

# Chem 400 Basics

## What You Need to Know Before Coming to Class

A 'C' grade or better in Chem 305, Chem 310, or high school chemistry is a prerequisite for this class. You are therefore expected to know, or be able to quickly brush up on the basics for most sections of the Chem 400 course. Although I will typically do a quick review as we encounter this material, I will not be spending time re-teaching the basic concepts and calculations from scratch. This document is meant to serve as a guide to what you should be able to do upon entering this class. If you have great difficulty with any part of the following material (solutions are given after the questions), **this may not be the class for you**. At best, you will have to work extremely hard to catch up, and you will have to do this while also mastering the more advanced material that is presented. If you have met the prerequisite through a high school chemistry class and are struggling with the material below, I would strongly recommend taking Chem 310 before attempting Chem 400.

### Chapter 1: Getting Started

- Understanding scientific (exponential) notation and correctly using the EXP (or EE) key on a calculator
  - a) Write 345.9, 450000, and 0.00387 using scientific notation
  - b) Write  $2.846 \times 10^4$  and  $0.07 \times 10^{-2}$  as regular numbers
  - c) Calculate  $2.846 \times 10^4 / 1.04 \times 10^{-3}$
- Significant figures
  - a) How many sig. figs. are in the following numbers? 1200, 3.877, 43.0001, 0.0092
  - b) Round the following numbers to the sig. figs. shown; 2938 to 2 s.f., 0.00455 to 1 s.f., 559.32 to 4 s.f.
  - c) Perform the following calculations and give the answers to the appropriate number of sig. figs.;  $2300 + 45.8$ ,  $2300. - 45.8$ ,  $36 \times 21$ ,  $0.003 / 0.020001$
- Basic unit analysis
  - a) How many inches in 39.6 cm (1 inch = 2.54 cm)?
  - b) How many  $\text{cm}^2$  in  $99.3 \text{ m}^2$ ?
  - c) What is the volume (in mL) of a 10.0 g sample of material with density 16.3 g/mL ( $D = m/V$ )?

### Chapter 2: Atoms and Elements

- Basic structure of the atom and concept of isotopes.
  - a) Name the three subatomic particles, and give their charges.
  - b) Where are these particles located in an atom?
  - c) What is the difference between carbon-13 and carbon-11 isotopes?
- Basic concept of ions and writing ionic formulas
  - a) What is the charge on all group 2 metal ions?
  - b) Write the formulas of the ionic compounds made from the following pairs of ions;  $\text{Na}^+$  and  $\text{O}^{2-}$ ,  $\text{Cr}^{3+}$  and  $\text{S}^{2-}$ ,  $\text{Zn}^{2+}$  and  $\text{OH}^-$

### Chapter 3: Stoichiometry

- Mole concept and calculations
  - a) How many atoms are in 3.5 moles of gold (avogadro's number =  $6.02 \times 10^{23}$ )
  - b) How many moles are  $19.3 \times 10^{25}$  molecules of water?
- Molar mass calculations
  - a) What is the molar mass of the following compounds to 3 s.f.?  $\text{H}_2\text{SO}_4$ ,  $\text{NaC}_2\text{H}_3\text{O}_2$ ,  $\text{Al}(\text{OH})_3$
  - b) How many moles are in 34.8g of  $\text{H}_2\text{SO}_4$ ?
  - c) What is the mass of 0.984 mol of  $\text{Al}(\text{OH})_3$ ?

- Empirical formula concept
  - a) What is the correct empirical formula for a molecule containing 6 carbon atoms and 6 hydrogen atoms?
- Equation balancing
  - a) Balance the following equations;  $C_2H_6 + O_2 \rightarrow CO_2 + H_2O$   
 $Na_2SO_4 + Pb(C_2H_3O_2)_2 \rightarrow NaC_2H_3O_2 + PbSO_4$
- Simple stoichiometry calculations
  - a) For the reaction;  $2 Na + 2 H_2O \rightarrow 2 NaOH + H_2$  what mass of  $H_2$  is produced from 639 g of Na metal?

