Old exam 1

1. During a titration the following data were collected. A 100.0 mL portion of an HCl solution was titrated with 0.500 M $Ba(OH)_2$; 200.0mL of the base was required to neutralize the sample.

   a. Write the balanced chemical equation.

$$2HCl(aq) + Ba(OH)_2(aq) \longrightarrow 2H_2O(l) + BaCl_2(aq)$$

   b. What is the molarity of the acid solution?

$$0.500\ \frac{\text{mol } Ba(OH)_2}{\cancel{L}} \times \frac{0.2000\cancel{L}}{1} = 0.100\ \cancel{\text{mol } Ba(OH)_2}\left(\frac{2\text{ mol HCl}}{1\ \cancel{\text{mol } Ba(OH)_2}}\right) = \frac{0.200\text{ mol HCl}}{0.1000\text{ L}} = \boxed{2.00\ \frac{\text{mol}}{\text{L}}}$$

   c. How many moles of acid are present in 2.0 liters of this unknown solution?

$$2.00\ \frac{\text{mol}}{\cancel{L}}\left(\frac{2.0\cancel{L}}{1}\right) = \boxed{4.0\text{ mol}}$$

2. a. Calculate the value of x if 6ln7x =9.8. Round to 3 decimal places.

$\ln 7 = 1.94591$

$6(1.94591)x = 9.8$

$\frac{11.675x}{11.675} = \frac{9.8}{11.675}$

$x = 0.8394 \rightarrow \boxed{0.84}$

   b. Calculate the value of x if log(23x+22)=1.2. Round to 3 decimal places.

$\log(23x+22) = 1.2$

$23x + 22 = 10^{1.2}$

$23x + \cancel{22} = 15.8489$

$-\cancel{22}\quad -22$

$\frac{23x}{23} = \frac{-6.151}{23}$

$x = -0.2674$

$\rightarrow \boxed{-0.267}$

   c. $-5+6e^x = 44$. Solve for x. Round to 3 decimal places.

$-\cancel{5} + 6e^x = 44$

$+\cancel{5}\qquad +5$

$\frac{6e^x}{6} = \frac{49}{6}$

$e^x = 8.166667$

$x = \ln(8.166667)$

$= 2.100061$

$\rightarrow \boxed{2.100}$

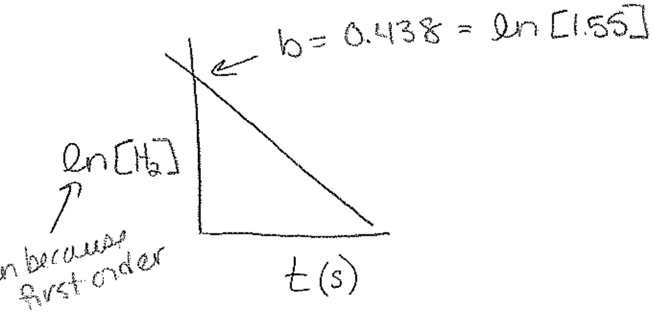
3. The rate at which hydrogen gas reacts in the reaction $N_2 + 3H_2 \rightarrow 2NH_3$ is 0.050 atm/s. The initial concentration of hydrogen is 1.55atm

a. What is the rate of formation of ammonia in atm/s at the time the hydrogen rate was measured . Include both the sign and the value in your answer.

Rate of NH_3 production is $\frac{2}{3}$ rate of H_2 reaction. Forming NH_3 so positive

$\frac{2}{3}(0.050\ atm/s) = +0.0333\ atm/s$

b. If this were a first order reaction, sketch a brief LINEAR graph to describe the disappearance of the $H_2(g)$ over time. Be sure to label the axes.



c. If the rate constant for this first order reaction is 0.24/min, what is the pressure of the hydrogen at 2.2minutes?

$\ln[H_2] = -kt + \ln[H_2]_0$

$\ln[H_2] = -\left(\frac{0.24}{min}\right)(2.2\,min) + \ln[1.55\ atm]$ $\boxed{[H_2] = 0.91\ atm}$

$\ln[H_2] = -0.528 + 0.438255$

$\ln[H_2] = -0.089745 \quad [H_2] = e^{-0.089745} \approx 0.9142\ atm$

4. $(14.2g+3.46g+9.052g) \times 1.5\times10^{-4} = x$

a. Solve for x and write your answer in scientific notation and units.

