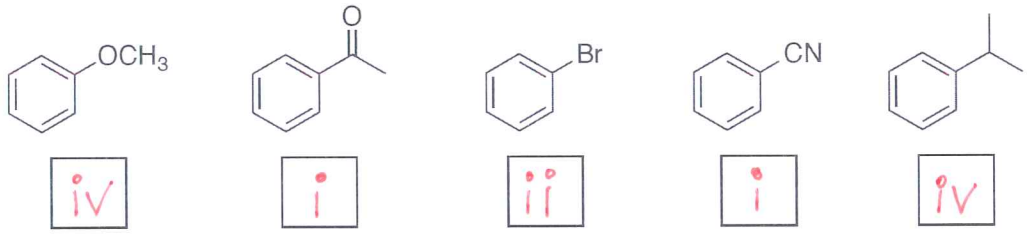
1. Fundamentals

(a) (*10 points*) Each substituent on the benzene rings below effects the **rate and substitution pattern in electrophilic aromatic substitution (EArS) reactions.** Indicate the effect of each substituent in the box below it using choices **(i)** through **(iv)**.

(i) meta-deactivator **(ii)** ortho/para-deactivator

(iii) meta-activator **(iv)** ortho/para-activator

2pts each

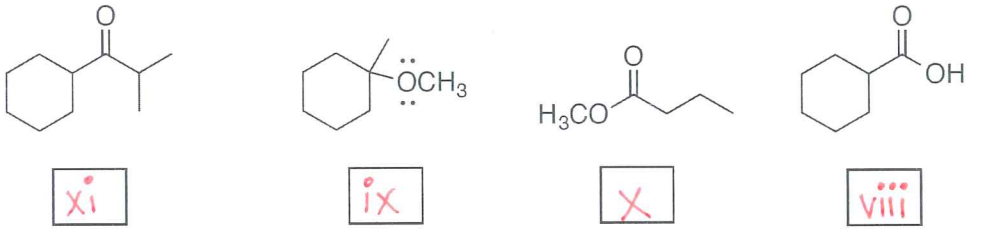


iv i ii i iv

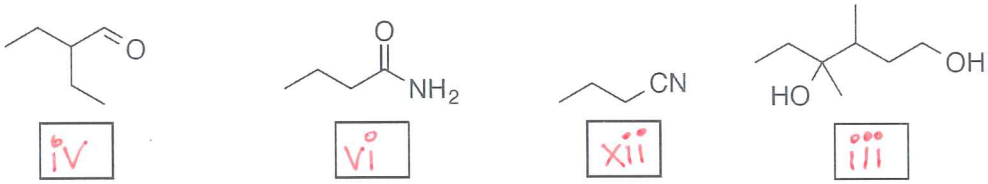
(b) (*16 points*) Indicate the functional group in the box below each using **(i)** through **(xii)**.

(i) acid anhydride	**(ii)** acid chloride	**(iii)** alcohol	**(iv)** aldehyde
(v) arene	**(vi)** amide	**(vii)** amine	**(viii)** carboxylic acid
(ix) ether	**(x)** ester	**(xi)** ketone	**(xii)** nitrile

2pts each



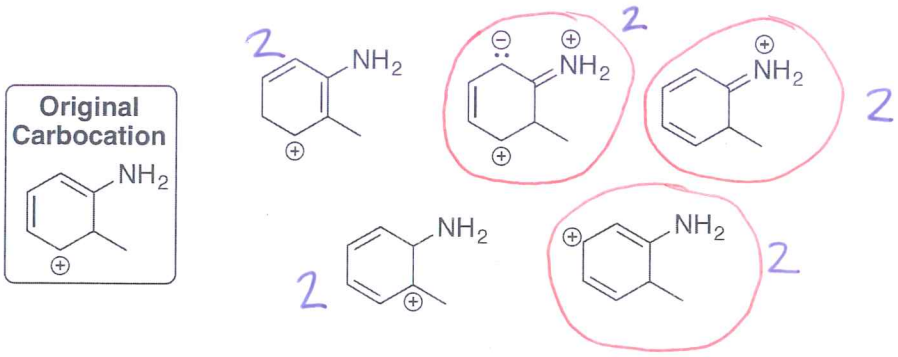
xi ix X viii



iv vi xii iii

2. More Fundamentals & Nomenclature

(a) (*10 points*) **Circle all structures** that are valid resonance forms of the **original carbocation**.



