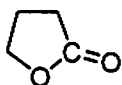
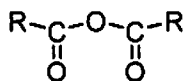
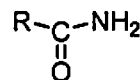
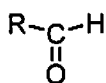
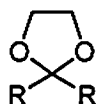
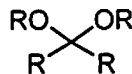
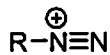
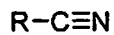


Name _____

1) Identify the class of compounds each of the following molecules belongs to. (10pts)



2) Circle the molecule (above) whose name means “without water”. (1pt)

3) Explain the following terms. (4x2= 8pts)

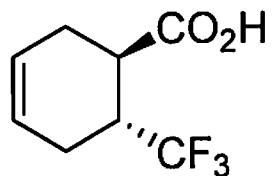
(a) *Organometallic reagent*

(b) *Symmetrical ether*

(c) *Meta director*

(d) *Nitrogen inversion*

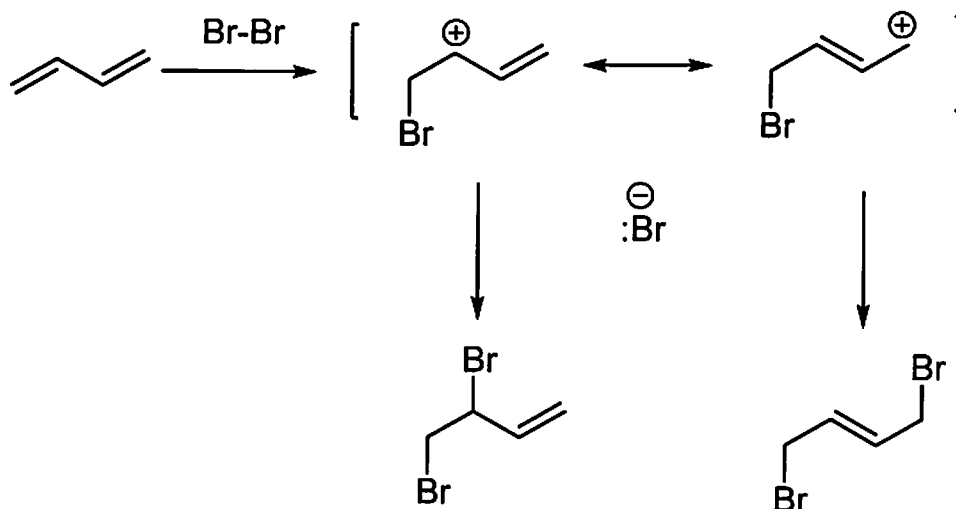
4) (1+4=5pts) The following compound was produced in a [4+2] cycloaddition (Diels-Alder) reaction:



a) How many carbon atoms are in this product?

b) Draw the *diene* and *dienophile* which would react together to give this product.

5) (3+1=4pts) i) Draw in the curly arrows to show the formation of these 1,2- and 1,4-addition products.



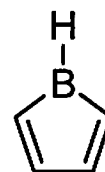
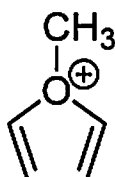
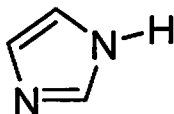
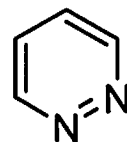
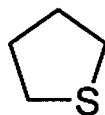
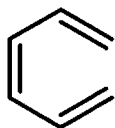
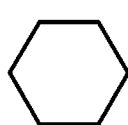
ii) Indicate which product is the *kinetic* product.

6) Write the mechanism (*i.e. curly arrows*) for the reaction of a PRIMARY AMINE with an ACID CHLORIDE to generate an AMIDE and HCl. (5pts)

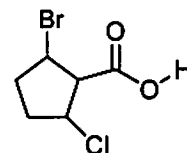
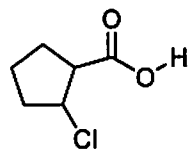
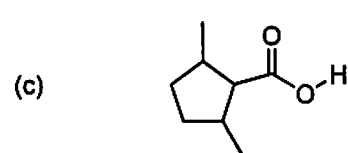
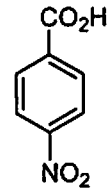
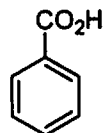
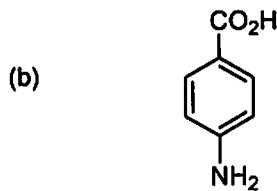
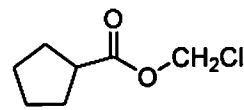
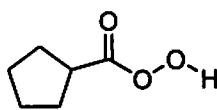
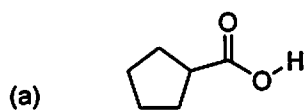
7) i) Write the mechanism (*i.e. curly arrows*) for the reaction of a ketone with a Grignard reagent that upon treatment with acidic water produces a tertiary alcohol. (4+1=5pts)

ii) What type of reaction (*a two word answer*) describes the overall transformation of ketone → tertiary alcohol?

