NAME _____

ID # _____

# ORGANIC CHEMISTRY II (2302)

## 8:00 – 9:15 am, August 4, 2016

## Final Exam

You will be able to pick up your graded exam from Chemistry department staff in 115 Smith beginning Friday, August 5th at 10 AM. Exams that are not picked up within two weeks will be disposed of.

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A chart of reaction conditions, charts of amino and nucleic acid structures, and a periodic table 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).

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.

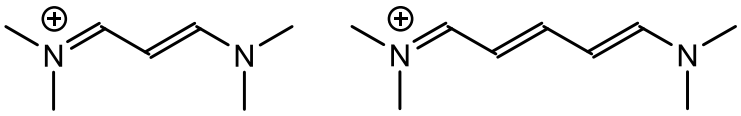
Please write your answers in the boxes/spaces provided. If your answer is not in the appropriate space (say, for example, it's on the back of the page), draw us an arrow and/or note telling us where to look.

NAME _____

| Scoring: | | |
|---|---|---|
| | 1. _____ / 9 | 6. _____ / 20 |
| | 2. _____ / 24 | 7. _____ / 6 |
| | 3. _____ / 16 | 8. _____ / 8 |
| | 4. _____ / 12 | 9. _____ / 20 |
| | 5. _____ / 18 | 10. _____ / 17 |

**Total Score: _____ / 150**

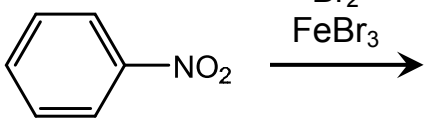
1. (9 pts) How do the two cyanine dyes **A** and **B** compare? *For each question below, circle one answer.*



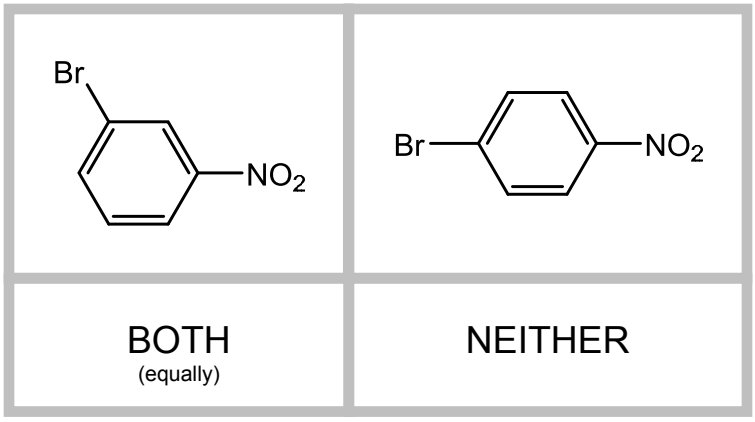
**A** **B**

| | | | | |
|---|---|---|---|---|
| Which will have a larger HOMO-LUMO gap? | **A** | **B** | **A** *and* **B** *will be the same* | *cannot determine* |
| Which will absorb at longer wavelengths? | **A** | **B** | **A** *and* **B** *will be the same* | *cannot determine* |
| Which has more molecular orbitals in its conjugated π system? | **A** | **B** | **A** *and* **B** *will be the same* | *cannot determine* |

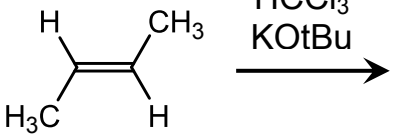
2. (24 pts) Each of the reactions on the following two pages is drawn with two possible products. If one of the two products predominates, circle that preferred product. If the two products are produced equally, circle "BOTH". If neither product would result from the reaction, circle "NEITHER". **Circle one answer only.**



