

This test is closed book, closed notes, and closed neighbors. A periodic table and other useful information is available at the end of the test. When told to begin, read through the entire exam, and decide which questions you can answer quickly. After you have answered those questions, return to the more involved questions and answer them.

By signing below, I agree to abide by the University rules and regulations regarding honesty on exams. I understand that I am not to look at others' exams nor allow others to view mine. I hereby state that all answers on the answer sheet are my own.

I understand that Professor Martin considers academic honesty to be central to the goals of the University and that dishonest behavior will be dealt with very seriously.

Printed Name: _____

Signature: _____

As soon as you have your OpScan (answer) sheet:

- 1) Place your name where indicated.
- 2) Place your student ID number where indicated, starting at column A.
- 3) Place a "2" in column "K" of the special codes section.

Fill in the bubbles corresponding to the above.

<p>Failure to correctly enter any of the above 3 items will result in the deduction of 5 points from your exam.</p>
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Tear this page off and return with your completed answer sheet.

You should take the rest of your exam home with you because

As a homework assignment, you may earn up to 10% of the points you missed on this exam. Details are at the end of this exam.

**Proceed immediately to the end of this exam
and write your exam code on your OpScan Sheet.**

- 1b. 7(5 points) Schroedinger's model of the hydrogen atom revolutionized our understanding of atomic structure because:
- (a) it treated electrons as waves
 - (b) the solution of the equation he set up resulted naturally in the conclusion that the energy of the electron is quantized
 - (c) the wave functions which result from the solution are related to the probability of finding an electron at a given location in space
 - (d) it introduces the concept of "electron density" rather than the electron's unique position
 - (e) all of the above

(Questions 2-6) Just as we need 3 coordinates (x,y,z) to specify the position of a particle in space, Schroedinger's equation requires 3 "quantum numbers" n, l, m to define an energy state and orbital which the electron can "occupy."

- 2b. 7(3 points) These quantum numbers are called: n, principal quantum number; l, angular momentum quantum number; m, magnetic quantum number.
- (a) True (b) False
- 3b. 7(3 points) Analogous to the coordinates x,y,z, n, l, m can each take on any positive integer value.
- (a) True (b) False
- 4b. 7(3 points) The value of n indicates the "shell" the electron is in, l the subshell and m, the specific orbital.
- (a) True (b) False
- 5b. 7(3 points) The orbitals have shapes, for example "s" orbitals can be characterized as spherical; "p" orbitals are cloverleaves (i.e., 4 lobes in a plane), and "d" orbitals have two spherical lobes looking approximately like a 3-dimensional figure 8.
- (a) True (b) False
- 6b. 8(3 points) The Pauli Exclusion Principle states that no two electrons could have the same values of the principal quantum number n, and the angular momentum quantum number l.
- (a) True (b) False

7b. **8**(5 points) Which of the following atoms would be most paramagnetic: (hint -- draw a "box" diagram):

- a •) N $1s^2 2s^2 2p^3$
- b) Si $1s^2 2s^2 2p^6 3s^2 3p^2$
- c) Ne $1s^2 2s^2 2p^6$
- d) Li $1s^2 2s^2$
- e) B $1s^2 2s^2 2p^1$

8b. **8**(5 points) Electrons are attracted to protons in the nucleus. However, electrons in shells closer to the nucleus "shield" electrons in outer shells from the attractions of the protons. That is, the electrons in outer shells "see" or "feel" an effective positive charge less than the full nuclear charge. Which electron "feels" the largest nuclear charge?

- | | | | | |
|----------------------------------|--------|----|----------------------------|-----|
| a) a 2p electron in carbon | Z = 6 | C | $1s^2 2s^2 2p^2$ | +4 |
| b) a 2p electron in neon | Z = 10 | Ne | $1s^2 2s^2 2p^6$ | +8 |
| c •) a 2p electron in phosphorus | Z = 15 | P | $1s^2 2s^2 2p^6 3s^2 3p^3$ | +13 |
| d) a 2s electron in oxygen | Z = 8 | O | $1s^2 2s^2 2p^4$ | +6 |
| e) a 2s electron in lithium | Z = 3 | Li | $1s^2 2s^1$ | +1 |

9b. **8**(3 points) Hund's rule states that electrons want to be paired. Thus, the most stable electron configuration is to have the most paired electrons. For example, carbon has 6 electrons, C $1s^2 2s^2 2p^2$. According to Hund's rule, the last two electrons would go into the same 2p orbital, one with spin up, and one with spin down.