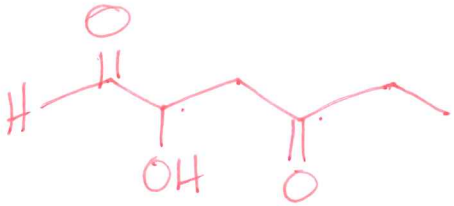
(b) (*30 points*) **Draw structures** corresponding to the following names.

3-methoxy-1-hexene

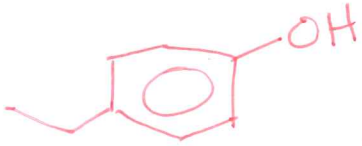
1-Bromo-2-cyclopentenol

Cyclohexane carbaldehyde

2-Hydroxy-4-oxohexanal



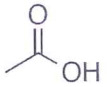
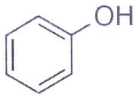
para-ethyl phenol



3. Acid-Base Chemistry

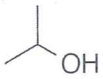
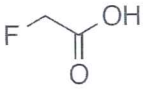
(a) (*7 points*) The following compounds are arranged from most (left) to least (right) acidic. Fill in the **pKa** values of each in the boxes provided.

1pt each ±2 ok pKa units

HCl	H_3O^+			H_2O	NH_3	CH_4
-7	0 or 2 ok	5	10	16	35	50

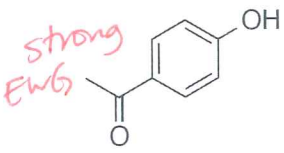
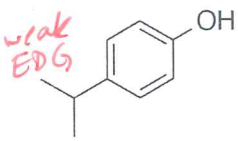
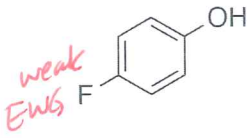
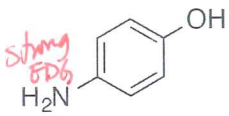
(b) (*10 points*) Rank the following sets of acids from **most acidic (1)** to **least acidic (4)**. Put your answers in the box below each compound.

Set 1

CF_3OH	CH_3NH_2		
2	4	3	1

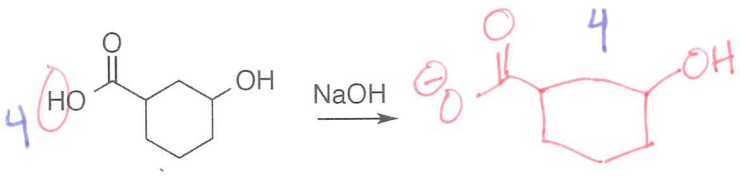
5pts

Set 2

			
strong EWG	weak EDG	weak EWG	strong EDG
1	3	2	4

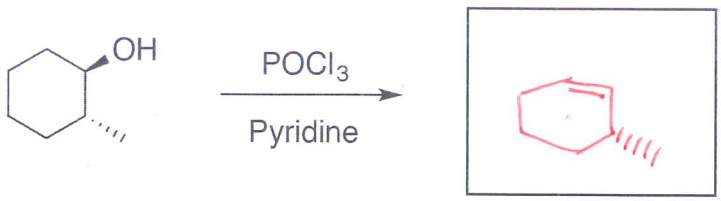
5pts

(c) (*8 points*) **Circle the most acidic proton** on the molecule below and draw its **conjugate base** upon reaction with sodium hyroxide. Assume exactly 1 mole of each is used.

