

NAME \_\_\_\_\_

ID # \_\_\_\_\_

## ORGANIC CHEMISTRY II (CHEM 2302)

8:00 – 8:50 am, June 29, 2015

### Exam 1

If you want to pick this exam up Wednesday in class (in public), please check the box on the right:

If you do not check the box, I will not bring your exam to class on Wednesday, and you will need to pick up your exam in private from Chemistry department staff in 115 Smith beginning Thursday, July 2<sup>nd</sup>. Exams that are not picked up within two weeks will be disposed of.

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A periodic table and a chart of reaction conditions are attached to the back of this exam as an aid. Otherwise, you are not permitted to use any other materials (including notes, books, or electronic devices of any kind).

Right now, write your name and student ID number at the top of this page. When the exam begins, please write your name at the top of the next page.

You may use pen or pencil. However, re-grades will be considered only for exams completed in pen.

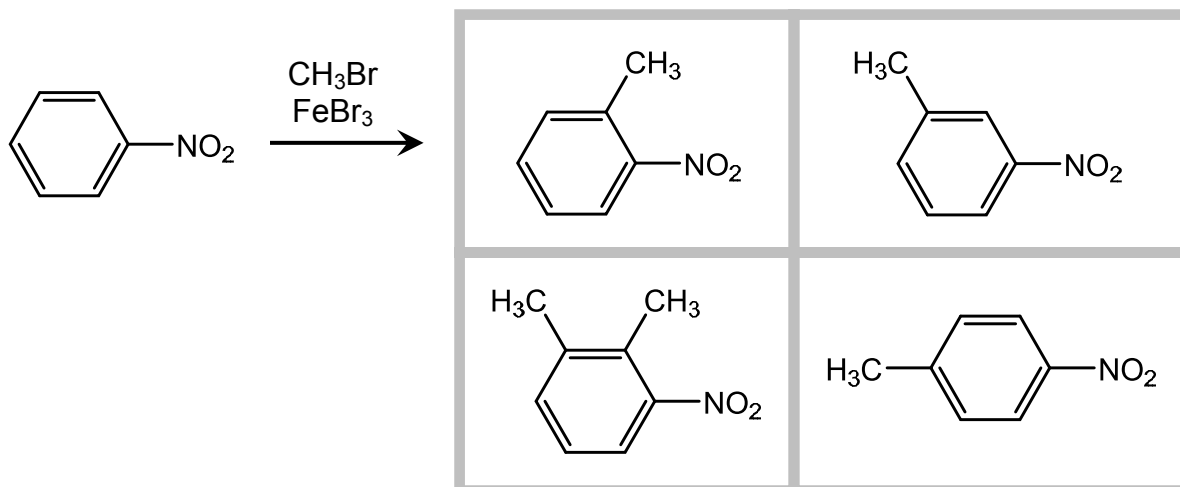
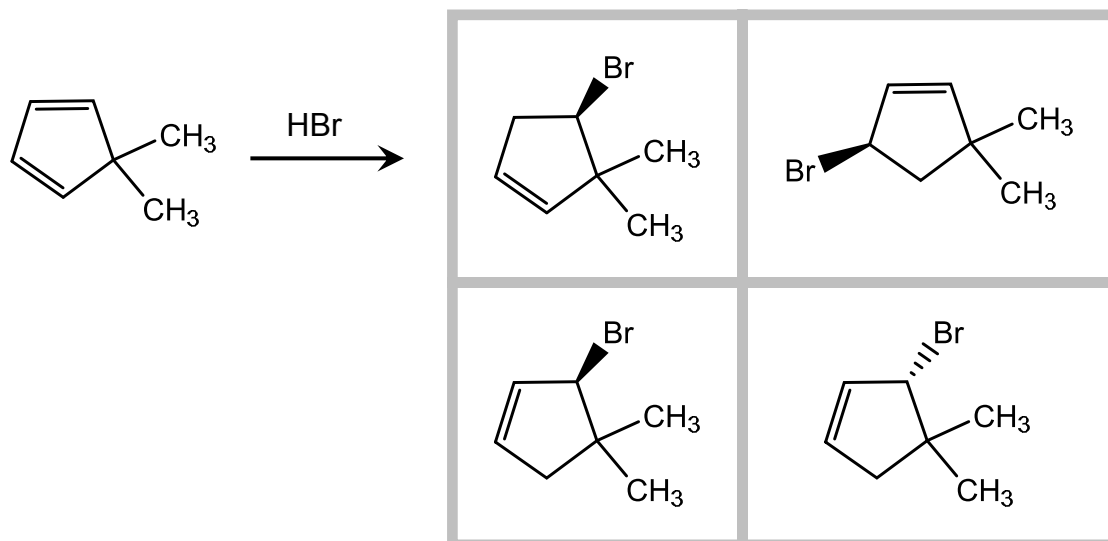
Please write your answers in the boxes/spaces provided. If your answer is not in the appropriate space (say, for example, it's on the back of the page), draw us an arrow and/or note telling us where to look.