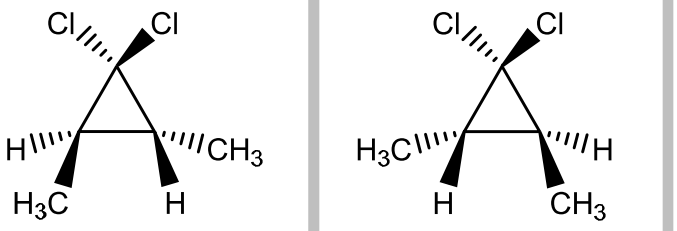

$Br_2$
$FeBr_3$



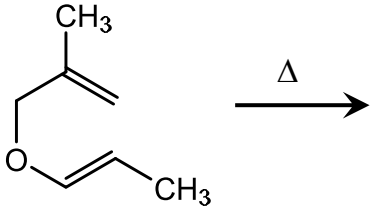

| BOTH (equally) | NEITHER |
|---|---|



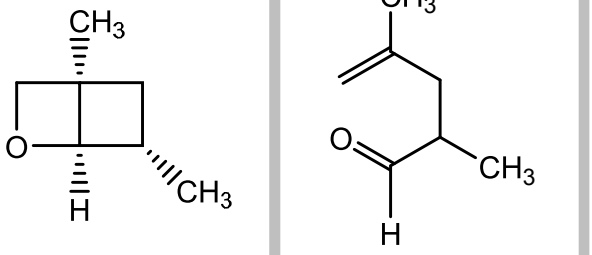

$HCCl_3$
$KOtBu$




| BOTH (equally) | NEITHER |
|---|---|

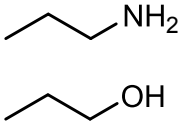



$\Delta$



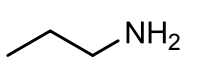

| BOTH (equally) | NEITHER |
|---|---|

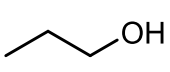
*cell sample containing:*



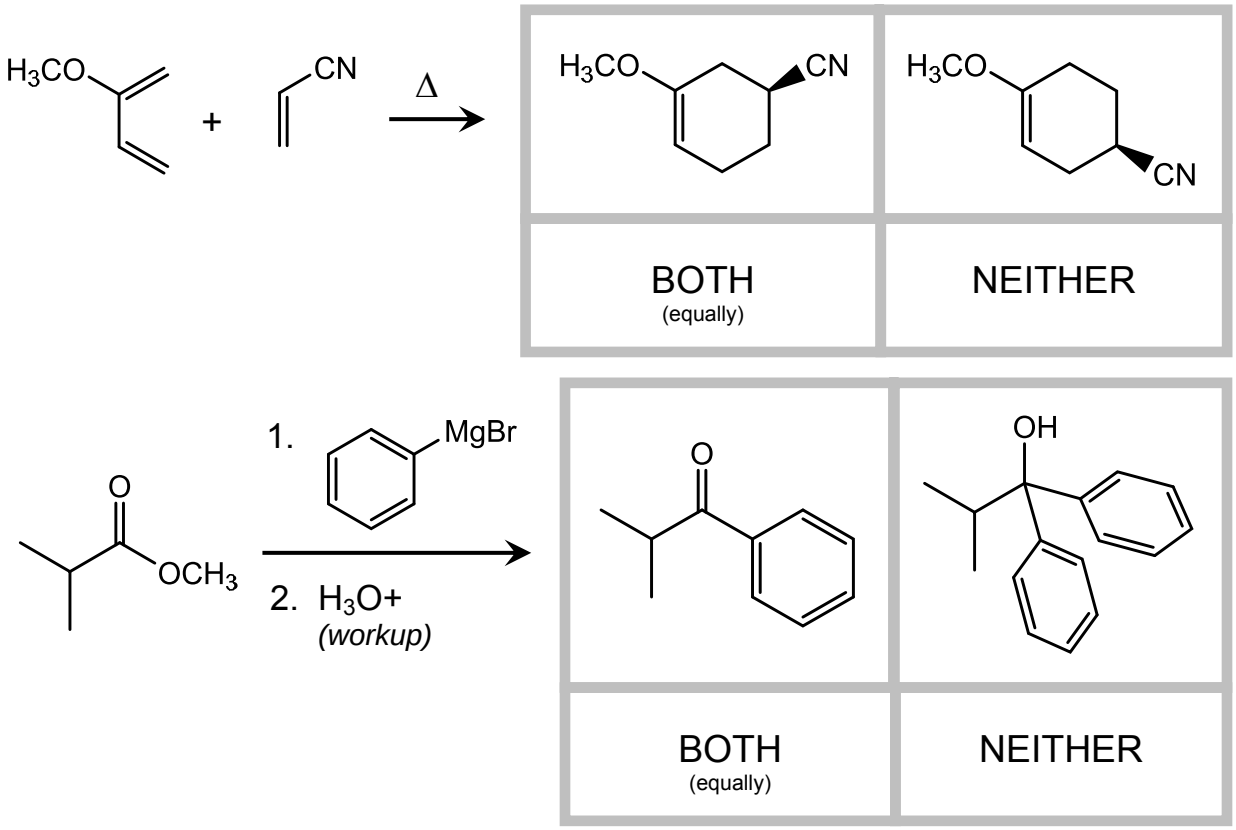

*+ inorganic salts*

1. Dissolve in a mixture of acidic $H_2O$ and $CHCl_3$.
2. Discard $CHCl_3$ layer.
3. Add NaOH and $CHCl_3$. Mix well.
4. Discard $H_2O$ layer.

