Final Exam Review

Stoichiometry problems

1. Methanol, CH3OH, can be produced by the following reaction: $2H_2 + CO \rightarrow CH_3OH$
   a) Calculate the theoretical yield of CH_3OH if 68.5 g of CO is reacted with 8.6 g of H_2. (2 givens and 2 calculations)

$$T.Y. = \frac{68.5\text{g CO}}{} \left| \frac{1\text{mol CO}}{28.01\text{g CO}} \right| \frac{1\text{mol } CH_3OH}{1\text{mol CO}} \left| \frac{32.05\text{g } CH_3OH}{1\text{mol } CH_3OH} \right. = 78.4\text{g}$$

$$= \frac{8.6\text{g } H_2}{} \left| \frac{1\text{mol } H_2}{2.02\text{g } H_2} \right| \frac{1\text{mol } CH_3OH}{2\text{mol } H_2} \left| \frac{32.05\text{g } CH_3OH}{1\text{mol } CH_3OH} \right. = 68.2\text{g}$$

Theoretical yield = 68.2g

   b) What is the limiting reactant in the reaction? The reactant in excess?

H_2 is LR, CO is in excess

   c) If 35.7 g CH_3OH is actually produced, what is the % yield of methanol?

$$\% \text{ Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100\% = \frac{35.7\text{g}}{68.2\text{g}} \times 100 = 52.3\% \text{ yield}$$

2. 3 $BaCl_2$ + 2 Na_3PO_4 → ____ $Ba_3(PO_4)_2$ + 6 NaCl

   a. Balance the equation above.
   b. How many molecules of NaCl are produced when 3.98 mol of $BaCl_2$ reacts?

$$\frac{3.98\text{mol } BaCl_2}{} \left| \frac{6\text{mol NaCl}}{3\text{mol } BaCl_2} \right| \frac{6.02\times10^{23}\text{ molec.}}{1\text{mol NaCl}} = 4.79\times10^{24} \text{ molecules NaCl}$$

   c. If 5.17×10^{30} molecules of Na_3PO_4 react, how many grams of $Ba_3(PO_4)_2$ are made?

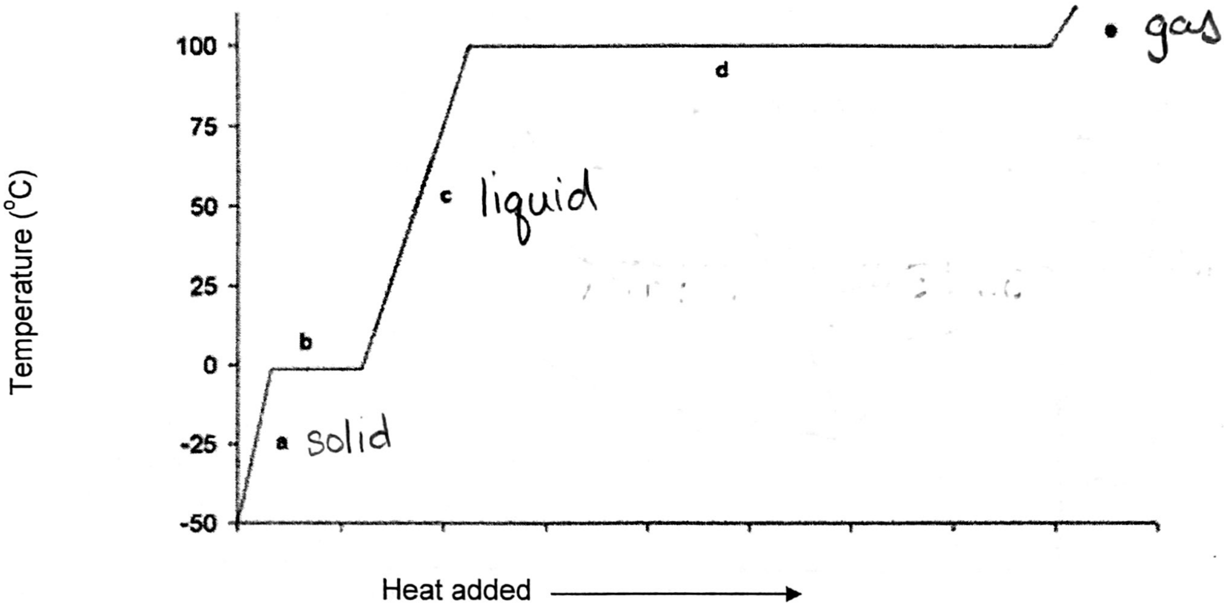
$$\frac{5.17\times10^{30}\text{ molec } Na_3PO_4}{} \left| \frac{1\text{mol } Na_3PO_4}{6.02\times10^{23}\text{ molec.}} \right| \frac{1\text{mol } Ba_3(PO_4)_2}{2\text{mol } Na_3PO_4} \left| \frac{601.92\text{g } Ba_3(PO_4)_2}{1\text{mol } Ba_3(PO_4)_2} \right. = 2.58\times10^{9}\text{g } Ba_3(PO_4)_2$$

   d. If 10.9 moles of NaCl are produced in a reaction, how many moles of Na_3PO_4 were reacted?

$$\frac{10.9\text{mol NaCl}}{} \left| \frac{2\text{mol } Na_3PO_4}{6\text{mol NaCl}} \right. = 3.63\text{ mol } Na_3PO_4$$

Unit 10 States of Matter Practice

For #23-26, refer to the heating curve below for water as heat is added at a constant rate.