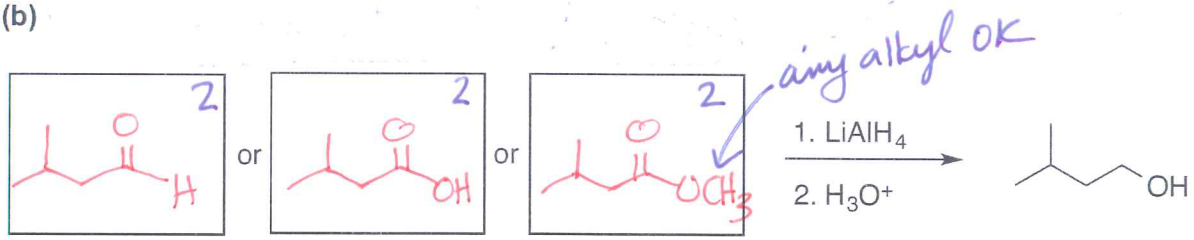


4. (*30 points*) **Single Step Reactions - Fill in the missing product or reactants in each reaction.**

(a)

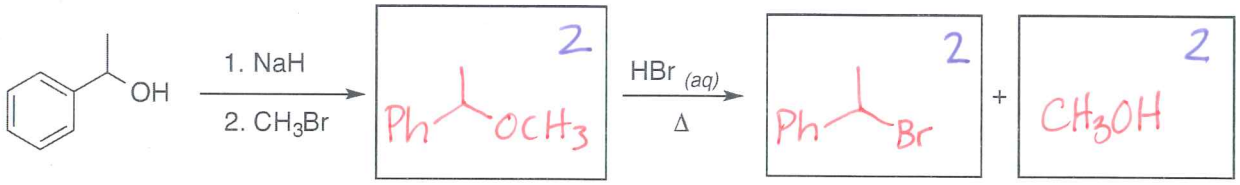


(b)

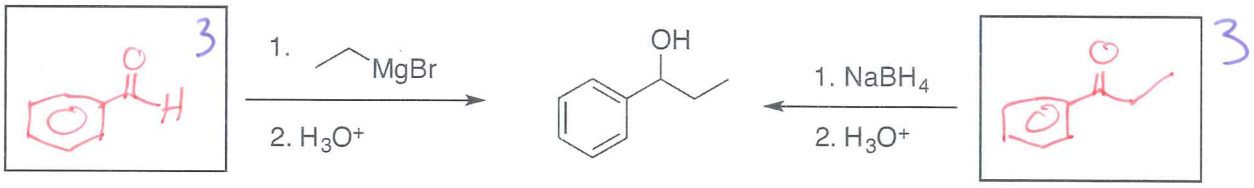


Draw structures of 3 different compounds that would react with $LiAlH_4$ to give this same product.

(c)

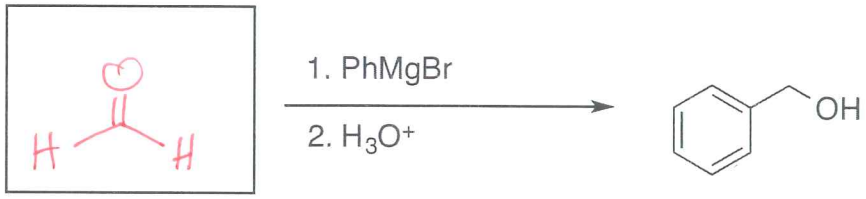


(d)



