Name: _____ Student Number: _____

Chemistry 2600 Final Exam (Version A)
December 14th, 2019

INSTRUCTIONS

1) Read the exam carefully before beginning. There are 9 questions on pages 2 to 14 followed by a periodic table and a blank page for rough work. You are also provided with a Spectroscopy Data Package (as posted on the class website). **Please ensure that you have a complete exam. If not, let an invigilator know immediately**. All pages must be submitted.
2) You are allowed to bring one index card (maximum size 3"x5") into the exam with you as a "cheat sheet". This card must be submitted with your exam.
3) You are allowed to bring a ruler and a molecular model kit.
4) You may use a calculator. It may not have wireless capability. You may not have any other electronic devices (phone, iPod, etc.) with you when you write the exam.
5) If your work is not legible, it will be given a mark of zero.
6) Marks will be deducted for incorrect information added to an otherwise correct answer.
7) When drawing molecules, clearly show any relevant stereochemistry. If a mixture of diastereomers is produced, draw both/all of them.
8) **DO NOT OPEN THE EXAM UNTIL YOU ARE TOLD TO BEGIN.**
   Beginning prematurely will result in removal of your exam paper and a mark of 0.
9) You have **3 hours** to complete this exam. Nobody may leave the exam room during the first hour or the last 15 minutes of the exam.

Q	Mark
1	/ 10
2	/ 8
3	/ 15
4	/ 12
5	/ 6

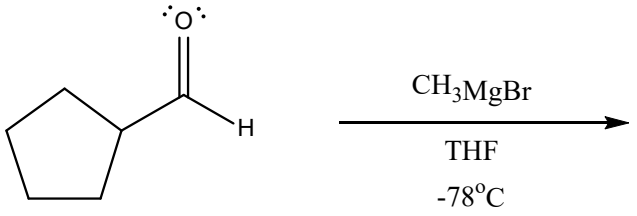
Q	Mark
6	/ 26
7	/ 18
8	/ 4
9	/ 1
10	

Total	/ 100

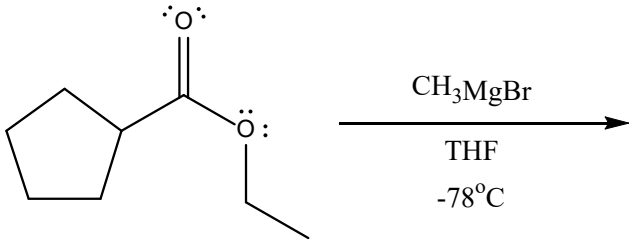
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1. For each of the following reactions, draw the major organic product. **[10 marks]**
Reagents listed above or below the arrow are present in sufficient quantity to allow for full reaction. Do **not** assume an aqueous work-up if none is shown.

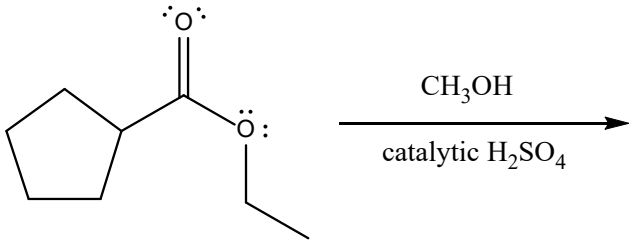
(a)



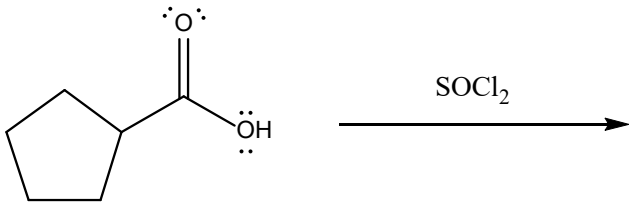
(b)



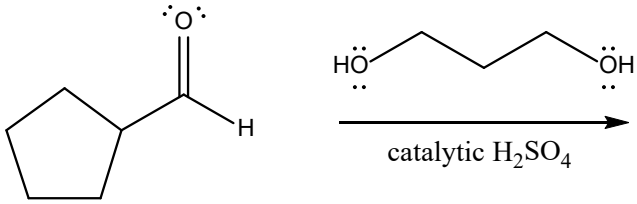
(c)



