

CHM1311 D: Principles of Chemistry (Prof. N. Goto)

Assignment #8

Due Dec 4<sup>th</sup>, at the beginning of class. Late assignments will not be accepted.

Assignments can be submitted individually, or by groups of up to 4 students.

1) Last Name: \_\_\_\_\_ First Name: \_\_\_\_\_ Student ID: \_\_\_\_\_

2) Last Name: \_\_\_\_\_ First Name: \_\_\_\_\_ Student ID: \_\_\_\_\_

3) Last Name: \_\_\_\_\_ First Name: \_\_\_\_\_ Student ID: \_\_\_\_\_

4) Last Name: \_\_\_\_\_ First Name: \_\_\_\_\_ Student ID: \_\_\_\_\_

Solutions must be written legibly in the space provided. Adequate detail to the calculation (including units, appropriate sig figs) must be provided to make it possible for other students to understand how you arrived at the final solution. If more space is needed, use the back of the page. Do not add extra pages, as they will not be marked. Assignment pages must be stapled together.

**NOTE:** For each question a hint, reference to an Office Hours video, or an Interactive LearningWare (ILW) problem in WileyPLUS is given in brackets.

**Question 1. (Video 4.36)**

List all the valid set of quantum numbers for a 3p electron. (2 marks)

$n$	$l$	$m_l$	$m_s$
3	1	1	$\pm \frac{1}{2}$
3	1	0	$\pm \frac{1}{2}$
3	1	-1	$\pm \frac{1}{2}$

**Question 2.**

Complete the table below: (4 marks)

	$n$	$l$	$m_l$	$m_s$	Allowed state? (Y or N)	If not allowed, why not? If allowed, give orbital. (s, p, d, f)
a)	3	1	2	$\frac{1}{2}$	N	$m_l$ CAN'T BE GREATER THAN $l$
b)	4	3	-2	$-\frac{1}{2}$	Y	4f
c)	5	5	4	$\frac{1}{2}$	N	THE HIGHEST VALUE THAT CAN BE ASSIGNED TO $l$ IS $n-1=4$
d)	6	1	-1	$-\frac{1}{2}$	Y	6p

**Question 3. (Similar to 4.25. Solution is on-line in solution manual)**Determine the wavelength that hydrogen atoms emit in the transition from  $n=4$  back to the ground state. In what region of the electromagnetic spectrum do these photons lie? (4 marks)

$$\Delta E = -2.18 \times 10^{-18} \text{ J} \left( \frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

$$= -2.18 \times 10^{-18} \text{ J} \left( \frac{1}{1^2} - \frac{1}{4^2} \right)$$

$$= -2.04 \times 10^{-18} \text{ J}$$

$$\Delta E = h\nu = \frac{hc}{\lambda} \quad \lambda = \frac{hc}{\Delta E}$$

$$= \frac{(6.626 \times 10^{-34} \text{ J}\cdot\text{s})(2.998 \times 10^8 \text{ m/s})}{2.04 \times 10^{-18} \text{ J}}$$

$$= 9.72 \times 10^{-8} \text{ m} = 97.2 \text{ nm}$$

ULTRAVIOLET  
LIGHT



**Question 6. (ILW 5.15)**

For the species below:

- i) Write the complete electron configuration.  
 ii) Is the shell completely occupied?  
 iii) If the shell is not full, write the quantum number for one of the outermost (and therefore most reactive) valence electrons.

(7 marks)

a) O

 $1s^2 2s^2 2p^4$ , SHELL IS NOT COMPLETELY OCCUPIED  
 $n=2, l=1, m=\pm 1, 0, m_s = \pm \frac{1}{2}$ 
b)  $Cl^-$ 
 $1s^2 2s^2 2p^6 3s^2 3p^6$  FULL SHELL

c) F

 $1s^2 2s^2 2p^5$  SHELL IS NOT COMPLETELY FULL  
 $n=2, l=1, m=\pm 1, 0, m_s = \pm \frac{1}{2}$ 
d)  $Mg^{2+}$ 
 $1s^2 2s^2 2p^6$  FULL SHELL

e) Cr

 $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$  SHELL IS NOT COMPLETELY FULL  
 $n=3, l=2, m=\pm 2, \pm 1, 0, m_s = \pm \frac{1}{2}$ 
**Question 7 (Video 5.19)**

Consider the following hypothetical configurations for a chlorine atom: (6 marks)

- 1)  $1s^2 2s^2 2p^6 3s^3 3p^4$
- 2)  $1s^2 2s^2 2p^6 3s^1 3p^6$
- 3)  $1s^2 2s^2 2p^6 3s^2 2d^5$
- 4)  $1s^2 2s^2 2p^6 3s^2 3p^5$
- 5)  $1s^2 2s^2 2p^6 3s^2 3p^6$
- 6)  $1s^2 2s^2 2p^7 3s^2 3p^6$

Indicate the number for the configuration(s) with:

a) nonexistent orbitals 3

b) a state that is forbidden by the Pauli Exclusion Principle 1, 6

c) an excited state 2

d) the correct ground state configuration for the neutral atom 4

e) the correct ground state configuration for the most stable charged state of chlorine.

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**Question 8. (ILW 6.21, video 6.45)**

For each of the species below: (24 marks)

- i) Draw the Lewis structure.
- ii) What is the formal charge on each atom?
- iii) What is the electron group geometry?
- iv) What is the molecular shape?
- v) What are the ideal bond angles?
- vi) Is this a polar molecule? If so, draw the net dipole for the molecule.

a)  $\text{SO}_3^{2-}$

VALENCE  $e^-$   
 S: 6  
 3 O:  $6 \times 3$   
 $2e^- : 2$   


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CHARGED

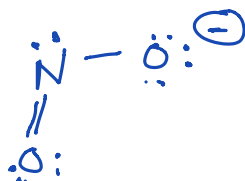
E.G. GEOMETRY = TETRAHEDRAL  
 MOLECULAR SHAPE  
 = TRIGONAL PYRAMIDAL  
 IDEAL BOND ANGLES  
 =  $109.5^\circ$

b)  $\text{NO}_2^-$

VALENCE  $e^-$   
 N: 5  
 2 O:  $6 \times 2$   
 $1e^- : 1$   


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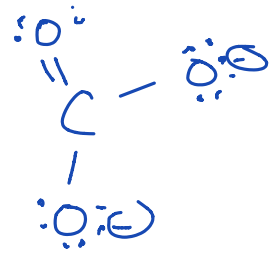
ELECTRON GROUP GEOMETRY  
 = TRIGONAL PLANAR  
 MOL. SHAPE = BENT  
 IDEAL BOND ANGLES  
 $120^\circ$

c)  $\text{CO}_3^{2-}$

VALENCE  $e^-$   
 C: 4  
 3 O:  $6 \times 3$   
 $2e^- : 2$   


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 24  $e^-$



CHARGED

ELECTRON GROUP GEOMETRY = MOL.  
 SHAPE = TRIGONAL PLANAR  
 IDEAL BOND ANGLES  
 $120^\circ$

d)  $\text{ClF}_3$

VALENCE  $e^-$   
 Cl: 7  
 F:  $7 \times 3$   


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 28  $e^-$



POLAR

ELECTRON GROUP GEOMETRY =  
 TRIGONAL BIPYRAMIDAL  
 MOL. SHAPE = T-SHAPE  
 IDEAL BOND ANGLE =  $90^\circ$