NAME \_\_\_\_\_

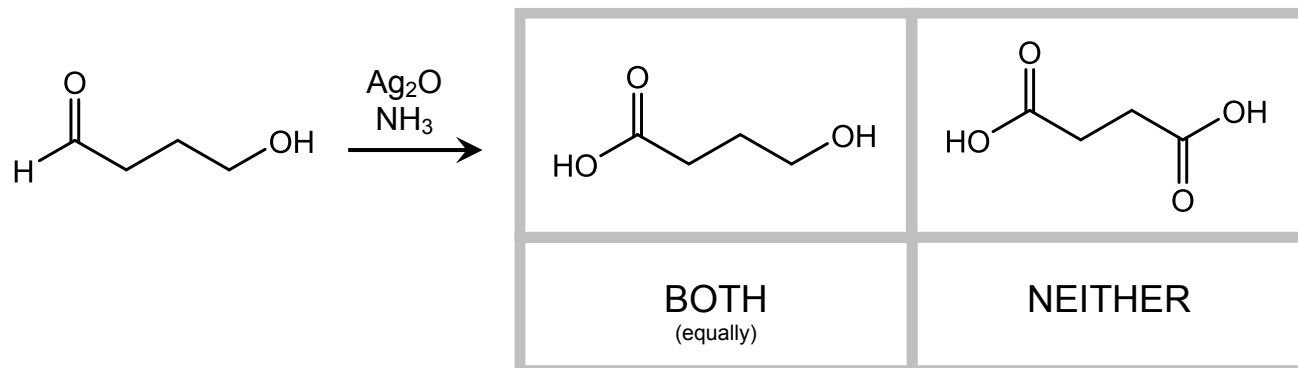
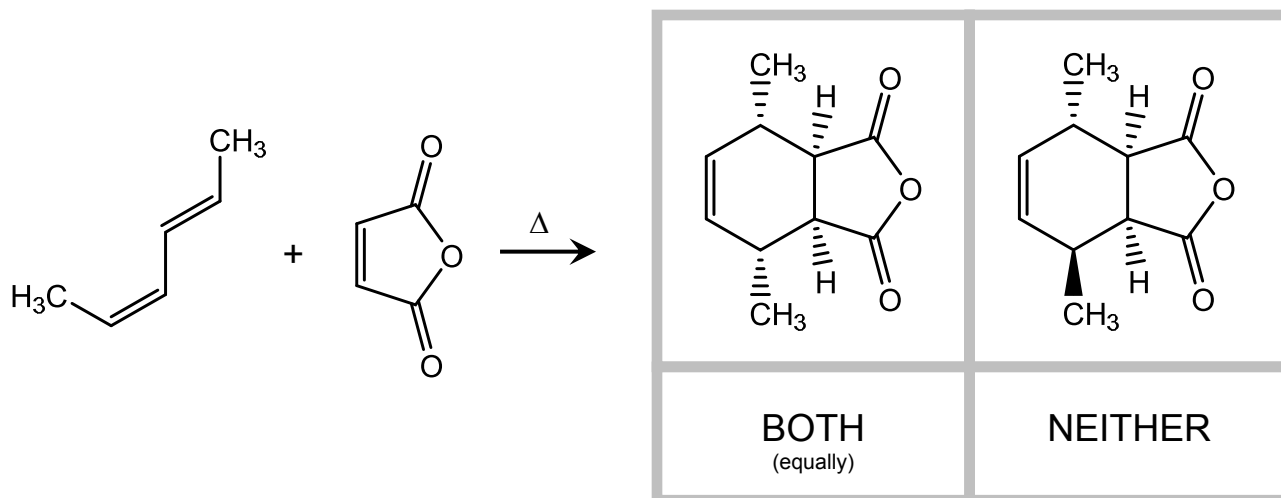
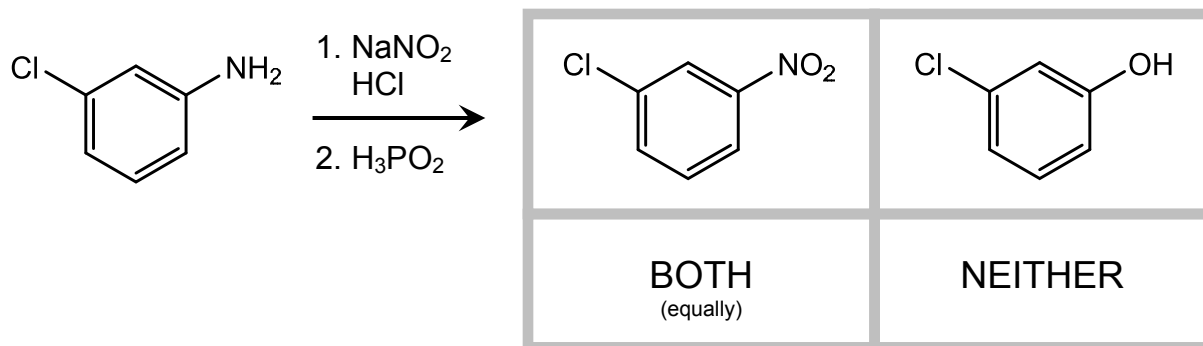
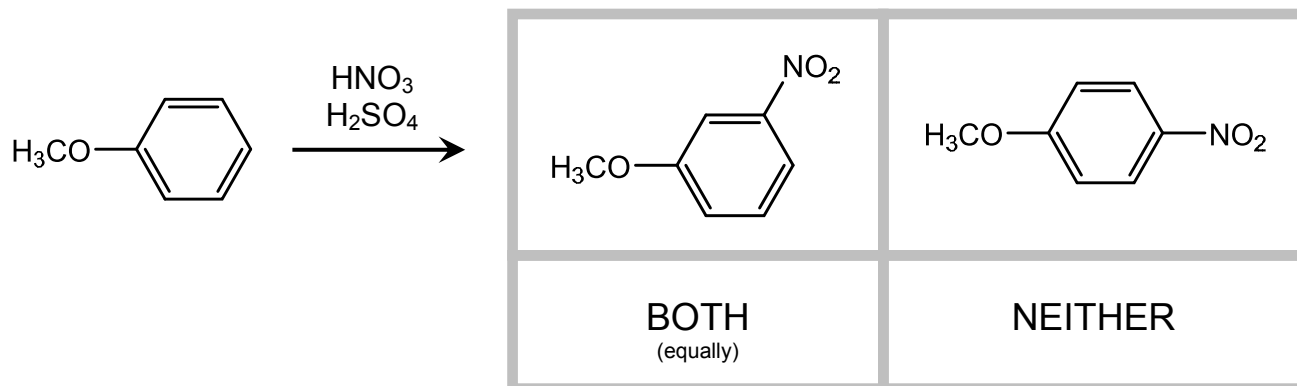
Scoring: 1. \_\_\_\_\_ / 10      5. \_\_\_\_\_ / 15  
 2. \_\_\_\_\_ / 16      6. \_\_\_\_\_ / 18  
 3. \_\_\_\_\_ / 12      7. \_\_\_\_\_ / 17  
 4. \_\_\_\_\_ / 12

