Formulas and Constants

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$N_A = 6.022 \times 10^{23}\ mol^{-1}$ $h = 6.626 \times 10^{-34}\ J\ s$ $c = 2.998 \times 10^{8}\ m\ s^{-1}$

$e = 1.602 \times 10^{-19}\ C$ $m_e = 9.109 \times 10^{-31}\ kg$ $1\ Å = 1 \times 10^{-10}\ m = 100\ pm$

$1\ atm = 760\ torr$ $R = 0.08206\ L\ atm\ K^{-1}\ mol^{-1} = 8.314\ J\ K^{-1}\ mol^{-1}$

$\tilde{\nu} = \frac{1}{\lambda}$ $\Delta E = \frac{hc}{\lambda} = hc\tilde{\nu}$

$[gas(aq)]_{eq} = K_H\,(P_{gas})_{eq}$ $vp_{solution} = X_{solvent}\ vp_{pure\ solvent}$

$\Delta T_f = K_f\,m$ $\Delta T_b = K_b\,m$ $\Pi\,V = nRT$ $\Pi = MRT$

$\ln\left(\frac{[A]}{[A]_o}\right) = -kt$ $[A] = [A]_o\,e^{-kt}$ $\frac{1}{[A]} - \frac{1}{[A]_o} = kt$

$t_{½} = \ln 2/k = 0.6931/k$ $t_{½} = \frac{1}{[A]_o k}$ $\Delta E = E_{a,f} - E_{a,r}$

$\ln\left(\frac{k_2}{k_1}\right) = -\frac{\Delta E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$ $\ln\left(\frac{k_1}{k_2}\right) = \frac{\Delta E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$ $k = A\,e^{-Ea/RT}$

1 IA 1A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8 --- ---	9 VIII 8	10 --- ---	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.47	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La* 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 190.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.5	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At (210)	86 Rn (222)

Chemistry 145 Practice Test 2
Prof. Shattuck Name_____

R = 8.314 J mol^{-1} K^{-1} = 0.08206 L atm mol^{-1} K^{-1} T(°C) = 273.15 K

Part 1: Answer 8 of the following 10 questions. If you answer more than 8 cross out the one you wish not to be graded, otherwise only the first 8 will be graded. 8 points each.

1. In the following pairs, which substance has the higher boiling point:
   a. C_2H_6 or C_6H_{14} ? *more electrons*
   b. H_2S or H_2O ? *hydrogen-bonding*
   c. CO_2 or NO_2 ? *NO_2 has a dipole moment*

2. Which of these statements about benzene is true?
   __ A. All carbon atoms in benzene are sp^3 hybridized.
   __ B. Benzene contains only π-bonds between C atoms.
   _* C. The bond order of each C—C bond in benzene is 1.5.
   __ D. Benzene is an example of a molecule that displays ionic bonding.
   __ E. All of these statements are false.

3. From the following information calculate the K_{eq} for reaction 3.

Reaction 1	$Ag^+ + NH_3 = Ag(NH_3)^+$	$K_1 = 1.7x10^3\ M^{-1}$
Reaction 2	$Ag(NH_3)^+ + NH_3 = Ag(NH_3)_2^+$	$K_2 = 1.1x10^7\ M^{-1}$
Reaction 3	$Ag^+ + 2\ NH_3 = Ag(NH_3)_2^+$	$K_{eq} = K_1 K_2 = 1.87x10^{10}$

4. Give the hybridization for NH_3 __*sp^3*_____ and for SO_2 _*sp^2*_____.

5. For the reaction $NO_2 + CO \rightarrow NO + CO_2$ the experimental rate law is:
   rate = k $[NO_2]^2$
   The following mechanism has been proposed:
   $2\ NO_2 \rightarrow NO_3 + NO$
   $NO_3 + CO \rightarrow NO_2 + CO_2$
   a. Which step is the rate determining step? *Slow step is the rate detemrinining step—step 1*
   b. Is there a reactive intermediate in this reaction? If so what is it?
   NO_3 (not a reactant or product)

6. For a first order reaction, the concentration of the reactant dropped from 0.200 M to 0.100 M in 6.00 minutes. How long does it take for the concentration to drop from 0.200 M to 0.0100 M?

