## Exam 1 Chm 205 (Dr Mattson) 5 February 2016

Name:

Chemistry Student Number: _____

Instructions: <mark>Show all work whenever a calculation box is provided!</mark> Write legibly. Include units whenever appropriate. You will receive credit for **how** you worked each problem as well as for the correct answer. If you need more space, you may use the back of the data sheet provided — Write: "See data sheet" in the answer box – then write your name on the data sheet. On your desk you are allowed only pencils (but no pencil pouch), an eraser, and a non-programmable calculator without a slipcover. Backpacks, bags, and purse-like items must be stored in the rear section of the room. Cell phones must be silent and placed in your backpack/bag/purse – not in your pocket.

1. Glycine is the simplest of the 20 or so amino acids found in proteins. In this stick drawing, the electron pairs are not shown.
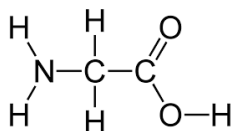
1a. (2 pts) Add the electron pairs wherever needed to the structure above.

1b. (1 pt) Do you predict that glycine is soluble in water?

Circle Yes or No

1c. (1 pt) What is the name of the functional group at the right in the figure: -COOH? Print. Spelling counts.

2. (3 pts) Circle which of these solutes would you predict to be soluble in water? Hint: More than one.

    NaBr CH_3OH CCl_4 NH_2NH_2

3. (3 pts) Which of these solutes would you predict to be soluble in benzene, C_6H_6, a non-polar solvent? (>1)

    CS_2 K_2SO_4 CCl_4 NH_4NO_3

4. Suppose a solution was prepared by dissolving 40.0 g sodium acetate, $NaC_2H_3O_2$, in 100.0 g water. You may use this table to organize your calculations if you wish.

	MM	m	n
$NaC_2H_3O_2$	82.0 g mol^{-1}		
H_2O	18.0 g mol^{-1}		

4a. (4 pts) What is the mole fraction of $NaC_2H_3O_2$?

Answer: _____

4b. (4 pts) What is the mass percent of $NaC_2H_3O_2$?

Answer with units: _____

5. An aqueous solution of sodium bromide is 44.7 mass% NaBr with a density of 1.49 g/cm^3.

	MM	m	n	V
NaBr	102.9 g mol^{-1}			
H_2O	18.0 g mol^{-1}			
Solution				

5a. (4 pts) What is the mole fraction of NaBr?

Answer: _____

5b. (4 pts) What is the molarity of NaBr?

Answer with units: _____

6. (5 pts) At 25 °C, pure water has a vapor pressure of 24.0 mmHg. What is the vapor pressure of a solution containing 85.0 g glucose, $C_6H_{12}O_6$, a non-volatile solute (MM = 180 g mol^{-1}) in 100 g water?

Answer with units: _____

7. (5 pts) What is the freezing point of the solution described in Question 6? Given: K_f = 1.86 deg/molal

Answer with units: _____

8. (5 pts) What is the molar mass of an unknown, non-electrolyte given that 15.44 g of the unknown dissolved in 50.0 g water lowers the freezing point of water by 3.1 degrees? See Question 7 for the K_f value.
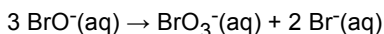
Answer with units: _____

9. (4 pts) Suppose an aqueous solution contains 2.0 ppm Pb^{2+} ion. What is $[Pb^{2+}]$? Density of water is 1.0 g/mL.

Answer with units: _____

10. (10 pts) True or False

T F The solubility of gases decreases as the temperature of the solution increases.

T F Entropy increases as a gas dissolves in a liquid.

T F Osmotic pressure is independent of temperature.

T F Ionic substances that dissolve in water dissociate into ions.

T F Propane has a higher boiling point than ethane.

T F A solution of two volatile liquids will have a vapor pressure between that of the components.

T F The solution described in Question 4 has a boiling point higher than that of pure water.

T F Propane has a higher boiling point than propanol.

T F Propanoic acid is soluble in water due to H-bonding.

T F Propene has two carbons with sp^2 hybridization and one with sp^3 hybridization.

11a. (4 pts) Consider the reaction and data from a series of experiments. Determine the **order and rate law.**

$$3\ BrO^-(aq) \rightarrow BrO_3^-(aq) + 2\ Br^-(aq)$$

	Initial [BrO$^-$] mol/L	$-\Delta[BrO^-]/\Delta t$ mol/Ls
Expt 1	0.107	5.6×10^{-4}
Expt 2	0.345	5.8×10^{-3}
Expt 3	0.221	?

Answer (rate law): _____

11b. (4 pts) Determine the rate constant and use it to calculate that rate when [BrO$^-$] = 0.221 M (Expt 3)

Answer with units: _____

12. (4 pts) Suppose the reaction, A → B gives a straight line when $[A]_t$ is plotted against time. The slope of the line is -7.2×10^{-4} mol L^{-1} min^{-1}. Given that $[A]_0$ = 0.0448 mol L^{-1}, what is [A] after 20.0 min?

