# 

# Chatfield Senior High School

# Chemistry Workbook

Spring 2020 Edition

Mr. Fitch, Ms. Goldner, & Mrs. Galindo

This Book Belongs to:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# 

# To the Student

This course is probably very different from any other class that you have taken. Your success will depend on your knowledge of science and math. You will find that this book is also different from any other that you have used.

This workbook contains the homework assignments that you will be responsible for completing during the semester. It is yours to keep, and you are responsible for bringing it to class each day.

This workbook does contain summaries of much of the information from class, but it does NOT contain all of the information that you will need to answer the questions. You must attend class, listen during lectures, take notes, participate in class discussions, and be active during lab work.

Our Thanks…

* 1. To Mr. Bertelsen, for authoring the first version of this book. It was an enormous undertaking for a teacher who was supposed to be on summer break…
  2. And to the students in our classes who continually help us develop and improve these materials and who point out errors so that we can correct ~~then~~ them.

# Constants

Charge on an electron qe = 1.6 x 10-19 C

Mass of an electron me = 9.1 x 10-31 kg

Atomic Mass Unit amu = 1.66 x 10-27 kg

Avogadro’s Number 6.022 x 1023 mol-1

Universal gas constant R = 0.0821 L·atm / mol·K

Absolute zero – 273°C or 0 kelvins

Plank’s Constant h = 6.626 x 10-34 J·s

Speed of light c = 3.00 x 108 m/s

Density of water at 25oC 1 g/1 mL

# Metric Units Summary

## Prefixes

pico = 10-12 = p nano = 10-9 = n micro = 10-6 = **

milli = 10-3 = m centi = 10-2 = c

kilo = 103 = k mega = 106 = M giga = 109 = G

## Common SI Units and conversions

Length: centimeters or meters 100 cm = 1 m

1 inch = 2.54 cm

Mass: grams or kilograms 1000 g = 1 kg

1 kg = 2.205 lbs.

1 oz. = 28.35 g

Volume: liters, milliliters, or cm3 1 L = 1000 ml

1 gallon = 3.785 L

1 ml = 1 cm3

Temperature: °C or kelvins oC + 273 = kelvin temp.

# Exponents

The form 2.3E+5 on your calculator means 2.3 x 105 = 230,000

The form 1.6E-3 on your calculator means 1.6 x 10-3 = 0.0016

When multiplying values in scientific notation, add exponents.

When dividing values in scientific notation, subtract exponents.

# Contents

cover page [1](#_Toc30004448)

[To the Student 3](#_Toc30004451)

[Constants 4](#_Toc30004452)

[Metric Units Summary 4](#_Toc30004453)

[Prefixes 4](#_Toc30004454)

[Common SI Units and conversions 4](#_Toc30004455)

[Exponents 4](#_Toc30004456)

[Contents 5](#_Toc30004457)

[What You Should Learn in Chemistry – Semester 2 6](#_Toc30004458)

[General Chemistry Course Expectations 7](#_Toc30004459)

[Lab Safety Contract 11](#_Toc30004459)

[Metric System 14](#_Toc30004460)

[I Get A’s On My Homework – But I still Bomb the Tests!... 15](#_Toc30004461)

[Unit 6 – Gases 16](#_Toc30004462)

[Strain Your Brain #1 16](#_Toc30004463)

[Homework #1 – Conversions and Gas Relationships 19](#_Toc30004464)

[Homework #2 – Dalton’s Law of Partial Pressures and More… 23](#_Toc30004465)

[Homework #3 – The Ideal Gas Law 26](#_Toc30004466)

[Homework #4 – Gas Stoichiometry 29](#_Toc30004467)

[Homework #5 – More Stoichiometry 32](#_Toc30004468)

[Unit 7 - Solutions 35](#_Toc30004469)

[Homework #1 – Concentration Problems 35](#_Toc30004470)

[Homework #2 – Ions, Ions and then more Ions! 39](#_Toc30004471)

[Homework #3 – Dilution Problems 41](#_Toc30004472)

[Homework #4 – Solubility 43](#_Toc30004473)

[Homework #5 – Solution Stoichiometry 44](#_Toc30004474)

[chemical equilibrium](#_Toc30004475)

*This unit has not yet been developed for general chemistry*

[Unit 8 – Acids and Bases 47](#_Toc30004475)

[Homework #1 – Acid/Base Reactions 47](#_Toc30004476)

[Homework #2 – Acid/Base Neutralizations 50](#_Toc30004477)

[Homework #3 – Acid/Base Titrations 52](#_Toc30004478)

[Homework #4 – Acid/Base Conjugate Pairs 55](#_Toc30004479)

[Unit 8 – Review 56](#_Toc30004480)

[Unit 9 – Organic Chemistry 60](#_Toc30004481)

[Naming Rules for the Alkanes (SATURATED HYDROCARBONS) 60](#_Toc30004482)

[Homework #1 – An Investigation 61](#_Toc30004483)

[Homework #2 – Alkanes and Alkenes 64](#_Toc30004484)

[Homework #3 – anes, enes and yns… a shortcut 66](#_Toc30004485)

[Homework #4 – Halogenated Hydrocarbons 68](#_Toc30004486)

[Homework #5 – Alkynes and Aromatic Compounds 71](#_Toc30004487)

## What You Should Learn in Chemistry – Semester 2

**Unit 5 – Thermochemistry… By the end of this unit, you should:**

1. Understand what heat is and how to quantify the heat gained or lost by a system using calorimetry;
2. Understand how to quantify the energy absorbed or released by substances phase changes;
3. Renew your understanding of stoichiometry;
4. Understand and interpret enthalpy diagrams in order to identify reactions as endothermic or exothermic;
5. Understand the role of catalysts in lowering activation energy of a reaction;
6. Understand the changes in energy associated with chemical reactions.

**Unit 6 – Gases… By the end of this unit, you should:**

1. Understand the behavior of gases according to the kinetic molecular theory;
2. Understand what is meant by an “ideal gas”;
3. Understand the relationships between temperature, pressure, and volume of a gas;
4. Understand how number of particles of a gas affects its pressure and volume;
5. Understand the additive effect of a mixture of gases on total gas pressure;
6. Understand the relationships between the temperature, kinetic energy, mass, and velocity of a gas.

**Unit 7 – Solutions… By the end of this unit, you should:**

1. Understand what solutes, solvents, and solutions are;
2. Understand what the term “solubility” means;
3. Understand how to calculate concentrations of solutions;
4. Understand how to prepare solutions of known concentrations;
5. Understand how to perform dilutions;
6. Understand solubility rules in order to predict products of reactions.

**Unit 8 – Acids and Bases… By the end of this unit, you should:**

1. Understand the properties of acids and bases;
2. Understand what a neutralization reaction is and how to predict the products of such a reaction;
3. Understand the difference between strong and weak acids and bases;
4. Understand how to calculate pH of an acidic or basic solution using its concentration.

**Unit 9 – Organic Chemistry… If time allows.**

## 

## General Chemistry Course Expectations

***Mr. Fitch, Spring 2020***

1. **Participation** is very important in this class, therefore attendance is vital. Beginning with your 4th unexcused tardy, you will lose 1% off your final grade for each tardy. Beginning with your 1st unexcused absence, you will lose 3% off your final grade. These can be made up after school: ½ hour for each tardy, and 1 hour for each absence

2. **Grading Percentages:**

Tests 30%

Quizzes 20%

Final Exam 20%

Lab work 20%

Homework 10%

1. **Homework:** The purpose of homework is to allow you to practice the computations that we are learning and to reinforce key concepts that we cover. An important aspect of this is to ‘think in writing’. What this means is, while solving a problem, write out the steps that you take to solve it and then box your solution. All of your homework is to be done in a comp book, which I will check once each unit for your homework grade. We will discuss this more in class, but the 3 things that I will expect of all of your homework assignments.