23. Circle which phase(s) of water exist(s) in each section of the heating curve.

section A.	**solid**	liquid	gas
section B.	**solid**	**liquid**	gas
section C.	solid	**liquid**	gas
section D.	solid	**liquid**	**gas**
section E.	solid	liquid	**gas**

24. Circle which type of energy is increasing in the sample during each section as heat is being added.

section A.	**kinetic**	potential
section B.	kinetic	**potential**
section C.	**kinetic**	potential
section D.	kinetic	**potential**
section E.	**kinetic**	potential

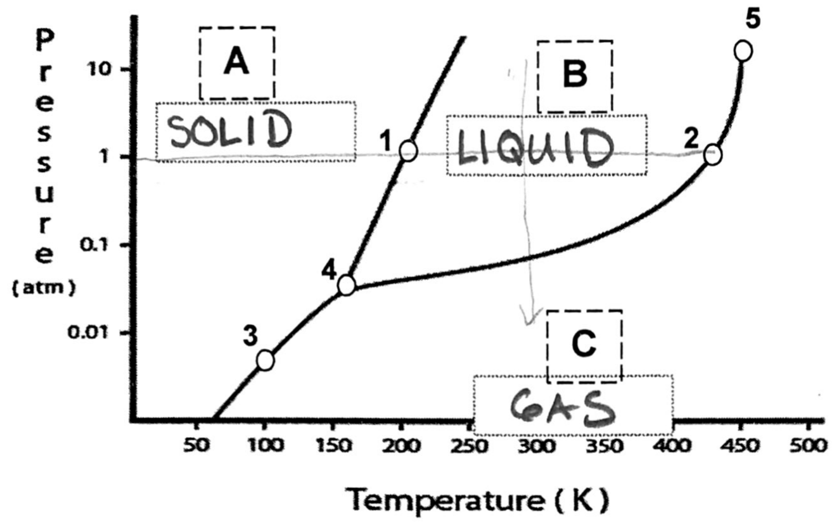
25. If heat were removed instead of added, the process occurring in section D would be C.

A. vaporization
B. freezing
C. condensation
D. NONE of the above

26. Section B is shorter than section D because water has a lower heat of fussion than heat of vaporization so it takes more energy to vaporize a sample of water than it does to melt the same sample of water.

27. A cup of water contains 55 g of water at a temperature of 21.4°C. How much heat must be removed from the water to lower its temperature to 2.5°C? (the specific heat of water is 4.18 J/g°C)

For #28-33, refer to the phase diagram below for water.



Label each section on the diagram (A, B, C) with the correct phase (*s*, *l*, *g*)

28. The phase change from A to C is called sublimation and from C to B is condensation

29. The boiling point of the substance is shown at Point 2 which is the point at which liquid and gas phases coexist in equilibrium.

30. Point 4 represents the triple point, which is the point at which... all 3 phases exist in equillibrium.

31. The critical point is shown at Point 5 which represents the temperature above which a liquid could not exist and the pressure above which a gas could not exist.

32. A sample of the substance is held constant at a temperature of 300 K while the pressure is decreased from 10 atm to 0.01 atm. The phase change that occurs is vaporizing (boiling, evaporating).

33. A sample of the substance is held constant at a pressure of 1 atm while the temperature is increased from 150 K atm to 250 K. The phase change that occurs is melting.

Ideal Gas Problems

Gases at low pressures obey the ideal gas law,

$$pV = nRT \qquad (1)$$

where R is a constant (known as the *gas constant*) that has the value

$$R = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1} \qquad (2)$$

Appropriate units to use for p, V, n, and T in the ideal gas equation are those used for R above. Thus the pressure (p) should be in atm, the volume (V) in L, the temperature (T) in degrees K, and the amount of gas (n) should be in moles. Useful conversion factors are

Pressure: 1 atm = 760 Torr = 760 mmHg = 101.3 kPa = 1.013 bar

Temperature: K = 273 + °C

Volume: 1 L = 1000 mL = 1000 cm^3

STP

Often you will see gas volumes reported at STP (*standard temperature and pressure*). STP is defined as T = 273 K (0°C) and p = 1 atm. Substitution of these values into Eq(1) shows that the *volume of 1 mol of any gas is approximately 22.4 L at STP*. (You should verify this for yourself using Eq(1)!).

