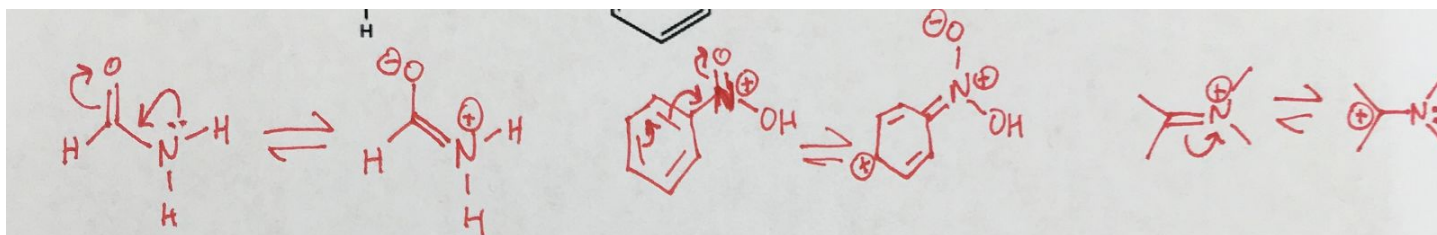
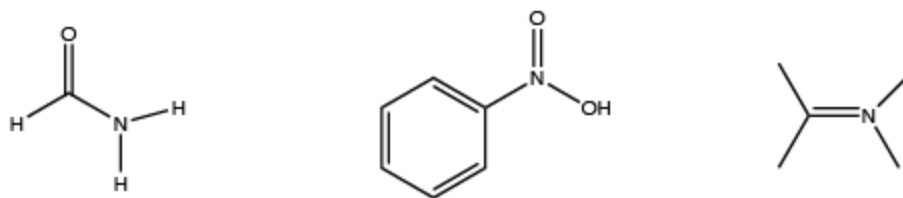
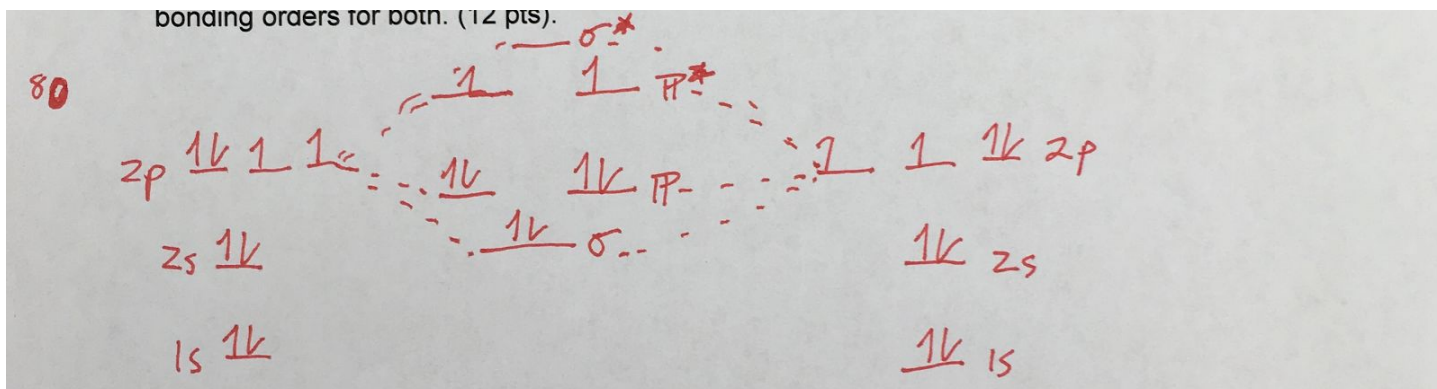


Warning: formal charges not always indicated/drawn, but you should in your answers!

1. Draw resonance forms for the following structures. (9 pts).



2. Which is more stable, O_2 or O_2^+ ? Explain your rationale using molecular orbitals and calculations of the bonding orders for both. (12 pts).



O_2^+ is more stable because O_2 has 2 pi antibonding electrons and O_2^+ only has 1. Bonding orders are 2 for O_2 and 2.5 for O_2^+ .

3. Identify if the below molecules are nucleophilic or electrophilic and where the electrons would originate or attack. (5 pts).

