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)

$$T.Y. = 68.5\text{g CO} \left| \frac{1\text{mol CO}}{28.01\text{g CO}} \right| \frac{1\text{mol CH}_3\text{OH}}{1\text{mol CO}} \left| \frac{32.05\text{g CH}_3\text{OH}}{1\text{mol CH}_3\text{OH}} \right. = 78.4\text{g}$$

$$= 8.6\text{g H}_2 \left| \frac{1\text{mol H}_2}{2.02\text{g H}_2} \right| \frac{1\text{mol CH}_3\text{OH}}{2\text{mol H}_2} \left| \frac{32.05\text{g CH}_3\text{OH}}{1\text{mol CH}_3\text{OH}} \right. = 68.2\text{g}$$

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?

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

$$3.98\text{mol BaCl}_2 \left| \frac{6\text{mol NaCl}}{3\text{mol BaCl}_2} \right| \frac{6.02\times10^{23}\text{molec.}}{1\text{mol NaCl}} = 4.79\times10^{24}\text{ molecules NaCl}$$

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

$$5.17\times10^{30}\text{molec. Na}_3\text{PO}_4 \left| \frac{1\text{mol Na}_3\text{PO}_4}{6.02\times10^{23}\text{molec.}} \right| \frac{1\text{mol Ba}_3(\text{PO}_4)_2}{2\text{mol Na}_3\text{PO}_4} \left| \frac{601.92\text{g Ba}_3(\text{PO}_4)_2}{1\text{mol Ba}_3(\text{PO}_4)_2} \right. = 2.58\times10^{9}\text{ g Ba}_3(\text{PO}_4)_2$$

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

$$10.9\text{mol NaCl} \left| \frac{2\text{mol Na}_3\text{PO}_4}{6\text{mol NaCl}} \right. = 3.63\text{ mol Na}_3\text{PO}_4$$

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®

$V_1 = 45.0 cm^3$ $V_2 = 150.0 cm^3$ $P_1 = 101 kPa \left| \frac{1 atm}{101.3 kPa} \right. = .997 atm$

$P_2 = \frac{P_1 V_1}{V_2} = \frac{(0.997 atm)(45.0 cm^3)}{(150.0 cm^3)} = 0.299 atm$

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?

$78.1 kPa \left| \frac{1 atm}{101.3 kPa} \right. = .771 atm$

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

$V_2 = \frac{P_1 V_1 T_2}{P_2 T_1} = \frac{(.771 atm)(4.87 L)(288 K)}{(.975 atm)(298 K)} = 3.72 L$

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

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

$V_2 = \frac{T_2 V_1}{T_1} = \frac{(295 K)(443 mL)}{(338 K)} = 387 mL$

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?

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

$P_2 = \frac{P_1 T_2}{T_1} = \frac{(2.50 atm)(398 K)}{(298 K)} = 3.34 atm$

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

② $0.00311 mol\ C_6H_{12}O_6 \left| \frac{180.16 g\ C_6H_{12}O_6}{1 mol\ C_6H_{12}O_6} \right. = 1.12 g\ C_6H_{12}O_6$

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

Solutions, Acids & Bases Review Key

1. Unsaturated – solute will dissolve. Saturated – solute will not dissolve. Supersaturated – rapid crystallization.
2. Solubility of gases increases with low temps & high pressure. Solubility of solids increases with high temps.
3. soluble (P/P)
4. insoluble (P/NP)
5. soluble (NP/NP)
6. insoluble (NP/P)
7. a) 55 g b) 95 °C c) $KClO_3$ d) KNO_3 e) 1. unsaturated 2. superdaturated f) 200 g
8. 9.00 g $AlCl_3$
9. 4.2 mL 12*M* HCl
10. Molarity – measure amount of solute, add enough water to reach the desired volume. Molality – measure amount of solute, measure kg of water, combine.
11. $C_{12}H_{22}O_{11}$ – 1, $MgBr_2$ – 3, **$AlCl_3$** – **4**, NH_4NO_3 – 2
12. – 4.8°C
13. acid
14. acid
15. base
16. acid
17. Arr acid – forms H_3O^+ in water. Arr base – forms OH^- in water. B-L acid – proton donor, B-L base – proton acceptor. Lewis acid – e^- pair acceptor, Lewis base – e^- pair donor.
18. A, B, CB, CA
19. NH_4^+ and HBr
20. H_2O and SO_4^{2-}
21. 0.12
22. 3.2×10^{-5} *M* KOH (pOH = 4.5)
23. basic
24. ~~acidic~~ $NaCl + H_2O$
25. 0.13*M* $Ca(OH)_2$

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