NAME ________________________

ID # ________________________

ORGANIC CHEMISTRY II (2302)

8:00 – 8:50 am, July 21, 2016

Exam 3

If you want to pick this exam up Monday 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 Monday, and you will need to pick up your exam in private from Chemistry department staff in 115 Smith beginning Tuesday, July 26th. Exams that are not picked up within two weeks will be disposed of.

A periodic table and a chart of reaction conditions are attached to the back of this exam as aids. 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.

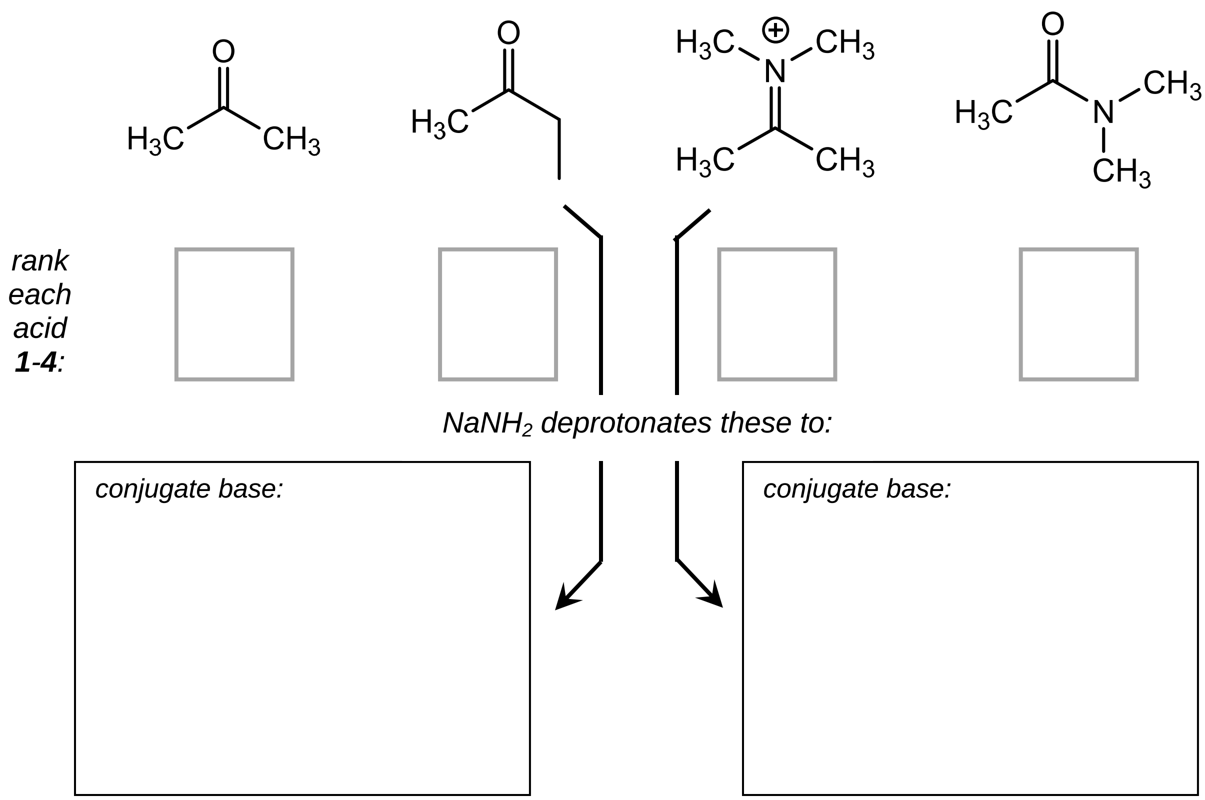
Please write your answers in the boxes/spaces provided. If your answer is not in the appropriate space (say, for example, it's on the back of the page), draw us an arrow and/or note telling us where to look.

