NAME _____

ID # _____

ORGANIC CHEMISTRY I (2301)

9:30 – 10:20 am, July 11, 2011

Exam 2

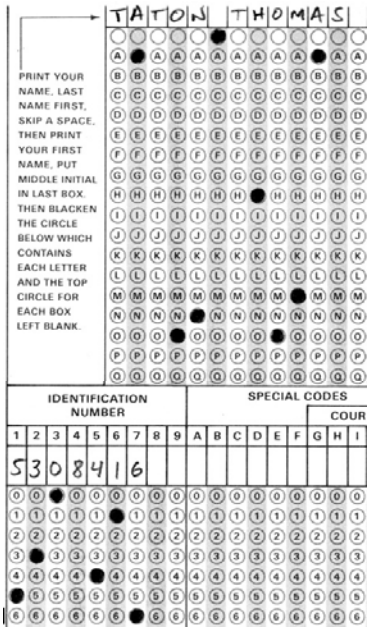
Form A

If you want to pick this exam up on Tuesday 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 Tuesday, and you will need to pick up your exam in private from Chemistry department staff in 115 Smith beginning Wednesday, July 13th. Exams that are not picked up within two weeks will be disposed of.

A periodic table is 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).

Right now, write your name at the top of this page, and fill in the bubbles on the multiple-choice answer sheet for your name and your 7-digit student ID number (in columns 1-7 of the "Identification Number" section, as shown at right). When the exam begins, also write your name at the top of page 4.



You may use pen or pencil. However, re-grades will be considered only for exams completed in pen.

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

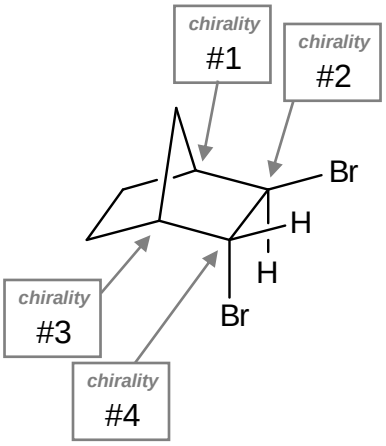
Multiple-Choice Problems

Please answer these problems on the bubble sheet.

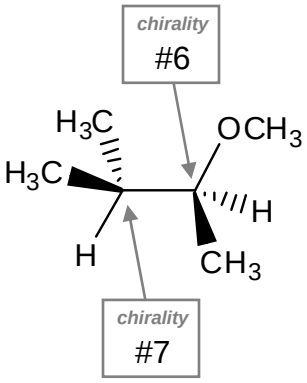
(2 pts each) For each of the molecules drawn below:

- For each atom marked "chirality", indicate whether the atom would be labeled as (a) an (*R*)-chiral center, (b) an (*S*)-chiral center, or (c) not a chiral center, according to the Cahn-Ingold-Prelog classification system.
- Indicate whether the molecule would be chiral or achiral.

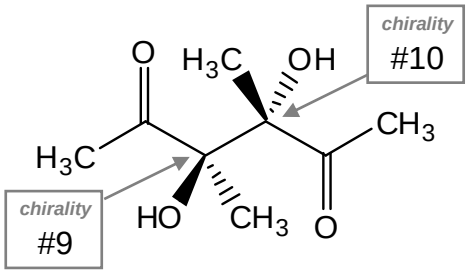
Mark each answer on the bubble sheet, with the problem number indicated inside each box.



5. Is this molecule
   a. chiral, or
   b. achiral?

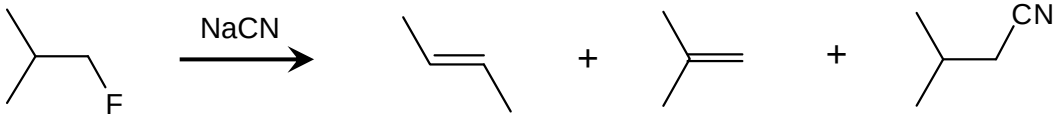


8. Is this molecule
   a. chiral, or
   b. achiral?



11. Is this molecule
    a. chiral, or
    b. achiral?

(2 pts each) Each reaction below is drawn with multiple potential products. Of these products, which would you actually expect to observe? Keep in mind that, for each reaction, you might predict one, multiple, or none of the products shown.