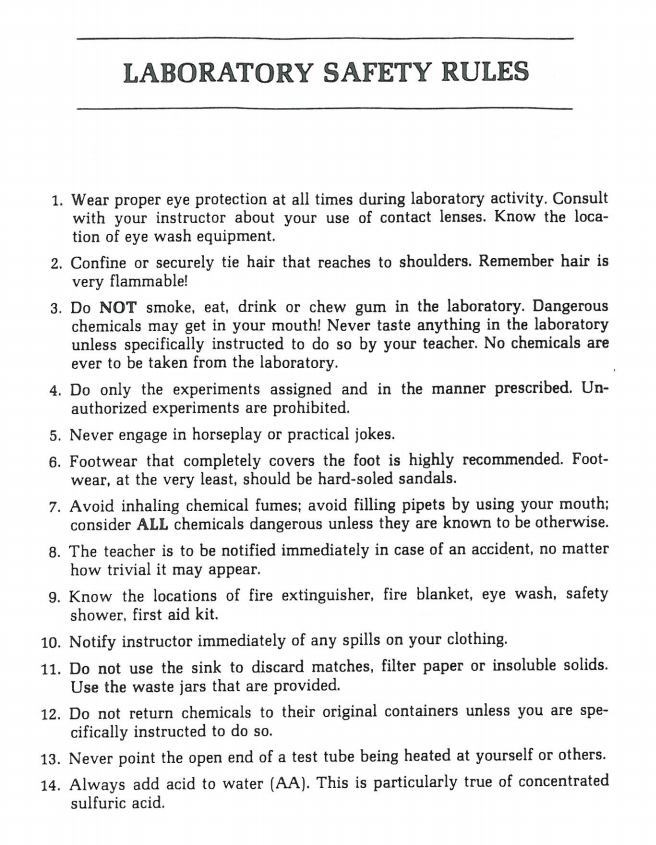
1. Do all work in your homework notebook (exceptions will be noted as we go).

2. Show all work that you do – if you use your calculator, write it down.

3. Box your final answer.

1. **Labs:** All lab work must be made up within the first week after the lab has taken place. After this, the experiment will be put away and you will not have an opportunity to make up that lab. If you fail to make up the lab in the week, you will still be responsible for the material covered by the experiment.
2. **LATE HOMEWORK AND LABS ARE NOT ACCEPTED FOR FULL CREDIT**. After the due date for an assignment, you will receive 75% within the first week, and 50% after that. Papers turned in at the end of the semester to try to ‘catch up’ may be subject to an additional deduction.
3. **The Semester Grade** will be cumulative. This means that each term grade will simply be a progress report.
4. **THERE WILL BE NO MAKE-UP TESTS!!** Exceptions to this rule will be made on an individual basis. If a student is going to be absent on test day, arrangements must be made in advance to take the test early. To accommodate for the strictness of this policy, each person’s lowest test score will be dropped at the end of the semester.
5. **FINAL EXAM:** The final exam will count for 20% of your final grade, and will not be dropped even if it happens to be your lowest test grade. The final exam will be cumulative.
6. **Make-Up Work:** If you have missed a day of class, it is your responsibility to determine what you missed and to make up the work. A calendar on my web site will assist in this. Along with the schedule will be a basket for returned papers and a file containing any assignment you may have missed. You may also find it helpful to get the notes for the day from a friend. You should only come to us after you have done the above-mentioned things. *NOTE!!* The passing period is *NOT* the time to ask questions about things you may have missed. If you have questions, please come in during access for help with your questions.
7. **Everyone** will be responsible for monitoring their own learning. Only you know if you understand the material, and therefore you need to come in for help when aspects of chemistry are confusing to you. You are expected to meet the standard on lab assignments by receiving at least a 70%. If you do not accomplish this, you will have an opportunity to earn up to an 80%. In order to receive this chance, you will need to make an appointment to come in for help within two days of receiving the assignment back. If you miss your scheduled appointment, the penalty will be decided individually.
8. **Take Pride in Your Work!** Whenever you do an assignment, it will be important that you turn in your best effort. This means taking pride in everything that you do. Each assignment must include your full name, your class period, the date and the title of the assignment. When you turn in a sloppy paper, it tells me that you don’t care. This is okay, but you won’t get the same grade as someone who does in fact care. (A 30% reduction is possible)
9. **Class.** You will be expected to come to class prepared. The items that you will need include a three-ring notebook with blank paper and dividers, something with which to write and a calculator. During class you will be expected to take notes, and to use these notes as a reference tool. Many of the problems that we will learn early in the course will be problems repeated throughout, and you will need to be able to reference these types of problems.
10. **Showing Your Work.** You will be required to show your work on all problems that you do for this class. On homework, if you turn in an assignment without work (only answers) you will a zero for the assignment. In addition, your work needs to make sense. If I can’t follow what you are doing, I won’t be able to give you any partial credit.
11. **Odds and Ends…** This is a college prep course and many things will reflect that. You will have a greater level of freedom and a greater level of responsibility. Please be aware that it is your responsibility to come to class prepared. You will also be expected to come to class and get ready to take notes first thing. Once you have your notebook out and ready, then you may chat with friends until attendance is complete.
12. **Homework:** This is another area of increased responsibility. Homework is a learning tool. Getting the answer correct the first time is not the goal – understanding the problem is. Because of this, you will be grading your own homework during the course, and keeping each in a separate section of your notebook. On the day before each exam, a homework grade will be given based on the completeness of your work. If you have completed the problems with all of your work shown, you will receive full credit. Its correctness will not be assessed. Answers will be supplied during work days or can be found on line.
13. **Food.** With very few exceptions, you will not be able to bring food or drink to class, nor will you be allowed to leave class to buy these things
14. **Electronic Devices:** Cell phones are not allowed to be out or used in class except as approved or in an emergency and with teacher approval. IPods or other musical device should only be used during work time. The general rule: your phone should not be out while trying to learn Chemistry. Any abuse of these guidelines may result in your device being confiscated for the remainder of the day. *On the day of a quiz or an exam, you are not allowed to have any electronic device out at any time during the entire class period. If you have such an item out on the day of a quiz or an exam, the device will be confiscated, and you will receive a 0% for that assessment.*
15. **Safety:** Everyone will be required to read and sign the safety contract that follows on the next two pages. It is provided here so that you will always have a copy for reference.





## Metric System

We will work exclusively in the metric system in this course, a measurement system with which few of us are completely comfortable. This review is designed to help you if you find that this system is difficult.

Within the metric system are two common systems of measurements. One you don’t need to know about for this course (it’s called the cgs system, which stands for centimeters, grams and seconds). The system that we will use is the **MKS** system. MKS stands for Meters, Kilograms and Seconds, the units we will use for distance, mass and time, respectively. Everything that measure during the course of this year will be in terms of these three quantities. If for some reason a measurement is taken using some other system, we will need to convert it into the MKS system. For this reason, understanding the basics of the metric system is quite important.

We start with the prefixes used in the metric system. These prefixes are used throughout, and are used with any base unit.

**Prefixes Equivalent Value Scientific Abbreviation**

**Notation**

Tera = 1,000,000,000,000 = 1012 T

Giga = 1,000,000,000 = 109 G

Mega = 1,000,000 = 106 M

Kilo = 1,000 = 103 k

Hecta = 100 = 102 h

Deka = 10 = 101 da

**Basic** = 1 = 100

Deci = 0.1 = 10-1 d

Centi = 0.01 = 10-2 c

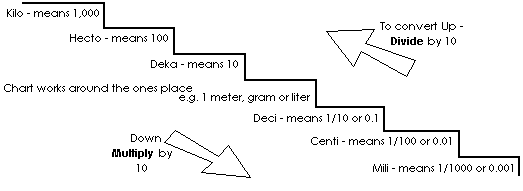
Milli = 0.001 = 10-3 m

Micro = 0.000 001 = 10-6 

Nano = 0.000 000 001 = 10-9 n

Pico = 0.000 000 000 001 = 10-12 p

When you need to convert within the metric system, (eg: meters to centimeters) you can use ratios or you can use the familiar metric stair-step. Moving to the left equates to dividing by 10 and moving to the right equates to multiplying by 10. If you move up the stairs, you move the decimal to the left and if you move down the stairs then you move the decimal to the right. So 1 km would be 1,000 m and 3 cm would be 0.03 m



# I Get A’s On My Homework – But I still Bomb the Tests!...

Some students feel they do all the homework but that they don’t do well on the exams. Most of these students have done well in school, but school really hasn’t been very hard – do the work, look over the notes, take the test, earn a good grade. For many students this strategy no longer works, and frustration sets in. Learning how to overcome this frustration and how to study for tests may be the most important skills you get from this class.

Chemistry is a branch of science, and science uses mathematical concepts to explain the relationships of matter. It is imperative to develop the skills necessary to manipulate the algebraic expressions that are used so often in this course.

I think most students need to work problems to prepare for chemistry exams. I believe they need to **work the problems before looking at notes or examples.** Since exams don’t come with examples, you need to be able to work problems without having a pattern to follow. Here are some recommendations:

* Look at the problems in the homework packet that the exam will cover. Notice when there are changes in directions or level of difficulty. For each change, pick at least one problem to work. Pick problems for which you have answers. Remember that about 70% of the test will be C level questions – basic problems, 10% - 15% will be B level problem – integrating a couple concepts, and 10% - 15% will be A level questions – integrating and extending concepts that we have covered.
* Work some example patterns without the answers by your side. Understand what problems challenged you the most, and figure out why. Once you have finished a couple of problems, check your answers and identify which ones you missed. Now is the time to look at notes and examples. Find some time before the exam to go back and try these problems again. Most students who have tried the above find that they did not know as much math as they thought they did. Working problems like this usually identifies what math you own and what math you don’t own.