Total Score: \_\_\_\_\_ / 100

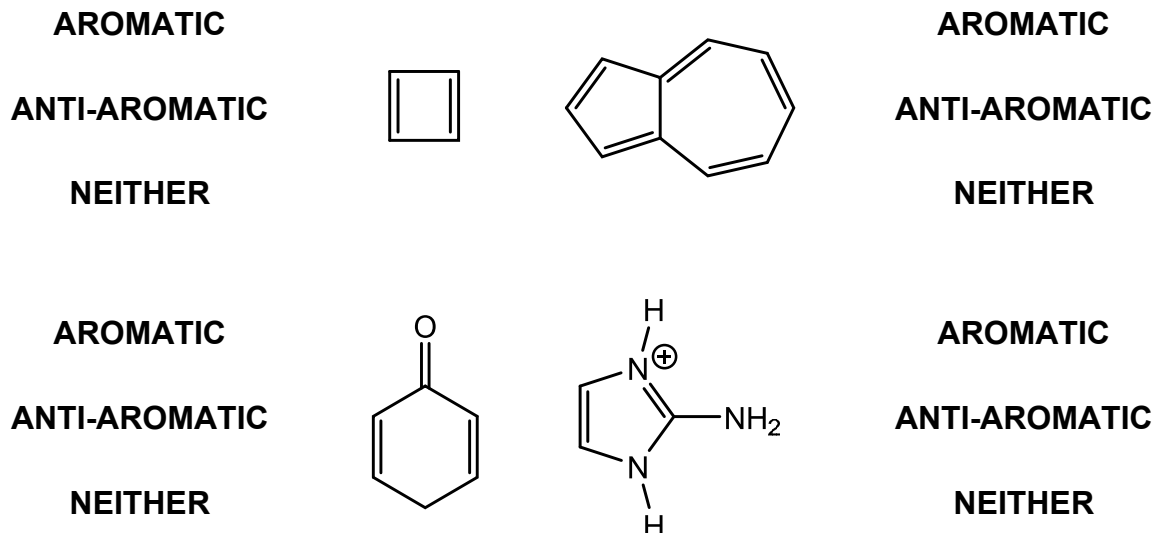
1. (10 pts) For each reaction shown below, **circle all possible products** (including minor ones). Keep in mind that, for each reaction, you might circle one, multiple, or no products.



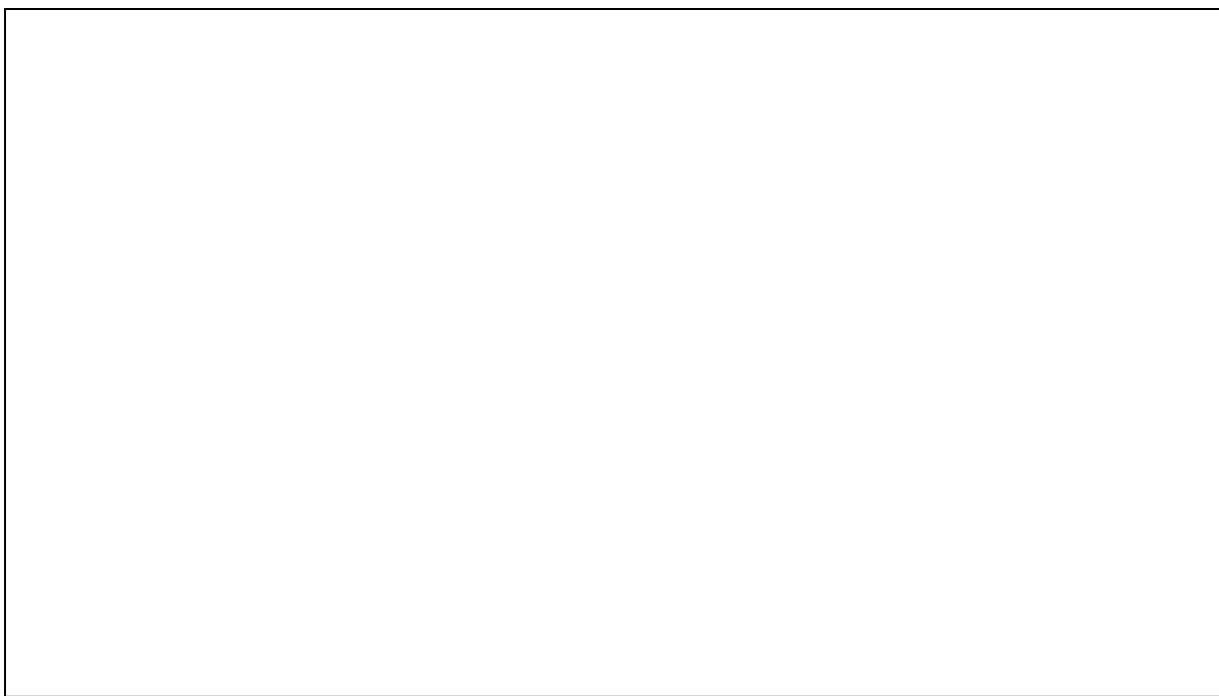
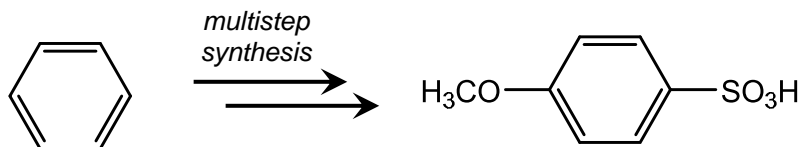
2. (16 pts) Each of the reactions below is drawn with two possible products. If one of the two products predominates, circle that preferred product. If the two products are produced equally, circle "BOTH". If neither product would result from the reaction, circle "NEITHER". **Circle one answer only.**