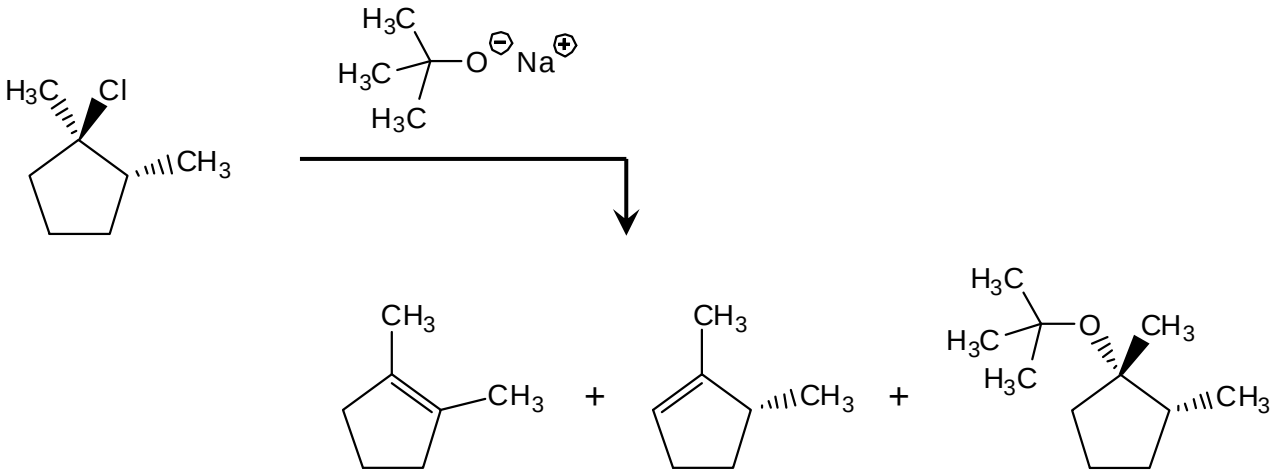


Would you expect this product?

12. a. Yes, or
    b. No?

13. a. Yes, or
    b. No?

14. a. Yes, or
    b. No?



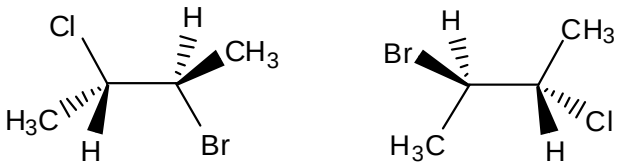
Would you expect this product?

15. a. Yes, or b. No?

16. a. Yes, or b. No?

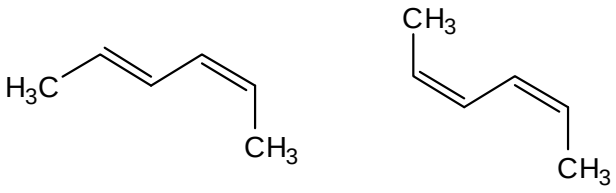
17. a. Yes, or b. No?

18. (3 pts) Are the two structures below



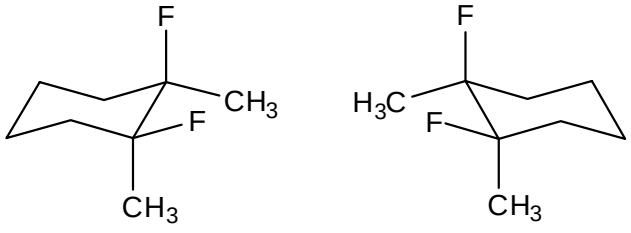
a. enantiomers,
b. diastereomers, or
c. the same molecule?

19. (3 pts) Are the two structures below



a. enantiomers,
b. diastereomers, or
c. the same molecule?

20. (3 pts) Are the two structures below



a. enantiomers,
b. diastereomers, or
c. the same molecule?

Multiple-choice problems 21 and 22 are at the end of the exam, on page 7.

