.

4. What is the concentration of a solution that has 2.45 mol of glucose in 890 ml of solution? (2.75 mol/L)

$$\frac{2.45\ \text{mol}}{0.890\ \text{L}} = 2.75\ \text{mol/L}$$

5. What is the concentration of a solution that has 4.4 grams of sucrose in 990 ml of solution? (0.0130 mol/L)

$$4.4\ \text{g}\ C_{12}H_{22}O_{11} \times \frac{1\ \text{mol}\ C_{12}H_{22}O_{11}}{342.34\ \text{g}\ C_{12}H_{22}O_{11}} \times \frac{1}{0.990\ \text{L}} = 0.0130\ \text{mol/L}$$

6. What is the volume if there is 0.750 mol/l solution if there was 2.50 grams of salt (sodium chloride)? (57.0 mL)

$$2.50\ \text{g NaCl} \times \frac{1\ \text{mol NaCl}}{58.44\ \text{g NaCl}} \times \frac{1\ \text{L NaCl}}{0.750\ \text{mol NaCl}} = 0.0570\ \text{L}$$

7. Calculate the mass of silver nitrate needed to prepare 1.00 liter of a 0.325 mol/L. (55.2 g)

$$1.00\ \text{L}\ AgNO_3 \times \frac{0.325\ \text{mol}\ AgNO_3}{1\ \text{L}\ AgNO_3} \times \frac{169.88\ \text{g}\ AgNO_3}{1\ \text{mol}\ AgNO_3} = 55.2\ \text{g}$$

8. How many liters of 1.50 mol/L solution of magnesium hydroxide would contain 40.0 g of solute? (457 mL)

$$40.0\ \text{g}\ Mg(OH)_2 \times \frac{1\ \text{mol}\ Mg(OH)_2}{58.33\ \text{g}\ Mg(OH)_2} \times \frac{1\ \text{L}\ Mg(OH)_2}{1.50\ \text{mol}\ Mg(OH)_2} = 0.457\ \text{L}$$

9. Calculate the volume of 0.825 mol/L of benzoic acid solution containing 0.360 mol of solute? (436 mL)

$$0.360\ \text{mol}\ C_6H_5COOH \times \frac{1\ \text{L}\ C_6H_5COOH}{0.825\ \text{mol}\ C_6H_5COOH} = 0.436\ \text{L}$$

10. Sodium phosphate solution is used to remove the scales at the bottom of a tea kettle. Calculate the mass of sodium phosphate needed to make 4.00 L of a 0.500 mol/L cleaning solution. (328 g)

$$4.00\ \text{L}\ Na_3PO_4 \times \frac{0.500\ \text{mol}\ Na_3PO_4}{1\ \text{L}\ Na_3PO_4} \times \frac{163.94\ \text{g}\ Na_3PO_4}{1\ \text{mol}\ Na_3PO_4} = 328\ \text{g}\ Na_3PO_4$$

11. Express the following in % (v/v) or % (m/v).
    a. 6.0 g of potassium chromate in 100 mL solution (6.0%)

$$\%\,m/v = \frac{6.0\,g}{100\,mL} \times 100\% = 6.0\%$$

    b. 0.75 ml of methanol in 12.0 ml of solution (6.3 %)

$$\%\,v/v = \frac{0.75\,mL}{12.0\,mL} \times 100\% = 6.3\%$$

    c. 4.5 g of calcium chloride in 50.0 ml of solution (9.0 %)

$$\%\,m/v = \frac{4.5\,g}{50.0\,mL} \times 100\% = 9.0\%$$

12. What mass or volume of solute is contained in the following solutions
    a. 150.0 ml of 2.2% (m/v) solution containing sulfuric acid (3.3 g)

$$m = \frac{\%\,m/v \cdot V_{soln}}{100\%}$$

$$\%\,m/v = \frac{m_{solute}}{V_{solution}} \times 100\% \qquad m = \frac{2.2\% \cdot 150.0\,mL}{100\%} = 3.3\,g.$$

    b. 50.0 ml of 6.5% (m/v) solution of ammonium phosphate (3.3 g)

$$m = \frac{6.5\% \cdot 50.0\,mL}{100\%} \qquad m = 3.3\,g$$

    c. 89.0 ml of 75% (v/v) solution of ethanol (67 mL)