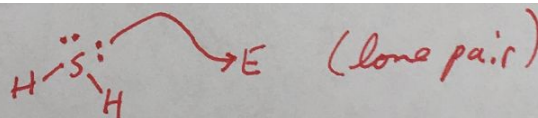
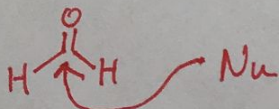
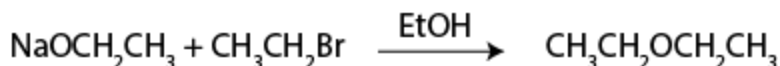
H_2S

CH_2O

H_2S nucleophilic (lone pair)

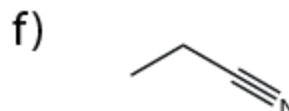
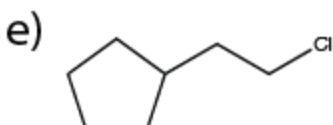
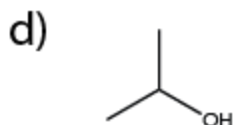
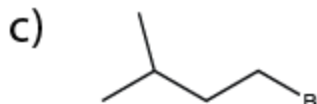
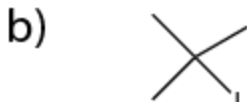
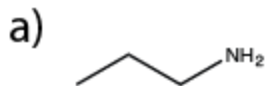
CH₂O electrophilic (carbonyl carbon)

or attack. (5 pts).

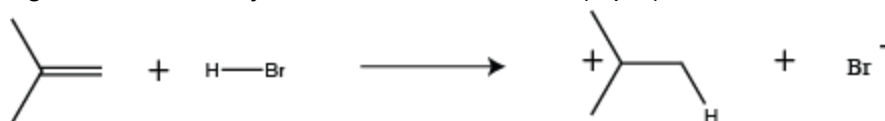
H₂SCH₂OH₂S nucleophilic (lone pair)CH₂O electrophilic (carbonyl carbon)4. For the following SN₂ reaction: (6 pts).

a) Replace bromoethane with bromomethane. Will the reaction happen slower, faster, or at the same rate?

Reaction is faster, less sterically hindered.

b) Replace EtBr with EtNH₃? Will the reaction happen slower, faster, or at the same rate?Reaction is faster, NH₃ is a better leaving group.5. Which of the following compounds would be expected to react in an SN₂ manner at a reasonable rate with sodium azide (NaN₃) under basic conditions in an aprotic solvent? For those that do not react at a reasonable rate, explain why not. (12 pts).a) NH₂ not a good LG, b) tertiary carbon, c) YES, d) OH not a good LG, e) YES, f) not a good LG.