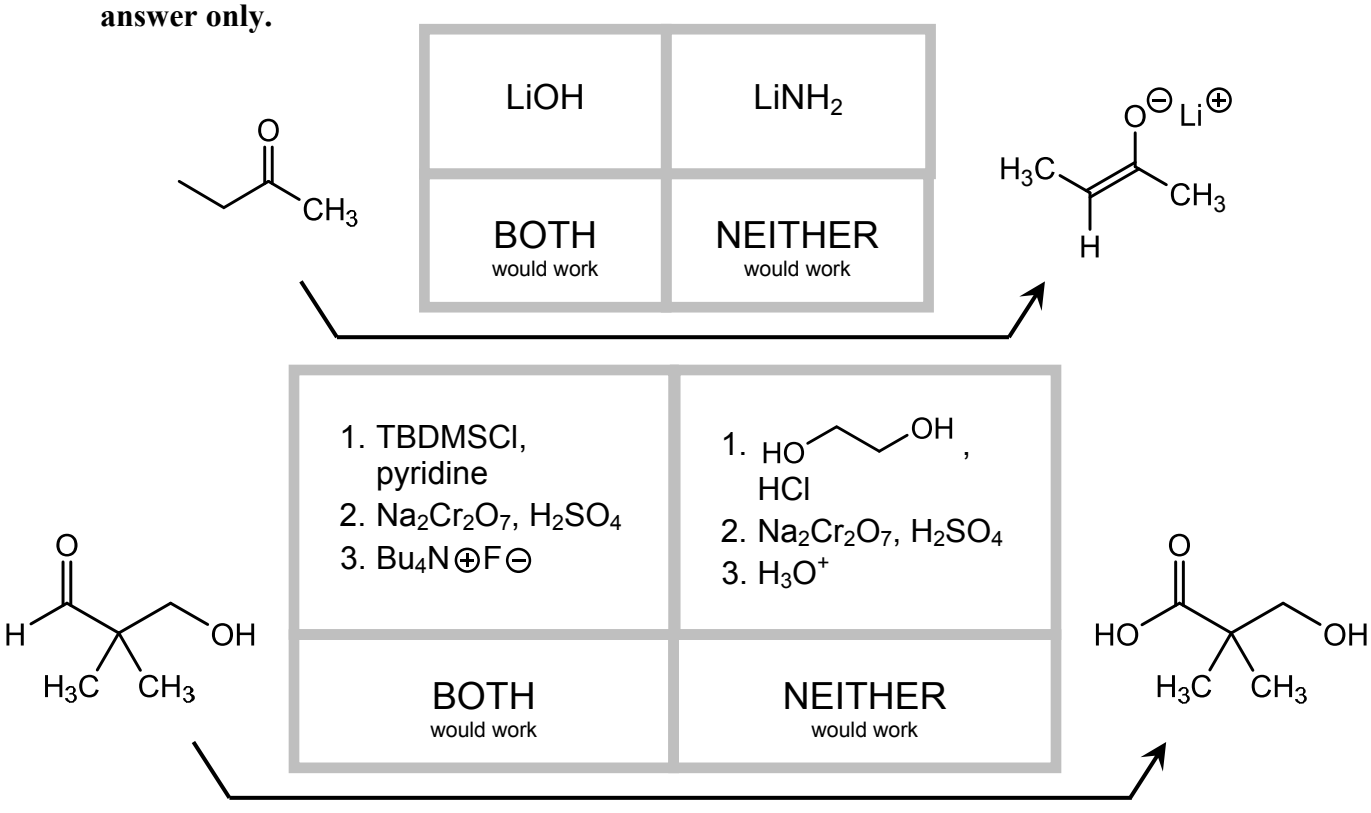


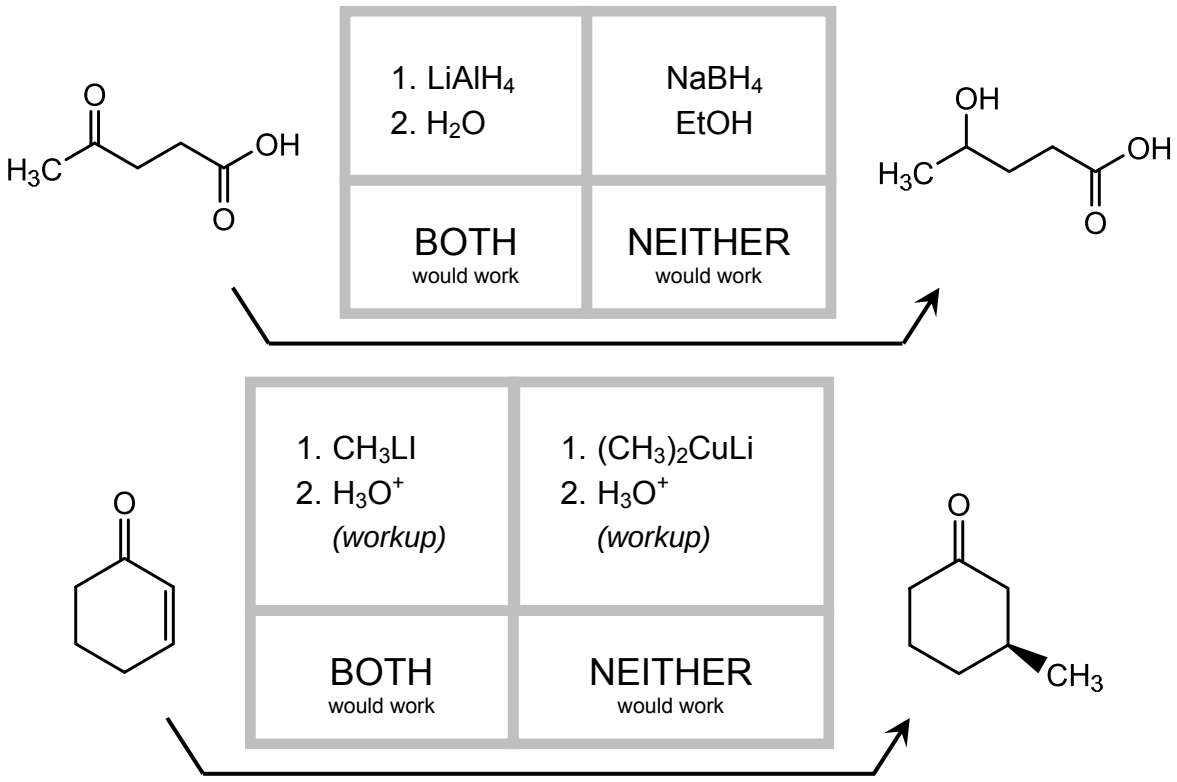




| BOTH (equally) | NEITHER |
|---|---|

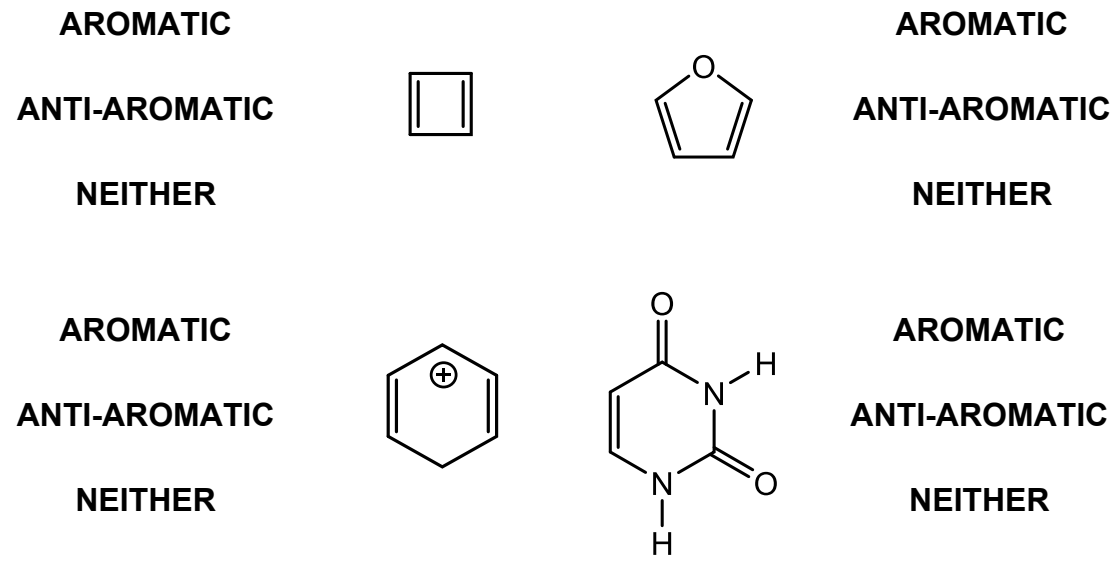



3. (16 pts) Each of the reactions below is drawn with two possible reaction conditions. If only one of the two reaction conditions would generate the given molecule as the major product, circle those conditions. If both sets of conditions would accomplish the reaction, circle "BOTH". If neither set of reaction conditions would succeed, circle "NEITHER". **Circle one answer only.**

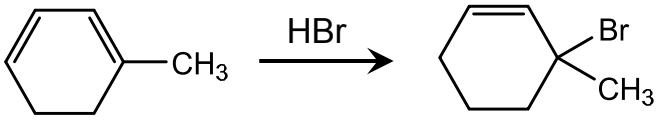




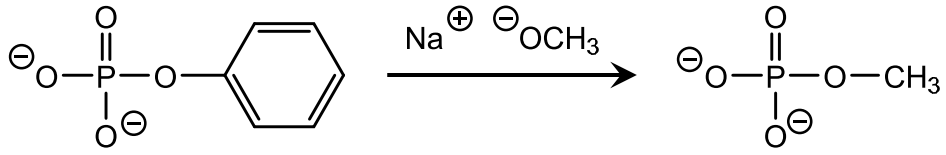

4. (12 pts) For each of the following molecules, circle whether the molecule is aromatic, anti-aromatic, or neither.




5. (18 pts) **Draw a mechanism** (using "electron pushing") for each of the reactions shown on the next page. Draw each mechanistic step explicitly; don't cheat by combining multiple processes in a single step, or by taking shortcuts. Use only the molecules shown in the problem.

