CHM1311 D: Principles of Chemistry (Prof. N. Goto)
Assignment #8
Due Dec 5th, 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 4d electron. (2 marks)

n	l	m_l	m_s
4	0	0	$\pm\frac{1}{2}$
4	1	-1	$\pm\frac{1}{2}$
4	1	0	$\pm\frac{1}{2}$
4	1	+1	$\pm\frac{1}{2}$
4	2	+2	$\pm\frac{1}{2}$
4	2	+1	$\pm\frac{1}{2}$
4	2	0	$\pm\frac{1}{2}$
4	2	-1	$\pm\frac{1}{2}$
4	2	-2	$\pm\frac{1}{2}$

CHM1311 D - Assignment #8 **Student ID (first student only): _______________**

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	0	½	Y	3p
b)	4	1	2	-½	N	m_l CAN'T BE GREATER THAN l
c)	5	3	-2	½	Y	4f
d)	4	4	2	-½	N	THE HIGHEST VALUE THAT CAN BE USED FOR l IS $n-1$. (3 IN THIS CASE)

Question 3. (Similar to 4.25. Solution is on-line in solution manual)
Determine the wavelength that hydrogen atoms emit in the transition from the n=5 to the n=2 level. In what region of the electromagnetic spectrum do these photons lie? (4 marks)

INITIAL FINAL

$$\Delta E = -2.18\times10^{-18}\,J\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$= -2.18\times10^{-18}\,J\left(\frac{1}{2^2} - \frac{1}{5^2}\right)$$

$$= -4.58\times10^{-19}\,J$$

$$\Delta E = h\nu = h\frac{c}{\lambda}$$

$$\lambda = \frac{hc}{\Delta E} = \frac{(6.626\times10^{-34}\,J\cdot s)(2.99\times10^{8}\,m/s)}{4.58\times10^{-19}\,J}$$

$$= 4.33\times10^{-7}\,m$$

$$= 433\,nm$$

⇒ THIS IS IN THE VISIBLE RANGE (AT THE EDGE) - VIOLET

CHM1311 D - Assignment #8 **Student ID (first student only): _______________**

Question 4. (Video 4.85)

The emission of photons at a single wavelength by elements such as helium and argon has been used to create lasers with a wide range of practical applications. For example, argon-ion lasers are used to visualize fluorescent molecules in cells by fluorescence microscopy. If an argon-ion laser emits 25 mJ/s of light at 488 nm, how many photons will be emitted in one minute? (4 marks)

ENERGY OF 1 PHOTON

$$\Delta E_{PHOTON} = h\nu = h\frac{c}{\lambda}$$

$$= \frac{(6.626 \times 10^{-34}\ J \cdot s)(2.99 \times 10^{8}\ m/s)}{488\ nm \times 10^{-9}\ m\ nm^{-1}}$$

$$= 4.06 \times 10^{-19}\ J$$

IN 1 MIN THE LASER EMITS

$$25\ mJ/s \times 10^{-3}\ \frac{mJ}{J} \times 60\ \frac{s}{min}$$

$$= 1.5\ \frac{J}{min}$$

NUMBER OF PHOTONS = $\frac{\text{TOTAL ENERGY EMITTED}}{\text{ENERGY PER PHOTON}}$

$$= \frac{1.5\ J}{4.06 \times 10^{-19}\ J/PHOTON}$$

$$= 3.69 \times 10^{18}\ \text{PHOTONS}$$

Question 5.

For the two ions below, draw partial orbital diagrams and Indicate whether each species is paramagnetic or diamagnetic. If it is paramagnetic, what is the net spin? (3 marks)

i) Fe^{2+}

↑↓ ↑ ↑ ↑ ↑

3d

PARAMAGNETIC

NET SPIN = $4 \times \frac{1}{2} = 2$

ii) Cd^{2+}

↑↓ ↑↓ ↑↓ ↑↓ ↑↓

4d

DIAMAGNETIC

NOTE: SINCE BOTH OF THESE ARE IONS OF TRANSITION METALS, THE ENERGY OF THE OUTER d-ORBITALS WILL BE LOWER THAN THE s-ORBITAL ENERGY

