

1. (5 points) Names and Formulas of Common Compounds and Ions

Ammonium nitrate	
Aluminum hydroxide	
	Na_2CO_3
Copper(I) oxide	
Sulfur trioxide	

MOSTLY ABOUT COPPER CHEMISTRY

1. (12 points) Copper is a (metal)(metalloid)(nonmetal) _____ with a symbol of _____ and an atomic number of _____. It is in Group _____ and period _____ of the periodic table. The element has _____ protons in the nucleus. A copper(II) ion has _____ electrons outside of the nucleus.

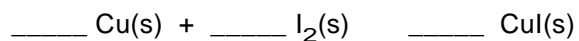
The electron configuration for a copper atom is (use the spectroscopic notation and the noble gas notation)

The electron configuration for the copper(II) ion (Cu^{2+}) is

If copper-63 is the most abundant isotope of the element, an atom of this isotope has _____ neutrons in the nucleus.

2. (11 points) When copper reacts with iodine, it forms CuI.

a) Balance the following equation



b) If you used 2.36 g of copper, how many moles is this?

i) 26.9 mol

ii) 2.36 mol

iii) 0.424 mol

iv) 0.037 mol

c) Copper metal has a density of 8.96 g/cm³. If you use 50.0 g of copper, this amounts to

_____ cm³ of the metal.

d) If you use 0.20 mol of copper, what mass of iodine, I₂, is required to completely consume the metal and form CuI?

i) 25.38 g

ii) 50.8 g

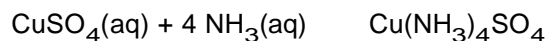
iii) 101.5 g

iv) 126.9 g

3. (4 points) Identify each of the following reactions as an *acid-base* reaction, a *precipitation* reaction, a *gas-forming* reaction, or a *redox* reaction.

$\text{CuCl}_2 + \text{Na}_2\text{CO}_3 \rightarrow \text{CuCO}_3 + 2 \text{NaCl}$	
$\text{Cu} + 2 \text{AgNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2 \text{Ag}$	
$\text{Cu}(\text{OH})_2 + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + 2 \text{H}_2\text{O}$	
$\text{CuCO}_3 + 2 \text{HCl} \rightarrow \text{CuCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$	

4. (6 points) The reaction you recently did in the lab was



If you used 10.0 g of CuSO_4 (molar mass = 159.5 g/mol), what volume of 3.0 M $\text{NH}_3(\text{aq})$ is required to completely consume the CuSO_4 ?

- a) 10.0 mL
- b) 20.0 mL
- c) 83.6 mL
- d) 750. mL

If you isolated 12.6 g of $\text{Cu}(\text{NH}_3)_4\text{SO}_4$, but the theoretical yield was 15.0 g, what was the percentage yield of $\text{Cu}(\text{NH}_3)_4\text{SO}_4$?

- a) 12.6 %
- b) 15.0 %
- c) 18.9 %
- d) 84.0 %

5. (3 points) In the industrial production of copper metal, copper(I) oxide (143.1 g/mol) reacts with copper(II) sulfide (159.1 g/mol).



If you combine 500.0 g of Cu_2O and 500.0 g of Cu_2S , what is the theoretical yield of Cu?

- a) 500. g
- b) 665 g
- c) 1000 g
- d) 1197 g
- e) 1330 g
- f) Not a one of these answers is correct!

6. (3 points) Describe each compound below as *soluble* or *insoluble* in water.

a) CuCO_3 _____

c) CuBr_2 _____

d) $\text{Cu}_3(\text{PO}_4)_2$ _____

6. (3 points) A compound with the *empirical formula* KCuCl_3 has been isolated. Its molar mass is 418 g/mol. What is the *molecular formula* of the compound?

- a) KCuCl_3
- b) $\text{K}_2\text{Cu}_2\text{Cl}_6$
- c) $\text{K}_3\text{Cu}_3\text{Cl}_9$
- d) None of the above.

