The Chemistry 151 Companion

Lab Manual, Problem Sets, Lecture Slides and Learning Resources

Dr. Michael A. Russell
Mt. Hood Community College
Summer 2024

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Welcome to Chemistry 151!

My name is **Dr. Michael Russell** and I am pleased that you have decided to take Chemistry 151 with me this quarter. I look forward to an exciting term with you!

Here are some hints on how to get the most out of the ***Chemistry 151 Companion***:

- Glance over the **Table of Contents** that follows this introduction. The Table of Contents lists the respective page numbers for each of the sections.

- Information on **how to construct a graph** can be found in the lab section (with a Roman number "***I***" leading.) A handy **pictorial guide to common glassware**, a ScienceNotes.org **Periodic Table** and a **parts per thousand handout** follow shortly afterwards. The **labs** we will be performing this quarter follow.

- The **problem sets** that we will use this quarter follow the lab section. They are listed with a Roman number "***II***".

- A printed version of the **Lecture slides** that will be covered this quarter can be found next. The PowerPoint notes use a Roman number "***III***" followed by the Chapter number, then the page number. For example, ***Page III-6-3*** would refer to a PowerPoint note (the "***III***") in Chapter ***6*** (the "***6***"), and the "***3***" refers to the ***third*** page of notes for Chapter 6.

- **Learning Resources** follow the lecture slides and augment difficult concepts discussed in lecture. The numbering system is similar to the PowerPoint slides system but with a "**IV**". For example, if you see ***Page IV-5-1*** this would refer to a Learning Resource handout (the "***IV***") in Chapter ***5*** (the "***5***"), and the "***1***" refers to the ***first*** page of lecture handouts for Chapter 5.

- Finally, **sample quizzes and exams** (with answers, they start with a Roman number **V**) follow. Note that additional quiz and exam testing resources are available on the CH 151 website (http://mhchem.org/151).

If you have questions throughout the quarter, please do not hesitate to contact me using the contact information below. Good luck with your studying!

Peace,

Dr. Michael Russell
mike.russell@mhcc.edu - *email address*
http://mhchem.org/151 - *CH 151 website*
(503) 491-7348 - *phone*
AC 2568 - *office*

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CHEMISTRY 151 TABLE OF CONTENTS

All of these materials can be found on the Chemistry 151 website (http://mhchem.org/151)

CH 151 Laboratory Experiments

Labs for Section W1 ("online"):

CH 151 Problem Sets

CH 151 Lecture Slides

CH 151 Learning Resources

CH 151 Sample Quizzes and Exam *(with answers)*

More learning resources can be found on the CH 151 website: ***http://mhchem.org/151***