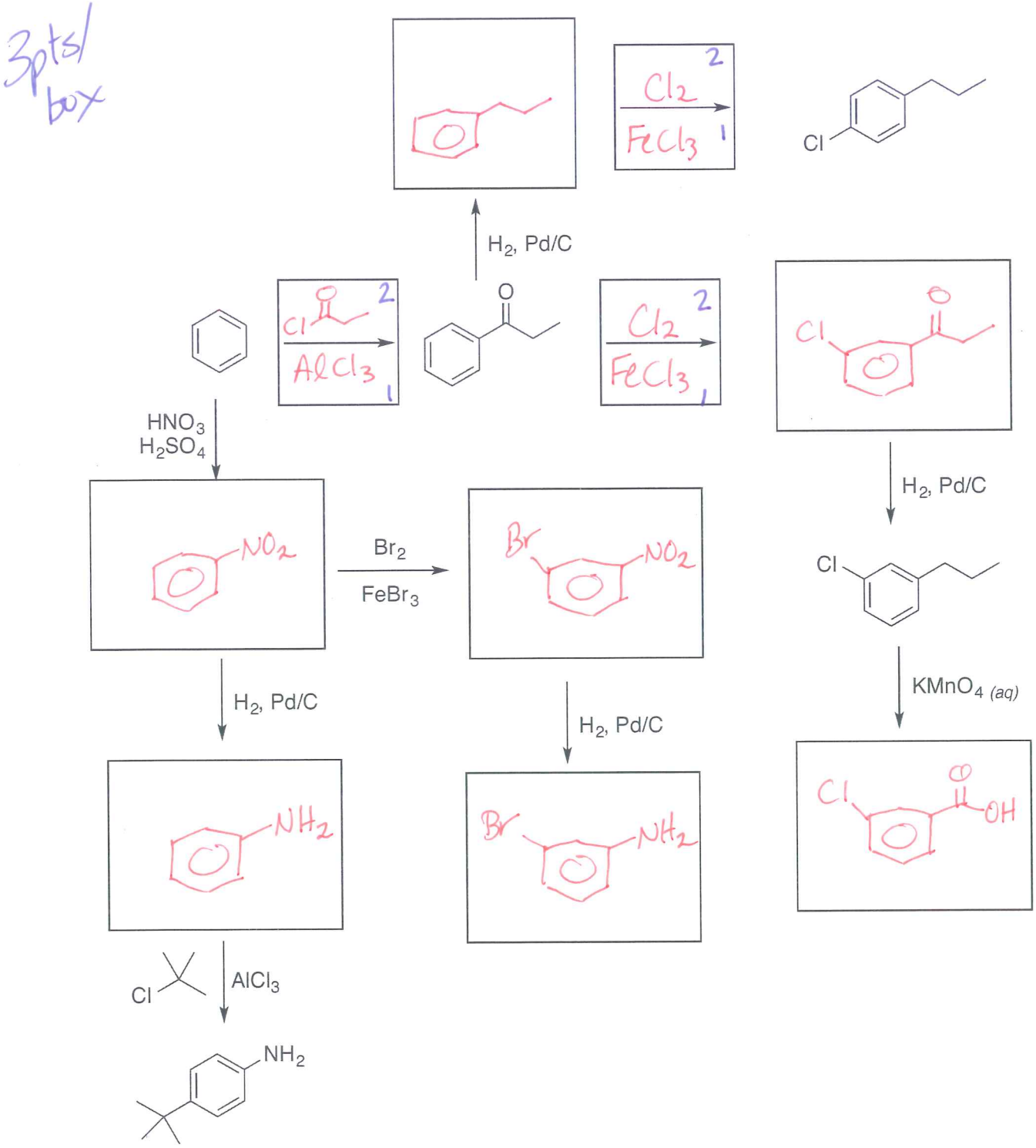
Draw structures of two different compounds that undergo different reactions to form the same product.

(e)



5. (*30 points*) **Reaction Puzzles** – Fill in the missing **reagents** and **products**.