Answer with units: _____

13. Cyclopropane, $C_3H_6(g)$, decomposes following first order kinetics with a rate constant, k = 6.7×10^{-4} s^{-1}.

13a. (5 pts) If $[C_3H_6]_{t=0}$ = 1.34 M, how long does it take for $[C_3H_6]$ = 0.25 M? Express your answer in minutes.

Answer with units: _____

13b. (5 pts) If the initial $[C_3H_6]_{t=0}$ = 1.34 M, what is $[C_3H_6]$ after 475 s?

Answer with units: _____

13c. (3 pts) What is the half-life for the reaction? Express your answer in minutes.

Answer with units: _____

13d. (4 pts) True or false.

T F The rate constant will increase as temperature is increased.

T F The rate will increase if the temperature is increased.

T F The rate will increase if $[C_3H_6]$ is increased.

T F The rate constant will increase if $[C_3H_6]$ is increased.

14. Use this diagram to answer the questions that follow. Use **R to represent each red atom** and **B for each blue atom**, just like in the book problems.
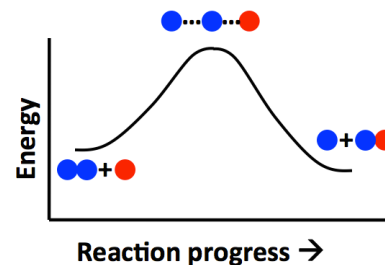
14a. (2 pts) What is the overall balanced reaction that takes place?

14b. (2 pts) How many steps are there in the reaction mechanism?

14c. (1 pt) The mechanism is ☐ unimolecular or ☐ bimolecular or ☐ termolecular

14d. (3 pts) What is the rate law for this reaction mechanism represented here? Start with rate =

14e. (5 pts) Which of the following would increase the rate of this reaction? Check all that apply.

☐ Increasing [R]   ☐ Increasing [B$_2$]   ☐ Increasing [B]

☐ Increasing [BR]   ☐ Increasing temperature

14f. (1 pt) Clearly label E_{act} on this diagram.

14g. (1 pt) Circle the transition state.

14h. (1 pt) The reaction is ☐ Exothermic or ☐ Endothermic

Total score (out of 100): _____

A+ ≥ 95% A ≥ 90% B+ ≥ 85% B ≥ 80% C+ ≥ 75% C ≥ 70% D ≥ 60%

	Zero Order	First Order	Second Order
Rate Expression	rate = k	rate = k[A]	rate = k[A]^2
Units on k, the rate constant	mol/ L s	1/s or s^{-1}	L/mol s
Test for order: Makes a straight-line Plot	$[A]_t$ vs t	$\ln[A]_t$ vs t	$^1/[A]_t$ vs t
Time-Conc. Expression	$[A]_t = -kt + [A]_o$	$\ln([A]_o/[A]_t) = kt$	$^1/[A]_t = kt + {}^1/[A]_o$
Half-life	$t_{1/2} = [A]_o/2k$	$t_{1/2} = {}^{0.693}/k$	$t_{1/2} = {}^1/k[A]_o$

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 24.30											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.70	29 Cu 63.55	30 Zn 65.38	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 (97)	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	71 Lu 175.0	72 Hf 178.5	73 Ta 181.0	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	103 Lr (262)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (264)	108 Hs (265)	109 Mt (268)	110 Uun (269)	111 Uuu (272)	112 Uub (277)		114 Uuq (289)		116 Uuh (289)		118 Uuo (293)

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
89 Ac (227)	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

Answers

1a. Add a pair of electrons to the N atom and two pairs of electrons to each of the O atoms.

1b. **Yes**

1c. carboxylic acid

2. NaBr CH_3OH NH_2NH_2

3. CS_2 CCl_4

4.

	MM	m	n
$NaC_2H_3O_2$	82.0 g mol^{-1}	40.0 g	0.488 mol
H_2O	18.0 g mol^{-1}	100.0 g	5.56 mol

4a. 0.0807

4b. 28.6%

5.

	MM	m	n	V
NaBr	102.9 g mol^{-1}	44.7 g	0.434 mol	
H_2O	18.0 g mol^{-1}	55.3 g	3.07 mol	
Solution		100 g		67.1 mL

5a. 0.124

5b. 6.47 M

6. 22.1 mmHg

7. -8.8 ^oC

8. 185 g/mol

9. 9.7 x 10^{-6} M Pb^{2+}

10.   T   F   F   T   T   T   T   F   T   T

11a. 2nd order; rate = k[BrO$^-$]^2

11b. k = 0.0489 L/mol s and the rate is 2.39 x 10^{-3} mol/L s

12. 0.0304 mol/L

13a. 41.8 min

13b. 0.975 M

13c. 17.2 min

13d.   T   T   T   F

14a. B_2 + R → B + BR

14b. one

14c. bimolecular

14d. rate = k [B_2][R]

14e. Increasing [R]; Increasing [B_2]; Increasing temperature

14f. Draw a horizontal line from bottom of left hill and another from top of hill top. The vertical distance is the E_{act}.

14g. The transition state is the tip top of the hill.

14h. Exothermic