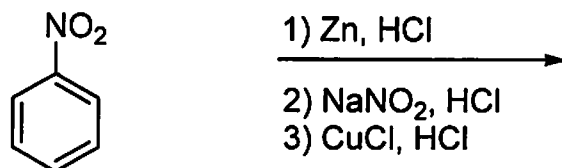
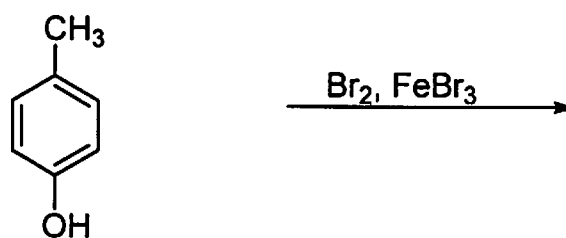
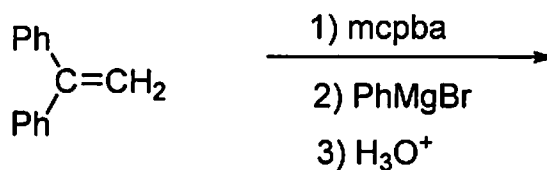
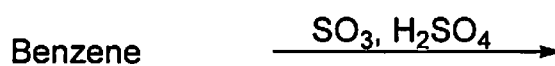
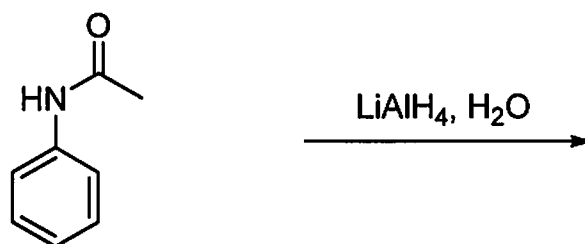
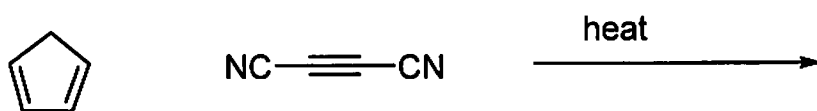
8) Indicate which of the following molecules are *aromatic*, *non-aromatic* or *anti-aromatic*. Assume all the molecules are planar. (8pts)



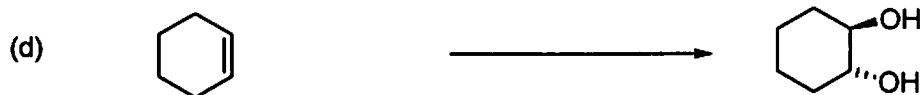
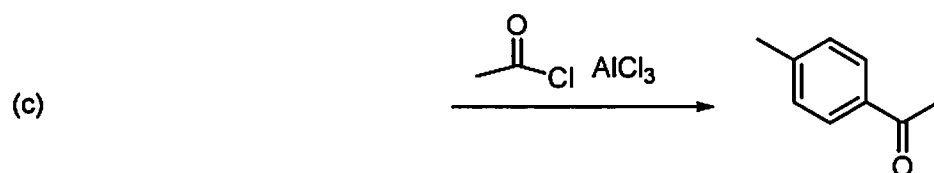
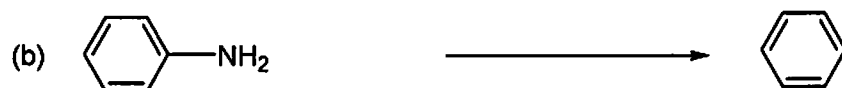
9) Circle the *strongest* acid in the following threesomes. (3pts)



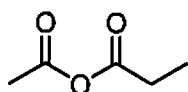
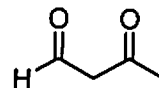
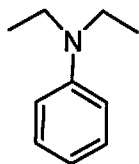
10) Give the products in six of the following reactions, paying attention to *regio/stereochemistry* where applicable. (12pts)



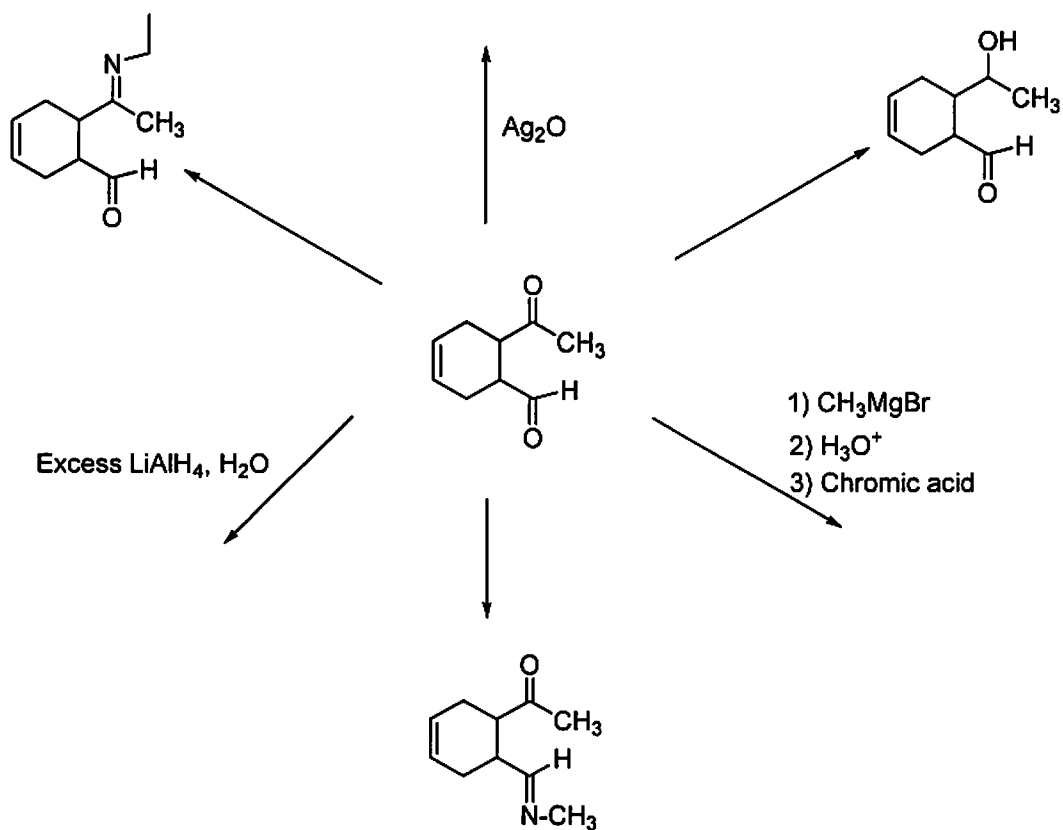
11) Fill in the gaps (SM/reagents/products) for five of the following transformations.
(5x2=10pts)