(d)

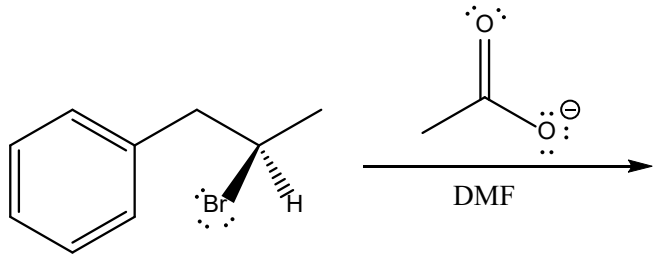


(e)



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2. *(R)*-(2-bromopropyl)benzene is reacted with sodium acetate (CH_3CO_2Na): **[8 marks]**



(a) Draw the organic product(s) that you would expect to observe if this reaction proceeded according to an S_N1 mechanism. Clearly show any relevant stereochemistry. *[2 marks]*

(b) Draw the organic product(s) that you would expect to observe if this reaction proceeded according to an S_N2 mechanism. Clearly show any relevant stereochemistry. *[2 marks]*

(c) Briefly, describe an experiment that would use kinetics to determine which mechanism is followed for this reaction. What parameters would you vary, and what results would support each mechanism? *[4 marks]*

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3. If 2-hexanol is reacted with sulfuric acid, three elimination products are possible.

[15 marks]

(a) Draw all three potential elimination products. *[3 marks]*

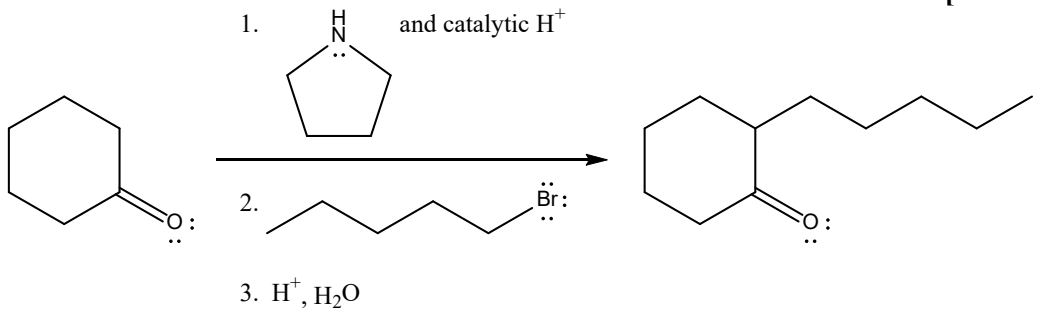
(b) Which of your answers to part (a) would you expect to be the thermodynamic product? Justify your choice. *[3 marks]*

(c) How would you favour production of the thermodynamic product over the other two potential elimination products? Give two suggestions. *[2 marks]*

(d) Draw a mechanism for the reaction of 2-hexanol with sulfuric acid to produce the thermodynamic equilibrium product **and** classify your mechanism as E1 or E2. *[7 marks]*

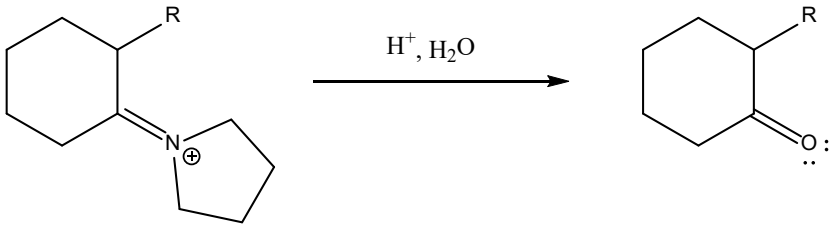
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4. A student decides to use an enamine strategy to prepare 2-pentylcyclohexanone from cyclohexanone: **[12 marks]**