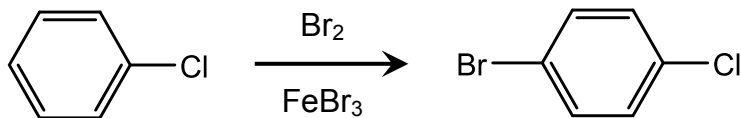
3. (12 pts) For each of the molecules below, circle whether the molecule is aromatic, anti-aromatic, or neither.



4. (12 pts) **Propose a multistep synthesis** of the product shown below, starting from benzene. You may use any reagents and reactions we've learned about in class and/or in the text. You might discover multiple answers to this problem; draw only your best (one) synthetic route. Feel free to draw an incomplete route—we will give you partial credit where we can.

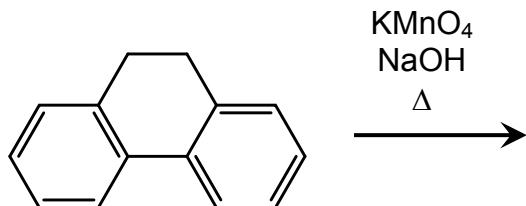


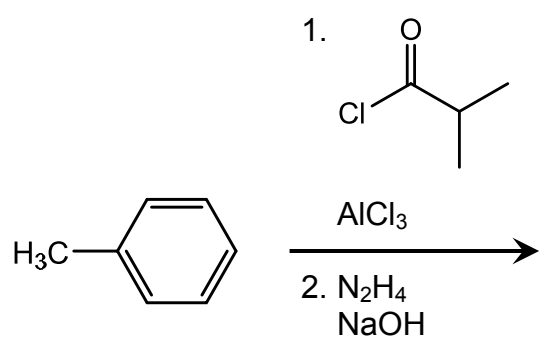
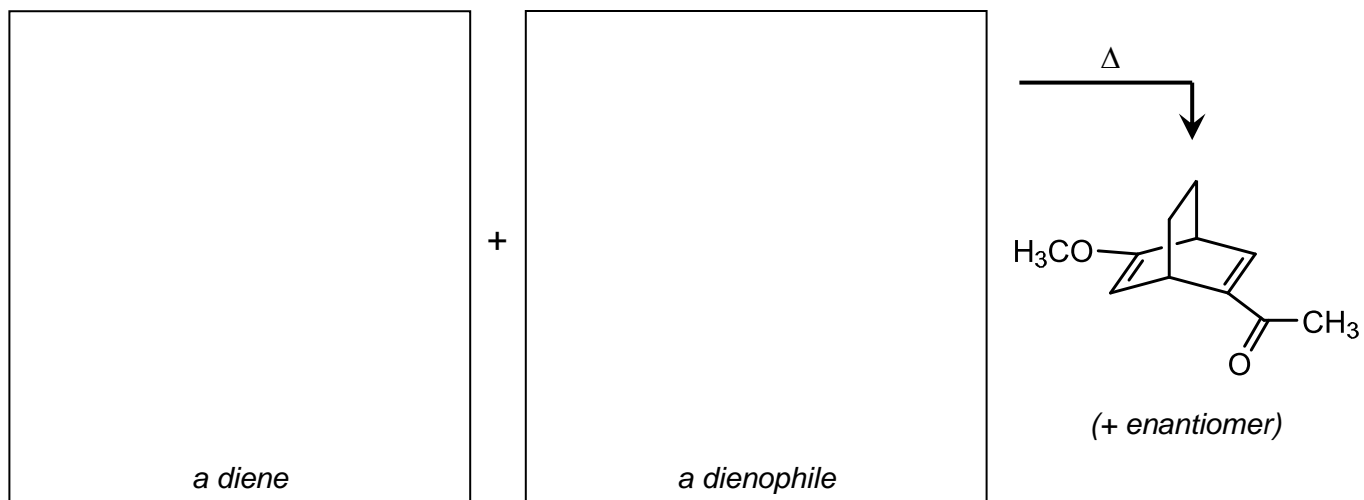
5. (15 pts) **Draw a mechanism** (using “electron pushing”) for the electrophilic aromatic substitution reaction shown below. Draw each mechanistic step explicitly; don’t cheat by combining multiple processes in a single step. Use only the molecules shown in the problem; don’t invoke generic species. (E.g., don’t use “B:” as a generic base.)



