Name_____

Student ID Number_____

LAB Sec. # ___; TA: _____; Lab day/time: _____

Dr. Bryan Enderle   Fall 2016

CHEMISTRY 2C (Section B) Exam II

CLOSED BOOK EXAM! No books, notes, or additional scrap paper are permitted. All information required is contained on the exam. Place all work in the space provided. A scientific calculator may be used (if it is a programmable calculator, its memory must be cleared before the exam).

(1)   Read each question carefully.

(2)   For Part I, there is not partial credit. There is partial credit for Part IV. For Part I & II, *only answers marked on this cover page will be graded. You must also fill in your TA's name at the top of the page. Failure to do either of these will result in a 10 point deduction.*

(3)   The last page contains a periodic table and some useful information. You may remove this for easy access.

(4)   If you finish early, RECHECK YOUR ANSWERS!

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Possible Points	Points
M/C #1-9 27 points	
Page 4 24 points	
Page 5 22 points	
Page 6 06 points	
Page 7 09 points	
Page 8 15 points	
Page 9 11 points	
Total Score (114)	

Multiple Choice

1.	A	B	C	D	E
2.	A	B	C	D	E
3.	A	B	C	D	E
4.	A	B	C	D	E
5.	A	B	C	D	E
6.	A	B	C	D	E
7.	A	B	C	D	E
8.	A	B	C	D	E
9.	A	B	C	D	E

10.	A	B	C	D	E
11.	A	B	C	D	E
12.	A	B	C	D	E
13.	A	B	C	D	E

Part I: Multiple Choice, Concepts
Circle the correct answer and enter your response on the cover – No partial credit

1.   What is the overall order of a reaction with the following rate law?
$$\text{rate} = k\,[A]^2[B]^{1/2}/\,[C]$$
     A. ½   B. 1   C. 1½   D. 2   E. Cannot be determined

2.   Which of the following is not a halogen containing compound?
     A. Teflon   B. Freon   C. Pewter   D. PVC

3.   Which of the following is true about noble gases?
     A. Noble gases are not completely inert.
     B. Larger noble gases that are readily ionizeable are more likely to react.
     C. Xe may react with highly electronegative elements, such as O or F.
     D. All of the above.

4.   In which of the following oxyacids does the chlorine atom have an oxidation state of +1?
     A. hypochlorous acid   B. chlorous acid   C. chloric acid   D. perchloric acid

5. Which statement is correct for the structure shown?
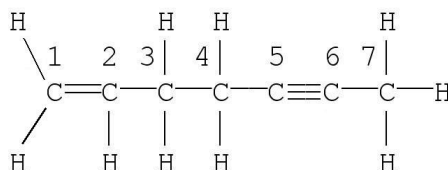
     A. Carbon number 1 is described by sp^3 hybridization.
     B. The molecule contains 19 σ bonds.
     C. Carbon number 2 is described by sp^2 hybridization.
     D. The molecule contains a total of five π bonds.
     E. Carbon number 7 is described by sp hybridization.

6.   The correct units of the rate constant for a zeroth order reaction are:
     A. $(Ms)^{-1}$ B. s^{-1} C. M/s   D. $(M^2s)^{-1}$

7. If a particular reaction has a very slow rate, which of the following is true? (*There may be more than one correct answer.*)
    A. The rate is a large number   B. The rate constant is a large number
    C. The rate is a small number   D. The rate constant is a small number
    E. The activation energy is a large number.

8. Select the true statement.
    A. Magnetic Resonance Imaging (MRI) is a medicinal application of NMR spectroscopy.
    B. Infrared spectroscopy is used to determine what functional groups are in the molecule.
    C. Some sunscreen contains molecules having a conjugated π system, which protects the skin by absorbing ultraviolet light from the atmosphere.
    D. In spectroscopy, each type of electromagnetic radiation studies a different aspect of the molecule.
    E. All of the above.

9. For the reaction: $C_2H_4Br_2 + 3 KI \rightarrow C_2H_4 + 2 KBr + KI_3$, when the average rate of reaction is 2.0 M/s, what is the rate of disappearance of KI (in M/s)?
    A. -0.67   B. -2.0   C. -4.0   D. -6.0   E. -1.0

Part II: Multiple Choice, Short Calculations, Fill in the Blank
Select the <u>best</u> answer and enter your choice <u>on the cover sheet</u>. If you do not select the correct answer, you may show work for up to half credit per question.