CHM1311 D - Assignment #8 **Student ID (first student only): _______________**

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) S $1s^2 2s^2 2p^6 3s^2 3p^4$ THE SHELL IS NOT COMPLETELY OCCUPIED
$n = 3$, $l = 1$, $m_l = +1, 0$ OR -1 $m_s = \frac{1}{2}$ OR $-\frac{1}{2}$

b) Na^+ $1s^2 2s^2 2p^6$ THE SHELL IS COMPLETELY OCCUPIED

c) F^- $1s^2 2s^2 2p^6$ THE SHELL IS COMPLETELY OCCUPIED

d) Al^{3+} $1s^2 2s^2 2p^6$ THE SHELL IS COMPLETELY OCCUPIED

e) Cu
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$ THE SHELL IS NOT COMPLETELY OCCUPIED
$n = 3$ $l = 2$ $m_l = -2, 1, 0, 1$ OR 2 $m_s = \frac{1}{2}$ OR $\frac{1}{2}$

Question 7 (Video 5.19)
Consider the following hypothetical configurations for a sodium atom: (6 marks)

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

Indicate the number for the configuration(s) with:

a) nonexistent orbitals
5

b) a state that is forbidden by the Pauli Exclusion Principle
2, 3

c) an excited state
1

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

e) the correct ground state configuration for the the most stable charged state of sodium.
6

CHM1311 D - Assignment #8 **Student ID (first student only): _______________**

Question 8. (ILW 6.21, video 6.45)

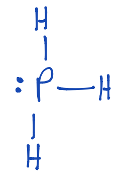
For each of the species below:

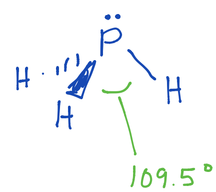
i) What is the total number of valence electrons?
ii) Draw the Lewis structure.
iii) What is the molecular shape?
iv) What are the ideal bond angles?
v) Is this a polar molecule? If so, draw the net dipole for the molecule.

a) PH_3

SHAPE = TRIGONAL PYRAMIDAL

P : 5e−
H : 1e− x3
TOTAL VALENCE ELECTRONS = 8
− 6 (BONDS)
− 2 (FILL P)
0



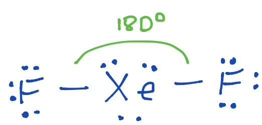


$\chi_P = \chi_H$ ∴ BONDS ARE NOT POLAR
∴ COMPOUND IS NOT POLAR

FORMAL CHARGE IS 0 FOR H AND P

b) XeF_2

VALENCE e : Xe 8e−
2 F 14e−
TOTAL 22e−
− 4e− (BONDS)
− 12e− (FILL F)
− 6e− (FILL Xe)
∅



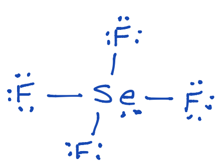
SHAPE = LINEAR

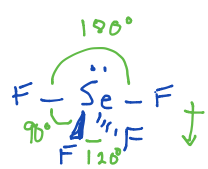
BOND DIPOLES CANCEL EACH OTHER OUT
∴ NON-POLAR

FORMAL CHARGE IS ∅ FOR Xe AND F

c) SeF_4

VALENCE e−
Se : 6e
F : 7e x4
TOTAL 34 e−
−8 e− (BONDS)
−24e− (FILL F)
−2e (PUT REMAINING e− ON Se)
∅





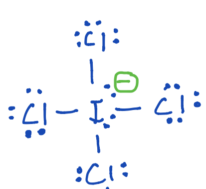
MOLECULAR SHAPE IS SEE-SAW

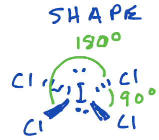
AXIAL BOND DIPOLES CANCEL EACH OTHER OUT, EQUATORIAL DIPOLES CREATE NET DIPOLE

FORMAL CHARGE ON F AND Se IS ZERO

d) ICl_4^-

VALENCE e−
I : 7e−
Cl : 7e− x4
−1 CHARGE : 1e−
TOTAL 36e−
−8e− (BONDS)
−24e− (FILL Cl)
4e− (ADD REMAINING e− TO Cl)
∅





SHAPE IS SQUARE PLANAR

- BOND DIPOLES CANCEL EACH OTHER OUT
- NO NET BOND DIPOLE
- COMPOUND IS CHARGED, SO NET CHARG ACTUALLY MAKES IT POLAR
- FORMAL CHARGE ON Cl IS ZERO AND −1 ON I