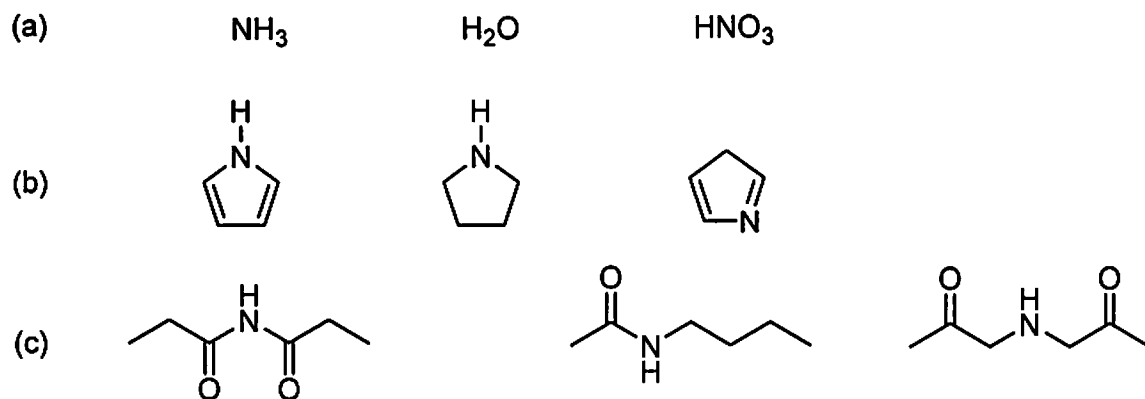
12) Name two of the following compounds in IUPAC form. (2x3=6pts)



13) Fill in the gaps (products or reagents) for five of the following transformations. (5x2=10pts)



14) Circle the *strongest base* in the following threesomes. (3pts)



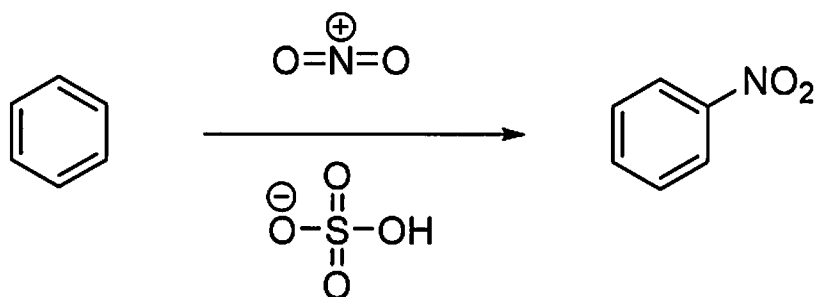
15) Draw in line angle form (*stick figure*) two of the following named molecules.
(2x3=6pts)

2-Bromobutanoyl Bromide

3-Hydroxypropanoic acid Lactone

Propanenitrile

16) Write the mechanism (*i.e. curly arrows*) for this Electrophilic Aromatic Substitution (EAS reaction) that produces Nitrobenzene. You do **not** need to draw all the resonance structures of the intermediate sigma complex. (4pts)



*****Bonus question* (up to 3 points)*****

Match these named reactions with the functional group they famously produce.

