REVIEW- Honors
Solutions

Name Answer Key
Period _______ ***Date*** ___________

Topics:

- Saturated, unsaturated, supersaturated solutions; using solubility curves chart
- Temperature and pressure effects on solubility (for solids and gases)
- Molarity of solutions (preparing solutions from solids and by diluting solutions)
- Beer's Law & direct relationship between concentration & absorbance.
- Stoichiometry calculations involving solution concentrations
- Colligative properties of mixtures: freezing point depression and boiling point elevation
- Colligative property calculations: FPD, BPE, Molar Mass of solute. Important equations:
    - ○ $$\text{molality } m = \frac{\text{mol solute}}{\text{kg solvent}} \quad \begin{array}{|c|c} \Delta T_f = iK_f m & \Delta T_b = iK_b m \\ \hline T_f = T_f^\circ - \Delta T_f & T_b = T_b^\circ + \Delta T_b \end{array}$$

Practice Problems:

1) Refer to the solubility curve in your reference charts (Chart E) for these questions.
    a) At what temperature can one dissolve exactly 40g of NH_4Cl in 100 g of water? 24-25°C
    b) At what temperature do NaCl and KCl share the SAME solubility limit? 36-37°C
    c) If 80 g of KNO_3 are added to 100 g of water at 60°C, is the solution **sat**, [✓ **unsat**] or **supersat**?
    d) If 110 g of $NaNO_3$ are added to 100 g of water at 30°C, is the solution [✓ **sat**], **unsat** or **supersat**?
    e) A chemist wants to make a solution with 70g of KNO_3 dissolved in 100 g of water at 30°C. What type of solution would this be? supersaturated Describe how this solution could be made.
    70 g KNO_3 would have to be completely dissolved in 100g of water at a temperature at or above ~43°C, the temperature at which 70 g KNO_3 is exactly a saturated solution, and then cooled to 30°C without disturbing.

    f) The solubility of NH_3, HCl and SO_2 decreases with increased temperature, but solubility increases with increased temperature for all the other compounds. What accounts for this difference?
    NH_3, HCl, and SO_2 are all gases, whose solubility decreases with increasing temperature. The other compounds are all solids, whose solubility *generally* increases (there are some unusual exceptions not shown on this chart) with increasing temperature.

2) The solubility of a gas ([✓ **increases,**] **decreases**) with increased pressure.

3) Why is it important that a scuba diver come to the surface slowly after spending some time deep underwater?
When submerged, the diver is breathing gas at an increased pressure, so the solubility in her blood is increased. As she surfaces, the pressure decreases and so does the solubility, so ascending too quickly will cause the dissolved gas to form bubbles as its solubility decreases, leading to the Bends.

4) Calculate and describe how one would make 500. mL of a 3.00 M solution of $FeCl_3$ from solid $FeCl_3$.

$$?\text{ g FeCl}_3 = 500.\text{ mL} \times \frac{3.00\text{ mol FeCl}_3}{1000\text{ mL}} \times \frac{162.2\text{ g FeCl}_3}{1\text{ mol FeCl}_3} = \boxed{243\text{ g FeCl}_3}$$

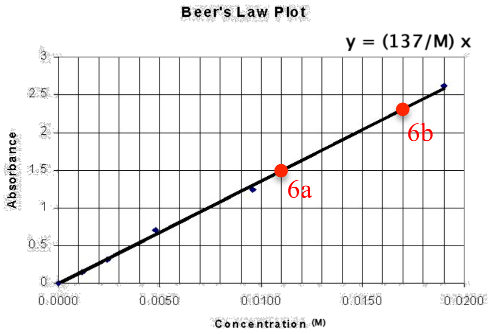
Measure 243 g $FeCl_3$ into a 500-mL volumetric flask. Fill ~¾ full with H_2O, stopper, and shake until fully dissolved. Add H_2O to the calibration mark (500 mL), using a dropper to add the final amounts for precision. Stopper and shake until mixed. You may need to top off the solvent, as the volume of the solution can sometimes decrease after the second step.

5) Calculate and describe how one would make 250. mL of 5.00 M HCl from a 12.0 M HCl solution (remember to specify how to mix acid with water).

$$V_{conc} = V_{dil}\frac{M_{dil}}{M_{conc}} = 250.\ mL \times \frac{5.00\ M}{12.0\ M} = \boxed{104\ mL\ of\ 12.0\ M\ HCl}$$

Measure out 104 mL of 12.0 M HCl (use a pipette or graduated cylinder) and add to a 250-mL volumetric flask ~½ full of H_2O (always add conc. acid to water). Fill to the line with H_2O, stopper and mix. As in #4, you may need to top off the solvent if the volume of the solution decreases.

6) The Beer's Law calibration plot for $CoCl_2$ at 545 nm is shown at right. Use the plot or the equation for the line (the unit for slope is 1/M or M^{-1}) to determine the following:



a) What is the concentration of a solution with absorbance = 1.5?

$$1.5 = \left(137\ M^{-1}\right) \times M;\ M = \frac{1.5}{137\ M^{-1}} = \boxed{0.011\ M}$$

b) What is the absorbance of a 0.0170 M solution?

$$A = \left(137\ M^{-1}\right)\left(0.0170\ M\right) = \boxed{2.3}$$

7) What is the theoretical yield of $PbCl_2$ when 100. mL of 0.050 M $AlCl_3$ is mixed with excess $Pb(NO_3)_2$ according to the following equation (balance!)?