NAME _____

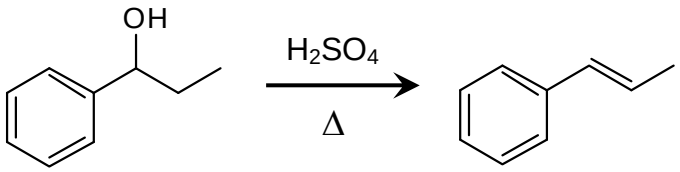
Scoring: 23. _____ / 12 24. _____ / 24

25. _____ / 15

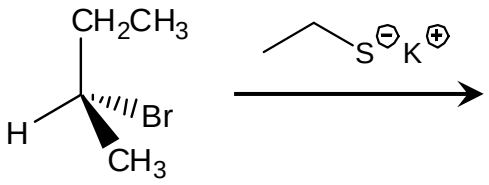
Total Score: _____ / 51

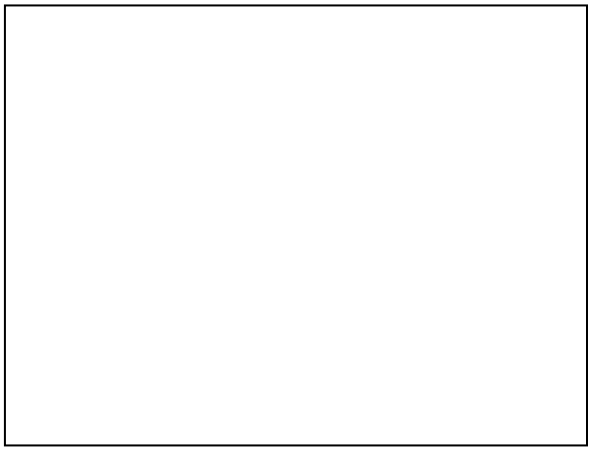
23. (12 pts) For the reaction shown below, draw a mechanism that explains how the product is generated from the starting material. In your answer, make sure that you:

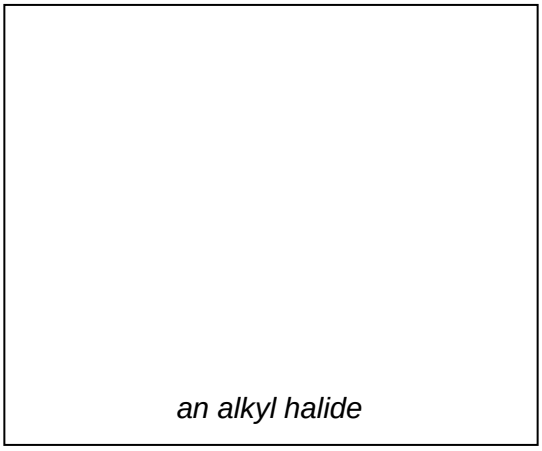
- Draw each step of the mechanism separately;
- Use "electron pushing" to show where the electrons in each step go;
- Use only the molecules that you are given; do not invoke reactants or solvents that aren't in the problem.

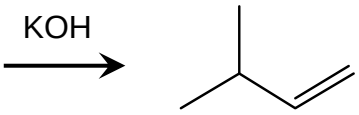


24. (15 pts) Draw the missing reactant or product in the empty boxes. For products, give the predominant, most favored product. Illustrate stereochemistry in your answer where appropriate. For reactions that yield multiple enantiomers, draw only one enantiomer in the box, and include the note "+ enantiomer".