WITTIG

Alkane

Alkene

Alkyne

Alcohol

Ether

GATTERMANN-KOCH

Aldehyde

Ketone

Carboxylic acid

Ester

Amine

Amide

Nitrile

FISCHER

Anhydride

hydrogen	1	H	1.0079	beryllium	4	Be	9.0122	helium	2	He	4.0026
lithium	3	Li	6.941	boron	5	B	10.811	lithium	3	Li	6.941
sodium	11	Na	22.990	carbon	6	C	12.011	beryllium	4	Be	9.0122
potassium	19	K	39.098	nitrogen	7	N	14.007	boron	5	B	10.811
calcium	20	Ca	40.078	oxygen	8	O	15.999	carbon	6	C	12.011
strontium	38	Sr	87.62	fluorine	9	F	18.998	nitrogen	7	N	14.007
rubidium	37	Rb	85.468	neon	10	Ne	20.180	oxygen	8	O	15.999
cesium	55	Cs	132.91	argon	18	Ar	39.948	fluorine	9	F	18.998
barium	56	Ba	137.33	potassium	19	K	39.098	neon	10	Ne	20.180
lanthanum	57	La	138.91	calcium	20	Ca	40.078	argon	18	Ar	39.948
cerium	58	Ce	140.12	scandium	21	Sc	44.956	potassium	19	K	39.098
praseodymium	59	Pr	140.91	titanium	22	Ti	47.887	calcium	20	Ca	40.078
neodymium	60	Nd	144.24	vanadium	23	V	50.942	strontium	38	Sr	87.62
promethium	61	Pm	144.91	chromium	24	Cr	51.996	rubidium	37	Rb	85.468
samarium	62	Sm	150.36	manganese	25	Mn	54.938	cesium	55	Cs	132.91
europium	63	Eu	151.96	iron	26	Fe	55.845	barium	56	Ba	137.33
gadolinium	64	Gd	157.25	cobalt	27	Co	58.933	lanthanum	57	La	138.91
terbium	65	Tb	158.93	nickel	28	Ni	58.693	cerium	58	Ce	140.12
dysprosium	66	Dy	162.50	copper	29	Cu	63.546	praseodymium	59	Pr	140.91
holmium	67	Ho	164.93	zinc	30	Zn	65.39	neodymium	60	Nd	144.24
erbium	68	Er	167.26	gallium	31	Ga	69.723	promethium	61	Pm	144.91
thulium	69	Tm	168.93	germanium	32	Ge	72.61	samarium	62	Sm	150.36
ytterbium	70	Yb	173.04	arsenic	33	As	74.922	europium	63	Eu	151.96
lutetium	71	Lu	174.97	selenium	34	Se	78.96	gadolinium	64	Gd	157.25
hafnium	72	Hf	178.49	bromine	35	Br	79.904	terbium	65	Tb	158.93
tantalum	73	Ta	180.95	cadmium	48	Cd	112.41	dysprosium	66	Dy	162.50
niobium	41	Nb	92.906	indium	49	In	114.82	holmium	67	Ho	164.93
vanadium	42	V	50.942	tin	50	Sn	118.71	erbium	68	Er	167.26
chromium	43	Cr	51.996	antimony	51	Sb	121.76	thulium	69	Tm	168.93
niobium	41	Nb	92.906	tellurium	52	Te	127.60	ytterbium	70	Yb	173.04
molybdenum	42	Mo	95.94	lead	82	Pb	207.2	lutetium	71	Lu	174.97
technetium	43	Tc	98	bismuth	83	Bi	208.98	beryllium	4	Be	9.0122
rhodium	45	Rh	101.07	polonium	84	Po	[209]	lithium	3	Li	6.941
iridium	76	Ir	223	astatine	85	At	[210]	beryllium	4	Be	9.0122
platinum	78	Pt	195.08	astatine	85	At	[210]	beryllium	4	Be	9.0122
gold	79	Au	196.97	astatine	85	At	[210]	beryllium	4	Be	9.0122
mercury	80	Hg	200.59	astatine	85	At	[210]	beryllium	4	Be	9.0122
thallium	81	Tl	204.38	astatine	85	At	[210]	beryllium	4	Be	9.0122
lead	82	Pb	207.2	astatine	85	At	[210]	beryllium	4	Be	9.0122
bismuth	83	Bi	208.98	astatine	85	At	[210]	beryllium	4	Be	9.0122
polonium	84	Po	[209]	astatine	85	At	[210]	beryllium	4	Be	9.0122
astatine	85	At	[210]	astatine	85	At	[210]	beryllium	4	Be	9.0122
radon	86	Rn	[222]	astatine	85	At	[210]	beryllium	4	Be	9.0122

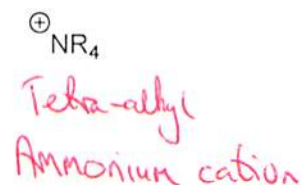
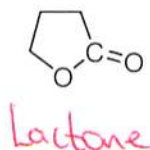
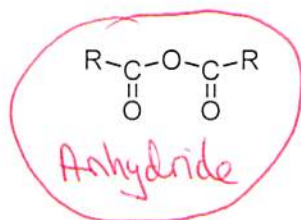
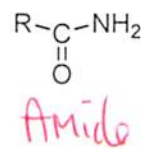
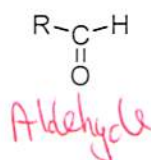
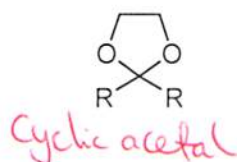
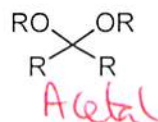
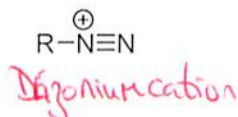
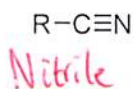
* Lanthanide series

** Actinide series

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

Name C.U. Bi

1) Identify the class of compounds each of the following molecules belongs to. (10pts)



2) Circle the molecule (above) whose name means "without water". (1pt)

3) Explain the following terms. (4x2= 8pts)

(a) Organometallic reagent

A species with a carbon-metal covalent bond.

(b) Symmetrical ether

 $\text{R}_1-\text{O}-\text{R}_2$ where $\text{R}_1 = \text{R}_2$.

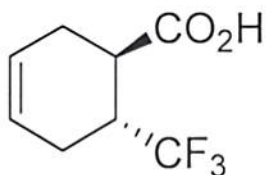
(c) Meta director

A substituent that directs the electrophile meta (1,3) in an E.A.S. reaction.

(d) Nitrogen inversion

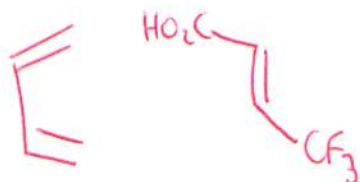
The rehybridization of a N from $\text{sp}^3 \rightarrow \text{sp}^2 \rightarrow \text{sp}^3$ that can racemize a chiral amine.

