A.P. Chemistry Practice Problems

Matter and Measurement

1. Classify each as a pure substance or a mixture. If a mixture, indicate if it is homogenous or heterogeneous.
   1. Rice pudding e. Air
   2. Seawater f. Tomato juice
   3. Magnesium g. Sand
   4. Gasoline h. Iodine crystals
2. Read the following description of the element zinc, and indicate which are physical properties and which are chemical properties. Zinc is a silver-gray colored metal that melts at 420°C. when zinc granules are added to dilute sulfuric acid, hydrogen is given off and the metal dissolves. Zinc has a hardness on the Mohs scale of 2.5 and a density of 7.13g/cm3 at 25°C. It reacts slowly with oxygen gas at elevated temperatures to form zinc oxide (ZnO).
3. The temperature on a warm spring day is 87°F. What is that in °C? in K?
4. Gold can be hammered into extremely thin sheets called gold leaf. If a 200.mg piece of gold (density = 19.32g/cm3) is hammered into a sheet measuring 2.4 x 1.0 ft, what is the average thickness of the sheet in meters?
5. Carry out the following operations and express your answers in the correct amount of significant figures.
   1. 12.0550 + 9.05 =
   2. 257.2 – 19.789 =
   3. (6.21 × 103)(0.1050) =
   4. 0.0577/0.75300 =
6. If an electric car is capable of going 225km on a single charge, how many charges will it need to travel from Boston, Ma to Miami, Fl, a distance of 1486miles, assuming the trip begins with a full charge?
7. In March 1989 the Exxon Valdez ran aground and spilled 240000 barrels of crude petroleum off the coast of Alaska. One barrel of petroleum is equal to 42gallons. How many liters of petroleum were spilled?

Structure of the Atom

1. How does Dalton’s atomic theory account for the fact that when 1.000g of water is decomposed into its elements, 0.111g of hydrogen and 0.889g of oxygen are obtained regardless of the source of the water?
2. Summarize the evidence used by JJ Thomson to argue that cathode rays consist of negatively charged particles.
3. Define atomic number and mass number. Which of these can change without changing the identity of the element?
4. Which of the following are isotopes of the same element: 3116X, 3115X, 3216X? Which element is this?
5. Fill in the gaps in the following table, assuming each column represents a neutral atom:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **symbol** | **52Cr** |  |  |  |  |
| **protons** |  | **25** |  |  | **82** |
| **neutrons** |  | **30** | **64** |  |  |
| **electrons** |  |  | **48** | **86** |  |
| **mass #** |  |  |  | **222** | **207** |

1. For each of the following elements, write its chemical symbol, locate it on the periodic table, and indicate whether it is a metal, nonmetal, or metalloid.
   1. Chromium d. Zinc
   2. Helium e. Magnesium
   3. Phosphorous f. Bromine
2. How many hydrogen atoms are in each of the following compounds?
   1. C2H5OH
   2. Ca(CH3COO)2
   3. (NH4)3PO4
3. Fill in the gaps in the following table. Remember these are ions, not neutral atoms.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **symbol** | **59Co3+** |  |  |  |
| **protons** |  | **34** | **76** | **80** |
| **neutrons** |  | **46** | **116** | **120** |
| **electrons** |  | **36** |  | **78** |
| **net charge** |  |  | **2+** |  |

1. Write the name or formula for these ionic compounds.
   1. AlCl3 e. potassium sulfate
   2. Li3PO4 f. copper (I) oxide
   3. Cu(NO3)2 g. iron (III) carbonate
   4. KMnO4 h. potassium dichromate
2. Write the name or formula for these covalent compounds.
   1. SF6 d. dinitrogen tetroxide
   2. IF5 e. carbon tetrachloride
   3. XeO3 f. tetraphosphorous hexasulfide
3. Write the name or formula for these acidic compounds.
   1. HBr d. hydrofluoric acid
   2. H3PO4 e. carbonic acid
   3. H2SO3 f. nitrous acid
4. Name these alkanes
   1. C3H8
   2. C5H12
   3. C8H18
5. What is meant by the term effective nuclear charge?
6. Detailed calculations show that the value of Zeff for Si and Cl atoms is 4.29+ and 6.12+, respectively.
   1. What value do you estimate for Zeff experienced by the outermost electron in both Si and Cl by assuming core electrons contribute 1.00 and valence electrons contribute 0.00 to the screening constant?
   2. What values do you estimate for Zeff using Slater’s rules for Si and Cl?
7. Arrange the following atoms in terms of increasing atomic radius:
   1. Ca, Mg, and Be
   2. Al, Tl, Si
8. Why are monatomic cations smaller than their neutral atoms?
9. Why are monatomic anions larger than their neutral atoms?
10. Based on their location on the periodic table, which atom of the following pairs will have the larger first ionization energy?
    1. Cl, Ar b. Be, Ca c. Ti, Ba
11. Write the electron configuration for the following atoms or ions.
    1. Te
    2. Te2+
    3. Sc
    4. Sc3+
    5. Cl
    6. Cl1-
12. Compare the metals, sodium and magnesium with respect to the following
    1. Electron configurations
    2. Most common ion charge
    3. 1st ionization energy
    4. reactivity with water
    5. atomic radius

