

Chemistry 150

Exam 1

Be sure to put your name on each page. This page can be removed from your exam so that you will have a Periodic Table handy throughout the exam, it does not need to be turned in. Show all your work for non-multiple choice problems which require any sort of calculation, no credit will be given for answers without work shown. If you have shown a significant amount of work or multiple drawings for a problem, draw a box around what you consider your final answer.

Avogadro's Number = 6.022×10^{23} units/mol

$32.00^\circ\text{F} = 0.000^\circ\text{C} = 273.15\text{K}$

1 foot = 12 inches

1 inch = 2.54cm (exactly)

1 pound = 453.6 g = 16 ounces

1 gallon = 3.785L

1 amu = 1.6605×10^{-24} g

Masses of subatomic particles:

Proton $1.00728\text{amu} = 1.6726 \times 10^{-24}$ g

Neutron $1.00866\text{amu} = 1.6749 \times 10^{-24}$ g

Electron $0.000549\text{amu} = 9.1094 \times 10^{-28}$ g

1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.066	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.03	89 Ac 227.03	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (279)		116 (288)		

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.94	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (258)	101 Md (258)	102 No (259)	103 Lr (260)

Multiple Choice: Circle the letter of the most correct response. (5pts. per question)

- Which of the following sets of elements contains a metal, a metalloid and a nonmetal?
 - Mg, Ru, Pb
 - Cu, Te, N**
 - Na, Sr, Co
 - F, Ar, Ti
 - P, I, Ne
- Which of the following organic molecules has the *most carbon atoms*?
 - Methyl amine
 - Hexene**
 - Butanol
 - Ethane
 - Propyne
- Which of the following formulas is *most ionic*?
 - PbO
 - RbBr
 - Fe₂S₃
 - SF₆
 - FrCl**
- Different isotopes of an element:
 - Have the same number of protons**
 - Have the same charge
 - Have the same number of electrons
 - Have the same mass number
 - Have the same number of neutrons
- Which of the following represents the *smallest mass*?
 - 0.112mg
 - $1.62 \times 10^8 \mu\text{g}$
 - 7.25g
 - $9.37 \times 10^{-9} \text{ kg}$
 - $4.38 \times 10^{-7} \text{ g}$**
- Which of the following polyatomic ions has the *fewest oxygen atoms*?
 - phosphite
 - hydroxide
 - cyanide**
 - perchlorate
 - nitrite

7. Complete each row of the following table (3pts per box):

Symbol	Number of Protons	Number of Neutrons	Number of Electrons	Atomic Number	Mass Number	Charge
P	15	18	15	15	33	0
Fe	26	31	23	26	57	+3
Se	34	46	36	34	80	-2
Cu	29	37	29	29	66	0

Multiple Choice Calculations (9pts each):

8. What is the formula weight of rubidium carbonate? (Atomic # of rubidium = 37)

- a. 97.479 g/mol
- b. 145.476 g/mol
- c. 230.944 g/mol**
- d. 246.943 g/mol
- e. 316.412 g/mol

9. How many vanadium atoms are present in a 17.681g sample of vanadium (Atomic # = 23)?

- a. 0.3471 atoms
- b. 406.7 atoms
- c. 2.090×10^{23} atoms**
- d. 4.629×10^{23} atoms
- e. 6.022×10^{23} atoms

10. 3.116mols of phosphorus (Atomic # = 15) has a mass of how many grams?

- a. 0.1006 g
- b. 9.940 g
- c. 30.974 g
- d. 46.74 g
- e. 96.51 g**

11. What is the mass of a sample of zirconium (Atomic # = 40) that contains 1.31×10^{24} Zr atoms?

- a. 2.18 g
- b. 87.0 g
- c. 198 g**
- d. 8.65×10^{45} g
- e. 7.20×10^{49} g

12. The flow of the Red River yesterday was approximately 2.434×10^4 gallons every second. What is this volume in milliliters?

- a. 6.431mL
- b. 92.13mL
- c. 6.431×10^6 mL
- d. 2.434×10^7 mL
- e. **9.213×10^7 mL**

Problems:

13. The element Ubiqium (Ub) is found in all interstellar space and has two stable isotopes. ^{382}Ub has a mass of 382.993amu and 18.374% abundant. If the average atomic mass of Ub is 385.114amu, what is the mass of the other isotope? (13pts)

$$\begin{aligned}(\text{fraction } ^{382}\text{Ub})(\text{mass } ^{382}\text{Ub}) + (\text{fraction } ^? \text{Ub})(\text{mass } ^? \text{Ub}) &= \text{average atomic mass of Ub} \\(0.18374)(382.993\text{amu}) + (1-0.18374)(X \text{amu}) &= 385.114\text{amu} \\(0.18374)(382.993\text{amu}) + (0.81626)(X \text{amu}) &= 385.114\text{amu} \\x &= 385.59\text{amu}\end{aligned}$$

As a self-check, since the average atomic mass is higher than the mass of ^{382}Ub , the other isotope must be the heavier one, so the answer *should* be larger than 385.114amu.

Another self-check, since ^{382}Ub is only 18% abundant, the mass of the other isotope should be quite a bit closer to the average. 385.59 is closer to 385.114 than 382.993, so this is also consistent.

14. You are working in a facility that produces a new energy drink and have found a barrel of one of the ingredients, but the label has fallen off. From inventory records, you know that it is either aspartame which has a molecular weight near 300g/mol or niacin which has a molecular weight of about 125g/mol . You send a sample for analysis and receive the following results: %C = 57.14, %H = 6.16, %N = 9.52, %O = 27.18. What is the *empirical* formula of this substance? What is the molecular weight of this empirical formula? Does the barrel contain aspartame or niacin? Explain. (14pts)

What are the chemical formulas of aspartame and niacin? It doesn't matter! Assume 100g of sample, convert to moles, divide to get mole ratio of the empirical formula.

C:	$57.14\text{g} / 12.011 \text{g/mol} = 4.76\text{mols C}$	$4.76\text{mols C} / 0.680\text{mols N} = 7 \text{ C/N}$
H:	$6.16\text{g} / 1.0079 \text{g/mol} = 6.11\text{mols H}$	$6.11\text{mols H} / 0.680\text{mols N} = 9 \text{ H/N}$
N:	$9.52\text{g} / 14.007 \text{g/mol} = 0.680\text{mols N}$	$0.680\text{mols N} / 0.680\text{mols N} = 1 \text{ N/N}$
O:	$27.18\text{g} / 15.999 \text{g/mol} = 1.70\text{mols O}$	$1.70\text{mols O} / 0.680\text{mols N} = 2.5 \text{ O/N}$

Since the oxygen ratio is a half-integer, we should double all the ratios to give all whole numbers.

So the empirical formula is: $\text{C}_{14}\text{H}_{18}\text{N}_2\text{O}_5$

The molecular weight of the empirical formula is:

$$14(12.011 \text{g/mol}) + 18(1.0079 \text{g/mol}) + 2(14.007 \text{g/mol}) + 5(15.999 \text{g/mol}) = 294.305 \text{g/mol}$$

The *molecular* formula of a substance has to be a whole number multiple of the empirical formula, so for the substance that was tested, the molecular weight must be a whole number multiple of 294.305. Since niacin's molecular weight is much smaller than the empirically found molecular weight, the substance in the barrel cannot be niacin. 294 is near 300, so aspartame is reasonable.

I hope they do more tests before they dump this "mystery ingredient" in something *I'm* going to drink...