4) (1+4=5pts) The following compound was produced in a [4+2] cycloaddition (Diels-Alder) reaction:

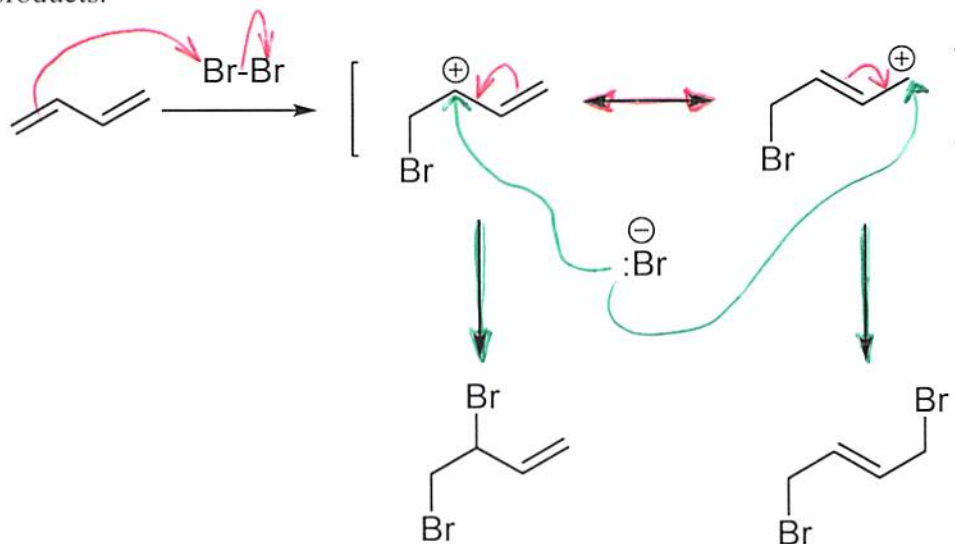


a) How many carbon atoms are in this product? 8

b) Draw the *diene* and *dienophile* which would react together to give this product.

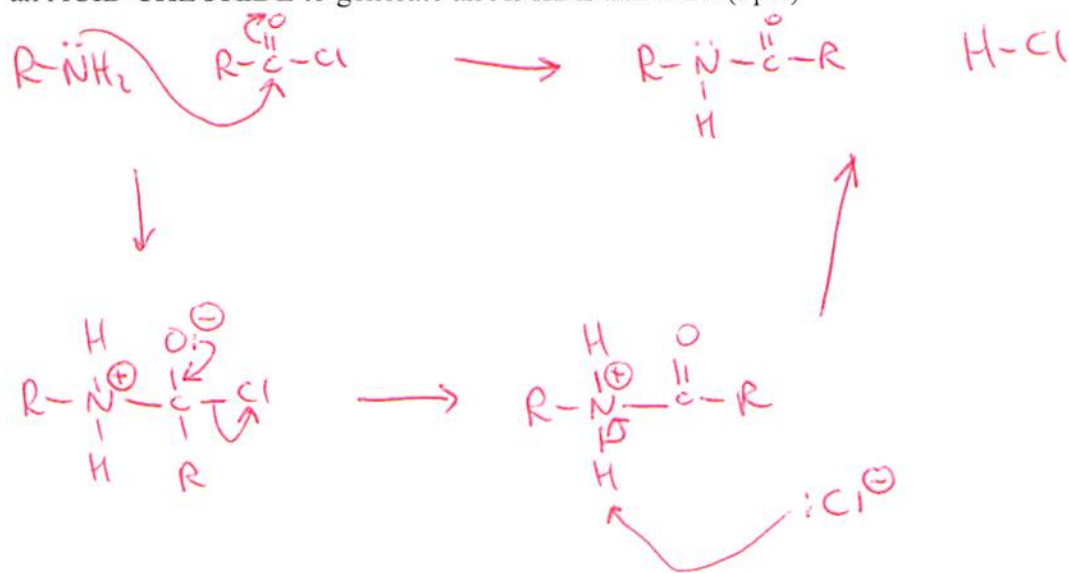


5) (3+1=4pts) i) Draw in the curly arrows to show the formation of these 1,2- and 1,4-addition products.

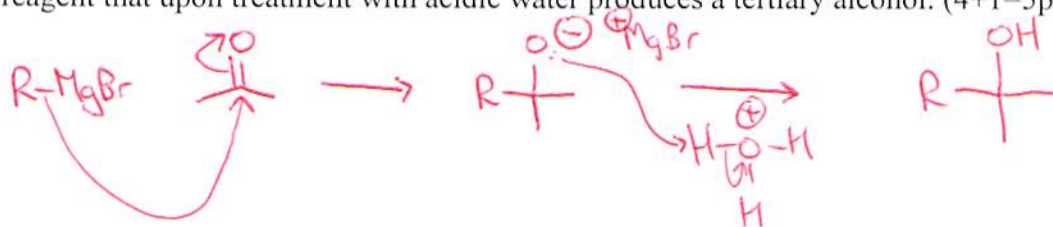


ii) Indicate which product is the *kinetic* product.

6) Write the mechanism (i.e. curly arrows) for the reaction of a PRIMARY AMINE with an ACID CHLORIDE to generate an AMIDE and HCl. (5pts)



7) i) Write the mechanism (i.e. curly arrows) for the reaction of a ketone with a Grignard reagent that upon treatment with acidic water produces a tertiary alcohol. (4+1=5pts)



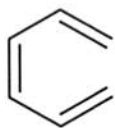
ii) What type of reaction (a two word answer) describes the overall transformation of ketone \rightarrow tertiary alcohol?