**Radical Concept**

You don’t have to wait until the night before a test to study. If you have a quiz on Wednesday and do most of your studying on Monday, you have Tuesday’s class to get help and Tuesday night to rework any problems you missed on Monday.

Word problems are hard to study. As you do a series of word problems, pick the two or three that you think are the most typical of the assignment. Since we usually have labs that demonstrate or mimic real life examples, use your lab write ups to review these real-world problems as well. Too often students complete the labs to get a result - they don’t consider that the labs are designed to demonstrate the process of problem solving. If you have trouble understanding the labs, then chances are any word problem will be a challenge as well. If the exam includes word problems (and it usually does), go back and set up various examples and problems similar to the ones asked in labs.

Tests should be easier to prepare for than quizzes because I’ve already given you samples of what I think are the most important concepts. **Make sure you look at (rework?) any quizzes over material that a test will cover.**

**For most students, success in chemistry results from hard work, fighting through the frustration, and:**

* **Completing assignments on time**
* **Getting questions answered as soon as possible**
* **Good preparation for exams**
* **Paying attention to details (especially arithmetic)**

# Unit 6 – Gases

## Strain Your Brain #1

Using any resource available to you, please answer the following questions on another piece of paper. Remember…Sometimes the best resource is sitting next to you.

1. Explain in complete detail what is meant by the Kinetic Theory of Gases.
2. How is Kinetic Energy measured? How can Kinetic Energy be varied?
3. What is the formula for Kinetic Energy? Kinetic Energy of a particle depends upon what two properties of the particle? What would happen to the Kinetic Energy if the velocity of the particle were increased?
4. Explain fully the meaning of the terms “diffusion” and “compression”.
5. How do the densities of solids, liquids and gases compare? Explain why the densities of gases are so different from those of solids and liquids.
6. What is meant by the term “pressure”? Explain what factors affect the pressure of a gas.
7. How is molar volume defined and, what is its value for any gas at STP?
8. Pick your two favorite gases. Answer the following:
9. What are their molecular formulas?
10. Which molecule would travel faster if they were both at the same temperature and pressure?

Extra Credit: How much faster will the lighter molecule travel than the heavier molecule, if their temperatures are equal? (This needs to be a numerical answer)

Now, consider the following questions. Oh… and answer them too.

Consider a sealed, non-expandable container (a glass jar with a lid is a good example) which undergoes the following changes. Explain in molecular terms what is happening, then state what happens to the temperature, pressure, volume and number of moles for that gas in qualitative terms.

1. The container is slightly heated.
2. After being heated, the container is opened momentarily allowing some of the gas to escape, then it is resealed.
3. The air pressure outside the container is slightly increased.

Now consider a sealed container that *can* expand (like a balloon), and address the same things that you did in questions 8-10.

1. The container is slightly heated.
2. After being heated, the container is opened momentarily allowing some of the gas to escape, then it is resealed.
3. The air pressure outside the container is slightly increased.

Finally, two glass containers have the same volume. One is filled with hydrogen gas and the other with carbon dioxide gas. Both containers are at the same temperature and pressure.

1. Compare the number of molecules for the two gases.
2. Compare the masses of the two gases, making a ratio of the heavier to the lighter. (this is how much heavier the one gas is than the other)
3. Compare the kinetic energies of the two gases. Which one has a greater kinetic energy?

Extra Credit: How much faster will the lighter gas be traveling? (again this will be a numerical answer)

## Homework #1 – Conversions and Gas Relationships

1. Given the following relationships, convert the following.

1 atm = 760 mmHg (millimeters of mercury)

1 atm = 101.3 kPa (kilopascals)

1 atm = 760 torr

1. 755 mmHg to atm
2. 1.54 atm to pascals
3. 800 mmHg to kPa
4. 5 atm to mmHg
5. 500 kPa to atm
6. 500 kPa to mmHg
7. 700 torr to atm
8. 550 mmHg to torr
9. Convert the following temperature measurements.
10. 0°C to Kelvin
11. 27°C to Kelvin
12. 300 K to °C
13. 212 °F to °C
14. 150 K to °C
15. 70°F to K
16. 100°C to K
17. 0 K to °C
18. Solve for the unknown in each case: (Hint – use Boyle’s Law)
19. P1=350. mmHg, V1=200. mL, P2=700. mmHg, V2=?
20. P1=0.75 atm, V2=435 mL, P2=0.48 atm, V1=?
21. V1=2.4 X 105 L, P2=180 torr, V2=1.8 X 103 L, P1=?
22. If the pressure exerted on a 240. mL sample of hydrogen gas at a constant temperature is increased from 325 mmHg to 550 mmHg, what will be the final volume of the sample?
23. A flask containing 155 cm3 of hydrogen was collected under a pressure of 22.5 kPa. What pressure would have been required in order for the volume of the gas to have been 90.0 cm3 at constant temperature?
24. A gas has a volume of 450.0 mL at standard pressure. If the temperature is held constant, what volume would the gas occupy if the pressure were
25. doubled
26. reduced to one-fourth of its original value
27. If a sample of oxygen that occupies 1.00 X 106 mL at 575 mmHg is subjected to a pressure of 1.25 atm. what will be the final volume of the sample if the temperature is held constant?
28. Solve for the unknown in each case. (Hint – use Charles’ Law)
29. V1=80.0 mL, T1=27°C, T2=77°C, V2=?
30. V1=125 L, V2=85.0L, T2=127°C, T1=?
31. A sample of air has a volume of 140.0 mL at 67.0°C. To what temperature must the gas be lowered to reduce its volume to 50.0 mL at constant pressure?
32. At standard temperature (273K) a sample of gas has a volume of 275 mL. If the temperature is increased to 130°C, but the pressure is held constant, what is its new volume?
33. A weather balloon has a volume of 5000 L at a sea level temperature of 298 K. What will the new volume be as the balloon rises to an altitude of 10 kilometers and a temperature of 250 K?
34. A 500-mL can of spray paint at 298 K has a warning telling you not to leave it near a fire. Near the fire it may reach a temperature of 325 K. What volume would the gas like to occupy at this temperature? Why should you not leave it near the fire?
35. A sample of hydrogen at 47°C exerts a pressure of 250 mmHg. If the gas is heated to 77°C at constant volume, what will its new pressure be?
36. If the pressure on a sample of nitrogen at -73°C is doubled but its volume is held constant, what will its final temperature be in degrees Celsius?
37. A 350-mL air sample collected at 35°C has a pressure of 550 mmHg. What pressure will the air exert if it is allowed to expand to 425 mL at 57°C?
38. A gas at 7.75 X 104 Pa and 17°C occupies a volume of 850. cm3. At what temperature, in degrees Celsius, would the gas occupy 720. cm3 at 8.10X 104 Pa?

1. A weather balloon contains 250 L of helium at 22°C and 740 mmHg. If the volume of the balloon can vary according to external conditions, what volume would it occupy at an altitude at which the temperature is -52°C and the pressure is 0.750 atm?
2. A sample of gas at STP has a volume of 15 L. What would the new volume be, if the gas were heated to 350 K and the pressure reduced to 500 mmHg?

## Homework #2 – Dalton’s Law of Partial Pressures and More…

**Part I – Dalton’s Law of Partial Pressures**

1. What is the algebraic expression for Dalton’s law of partial pressures?
2. Two gasses are contained in a flask. If the pressure of the first gas, P1 = 550 mmHg and the pressure of the second gas P2 = 152 mmHg, what is the total pressure?
3. A third gas is added to the mixture from the previous problem contributing a pressure P3 of 75 mmHg. What is the new pressure?
4. Three of the primary components of air are carbon dioxide, nitrogen and oxygen. In a sample containing a mixture of these gases at one atmosphere of pressure, the partial pressures of carbon dioxide and nitrogen are given as PCO2 = 0.285 mmHg and PN2 = 593.525 mmHg. What is the partial pressure of oxygen?
5. When gas is collected over water, there is always some water vapor mixed in with the gas. The partial pressure of the water vapor can be found on the back of your periodic table. If the partial pressure of the gas is 0.82 atm at 20°C what is the total pressure of the mixture of the gas and the water vapor?
6. Determine the partial pressure of oxygen collected by water displacement if the water temperature is 20.0 °C and the total pressure of the gases in the collection bottle is 730.0 mmHg.
7. What are the conditions of STP?
8. A sample of gas is collected over water at a temperature of 35.0 °C when the barometric pressure reading is 742.0 mmHg. What is the partial pressure of the dry gas?
9. A sample of oxygen is collected in a 175 mL container over water at 15°C. If the barometer reads 752.0 mmHg, what volume would the dry gas occupy at 770 mmHg and 15 °C?
10. When working with any of the gas laws, what should you keep in mind about temperature?