Electronic Structure of Atoms

1. What is the relationship between the wavelength and the frequency of radiant energy?
2. Determine which of the following statements are false, & correct them.
   1. Electromagnetic radiation is incapable of passing through water.
   2. Electromagnetic radiation travels through a vacuum at constant speed, regardless of wavelength.
   3. Infrared light has higher frequencies than visible light.
   4. The glow from a fireplace, the energy within a microwave oven, and a foghorn blast are all forms of electromagnetic radiation.
3. What is the frequency of radiation that has a wavelength of 10υm, about the size of a bacterium?
4. What is the wavelength of radiation that has a frequency of 7.6 × 10-1 s-1?
5. A red laser pointer emits light with a wavelength of 650 nm. What is the frequency of the light? How much energy does the light emit?
6. Sodium metal requires a photon with a minimum energy of 4.41 × 10-19J to emit electrons.
   1. What is the minimum frequency of light necessary to emit electrons from sodium via the photoelectric effect?
   2. What is the wavelength of this light?
7. Is energy emitted or absorbed when the following electronic transitions occur in hydrogen:
   1. From n = 4 to n = 2?
   2. From an orbit of radius 2.12Å to one of radius 8.46Å?
8. According to the Bohr model, an electron in the ground state of a hydrogen atom orbits the nucleus at a specific radius if 0.53Å. In the quantum mechanical description of the hydrogen atom the most probably distance of the electron from the nucleus is 0.53Å. Why are these two statements different?

Stoichiometry

1. Balance the following equations:
   1. CO(g) + O2(g) 🡪 CO2(g)
   2. N2O5(g) + H2O(l) 🡪 HNO3(aq)
   3. CH4(g) + Cl2(g) 🡪 CCl4(l) + HCl(g)
   4. Al4C3(s) + H2O(l) 🡪 Al(OH)3(s) + CH4(g)
2. Write balanced chemical equations for the following reactions:
   1. Solid calcium carbide, CaC2, reacts with water to form an aqueous solution of calcium hydroxide and acetylene gas, C2H2.
   2. When solid potassium chlorate is heated, it decomposes to for solid potassium chloride and oxygen gas.
   3. Solid zinc reacts with an aqueous solution of sulfuric acid to form hydrogen gas and an aqueous solution of zinc (II) sulfate.
3. What is the mass, in grams, of 2.50 × 10-3 mol of (NH4)3PO4?
4. What is the mass, in grams, of 7.70 × 1010 molecules of caffeine, C8H10N4O2?
5. How many molecules of SO2(g) are in 20.0L of the gas at STP?
6. Determine the empirical formula for a compound with the following composition:21.7% carbon, 9.6% oxygen, and 68.7% fluorine.
7. Determine the molecular formula for a compound with an empirical formula of C2H4O and a molecular mass of 88g/mol.
8. Automotive airbags inflate when sodium azide, NaN3, rapidly decomposes to its component elements:

2NaN3(s) 🡪 2Na(s) + 3N2(g)

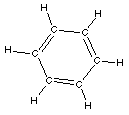
* 1. How many grams of NaN3 are required to form 10.0g of nitrogen gas?
  2. How many grams of NaN3 are required to produce 10.0ft3 of nitrogen gas, about the size of an airbag in a car if the density of nitrogen is 1.25g/L?

1. Hydrogen sulfide is an impurity in natural gas (a stinky one too!) that must be removed. One common removal method is called the Claus process, which relies on the reaction below. If you started with 30.0g of H2S and 50.0g of O2, how many grams of S8 would theoretically be produced and which reactant is the limiting reactant?

8H2S(g) + 4O2(g) 🡪 S8(l) + 8H2O(g)

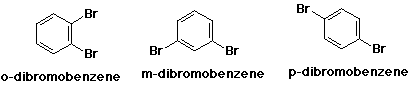
Chemical Bonding

1. Use electron dot diagrams (or Lewis symbols) to show the reaction between Ca and F atoms.
2. What is lattice energy? What factors govern the lattice energy of an ionic compound?
3. Draw Lewis structures for the following covalent molecules
   1. H2CO(both H atoms are bonded to C)
   2. H2O2
   3. C2F6 (contains a C-C bond)
   4. NO2+ (draw any and all resonance structures)
4. Below is the Lewis structure for benzene.