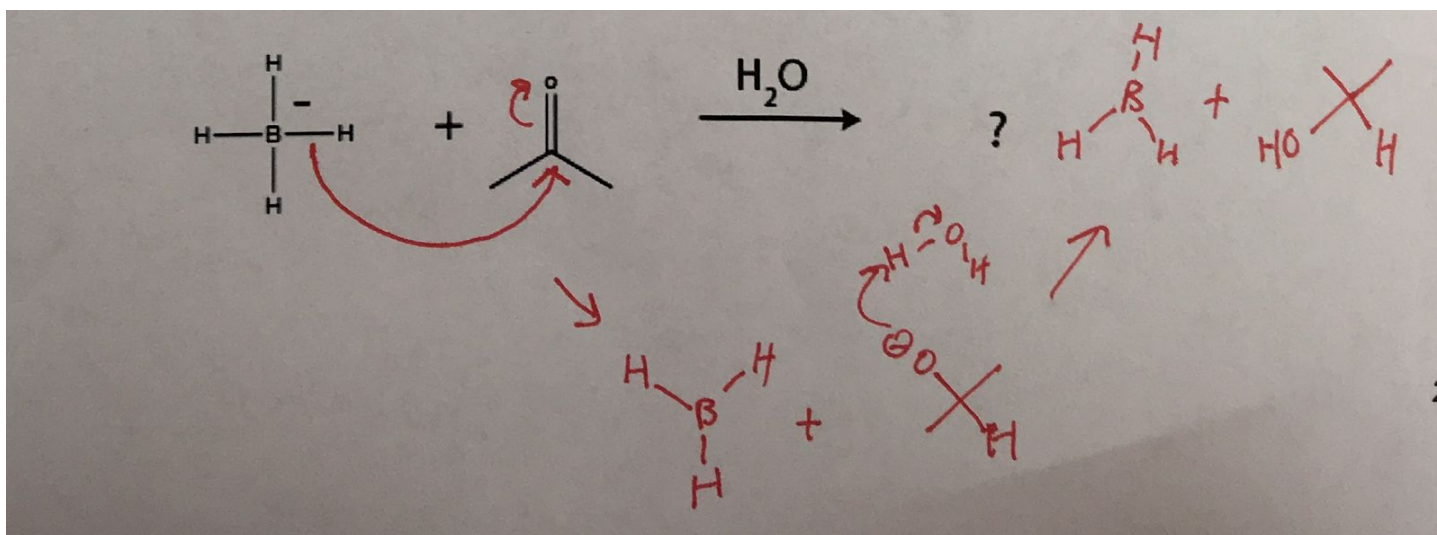
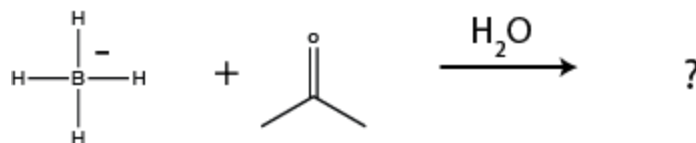
6. For the following reaction, identify the HOMO and LUMO: (8 pts).



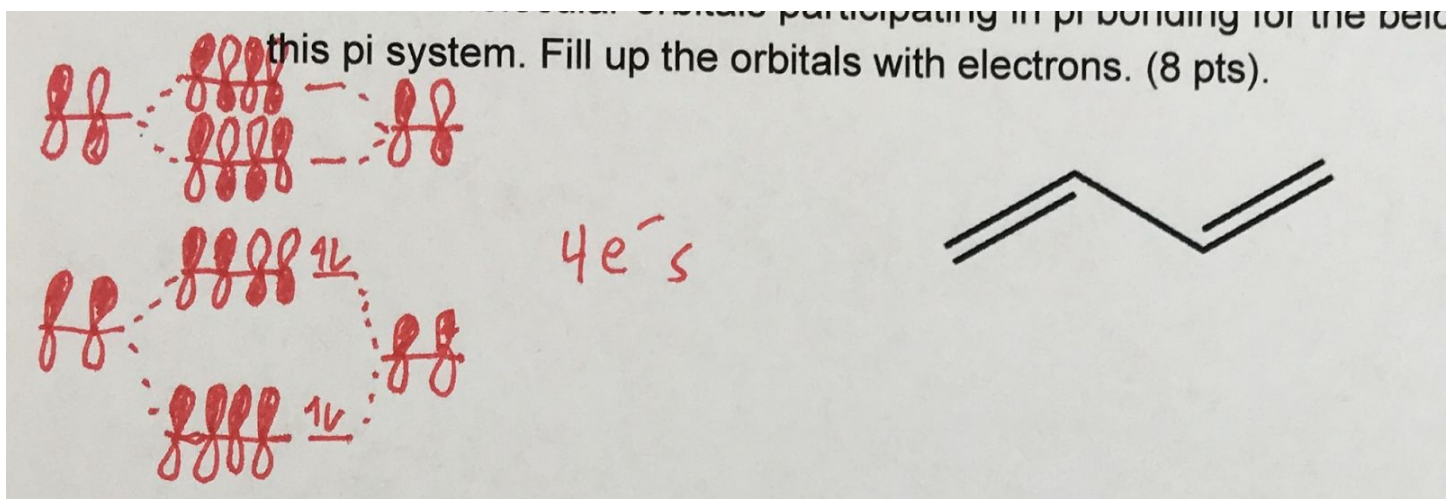
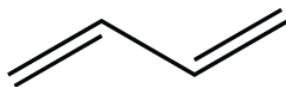
HOMO: pi bond

LUMO: H-Br anti-sigma bond

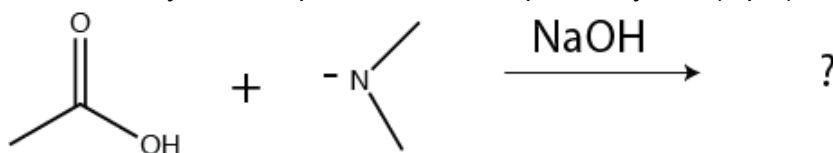
7. Draw a mechanism with an arrow-pushing mechanism for the following reaction: (5 pts).