**Part II – More Gas Laws**

1. A 5 L balloon at STP is heated to 150°C which also causes an increase in the volume to 7 L. What is the new pressure in the balloon?
2. A can of Coke® is dropped into a fire (shhhhh…don’t tell Jeffco Schools). The gases inside the can are initially at 2 atm and 25°C. If the can will withstand a pressure of 8.5 atm before bursting, what temperature will cause the can to blow?
3. If the can in the previous problem heats up at a rate of 1 degree every 2 seconds, how long will it take before the can goes boom?
4. What happens to the molecules in the can as the can is heated?
5. An expandable container (such as a balloon or a piston arrangement) allows a sample of gas to expand as the energy of the molecules increases, without changing the pressure. A 10 L sample of gas in a balloon is heated from STP to a temperature of 50°C. What is the new volume?
6. A weather balloon (volume = 5000L) is released into the atmosphere. The temperature at launch of the gases in the balloon was 85°C and the pressure 660 mmHg. As the balloon rises, it expands as the pressure outside the balloon drops. Assuming that the temperature of the gases remains constant, what will the volume be when the pressure is 550 mmHg?
7. Suppose that the weather balloon in the previous problem also undergoes a temperature change as it ascends. If the temperature drops from its original temperature to 60°C, what would the volume be then?
8. The balloon, once it reaches altitude, springs a leak and the gas begins to leak out. If the gas escapes at a rate of 100 mL per hour, how long will it take for the balloon to lose all of its volume?
9. Typical tire pressure is around 30 psi (pounds per square inch) and a tire has a volume of about 2500 in3. On a nice sunny day, the temperature may be 25°C, but as the car travels the tires heat up. If the tires can increase in size by 100 in3, what would the new pressure be when the tires reached a temperature of 50°C?

## Homework #3 – The Ideal Gas Law

1. A sample of carbon dioxide is collected over water at a temperature of 35.0 °C when the barometric pressure reading is 742.0 mmHg. What is the partial pressure of the dry gas?
2. A sample of nitrogen is collected in a 200 mL container over water at 25°C. The pressure of the gas in the sample is 615.0 mmHg, what volume would the dry gas occupy at STP?
3. Calculate the pressure, in atmospheres, exerted by each of the following:
4. 2.50 L of HF containing 1.35 mol at 320. K
5. 4.75 L of nitrogen dioxide containing 0.86 mol at 300. K
6. 750. mL of CO2 containing 2.15 mol at 57 °C.
7. Calculate the volume, in liters, occupies by each of the following:
8. 2.00 mol of hydrogen at 300. K and 1.25 atm
9. 0.425 mol of ammonium at 37 °C and 550. mmHg
10. 4.00 g of oxygen gas at 57 °C and 675 mmHg
11. Determine the number of moles of gas contained in each of the following:
12. 1.25 L at 250. K and 1.06 atm
13. 0.80 L at 27 °C and 0.926 atm
14. 750. mL at -50. °C and 700. mmHg
15. Find the mass of each of the following:
16. 5.60 L of oxygen at 1.75 atm and 250. K
17. 3.50 L of ammonia at 700. mmHg at 27 °C
18. 125 mL of sulfur dioxide at 625 mmHg and -53 °C
19. Find the molar mass of each gas measured at the specified conditions:
20. 0.650 g occupies 1.12 L at 280. K and 1.14 atm
21. 1.05 g occupies 2.35 L at 37 °C and 0.840 atm
22. 0.432 g occupies 750. mL at -23 °C and 785 mmHg
23. A sample of gas is at 25 °C and 620 mmHg. If the gas occupies a volume of 20 L, how many moles of the gas are present?
24. 25 g of methane, a favorite gas of a certain bio teacher…, are at 30 °C and a pressure of 0.82 atm. What volume does the gas occupy?
25. What would be the temperature of 5 moles of Ne trapped in a tube with a volume of 15 mL at a pressure of 760 mmHg?
26. It’s time to blow up some more hydrogen!! If your fearless leader filled a 4 L balloon with hydrogen at 23°C and 620 mmHg, how many moles of gas will go boom?
27. One of the products of hydrogen combustion is water, which because of the heat will be quite hot. If the ratio for hydrogen to water is 2:2 in the balanced equation, what will the volume of the water vapor be if the temperature is 250°C and 620 mmHg?
28. Martin is having a great day and is laughing happily. He breathes in for another good laugh, drawing in 500 mL of gas at a pressure of 0.8 atm and a temperature of 72°F. What is the number of moles that he breathes in?

## Homework #4 – Gas Stoichiometry

1. What are the names of the following compounds? NH4Cl. CaF2. Al2O3.
2. What is the formula for calcium carbonate? What is its molar mass?
3. Hydrogen and oxygen produce water according to the following reaction. H2 + O2 🡪 H2O. Balance this reaction.
4. Sodium chloride is produced according to the following reaction:

Na + Cl2 🡪 NaCl. Balance this reaction.

1. Ammonium hydroxide reacts with hydrogen chloride (hydrochloric acid) to produce ammonium chloride and water. Write the balanced equation for this.

***For questions 6-11*: Methane (CH4) burns to produce water and carbon dioxide.**

1. Write the balanced equation.
2. If 5 moles of methane burn, how many moles of oxygen will be consumed?
3. How many moles of methane must burn to produce 10 moles of water?
4. If the methane burns at STP, how many liters of methane will this be?
5. Often, methane will be compressed in storage tanks. What volume would the methane from the last question occupy under 10 atm pressure and a temperature of 25°C?
6. After the combustion, the water will be in vapor form. If the water vapor (gas) is at a temperature of 300°C, and if the pressure is 1atm, what volume would the vapor occupy?
7. Carbon monoxide reacts with oxygen to produce carbon dioxide at STP.
8. Write the balanced equation for this process.
9. If 1.0 L of carbon monoxide react, how many liters of oxygen are required?
10. How many liters of carbon dioxide are produced?
11. Acetylene gas (C2H2) undergoes combustion to produce carbon dioxide and water vapor.
12. Write the balanced equation for this process.
13. How many moles of C2H2 are required to produce 3.0 moles of CO2?
14. If the reaction occurs at STP, how many liters of C2H2 must have been present?
15. How many liters of oxygen must have been used in the reaction?
16. Assume that 5.60 L of hydrogen gas at STP react with copper (II) oxide to produce copper and water.
17. Write the balanced equation for this process.
18. How many moles of hydrogen react?
19. How many moles of copper are produced?
20. How many grams of water are produced?
21. Balance the chemical equation: Mg + O2 🡪 MgO.
22. If 10 g of Mg react, how many moles oxygen will be required?
23. What mass of magnesium oxide will be produced?
24. What volume of oxygen is needed if the reaction takes place at 20°C and a pressure of 620 mmHg?

## Homework #5 – More Stoichiometry

1. If liquid carbon disulfide reacts with 450. mL of oxygen to produce the gases carbon dioxide and sulfur dioxide, what volume of each product is produced at 25°C and 0.8 atm? (hint: you will need to start by converting to moles)
2. Hydrogen and oxygen react to produce water according to the reaction:

2H2 + O2 🡪 2H2O.

a) How many moles of hydrogen would be required to produce 5.0 mol of water?

b) How many moles of oxygen would be required?

c) If the reaction occurred at 20°C and 700 mmHg, what volume of oxygen is required?

1. Ethane (C2H6) undergo combustion according to the *unbalanced* reaction

C2H6 + O2 🡪 CO2 + H2O

If 4.5 moles of ethane combust, how many moles of oxygen are required?

b) How many moles of each product are formed? c) What volume of carbon dioxide would be produced if the products are at 500°C and 0.8 atm

1. Sodium chloride is produced from its elements through a synthesis reaction.

a) Write the balanced equation for this process.

b) What mass of each reactant would be required to produce 25.0 mol of sodium chloride?

c) What volume of chlorine is needed if the reactants are at STP?

1. Iron is generally produced from iron ore through the following reaction in a blast furnace: Fe203(s) + CO(g) 🡪 Fe(s) + CO2 (g) (in the reaction, (s) = solid (g) = gas

a) Write the balancing the equation?

b) If 4.0 kg of iron (III) oxide are available to react, how many moles of CO are needed?

c) How many moles of each product are formed?

d) What volume of carbon dioxide would be produced if the products are at 1000°C and 1.5 atm?

1. Methanol (CH3OH) is an important industrial compound that is produced from the following reaction: CO(g) + H2(g) 🡪 CH3OH(g). What mass of each reactant would be needed to produce 100.0 kg of methanol? How many liters of hydrogen would be required at STP?
2. As early as 1938, the use of NaOH was suggested as a means of removing CO2 from the cabin atmosphere of spacecraft according to the following reaction:

NaOH + CO2 🡪 Na2CO3 + H2O

a) Write the balanced equation for this process.

b) If the average human body discharges 5000 L of CO2 per day at 30°C and 1 atm, what mass of NaOH would be needed each day?

c) What mass of each product would be formed each day?