10. Calculate rate constant (k) in units of $(M\ min)^{-1}$ for a second order reaction with a half-life of 75.0 min and initial reactant concentration of 1.0 M.
A. 108   B. 1.33×10^{-2} C. 6.67×10^{-3} D. 9.24×10^{-3}

11. For $2\ NO + O_2 \rightarrow 2\ NO_2$, initial rate data for three different experimental trials are reported in the table. If rate law is Rate = $k[NO]^x[O_2]^y$, find x and y.
A. x = 1, y = 2   B. x = 2, y = 1   C. x = 1, y = 1
D. x = 2, y = 2   E. x = 0, y = 2

	Trial 1	Trial 2	Trial 3
[NO] (M)	0.010	0.010	0.030
[O₂] (M)	0.010	0.020	0.020
Rate (M/s)	2.5	5.0	45.0

12. Acetoacetic acid, CH_3COCH_2COOH, a reagent used in organic synthesis, decomposes in acidic solution producing aqueous acetone and carbon dioxide gas. This first order decomposition has a rate constant of 4.81×10^{-3}/min. How long (in minutes) will it take for a sample of acetoacetic acid to be 65% decomposed?
A. 7.3×10^{-3} B. 2.07×10^{-3} C. 90   D. 218

13. For the first order reaction, $N_2O_5\ (g) \rightarrow 2\ NO_2\ (g) + \frac{1}{2}\ O_2\ (g)$, determine the rate constant (k) at 30°C if the activation energy is 103 kJ/mol and the frequency factor (A) is 2.05×10^{13}/s.
A. 1.97×10^{13} /s   B. 40.9 /s   C. 3.6×10^{-5} /s   D. 4.02×10^{-7} /s   E. 0 /s
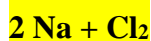
Part III: Short Answer
Fill in the blank

14. (8 points) For the molecule below, fill in the table with the correct total number of π bonds, σ bonds, H atoms, and C atoms.
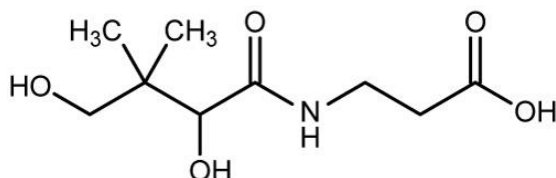
	π bonds	σ bonds	H atoms	C atoms
Total number in the molecule	2	31	17	9

15. (6 points) Reactions: fill in the blank with the appropriate molecule(s) and balance the reactions.

4 Li + O_2 →

$$2 Li_2O$$

3 Ca + N_2 →

$$Ca_3N_2$$

2 NaCl →

$$2 Na + Cl_2$$

16. (8 points) Draw the best Lewis structure for the following compounds. Include lone pairs. Remember to minimize formal charge!

A. Main Group: XeF_2O
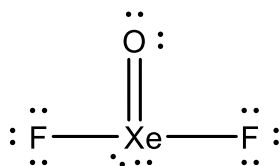
B. Organic Chemistry: $(CH_3)_2CHCO_2CH_3$ (ester)
(should be lone pairs on oxygens below)

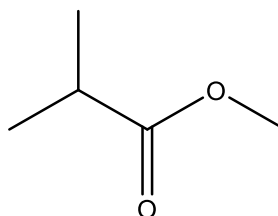17. (6 points total) Answer the questions in the table below regarding the given reaction profile for the reaction A → G (*consider the forward reactions only*). A, B, C, D, E, F, and G represent molecules.
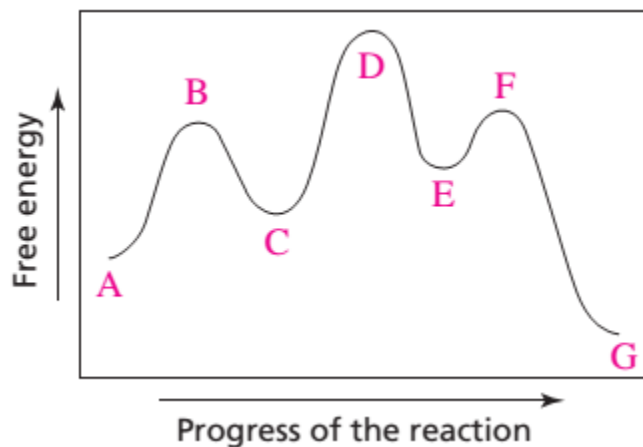
Question	Answer
Which of the molecules represent intermediates?	C, E
Which of the molecules represent transition states?	B, D, F
Is the overall reaction endothermic or exothermic?	Exothermic
Which step is kinetically and thermodynamically unfavored? C → E or E → G.	C → E
Which step is the rate determining step?	C → E
Which step has the smallest activation energy?	E → G

18. (9 points) Fill in the blank: in the column marked "Answer" to the left of each statement, write in the answer (element or effect) that best matches the statement.