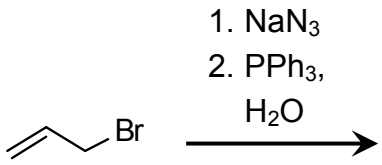


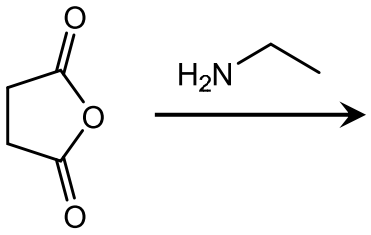

*Mechanism:*

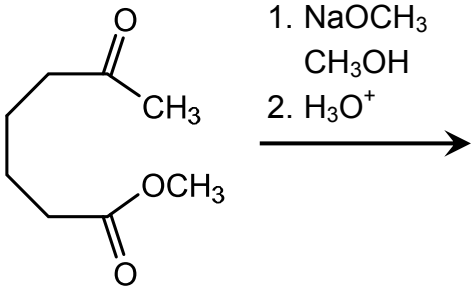


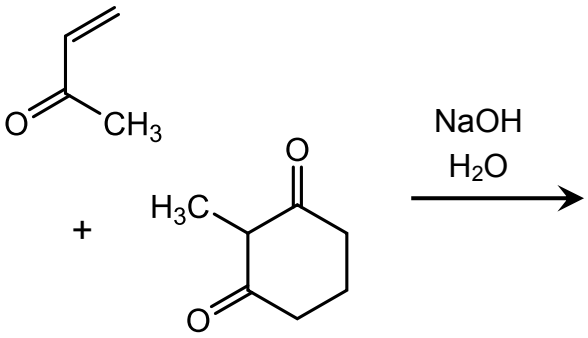

*Mechanism:*

6. (20 pts) For each of the reactions on the next page, fill in the empty box corresponding to product. 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".

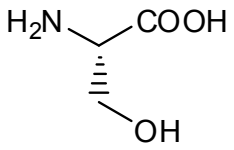

1. NaN3
2. PPh3,
H2O
Br


O
O
O
H2N

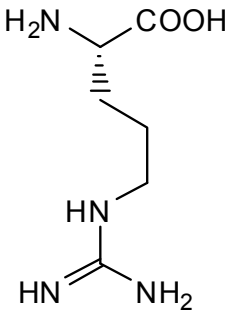

O
CH3
OCH3
O
1. NaOCH3
CH3OH
2. H3O+


O
CH3
+
H3C
O
O
NaOH
H2O

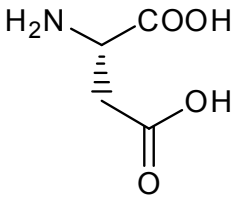
7. (6 pts)
   (a) Sort the three amino acids serine (Ser), arginine (Arg), and aspartic acid (Asp) in order of increasing isoelectric point (pI). Write their three-letter abbreviations in the appropriate boxes below.