1. Sodium bicarbonate decomposes into sodium carbonate, carbon dioxide and water when exposed to high heat. What volume of water vapor is produced when 0.95 g of sodium bicarbonate decomposes at 1 atm and 450 K? What volume of carbon dioxide is produced?

# Unit 7 - Solutions

## Homework #1 – Solution Concentrations

**Molarity:**

1. How many moles of sodium hydroxide are contained in 65.0 ml of a 2.2 M solution of sodium hydroxide in water? How many grams of sodium hydroxide does this represent?
2. Determine the number of grams of solute needed to make solutions of the following volumes and concentrations:
3. 1.00 L of 3.5 M solution of sulfuric acid
4. 2.5 L of a 1.75 M solution of barium nitrate
5. Determine the molarity of each of the following solutions.
6. 20.0 g sodium hydroxide in 2.0 L of solution
7. 14.0 g of ammonium bromide in 150 mL of solution
8. 32.7 g phosphoric acid in 500. mL of solution
9. How many grams of calcium hydroxide are contained in 50.0 mL of a 0.2 M solution of calcium hydroxide in water?
10. What is the molarity of a solution made by dissolving 26.42 g of ammonium sulfate in enough water to make 50.00 mL of solution?

1. How many milliliters of 0.54 M silver nitrate would contain 0.34 g of pure silver nitrate?

Extra Credit: If 75.0 mL of silver nitrate solution reacts with enough copper to produce 0.250 g of silver by a single replacement reaction, what was the molarity of the initial silver nitrate solution if the copper (II) nitrate is the other product?

**Molality:**

1. Determine the molality of each of the following solutions:
2. 294.3 g sulfuric acid in 1.0 kg of water
3. 63.0 g nitric acid in 0.25 kg of water
4. 10.0 g of sodium hydroxide in 300 g water
5. Determine the number of grams of solute needed to make each of the following solutions:
6. a 4.5 *m* solution of sulfuric acid in 1.0 kg of water
7. a 1.0 *m* solution of nitric acid in 2.0 kg of water
8. a 3.5 *m* solution of magnesium chloride in 0.450 kg of water
9. A solution is prepared by dissolving17.1 g of sucrose (C12H22O11) in 275 g water. What is the molality of the solution?
10. How many kilograms of water must be added to 75.5 g of calcium nitrate to form a 0.5 *m* solution?
11. How many grams of glucose (C6H12O6), must be added to 750. g of water to make a 1.25 *m* solution?
12. In how many liters of water should 65.0 g of NaCl be dissolved to make a 0.450 *m* solution?

**Percent by mass:**

1. Find the percent by mass of each of the following solutions:
2. 10.0 g of sugar in 60 g water.
3. 0.63 g of silver nitrate in 12.0 g of water.

1. If you dissolve 25 grams of sodium chloride in 5 liters of water, what is the percent by mass of the sodium chloride?

Extra Credit: Find the mass of each solute present in each of the following solutions.

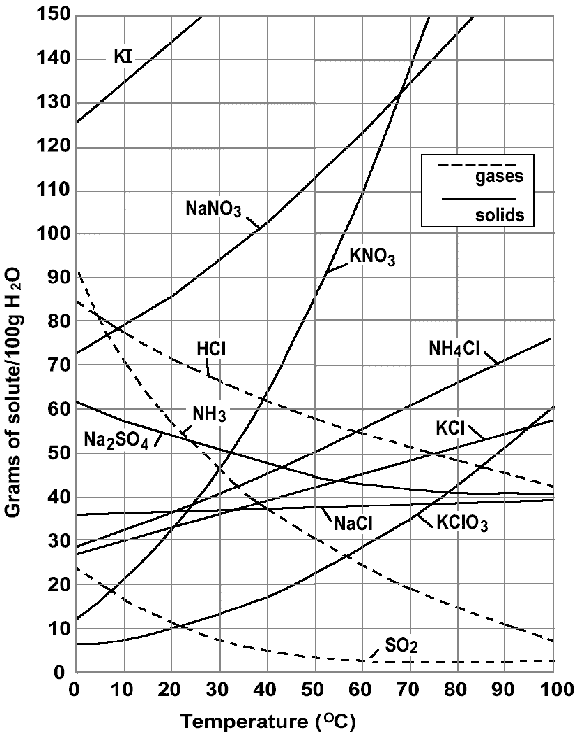
1. 50 g solvent in a 10.0% by mass sodium chloride solution.
2. 8.5 g of solvent in a 2.4% by mass potassium hydroxide solution.

**Solubility:**

1. Plot the solubility graph for silver nitrate from the following data, with grams of solute per 100 grams of water on the vertical axis and temperature in degrees Celsius on the horizontal axis.

|  |  |
| --- | --- |
| Temperature °C | Grams solute/100 g H2O |
| 0 °C | 122 g |
| 20 °C | 216 g |
| 40 °C | 311 g |
| 60 °C | 440 g |
| 80 °C | 585 g |
| 100 °C | 733 g |

1. How does the solubility of silver nitrate vary with the temperature of the water?
2. Estimate the solubility of silver nitrate at 30°C, 55°C and 75°C.



1. At what temperature would the solubility of silver nitrate be 275 g/100. g water?
2. If 60.0 g of potassium nitrate were dissolved in 50.0 g of water at 60.0°C, would the resulting solution be saturated or unsaturated?
3. If a saturated solution of potassium nitrate in 100. g of water at 60.0°C is cooled to 10.0°C, approximately how many grams of solute would precipitate out of the solution?

## Homework #2 – Ions, Ions and then more Ions!

Write the equation for the dissolution of the following solids:

1. CaCl2 in water
2. Potassium sulfate in water
3. Ammonium sulfide in 250 mL of solution, using water as the solvent

Begin by writing the equation for the dissolution and then answer the questions.

1. 35 g sodium chloride are dissolved in 350 mL of solution.
2. How many moles of sodium chloride are dissolved?
3. What is the total molarity of the solution?
4. What is the molarity of the sodium ions?
5. 5 mol of calcium nitrate are dissolved in 3L of solution.
6. What mass of calcium nitrate is dissolved?
7. How many moles of nitrate ions are in solution?
8. What is the molarity of the nitrate ions in the solution?
9. 250 ml of a 1.5 M ammonium sulfate solution.
10. What are the two ions in solution?
11. How many moles of ammonium sulfate are in solution?
12. What is the volume of the solution in liters?

When solutions are mixed, the ions mix together, and concentrations are calculated based on the total number of moles of an ion and the total volume. We can then write an equation to represents the ions in solution.

For example: 3 moles sodium chloride and 1.5 moles calcium chloride are dissolved in 10 L of solution. Write an equation showing the solids as reactants, the ions as products, and determine the concentration of each ion.

Both sodium chloride and calcium chloride are soluble in water, yielding sodium, calcium and chloride ions in solution.

H2O

NaCl (s) + CaCl2 (s) 🡪 Na+1 (aq) + Ca+2 (aq) + 3Cl-1 (aq)

3.0 mol 1.5 mol 3.0 mol 1.5 mol 6.0 mol (3.0 moles from calcium chloride

and 3.0 moles from sodium chloride)

all are in 10.0 L solution so that the molarity of each ion will be:

0.30 M 0.15 M 0.60 M

The number of moles were determined from mole ratios and the molarity using the molarity equation: M = mol/V.

For the following, write an equation showing the solids as reactants, the ions as products, and determine the concentration of each ion.

1. 4.0 mole of ammonium chloride and 2.1 mole sodium chloride in 10.0 L solution
2. 0.30 mol calcium bromide and 0.40 mol of magnesium bromide are dissolved into 1.0 L of solution.
3. 30.0 g sodium hydroxide and 40.0 g sodium sulfate are put into 1.0 L of solution.
4. 100. g of C12H22O11 and 2.00 moles of table salt (sodium chloride) are put into 300. g of water.