$$V = \frac{75\% \cdot 89.0\,mL}{100\%} \qquad V = 67\,mL$$

13. What volume would be needed for the following?
    a. 3.6 g from a 5.5% (m/v) solution of sodium acetate (65 mL)

$$\%\,m/v = \frac{m_{solute}}{V_{solution}} \times 100\%$$

$$V_{solution} = \frac{m_{solute} \cdot 100\%}{\%\,m/v} \qquad V_{soln} = \frac{3.6\,g \cdot 100\%}{5.5\%} \qquad V_{soln} = 65\,mL$$

    b. 25.0 ml from a 10.5% (v/v) solution of hydrogen peroxide (238 mL)

$$V_{soln} = \frac{25.0\,mL \cdot 100\%}{10.5\%} \qquad V_{soln} = 238\,mL$$

    c. 9.6 g from a 30% (m/v) solution of calcium chloride (32 mL)

$$V_{soln} = \frac{9.6\,g \cdot 100\%}{30\%} \qquad V_{soln} = 32\,mL$$

$$\%\,v/v = \frac{V_{solute}}{V_{solution}} \times 100$$

14. Calculate the volume of solute in the following concentrations of solutions.

$$V_{solute} = \frac{V_{solution} \cdot \%\,v/v}{100\%}$$

a. 4.50 litres of 25% v/v of hydrochloric acid (1.13 kg)

$$V_{solute} = \frac{4.50\,L \cdot 25\%}{100\%} = 1.13\,L$$

b. 75.0 ml of 89.0% v/v of acetic acid (66.8 g)

$$V_{solute} = \frac{75.0\,mL \cdot 89.0\%}{100\%} = 66.8\,mL$$

15. What is the % (m/v) concentration of 2.50 mol/L of hydrogen peroxide? (8.51 %)

$$\frac{2.50\,mol\,H_2O_2}{1\,L\,H_2O_2} \times \frac{34.02\,g\,H_2O_2}{1\,mol\,H_2O_2} \times \frac{1\,L}{1000\,mL} \times 100\% = 8.51\%\,(m/v)$$

16. What is the % (m/v) concentration of 433 ppm of sodium chloride? (0.0433%)

$$\frac{433\,g}{1000000\,mL} \times 100\% = 0.0433\%$$

17. Calculate the molar concentration when two stock solutions of calcium acetate are combined: the 1st solution has a concentration of 0.250 mol/L at 180 ml. The 2nd solution has a concentration of 0.300 mol/L at 200 ml. (0.276 mol/L)

$$0.180\,L \cdot \frac{0.250\,mol}{1\,L} = 0.0450\,mol$$

$$0.200\,L \cdot \frac{0.300\,mol}{2\,L} = 0.0600\,mol$$

$$\frac{0.1050\,mol}{0.380\,L} = 0.276\,mol/L$$

18. You are diluting a solution and you want to prepare 0.500 mol/L at 200.0 ml from a stock solution of 1.00 mol/L, what volume do you need from your stock solution? (100 mL)

$$C_1V_1 = C_2V_2$$

$$0.500\,\frac{mol}{L} \cdot 200.0\,mL = 1.00\,mol/L \cdot V_2$$

$$V_2 = 100\,mL$$

19. Pure methanol has a concentration of 24.7 mol/L. Calculate the volume of concentrated methanol needed to prepare 4.00 liter of a 10.0 mol/L windshield washer antifreeze solution from pure methanol. (1.62 L)

$$C_1V_1 = C_2V_2$$

$$24.7\,mol/L \cdot V_1 = 10.0\,mol/L \cdot 4.00\,L$$

$$V_1 = 1.62\,L$$

20. Commercial sulfuric acid is 17.6 mol/L. If one uses 170 ml of the concentrated acid and dilutes it to a volume of 1.50 L, what is the concentration of the diluted sulfuric acid solution? (1.99 mol/L)

$C_1V_1 = C_2V_2$

$17.6\ mol/L \cdot 0.170\ L = 1.50\ L \cdot C_2$

$C_2 = 1.99\ mol/L$

21. Calculate the mass of solute needed to prepare a 500 ml of a 0.800 mol/L solution of potassium chromate. (77.7 g)

$0.500\ L\ K_2CrO_4 \times \frac{0.800\ mol\ K_2CrO_4}{1\ L\ K_2CrO_4} \times \frac{194.20\ g\ K_2CrO_4}{1\ mol\ K_2CrO_4}$