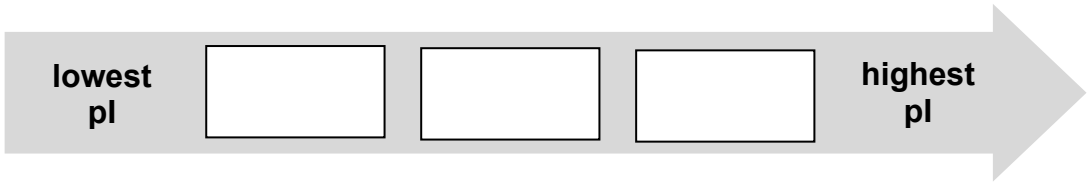

serine (Ser)



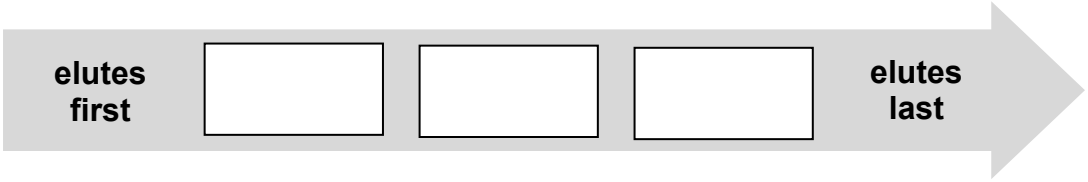

arginine (Arg)



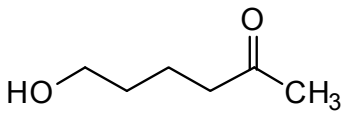

aspartic acid (Asp)

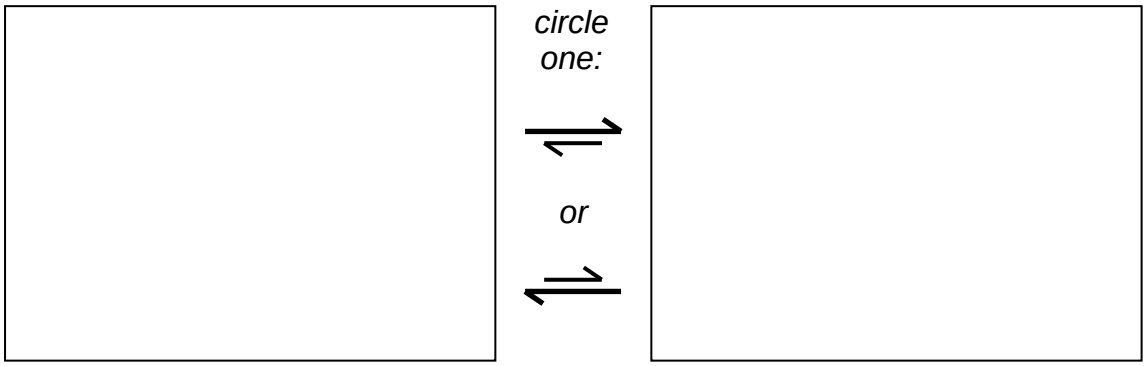



   (b) If these three amino acids were analyzed by ion exchange chromatography, using an anionic column subjected to a solvent gradient of gradually increasing pH, what would be the order of elution of these three amino acids?