1. A Marshmallow Peep® has a volume of about 45.0 cm^3 at 101 kPa. What pressure is required to increase its size to 150.0 cm^3 assuming no air escapes from the Peep®

   $V_1 = 45.0 cm^3$ $V_2 = 150.0 cm^3$ $P_2 = \frac{P_1V_1}{V_2} = \frac{(0.997 atm)(45.0 cm^3)}{(150.0 cm^3)} =$ 0.299 atm

   $P_1 = 101 kPa \times \frac{1 atm}{101.3 kPa} = .997 atm$

2. What is the temperature of a 0.00893 mol sample of neon gas that has a volume of 302 mL and a pressure of 0.941 atm?

   n = 0.00893 mol
   V = .302 L
   P = 0.941 atm

   $T = \frac{PV}{Rn} = \frac{(0.941 atm)(.302 L)}{(0.0821 \frac{atm \cdot L}{mol \cdot K})(0.00893 mol)}$ = 388 K − 273 = 115°C

3. A gas occupies 4.78 L at 78.1 kPa and 25°C. What will the volume be at 0.975 atm and 15°C?

   $78.1 kPa \times \frac{1 atm}{101.3 kPa} = .771 atm$

   $V_1 = 4.87L$ $V_2 = ?$
   $P_1 = .771 atm$ $P_2 = .975 atm$
   $T_1 = 298K$ $T_2 = 288K$

   $V_2 = \frac{P_1V_1T_2}{P_2T_1} = \frac{(.771 atm)(4.87L)(288K)}{(.975 atm)(298K)} =$ 3.72 L

4. A shampoo bottle contains 443 mL of air at 65°C. What is its volume when it cools to 22°C?

   $V_1 = 443 mL$ $V_2 = ?$
   $T_1 = 338K$ $T_2 = 295K$

   $V_2 = \frac{T_2V_1}{T_1} = \frac{(295K)(443mL)}{(338K)} =$ 387 mL

5. The pressure in a can of hairspray is 2.50 atm at 298 K. What is the pressure in the can when it is heated to 398 K?

   $P_1 = 2.50 atm$ $P_2 = ?$
   $T_1 = 298K$ $T_2 = 398K$

   $P_2 = \frac{P_1T_2}{T_1} = \frac{(2.50 atm)(398K)}{(298K)} =$ 3.34 atm

6. What mass of glucose ($C_6H_{12}O_6$) is required to produce 150 mL of carbon dioxide at 102 kPa and 23°C? How many molecules of glucose is this?

   $\frac{101.3 kPa}{atm} = 1.01 atm$

   $C_6H_{12}O_6 + 2O_2 \rightarrow 2CH_3COOH + 2CO_2 + 2H_2O$

① $n = \frac{PV}{RT} = \frac{(1.01 atm)(.150L)}{(0.0821)(296K)} = 0.00622 mol CO_2 \times \frac{1 mol C_6H_{12}O_6}{2 mol CO_2} = 0.00311 mol C_6H_{12}O_6$

② $0.00311 mol C_6H_{12}O_6 \times \frac{180.16g C_6H_{12}O_6}{1 mol C_6H_{12}O_6} =$ 1.12 g $C_6H_{12}O_6$

$0.00311 mol C_6H_{12}O_6 \times \frac{6.02 \times 10^{23} molec}{1 mol} = 1.87 \times 10^{21}$ molec. $C_6H_{12}O_6$

Unit 12 Solutions

Part A: Solutions & Solubility

1. A solution consists of a solute dissolved in a solvent. It is also known as a homogeneous mixture. It has a uniform composition.

2. Circle the solute and underline the solvent.
   a) 85% isopropyl alcohol in 15% water
   b) 60 mL of oil in 4 L of gasoline
   c) Sugar water

3. Solubility is a measure of the total amount of solute that can dissolve in a given amount of solvent at a specific temperature.

4. The 3 factors that affect how fast a solid solute dissolves (rate of dissolving) are temperature, stirring, and surface area.

5. Gases are more soluble at high pressure and low temperature.

6. What phrase describes the types of substances that will dissolve in each other: LIKE dissolves LIKE.

   Accordingly, polar solvents (like water) can dissolve polar solutes (alcohols, sugars, ionic compounds, etc.), and nonpolar solutes (fats, oils, hydrocarbons, etc.) will dissolve in nonpolar solvents.

7. a) Molarity is the ratio of moles of solute per liter of solution.