$= 77.7\ g\ K_2CrO_4$

a. The above was the stock solution and you wanted to make a secondary solution that is 250.0 ml that is 0.4500 mol/L in concentration, what will be the volume needed to make it? (141 mL)

$C_1V_1 = C_2V_2$

$0.800\ mol/L \cdot V_1 = 0.4500\ L \cdot 250.0\ mL$

$V_1 = 141\ mL$

22. Describe the steps in detail the process of making a solution.

- Acquire mass of solute
- Dissolve in ~ 1/4 the solvent needed
- Transfer to volumetric flask
- Rinse glassware used for dissolving 3 times and pour into volumetric glassware.
- Add solvent to volume mark on volumetric flask.

23. Describe the steps in detail the process of making a secondary solution.

- Add small volume of solvent to a volumetric flask
- Using a volumetric pipet, dispense required volume of primary standard into volumetric flask for secondary standard

→ Add solvent up to volume mark on volumetric flask.

24. Make a flow chart in selectively precipitating out the following contaminants in a solution: Pb^{2+}, Ra^{2+}, and Hg^{+}.

$Pb^{2+} / Ra^{2+} / Hg^{+}$

↓ ADD Na_2SO_4 → $PbSO_{4(s)}$

Ra^{2+} / Hg^{+}

↓ Add NaCl → $HgCl_{(s)}$

Ra^{2+}

↓ Add NaOH

$Ra(OH)_{2(s)}$

25. What color of flame does the following show (check your databooklet…pg. 6…just sayin'…)?
    a. Lithium Red
    b. Sodium Yellow
    c. Lead Blue-white.

26. Write the dissociation equation for the following and give the ion concentrations for each solvated ion.
    a. 2.50 mol/L of Calcium nitrate

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

2.50 mol/L 5.00 mol/L

    b. 3.00 mol/L of Cobalt (III) acetate

$Co(CH_3COO)_{3(aq)} \rightarrow Co^{3+}_{(aq)} + 3CH_3COO^-{}_{(aq)}$

3.00 mol/L 9.00 mol/L

    c. 1.25 mol/L of Zinc chloride

$ZnCl_{2(aq)} \rightarrow Zn^{2+}_{(aq)} + 2Cl^-{}_{(aq)}$

1.25 mol/L 2.50 mol/L

    d. 0.750 mol/L of Ammonium sulfate

$(NH_4)_2SO_{4(aq)} \rightarrow 2NH_4^+{}_{(aq)} + SO_4^{2-}{}_{(aq)}$

1.500 mol/L 0.750 mol/L

    e. 0.250 mol/L of Acetic acid

$CH_3COOH_{(aq)} \rightarrow CH_3COOH_{(aq)}$

0.250 mol/L

(Weak acids don't ionize much at all…)

27. Calcium acetate is added to 10.0 ml of 0.0200 mol/L silver nitrate. What is the mass of the precipitate produced? (33.4 mg)

$$Ca(CH_3COO)_{2(aq)} + 2AgNO_{3(aq)} \rightarrow Ca(NO_3)_{2(aq)} + 2AgCH_3COO_{(s)}$$

$$0.0100\,L\,AgNO_3 \times \frac{0.0200\,mol\,AgNO_3}{1\,L\,AgNO_3} \times \frac{2\,mol\,AgCH_3COO}{2\,mol\,AgNO_3} \times \frac{166.92\,g\,AgCH_3COO}{1\,mol\,AgCH_3COO}$$

$$= 0.0334\,g\,AgCH_3COO$$

28. 50.0 ml of 0.250 mol/L potassium phosphate reacts with 25.0 ml of 1.00 mol/L lead (II) sulfate. What is the mass of the precipitate? (Hint: Limiting reagent question) (5.07 g)

$$2K_3PO_{4(aq)} + 3PbSO_{4(aq)} \rightarrow Pb_3(PO_4)_{2(s)} + 3K_2SO_{4(aq)}$$

$$0.0500\,L\,K_3PO_4 \times \frac{0.250\,mol\,K_3PO_4}{1\,L\,K_3PO_4} \times \frac{1\,mol\,Pb_3(PO_4)_2}{2\,mol\,K_3PO_4} \times \frac{811.54\,g\,Pb_3(PO_4)_2}{1\,mol\,Pb_3(PO_4)_2}$$