## Homework #3 – Dilution Problems

1. If you took 3.0 L of a 12 M hydrochloric acid solution and diluted it to 10. L, what would the new molarity be?

1. How many moles of HCl are present in the 10. L of solution in #1?
2. Suppose you have 300. mL of a 3.0 M acid. If you began with 100. mL of the concentrated stock solution, and then diluted it to the 300. mL volume, what was the original molarity of the stock solution?
3. You have 16 M sulfuric acid. How much of the acid must you dilute in order to get 500. mL of a 2.0 M sulfuric acid solution?
4. 2.0 kg of a 3.0 *m* salt solution are diluted so that the total mass of solvent is 5.0 kg. What is the new molality?
5. Mr. Bertelsen is making a secret potion for cranial massage. He has a 4.0 M bottle of the potion but finds this to be too strong. He decides to dilute it to a 1.0 M potion. What volume of the 4.0 M solution will he need to make 1.0 L of the 1M potion?
6. Fearsome Fitch wants to use this potion, too; but the 1.0 M solution is too strong for his delicate scalp. He decides to make 1.0 L of 0.35 M potion. How much of Bertelsen’s secret recipe (the 1.0 M variety) will Fitch need?
7. Coach Gisetti wants to make 3.0 L of 5.0 M sulfuric acid from an 18 M stock solution. How much H2SO4 and how much water should he use to make the solution?
8. The Great and powerful Oz decides to take 100 mL of Gisetti’s 5.0 M H2SO4 and combine it with 500. mL of water. What is the molarity of the new solution?
9. Mr. Cox takes 600. mL of Oz’s acid and decides to return it to its original 18 M state. He does this by evaporating the water, leaving a stronger solution behind. When should he stop boiling away the water... in other words, what should the final volume be?

## Homework #4 – Solubility

**Using your solubility rules, write the equation for the reaction. (include aq, s, g, and l as appropriate)**

1. Silver nitrate is mixed with lithium chloride
2. Hydrochloric acid and lead (II) nitrate
3. Sodium phosphate and calcium acetate
4. Sulfuric acid and barium nitrate
5. Ammonium hydroxide and zinc nitrate

Write the net ionic equation for the formation of the following solids. Example: Silver chloride is formed by Ag+ (aq) + Cl- (aq) 🡪 AgCl (s)

1. Vanadium (IV) hydroxide
2. Radium (II) sulfate
3. Mercury (II) dichromate
4. Silver Acetate

10) Calcium sulfite

## Homework #5 – Solution Stoichiometry

1. A solution has a volume of 0.250 L and contains 26.8 g of calcium chloride. What is the molar concentration of the calcium chloride?
2. Potassium permanganate is a common laboratory chemical. Assume you dissolve 0.395 g of KMnO4 in enough water to give 250.0 mL of solution. What is the molar concentration of the potassium permanganate?
3. 126.0 g of sodium chloride is added to enough water to prepare 793 cm3 of solution. What is its molar concentration?

**Making solutions of known concentrations**

1. How many grams of sodium nitrate must be used in order to prepare 5.00 x 102 mL of a 0.10 M solution?
2. A volume of 10.00 cm3 of 0.1738 M NaCl is delivered from a pipette during a lab. How many moles of NaCl are being dispensed?
3. 25.0 mL of a 0.485 M sodium sulfate solution was pipetted into a beaker. How many grams of sodium sulfate were delivered?
4. An experiment requires 500.0 mL of 0.0200 M solution of KMnO4. You are given a bottle of solid KMnO4, some distilled water, and a 500.0 mL volumetric flask. A volumetric flask is a special flask that allows you to measure 500.0 mL very precisely. Describe how you would go about making the required solution.
5. Determine the molarity of each of the following solutions.

a) 20.0 g sodium hydroxide in enough water to make 2.0 L of solution

b) 14.0 g ammonium bromide in enough water to make 150. mL of solution

1. Calculate the moles of solute needed to make these solutions:

a) 150 mL of 0.12 M magnesium nitrate

b) 1.00 liter of 0.0035 M sodium chloride

1. A chemist evaporated 25.0 mL of sodium chloride solution to dryness. He found 0.585 grams of salt. What was the original concentration?

**Determine the concentration of all ions in each of the following solutions.**

1. 300 mL of a 0.70 M calcium chloride
2. 250 mL of a 1.5 M ammonium sulfide

**Stoichiometry and Solutions**

1. Determine the concentration of all ions if 0.30 moles of calcium bromide and 0.40 moles of magnesium bromide are dissolved into 1.00 liters of solution.
2. Sodium chloride is placed into a beaker with a silver nitrate solution. Silver chloride precipitates out of solution.

a) Write the equation for this process.

b) If 5.0 mol of silver chloride were produced, how many moles of sodium chloride must have been used?

c) If the molarity of the salt solution was 2.0 M, what was the volume of salt solution used?

1. 3.0 g of zinc were dropped into 5.0 mL of a 1 M nitric acid solution.

a) Write the equation for this process.

b) How many moles of nitric acid are present in the solution?

c) Will all of the zinc participate in the reaction? (hint: use the moles nitric acid to determine mole zinc and compare with the actual moles of zinc)

1. Calcium nitrate is mixed with sodium hydroxide and a cloudy substance forms.

a) Write the equation for this process, including states (aq, s, l, and g) as appropriate.

b) If 30. ml of a 2.8 M calcium nitrate solution were mixed with an excess of sodium hydroxide, what mass of each product will be formed?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Chemical Equilibrium Unit**

This unit has not yet been developed for general chemistry.

# Unit 8 – Acids and Bases

## Homework #1 – Acid/Base Reactions

**Part I.** Write a balanced equation for each of the following neutralization reactions.

1. Hydrochloric acid plus potassium hydroxide
2. Zinc hydroxide plus nitric acid
3. Magnesium hydroxide plus sulfuric acid
4. Cobalt (II) hydroxide plus hydrochloric acid
5. Acetic acid plus potassium hydroxide
6. Phosphoric acid plus sodium hydroxide
7. Beryllium hydroxide plus nitric acid
8. Aluminum hydroxide plus sulfuric acid.
9. Manganese (IV) hydroxide and carbonic acid
10. Hydrochloric acid and sodium hydroxide

**Part II.** Given a salt, it is possible to write a balance equation for an acid-base reaction which would produce the salt, if you remember that the products are the salt and water. For example NaCl can be produced as follows: HCl + NaOH 🡪 H2O + NaCl

Write the balance equation for the reaction that produced the following salts.

1. KNO3
2. (NH4)2SO4
3. Na2CO3
4. Calcium bromide
5. Vanadium (IV) fluoride

**Part III.** Determine the pH and pOH of the following solutions. (use two significant figures)

1. 0.10 M hydrochloric acid

2. 0.0010 M potassium hydroxide

3. 0.0050 M nitric acid

4. 0.0050 M lithium hydroxide

5. 50 mL of a 0.00030 M NaOH solution

6. 200. mL of a 0.00030 M NaOH solution

7. 800. mL of a 7.0 x 10-6 M sulfuric acid solution

1. 400. mL of a 9.0 x 10-4 M calcium hydroxide solution
2. 5.0 moles of hydrogen chloride dissolved in 10. liters of solution
3. 25 g lithium hydroxide dissolved in 2.00 x 103 mL of solution

Determine the concentrations: [H3O+] and [OH-] for each of the following.

1. 200. mL of an hydrochloric acid solution with a pH of 2.0
2. 100. mL of a sulfuric acid solution with a pH of 5.4
3. 250. mL of a sodium hydroxide solution with a pOH of 7.00
4. 1.00 liter of a sulfuric acid solution with a pH of 5.0
5. Since sulfuric acid is a diprotic acid (H2SO4 🡪 2 H+ + SO42-, giving two H+ for each acid molecule) how many moles of H2SO4 are in the solution in problem 14?

## Homework #2 – Acid/Base Neutralizations

1. If 86.2 cm3 of 0.765M sodium hydroxide neutralize 30.0 cm3 of hydrochloric acid solution, what is the concentration of the acid?
2. If 40.8 cm3 of 0.106M sulfuric acid neutralize 61.8 cm3 of potassium hydroxide solution, what is the concentration of the base?
3. If 75.0 mL of 0.823M HCl04 requires 95.5 mL of Ba(OH)2 to reach a neutral solution, what is the concentration of the Ba(OH)2 solution?

(Hint: write the equation first. Remember, polyatomic ions don’t usually break apart.)

1. In an acid-base titration, 35.0 mL of a Ca(OH)2 solution requires 26.3 mL of 0.125 M HCl to neutralize it. What is the concentration of the base?
2. A student placed 0.90 grams of magnesium hydroxide into a beaker with enough water to make about 50.0 mL of solution. He then neutralized this with a 0.30 M nitric acid solution. What volume of the nitric acid would have been consumed? (Please report your answer to the nearest tenth of a mL).
3. If 25.0 mL 0.100 M hydrochloric acid solution are necessary to neutralize 55.0 mL of a solution of sodium hydroxide to a phenolphthalein end point, calculate the molarity of the sodium hydroxide solution.
4. If 32.0 mL of a dilute solution of lime water (calcium hydroxide) required 12.4 mL of 0.100 M hydrochloric acid solution for neutralization, calculate the molarity of the lime water.
5. If 20.0 mL of potassium hydroxide solution required 16.4 mL of 0.150 M hydrochloric acid solution for neutralization to a phenolphthalein end point, calculate the molarity of the potassium hydroxide solution.
6. If 37.5 mL of 0.5000 M sodium hydroxide solution is necessary to neutralize 25.0 mL of hydrochloric acid solution to phenolphthalein end point, calculate…

1. the molarity of the HCl

b) the percent by mass (density of solution = 1.013 g/mL) of the hydrochloric acid

1. Vinegar is a solution of acetic acid. In the titration of 5.00 mL of vinegar, 37.7 mL of 0.105 M sodium hydroxide solution were required to neutralize the vinegar to a phenolphthalein end point. Calculate…
2. the molarity of the vinegar

b) the percent by mass (density of solution =1.007 g/mL) of the vinegar. Hint: % mass = [mass of one component of a solution/total mass of solution] x 100%. For this solution, the mass of the component of interest is the mass of the acetic acid, found from the moles.