$$\underline{\ 3\ }\ Pb(NO_3)_2\ (aq) + \underline{\ 2\ }\ AlCl_3\ (aq) \longrightarrow \underline{\ 3\ }\ PbCl_2\ (s) + \underline{\ 2\ }\ Al(NO_3)_3\ (aq)$$

$$?\ g\ PbCl_2 = \underbrace{100.\ mL \times \frac{0.050\ mol\ AlCl_3}{1000\ mL}}_{0.0050\ mol\ AlCl_3} \times \underbrace{\frac{3\ mol\ PbCl_2}{2\ mol\ AlCl_3}}_{0.0075\ mol\ PbCl_2} \times \frac{278.1\ g\ PbCl_2}{1\ mol\ PbCl_2} = \boxed{2.09\ g\ PbCl_2}$$

8) What is the concentration of a hydrobromic acid solution if 15.8 mL of the solution reacts with excess Zn according to the following reaction (balance!) and produces 62.3 mL of dry H_2 at 0.955 atm and 21.5°C.

$$\underline{\ 2\ }\ HBr\ (aq) + \underline{\quad}\ Zn\ (s) \longrightarrow \underline{\quad}\ ZnBr_2\ (aq) + \underline{\quad}\ H_2\ (g)$$

$$mol\ H_2 = \frac{PV}{RT} = \frac{\left(0.955\ atm\right)\left(0.0623\ L\right)}{\left(0.0821 \frac{L\cdot atm}{mol\cdot K}\right)\left(294\ K\right)} = 0.00246\ mol\ H_2$$

$$mol\ HBr = 0.00246\ mol\ H_2 \times \frac{2\ mol\ HBr}{1\ mol\ H_2} = 0.00493\ mol\ HBr$$

$$M_{HBr} = \frac{0.00493\ mol\ HBr}{0.0158\ L} = \boxed{0.312\ M\ HBr}$$

9) A solution of antifreeze (ethylene glycol) and water....

a) has a freezing point which must be **(at, above or [✓ below])** 0°C.

b) has a boiling point which must be **(at, [✓ above] or below)** 100°C.

10) Explain **why** the freezing point gets lower the more salt one dissolves into water.

Salt blocks the water molecules trying to form the hydrogen bonds needed to create the hexagonal crystal structure of ice. Since freezing is an exothermic process and energy must be removed for it to occur, more energy must be removed to get through the solute, requiring a lower temperature.

11) Suppose the temperature outside is –5°C and there is ice on the roads. Salt is put on the roads to melt the ice. Why does the ice melt when salt is added?

When salt is added to the ice the freezing point must become lower than –5°C. Thus, the ice melts because the temperature outside (–5°C) is higher than the freezing point of the ice/salt mixture.

12) Arrange the following from lowest to highest freezing point: *1.5 M Na_2S, 0.5 M Na_2S, 1.0 M Na_2S*

Lowest FP ___1.5 M Na_2S___ ___1.0 M Na_2S___ ___0.5 M Na_2S___ **highest FP**

Note: pure H_2O (0 M Na_2S) would have the highest FP of all.

13) a) What does the van't Hoff factor, *i*, indicate?

The van't Hoff factor indicates the number of particles formed when a compound dissolves in H_2O. For covalent (molecular) compounds, $i = 1$ since they do not dissociate into ions; for ionic compounds, i is the number of ions in the formula unit of the compound.

molecular $Li^+ + OH^-$ $Fe^{3+} + 3\,Cl^-$

b) What are the values of *i* for the following compounds? C_3H_7OH _1___; LiOH _2___; $FeCl_3$ _4___

14) Determine the boiling point of an aqueous solution of 94.6 g of Na_3PO_4 (what is *i*?) dissolved in 250.0 g H_2O ($K_b = 0.512°C/m$).

a) What is the molality of the solution?

$$\text{mol Na}_3\text{PO}_4 = 94.6\text{ g Na}_3\text{PO}_4 \times \frac{1\text{ mol Na}_3\text{PO}_4}{163.9\text{ g Na}_3\text{PO}_4} = 0.577\text{ mol Na}_3\text{PO}_4;\ m = \frac{0.0577\text{ mol}}{0.2500\text{ kg}} = \boxed{2.31m}$$

b) What is the boiling point elevation?

$$i = 4\text{ since Na}_3\text{PO}_4 \rightarrow 3\text{ Na}^+ + \text{PO}_4^{3-}\text{ so }\Delta T_b = iK_bm = (4)(0.512°\text{C}/m)(2.31m) = \boxed{4.73°\text{C}}$$

c) What is the boiling point of the solution?

$$T_b = T_B^\circ + \Delta T_b = 100.00°\text{C} + 4.73°\text{C} = \boxed{104.73°\text{C}}$$

15) A 0.300 g sample of caffeine (a molecular compound) was dissolved in 20.0 g of camphor ($K_f = 39.7\ °C/m$, $T^\circ_f = 179.00°C$), decreasing the freezing point of camphor to 175.93°C.

a) What is the molality of the solution?

$i = 1$ since caffeine is molecular

$$\Delta T_f = 179.00°\text{C} - 175.93°\text{C} = 3.07°\text{C};\ m = \frac{\Delta T_f}{iK_f} = \frac{3.07°\text{C}}{(1)(39.7°\text{C}/m)} = \boxed{0.0773m}$$

b) How many moles of caffeine are present?

$$\text{mol} = m \times K_f = \left(0.0773\tfrac{\text{mol}}{\text{kg}}\right)(0.0200\text{ kg}) = \boxed{0.00155\text{ mol}}$$

c) What is the molar mass of caffeine?

$$\text{MM} = \frac{\text{mass}}{\text{mol}} = \frac{0.300\text{ g}}{0.00155\text{ mol}} = \boxed{194\text{ g/mol}}$$