*Mechanism:*

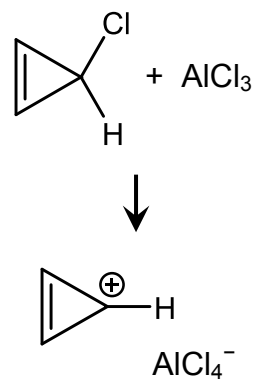
6. (18 pts) For each of the reactions below, fill in the empty box corresponding to reactants or products. Give only one answer in each box. For reactions that you expect to yield multiple products, give the major product. For reactions that yield multiple enantiomers, draw only one enantiomer in the box, and include the note “+ enantiomer”.



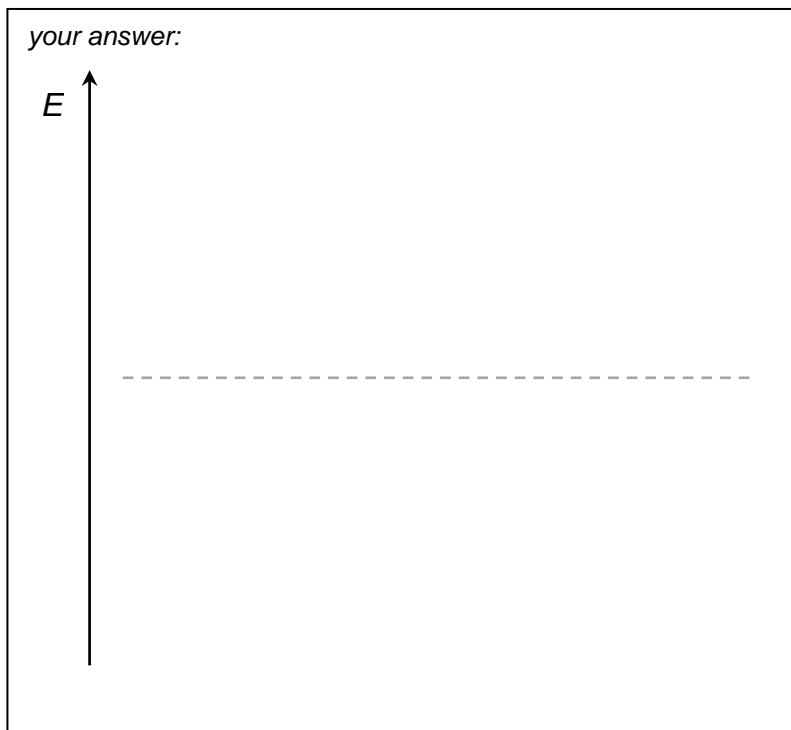
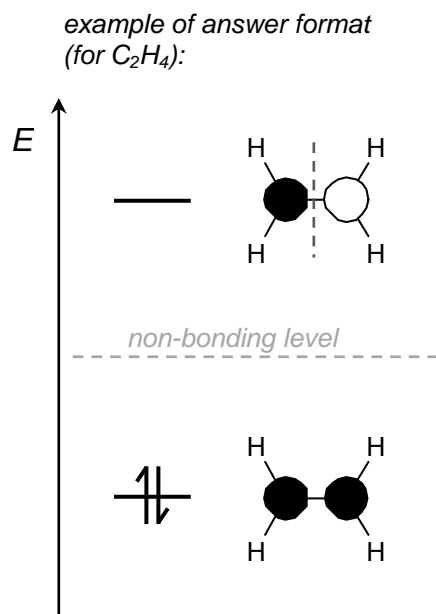


7. (17 pts) When cyclopropyl chloride (shown at right) is combined with AlCl<sub>3</sub>, the result is a stable organic salt of cyclopropenyl cation (C<sub>3</sub>H<sub>3</sub><sup>+</sup>).

a. In the box below, draw a mechanism (using “electron pushing”) that illustrates the formation of C<sub>3</sub>H<sub>3</sub><sup>+</sup>.