NAME ________________________

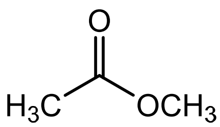
Scoring:	1. _________ / 12	4. _________ / 21
	2. _________ / 12	5. _________ / 23
	3. _________ / 20	6. _________ / 12

Total Score: _________ / 100

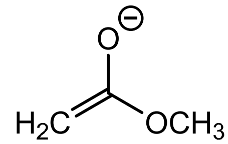
1. (12 pts) Each of the four carbonyl-containing compounds below is acidic, and would be deprotonated by a strong base like amide anion (NH_2^-). Rank each molecule **1** through **4** in terms of its acidity, from most acidic (**1**) to least acidic (**4**). Then, for the two acids in the middle, draw the preferred conjugate base structure that would be generated by deprotonation with sodium amide ($NaNH_2$).

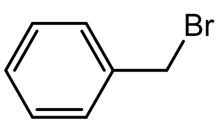


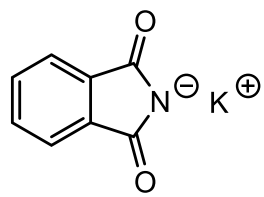
2. (12 pts) Each of the reactions on the next page is drawn with two possible reaction conditions. If only one of the two reaction conditions would generate the given molecule as the major product, circle those conditions. If both sets of conditions would accomplish the reaction, circle "BOTH". If neither set of reaction conditions would succeed, circle "NEITHER". **Circle one answer only.**

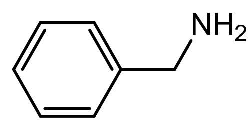


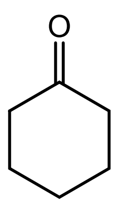
NaOH	LDA
BOTH would work	NEITHER would work



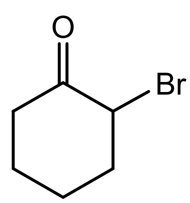


1. NaN_3 *(1 equiv)* 2. PPh_3, H_2O	1.  2. H_2NNH_2
BOTH would work	NEITHER would work

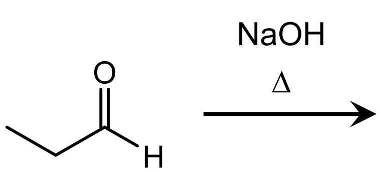


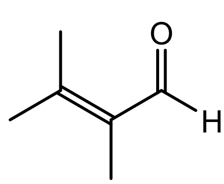
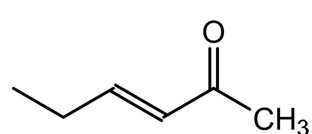


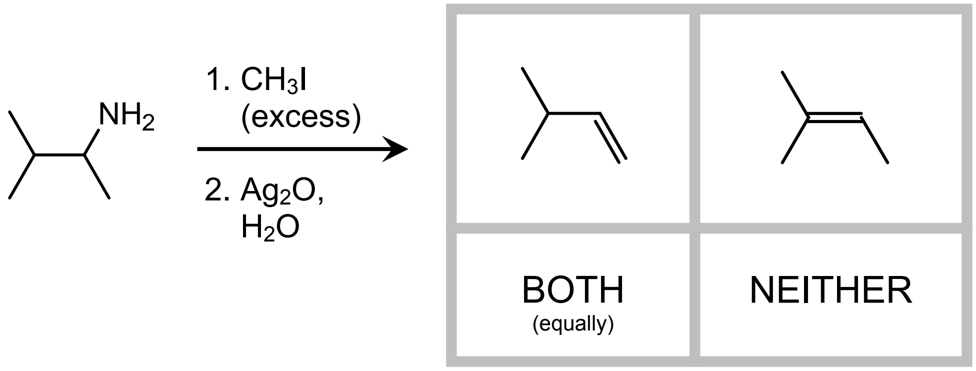
Br_2 NaOH	Br_2 H_3O^+
BOTH would work	NEITHER would work

