Name: Key Period: _____

Solutions and Gas Laws Study Guide

Solutions

1. Define solvent, solute, and solutions.
   Solute placed in solvent to make solution

2. How does the temperature affect the solubility of gases? What about pressure?
   Think of a bottle of pop!
   high temp. = low solubility ; high pressure = high solubility

3. What is Henry's Law?
   solubility of a gas based on pressure exerted on one a liquid. ($P_1 S_1 = P_2 S_2$)

4. If the solubility of a gas in water is 0.77g/L at 3.5 atm of pressure what is the solubility in 1.0 atm of pressure?
   $\frac{S_1}{P_1} = \frac{S_2}{P_2}$ $\frac{0.77\,g/L}{3.5\,atm} \times \frac{x}{1\,atm}$ **0.22 g/L**

5. Contrast Immiscible vs. Miscible? What is an emulsifier? → polar + nonpolar ends, attracts both to make an emulsion.
   Immiscible - Substances not soluble.
   Miscible - Substances soluble (like dissolved like)

6. Calculate the molarity of a solution that contains 65 g of glucose ($C_6H_{12}O_6$) in 1.56 L of water.
   $M = \frac{mol\,solute}{L\,solution}$ $\frac{65g}{180g} = 0.36\,mol$ 1mL = 1g $0.65mL \rightarrow 0.36mol$ $+1.86$ $1.625\,L \rightarrow 1.625L$ $\frac{0.36mol}{1.625L} = 0.22\,M$

7. How much water should be added to 5.00 g of KCl to prepare a 0.500m solution?
   $m = \frac{mole\,solute}{Kg\,solvent}$ m = 0.500m mol KCl = 0.07 Kg H_2O = ? $\frac{5g}{74.55g} = 0.07mol$ $x(0.500) = (\frac{0.07}{x})x$ $\frac{0.500x}{0.5} = \frac{0.07}{0.5}$ **x = 0.14 Kg H_2O**

8. What is the molality of a solution that in which 15 g of I_2 is dissolved in 500 g of alcohol.
   $m = \frac{mol\,Solute}{Kg\,solvent}$ $\frac{0.06}{0.500} = 0.12m$ $\frac{15g}{253.8g} = 0.06\,mol$ 0.500kg

9. Calculate the mole ratio for each substance. A solution is composed of 45 g of CaCl2 dissolved in 150 mL of water.
   $\frac{mol.\,Substance\,X}{total\,moles}$ 110.98g 150mL = 150g $\frac{45}{110.98} = 0.41\,mol\,CaCl_2$ $\frac{150g}{18g} = 8.33\,mol\,H_2O$ 8.33 + 0.41 = 8.74 total moles
   $\frac{0.41}{8.74} = 0.05$ $CaCl_2$ $\frac{8.33}{8.74} = 0.95$ H_2O

10. What mass of KI must be dissolved in 1000L of solution to make a 5% KI solution?
    $\%\,conc. = \left(\frac{mass/volume\,x}{total\,mass/volume}\right) \times 100$ 1000L → 1,000,000mL = 1,000,000 g $5 = \left(\frac{x}{1,000,000}\right) \times 100$ **x = 50,000g KI**

$5 = \frac{x}{1000} \times 100$ $\frac{5}{100} = \frac{x}{1000}$ $0.05 = \frac{x}{1000}$ $x = 50\,KI$

Colligative Properties

1. A property that depends on the number of solute particles (concentration) is said to be a Colligative property.
2. List 3 examples of colligative properties:
   a. Freezing Point Depression
   b. Boiling Point Elevation
   c. osmotic pressure
3. What colligative property is responsible for keeping water from freezing in a car's cooling system? boiling
4. List the van't Hoff factor and explanation for the following:
   i. NaI 2 will dissociate into 2 ions (ionic)
   ii. SO_3 1 won't dissociate; all non-metals (covalent)
   iii. Ca_3N_2 5 $Ca_3N_2 \rightarrow 3Ca + 2N$ dissociates into 5 ions (ionic)
5. What is the boiling point of a 1.50m NaCl solution?

$\Delta T = m \cdot i \cdot K = (1.5)(2)(0.52) = 1.56°C$

$100 + 1.56 = \boxed{101.56°C}$

6. What is the new freezing **and** boiling point of water if 50. g of ethylene glycol (MW=62.07 g/mol) is added to 50. g of water? (ethylene glycol ← solute, $i = 1$; water ← solvent, $i = 1$)

$\frac{50g}{62.07g} = 0.81$ moles

$m = \frac{0.81}{0.05} = 16.2m$

$\Delta T_B = (16.2)(1)(0.52) = 8.42°C + 100 = \boxed{108.42°C}$ BP

$\Delta T_F = (16.2)(1)(1.86) = 30.1°C$ $0 - 30.1 = \boxed{-30.1°C}$

7. What is the freezing point of a solution of 12.0g of CCl_4 dissolved in 750.0 g of benzene? The freezing point of benzene is 5.48 °C; K_f is 5.12 °C/m.

