Exam Booklet No.

CHEM 2410 – Organic Chemistry 1 – Fall 2017

Instructors: Erin Whitteck & Paul Bracher

Hour Examination #2

Wednesday, October 18th, 2017

6:10–8:10 p.m. in the Lecture Halls at Saint Louis University

Student Name (Printed)	
Student Signature	

Instructions & Scoring

- Please write your answers on the official answer sheet. No answers marked in this booklet will be graded.
- You may use a plastic model kit. No electronic resources or note sheets are permitted, and you may not communicate with others.
- Your exam answer sheet may be copied or scanned.
- The examination room may be monitored by audio, photo, and/or video recording.

Problem	Points Earned	Points Available
I		60
II		12
		16
IV		6
V		6
TOTAL		100

This exam focuses on Chapters 5 through 8 in Janice Smith's Organic Chemistry, 4th ed.

Examination Instructions

DO NOT TURN THE PAGE ON THIS BOOKLET UNTIL DIRECTED BY A PROCTOR TO BEGIN

Please Make Sure to Do the Following Before Starting Your Exam

- 1. Both <u>print</u> your name and <u>sign</u> the front of the answer sheet <u>and this exam booklet</u> in the appropriate boxes.
- 2. Also print your name at the <u>top</u> of the <u>back</u> of the answer sheet.
- 3. Enter your SLU Banner ID number on the front of the answer sheet and <u>bubble</u> the corresponding numbers. <u>Failure to do this correctly will result in the loss of 2 points.</u> If you have forgotten your Banner ID, tell a proctor.
- 4. Write the serial number of this exam booklet on your answer sheet in the appropriate box.
- 5. Check the "Hold for Pick-Up" box on the back of the answer sheet if you want your graded sheet withheld from the distribution pile on Monday and handed back to you privately. Checking this box will delay your receipt of your graded exam.

Please Make Sure to Do the Following After Completing Your Exam

- 1. Ensure that all of your selected circles are darkened completely.
- 2. Submit your answer sheet, exam booklet, data tables, and scratch paper to the proctors. You may not remove these items from the exam room.

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Problem I. Multiple Choice (60 points total). Correct answers score +3 points, answers of 'E' score +1 point, and incorrect answers score 0 points. Questions filled with zero or multiple responses will score 0 points. For each question, select the best and most complete answer of the choices given. Bubble the answer, darkly, in the space provided on the answer sheet. For all questions that ask you to name or count compounds or products, include all distinct compounds that not interconvertible under ambient conditions (i.e., include or count different constitutional isomers and stereoisomers separately, but not different conformations that can interconvert).

(1) _____ How many of the following compounds is/are <u>achiral</u> and <u>not meso</u>?



(2) _____ What are the absolute configurations of the two labeled stereogenic centers in compound **A**?



- (A) leftmost: R; rightmost: R
- (B) leftmost: *R*; rightmost: *S*
- (C) leftmost: S; rightmost: R
- (D) leftmost: S; rightmost: S

- (3) _____ How many stereogenic centers are found in 1-bromo-4-ethyl-3-fluorohexane?
 - (A) no stereogenic centers
 - (B) one stereogenic center
 - (C) two stereogenic centers
 - (D) three stereogenic centers
- (4) If compound **B** has a specific rotation of +24 deg·g⁻¹·mL·dm⁻¹ at a particular temperature and wavelength of light, what is the specific rotation of compound **C** at the exact same temperature and wavelength?



- (A) +24 deg·g⁻¹·mL·dm⁻¹
- (B) $-24 \text{ deg} \cdot \text{g}^{-1} \cdot \text{mL} \cdot \text{dm}^{-1}$
- (C) $0 \text{ deg} \cdot \text{g}^{-1} \cdot \text{mL} \cdot \text{dm}^{-1}$
- (D) there is not enough information provided to determine the specific rotation of ${\bf C}$

(5)

Which of the following is best estimated by measuring the concentrations of the reactants and products of a reaction at equilibrium?

- (A) ∆*G*°
- (B) *∆H*°
- (C) ∆*S*°
- (D) [α]

(6) ______ How many different substitution and elimination products are possible when compound D is heated in methanol? Assume that any carbocation intermediates do not undergo rearrangement.



(7) _____ How many different compounds of formula $C_3H_6F_2$ exist that are optically active?

- (A) zero
- (B) one
- (C) two
- (D) three or more
- (8) _____ Which of the following will <u>not</u> have a significant effect on the rate of the following reaction?



- (A) changing chlorine to iodine in E
- (B) changing the solvent from water to hexane
- (C) heating the reaction
- (D) none of the above all three changes would affect the rate

(9) _____ What is the IUPAC systematic name for compound **G**?