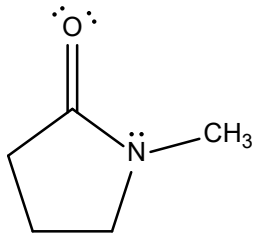
(a) Draw the structure of the enamine made in step 1 of the three-step process outlined above. *[2 marks]*

(b) The product of step 2 is an iminium ion *(see below)*. Propose a reasonable mechanism for the hydrolysis of the iminium ion to the desired ketone. *[10 marks]*

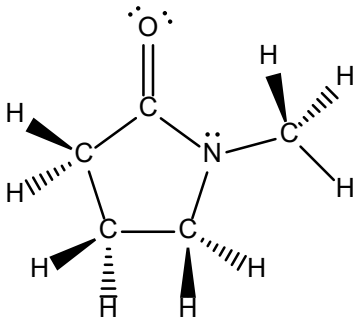


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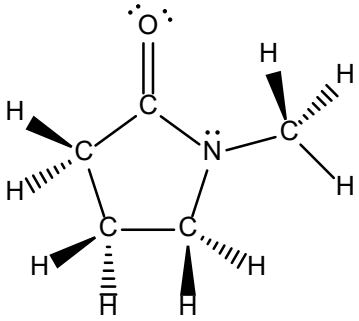
5. Consider the following molecule. The nitrogen atom is trigonal planar. **[6 marks]**



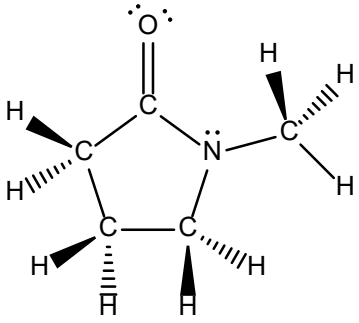
(a) On the picture below, circle two hydrogen atoms which are enantiotopic: *[2 marks]*



(b) On the picture below, circle two hydrogen atoms which are homotopic: *[2 marks]*



(c) On the picture below, circle two hydrogen atoms which are constitutionally different: *[2 marks]*



Name: _____ Student Number: _____

6. The following **two** pages contain spectra for Unknown X. **[26 marks]**

(a) Identify Unknown X based on these spectra. Draw your answer in the box provided below.

(b) Use this page to explain your logic (including how you determined the molecular formula).

(c) On both NMR spectra, assign as many peaks as you can by numbering the peaks from left to right, drawing Unknown X in the box provided on the spectrum, and labeling each carbon or hydrogen atom with the appropriate peak number. *For atoms that cannot be assigned with certainty, list the signals to which they might reasonably correspond.*

(d) Label any important peaks on the IR.

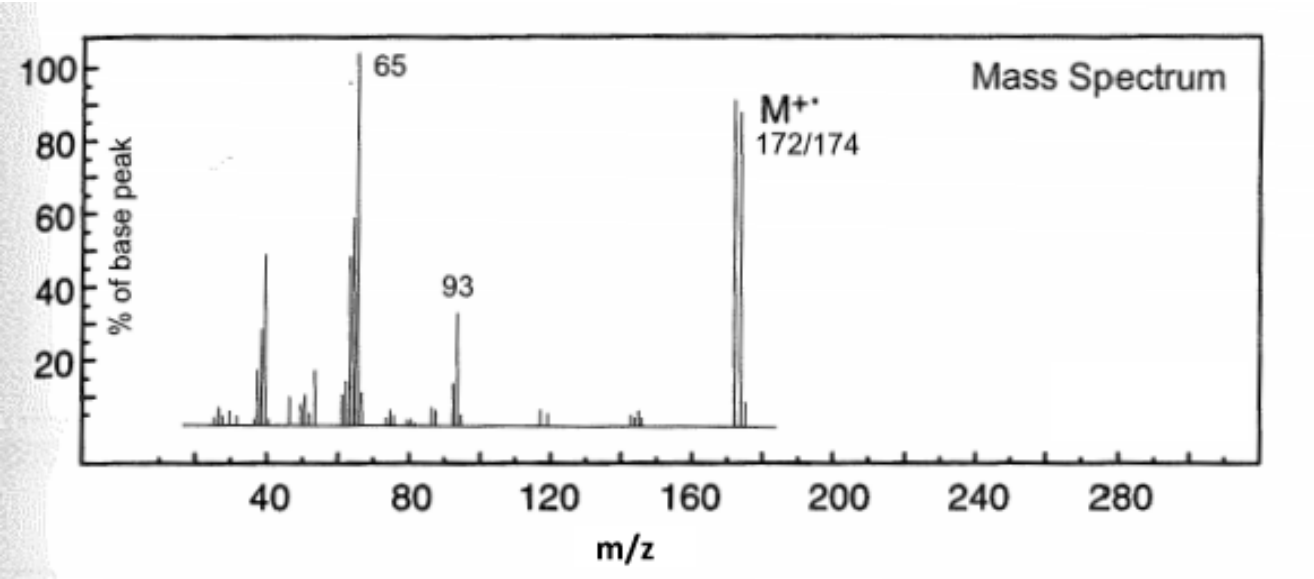
(e) Identify the fragment corresponding to the peak at m/z 93 on the Mass Spectrum.