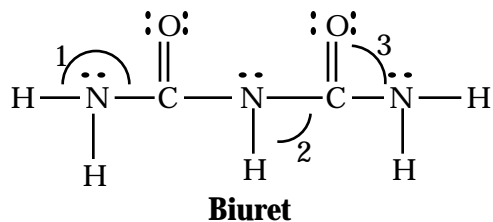
7. (3 points) Bubbling CO through a solution of CuCl in concentrated HCl, gives the compound $\text{Cu}(\text{CO})\text{Cl}$.



The reaction can be used to estimate the CO content of gases. Let us say you want to determine the CO content of the exhaust gas from your car. You use 100 L of exhaust gas and isolate from it 11.16 g of $\text{Cu}(\text{CO})\text{Cl}$ (molar mass = 127 g/mol). How many grams of CO did the 100 L of exhaust gas contain?

- a) 2.46 g
- b) 9.63 g
- c) 100. g
- d) None of the above. My car does not emit CO!

8. (6 points) Copper ion forms complexes with many organic and inorganic molecules and ions. One is with biuret, and the result is a beautiful violet material.



a) What are the angles indicated on the molecule's structure?

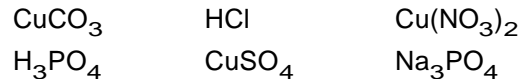
$$1 = \underline{\hspace{2cm}} \quad 2 = \underline{\hspace{2cm}} \quad 3 = \underline{\hspace{2cm}}$$

b) How many bonds are there in the molecule? _____

c) What is the weight percent of N in the molecule?

- i) 13.6 %
- ii) 23.3 %
- iii) 40.8 %
- iv) 73.6 %

9. (2 points) You wish to prepare copper(II) phosphate. Use some combination of the compounds below to make this compound.



Describe your approach by writing a *complete*, balanced equation.

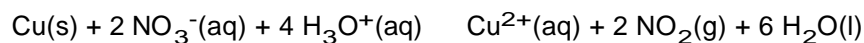
10. (3 points) You need 100. mL of 0.15 M CuSO_4 . You are given 1.00 L of 0.60 M CuSO_4 and the necessary glassware. Describe how you would prepare the desired solution.

11. (6 points) You have synthesized a compound with the formula $\text{Li}_n\text{CuH}_{n+1}$. To find the value of n , you react the compound with acid. For example, if $n = 1$, then the reaction is

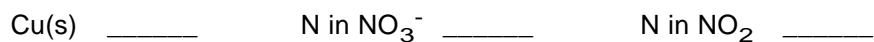


If you analyze the solution for copper ion, and know that $n = 1$ or 2, you can find the formula for the compound. If 0.200 g of $\text{Li}_n\text{CuH}_{n+1}$ (where $n = 1$ or 2) gives 10.0 mL of a solution with a Cu^{2+} concentration of 0.249 M, does $n = 1$ or 2? **Please show your work!**

12. (5 points) Copper metal reacts with nitric acid.



Assign oxidation numbers to



The substance that has been oxidized in the reaction is _____ and the oxidizing agent is _____

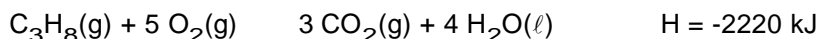
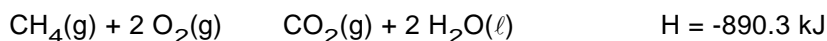
THERMOCHEMISTRY

1. (3 points) Suppose 81.0 J of heat energy is transferred into a copper bar with a mass of 16.44 g. The temperature of the bar increases from 20.0 °C to 32.8 °C. What is the specific heat capacity of the copper?

- a) 0.200 J/g·K
- b) 0.385 J/g·K
- c) 1.385 J/g·K
- d) 4.184 J/g·K
- e) None of the above

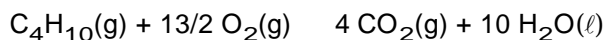
2. (2 points) Which requires more heat to warm from 22 °C to 85 °C, 50.0 g of water or 100.0 g of ethylene glycol. (Specific heat of glycol = 2.39 J/g·K and of water = 4.184 J/g·K)

3. (2 points) Methane (CH_4) and propane (C_3H_8) are used as fuels.