- (A) (5*S*,6*R*,8*R*)-8-bromo-6-isopropyl-2,5-dimethyldecane
- (B) (2S,5S,6S,8R)-8-bromo-2,5-dimethyl-6-isopropyldecane
- (C) (5*S*,6*S*,8*R*)-8-bromo-6-isopropyl-2,5-dimethyldecane
- (D) (3S,5R,6S)-3-bromo-5-isopropyl-6,9-dimethyldecane
- (10) _____ Which of the following alkyl halides is most likely to form an elimination product through first-order kinetics?





(C)



(A)

(B)

(D)

(11) Which of the following statements best describes carbocations **H** and **J**?



- (A) **H** is more stable due to the interaction of the 1*s* orbital on H with the empty *p* orbital on C
- (B) H is more stable due the interaction of the 1s orbital on H with the empty σ^{*} orbital on C
- (C) J is more stable due to the interaction of C–H σ bonding orbitals with the empty *p* orbital on C
- (D) J is more stable due to the interaction of C–H σ bonding orbitals with the empty σ^* orbital on C

(12) _____ Which of the following compounds has the <u>most stable</u> C=C π bond?



(A)



(13) _____ For which of the following compounds would heterolytic cleavage of the carbon–bromine bond be the <u>least</u> facile (*i.e.*, be the most endothermic)?

(B)



(14) _____ Which of the following is a <u>protic</u> compound that would generally be considered an unwise choice of solvent for running many S_N2 reactions?



(15) _____ Which of the following statements is <u>not</u> true of a reaction that corresponds to the following energy diagram?



Reaction Coordinate

- (A) the reaction is endothermic
- (B) the equilibrium will favor the reactants (K & L)
- (C) the reaction is concerted
- (D) the reaction has one intermediate

Br

(A)

(16) _____ Which of the following reactions would most likely result in the greatest increase in the entropy of the system (i.e., which reaction has the <u>highest</u> ΔS°)? Assume that solvation effects do not play a significant role.



(17)

What alkyl halide would produce **N** upon reaction with NaOCH₃?



Ν







Problem II. Synthesis (12 points).

(1) (6 points) For the synthetic scheme below, fill in the intermediate (S) and reagents necessary (R and T) to produce the desired alkene (U) from compound Q. It is not necessary to include solvents.



(2) (6 points, 3 points each) Write the <u>major</u> product of each reaction below in the corresponding box on your answer sheet.



Problem III. Reaction Energy Diagram (16 points). Consider the reaction of AA with HCl to produce CC and DD.



(1) Draw the curved arrow mechanism for the production of **BB** from **AA**.



(2) **BB** then goes on to react with chloride to produce two major products, **CC** and **DD**. In the boxes on your answer sheet, draw the structures of products **CC** and **DD**. It does not matter which you choose to be **CC** and which you choose to be **DD**.

(3) <u>Read carefully and follow all directions...</u> Draw a reaction energy diagram of ΔH° (enthalpy) versus the progress of the reaction from **AA** to **CC** on the set of axes found on your answer sheet. Explicitly label the ΔH for the reaction (on your plot) as well as the activation energy (E_a) for the rate-determining step. Explicitly label where **BB** is on your graph. Also label any transition states as "T.S.". You do not need to draw the Lewis structure of any transition state or intermediate.



Reaction Coordinate

(4) (2 points) On your answer sheet, circle the term that best describes the relationship between **CC** and **DD**.

diastereomers enantiomers conformers constitutional Isome	rs
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(5) (2 points) On your answer sheet, go back to Part (2) and circle your drawing of **CC** and/or **DD** if each is optically active. If either compound is not optically active, leave it uncircled.

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Problem IV. Explanation (6 points). Consider the following two molecules.



- (1) Which substrate, **FF** or **GG**, will react fastest in a solvolysis reaction with methanol to form an ether as a product? Write the letter of your answer in the box on the answer sheet (3 points).
- (2) In two sentences and relevant drawings, use the Hammond Postulate to justify your choice (3 points).

Problem V. Explanation (6 points). Consider the temperature dependence of the Diels–Alder reaction of ethylene (**JJ**) and 1,3-butadiene (**HH**):



At 200 °C, the equilibrium favors the product's side (right), while at 900 °C, the equilibrium favors the reactants' side (left). Briefly explain the reason for this difference using the relation:

 $\Delta G = \Delta H - \mathsf{T} \Delta S$

2	He	helium 4.003	10	Ne	neon	20.180	18	Ar	argon	39.948	36	Кr	krypton	83.798	54	Xe	xenon	131.29	86	Rn	radon	(222)	118	0g g	oganesson (294)
			6	щ	fluorine	18.998	17	ບ	chlorine	35.45	35	Br	bromine	79.904	53	_	iodine	126.90	85	At	astatine	(210)	117	Ts	tennessine (294)
			8	0	oxygen	15.999	16	S	sulfur	32.06	34	Se	selenium	78.972	52	Te	tellurium	127.60	84	Ъо	polonium	(209)	116	2	livermorium (293)
			7	z	nitrogen	14.007	15	٩	phosphorus	30.974	33	As	arsenic	74.922	51	Sb	antimony	121.76	83	<u>.</u>	bismuth	208.98	115	Š	moscovium (290)
			9	ပ	carbon	12.011	14	Si	silicon	28.085	32	Ge	germanium	72.631	50	Sn	tin	118.71	82	Ъb	lead	207.2	114	Ξ	flerovium (289)
			ß	В	boron	10.81	13	Ā	aluminum	26.982	31	Ga	gallium	69.723	49	2	indium	114.82	81	F	thallium	204.38	113	ЧZ	nihonium (286)
											30	Zn	zinc	65.38	48	Cd	cadmium	112.41	80	Hg	mercury	200.59	112	S	copernicium (285)
											29	CC	copper	63.546	47	Ag	silver	107.87	79	Au	gold	196.97	111	Rg	roentgenium (282)
											28	ïZ	nickel	58.693	46	Ъd	palladium	106.42	78	£	platinum	195.08	110	Ds	darmstadtium (281)
											27	ပိ	cobalt	58.933	45	Rh	rhodium	102.91	77	느	iridium	192.22	109	Ę	meitnerium (278)
											26	Бе	iron	55.845	44	Ru	ruthenium	101.07	76	0s	osmium	190.23	108	Hs	hassium (277)
											25	Мл	manganese	54.938	43	Ľ	technetium	(98)	75	Re	rhenium	186.21	107	Bh	bohrium (270)
											24	ر ک	chromium	51.996	42	ŝ	molybdenum	95.95	74	≥	tungsten	183.84	106	Sg	seaborgium (269)
											23	>	vanadium	50.942	41	qN	niobium	92.906	73	Ta	tantalum	180.95	105	Db	dubnium (268)
											22	iΞ	titanium	47.867	40	Zr	zirconium	91.224	72	Ŧ	hafnium	178.49	104	Rf	rutherfordium (267)
											21	Sc	scandium	44.956	39	≻	yttrium	88.906		* *				* *	acuniaes
			4	Be	beryllium	9.01	12	8 ه	magnesium	24.305	20	Ca	calcium	40.078	38	Sr	strontium	87.62	56	Ba	barium	137.33	88	Ra	radium (226)
1	т	hydrogen 1.008	m	:=	lithium	6.94	11	Na	sodium	22.990	19	¥	potassium	39.098	37	Rb	rubidium	85.468	55	S	cesium	132.91	87	Ļ	francium (223)

57	58	59	60	61	62	63	64	65	99	67	68	69	70	71
J	Se	Pr	PQ	Рд	Sm	Eu	bQ	Тb	D V	Я	Д	Tm	٩Y	Lu
mune	cerium	praseodymium	neodymium	promethium	samarium	europium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium	lutetium
.91	140.12	140.91	144.24	(145)	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.05	174.97
6	06	91	92	93	94	95	96	97	98	66	100	101	102	103
S	Ч	Pa	D	dN	Pu	Am	С С	BĶ	Ç	Es	Fa	Вd	° N	۲
min	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium	lawrencium
(27)	232.04	231.04	238.03	(237)	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(266)



pK_a Table

Bond Dissociation Energies (BDEs)

		Average Bo	nd Di	ssociation E	nergie	es, D (kJ/mo	ol) ^a		
н—н	436 ^a	С—Н	410	N-H	390	О—Н	460	F-F	159 ^a
н-с	410	С-С	350	N-C	300	О-С	350	Cl-Cl	243 ^a
H—F	570 ^a	C-F	450	N-F	270	O-F	180	Br — Br	193 ^a
H—Cl	432 ^a	C-Cl	330	N-Cl	200	O-Cl	200	I—I	151 ^a
H—Br	366 ^a	C—Br	270	N—Br	240	O—Br	210	S—F	310
H—I	298 ^a	C—I	240	N-I		O-I	220	S-Cl	250
H—N	390	C-N	300	N-N	240	O-N	200	S—Br	210
н—о	460	с—о	350	N-O	200	0-0	180	s—s	225
H—S	340	C—S	260	N-S		o—s	5. 		
Multipl	e coval	ent bonds							
C = C	611	$C \equiv C$	835	C=O	732	0=0	498 ^a	$N \equiv N$	945 ^a

Exact value

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Scratch Paper

You may rip this sheet out of the exam booklet, but you are responsible for turning it in at the end of the exam.

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