$\frac{12g}{153.8g} = 0.08$ mol CCl_4

$m = \frac{0.08}{0.750} = 0.104m$

$\Delta T_F = (0.104)(1)(5.12) = 0.53°C$

$5.48 - .53 = \boxed{4.95°C}$

8. When 5.0 g of a covalent compound is added to 25 g of water the new freezing point is -2.5 °C. What is the molecular mass of the unknown compound?

$i = 1$

$2.5 = m(1)(1.86)$

$1.34 = m$

$1.34 = \frac{x}{0.025 kg H_2O}$

$x = 0.034$ moles (g/mol)

$\frac{5g}{0.034 mol} = \boxed{147 g/mol}$

625 mmHg = 0.8224 atm.

Gas Laws

Fill in the following Gas Laws:

Charles' Law: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Boyle's Law: $P_1V_1 = P_2V_2$

Gay-Lussac's Law: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Combined Gas Law: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Ideal Gas Law: $PV = nRT$

Possible R values (include units) $R = 0.0821 \frac{atm \cdot L}{mol \cdot K}$ or $R = 8.314 \frac{kPa \cdot L}{mol \cdot K}$

1. A given mass of air has a volume of 6.00L at 101kPa. What volume will it occupy at 25.0 kPa if the temperature does not change? (V, P)

$P_1V_1 = P_2V_2$

$(101)(6) = (25)V_2$ $\quad V_2 = 24.24L$

2. A balloon filled room at 24°C has a volume of 4.00L. The balloon is then heated to a temperature of 58°C. (331K T, 297K, V)

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\quad \frac{4}{297} = \frac{x}{331}$ $\quad 4.46L$

3. Complete the following table for an ideal gas;

$PV = nRT$

P (atm)	V (L)	n (mol)	T
5.00	A	2.00	155 °C → 428K
0.300	2.00	B	155K
4.47	25.0	2.01	C
D	2.25	10.5	75°C → 348K

A= 14.016L

B= 0.047 mol

C= 677K

D= 133 atm.

$n = \frac{g}{mw}$

4. 0.322-g of an unknown gas was collected. The gas had a volume of 598-mL (0.0598L) a pressure of 655mm Hg and a temperature of 52°C (325K). What is the molar mass of the gas? mw = 164g/mol

$PV = \frac{g}{mw}RT$ (0.862 atm)

$0.862(.0598) = \frac{0.322}{mw}(0.0821)(325)$

5. 324-mL of oxygen is collected over water at 685-mmHg and 18°C. It is released when hydrogen peroxide (H_2O_2) decomposes. It also forms water. How many grams of hydrogen peroxide decomposed?

0.901 atm.

.324L

291K

$(0.901)(0.324) = n(0.0821)(291)$

$n = (0.012 \text{ moles})(34) = .415g\ H_2O_2$

Partial Pressure, Diffusion, and Effusion

1. In your own words, state Dalton's Law of Partial Pressures.

individual pressures add up to total pressure.

2. The partial pressure of helium is 13.5 kPa in a mixture of helium, oxygen, and methane gases. If the total pressure is 96.4 kPa and the partial pressure of oxygen is 29.3 kPa, what is the partial pressure of methane gas?

$96.4 = 13.5 + 29.3 + P_{CH_4}$ $\quad \boxed{P_{CH_4} = 53.6 \text{ kPa}}$

3. Determine the partial pressure of oxygen collected over water if the temperature is 28 °C and the total gas pressure is 98.74 kPa. (Vapor pressure of water at 28 °C is 3.8 kPa)

$98.74 = 3.8 + P_o$

$\boxed{P_o = 94.9 \text{ kPa}}$

4. A mystery gas effuses 4.0 times faster than oxygen. What is likely the identity of the mystery gas? (Hint, find the molar mass)

SKIP

$$\frac{4}{1} = \sqrt{\frac{32}{x}}$$

$$\frac{16}{1} = \frac{32}{x}$$

$x = 2 \text{ g/mol}$ so $\boxed{H_2 \text{ gas}}$

(6) They gave you the mass of $C_6H_{12}O_6$. Use it to find the moles.

given $\longrightarrow \frac{65g}{180g} = 0.36$ moles

1 mole $C_6H_{12}O_6 \longrightarrow$

The gave you liters of water. This is only the solvent. You need liters of the <u>whole solution</u>. So convert 65g to L.