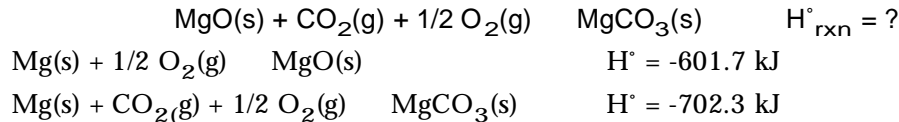
Which fuel provides more heat energy *per gram*, methane or propane? _____

4. (3 points) Use the table of standard enthalpies of formation in your textbook to calculate the enthalpy change for the combustion of 1.00 mol of butane, C_4H_{10} .



- a) $H^\circ_{\text{rxn}} = +200.7 \text{ kJ}$
- b) $H^\circ_{\text{rxn}} = -888 \text{ kJ}$
- c) $H^\circ_{\text{rxn}} = -4306 \text{ kJ}$
- d) $H^\circ_{\text{rxn}} = -5320 \text{ kJ}$
- e) Not a one of them!

5. (3 points) Using the enthalpy data below, and Hess's Law, calculate the standard molar enthalpy change for the formation of magnesium carbonate from MgO, CO₂, and O₂.



- (a) $\text{H}^\circ_{\text{rxn}} = +1304.0 \text{ kJ/mol}$
 (b) $\text{H}^\circ_{\text{rxn}} = -1304.0 \text{ kJ/mol}$
 (c) $\text{H}^\circ_{\text{rxn}} = +100.6 \text{ kJ/mol}$
 (d) $\text{H}^\circ_{\text{rxn}} = -100.6 \text{ kJ/mol}$
 (e) I don't think it is any of these. But then who knows!

ATOMS, ELECTRON CONFIGURATIONS, PERIODIC PROPERTIES

1. (3 points) ***Spectra and Radiation***

- a) Which color of light in the visible spectrum has the shortest wavelength? _____
 b) Which color of light in the visible spectrum has the lowest energy? _____
 c) Is the energy of red light higher or lower than that of x-rays in the dentist's office? _____

2. (4 points) Using the **spectroscopic notation** [e.g., 1s²2s²], write electron configurations for each of the following:

S (*do not use the noble gas notation for this case*)

Uranium

3. (4 points) Using the **orbital box notation**, write electron configurations for the following atoms or ions. *Please use the noble gas notation for both of these!*

Cl

V²⁺

4. (6 points) **Electron Configurations**

- a) What element has the electron configuration $[\text{Ar}] 3d^8 4s^2$? _____
- b) What element has a $2+$ ion with the configuration $[\text{Ar}] 3d^7$? _____
- c) How many unpaired electrons are there in a Mn^{2+} ion? _____
- d) Is a mercury(II) ion, Hg^{2+} , paramagnetic or diamagnetic? _____
- e) What $2+$ ions in the first series of transition elements (Sc through Zn) have two unpaired electrons? _____
- f) With what element is the $n = 4$ shell of electrons completed? _____

5. (9 points) **Atomic Structure**

- a) How many orbitals are there in a subshell labeled d ? _____
- b) How many orbitals are there in the $n = 4$ shell? _____
- c) For a $3d$ orbital, the value of n is _____ and the value of ℓ is _____.
- d) Indicate what type of orbital is illustrated below.



letter _____





- e) How many **electrons** can be associated with each of the following sets of quantum numbers?