Unknown X:

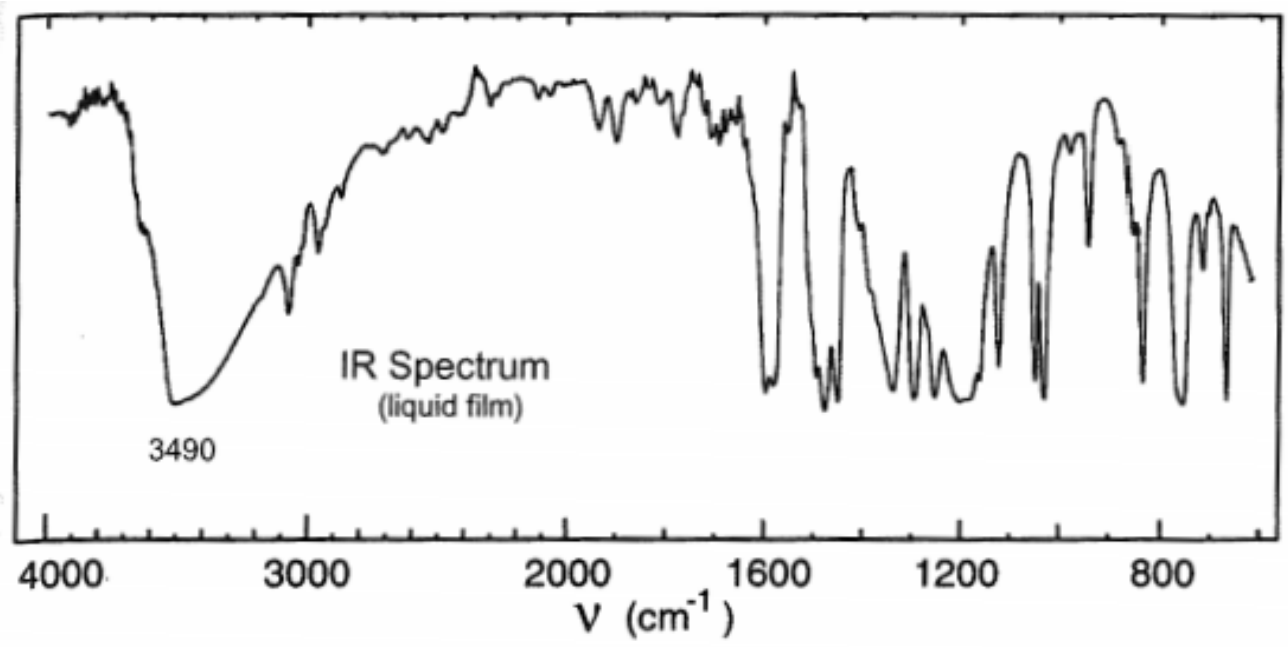
Name: _____ Student Number: _____

6. *…continued…*

Mass Spectrum



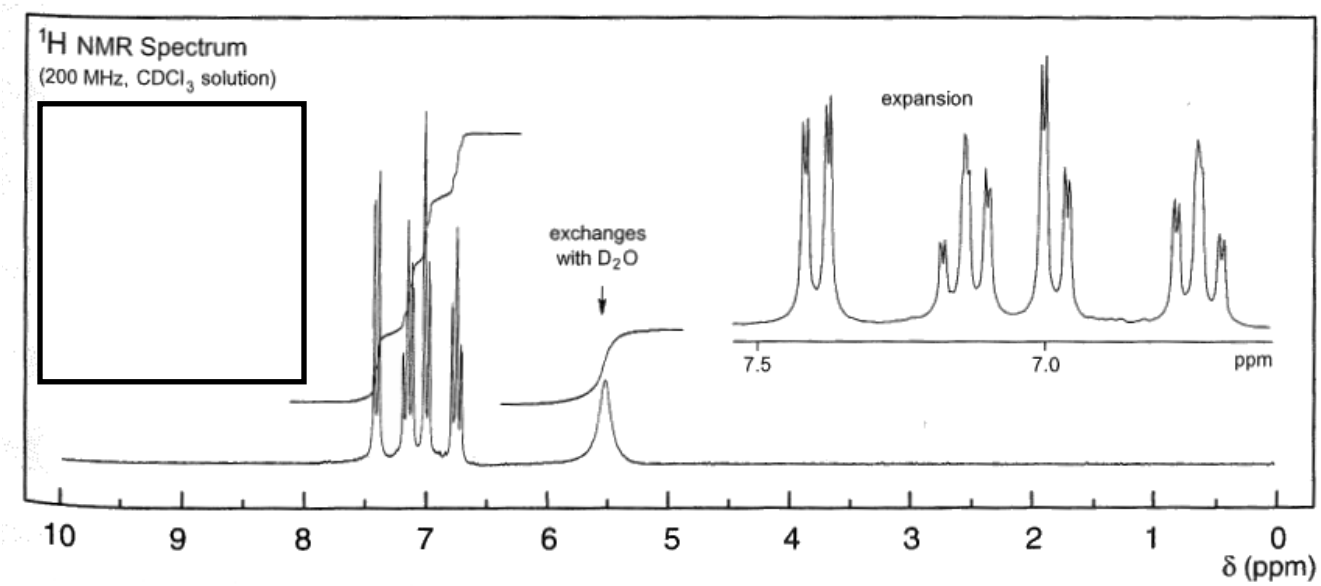
IR



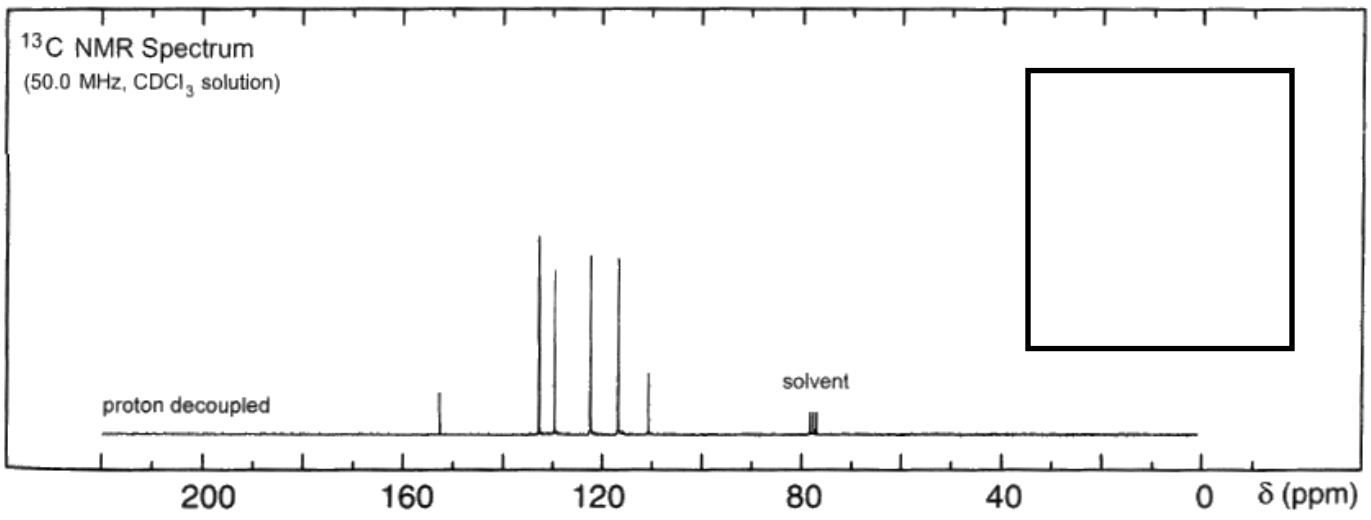
Name: _____ Student Number: _____

6. *…continued…*

^{1}H NMR



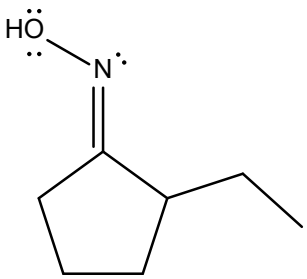
^{13}C NMR

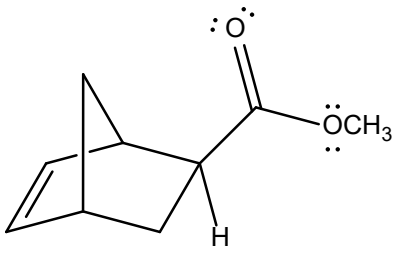


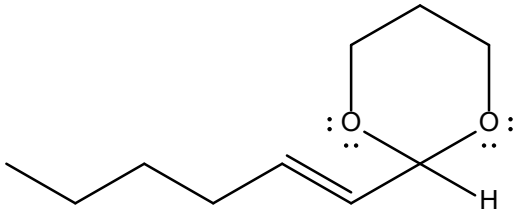
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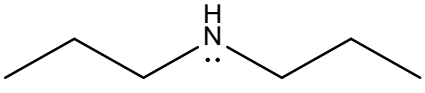
7. Choose any **three** of the molecules below and propose a synthesis for each one. **[18 marks]**

- If your synthesis involves more than one step, write an equation for each step. Show all required reactants. Number steps within a reaction if order of addition is important.
- All organic reactants must be stable compounds containing **no more than five carbon atoms**. They may be **hydrocarbons, alkyl halides or