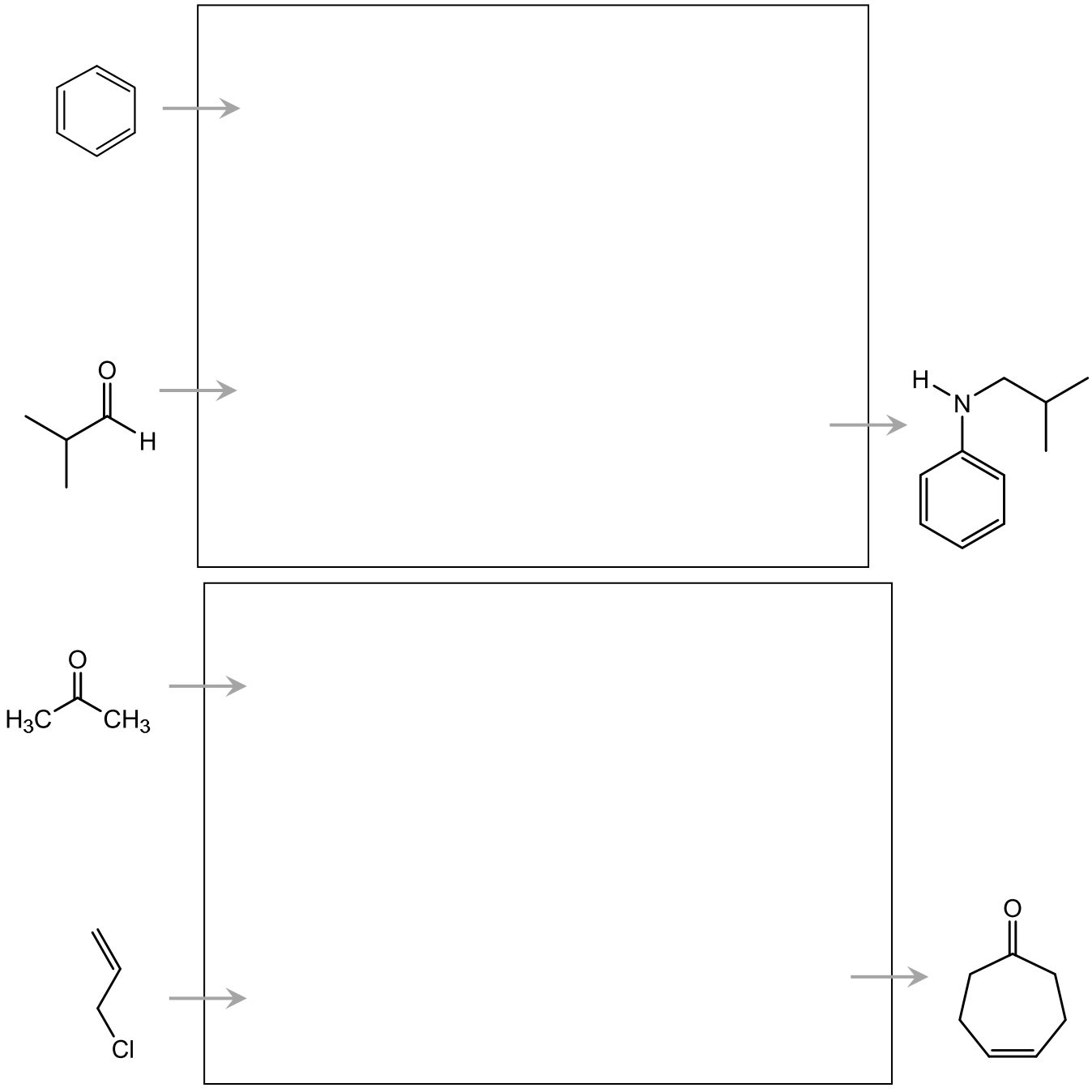



8. (8 pts)
   a. 1-hydroxy-5-hexanone (shown at right) equilibrates with a cyclic hemiketal that can assume two different chair conformations. In the boxes below, draw those two hemiketal chairs. Then, indicate which conformation you think is more stable.

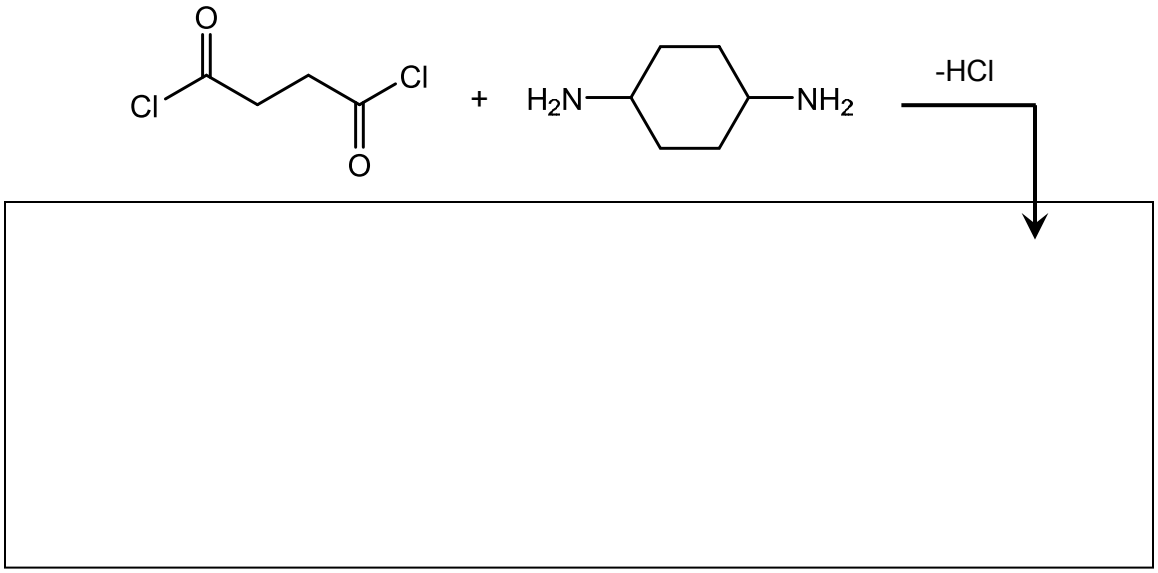


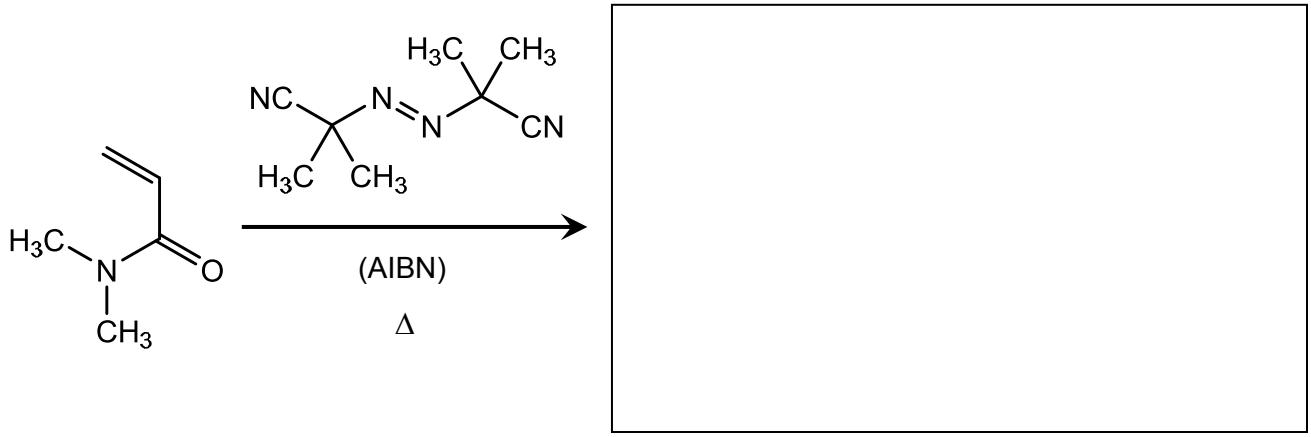



9. (20 pts) Each of the syntheses shown below can be accomplished in a few steps. For each synthesis, fill in the empty boxes with any appropriate reagents (or sets of reagents) and synthetic intermediates that can be used in the synthesis of the drawn product from the starting material(s).