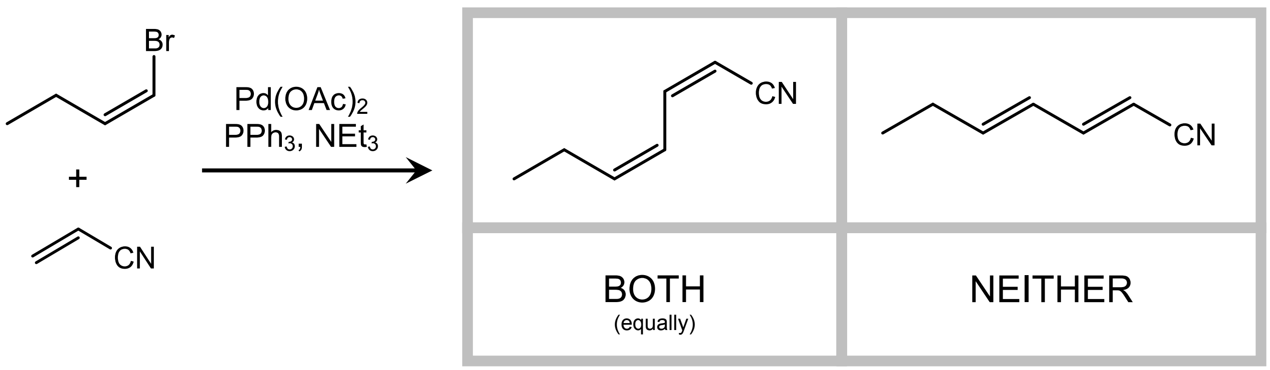


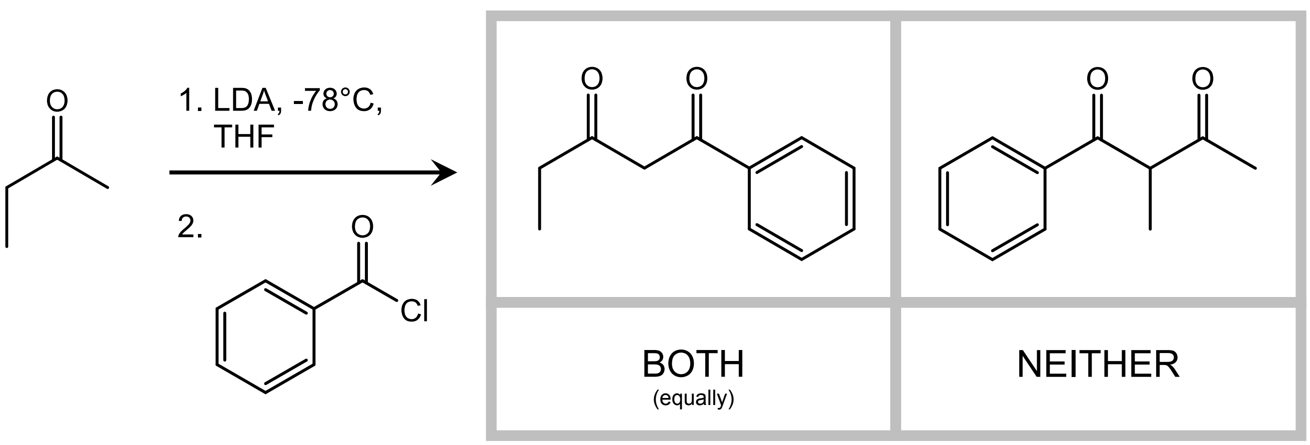
3. (20 pts) Each of the reactions on the next page is drawn with two possible products. If one of the two products predominates, circle that preferred product. If the two products are produced equally, circle “BOTH”. If neither product would result from the reaction, circle “NEITHER”. **Circle one answer only.**