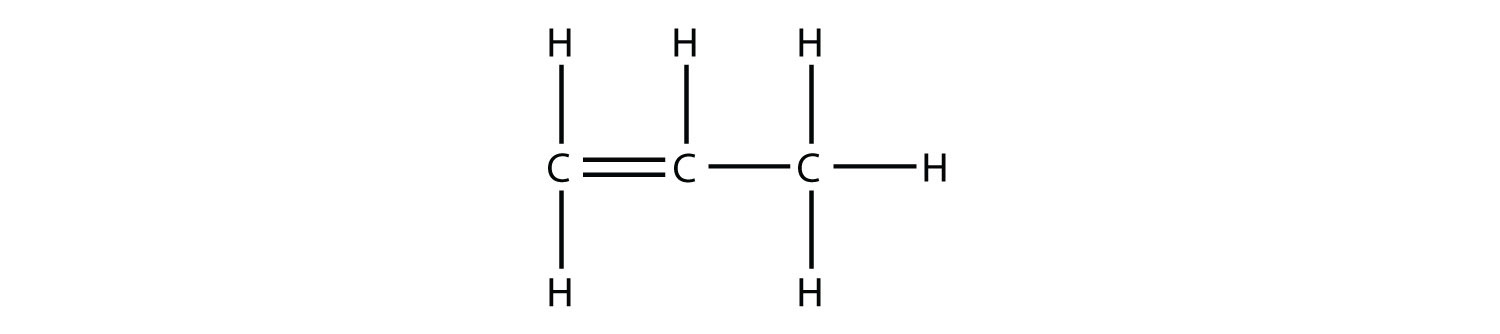


* 1. Use the concept of resonance to explain why all 6 C-C bonds are the same length instead of the C-C bonds being longer than the C=C bonds.

1. Draw the Lewis structure for each molecule and predict its molecular geometry
   1. PF3
   2. ClO4-
   3. XeF2
2. Predict whether the following molecules are polar or nonpolar.
   1. IF
   2. CS2
   3. SO3
   4. PCl3
   5. SF6
   6. IF5
3. Dibromobenzene, C6H4Br2 exists in 3 forms or isomers, called ortho, meta, and para. Their structures are below. Which of these would have a nonzero dipole moment and why.



1. Propylene, C3H6, is a gas that is used to form the important polymer called polypropylene. Its Lewis structure is below.



* 1. What is the total number of valence electrons in the propylene molecule?
  2. How many valence electrons are used to make σ bonds?
  3. How many valence electrons are used to make π bonds?
  4. How many valence electrons remain in nonbonding pairs in the molecule?
  5. What is the hybridization at each carbon atom in the molecule?

1. What is the difference between a hybrid orbital and a molecular orbital?
2. Sketch the molecular orbitals of the H2+ ion.
3. What does diamagnetism mean? Which of the following ions would you expect to be diamagnetic? N22-, O22-, Be22+, C2-?
4. What does paramagnetism mean?

Gases

1. The typical atmospheric pressure on top of Mount Everest is about 265torr. Convert this into: mmHg, atm, kPa.
2. A gas is confined to a cylinder with a movable piston. The pressure of the gas in the container at 0.950L is 1.65atm. What is the pressure of the gas if the volume is increased to 2.45L?
3. A gas in a container with a movable piston is heated from 298K to 360K. The final volume of the container was 2.50L. What was the original volume of the container?
4. Using the gas from #59 in its final volume at 360K, there were 6.75mol of He gas in the container. If you removed 2.25mol of gas, what would be the new volume now?
5. Tennis balls are usually filled with air or N2 gas to a pressure above atmospheric pressure to increase their “bounce”. If a tennis ball has a volume of 144mL and contains 0.33g of N2 gas, what is the pressure inside the ball at 23°C?
6. What is the density of the N2 gas in the tennis ball in g/L if it is at a pressure of 2.50atm in a volume of 144mL at 23°C?
7. Which gas is most dense at 1.00atm and 298K: CO2, N2O or Cl2? Explain.
8. The metabolic oxidation of glucose, C6H12O6, in our bodies produces CO2, which is expelled from our lungs as a gas. Calculate the volume of dry CO2 produced at body temperature of 37°C and 0.970atm when 24.5g of glucose is consumed in the reaction below.

C6H12O6(aq) + 6O2(g) 🡪 6CO2(g) + 6H2O(l)

1. A mixture containing 0.477mol of He gas, 0.280mol of Ne gas, and 0.110mol of Ar gas is confined to a 7.00L container at 25°C. Calculate the partial pressure of each gas and the total pressure in the container.
2. What is the mole fraction of Ne gas in the container in #65?
3. The temperature of a 5.00L container of N2 gas is increased from 20°C to 250°C. If the volume is held constant, predict qualitatively how this change affects the following:
   1. The average kinetic energy of the molecules.
   2. The average speed of the molecules.
   3. The strength of the impact of an average molecule with the container walls.
   4. The total number of collisions of molecules with the walls per second.
4. Give 2 situations when real gases don’t behave like ideal gases.
5. Consider a sample of 2.000mol of CO2(g) confined to a volume of 4.000L at 0.0°C. Calculate the pressure of the gas using
   1. Ideal gas law.
   2. van der Waal’s equation.