- (a) True (b •) False

(Questions 10-13) We can use the concept of electron screening to help us understand and predict trends in ionization energies. We would expect:

10b. **8**(3 points) The first ionization energy of Li ($\text{Li} \rightarrow \text{Li}^+ + e^-$) is less than that of Be ($\text{Be} \rightarrow \text{Be}^+ + e^-$).

- (a •) True (b) False

11b. **8**(3 points) The second ionization energy of Li ($\text{Li}^+ \rightarrow \text{Li}^{2+} + e^-$) is less than that of Be ($\text{Be}^+ \rightarrow \text{Be}^{2+}$).

- (a) True (b •) False

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12b. **8**(3 points) The ionization energy of Ar ($\text{Ar} \rightarrow \text{Ar}^+ + e^-$) is greater than the ionization energy of sulfur ($\text{S} \rightarrow \text{S}^+ + e^-$).

(a) True

(b) False

13b. **8**(3 points) The second ionization energy of Na ($\text{Na}^+ \rightarrow \text{Na}^{2+} + e^-$) is less than the ionization energy of Ne ($\text{Ne} \rightarrow \text{Ne}^+ + e^-$).

(a) True

(b) False

14b. **8**(5 points) Which is the correct ordering of increasing radii (smallest < ... < largest)?

(a) $\text{Ne} < \text{O}^{2-} < \text{N}^{3-} < \text{F}^-$ (b) $\text{Ne} < \text{F}^- < \text{O}^{2-} < \text{N}^{3-}$ (c) $\text{N}^{3-} < \text{O}^{2-} < \text{F}^- < \text{Ne}$ (d) $\text{F}^- < \text{O}^{2-} < \text{N}^{3-} < \text{Ne}$ (e) $\text{F}^- < \text{N}^{3-} < \text{O}^{2-} < \text{Ne}$

15b. **8**(5 points) The 3p electrons on P (phosphorous) "see" an effective nuclear charge of:

(a) 15

(b) 5

(c) 31

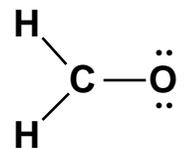
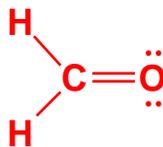
(d) 6

(e) 3

The 3p electrons on P are screened by the 1s, 2s, and 2p electrons (a total of 10). Thus the total nuclear charge of +15 is reduced to +5.

16b. **9**(5 points) What is wrong with the Lewis structure for CH_2O , shown below?

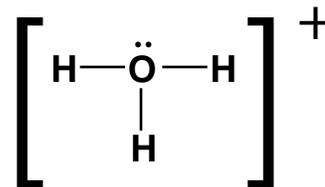
- (a) oxygen does not have an octet
- (b) oxygen's formal charge is too negative
- (c) carbon's formal charge is too positive
- (d) carbon does not have an octet
- (e) b, c, and d



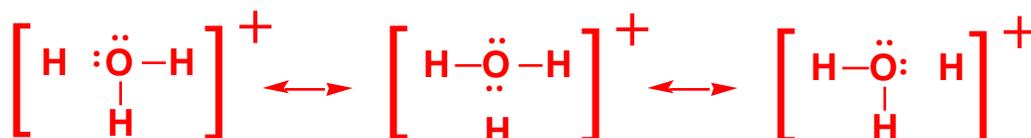
A much better Lewis structure for this is:

17b. 9(5 points) What is wrong with the Lewis structure for H_3O^+ , shown below?

- (a) oxygen does not have an octet
 (b) oxygen's formal charge is too negative
 (c) there are too few electrons overall
 (d•) oxygen's formal charge is too positive
 (e•) nothing is wrong; it is a perfect Lewis structure



OK, the wording on this question was *unintentionally* misleading. "Wrong" should have read "less than optimal." Although the structure shown is a technically correct Lewis structure (oxygen does have an octet), we have learned in class that there are better and worse Lewis structures. The primary problem with this Lewis structure is that the positive charge on this ion is localized on oxygen and we know that oxygen has a much higher electronegativity than hydrogen (**therefore, oxygen's formal charge is too positive**) – this was the point of the question. Although you were not expected to know this, better structures for this are:



18b. 9(5 points) In the molecule NOCl, what is the bond order of the NO bond?