Answer: The first time interval is for $[A] = [A]_o/2$, that is one half-time, $t_{½} = 0.6931/k = 6.00$ min. The rate constant is then $k = 0.115_5$ min^{-1}. The second time interval is:
$\ln([A]/[A]_o) = \ln(0.0100\ M/0.200\ M) = -2.99_6 = -(0.115_5\ min^{-1})\ t$ or $t = 25.9$ min

7. The rate law for a third order reaction is

$$\frac{1}{[A]^2} - \frac{1}{[A]_o^2} = 2kt$$

To make a straight line plot to verify third order behavior,

a. what do you plot on the vertical axis?__$1/[A]^2$_____.

b. what do you plot on the horizontal axis? _____*t (time)*_____.

c. what is the slope equal? _____*slope = 2 k*_____

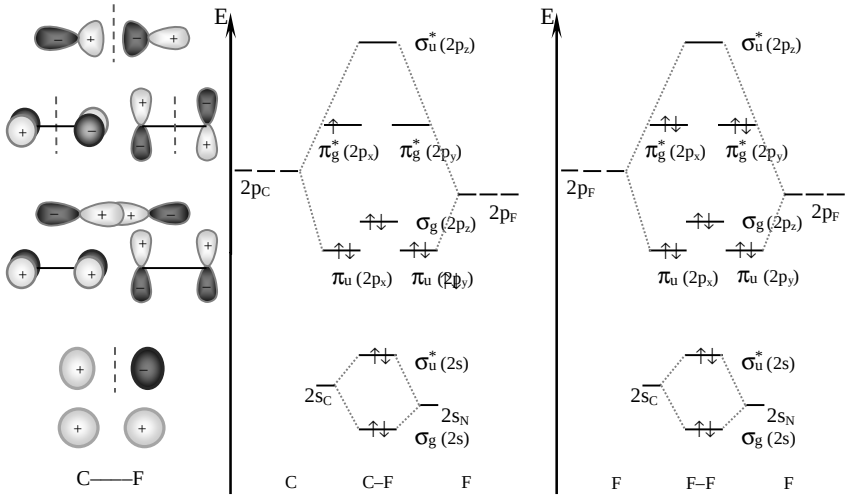
8. The osmotic pressure of a solution of a protein in water is 1.54 torr at 25.0°. The solution contained 0.700 g of protein per liter of solution. Calculate the molar mass of the protein.

Answer: In atmospheres, Π = 1.54 torr/760 torr/atm = 2.026×10^{-3} atm.

From $\Pi = MRT$ the molar concentration is $M = \Pi/RT = 2.026 \times 10^{-3}$ atm/0.08206 L atm K^{-1} mol^{-1}/298.15 K = 8.281×10^{-5} mol L^{-1}. The molar mass is then MM = 0.700 g/8.281×10^{-5} mol = 8.45×10^{3} g mol^{-1}.

9. Which molecule has a stronger bond, CF or F_2? Explain your answer for credit.

CF F_2



Bond order: BO = $\frac{8-3}{2}$ = 2½ BO = $\frac{8-6}{2}$ = 1

stronger bond in CF (greater bond order)

10. Determine the rate law for the reaction 2NO (g) + Br_2(g) → 2NOBr(g) from the following initial rate study (you don't need to get a numerical value for k, just leave it as "k"):

[NO] (mol L^{-1})	[Br_2] (mol L^{-1})	rate (L mol^{-1} sec^{-1})
1.00	1.00	1.00×10^{-6}
2.00	1.00	2.00×10^{-6}
1.00	2.00	4.00×10^{-6}

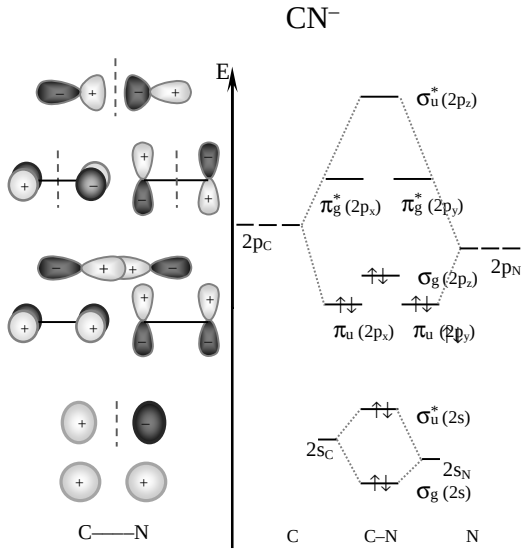
Answer: Experiments 1&2: when [NO] doubles the rate doubles—the order with respect to NO is one. Experiments 1&3: when [Br_2] doubles the rate quadruples –the order with respect to Br_2 is two: rate = k [NO][Br_2]^2