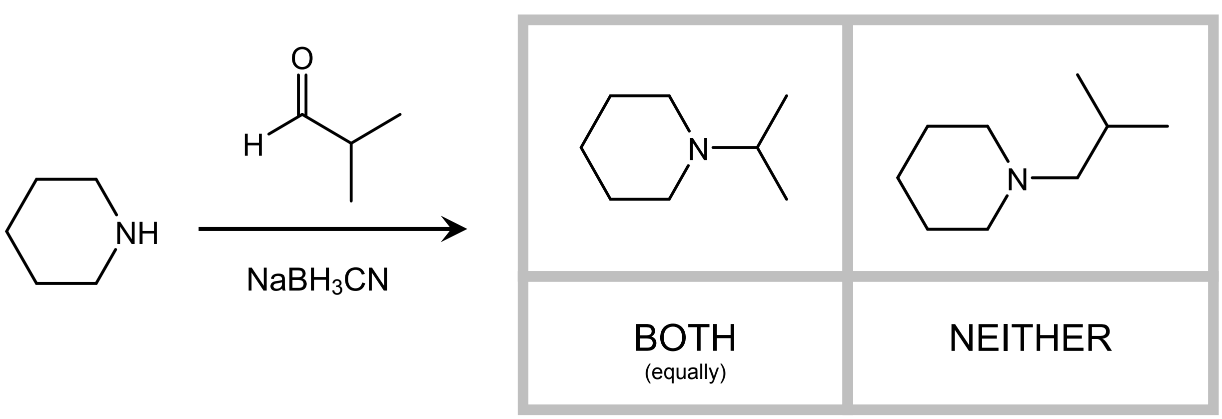


	
BOTH (equally)	NEITHER


NH2
1. CH3I (excess)
2. Ag2O, H2O
BOTH (equally)
NEITHER

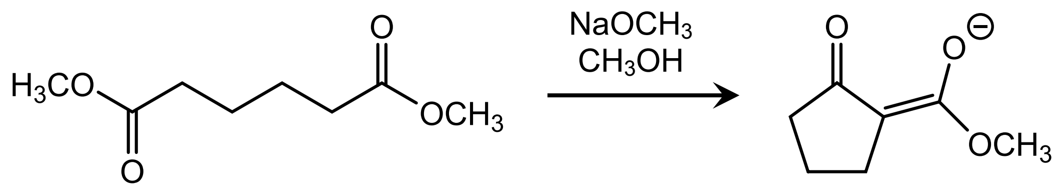

Br
CN
Pd(OAc)2
PPh3, NEt3
CN
CN
BOTH (equally)
NEITHER


O
1. LDA, -78°C, THF
2.
O
Cl
O
O
O
O
BOTH (equally)
NEITHER


NH
O
H
NaBH3CN
N
N
BOTH (equally)
NEITHER

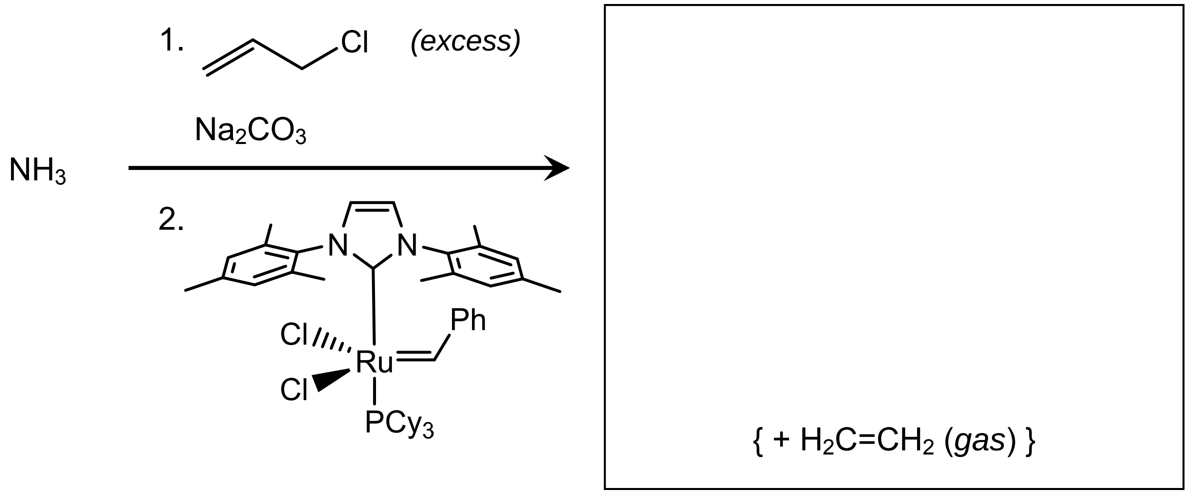
4. (21 pts) For the reaction shown below, draw a mechanism that explains how the product is generated from the starting material. In your answer, make sure that you:

