

City College, Chemistry Department
Chemistry 10301, sections L and L2, Prof. T. Lazaridis
Third Midterm exam, Dec 4, 2001

Name (last name first): _____

I.D. Number: _____

Workshop leader: _____

Note: There are 7 questions in this exam. Fill in your answer in the blank space provided immediately following each question. One point will be subtracted every time you report a numerical result with an incorrect number of significant figures.

Useful data: Speed of light : 2.9979×10^8 m/s
 Planck's constant : 6.626×10^{-34} Js
 $E_n = -2.179 \times 10^{-18} \text{ J/n}^2$

1. The electron in a hydrogen atom drops from the excited state with $n=3$ to the ground state, emitting a photon.
a. (5) What is the energy of this photon?

$$\Delta E = -2.179 \times 10^{-18} \text{ J} \times \left(\frac{1}{1^2} - \frac{1}{3^2} \right) = -1.937 \times 10^{-18} \text{ J}$$

- b. (5) What is the wavelength of this photon?

$$\Delta E = h \nu = h c / \lambda \Rightarrow \lambda = 1.026 \times 10^{-7} \text{ m} = 102.6 \text{ nm}$$

- c. (5) How many electrons in an atom can have principal quantum number $n=3$?

$$2n^2 = 18$$

or by considering the possible values for l, m, m_s :

$l=0$	$m=0$	$m_s = +1/2, -1/2$
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$l=1$	$m=-1$	$m_s = +1/2, -1/2$
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	$m=0$	$m_s = +1/2, -1/2$
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	$m=+1$	$m_s = +1/2, -1/2$
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$l=2$	$m=-2$	$m_s = +1/2, -1/2$
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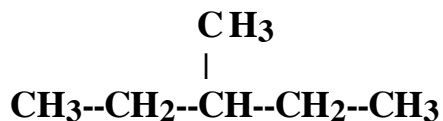
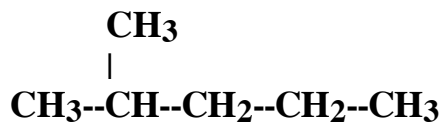
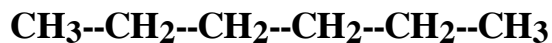
	$m=-1$	$m_s = +1/2, -1/2$
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	$m=0$	$m_s = +1/2, -1/2$
--	-------	--------------------

	$m=+1$	$m_s = +1/2, -1/2$
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	$m=+2$	$m_s = +1/2, -1/2$
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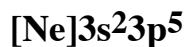
2. a. (5) Write three structural isomers of hexane (C₆H₁₄).



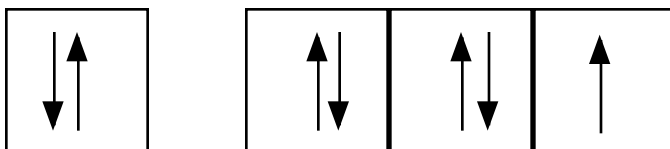
- b. (5) Write the following bonds in order of increasing polarity:
C-C, C-N, C-O



3. a. (4) Write the ground state configuration of chlorine using a noble gas core



- b. (3) Draw an orbital diagram for this atom



- c. (3) Is Cl diamagnetic or paramagnetic?

Paramagnetic

4. a. (4) What is the electron configuration of Ni²⁺ ?



b. (4) What is the electron configuration of S^{2-} ?

Same as that of Ar: [Ar] ($1s^2 2s^2 2p^6 3s^2 3p^6$)

c. (2) Which one is larger in size, S or S^{2-} ?

S^{2-}

5. a. (5) Write Zr, V, and Mn in order of increasing atomic radius

Mn < V < Zr

b. (5) Write O, N, P in order of increasing ionization energy

P < N < O

c. (5) Write the atoms O, F, S in order of increasing electronegativity

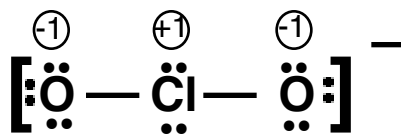
S < O < F

6. a. (15) Draw two Lewis structures for the chlorite ion (ClO_2^-), one satisfying the octet rule and one with the least formal charge. Indicate the formal charge on each of the atoms.

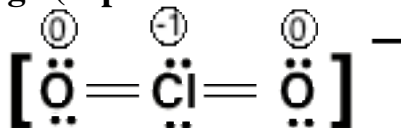
Valence electrons: $7+6+6+1 = 20$

Skeleton: 4 Remaining: 16 For octet rule need: 16

Octet rule:



Least formal charge (expanded octet on Cl):



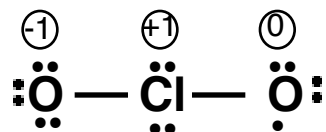
b. (5) What is the geometry of this ion (tetrahedral, linear, trigonal, etc) and the approximate value of the O-Cl-O bond angle?

**4 VSEPR pairs around Cl ---> tetrahedral arrangement
2 bonds and 2 lone pairs ---> bent geometry**

Approximate O-Cl-O angle: 109.5 degrees

c. (5) Chlorine dioxide gas (ClO₂) was recently proposed as a substance that can kill anthrax bacteria. Propose a Lewis structure for it.

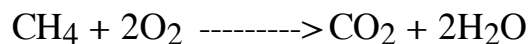
**This has one electron less than chlorite. One possible
Lewis structure:**



d. (5) Which one is a free radical, ClO₂ or ClO₂⁻ ?

ClO₂

7. (10) Estimate the enthalpy of the following reaction using the bond energies for C-H (413 kJ/mol), O=O (498.3 kJ/mol), C=O (802 kJ/mol), and O-H (463 kJ/mol).



$$\begin{aligned} \Delta H &= \text{bonds destroyed} - \text{bonds forming} = 4 \text{ CH} + 2 \text{ OO} - 2 \text{ CO} - 4 \text{ OH} \\ &= -807.4 \text{ kJ} \end{aligned}$$