8. Draw the molecular orbitals participating in pi bonding for the below allyl. How many electrons are in this pi system. Fill up the orbitals with electrons. (8 pts).

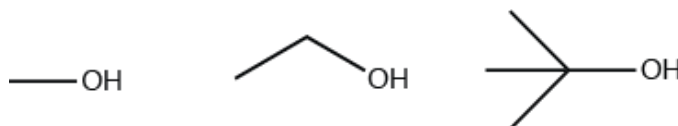


9. Will a product be formed? If yes, what product? If no, explain why not. (8 pts).



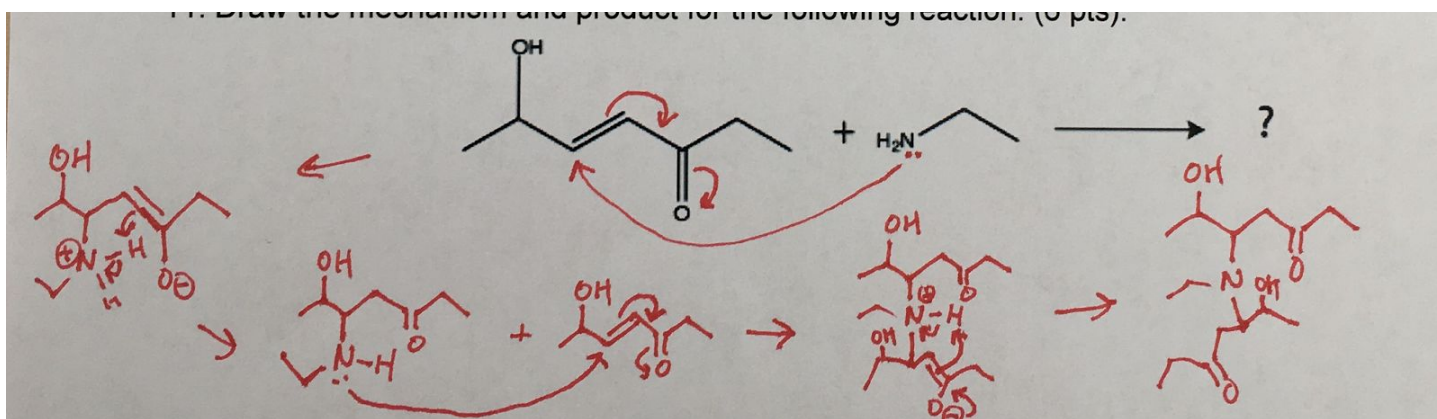
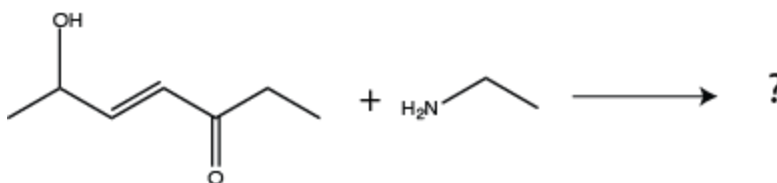
No product, carboxylate has negative charge distributed to make carbonyl carbon a poor electrophile.

10. Which molecule is the best acid of those listed below? (6 pts).

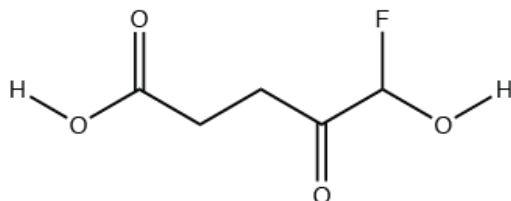


Primary carbon makes methanol more acidic (fewer electron donating carbons).