Quantum Number Set	Number of Electrons
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$n = 4$ and $\ell = 1$	_____
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$n = 3, \ell = 2, m_\ell = -1$	_____
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6. (12 points) **Periodic Trends**

- a) Of the elements O, S, and F, which has the largest atomic radius? _____
- b) Which is larger, Cl or Cl⁻? _____
- c) What element in the alkali metal group has the largest radius? _____
- d) What element in the second period has the largest (most positive) electron affinity? _____
- e) What element in Group 3A has the largest ionization energy? _____
- f) Place the following elements in order of increasing ionization energy: B, Al, C

_____ lowest IE

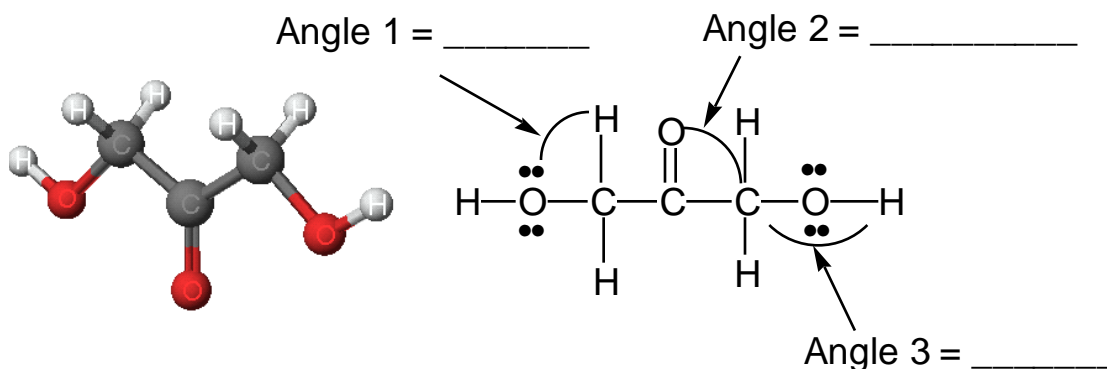
_____ highest IE

- g) Which ion is larger, Ca²⁺ or Cl⁻? _____
- h) Which of the following ions is (are) unlikely to exist: Ti⁵⁺, F³⁻, Al³⁺, Sr²⁺, Pt⁴⁺?

- i) Of the elements Na, O, F, Cl, which has the largest atomic radius _____ and which has the largest ionization energy? _____

STRUCTURE AND BONDING

1. (4 points) Geometry of molecules.



- a) Indicate the bond angles in the dihydroxyacetone molecule pictured below.
- b) **CIRCLE** the *shortest* carbon-oxygen bond (or bonds) in the molecule.

2. (17 points) Copper reacts with NO_3^- to produce NO_2^- and N_2O .

a) Number of valence electrons in NO_3^- = _____. Draw an electron dot structure for NO_3^- .

The *electron pair geometry* of NO_3^- is _____. The shape or *molecular geometry* of the NO_3^- ion is _____ and the O—N—O angle is _____.

b) Number of valence electrons in NO_2^- = _____. Draw an electron dot structure for NO_2^- and *all* possible resonance structures.

The *electron pair geometry* of NO_2^- is _____. The shape or *molecular geometry* of the NO_2^- ion is _____ and the O—N—O angle is _____.

c) Draw an electron dot structure for the N_2O molecule. (The arrangement of atoms is N—N—O.)

Is N_2O a polar or nonpolar molecule? _____

What is the *formal charge* on the central or middle N atom? _____

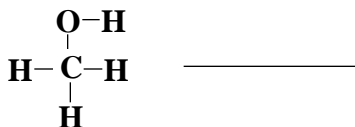
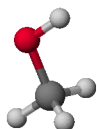
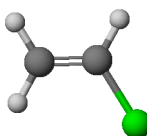
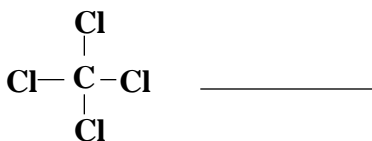
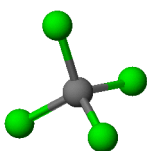
3. (5 points) ***Polarity of Bonds and Molecules***

Indicate which bond is more polar:

a) C—O or B—O _____

b) C—H or O—H _____

Indicate whether each molecule below is or is not polar.

***A Holiday Gift*** (1 points)

1. Who will win the Superbowl next January? _____
2. What is your favorite holiday recipe? Give us the recipe for our collection.