Answer	Statement – Which element or effect is it?
Inert Pair Effect	1. This effect explains the increased stability from CCl_2, $SiCl_2$, $GeCl_2$ and $PbCl_2$ and the decreased stability from CCl_4, $SiCl_4$, $GeCl_4$ and $PbCl_4$.
B	2. This nonmetal is electron deficient and used as a dopant in semiconductor industry. It is sometimes used in fireworks to give a green flame.
Po	3. The name of this metal comes from an Eastern European country. It has been historically used as anti-static agents for gramophone records. Such use is now rarer due to its extreme radioactivity and toxicity.
P	4. This element has two major allotropes (white and red). Its illegal use is highlighted in the TV show *Breaking Bad*. Therefore, this element is on United States Drug Enforcement Administration's list 1 chemicals.
S	5. This element has wide range applications from fertilizer to chemical warfare. The oxides from vehicle emission is notoriously known to produce acid rain. Its compounds generally smell bad. The surface of Jupiter's moon Io is coated with this element due to over 400 active volcanoes.
Na	6. This metal forms a peroxide with oxygen. A common application is when its basic form is mixed with fat to make soap or detergent. Its use in ion exchange columns helps remove hard water precipitates.
Ca	7. This metal is found in concrete, chalk, lime, hard water, stalactites, and stalagmites.
Al	8. This metal is the most abundant in the earth's crust. It is strong and light. Topaz, a prized gem, is the presence of ferric ions within an oxide of this metal.
H	9. This element has few similarities with any group. It is colorless, tasteless, and odorless. 89% of all atoms in the universe are this element.

19. (15 points total) Organic chemistry functional groups and hybridization.
   A. (6 points) Draw any example of an organic molecule with the listed ***functional group*** in the appropriate box below. Your molecule must have structural integrity with formal charges of zero on each atom. There must not be any additional functional groups on your molecule.

Organic Halide	**Alkyne**	**Aldehyde**

   B. (3 points) For the following molecule, list the functional groups present below.
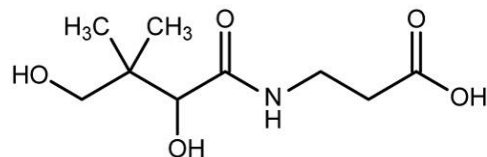
Alcohol, amide, carboxylic acid

   C. (6 points) Draw any example of an organic molecule with at least one atom having the listed ***hybridization*** in the appropriate box below. Your molecule must have structural integrity with formal charges of zero on each atom.

sp	**sp^2**	**sp^3**

Part IV: Long Answer

Please show all work – Partial credit

20. (11 points) The overall reaction describing the decomposition of NO_2Cl is
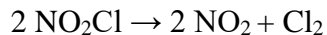
$$2\ NO_2Cl \rightarrow 2\ NO_2 + Cl_2$$

The reaction mechanism is:

1. $NO_2Cl \rightleftarrows NO_2 + Cl\cdot$
2. $Cl\cdot + NO_2Cl \rightarrow NO_2 + Cl_2$

A. (3 points) Write the rate of **each** reaction below,

$r_1 = k_1\ [NO_2Cl]$ $r_1{}' = k_1{}'\ [Cl\cdot][NO_2]$

$r_2 = k_2\ [Cl\cdot][NO_2Cl]$

B. (4 points) Assuming the second step is RDS (i.e., $k_2 \ll k_1$, $k_1{}'$) derive a rate law for the overall reaction.

$r_2 = k_2\ [Cl\cdot][NO_2Cl]$
$r_1 = r_1{}'$
$[Cl\cdot] = k_1/k_1{}'[NO_2Cl]/[NO_2]$
$r_2 = k_1k_2/k_1{}'[Cl\cdot][NO_2Cl]_2/[NO_2]$

C. (4 points) Assuming a pseudo steady state hypothesis, derive a rate law for the rate of formation of Cl_2.

$r_2 = k_2\ [Cl\cdot][NO_2Cl]$
PSSH $(Cl\cdot)$ $r_1 = r_1{}' + r_2$
$[Cl\cdot] = k_1[NO_2Cl] / (k_2[NO_2Cl] + k_1{}'[NO_2])$
$r_2 = k_1k_2\ [NO_2Cl]^2 / (k_2[NO_2Cl] + k_1{}'[NO_2])$

Spectrochemical Series:

$CN^->CO>\underline{N}O_2^->en>NH_3>H_2O>ox^{2-}>OH^->F^->\underline{S}CN^->Cl^->Br^->I^-$

Constants:

$R = 8.3145$ J / mol K $F = 96{,}485$ C / mol e^-

$R = 0.08206$ L atm / mol K $c = 2.9979$ x 10^8 m / s

$h = 6.626$ x 10^{-34} J s

Equations: $\Delta = h\,c\,/\,\lambda$

(first order)   *(zeroth order)*   *(second order)*

$\ln[A]_t = \ln[A]_o - kt$ $[A]_t = [A]_o - kt$ $[A]_t^{-1} = [A]_o^{-1} + kt$

$t_{1/2} = (\ln 2)\,/\,k$ $t_{1/2} = [A]_o/2k$ $t_{1/2} = 1\,/\,(k[A]_o)$

$$k = Ae^{-\dfrac{E_a}{RT}}$$

$$\ln\left(\frac{k'}{k}\right) = \frac{E_a}{R}\left(\frac{1}{T} - \frac{1}{T'}\right)$$

Periodic Table of the Elements

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
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 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.64	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	71 Lu 175.0	72 Hf 178.5	73 Ta 180.9	74 W 183.8	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 (266)	107 Bh (264)	108 Hs (269)	109 Mt (268)	110 Uun (271)	111 Uuu (272)	112 Uub (277)		114 Uuq (289)				

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
89 Ac (227)	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np (237)	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)