Nucleophilic Addition

8) Indicate which of the following molecules are *aromatic*, *non-aromatic* or *anti-aromatic*. Assume all the molecules are planar. (8pts)



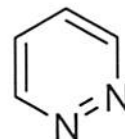
Non-aromatic



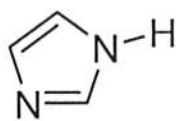
Non-aromatic



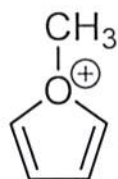
Non-aromatic



Aromatic



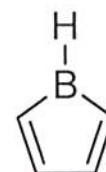
Aromatic



Aromatic



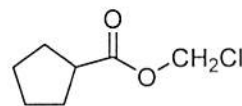
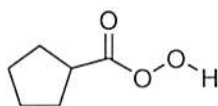
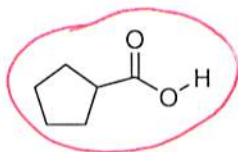
Anti-aromatic



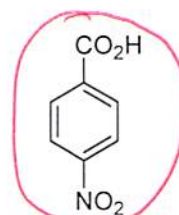
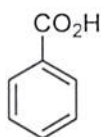
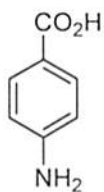
Anti-aromatic

9) Circle the *strongest* acid in the following threesomes. (3pts)

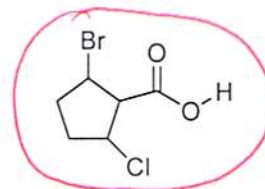
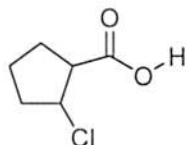
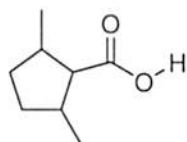
(a)



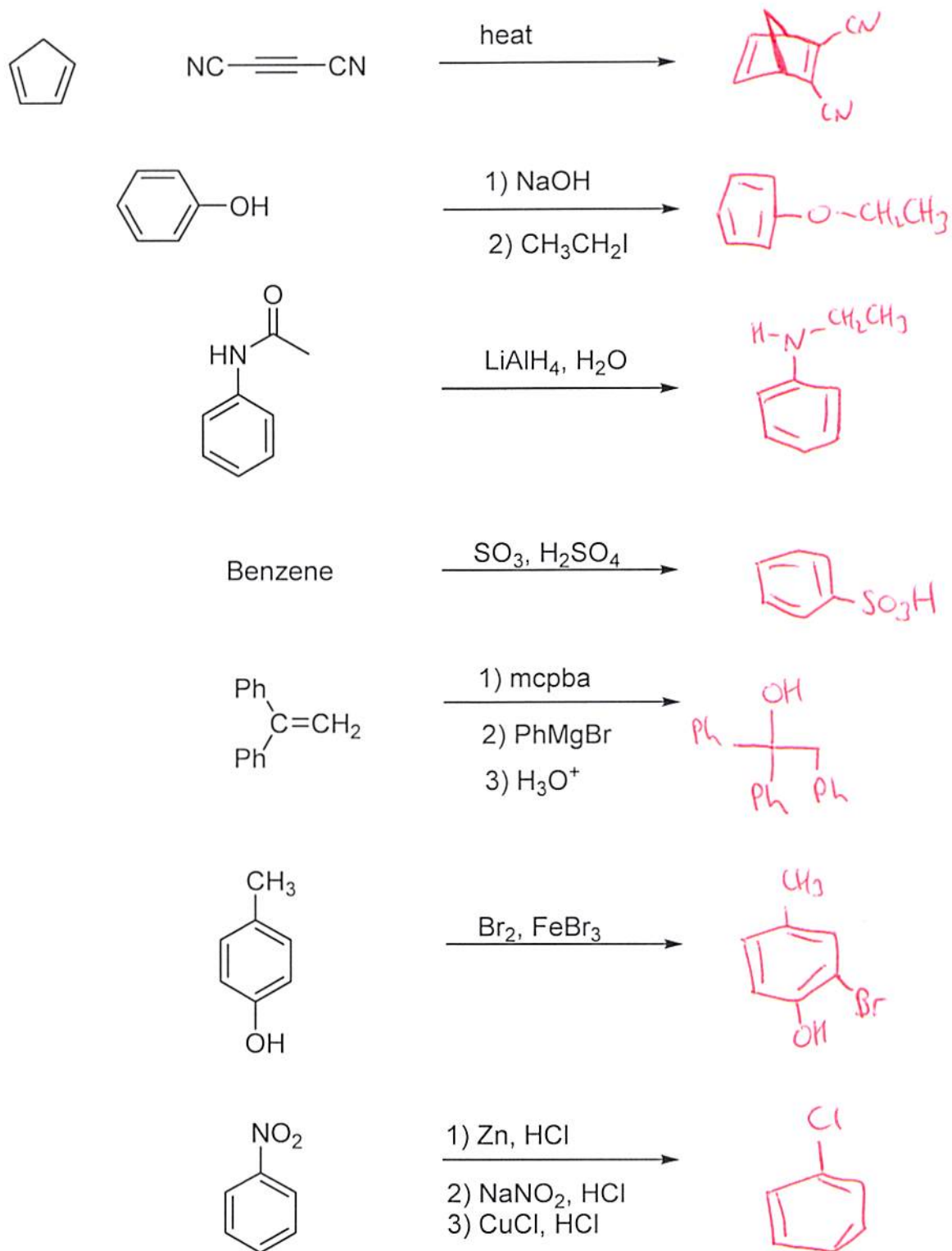
(b)