11. Draw the mechanism and product for the following reaction: (6 pts).

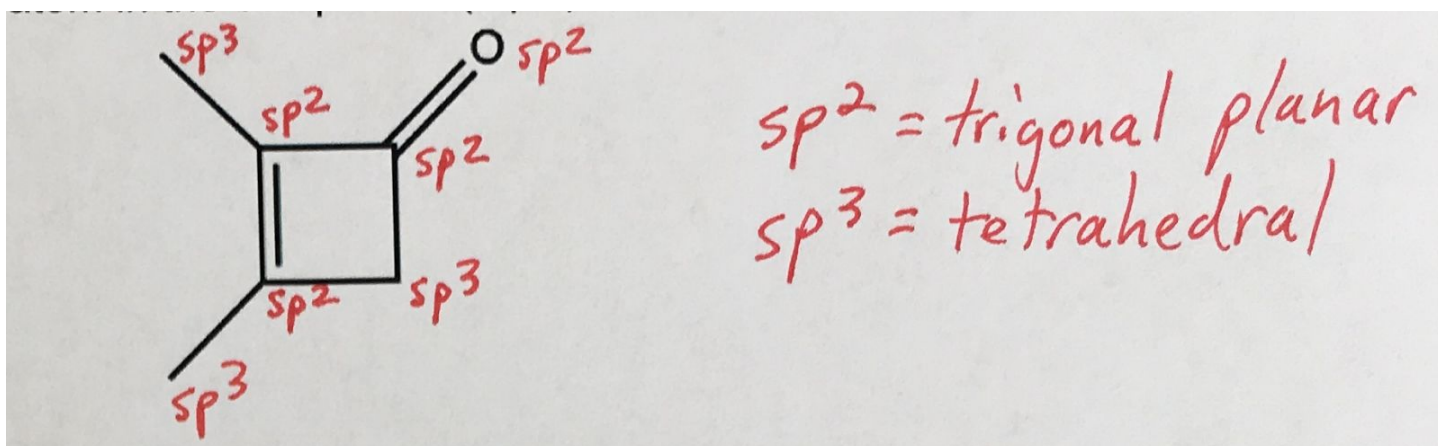
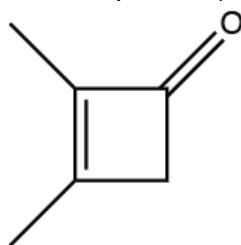


12. Compare the two protons identified below. Which proton is more acidic and explain why? (5 pts).



The Carboxyl proton is more acidic due to resonance

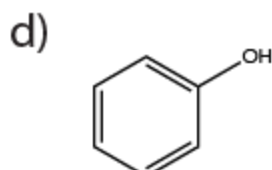
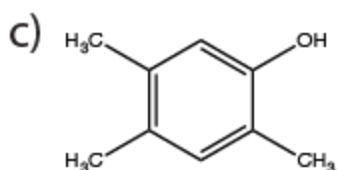
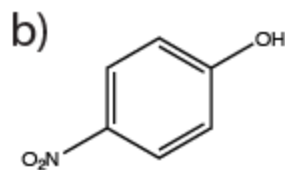
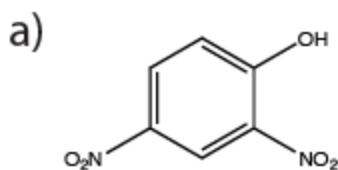
13. Identify the geometry for every atom in the compound. (5 pts).



Sp2 = trigonal planar

Sp3 = tetrahedral

14. These phenols have approximate pK_a values of 4, 7, 10, and 11. Suggest with explanations which pK_a value belongs to which phenol. (5 pts).



a)

b)

c)

d)