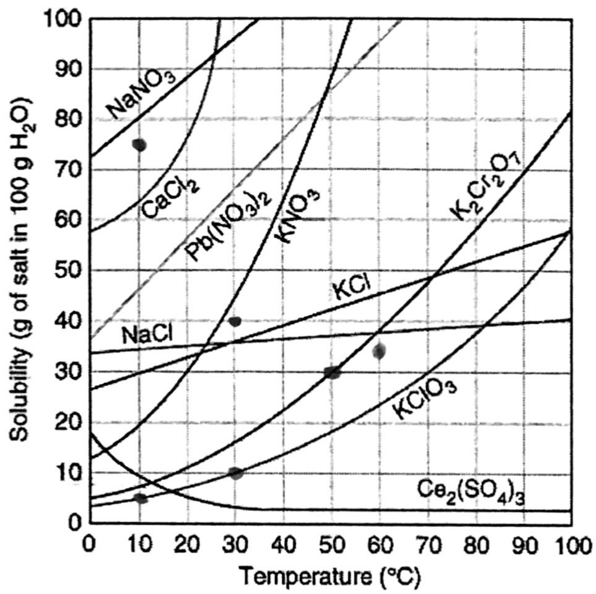
   b) A 12.0 molar solution of H_2SO_4 consists of 12 moles of H_2SO_4 in 1 liter(s) of water.

8. There is a large amount of solute dissolved in a concentrated / dilute solution.

9. How do you dilute a solution? Add more solvent.

10. The molarity of a solution increases / decreases / stays the same when it is diluted, and the number of moles increases / decreases / stays the same.

Use the solubility curve below to answer questions 11 - 13.



11. If ALL of the solute could be dissolved in 100 g of water at the given temperature, would the resulting solution be unsaturated, saturated, or supersaturated?

a) **40 g KCl at 30°C** supersaturated
c) **75 g $NaNO_3$ at 10°C** unsaturated

b) **10 g $KClO_3$ at 30°C** saturated
d) **35 g NaCl at 60°C** unsaturated

12. Which substance has the lowest solubility at 10°C? $KClO_3$

13. How many grams of $K_2Cr_2O_7$ can dissolve in 100 g of water at 50°C? 30g

Part B: Molarity & Dilutions Calculations

$$M = \frac{mol}{L}$$

$$M_1V_1 = M_2V_2$$

1. What is the molarity of a solution containing 85 g NaOH in 775 mL of solution?

$$\frac{85g\ NaOH \mid 1\ mol\ NaOH}{\mid 40g\ NaOH} = \frac{2.125\ mol\ NaOH}{0.775\ L\ soln.} = 2.74\ M\ NaOH$$

2. How many moles are in 3.20 L of a 2.50 M solution of potassium iodide?

$$moles = M \times L = 2.50\frac{Mol}{L} \times 3.20L = 8.00\ mol\ KI$$

3. How many mL of a 0.150 *M* NaBr solution are needed to make 100 mL of 0.0500 *M* NaBr?

V_1 M_1 V_2 M_2

$$V_1 = \frac{M_2V_2}{M_1} = \frac{(0.0500M)(100mL)}{(0.150M)} = 33.3\ mL$$

UNIT 13 ACIDS, BASES & SALTS

State whether the following are acids or bases (85-88).

1. Have a sour taste. A
2. React with metals. A
3. Feel slippery B
4. Turn blue litmus paper red. A

5. Define acids and bases according to Brønsted-Lowry

proton (H^+) donor — proton (H^+) acceptor

6. Identify each substance as acid, base, conjugate acid, or conjugate base. $H_2S + H_2O \rightarrow HS^- + H_3O^+$

A B CB CA

7. Give the conjugate acids of: NH_3 and Br^-.

NH_4^+ HBr

8. Give the conjugate bases of: H_3O^+ and HSO_4^-.

H_2O H_2SO_4

9. Find the pH of 0.75*M* HCl.

pH = −log(0.75 M) = 0.125

10. Find the molarity [OH^-] of a KOH solution with a pH of 9.5. (Base)

pOH = 14 − 9.5 = 4.5 antilog(−45) = $10^{-4.5}$ = 3.2×10^{-5} M

11. Is the solution in #10 acidic or basic?

BASIC

12. ~~When a neutralization reaction between a strong acid and a weak base reaches the equivalence point, will the solution be acidic, basic, or neutral?~~

13. If 43.5 mL (V_A) of 0.15 M (M_A) HBr is required to neutralize 25.0 mL (V_B) of $Ca(OH)_2$, what is the molarity (M_B) of $Ca(OH)_2$?

$2HBr + Ca(OH)_2 \rightarrow 2H_2O + CaBr_2$

$\frac{M_A V_A}{a} = \frac{M_B V_B}{b}$ $\frac{(0.15M)(43.5mL)}{2} = \frac{M_B(25.0mL)}{1}$ $M_B = 0.13M$

VOCAB:

- hydronium ion
- amphoteric substance
- strong/weak acid/base
- neutralization reaction
- titration
- equivalence point