$$= 5.07\,g \Leftarrow \text{Mass produced, } K_3PO_4 \text{ is L.R.}$$

$$0.0250\,L\,PbSO_4 \times \frac{1.00\,mol\,PbSO_4}{1\,L\,PbSO_4} \times \frac{1\,mol\,Pb_3(PO_4)_2}{3\,mol\,PbSO_4} \times \frac{811.54\,g\,Pb_3(PO_4)_2}{1\,mol\,Pb_3(PO_4)_2}$$

$$= 6.76\,g$$

29. 75 ml of 1.25 mol/L of HCl (aq) is reacted with 125 ml of 1.00 mol/L KOH (aq), what are the concentrations of the salt? (Hint: you need to know the L.R.) (0.43 mol/L)

$$HCl_{(aq)} + KOH_{(aq)} \rightarrow KCl_{(aq)} + H_2O_{(l)}$$

$V_{TOTAL} = 75\,mL + 125\,mL = 200\,mL$

$$0.075\,L\,HCl \times \frac{1.25\,mol\,HCl}{1\,L\,HCl} \times \frac{1\,mol\,KCl}{1\,mol\,HCl} \times \frac{1}{0.200\,L\,\text{solution}}$$

$$= 0.47\,mol/L\,KCl \Leftarrow$$

HCl is LR

$$0.125\,L\,KOH \times \frac{1.00\,mol\,KOH}{1\,L\,KOH} \times \frac{1\,mol\,KCl}{1\,mol\,KOH} \times \frac{1}{0.200\,L}$$

$$= 0.63\,mol/L\,KCl$$

∴ Resulting solution of KCl is 0.47 mol/L

30. Predict the volume of the base (0.250 mol/L of sodium hydroxide) needed to be added to neutralize 75.0 ml of nitric acid at 0.500 mol/L. (150 mL)

$$NaOH_{(aq)} + HNO_{3(aq)} \rightarrow H_2O_{(l)} + NaNO_{3(aq)}$$

$$0.0750\,L\ HNO_3 \times \frac{0.500\,mol\ HNO_3}{1\,L\ HNO_3} \times \frac{1\,mol\ NaOH}{1\,mol\ HNO_3} \times \frac{1\,L}{0.250\,mol\ NaOH}$$

$$= 0.150\,L\ NaOH.$$

31. A 150.0 ml sample of 0.7500 mol/L of aqueous solution of sodium sulfate is added to 250.0 ml of strontium hydroxide at 0.350 mol/L. Predict the mass of the precipitate. (16.1 g)

$$Na_2SO_{4(aq)} + Sr(OH)_{2(aq)} \rightarrow SrSO_{4(s)} + 2NaOH_{(aq)}$$

$$0.1500\,L\ Na_2SO_4 \times \frac{0.7500\,mol\ Na_2SO_4}{1\,L\ Na_2SO_4} \times \frac{1\,mol\ SrSO_4}{1\,mol\ Na_2SO_4} \times \frac{183.69\,g\ SrSO_4}{1\,mol\ SrSO_4}$$

$$= 20.7\,g\ SrSO_4$$

$$0.2500\,L\ Sr(OH)_2 \times \frac{0.350\,mol\ Sr(OH)_2}{1\,L\ Sr(OH)_2} \times \frac{1\,mol\ SrSO_4}{1\,mol\ Sr(OH)_2} \times \frac{183.69\,g\ SrSO_4}{1\,mol\ SrSO_4}$$

$$= 16.1\,g\ SrSO_4$$

$Sr(OH)_2$ is L.R.

Mass $SrSO_4$ Actually produced...

32. What volume of boric acid at 0.025 mol/L will be needed to neutralize 90 ml of 0.055 mol/L magnesium hydroxide? (132 mL)

$$2\,H_3BO_{3(aq)} + 3Mg(OH)_{2(aq)} \rightarrow Mg_3(BO_3)_{2(aq)} + 6H_2O_{(l)}$$

$$0.090\,L\ Mg(OH)_2 \times \frac{0.055\,mol\ Mg(OH)_2}{1\,L\ Mg(OH)_2} \times \frac{2\,mol\ H_3BO_3}{3\,mol\ Mg(OH)_2} \times \frac{1\,L\ H_3BO_3}{0.025\,mol\ H_3BO_3}$$

$$= 0.132\,L\ H_3BO_3.$$