## CHEM 3331 (Richardson) First Midterm Exam – Feb. 13, 2018

Your Name:		Question	Score	Out of
		1		15
Student ID:		2		15
		3		15
Recitation (check one)	O 8:00 Wed (Rachel Weintraub)	4		10
O 12:00 Wed (Patrick Li)	O 2:00 Wed (Patrick Li)	5		30
O 4:00 Wed (Michael Ortiz)	O 9:00 Thu (Josh Kamps)	6		15
O 11:00 Thu (Josh Kamps)	O 1:00 Thu (Aaron Hinds)	7		10 e.c.
O 3:00 Thu (Rachel Weintraub)	O 5:00 Thu (Rachel Weintraub)			
		Total		100

This is a closed-book exam. The use of notes, calculators, or cell phones will not be allowed during the exam. You may use models sets brought in a clear ziplock bag. Use the backs of the pages for scratch work. If your final answer is not clearly specified, you will lose points. For mechanisms, show all intermediates including correct formal charges, but do not show transition states.

hydrogen 1 H 1.0079																		helium 2 <b>He</b> 4,0026
lithium 3	beryllium											I	boron 5	carbon 6	nitrogen 7	oxygen 8	fluorine 9	neon 10
Ľi	Be												B	0	Ń	ô	F	Ne
	9.0122												10.811	C			18.998	
6.941 sodium	magnesium											ŀ	aluminium	12.011 silicon	14.007 phosphorus	15.999 sulfur	chlorine	20,180 argon
11	12												13	14	15	16	17	18
Na	Mg												Al	Si	Р	S	CI	Ar
22.990	24.305												26.982	28.086	30.974	32.065	35.453	39.948
potassium 19	calcium 20		scandium 21	titanium 22	vanadium 23	chromium 24	manganese 25	iron 26	cobalt 27	nickel 28	copper 29	zinc 30	gallium 31	germanium 32	arsenic 33	selenium 34	bromine 35	krypton 36
K	Ca		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
39.098	40.078		44.956	47.867	50.942	51.996	54.938	55.845	58.933	58.693	63,546	65.39	69.723	72.61	74.922	78.96	79.904	83.80
rubidium 37	strontium 38		yttrium 39	zirconium 40	niobium 41	molybdenum 42	technetium 43	ruthenium 44	rhodium 45	palladium 46	silver 47	cadmium 48	indium 49	50	antimony 51	tellurium 52	iodine 53	xenon 54
			v			1921/04/1911	1	20.000	1 YE 13 AV	C.C. 1000		(42.57.585)		27			33	
Rb	Sr		Y	Zr	Nb	Мо	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te		Xe
85.468	87.62		88.906	91.224	92.906	95.94	[98]	101.07	102.91	106.42	107.87	112.41	114.82	118,71	121.76	127.60	126.90	131.29
caesium 55	barium 56	57-70	lutetium 71	hafnium 72	tantalum 73	tungsten 74	rhenium 75	osmium 76	iridium 77	platinum 78	gold 79	mercury 80	thallium 81	lead 82	bismuth 83	polonium 84	astatine 85	radon 86
Cs	Ba	*	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	TI	Pb	Bi	Po	At	Rn
132.91	137.33		174.97	178.49	180.95	183.84	186.21	190.23	192.22	195.08	196.97	200.59	204.38	207.2	208.98	[209]	[210]	[222]
francium 87	radium 88	89-102	lawrencium 103	rutherfordium 104	dubnium 105	seaborgium 106	bohrium 107	hassium 108	meitnerium 109	ununnilium 110	unununium 111	ununblum 112		ununquadium 114				
۴r	Ra	* *	Lr	Rf	Db		Bh	Hs	Mt	Him	10000000	Uub		Uuq				
		/\ ./\				Sg				Guii								
[223]	[226]		[262]	[261]	[262]	[266]	[264]	[269]	[268]	[271]	[272]	[277]		[289]				