- b. In the box below, draw a molecular orbital diagram for the conjugated  $\pi$  system in  $\text{C}_3\text{H}_3^+$ . In your diagram, make sure to:
- Draw orbital energy levels;
  - Draw a molecular orbital for each energy level. Use dark and light shading to indicate the phase in each orbital lobe.
  - Fill your orbitals with the appropriate number of electrons.

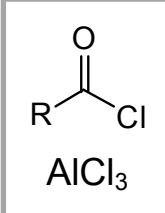


- c. On your diagram above, draw a vertical arrow to illustrate an electronic transition that could be observed as an absorption peak in the UV/vis spectrum of  $\text{C}_3\text{H}_3^+$ . Label the arrow " $\lambda$ ".

- d. Is  $\text{C}_3\text{H}_3^+$  **AROMATIC** , **ANTIAROMATIC** , or **NON-AROMATIC** ?

(Circle one.)

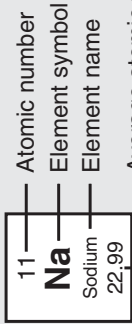
## Exam 1 Chart of Reaction Conditions

Br <sub>2</sub> FeBr <sub>3</sub>	Cl <sub>2</sub> AlCl <sub>3</sub>	H <sub>2</sub> SO <sub>4</sub> HNO <sub>3</sub>	Zn or Fe HCl/H <sub>2</sub> O	H <sub>2</sub> SO <sub>4</sub> SO <sub>3</sub>	KMnO <sub>4</sub> OH <sup>-</sup> , 100 °C
1. NaNO <sub>2</sub> HCl 2. CuCN or H <sub>3</sub> PO <sub>2</sub> or CuX or H <sub>3</sub> O <sup>+</sup>	 AlCl <sub>3</sub>	R-X (R = alkyl) AlCl <sub>3</sub> or FeBr <sub>3</sub>	Zn(Hg), HCl/H <sub>2</sub> O	1. N <sub>2</sub> H <sub>4</sub> 2. KOH, Δ	