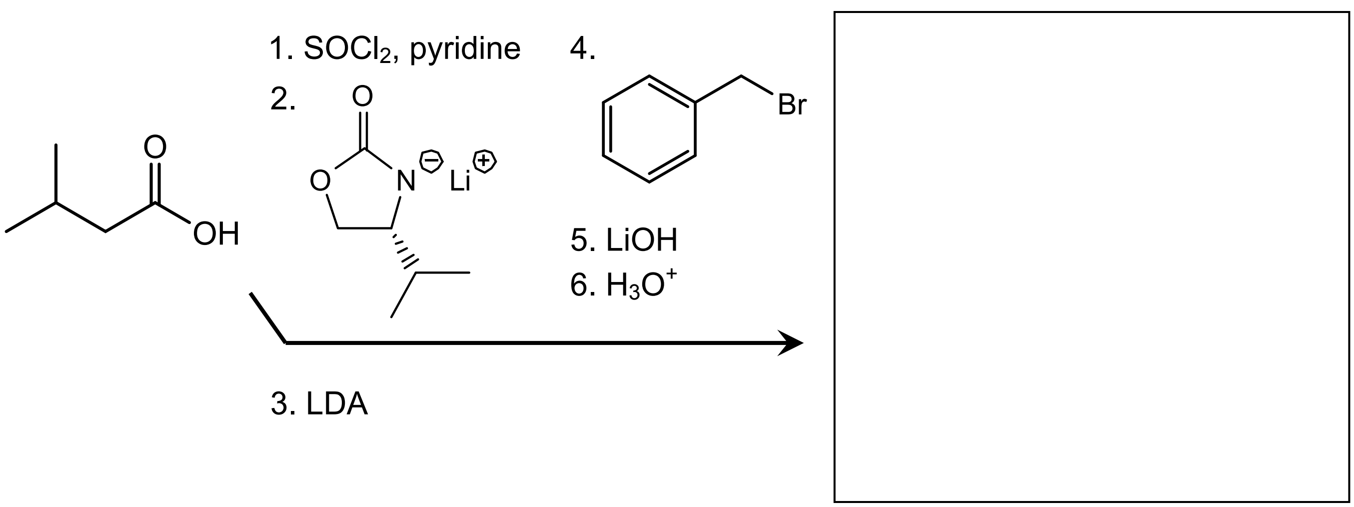
- Draw each step of the mechanism separately;
- Use "electron pushing" to show where the electrons in each step go;
- Use only the molecules that you are given; do not invoke reactants or solvents that aren't in the problem.

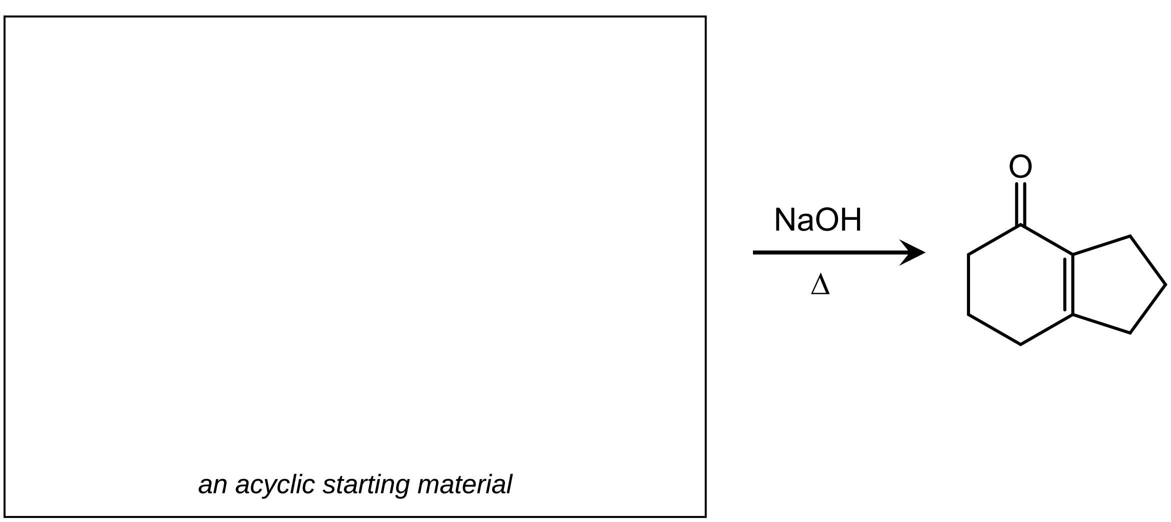


Mechanism:

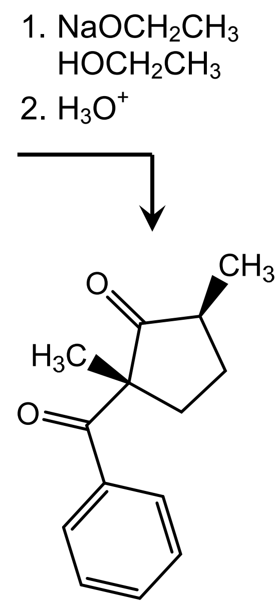
5. (23 pts) For each of the reactions on the following pages, fill in the empty box corresponding to reactants, reagents, or products. Give only one answer in each box. For reactions that you expect to yield multiple products, draw one major product. For reactions that yield multiple enantiomers, draw only one enantiomer in the box, and include the note "+ enantiomer".





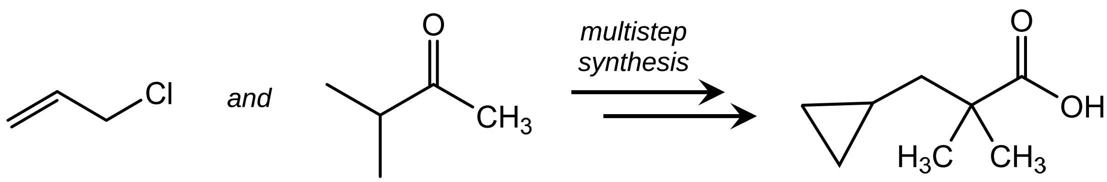


carbonyl-containing starting material + *carbonyl-containing starting material*



used in excess?	*used in excess?*
YES *or* **NO** *?*	**YES** *or* **NO** *?*
(circle one)	

6. (12 pts) Propose a multistep synthesis of the product below, beginning with the starting materials given. In addition to those organic starting materials, you can use any reagents and reactions we've learned about in class. 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.



Exam 3 Chart of Reaction Conditions

Br_2
$FeBr_3$

Cl_2
$AlCl_3$

H_2SO_4
HNO_3

Sn *or* Fe
HCl/H_2O

H_2SO_4
SO_3

$KMnO_4$
^-OH, 100 °C

Mg
Et_2O

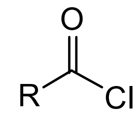
1. $NaNO_2$
   HCl
2. CuCN *or* H_3PO_2 *or* CuX *or* H_3O^+

R-X (R = alkyl)
$AlCl_3$ *or* $FeBr_3$

Zn(Hg),
HCl/H_2O

Li
hexane

H_2
Pd-C



$AlCl_3$

1. N_2H_4
2. KOH, Δ

1. O_3
2. H_2O

RMgX

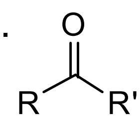
RLi

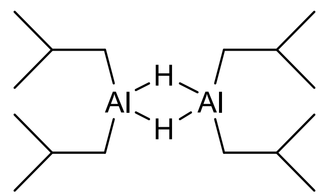
R_2CuLi

$Na_2Cr_2O_7$
H_2SO_4

$LiAlH(OtBu)_3$

1. Ag_2O
   NH_3
2. H_3O^+

1. PPh_3
2. *n*-BuLi
3. 



(DIBAL-H)

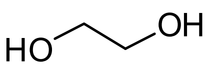
$Bu_4N^+F^-$

$PhCH_2Br$
Ag_2O

1. $LiAlH_4$
2. H_2O

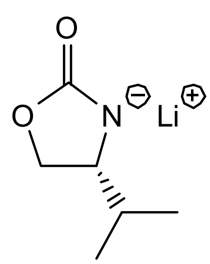
$(COCl)_2$

$(CH_3)_3SiCl$ {TMSCl},
or TBDMSCl;
Et_3N *or* imidazole

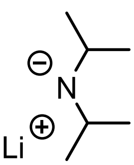


HCl

$NaNH_2$

1. 