If it were requested: For experiment 1, to get the rate constant rate = k [NO][Br_2]^2 or:

1.00×10^{-6} l mol^{-1} s^{-1} = k (1.00 mol L^{-1})(1.00 mol L^{-1})^2 giving k = 1.00×10^{-6} L^3 mol^{-3} s^{-1}

Part 2. Answer 3 of the following 5 questions. If you answer more than 3 cross out the ones you wish not to be graded, otherwise only the first 3 will be graded. 12 points each.

11. (a.) Draw an energy level diagram for the molecular orbitals for the CN^- ion. (b.) Label each orbital with the type of orbital, sigma, or pi and bonding or anti-bonding. (c.) Fill the levels with the proper number of electrons, and (d.) calculate the bond order.



Bond order: $BO = \frac{8-2}{2} = 3$

12. NOBr decomposes according to

$$NOBr\ (g) \rightleftarrows NO\ (g) + \tfrac{1}{2}\ Br_2\ (g)$$

With $K_p = 0.15$. If 1.0 atm of NOBr, 0.8 atm of NO, and 0.4 atm of Br_2 are mixed, will any reaction occur? If a net reaction is observed, will NO be formed or consumed?

Answer: $Q = \frac{P_{Br2}^{1/2}\, P_{NO}}{P_{NOBr}} = \frac{(0.4\text{ atm})^{1/2}\,(0.8\text{ atm})}{1\text{ atm}} = 0.506$ with $Q > K_p$ the reaction runs in the reverse direction.

13. What is the molarity of 50.0% by weight NaOH solution? The density of the solution is 1.53 g mL^{-1}. (Molar Mass(NaOH) = 40.0 g mol^{-1})

Answer: Assume 100 g of solution, which then contains 50.0 g of NaOH or 1.25 moles of NaOH. The volume of the solution is V_{soln} = 100.0 g/d_{soln} = 100. g/1.53 g mL^{-1} = 65.36 mL or 0.06536 L. The final molarity is c = (moles solute)/V_{soln} = 19.1 mol L^{-1}

14. The rate constant for the following reaction is $1.05\text{x}10^{-4}$ sec^{-1} at 786 K . The rate constant increases to $7.88\text{x}10^{-4}$ sec^{-1} at 834 K. Calculate the activation energy for the reaction:

$C_4H_8O \rightarrow C_4H_6 + H_2O$

Answer: $\ln\left(\frac{k_2}{k_1}\right) = -\frac{\Delta E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$ giving

$$\ln\left(\frac{7.88\text{x}10^{-4}}{1.05\text{x}10^{-4}}\right) = -\frac{\Delta E_a}{8.314\text{ J K}^{-1}\text{ mol}^{-1}}\left(\frac{1}{834.\text{ K}} - \frac{1}{786.\text{ K}}\right)$$

$$2.015 = -\Delta E_a/8.314\text{ J K}^{-1}\text{ mol}^{-1}(-7.322\text{x}10^{-5})$$

$$\Delta E_a = 229.\text{ kJ mol}^{-1}$$

15. NOBr decomposes according to

$NOBr_2\,(g) \rightleftarrows NO\,(g) + Br_2\,(g)$

With K_p = 2.15. If 1.00 atm of NOBr is placed in a constant volume container, calculate the equilibrium pressure of Br_2.

Answer: $NOBr_2\,(g) \rightleftarrows NO\,(g) + Br_2\,(g)$

initial	1.00 atm	0	0
change	–x	+x	+x
equil	1.000 – x	+x	+x

$K_p = \frac{P_{NO}\, P_{Br2}}{P_{NOBr2}} = \frac{x^2}{1-x} = 2.15$

cross multiplying gives: $x^2 = 2.15 - 2.15\,x$ or $x^2 + 2.15\,x - 2.15 = 0$

solving: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-2.15 \pm \sqrt{(2.15)^2 - 4(-2.15)}}{2} = \frac{-2.15 \pm 3.636}{2} = 0.743$ atm