		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18																																																																																																																																																																																																						
		1A		2A		3B		4B		5B		6B		7B		8B						1B		2B		3A		4A		5A		6A		7A		8A																																																																																																																																																																																																						
1	1	<b>H</b> Hydrogen 1.01	2	<b>He</b> Helium 4.00	3	4	<b>Li</b> Lithium 6.94	5	<b>Be</b> Beryllium 9.01	6	7	<b>B</b> Boron 10.81	8	<b>C</b> Carbon 12.01	9	<b>N</b> Nitrogen 14.01	10	<b>O</b> Oxygen 16.00	11	<b>F</b> Fluorine 19.00	12	<b>Ne</b> Neon 20.18	13	<b>Na</b> Sodium 22.99	14	<b>Mg</b> Magnesium 24.31	15	<b>Al</b> Aluminum 26.98	16	<b>Si</b> Silicon 28.09	17	<b>P</b> Phosphorus 30.97	18	<b>S</b> Sulfur 32.07	19	<b>Cl</b> Chlorine 35.45	20	<b>Ar</b> Argon 39.95	21	<b>K</b> Potassium 39.10	22	<b>Ca</b> Calcium 40.08	23	<b>Sc</b> Scandium 44.96	24	<b>Ti</b> Titanium 47.87	25	<b>V</b> Vanadium 50.94	26	<b>Cr</b> Chromium 52.00	27	<b>Mn</b> Manganese 54.94	28	<b>Fe</b> Iron 55.85	29	<b>Cobalt</b> Cobalt 58.93	30	<b>Ni</b> Nickel 58.69	31	<b>Cu</b> Copper 63.55	32	<b>Zn</b> Zinc 65.39	33	<b>Ga</b> Gallium 69.72	34	<b>Ge</b> Germanium 72.61	35	<b>As</b> Arsenic 74.92	36	<b>Se</b> Selenium 78.96	37	<b>Rb</b> Rubidium 85.47	38	<b>Sr</b> Strontium 87.62	39	<b>Y</b> Yttrium 88.91	40	<b>Zr</b> Zirconium 91.22	41	<b>Nb</b> Niobium 92.91	42	<b>Mo</b> Molybdenum 95.94	43	<b>Tc</b> Technetium (98)	44	<b>Ru</b> Ruthenium 101.07	45	<b>Rh</b> Rhodium 102.91	46	<b>Pd</b> Palladium 106.42	47	<b>Ag</b> Silver 107.87	48	<b>Cd</b> Cadmium 112.41	49	<b>In</b> Indium 114.82	50	<b>Sn</b> Tin 118.71	51	<b>Sb</b> Antimony 121.76	52	<b>Te</b> Tellurium 127.60	53	<b>I</b> Iodine 126.90	54	<b>Xe</b> Xenon 131.29	55	<b>Cs</b> Cesium 132.91	56	<b>Ba</b> Barium 137.33	57	<b>La</b> Lanthanum 138.91	58	<b>Ce</b> Cerium 140.12	59	<b>Pr</b> Praseodymium 140.91	60	<b>Nd</b> Neodymium 144.24	61	<b>Pm</b> Promethium (145)	62	<b>Sm</b> Samarium 150.36	63	<b>Eu</b> Europium 151.96	64	<b>Gd</b> Gadolinium 157.25	65	<b>Tb</b> Terbium 158.93	66	<b>Dy</b> Dysprosium 162.50	67	<b>Ho</b> Holmium 164.93	68	<b>Er</b> Erbium 167.26	69	<b>Tm</b> Thulium 168.93	70	<b>Yb</b> Ytterbium 173.04	71	<b>Lu</b> Lutetium 174.97	72	<b>Fr</b> Francium (223)	73	<b>Ra</b> Radium (226)	74	<b>Ac</b> Actinium (227)	75	<b>Rf</b> Rutherfordium (261)	76	<b>Hf</b> Hafnium 178.49	77	<b>Ta</b> Tantalum 180.95	78	<b>W</b> Tungsten 183.84	79	<b>Re</b> Rhenium 186.21	80	<b>Os</b> Osmium 190.23	81	<b>Ir</b> Iridium 192.22	82	<b>Pt</b> Platinum 195.08	83	<b>Au</b> Gold 196.97	84	<b>Hg</b> Mercury 200.59	85	<b>Tl</b> Thallium 204.38	86	<b>Pb</b> Lead 207.2	87	<b>Bi</b> Bismuth 208.98	88	<b>Po</b> Polonium (209)	89	<b>At</b> Astatine (210)	90	<b>Rn</b> Radon (222)	91	<b>Th</b> Thorium 232.04	92	<b>Pa</b> Protactinium 231.04	93	<b>U</b> Uranium 238.03	94	<b>Np</b> Neptunium (237)	95	<b>Pu</b> Plutonium (244)	96	<b>Am</b> Americium (243)	97	<b>Cm</b> Curium (247)	98	<b>Bk</b> Berkelium (247)	99	<b>Cf</b> Californium (251)	100	<b>Fm</b> Fermium (257)	101	<b>Md</b> Mendelevium (258)	102	<b>No</b> Nobelium (259)	103	<b>Lr</b> Lawrencium (262)	104	<b>Uu</b> Ununquadium (264)	105	<b>Uub</b> Ununbium (264)	106	<b>Uut</b> Ununtrium (266)	107	<b>Uuq</b> Ununquadium (266)	108	<b>Uuq</b> Ununquadium (266)	109	<b>Uuq</b> Ununquadium (266)	110	<b>Uuq</b> Ununquadium (266)	111	<b>Uuq</b> Ununquadium (266)	112	<b>Uuq</b> Ununquadium (266)	113	<b>Uuq</b> Ununquadium (266)	114	<b>Uuq</b> Ununquadium (266)	115	<b>Uuq</b> Ununquadium (266)	116	<b>Uuq</b> Ununquadium (266)	117	<b>Uuq</b> Ununquadium (266)	118	<b>Uuq</b> Ununquadium (266)

**Key**



Atomic number  
Element symbol  
Element name  
Average atomic mass\*

\* If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.