- a) 4
- b) 7
- c) 11
- d) 10

Periodic Table of the Elements

1 IA 1A	2 IIA 2A												13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 H Hydrogen (1.00784 u, 0.9998)	3 Li Lithium (6.941 u, 0.97)	4 Be Beryllium (9.0122 u, 0.01)	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: auto;"> Atomic Number Symbol Name Atomic Mass </div>										5 B Boron (10.806 u, 0.81)	6 C Carbon (12.0096 u, 0.01)	7 N Nitrogen (14.00643 u, 0.007)	8 O Oxygen (15.999 u, 0.007)	9 F Fluorine (18.998403 u, 0.001)	10 Ne Neon (20.1797 u, 0)
11 Na Sodium (22.98976928 u, 0.0001)	12 Mg Magnesium (24.304 u, 0.003)	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8 VIII 8	9 VIII 9	10 VIII 10	11 IB 1B	12 IIB 2B	13 Al Aluminum (26.9815386 u, 0.0001)	14 Si Silicon (28.0855 u, 0.0001)	15 P Phosphorus (30.973761998 u, 0.0001)	16 S Sulfur (32.06 u, 0.006)	17 Cl Chlorine (35.448 u, 0.003)	18 Ar Argon (39.948 u, 0)	
19 K Potassium (39.0983 u, 0)	20 Ca Calcium (40.078 u, 0)	21 Sc Scandium (44.955912 u, 0.0001)	22 Ti Titanium (47.867 u, 0)	23 V Vanadium (50.9415 u, 0)	24 Cr Chromium (51.9961 u, 0)	25 Mn Manganese (54.938045 u, 0)	26 Fe Iron (55.845 u, 0)	27 Co Cobalt (58.933194 u, 0)	28 Ni Nickel (58.6934 u, 0)	29 Cu Copper (63.546 u, 0)	30 Zn Zinc (65.38 u, 0)	31 Ga Gallium (69.723 u, 0)	32 Ge Germanium (72.630 u, 0)	33 As Arsenic (74.921595 u, 0)	34 Se Selenium (78.9718 u, 0)	35 Br Bromine (79.904 u, 0)	36 Kr Krypton (83.796 u, 0)	
37 Rb Rubidium (85.4678 u, 0)	38 Sr Strontium (87.62 u, 0)	39 Y Yttrium (88.905848 u, 0)	40 Zr Zirconium (91.224 u, 0)	41 Nb Niobium (92.90638 u, 0)	42 Mo Molybdenum (95.94 u, 0)	43 Tc Technetium (98 u, 0)	44 Ru Ruthenium (101.072 u, 0)	45 Rh Rhodium (102.90550 u, 0)	46 Pd Palladium (106.42 u, 0)	47 Ag Silver (107.8682 u, 0)	48 Cd Cadmium (112.411 u, 0)	49 In Indium (114.818 u, 0)	50 Sn Tin (118.710 u, 0)	51 Sb Antimony (121.757 u, 0)	52 Te Tellurium (127.603 u, 0)	53 I Iodine (126.90447 u, 0)	54 Xe Xenon (131.29 u, 0)	
55 Cs Cesium (132.90545196 u, 0)	56 Ba Barium (137.327 u, 0)	57-71 Lanthanide Series	72 Hf Hafnium (178.49 u, 0)	73 Ta Tantalum (180.94788 u, 0)	74 W Tungsten (183.84 u, 0)	75 Re Rhenium (186.207 u, 0)	76 Os Osmium (190.23 u, 0)	77 Ir Iridium (192.222 u, 0)	78 Pt Platinum (195.084 u, 0)	79 Au Gold (196.966569 u, 0)	80 Hg Mercury (200.59 u, 0)	81 Tl Thallium (204.3833 u, 0)	82 Pb Lead (207.2 u, 0)	83 Bi Bismuth (208.9804 u, 0)	84 Po Polonium (209 u, 0)	85 At Astatine (210 u, 0)	86 Rn Radon (222 u, 0)	
87 Fr Francium (223 u, 0)	88 Ra Radium (226 u, 0)	89-103 Actinide Series	104 Rf Rutherfordium (261 u, 0)	105 Db Dubnium (262 u, 0)	106 Sg Seaborgium (263 u, 0)	107 Bh Bohrium (264 u, 0)	108 Hs Hassium (265 u, 0)	109 Mt Meitnerium (266 u, 0)	110 Ds Darmstadtium (267 u, 0)	111 Rg Roentgenium (268 u, 0)	112 Cn Copernicium (269 u, 0)	113 Uut Ununtrium (270 u, 0)	114 Fl Flerovium (271 u, 0)	115 Uup Ununpentium (272 u, 0)	116 Lv Livermorium (273 u, 0)	117 Uus Ununseptium (274 u, 0)	118 Uuo Ununoctium (276 u, 0)	
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