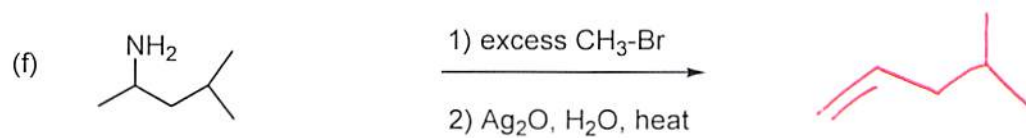
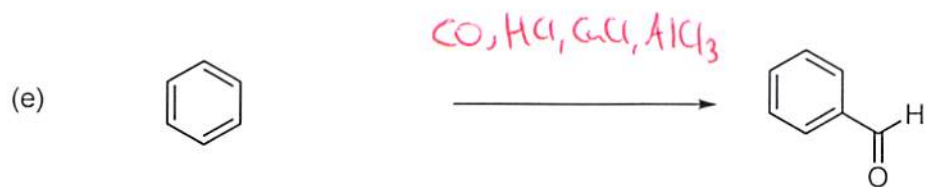
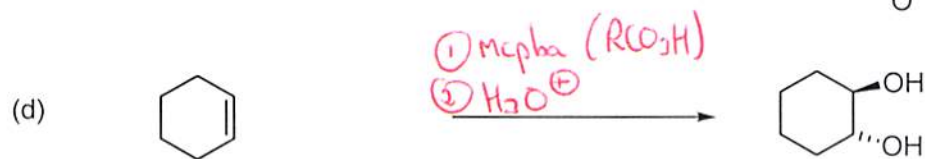
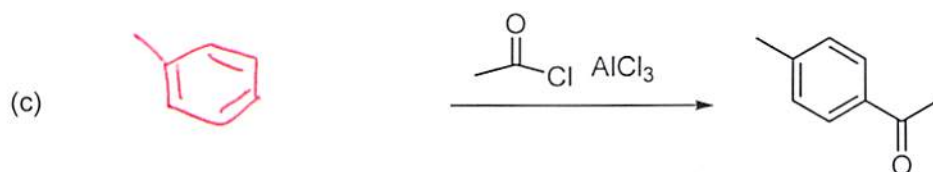
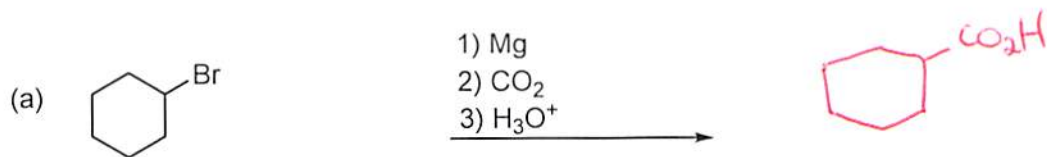
(c)



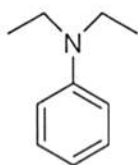
10) Give the products in six of the following reactions, paying attention to *regio/stereochemistry* where applicable. (12pts)



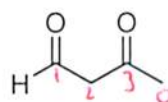
11) Fill in the gaps (SM/reagents/products) for **five** of the following transformations.
(5x2=10pts)



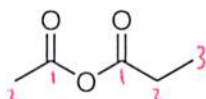
12) Name **two** of the following compounds in IUPAC form. (2x3=6pts)



