

Chemistry 231 Final review Guide

Measurement, Dimensional Analysis, Atoms and Elements in Chemistry

- 1) Calculate: $4.39 + 9.6881$ 5.63×3.40 $(5.003 - 2)/1.46$

- 2) ${}_x^y\text{Al}$ What are the values of x and y?

- 3) Which pair of elements illustrates the law of multiple proportions?

CO and CaCO_3 H_2SO_4 and H_2S SO and SO_2 CO_2 and $\text{C}_{12}\text{H}_{22}\text{O}_{11}$

- 4) Given tungsten (W-184)

- a) Determine number of protons, neutrons and electrons

b) Tungsten is dense, with a density of 19.3 g/cm^3 . What is the mass of a piece of tungsten whose volume is 14.0 cm^3 ?

- 5) Given calcium:

- a) Write the nuclear notation for a calcium atom that has the same number of protons and neutrons
b) Does the isotope have high or low natural abundance?
c) How many valence electrons does a Ca atom have? What is group 2A also known as?

- d) Valence electrons in calcium travel about 2.212 km in 1.50 second . How many minutes would it take this valence electron to travel around the Earth? ($24,901 \text{ miles}$) Note: $1 \text{ mile equals } 1600 \text{ meters}$.

- e) A calcium atom has a radius of 231 nm . What is its volume in cm^3 ?

6) Chlorine has two naturally occurring isotopes, chlorine-35 having a mass of 34.9689 amu and chlorine-37 having a mass of 36.9659 amu . If chlorine has an atomic weight of 35.4527 , what is the percent abundance of each isotope of chlorine?

7) James is trying to transfer currency. If one U.S. dollars is equivalent to $.60$ James dollars, and 1 James dollar is equivalent to 12 James quarters, and 5 James quarters equal to 1 James euros, how many James euros are in 77 U.S. quarters?

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The Quantum Mechanical Model of the Atom

1) Consider Rhodium (z=45)

- a) Provide Rhodium's electron configuration
- b) Represent Rhodium using an orbital box diagram and state whether it is paramagnetic or diamagnetic
- c) provide a valid set for electron's is Rh's highest energy subshell
- d) give the quantum numbers for Rh's 42nd electron and its 34th electron
- e) using the electron configuration from part a, choose which possible cation of rhodium (ranging from +1 to +8) would most readily form and explain why.
- f) how many electrons can be described with the quantum numbers $n=4$ $l=2$

2) Consider a hydrogen atom:

- a) Without doing any calculations, determine which of the electron transitions in a hydrogen atom would emit photons with the shortest wavelength. Justify your answer.
 $n=2 \rightarrow n=1$ $n=3 \rightarrow n=2$ $n=3 \rightarrow n=1$ $n=4 \rightarrow n=2$
- b) An excited hydrogen atom absorbs a photon of light of wavelength 487 nm. If the electron ends up in the $n=4$ level, in what level was it originally?
- c) Once the hydrogen starts returning to ground state and emits light, calculate the uncertainty in position of its electron (9.1094×10^{-28} g) if it is moving at 80% of the speed of light and if the uncertainty in the velocity is 2%?
- d) If the total energy of a mole of a photon emitted from this exothermic process is 120 kJ, what is the wavelength of the photons?

3) Answer the following questions about **light and the photoelectric effect**:

- a) Determine the longest wavelength of light that can remove an electron from a sample of potassium metal, if the binding energy for one electron in potassium is 4.59×10^{-18} J.
- b) A photon of light strikes a detector in a camera's light meter with an energy of 6.00×10^{-17} J. What is the frequency and wavelength of this photon?
- c) If a photon with a wavelength of 350 nm impacts a metal whose binding energy is 4.00×10^{-20} J, will the metal surface eject an electron? If so, what is the kinetic energy of the liberated electron?

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Periodicity

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

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

2) Using **modern periodic theory**, explain why:

- a) The radius of the chlorine atom is smaller than the radius of the chloride ion, Cl^-
- b) The first ionization energy of aluminum is lower than the first ionization energy of magnesium.
- c) The difference between the atomic radii of Na and K is relatively large compared to the difference between the atomic radii of Rb and Cs.

3) Provide four ions that are isoelectronic to Mn at ground state. Rank these in **increasing atomic radii**.