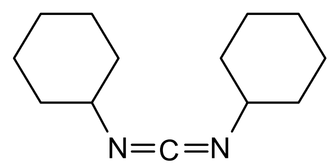
2. base
3. R-X
4. LiOH



(LDA)

$SOCl_2$
(& pyridine, usually)

1. $NaBH_4$
2. H_2O



(DCC)

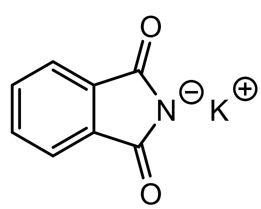
$Pd(OAc)_2$
PPh_3, NEt_3

1. CH_3I
   (excess)
2. Ag_2O
   H_2O
3. Δ

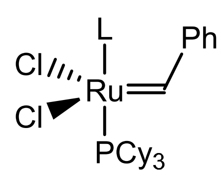
$CHCl_3$
KO*t*Bu

$Pd(PPh_3)_4$
NaOH

CH_2I_2
Zn(Cu)

1. 

2. N_2H_4 (or ^-OH)



(Grubbs catalyst)

RCHO
$Na(OAc)_3BH$
or
$NaBH_3CN$

Chemistry Reference Sheet

Key

11 — Atomic number
Na — Element symbol
Sodium — Element name
22.99 — Average atomic mass*

Period	1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 (8B)	9 8B	10 (8B)	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 **H** Hydrogen 1.01																	2 **He** Helium 4.00
2	3 **Li** Lithium 6.94	4 **Be** Beryllium 9.01											5 **B** Boron 10.81	6 **C** Carbon 12.01	7 **N** Nitrogen 14.01	8 **O** Oxygen 16.00	9 **F** Fluorine 19.00	10 **Ne** Neon 20.18
3	11 **Na** Sodium 22.99	12 **Mg** Magnesium 24.31											13 **Al** Aluminum 26.98	14 **Si** Silicon 28.09	15 **P** Phosphorus 30.97	16 **S** Sulfur 32.07	17 **Cl** Chlorine 35.45	18 **Ar** Argon 39.95
4	19 **K** Potassium 39.10	20 **Ca** Calcium 40.08	21 **Sc** Scandium 44.96	22 **Ti** Titanium 47.87	23 **V** Vanadium 50.94	24 **Cr** Chromium 52.00	25 **Mn** Manganese 54.94	26 **Fe** Iron 55.85	27 **Co** Cobalt 58.93	28 **Ni** Nickel 58.69	29 **Cu** Copper 63.55	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.72	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92	34 **Se** Selenium 78.96	35 **Br** Bromine 79.90	36 **Kr** Krypton 83.80
5	37 **Rb** Rubidium 85.47	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.91	40 **Zr** Zirconium 91.22	41 **Nb** Niobium 92.91	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.91	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.87	48 **Cd** Cadmium 112.41	49 **In** Indium 114.82	50 **Sn** Tin 118.71	51 **Sb** Antimony 121.76	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90	54 **Xe** Xenon 131.29
6	55 **Cs** Cesium 132.91	56 **Ba** Barium 137.33	57 **La** Lanthanum 138.91	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.95	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.21	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.22	78 **Pt** Platinum 195.08	79 **Au** Gold 196.97	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.38	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
7	87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (266)	107 **Bh** Bohrium (264)	108 **Hs** Hassium (269)	109 **Mt** Meitnerium (268)									

58 **Ce** Cerium 140.12	59 **Pr** Praseodymium 140.91	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.96	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.93	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.97
90 **Th** Thorium 232.04	91 **Pa** Protactinium 231.04	92 **U** Uranium 238.03	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

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