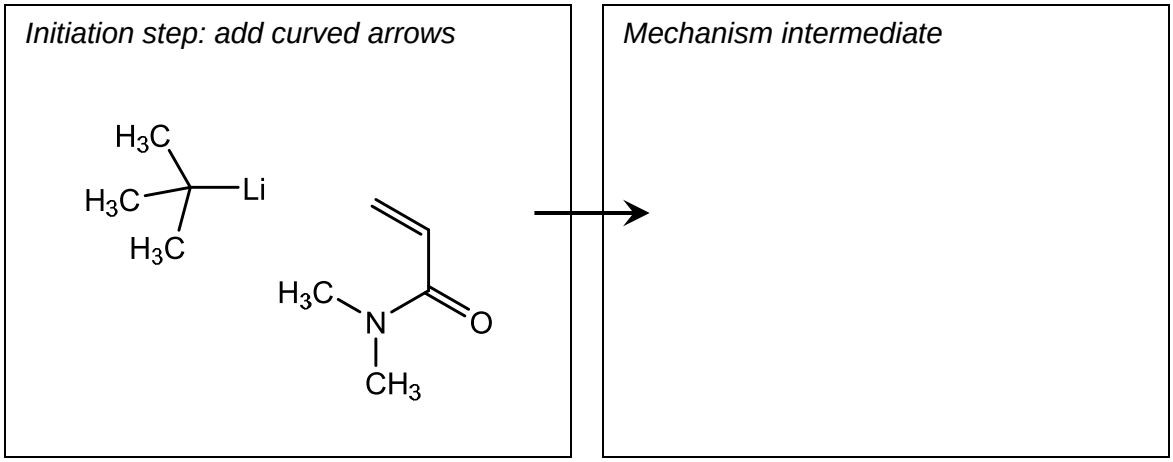



10. (17 pts)
    a. For each of the polymer syntheses proposed on the next page, draw the polymer product using bracket notation ("$[\text{-M-}]_n$"). If there is a part of the polymer structure that isn't known (*e.g.*, the initiating or terminating group), draw this as a squiggle in your structure.




b. If the second polymerization above were initiated with *tert*-butyllithium instead of with AIBN, the mechanism of vinyl polymerization would be different. In the box below, **add curved arrows** (using "electron pushing") that shows how *t*-BuLi would initiate polymerization. Then draw the intermediate formed from this mechanistic step.



# Final Exam 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
$Et_2O$

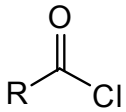
1. $NaNO_2$
   HCl
2. CuCN *or*
   $H_3PO_2$ *or*
   CuX *or*
   $H_3O^+$

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

$Zn(Hg)$,
$HCl/H_2O$

Li
hexane

$H_2$
Pd-C



$AlCl_3$

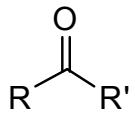
1. $N_2H_4$
2. KOH, $\Delta$

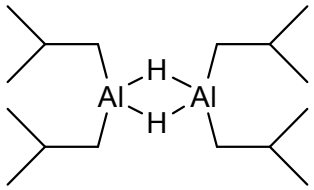
1. $O_3$
2. $H_2O$

RMgX

RLi

$R_2CuLi$

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

(DIBAL-H)

$Na_2Cr_2O_7$
$H_2SO_4$

$LiAlH(OtBu)_3$

1. $Ag_2O$
   $NH_3$
2. $H_3O^+$

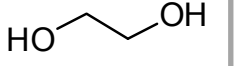
$Bu_4N^+F^-$

$PhCH_2Br$
$Ag_2O$

1. $LiAlH_4$
2. $H_2O$

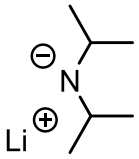
$(COCl)_2$

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



HCl

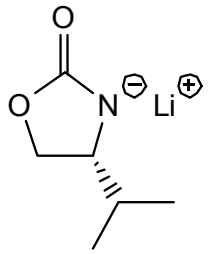
$NaNH_2$



(LDA)

$SOCl_2$
(& pyridine,
usually)

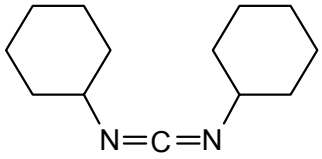
1. $NaBH_4$
2. $H_2O$

1. 

2. base
3. R-X
4. LiOH

$Pd(OAc)_2$
$PPh_3$, $NEt_3$

1. $CH_3I$
   (excess)
2. $Ag_2O$
   $H_2O$
3. $\Delta$



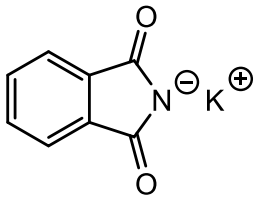
(DCC)

$CHCl_3$
$KOtBu$

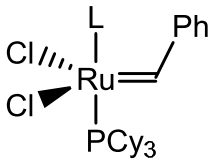
$Pd(PPh_3)_4$
NaOH

$CF_3COOH$

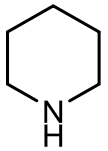
$CH_2I_2$
$Zn(Cu)$

1. 