alcohols** and may contain C=C or C≡C bonds. The only exception to this rule is that you are **also allowed** to use **benzene, bromobenzene or phenol**.
- If you wish to use an organic reactant (including Grignard reagent) that does not meet these requirements, you must show how to make it from starting materials that do.
- You may use any inorganic reagents, acids, bases, catalysts, etc.
- Acids, bases, catalysts, etc. do not need to meet the "organic reactant" requirements if the organic part will not be present in the final product.
- Clearly indicate stereochemistry of reaction products where appropriate. Assume that all stereochemistry shown is relative and that you are to make racemic product.
- You are **not** required to show mechanisms for this question.
- There are three pages after this page. Use one of those pages for each synthesis and clearly identify the synthetic target at the top of the page. This page is scrap paper.
- If you give more than three syntheses, I will only mark the first three (ignoring any that are crossed out).









Name: _____ Student Number: _____

7. *continued…* *[6 marks]*

Synthetic Target #1:

Synthesis:

Name: _____ Student Number: _____

7. *continued…* *[6 marks]*

Synthetic Target #2:

Synthesis:

Name: _____ Student Number: _____

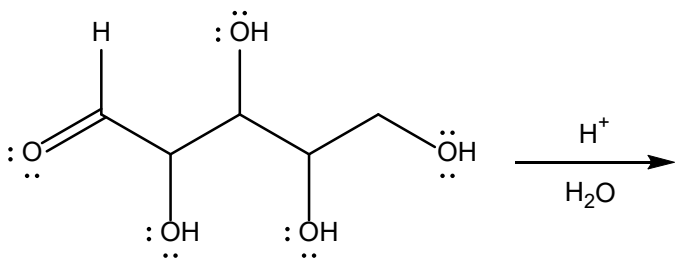
7. *continued…* *[6 marks]*

Synthetic Target #3:

Synthesis:

Name: _____ Student Number: _____

8. The sugar below can form two different hemiacetals. Draw them in the boxes provided. *You do not need to show the mechanisms for these reactions; however, you may find it helpful to work through them in order to determine what products are formed.* **[4 marks]**



and

9. What was the most interesting and/or useful thing you learned in CHEM 2600? **[1 mark]**

…AND THAT'S ALL FOR CHEM 2600.
HAPPY HOLIDAYS!

