

CH 231 Quest Review 2

1) A list of elements is provided:

Al P Ar Kr Ca S K Li B C

- a) What is effective nuclear charge? Describe the trend for **effective nuclear charge** and order the following in terms of increasing Z_{eff} ?
- b) From the same list as above, describe the trend in **electronegativity** and order the elements by increasing electronegativity.

2) Rank the following in terms of increasing atomic **radii**:

Ga^{2+} Ga N K^+ Li Be O^{2-} Cr

3) In James's Electroceramics Research Group, he is working on creating capacitors for cellphones. To prepare his ceramic, he writes the composition of each compound he needs in his notebook by their chemical formula. A new undergrad student is trying to recreate his sample but realizes the chemical bottles are identified by their chemical name. Help this student out by writing out the **chemical name** of each sample needed to prep.

Precursor written in James' Notebook:	What should the bottle that the student is looking for say?
BaCO_3	
TiO_2	
CeO_2	
NdO_3	
$\text{Pt}(\text{SO}_4)$	

4) Similarly, in the Subramanian Research group, James is working on solid-state synthesis of double perovskites that requires a selection of certain metal compounds. Write out the **chemical formulas**.

Labeled	Written in notebook:
Sodium Carbonate	
Iron (IV) Oxide	
Bismuth (III) nitrate	
Niobium tetroxide	
Calcium Hydroxide	
Phosphoric Acid	

5) Provide the **bond angles** for a molecule with molecular geometry of:

Bent	Square Planar	Tetrahedral	Octahedral
Trigonal Pyramidal	Trigonal Bipyramidal	Linear	T-shaped

CH 231 Quest Review 2

1) Toluene (C_7H_8) has a density of 8.65 g/ml. What volume in liters of toluene should be used if James has 5.4 moles of it?

2) Give 2 examples of cations that will have the ground state electron of each:

$[Kr]4d^6$

$[Ar]4s^23d^7$

$[Ar]3d^{10}$

Vanadium(III)

Cobalt(II)

3) Draw the orbital diagrams for:

Nitrogen

O^{2-}

Lithium

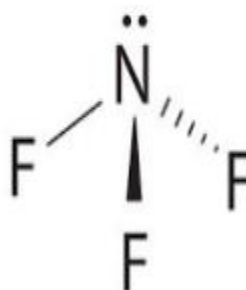
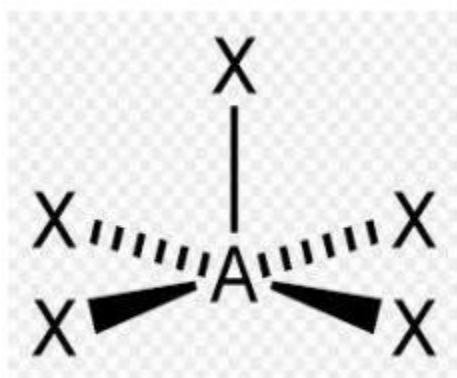
Ca^{2+}

Cu

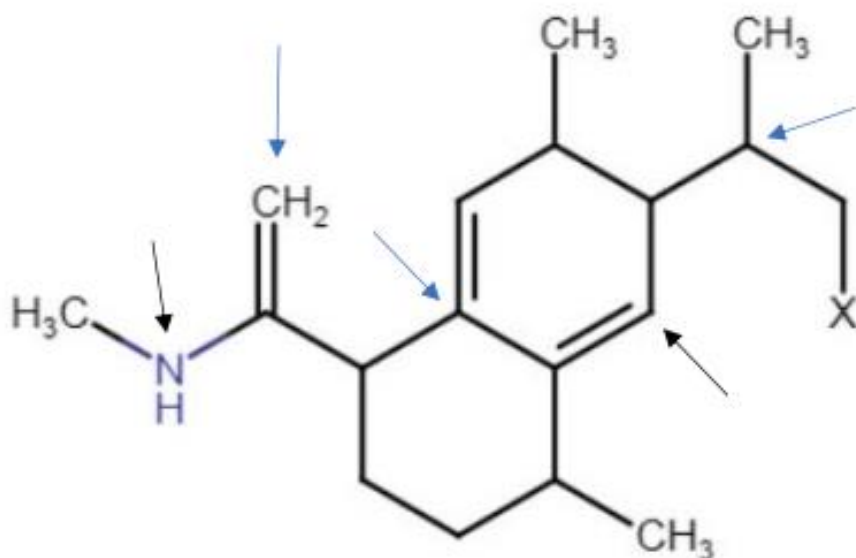
4) What is the mass percent of Cl in dichloromethane? (CH_2Cl_2)

What is the mass percent of oxygen in glucose? ($C_6H_{12}O_6$)

5) Identify the electron geometry, molecular geometry, and bond angles of the following molecule:



6) James synthesizes a new organic compound in his dormitory. The compound has a molecular formula that contains one new element, X, located at the end as a substituent.



**Reminder that for organic molecules, a sp^3 hybridization is preferred to be formed between carbons whenever possible by implied hydrogens unless otherwise noted. Carbons attachments are applied at the end and between every new line unless noted otherwise.

- For all of atoms that have an arrow pointing to it, label the **hybridization**.
 - Joey says that for every methyl group, an ending chain with a CH_3 attachment, contains a sp^3 hybridization that correlates with an electron geometry of trigonal planar and molecular geometry of tetrahedral. Is Joey right with his description? Explain why or why not.
 - How many **sigma and pi bonds** are in this compound?
 - Label **the electron geometries and molecular geometries** of the arrowed atoms from above.
 - Substituent X has a density when in liquid phase of 0.056kg/m^3 . When 100 moles of X is condensed into a solid, it measures to a length of 350 cm by 754 cm by 669 cm. What is the mass in kg of 100 moles of X? What is X's molar mass?
- When this new molecule, named Jamesonium, is reacted with ammonia, a strong conjugate base and nucleophile, a second order nucleophilic substitution reaction (SN_2) occurs that expels the X alkyl group. To catalyze this reaction, heat is applied, and X is energized into its excited state as an ion. The **electron configuration** for X at this moment is $[\text{Ar}]3d^5$.
- Give two examples of an elemental cation that would have the same configuration as X.