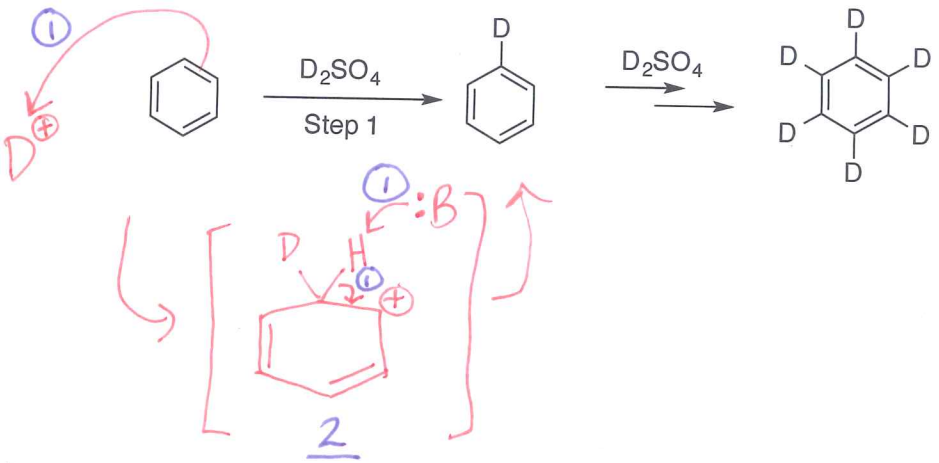
3pts/box



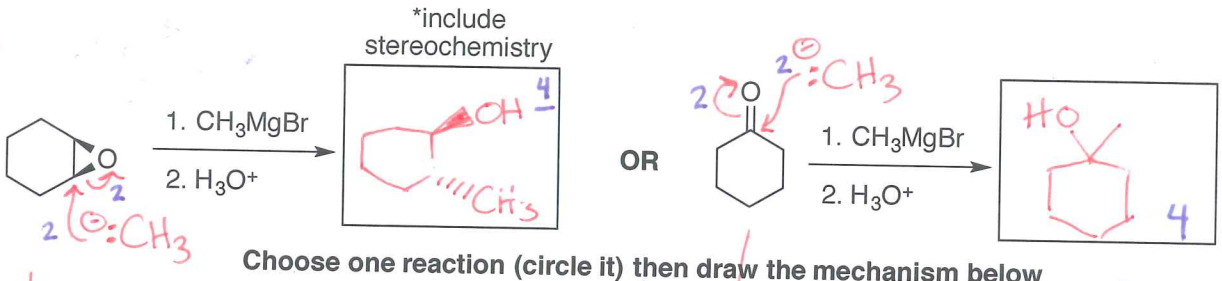
 Last Name, First Initial _____

6. Mechanisms pb same as VA

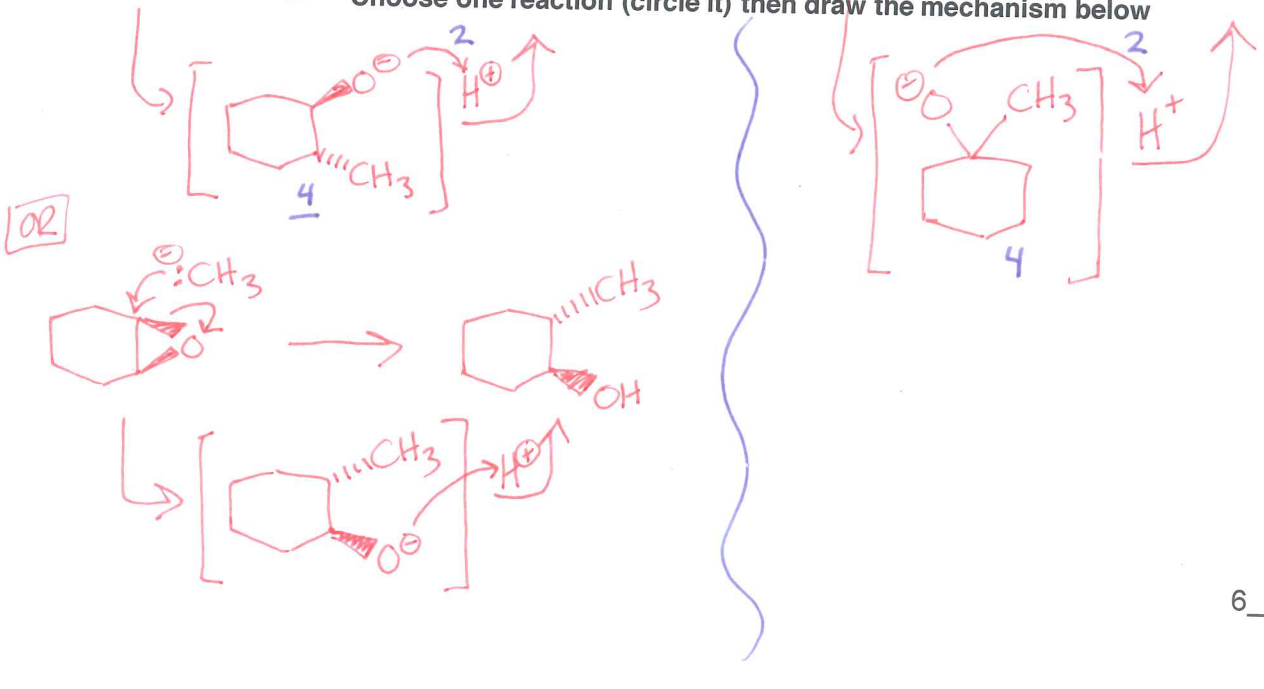
(a) (*5 points*) When benzene is treated with D_2SO_4, deuterium slowly replaces all six hydrogens in the aromatic ring. Explain by showing the **mechanism for Step 1 of the reaction only**. Include the **reaction intermediate** and **curved arrow notation**.