## Homework #3 – Acid/Base Titrations

1. If 0.625 g of pure sodium carbonate was dissolved in water and the solution titrated with 30.8 mL of hydrochloric acid to phenolphthalein end point, calculate the molarity of the hydrochloric acid solution.
2. In the titration of 24.5 mL of a potassium hydroxide solution of unknown concentration, 35.7 mL of 0.110 M sulfuric acid were required to neutralize the potassium hydroxide (assume that both hydrogen ions reacted). Calculate the molarity of the potassium hydroxide solution.
3. In the titration of a 0.125 M sodium hydroxide solution, 28.5 mL of 0.155 M sulfuric acid solution was required to neutralize the sodium hydroxide in reactions that replace both hydrogen ions of the sulfuric acid. Calculate the volume in mL of the sodium hydroxide solution needed in the reaction.
4. Calculate the pH and pOH of the following solutions:

a) hydrogen ion concentration is 1.0 X 10-9 mol/L

b) hydrogen ion concentration in household ammonia is 2.0 x 10-12 mol/L

c) hydrogen ion concentration in commercial milk is 2.0 x 10-7 mol/L

5. Calculate the pH and pOH of the following solutions:

a) hydrogen ion concentration is 2.4 x 10-5 mol/L

b) hydrogen ion concentration in vinegar is 7.9 x 10-4

c) hydrogen ion concentration in a dilute solution (0.133%) of citric acid found in various

fruits is 0.40 x 10-3 mol/L.

1. In general, the flavor of devil’s food cake is best if the hydrogen ion concentration is between 1.0 x 10-6 mol/L and 3.2 x 10-6 mol/L.

a) Calculate this range on the pH scale.

b) If the hydrogen ion concentration is less than 1.0 x 10-6 mol/L, the cake has a bitter, soapy taste. Explain.

1. The hydrogen concentration of soils varies considerably. In forest soils, the hydrogen ion concentration is about 3.2 x 10-6 mol/L, while in desert solids the hydrogen ion concentration is about 1.0 x10-10 mol/L. The higher hydrogen ion concentration in forest solids is due to the decomposition of organic matter resulting in the production of carbon dioxide. Calculate the pH and pOH for both types of soil.
2. Calculate the hydrogen ion concentration in moles per liter for the following solutions:

a) a solution whose pH is 5.2

b) a solution whose pH is 9.6

c) a solution whose pH is 2.5

d) a solution whose pOH is 12.0

e) a solution whose hydroxide concentration is 1.7 X 10-6 mol/L

f) a solution whose hydrogen concentration is 3.4 X 10-6 g/L

9. Calculate the hydroxide ion concentration in moles per liter for each of the following:

a) a solution whose pOH is 5.0

b) a solution whose pOH is 9.6

c) a solution whose pH is 5.7

d) a solution whose pH is 8.2

e) a solution whose hydrogen ion concentration is 4.0 X 10-4 mol/L

10. 0.200 g of sodium hydroxide are titrated with 5.70 mL of hydrochloric acid solution to a

phenolphthalein end point.

a) What is the molarity of the hydrochloric acid?

b) What is the percent by mass of the HCl?

## Homework #4 – Acid/Base Conjugate Pairs

For the following reactions, identify the acid, base, conjugate base and the conjugate acid.

1. H3­O+ + OH- ↔ H2O + H2O
2. H2S + NH3 ↔ HS- + NH4+
3. H3PO4 + H2O ↔ H3O+ + H2PO4-
4. C5H5N + H2O ↔ C5H5NH+ + OH-
5. H2PO4-  + H2PO4- ↔ H3PO4 + HPO42-
6. CO3-2 + H2O ↔ HCO3- + OH-

Write the products of the following reactions and identify the acid, base, conjugate base and conjugate acid.

1. H2O + H2O ↔
2. H2SO4 + H2O ↔
3. H2PO4- + H2O ↔
4. Vinegar and water
5. Nitric acid and water.
6. Nitrite ion reacting with hydronium. (Hint: Hydronium is the Br∅nsted-Lowry acid)
7. Ammonia and water. (Hint: Ammonia is the Br∅nsted-Lowry base)
8. Acetate ion and water

## Unit 8 Review

1. List five general properties of aqueous acids
2. Define and give an example of a traditional acid and base, as well as a Bronsted/Lowry acid and base.
3. Explain the difference between a strong acid and a weak acid, and give an example of each
4. Name five acids commonly found in industry and/or the laboratory and describe their nature (i.e.: strong, weak, number of H+ ions...)
5. Define and recognize Arrhenius and Bronsted/Lowry acid – base reactions
6. Define conjugate acid, conjugate base and understand the relationship between acid/base pairs
7. Predict the products of reactions involving aqueous acids and aqueous bases
8. Know the value for Kw and be able to use this value to determine hydrogen ion and hydroxide ion concentrations
9. Define pH and pOH and give the pH for a neutral solution
10. Use pH and pOH to predict acidity and be able to calculate ion concentrations using pH and pOH.
11. Using titration data, be able to determine the molarity of an unknown acid or base.
12. Understand the role of an indicator in an acid/base titration and be familiar with phenolphthalein

**Review problems**

1. If 0.247 g of pure sodium hydroxide was dissolved in water and the solution titrated with 30.8 ml of hydrochloric acid to phenolphthalein end point, calculate the molarity of the hydrochloric acid solution.
2. In the titration of 18.5 mL of potassium hydroxide solution of unknown concentration, 29.7 mL of 0.200 M nitric acid was required to neutralize the potassium hydroxide. Calculate the molarity of the potassium hydroxide solution.
3. In the titration of a 0.250 M barium hydroxide solution, 39.0 mL of 0.425 M hydrochloric acid solution was required to neutralize the barium hydroxide. Calculate the number of mL of the barium hydroxide solution needed in the reaction.
4. Calculate the pH and pOH of the following solution:

a) hydrogen ion concentration is 4.0 x 10-8 mol/L

b) hydrogen ion concentration in household cleaning solution is 8.5 x 10-12 mol/L

c) hydrogen ion concentration in milk is 2.0 x 10-7 mol/L

1. Calculate the pH and pOH of the following solutions:

a) hydrogen ion concentration is 2.4 x 10-5 mol/L

b) hydrogen ion concentration in vinegar is 7.9 x 10-4 M

c) hydrogen ion concentration in a dilute solution ( 0.133%) of citric acid found in various

fruits is 1.4 X 10-3 mol/L.

1. In general, the flavor of devil’s food cake is best if the hydrogen ion concentration is between 1.0 x 10-6 mol/L and 3.2 x 10-6.
2. Calculate this range on the pH scale.

(b) With hydrogen ion concentration of less than 1.0 x 10-6 mol/L, the cake is bitter with a slightly soapy taste. Explain.

1. The hydrogen concentration of soils varies considerably. In forest soils the hydrogen ion concentration is about 3.2 x 10-6 mol/L, while in desert solids the hydrogen ion concentration is about 1.0 x10-10 mol/L. The higher hydrogen ion concentration in forest solids is due to the decomposition of organic matter resulting in the production of carbon dioxide. Calculate the pH and pOH for both types of soil.
2. Calculate the hydrogen ion concentration in moles per liter for the following solutions:
   1. a solution whose pH is 5.2
   2. a solution whose pH is 9.6
   3. a solution whose pH is 2.5
   4. a solution whose pOH is 12.0
   5. a solution whose hydrogen concentration is 1.7 x 10-6 mol/L
   6. a solution whose hydrogen concentration is 3.4 x 10-6 g/L

9. Calculate the hydroxide ion concentration in moles per liter for each of the following solutions:

* 1. a solution whose pOH is 5.0
  2. a solution whose pOH is 9.6
  3. a solution whose pH is 5.7
  4. a solution whose pH is 8.2
  5. a solution whose hydrogen ion concentration is 4.0 X 10-4 mol/L

Write the balanced equation for each reaction. Label the acid, base, conjugate acid and conjugate base.