DATA SHEET/SCRAP PAPER

CHEM 1000 Standard Periodic Table

1												13	14	15	16	17	18
1.0079 **H** 1	2																4.0026 **He** 2
6.941 **Li** 3	9.0122 **Be** 4											10.811 **B** 5	12.011 **C** 6	14.0067 **N** 7	15.9994 **O** 8	18.9984 **F** 9	20.1797 **Ne** 10
22.9898 **Na** 11	24.3050 **Mg** 12	3	4	5	6	7	8	9	10	11	12	26.9815 **Al** 13	28.0855 **Si** 14	30.9738 **P** 15	32.066 **S** 16	35.4527 **Cl** 17	39.948 **Ar** 18
39.0983 **K** 19	40.078 **Ca** 20	44.9559 **Sc** 21	47.88 **Ti** 22	50.9415 **V** 23	51.9961 **Cr** 24	54.9380 **Mn** 25	55.847 **Fe** 26	58.9332 **Co** 27	58.693 **Ni** 28	63.546 **Cu** 29	65.39 **Zn** 30	69.723 **Ga** 31	72.61 **Ge** 32	74.9216 **As** 33	78.96 **Se** 34	79.904 **Br** 35	83.80 **Kr** 36
85.4678 **Rb** 37	87.62 **Sr** 38	88.9059 **Y** 39	91.224 **Zr** 40	92.9064 **Nb** 41	95.94 **Mo** 42	(98) **Tc** 43	101.07 **Ru** 44	102.906 **Rh** 45	106.42 **Pd** 46	107.868 **Ag** 47	112.411 **Cd** 48	114.82 **In** 49	118.710 **Sn** 50	121.757 **Sb** 51	127.60 **Te** 52	126.905 **I** 53	131.29 **Xe** 54
132.905 **Cs** 55	137.327 **Ba** 56	**La-Lu**	178.49 **Hf** 72	180.948 **Ta** 73	183.85 **W** 74	186.207 **Re** 75	190.2 **Os** 76	192.22 **Ir** 77	195.08 **Pt** 78	196.967 **Au** 79	200.59 **Hg** 80	204.383 **Tl** 81	207.19 **Pb** 82	208.980 **Bi** 83	(210) **Po** 84	(210) **At** 85	(222) **Rn** 86
(223) **Fr** 87	226.025 **Ra** 88	**Ac-Lr**	(265) **Rf** 104	(268) **Db** 105	(271) **Sg** 106	(270) **Bh** 107	(277) **Hs** 108	(276) **Mt** 109	(281) **Ds** 110	(280) **Rg** 111	(285) **Cn** 112	(284) **Nh** 113	(289) **Fl** 114	(288) **Mc** 115	(293) **Lv** 116	(294) **Ts** 117	(294) **Og** 118

138.906 **La** 57	140.115 **Ce** 58	140.908 **Pr** 59	144.24 **Nd** 60	(145) **Pm** 61	150.36 **Sm** 62	151.965 **Eu** 63	157.25 **Gd** 64	158.925 **Tb** 65	162.50 **Dy** 66	164.930 **Ho** 67	167.26 **Er** 68	168.934 **Tm** 69	173.04 **Yb** 70	174.967 **Lu** 71
227.028 **Ac** 89	232.038 **Th** 90	231.036 **Pa** 91	238.029 **U** 92	237.048 **Np** 93	(240) **Pu** 94	(243) **Am** 95	(247) **Cm** 96	(247) **Bk** 97	(251) **Cf** 98	(252) **Es** 99	(257) **Fm** 100	(258) **Md** 101	(259) **No** 102	(262) **Lr** 103

Developed by Prof. R. T. Boeré (updated 2016)