CH 231 Quest Review 2

When X leaves its excited state, a proton is emitted at a speed of 124 km/hr.

g) What is the **wavelength**, in nm, for this proton? (mass of proton is 1.672×10^{-24} g)

h) What is the total **energy** of 1 mole of this proton in kJ/mol?

Once atom X has returned from its excited state to ground state, it is finally extracted from Jamesonnum. James the Impostor sends an electric current in a closed vessel containing solely of X and records the successive **ionization energies** required for X to eject an electron. From this technique, properties of the atom can be determined.

First Ionization Energy	1649 kJ/mol
Second Ionization Energy	1426 kJ/mol
Third Ionization Energy	1715 kJ/mol
Fourth Ionization Energy	2075 kJ/mol
Fifth Ionization Energy	2750 kJ/mol
Sixth Ionization Energy	3109 kJ/mol
Seventh Ionization Energy	66598 kJ/mol
Eighth Ionization Energy	70134 kJ/mol
Ninth Ionization Energy	72513 kJ/mol

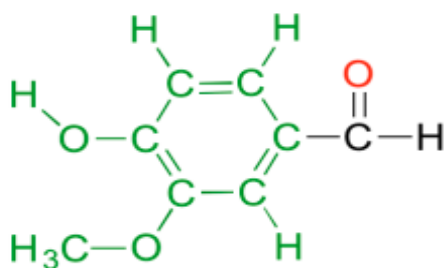
i) In which group on the periodic table does element X belong?

7) James finds that in a new organic compound he synthesizes, it contains 76.54% carbon and balance element Z, which has a molar mass of 0.02207 kg/kmol. What is the **empirical formula** of ZC?

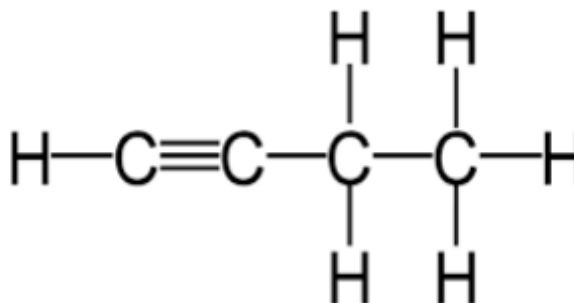
8) For each of the following, draw the **most stable Lewis Structure**, and provide the total number of valence electrons, total bonding sites, total lone pairs, formal charges on all atoms, and the bond angles of the molecule:



3) The condensed structures of vanillin, the natural flavoring of vanilla, and 1-butyne, a flammable colorless gas, are shown below.



vanillin



1-butyne

a) Designate the number of sigma bonds and pi bonds in vanillin and 1-butyne.

b) How many grams of carbon are in 24.5 grams of vanillin?

4) James wants to represent a new molecule, named Jamesonium, as a Lewis structure. Jamesonium can simply be written as XPZ^- where:

X has an electronegativity of 1.8

Z has an electronegativity of 2.5

P has an electronegativity of 2.0

In this universe,

X has similar properties to carbon

Z is in period 5

P has 6 valence electrons

Draw all resonance structures of XPZ^- and explain which one is the most stable and why.

5) Give the number of electrons in π^* orbitals, bond order, and state whether the following molecules would be paramagnetic/diamagnetic and if it were a likely structure to exist:

NO^+

SCL^+

Bonus

1) Answer the following questions using principles of atomic and molecular structure. The elements in the table below (W, X, Y, and Z) are actual elements found in either period 2 or 3 in the periodic table.

Element	1 st IE kJ/mol	2 nd IE kJ/mol	3 rd IE kJ/mol	4 th IE kJ/mol
W	520	7298	11815	
X	900	1757	14850	21000
Y	801	2428	360	25000
Z	496	4562	6910	9543

- Which of the elements listed above has a valence electron configuration of $3s^1$? Justify your answer.
- For element Z, identify the core electrons and valence electrons
- Which of the elements listed above is an alkaline earth metal? Explain.
- Which of the elements listed above has the largest atomic radius? Explain.
- Which element, X or Y has more protons? Assume both have the same principal valence energy level.

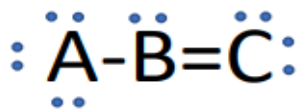
3) Professor James is grading Final exam free responses. While grading, he sees Mark answer the following question:

Draw the most likely Lewis Structure for ABC where electronegativities are such that $A < B < C$ and

A: 6 valence electrons

B: 5 valence electrons

C: 5 valence electrons



Score /5

What grade should James give Mark? Consider the following grade scale and draw the correct structure so that Mark hopefully learns.

Wrong central atom (-1) incorrect number of valence electrons (-1) Does not follow octet where needed (-1) Not the most stable (-1) formal charges not correctly assigned to most stable atom (-1)

3) James analyzes a compound containing the elements C, H, N, and O. When a 1.2359 g sample is burned in excess oxygen, 2.241 g of CO_2 (g) is formed. The combustion analysis also showed that the sample contained 0.0648 g of H. When the compound is analyzed for N content only, James finds that the mass percent of N is 28.84 percent. Determine the **empirical formula** of the original combusted sample.