1. NH3(aq) + H2O(l) ↔ NH4+(aq) + OH-(aq)
2. HNO2(aq) + H2(l) ↔ H3O+(aq) + NO2-(aq)
3. HCN(aq) + H2O(l) ↔ H3O+(aq) + CN-(aq)

For the following, indicate whether each refers to an acid, base or both.

1. Often feels smooth and slippery
2. Has a sour taste
3. Stings in open wounds
4. Typically reacts vigorously with metals
5. Has a bitter taste
6. Turns litmus paper from blue to red
7. Is an electrolyte
8. Often looks like pure water
9. Turns litmus paper form red to blue
10. Typically does not react with metals

# Unit 9 – Organic Chemistry

## Naming Rules for the Alkanes (SATURATED HYDROCARBONS)

1. Pick the longest chain as the “parent” (Check textbook for list of parent hydrocarbons)

1. Number the carbon atoms in the parent chain so that you have the lowest numbering system.
2. Name each substituted alkyl group in alphabetical order as a prefix to the parent.

alkyl groups: Methyl Ethyl Propyl

CH3 C2H5 C3H7

4. More than one alkyl group is given a prefix of:

di (2) tri (3) tetra (4) penta (5) hexa (6)

1. A comma is used to separate the two consecutive numbers and a dash is used to separate numbers from words.
2. If there are no functional groups, then the compound is referred to as being the “normal” hydrocarbon and labeled with as “n”

7. -ene is the suffix used for a hydrocarbons with at least one double bond, and -yne is the suffix used for a hydrocarbon with at least one triple bond.

8. If a ring compound is formed, then use “cyclo” as a prefix to the parent name.

Parent saturated hydrocarbons (alkanes – the number of carbon atoms in the chain are listed in parentheses). Please draw the structural formula next to the name.

Methane (1) Ethane (2)

Propane (3) Butane (4)

Pentane (5) Hexane (6)

Heptane (7) Octane (8)

Nonane (9) Decane (10)

## Homework #1 – An Investigation

Obtain a molecular model kit.

1. How many bonds does a carbon atom have.\_\_\_\_\_\_\_

2. How many bonds does a hydrogen atom have.\_\_\_\_\_\_

3. Using the appropriate number of carbon atoms and hydrogen atoms make each of the following molecules and complete the following chart.

Number of Maximum # of Molecular Structural Name of

carbon atoms hydrogen atoms formula formula compound

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |

4. Bonding with hydrogen and carbon give rise to only one possible structure when you use one, two, or three, carbon atoms. When you use four carbon atoms, however, and attach as many hydrogen atoms as possible, then two structural formulas are possible. Make a model of the alkane with four carbon atoms. Now rearrange the atoms to make a different molecule with the same number and kind of atoms. Draw the structural formula for each.

What is the molecular formula for the above two compounds?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

When compounds have the same molecular formula but different structural formulas then they are referred to as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Using the formula C5H12 construct all possible structural formulas. (it may be necessary to compare with other lab groups). Draw the structural formula for each of your isomers – there are three of them.
2. Using the formula C6H14, construct all possible structural formulas. Draw the structural formula of your isomers. (hint: it may be helpful to name your molecules – isomers will have different names.) There are five of them.
3. Define the term “isomers”
4. Draw the structural formula for the isomers of C7H16. Name all of your isomers according to the IUPAC nomenclature. There are 9 of them

## Homework #2 – Alkanes and Alkenes

1. Name each of the following organic compounds.

CH3

a.) b.) c.) /

H3C CH3 H CH3 H2C = C CH3

\ / \ / \ / C = C C = C C CH3

/ \ / \ / \ /

H3C CH3 H H H C = C

/ \

H CH3

d.) e.)

H CH3 H C2H5 f.)

⏐ ⏐ ⏐ ⏐

H3C – C – C – C – CH3 H5C2 – C – C2H5 (CH3)3CCH2CH(CH3)2

⏐ ⏐ ⏐ ⏐

H CH3 H C2H5

g.) h.) i.)

H H CH3 H H CH3 H H H H

⏐ ⏐ ⏐ ⏐ ⏐ ⏐ ⏐ ⏐ ⏐ ⏐

H – C – C – C – C – C – CH H – C = C – C = C – H CH2(CH2)4CHCH3

⏐ ⏐ ⏐ ⏐ ⏐ ⏐ \* the arc indicates a

H­ – C–H H H H H CH2 loop structure

⏐ ⏐

CH3 CH3

2. Determine the molecular formula for each of the following hydrocarbons.

a. An alkane with 32 carbon atoms. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

b. An alkene (with only one double bond)

having 21 carbon atoms. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

c. An alkene (with 3 double bonds)

having 26 carbon atoms. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Obtain a molecular model kit. Build a model of ethane and ethene.

Describe the difference in rotation of a single bond vs. the double bond.

4. Build a model of 2-butene. There are two different ways to make 2-butene that are structurally different, but are both named 2-butene. These two forms represent geometrical or stereo isomers. With your model, experiment to determine the two different forms, changing the orientation of the carbons around the double bond. Draw the structures of your two isomers below.

The butene with the carbon chain going “across” the double bond is called trans-2-butene, and the butene with the carbon chain staying on the same side of the double bond is called cis-2-butene.

5. Determine the molecular formula and calculate the molecular mass of the following organic compounds. (hint: draw the structural formula first)

a. 3-ethylpentane

1. butane
2. 4-methyl-1-pentene

d. 1,3,5-cyclohexatriene

e. 3-ethyl-4,7,7-trimethyl-3-decene

f. 1-hexene-4-yne

## Homework #3 – anes, enes and yns… a shortcut

1. Name the following organic compounds.

a.) b.) c.)

d.) e.) f.)

g.) h.) i.)

CH3(CH2)4(CH)2CH2CH3

1. Draw the structural formulas for the following compounds.

a. 3-hexene b. 4-ethyl-4-methyl-1-nonene

c. 1,3-dimethylcyclopentane d. 2-butene

e. 5-ethyl-3-heptyne f. cyclohexane

3. Draw the structural formulas for at least seven isomers of C5H10.

Name each isomer. (an additional sheet may be needed)

## Homework #4 – Halogenated Hydrocarbons

Obtain a molecular model kit.

In this lab you will be working with models of halogenated hydrocarbons. Carbon (black spheres) has\_\_\_\_\_\_ bonds sites and hydrogen (yellow) has\_\_\_\_\_\_ bond site. The halogens each have\_\_\_\_\_\_\_ bond site. Usually the green spheres represent chlorine, the orange represent bromine and the purple can be iodine or fluorine.

To name halogenated hydrocarbons the stems of fluoro, chloro, bromo and iodo are as prefixes to the parent hydrocarbon.

1. Make a model using one carbon, two hydrogen and two chlorine atoms.

1. What is the molecular formula for this compound?
2. Draw the structural formula for this compound.
3. What is the name of this compound?
4. Make models, then draw the structural formulas and name all isomers for

C2H5Cl.

1. Make models, draw the structural formulas and name all isomers for

C2H4Cl2.

For each of the following, make models where necessary.

4. Nine isomers exist for C4H8Cl2.  Draw the structural formulas for and then name 5 of the isomers.

5. For each of the following:

I. Draw structural formula

II. Determine the molecular formula

III. Calculate the mass of one mole

a. 2-bromobutane

b. 3-chloro-2,4-dimethylheptane

1. 2,3-dibromo-1-hexene

d. 3,4-dibromo-1,2-dichloro-3-nonene

1. 1,3,5-trinitrocyclohexane (nitro is a comprised of a nitrogen atom bonded to two oxygen atoms. The bond site is off of the nitrogen)
2. 1,3,5-cyclohexatriene (this compound is also known as benzene – an organic solvent)

## Homework #5 – Alkynes and Aromatic Compounds

1. Name the following organic compounds.

a.) b.) c.) Cl

H H

⏐ ⏐

H – C ≡ C – C – C – H

⏐ ⏐

H H Cl

d.) e.) CH3 f.) CH2CH3

⏐ ⏐

g.) h.) i.) CH3

H H H H H Br H Br

⏐ ⏐ ⏐ ⏐ ⏐ ⏐  ⏐

H – C – C ≡ C – C ≡ C – H H – C ≡ C – C – C = C – C – H

⏐ ⏐ ⏐

H H H Br NO2

j.) k.) Br l.) I

H – C ≡ C – C ≡ C – C ≡ C – H

I

Br

1. Draw the structural formula, determine the molecular formula, and determine the molar mass for each of the following organic compounds.
2. ethyne
3. 1,3-butadiyne
4. 1-hexene-4-yne
5. 3,4-dibromo-1-hexyne
6. benzene
7. 2,4,6-trinitro-1-methylbenzene