4) Give the condensed electron configuration for Au ($Z=79$)

5) Rank the following sets of elements by increasing effective nuclear charge:

Mg, Al, Cl, Na

Mg^{2+} , Al, Cl, Na

K, Na, Cs, Mg

Properties of Chemical Bonding and the Molecular Orbital Theory

- 1) Draw the Lewis Structure for $\text{CH}_3\text{CO}_2\text{H}$

Provide: the electron geometry and molecular geometry around each center C and O atom. For these center atoms, provide the bond angles, hybridization, and formal charge. Determine if this molecule is polar or non-polar. Can this molecule exhibit resonance? How many total lone pair electrons are there on the molecule? How many total pi bonds and sigma bonds on this molecule? At which bond between which atoms will have the highest polarity?

- 2) A molecule has 3 sigma bonds, 1 pi bond, and no lone pair of electrons on its center atom. What is the molecular geometry of this molecule?
- 3) In general, what is hybridization?
- 4) Complete a molecular orbital diagram, for N_2^{+1} and N_2^{-2}

Which are paramagnetic and which are diamagnetic? Rank N_2^{+1} , N_2 and N_2^{-2} from weakest to strongest bond order.

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Chemical Quantities of Different Reactions

1) 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 $\text{CO}_2(\text{g})$ 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.

a) Determine the empirical formula of the original combusted sample.

b) The molar mass of a molecule of this element is 1164 g/mol. What is the molecular formula of this molecule?

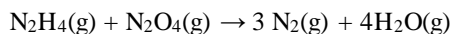
2) A 55.0 mL sample of .102 M potassium sulfate solution is mixed with 35.0 mL of .114 M lead(II) acetate solution.

a) Provide the total net ionic reaction and include phases. For the molecular formula, label oxidation states and identify the acid-base pairs of the reaction.

b) If the recovered mass of precipitate is 1.01 grams, what was the percent yield and theoretical yield?

2) James synthesizes a new compound in an alternate universe. In this reaction, 2.3 moles of X react with 1.6 moles of Y, and 71 grams of Z are produced. What is the molar mass of Z? $3\text{X} + 4\text{Y} \rightarrow 5\text{Z}$

This reaction has a 50% yield.



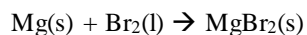
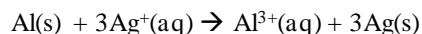
3) When 92 g of dinitrogen tetroxide and excess N_2H_4 are mixed and react according to the equation above, what is the maximum mass of H_2O that can be produced?

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4) Provide the oxidation state for each atom in each element, ion or compound:



5) For each reaction, identify the oxidizing agent and reducing agent and determine if it is a redox reaction.



6) Aqueous calcium nitrate and solid sodium metal react in a solution.

What will be the electrolytes and nonelectrolytes? Therefore, which are strong and weak?

Which one of these will molecules or elements will conduct electricity? Which will dissociate?

7) Write out a reaction of a strong acid reacting with water

8) James is trying to prepare a solution into a 1.0 L volumetric flask containing aluminum sulfate. How much aluminum sulfate, in moles, does James need to prepare if he wants to produce a solution that is exactly 0.88 M in Al^{3+} once he fills up the solution to the mark on the flask? How much in grams?

James the Imposter has created a new compound on another planet with two new elements he discovered, X and Z. He synthesizes the compound with naturally occurring phosphorus and finds that the mass percent of P and Z are 54.15 and 2.16 percent by mass respectively. The molar mass of X is 12.136 g/mol and the molar mass of Z is 170.64 and exists as a diatomic element. What is the empirical formula of XPZ ? After the correct calculations, round to the nearest whole number or to half whole number.

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Extra Problems:

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]4d⁶

[Ar]4s²3d⁷

[Ar]3d¹⁰

Vanadium(III)

Cobalt(II)

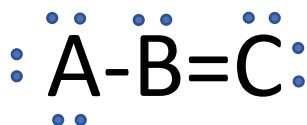
3) Professor James is grading Final exam free responses. While grading, he sees Mark answer the following question:

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)

4) If there are 5:4 times the amount of compound B as there is of compound A and they react such that $5A + 4B \rightarrow C$ and assuming the molar mass of compound of A and B are 4:5, which reactant will go to completion first?

5) What are some differences between the bonding between atoms in those that are ionic vs those that are covalent? (5 sentences and/or visuals)

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If a photon with a wavelength of 350 nm impacts a metal whose frequency threshold is 6.037×10^{13} hertz, will the metal surface eject an electron? If so, what is the velocity of the liberated electron? (mass of electron is 9.11×10^{-28} g)

Graph a kinetic energy vs wavefunction graph and describe the relationship

Oxidation state of each atom?