1 g = 1 mL

65g = 65 mL

65 mL $\longrightarrow$ 0.065L

$+ 1.56$ L of water

1.625L of solution

$$M = \frac{\text{moles of solute}}{\text{Liters of solution}} = \frac{0.36}{1.625} = 0.22\ M$$

(7) They gave mass of KCl. Use this to find mole of KCl.

given $\longrightarrow \frac{5g}{74.55g} = 0.07$ moles

1 mole KCl $\longrightarrow$ 74.55g

They also tell you it's a 0.500 m solution. This is molality (see the little m). So we're looking for the amt. of water which is the Kg of solvent.

$$m = \frac{\text{mole solute}}{\text{Kg of solvent}} \qquad x(0.500) = \left(\frac{0.07}{x}\right)x$$

$$\frac{0.500x}{0.500} = \frac{0.07}{0.500}$$

$$x = 0.14 \text{ Kg } H_2O$$

(8) They gave you 15g of I_2. Use this to solve for moles of I_2.

given $\longrightarrow \frac{15g}{253.8g} = 0.06$ moles

1 mole I_2 $\longrightarrow$ 253.8g

They gave you mass of alcohol in grams. Convert to Kg.

500 g $\longrightarrow$ 0.5 Kg

$$m = \frac{\text{mole solute}}{\text{Kg solvent}} = \frac{0.06}{0.50} = \boxed{0.12 \text{ m}}$$

(9) Given 45g of $CaCl_2$, determine moles.

$$\text{given} \rightarrow \frac{45g}{110.98g} = 0.41 \text{ moles}$$
$$1 \text{ mol } CaCl_2 \rightarrow$$

Given 150 mL water, convert to grams then determine moles.

$1 mL = 1g$

$150 mL = 150g$

$$\text{given} \rightarrow \frac{150g}{18g} = 8.33 \text{ moles.}$$
$$1 \text{ mol } H_2O \rightarrow$$

$$\text{mole fraction} = \frac{\text{moles of substance X}}{\text{total moles}}$$

$8.33 + 0.41 = 8.74$ total moles.

$CaCl_2$: $\frac{0.41}{8.74} = 0.05$

H_2O: $\frac{8.33}{8.74} = 0.95$

(10) This is percent concentration. They gave you percent. 5% KI.

Then gave you 1000L solution, which is volume. You want mass of KI so convert 1000L → g.

$$1000L \rightarrow 1{,}000{,}000 mL = 1{,}000{,}000g$$

$$\% = \left(\frac{\text{mass of X}}{\text{total mass}}\right) \times 100$$

$$\frac{5}{100} = \frac{\left(\frac{x}{1{,}000{,}000}\right) \times 100}{100}$$

$$1{,}000{,}000 \times .05 = \frac{x}{1{,}000{,}000} \times 1{,}000{,}000$$

$$\boxed{x = 50{,}000g \text{ KI}}$$

Colligative Prop.

$K_f = 1.86$ $K_b = 0.52$

(5) $\Delta T = m \cdot i \cdot K$

BP of 1.50m NaCl
↑
molality

$\Delta T = (1.50)(2)(0.52) = 1.56°C$

Boiling Pt. Elevation

so add number to 100°C

$100 + 1.56 = \boxed{101.56°C}$

$NaCl \rightarrow Na + Cl$

$i = 2$

Use K_b

(6) Ethylene glycol is covalent (all non-metals). $i = 1$

Need to determine molality.

Ethylene glycol is the solute

given → 50g = 0.81 moles
1 mole → 62.07g

Given 50g of water (solvent), convert to kg

50 → 0.050 kg

$m = \frac{0.81}{0.05} = 16.2m$

$\Delta T_{BP} = (16.2)(1)(0.52) = 8.42°C + 100 = \boxed{108.42°C}$

$\Delta T_{FP} = (16.2)(1)(1.86) = 30.1°C$

$0 - 30.1°C = \boxed{-30.1°C}$

FP Depression

(B) $\Delta T = m \cdot i \cdot K$ $i = 1$ because it is a covalent compound.

$\frac{2.5}{1.86} = \frac{m \cancel{(1)(1.86)}}{\cancel{1.86}}$

$m = 1.34$

$m = \frac{mol}{Kg} \xrightarrow{\times 0.025} (1.34) = \left(\frac{x}{0.025}\right) 0.025$

$35g\ H_2O \rightarrow 0.025kg$

$x = 0.034$ moles

$\downarrow$

$\frac{5g}{0.034mol} = \boxed{147 g/mol}$