#### Chapter 4: Chemical Reactions

- Recognize the basic types of chemical reaction; combination, decomposition, single-replacement, double-replacement, neutralization.
  - a) Identify the type of each of the following reactions;
 
$$NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$$

$$3 H_2 + N_2 \rightarrow 2 NH_3$$

$$Cu + 2 AuNO_3 \rightarrow 2 Au + Cu(NO_3)_2$$

$$HCl + KOH \rightarrow KCl + H_2O$$

$$2 NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

#### Chapter 5: Acids and Bases

- pH concept.
  - a) Which is more acidic, a solution at pH 3 or one at pH 10?
  - b) What is the pH of a neutral solution?
- Acid-Base titration concept.
  - a) What are titrations generally used for?
  - b) How do you know when to stop adding solution from the buret in a titration experiment?
  - c) What is equal when you reach the equivalence point in a titration experiment?

#### Chapter 6: Gases

- Pressure unit conversion (given conversion factors;  $1.00 \text{ atm} = 760. \text{ mmHg} = 14.7 \text{ psi}$ ).
  - a) Convert 189.2 psi to atm.
  - b) Convert 18.5 mmHg to atm
  - c) Convert 0.34 atm to mmHg
- Basic concept of gases and gas behavior.
  - a) Approximately how much more volume does 1 g of gas occupy, compared to 1 g of liquid – x2, x10, x100, x1000, x1,000,000?
  - b) How far apart are the particles in a gas?
  - c) What happens to gas pressure if the volume of a gas is reduced, but the temperature is kept constant?
- Simple gas law calculations using given equations ( $P_1V_1 = P_2V_2$ ,  $V_1/T_1 = V_2/T_2$ ).
  - a) If the initial volume of a fixed quantity of gas at 288 K is 183 mL, at what temperature has the volume increased to 244 mL (assume constant pressure).
  - b) A 3.9 L balloon contains gas at a 2.78 atm pressure. If the balloon is placed in a low pressure environment at constant temperature, its volume increases to 4.8 L. What is the pressure of the gas inside the balloon at this new volume?

#### Chapter 7: Thermochemistry

- The difference between exothermic and endothermic reactions.
  - a) A chemical reaction produces bubbles of gas and the reaction vessel feels cold to the touch. Is this an exothermic or endothermic reaction?

## Chapter 8: Quantum Theory

- The Bohr atomic model.
  - a) Briefly describe the Bohr model of the atom.

## Chapter 9: Periodic Trends

- No prior knowledge required.

## Chapter 10: Chemical Bonding

- Basic chemical bonding concepts.
  - a) What is the charge on an ionic compound?
  - b) What are ionic compounds made up of, and what hold the parts together?
  - c) What is the charge on a molecule?
  - d) What are molecules made up of and what holds the parts together?
- Basic understanding of Lewis Dots (electron dots).
  - a) What does a Lewis dot represent?
  - b) Write the Lewis Dot formula for an aluminum atom, and for an oxygen ion.

## Chapter 11: Intermolecular Forces

- No prior knowledge required.

## Chapter 12: Solutions

- Understanding of the terms; solution, solvent, solute.
  - a) Carbon dioxide gas is pumped into cold water to make sparkling water. What is the solution, the solvent, and the solute in this description?
  - b) A liter of water is poured into a beaker containing 100 g of sugar and stirred to make sugar water. What is the solution, the solvent, and the solute in this description?
- Basic molarity and percent composition calculations (molarity = moles solute / Liters solution).
  - a) How many moles of sulfuric acid are in 100. mL of a 6 M solution?
  - b) What volume of a 0.114 M saline solution contains 0.29 moles of salt?
  - c) What is the molarity when 4.02 moles of copper sulfate is dissolved in water to make 16 Liters of solution?
  - d) What is the mass percent composition of a sugar solution containing 9.32 g of sugar and 135 g of water?