(b) (*14 points*) Methyl magnesium bromide is a powerful reagent for the formation of C-C bonds. **Choose only one reaction** below to complete and **draw its mechanism**. Draw the **product** in the box and include **intermediate(s)** and **curved arrow notation**.



Choose one reaction (circle it) then draw the mechanism below

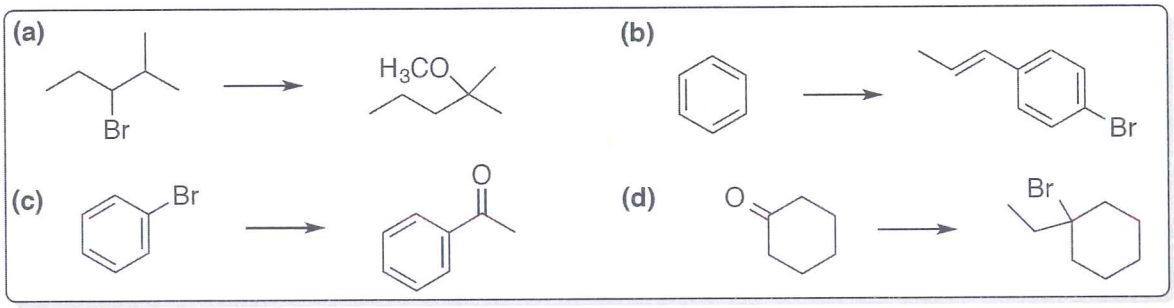


7. (*30 points*) **Multi-Step Synthesis – Choose any two**

15 pts each

Carry out the synthesis of the indicated target molecules using the starting material provided and any other reagents or sources of carbon needed. **Show the product after each reaction.** No mechanisms. Partial credit is given where possible so if you're stuck, take a deep breath then work backwards and/or forwards.

Some alternate solutions are in the other version's key. We did our best in awarding partial credit.



CHOOSE TWO – CIRCLE THEM. PUT A LARGE "X" THROUGH THE REACTIONS TO SKIP. YOU WILL LOSE POINTS IF IT IS UNCLEAR WHICH PROBLEMS YOU ARE CHOOSING!

(b) Br_2, $FeBr_3$; $AlCl_3$; 1. $NaBH_4$ 2. H_3O^+; H_3O^+, Δ, $POCl_3$, py

(c) 1. Mg 2.  3. H_3O^+; DMP

(d) 1.  2. H_3O^+; HBr, not PBr_3

(a) KOH; 1. $Hg(CF_3CO_2)_2$, CH_3OH 2. $NaBH_4$

(b) Br_2, $FeBr_3$; $AlCl_3$; H_2, Pd/C; NBS, $(PhCO_2)_2$; KOH