$26.712g \times 1.5\times10^{-4} = 0.0040068g = 4.0\times10^{-3}\ g$

b. How many significant figures should be in your answer?

Two

c. Convert your answer into milligrams from grams.

$4.0\times10^{-3}\ \cancel{g}\left(\frac{1000\ mg}{\cancel{g}}\right) = 4.0\ mg$

5. For the reaction, A + 2 B $\rightarrow$ C + 2 D, some measurements of the rate of reaction at varying concentration gave the following data.

run #	[A]	[B]	rate, mol L^{-1} s^{-1}
1	0.20	0.20	1.0
2	0.20	0.40	2.0
3	0.60	0.40	2.0

a1. Calculate the order with respect to A. $\left(\frac{0.60}{0.20}\right)^m = \left(\frac{2.0}{2.0}\right) = (3)^m = 1$ $\boxed{m = 0 \text{ (zero)}}$

a2. Calculate the rate constant of the reaction.

order in B: $\left(\frac{0.40}{0.20}\right)^n = \frac{2.0}{1.0}$ $2^n = 2$ $n = 1$

Rate = $k[A]^0[B]^1$

$1.0\ M/s = k\cancel{[0.20]^0}[0.20]^1 = k = 5s^{-1}$

$2.0\ M/s = k\cancel{[0.20]^0}[0.40]^1 = k = 5s^{-1}$

$2.0\ M/s = k\cancel{[0.60]^0}[0.40]^1$ $k = 5s^{-1}$

b. Write the rate law for this reaction.

Rate = $5s^{-1}[B]$

c. What concentration of B would you need to maintain a rate of 1.0mol $L^{-1}s^{-1}$ if [A] = 6.0M?

$[B] = 0.20M$

[A] is zero order → changing [A] does not change rate

6. For the following polyatomic ion: SO_4^{2-}

a. What is the name of this ion?

sulfate

b. Write the oxidation numbers of both elements in the ion.

$\boxed{O = -2}$ $-2(4) = -8$ $-8 + S = -2$ $\boxed{S = +6}$

c. Give the chemical formula and name of the acid associated with this ion.

H_2SO_4

Sulfuric Acid

You should be able to recognize names & formulas of acids based on their similarities to the ions involved (eg pick a name or formula from options) but I do not expect you to have them memorized yet.

7. A reaction mechanism contains the following elementary reactions:
   Step 1: 2A + B → 2C+D
   Step 2: 2C → D

   a1. What is the order of Step 1 with respect to A? 2nd order (coefficient of A is 2)
   a2. Write the rate law for Step 1.

   $\text{Rate} = k[A]^2[B]$

   b1. Which reaction would be considered the rate limiting step? Step A → termolecular
   b2. Identify an intermediate in this mechanism.

   C (formed in step 1, used up in step 2)

   c. What is the overall reaction described by these elementary reactions?

   $2A + B \rightarrow 2D$

   $$\begin{array}{l} 2A + B \rightarrow \cancel{2C} + D \\ \underline{\cancel{2C} \rightarrow D} \\ 2A + B \rightarrow 2D \end{array}$$

   both steps make a D

8. The rate constant for a first order decomposition reaction is 0.051 min^{-1}.

   a. If the initial concentration the reactant is 2.5M, calculate the half-life of the reaction.

   1st order $t_{1/2} = \frac{0.693}{k} = \frac{0.693}{0.051\ min^{-1}} = 13.6\ min$

   b. What is the concentration of the reactant at $t_{1/2}$?

   $\ln[A] = -kt + \ln[A]_0$

   $\ln[A] = -(0.051\ min^{-1})(13.6\ min) + \ln(2.5M)$

   $\ln[A] = -0.693 + 0.91629$

   $\ln[A] = 0.22329$ $[A] = e^{0.22329}$

   $[A] = 1.25\ M$

   or for the short version: $\frac{1}{2}(2.5M) = 1.25M$ (definition of half life)

   c1. If plotting concentration vs. time, will this be a linear relationship?
   c2. Write the integrated rate equation for this reaction.

   no → not zero order

   $\ln[A] = -kt + \ln[A]_0$

   $\ln[A] = (-0.051\ min^{-1})(t) + \ln[A]_0$