\*Lanthanide series

\* \* Actinide series

lanthanum 57	cerium 58	praseodymium 59	neodymium 60	promethium 61	samarium 62	europium 63	gadolinium 64	terbium 65	dysprosium 66	holmium 67	erbium 68	thulium 69	ytterbium 70
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Но	Er	Tm	Yb
138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04
actinium 89	thorium 90	protactinium 91	uranium 92	neptunium 93	plutonium 94	americium 95	curium 96	berkelium 97	californium 98	einsteinium 99	fermium 100	mendelevium 101	nobelium 102
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]

pKa Values

HI	-10	CH <sub>3</sub> COOH	4.7	ArOH	10	$H_2$	35
HBr	-8	HN <sub>3</sub>	4.7	RSH	10-12	NH <sub>3</sub>	36
HCl	-6	H <sub>2</sub> S	7.0	H <sub>2</sub> O	15.7	H <sub>2</sub> C=CH <sub>2</sub>	45
$H_3O^+$	-1.7	$\mathrm{NH_4}^+$	9.3	ROH (R=alkyl)	16-18	CH <sub>4</sub>	60
HF	3.2	HCN	9.4	НС≡СН	26		

1) Patchouli oil, or patchoulol, is responsible for the smell of many types of incense and also hippies. In addition, it is used as a precursor to the chemotherapy drug Taxol. Patchoulol can be synthesized from the precursor shown below. (15 pts total)

a. There are two steps in this synthesis: one generates a new ring, and the other changes a functional group. Show the mechanism for the ring formation step. You don't have to show the 3d shape perfectly – just focus on correct connectivity. (10 pts)

b. What reagents are needed for the second step, to finish converting the precursor to patchoulol? (5 pts)

2) Describe each of the structures below as aromatic, nonaromatic, or antiaromatic. Assume each structure is planar. In addition, list the hybridization of each heteroatom. (15 pts total)







3) The reagents shown below react to form an intermediate, which, in the presence of acid, continues on to form the final product shown below. (15 pts total)

a. Show the structure of the intermediate, and the mechanism for its formation. (5 pts)

b. Show the mechanism for the formation of the final product. (10 pts)

4) Predict the major product of the following reactions. If no reaction occurs, then write NR. Show stereochemistry where necessary – if a racemic mixture is formed, you can show only one product and write "racemic" or "rac". (10 pts; 2 pts each)

a. 
$$NO_2$$
  $O$ 
AICI<sub>3</sub>

c. 
$$H_2$$
, Ni, very high temp & pressure

d. Br 
$$\frac{\text{Br}}{\text{Br}}$$
  $\frac{1) \text{ NaNH}_2}{2) \text{ MeBr}}$ 

e. 
$$\frac{1) BH(sia)_2}{2) H_2O_1, H_2O_2, OH^2}$$

5) Find a way to synthesize the desired product from the given starting material(s) and any other reagents containing at most 5 carbon atoms. If more than one step is necessary, show the product of each step. Do not show mechanisms. (30 pts; 10 pts each)

b. 
$$\longrightarrow$$
  $\bigcirc$ 

6) The reaction shown below could hypothetically produce three isomers – the ortho, meta, and para products. (15 pts)

$$\mathsf{HO} = \underbrace{\begin{array}{c} \mathsf{HNO}_3, \\ \mathsf{H_2SO_4} \end{array}}$$

a. Show the mechanism for the formation of the para product, including all resonance forms for the intermediate. (5 pts)

b. Show the mechanism for the formation of the meta product, including all resonance forms for the intermediate. (5 pts)

- c. In twenty words or less, explain which of these outcomes is favored and why. (5 pts)
- 7) Extra credit! Calicene, shown below, has a surprisingly high dipole moment for a hydrocarbon. Explain why this is true in thirty words or less, and show the dominant resonance form for this molecule. (10 pts e.c.)