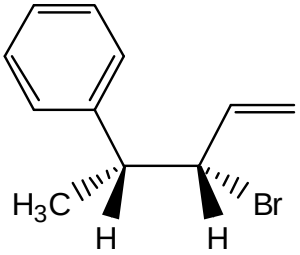


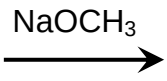


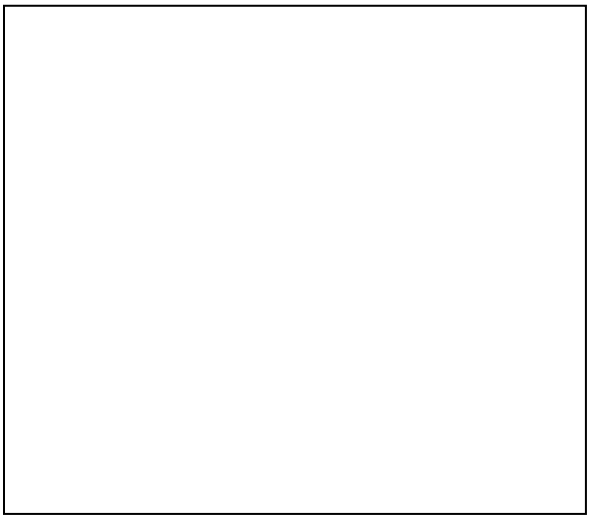




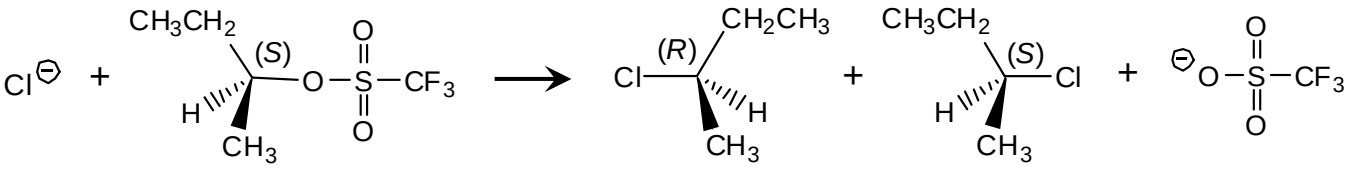
(as the major product)







25. (24 pts) The triflate group ($CF_3SO_3^-$) is such a good leaving group that alkyl triflates will undergo nucleophilic substitution reactions even with poor nucleophiles, such as chloride ions.



[α] = -23° *(rotates polarized light **counterclockwise**)*

[α] = +23° *(rotates polarized light **clockwise**)*

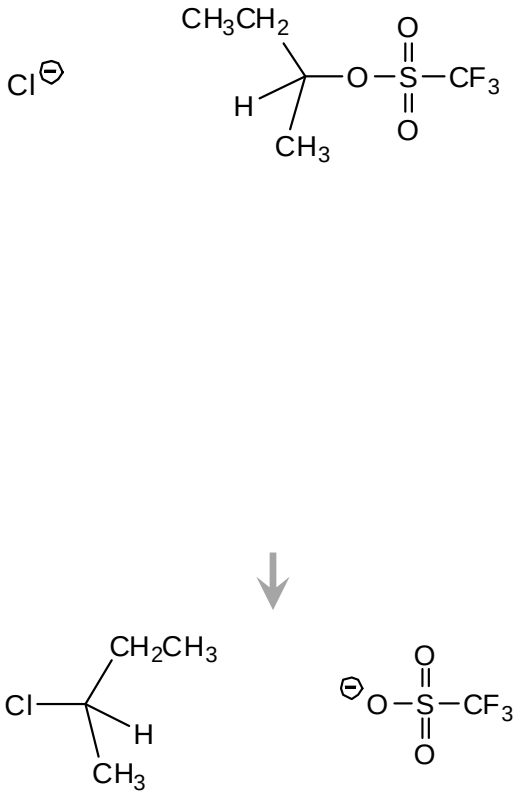
For the reaction of the triflate shown above, <u>both</u> S_N1 and S_N2 mechanisms occur, and some of each product enantiomer would be generated. We'll assume that the rate of S_N1 and S_N2 reactions are <u>exactly</u> equal.

a. In the boxes below, draw mechanisms that explain how the products above are generated from starting materials via S_N1 and S_N2 reactions. In your answer, make sure that you:

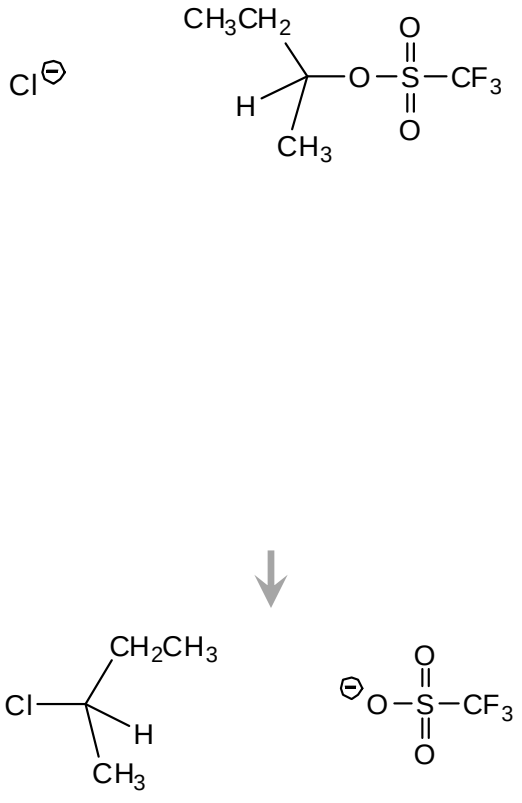
- Draw each step of the mechanism separately;
- Use "electron pushing" to show where the electrons in each step go;
- Use only the molecules that you are given.

Feel free to add arrows, any necessary electron pairs, and intermediates directly to my drawings. Ignore stereochemistry for this part of the problem.

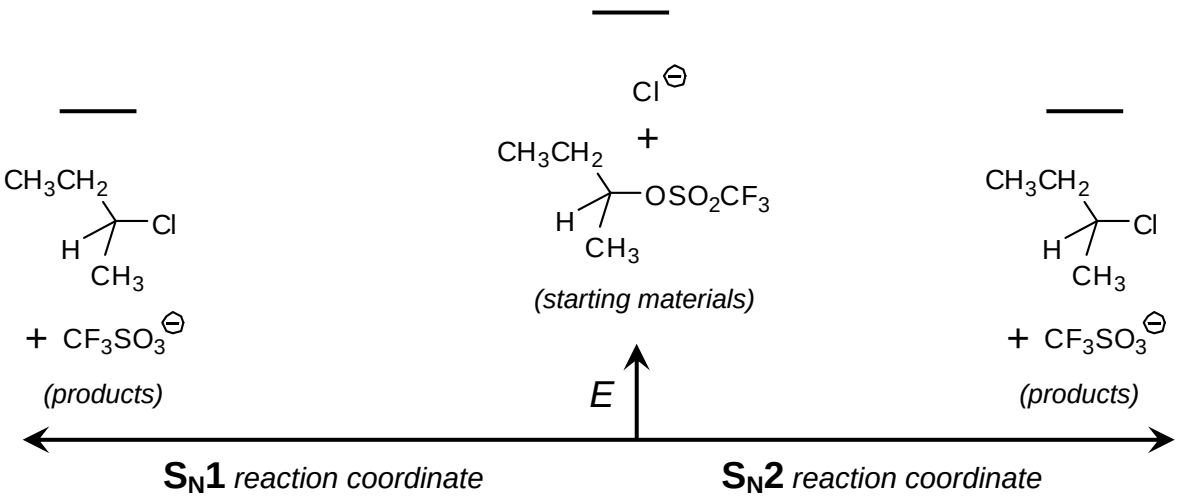
S_N1 *mechanism:*



S_N2 *mechanism:*



b. On the diagram below, draw potential energy curves for these two mechanisms. (I have already drawn the energies of starting materials and products; you need to connect them with curves. You do *not* need to draw transition-state structures.) Make sure your curves illustrate the relative energies of the rate-determining transition states for the two mechanisms.



Answer the following questions on your multiple-choice bubble form.

21. (3 pts) Once the reaction above is complete, and all of the starting material has been converted to products, the product mixture would
    a. rotate polarized light counter-clockwise;
    b. rotate polarized light clockwise;
    c. not rotate polarized light.

22. (3 pts) What would happen if iodide (I^-) were used as the nucleophile instead of chloride? How would the stereoselectivity of the total reaction—that is, the preference for one product enantiomer over the other—change?
    a. The stereoselectivity would decrease.
    b. The stereoselectivity would increase.
    c. The stereoselectivity wouldn't change.

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.