# Solutions

## Chapter 1: Getting Started

- Understanding scientific (exponential) notation and correctly using the EXP (or EE) key on a calculator
  - a)  $3.459 \times 10^2$ ,  $4.5 \times 10^5$ ,  $3.87 \times 10^{-3}$
  - b) 28460, 0.0007
  - c)  $2.74 \times 10^7$
- Significant figures
  - a) 2, 4, 6, 2
  - b) 2900, 0.005, 559.3
  - c) 2300, 2254, 760, 0.1
- Basic unit analysis
  - a) 15.6 inch
  - b)  $993,000 \text{ cm}^2$
  - c) 0.613 mL

## Chapter 2: Atoms and Elements

- Basic structure of the atom and concept of isotopes
  - a) Electron (-1), proton (+1), neutron (0)
  - b) Protons and neutrons are in the center of the atom (nucleus), the electrons are outside the nucleus
  - c) Carbon-13 atoms have 2 more neutrons
- Basic concept of ions and writing ionic formulas
  - a) +2
  - b)  $\text{Na}_2\text{O}$ ,  $\text{Cr}_2\text{S}_3$ ,  $\text{Zn}(\text{OH})_2$

## Chapter 3: Stoichiometry

- Mole concept and calculations
  - a)  $2.1 \times 10^{24}$  atoms
  - b) 321 moles
- Molar mass calculations
  - a) 98.1 g/mol, 82.0 g/mol, 78.0 g/mol
  - b) 0.355 mol
  - c) 76.8 g
- Empirical formula concept
  - a) CH
- Equation balancing
  - a)  $2 \text{C}_2\text{H}_6 + 7 \text{O}_2 \rightarrow 4 \text{CO}_2 + 6 \text{H}_2\text{O}$   
 $\text{Na}_2\text{SO}_4 + \text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 \rightarrow 2 \text{NaC}_2\text{H}_3\text{O}_2 + \text{PbSO}_4$
- Simple stoichiometry calculations
  - a) 28.0 g of  $\text{H}_2$

## Chapter 4: Chemical Reactions

- Recognize the basic types of chemical reaction; combination, decomposition, single-replacement, double-replacement, neutralization.
  - a) Double-replacement  
Combination  
Single- replacement  
Neutralization  
Decomposition

## Chapter 5: Acids and Bases

- pH concept.
  - a) A solution at pH 3 is more acidic.
  - b)  $\text{pH} = 7$ .
- Acid-Base titration concept.
  - a) To find the concentration of a solution.
  - b) A color change (due to an added indicator) occurs.
  - c) The moles of  $\text{H}^+$  and  $\text{OH}^-$  ions in the reaction vessel are equal at the equivalence point.

## Chapter 6: Gases

- Pressure unit conversion.
  - a) 12.9 atm.
  - b) 0.0243 atm
  - c) 260 mmHg
- Basic concept of gases and gas behavior.
  - a) Gas occupies about 1000 times the volume of a liquid.
  - b) Very far apart.
  - c) Pressure increases.
- Simple gas law calculations using given equations.
  - a) 384 K.
  - b) 2.3 atm.

## Chapter 7: Thermochemistry

- The difference between exothermic and endothermic reactions.
  - a) Endothermic – heat is absorbed by the reaction.

## Chapter 8: Quantum Theory

- The Bohr atomic model.
  - a) A tiny nucleus in the center of the atom contains all the protons and neutrons. This is surrounded by the electrons, which are located in fixed orbits around the nucleus. The electrons can jump from orbit to orbit as they gain or lose energy, but they are never found between the fixed orbits.

## Chapter 10: Chemical Bonding

- Basic chemical bonding concepts.
  - a) Zero.
  - b) Ionic compounds are made of ions, held together by the electrostatic attraction of their opposite charges.
  - c) Zero.
  - d) Molecules are made of atoms, held together by covalent bonds (the sharing of valence electrons).
- Basic understanding of Lewis Dots (electron dots).
  - a) A valence electron.
  - b) Aluminum atom;  $:\text{Al}\cdot$       Oxygen ion;  $:\ddot{\text{O}}:^{2-}$

## Chapter 12: Solutions

- Understanding of the terms; solution, solvent, solute.
  - a) Solute - carbon dioxide gas; solvent - water; solution - sparkling water.
  - b) Solvent – water; solute – sugar; solution - sugar water.
- Basic molarity and percent composition calculations.
  - a) 0.6 moles.
  - b) 2.5 L.
  - c) 0.25 mol/L.
  - d) 6.46%