- (a) 4 (b) 3 (c•) 2 (d) 1 (e) 0

19b. 9(5 points) Predict the enthalpy H_{rxn} of the following reaction:



Bond Energies

$D_{\text{C-H}}$	= 413 kJ/mol
$D_{\text{C-O}}$	= 358 kJ/mol
$D_{\text{O-O}}$	= 146 kJ/mol
$D_{\text{O=O}}$	= 498 kJ/mol
$D_{\text{C-C}}$	= 346 kJ/mol

- (a) -1,202 kJ/mol (b•) +224 kJ/mol (c•) -486 kJ/mol
 (d•) -128 kJ/mol (e) +1,202 kJ/mol

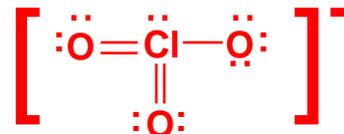
$$\begin{aligned} H &= 6 \times (\text{C-H}) + 2 \times (\text{CO}) - [(\text{O=O}) + 6 \times (\text{C-H}) + 2 \times (\text{C-C})] = \\ &= 2 \times (\text{CO}) - [(\text{O=O}) + 2 \times (\text{C-C})] = \\ &= 2 \times (358) - [(498) + 2 \times (346)] \text{ kJ/mol} = -474 \text{ kJ/mol} \end{aligned}$$

Whoops! Error on the exam. The three closest answers (in absolute value) will be counted as correct...

20b. 9(5 points) What is the (molecular) geometry for the chlorate anion, ClO_3^- ?

- (a) linear (b) bent (c •) trigonal pyramid (d) triangular-planar (e) tetrahedral

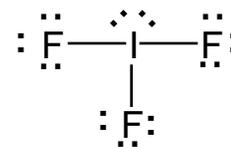
The structure at right shows one resonance form for this molecule. The other forms should be obvious. There are 4 "groups" of electrons around Cl, resulting in a tetrahedral electron-pair geometry. One is a lone pair, resulting in a trigonal pyramid molecular geometry.



21b. 9(5 points) What is the molecular geometry of IF_3 (I is at the center)?

- (a •) T-shaped (b) trigonal pyramid (c) tetrahedral
(d) triangular-bipyramidal (e) trigonal planar

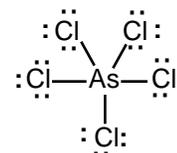
The structure at right shows that there are 5 "groups" of electrons around I, resulting in a trigonal bipyramid electron-pair geometry. Two are lone pairs, resulting in a T-shaped molecular geometry.



22b. 9(5 points) What is the molecular geometry of AsCl_5 (As is at the center)?

- (a) T-shaped (b) octahedral (c •) trigonal-bipyramidal
(d) tetrahedral (e) trigonal pyramid

The structure at right shows that there are 5 "groups" of electrons around As, resulting in a trigonal bipyramid electron-pair geometry. There are no lone pairs, resulting in a trigonal bipyramid molecular geometry.



23b. 9(5 points) Which molecule below is **not** polar?

- (a) H_2O (b) IF (c •) CCl_4 (d) NH_3
(e) they are all polar

24b. 9(5 points) In which molecule below are the bonds **most** polar?

- (a) CH_4 (b) H_2 (c •) H_2O (d) NH_3 (e) O_2

You have version **2** of the exam. Place **2** in column **K** of your answer sheet.

Exam 3

Chem 111, Section 2 (10:10 am)

Fall 1998

Remember:

As a homework assignment, you may earn up to 10% of the points you missed on this exam (eg., if you scored a 60 on the exam, you can earn up to an extra 4 points), by doing the following:

- 1) Pick up an extra Op-Scan sheet when you turn in your exam.
- 2) Work through all of the problems at home (consultation with others is OK, but you should answer the questions yourself). Answer all of the questions. Turn in the Op-Scan sheet in class on Monday, November 23 (***no later!***).

Your revised exam will be scored and credit applied proportional to the total number of questions answered correctly. Complete the exam exactly as you did previously (except with all correct answers, of course!).

Answers and scores for the original exam will be available by November 23, after the deadline for turning exam re-takes in. Check our home page.