N,N-diethyl aniline

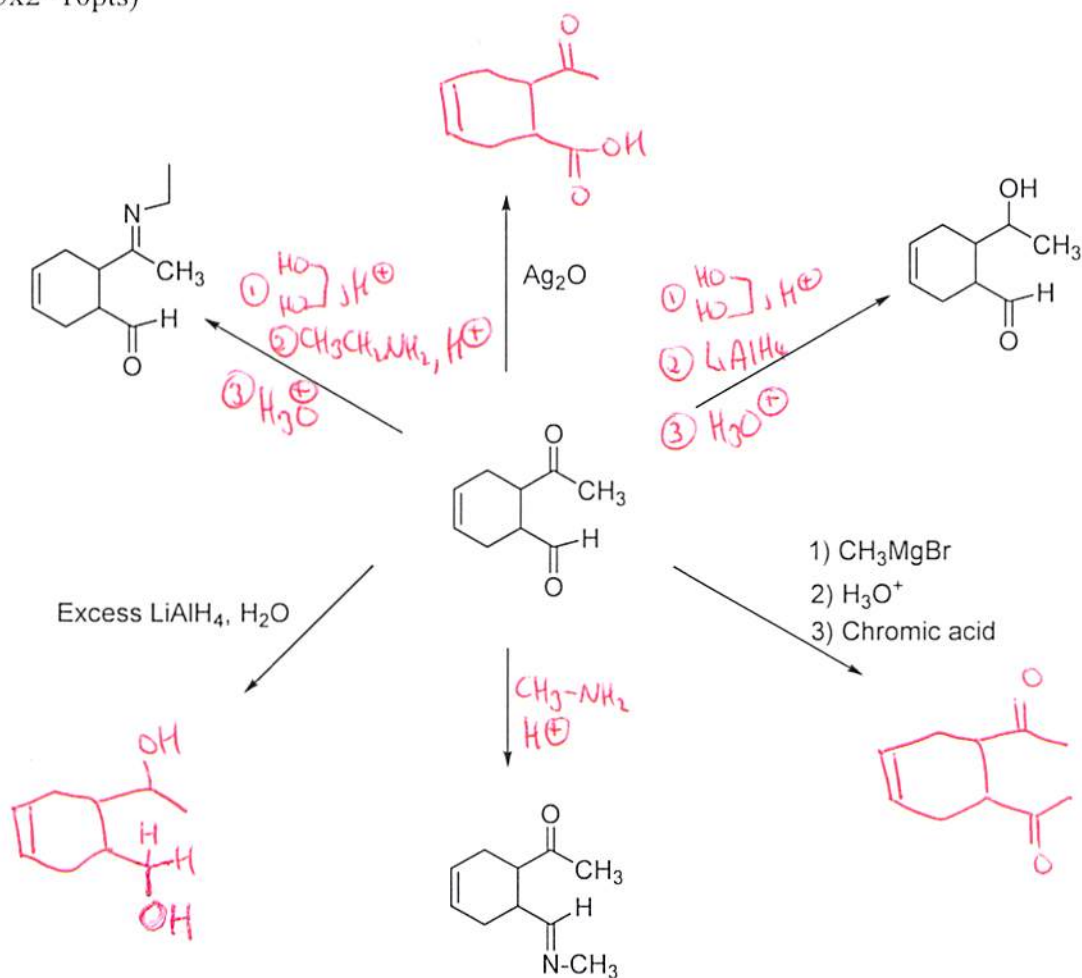


3-oxobutanal

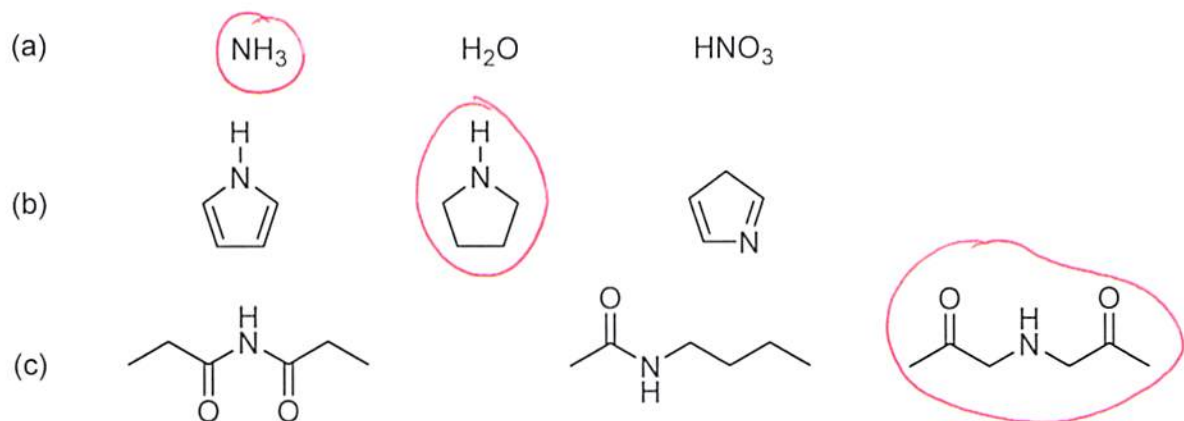


Propanoic ethanoic anhydride

13) Fill in the gaps (products or reagents) for **five** of the following transformations. (5x2=10pts)

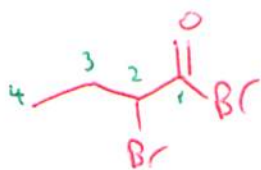


14) Circle the *strongest base* in the following threesomes. (3pts)

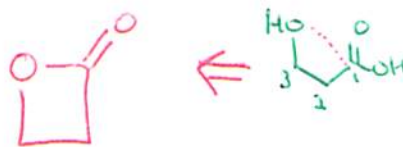


15) Draw in line angle form (*stick figure*) **two** of the following named molecules.
(2x3=6pts)

2-Bromobutanoyl Bromide



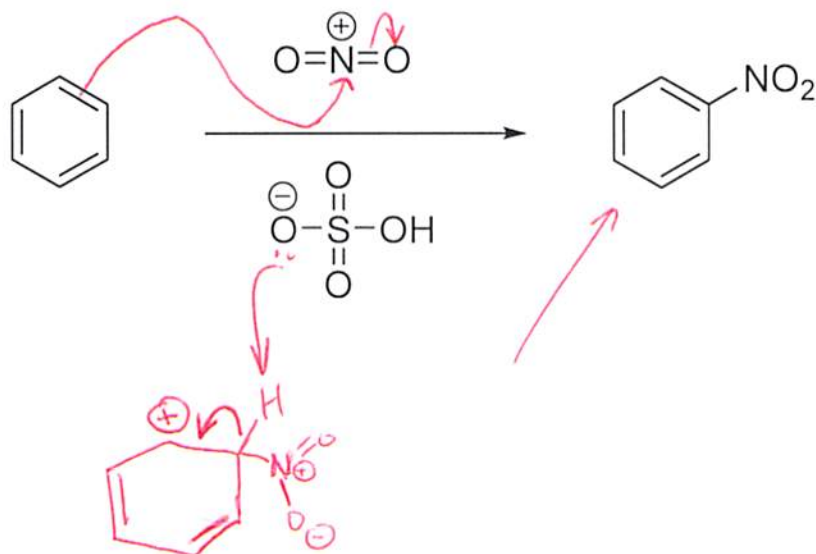
3-Hydroxypropanoic acid Lactone



Propanenitrile



16) Write the mechanism (*i.e. curly arrows*) for this Electrophilic Aromatic Substitution (EAS reaction) that produces Nitrobenzene. You do **not** need to draw all the resonance structures of the intermediate sigma complex. (4pts)



*****Bonus question*** (up to 3 points)***

Match these named reactions with the functional group they famously produce.

WITTIG	<i>Alkane</i>
	<i>Alkene</i>
	<i>Alkyne</i>
	<i>Alcohol</i>
	<i>Ether</i>
GATTERMANN-KOCH	<i>Aldehyde</i>
	<i>Ketone</i>
	<i>Carboxylic acid</i>
	<i>Ester</i>
	<i>Amine</i>
	<i>Amide</i>
FISCHER	<i>Nitrile</i>
	<i>Anhydride</i>