2. $N_2H_4$ (or $^-OH$)

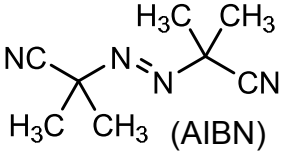


*(Grubbs catalyst)*



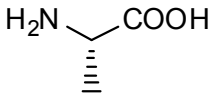

HF

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

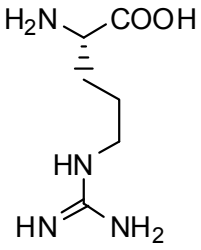


(AIBN)

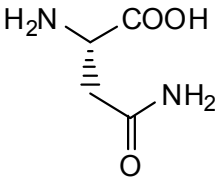
# Final Exam Chart of Amino Acids
# (in Alphabetical Order)



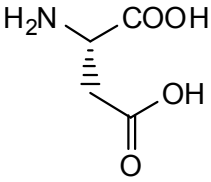
alanine
(Ala, A)



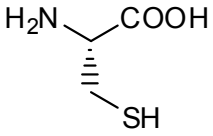
arginine
(Arg, R)



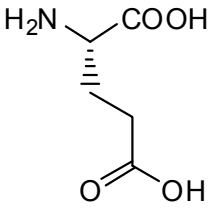
asparagine
(Asn, N)



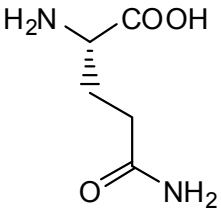
aspartic acid
(Asp, D)



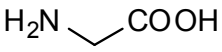
cysteine
(Cys, C)



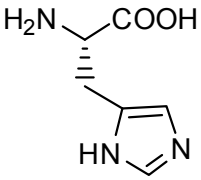
glutamic acid
(Glu, E)



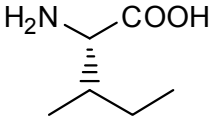
glutamine
(Gln, Q)



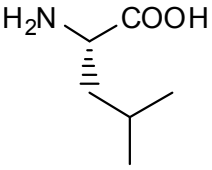
glycine
(Gly, G)



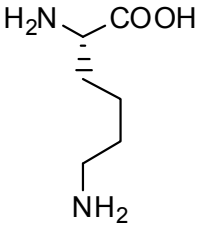
histidine
(His, H)



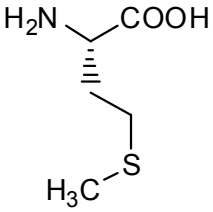
isoleucine
(Ile, I)



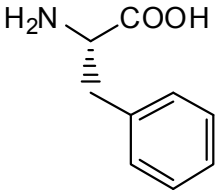
leucine
(Leu, L)



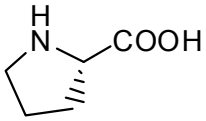
lysine
(Lys, K)



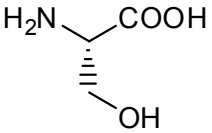
methionine
(Met, M)



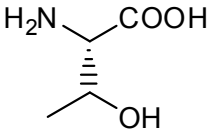
phenylalanine
(Phe, F)



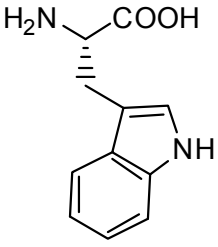
proline
(Pro, P)



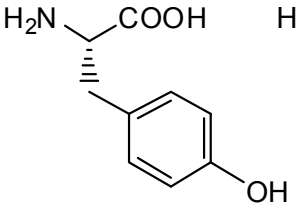
serine
(Ser, S)



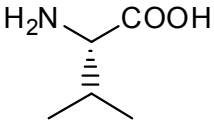
threonine
(Thr, T)



tryptophan
(Trp, W)

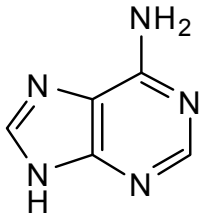


tyrosine
(Tyr, Y)



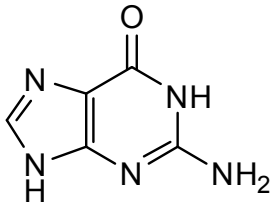
valine
(Val, V)

# Final Exam Chart of Nucleic Acid Bases
# (in Alphabetical Order)

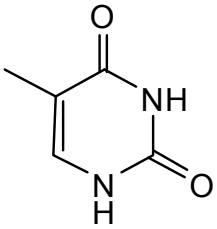



adenine
(A)

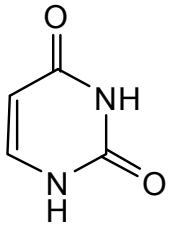

cytosine
(C)




guanine
(G)




thymine
(T)




uracil
(U)

Periodic Table of the Elements

# Chemistry Reference Sheet

California Standards Test

| | 1 1A | | | | | | | | | | | | 13 3A | 14 4A | 15 5A | 16 6A | 17 7A | 18 8A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 **H** Hydrogen 1.01 | 2 2A | | | | | | | | | | | | | | | | 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 | 3 3B | 4 4B | 5 5B | 6 6B | 7 7B | 8 | 9 8B | 10 | 11 1B | 12 2B | 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) |

**Key**

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

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