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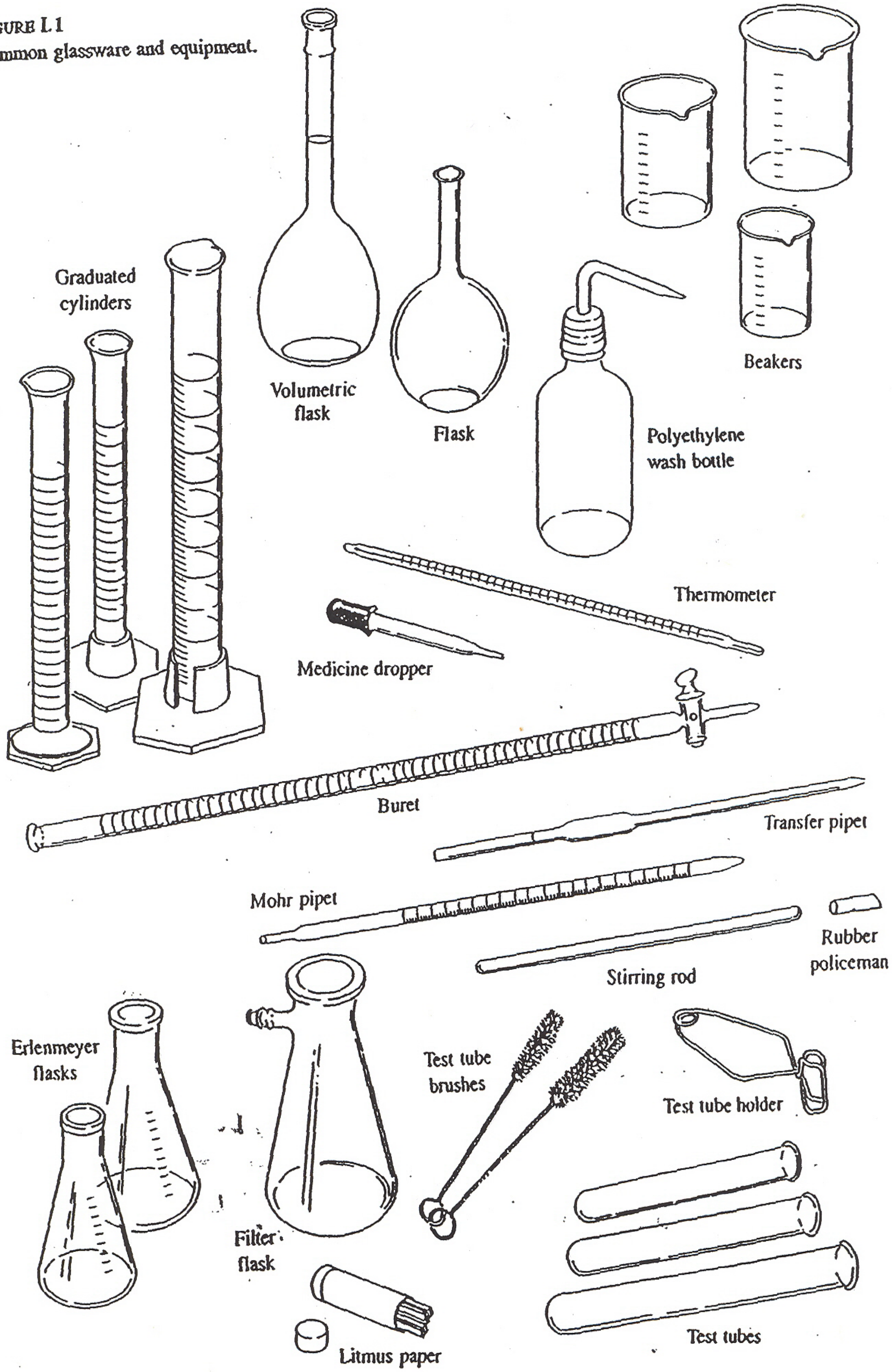
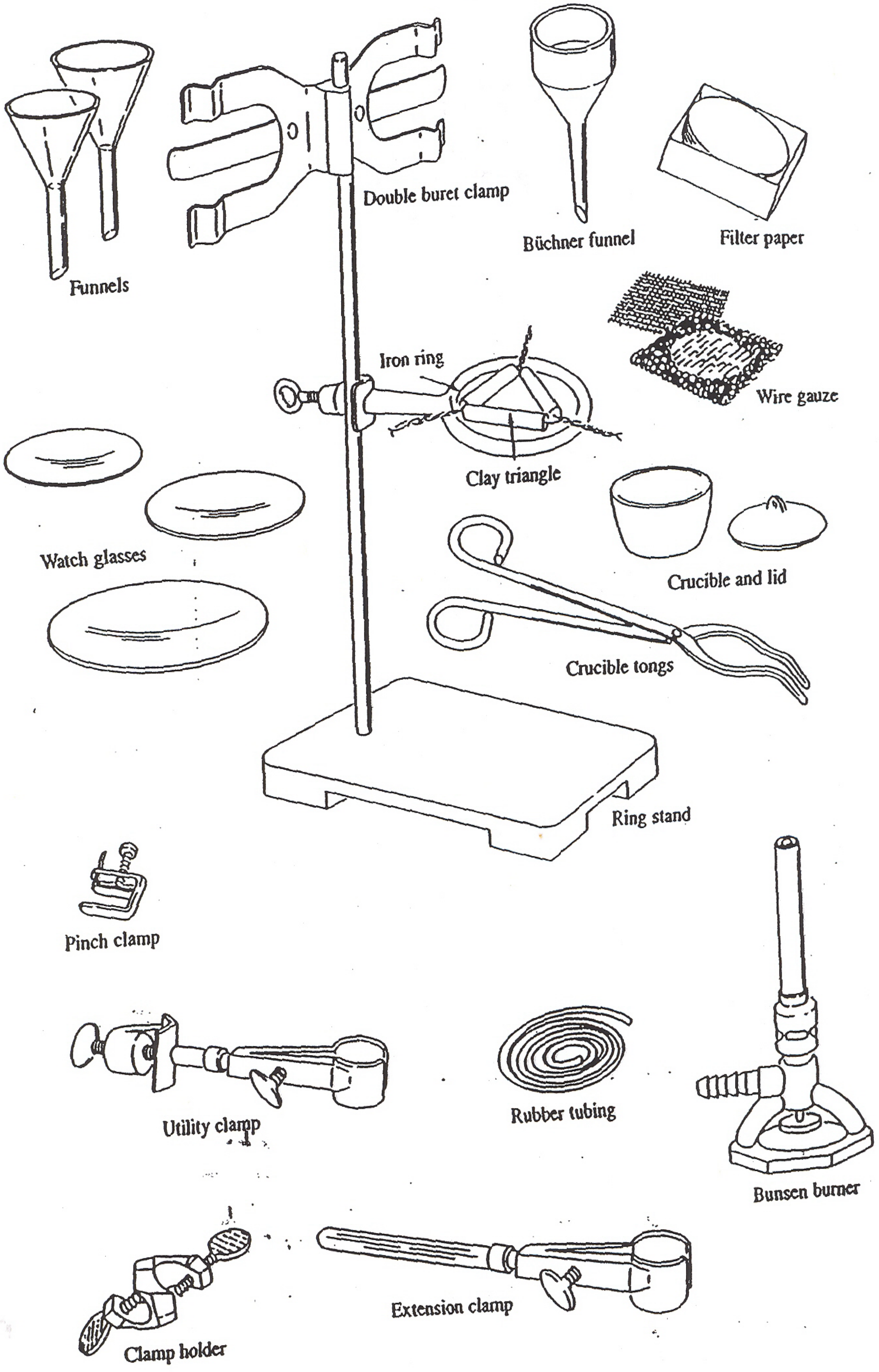
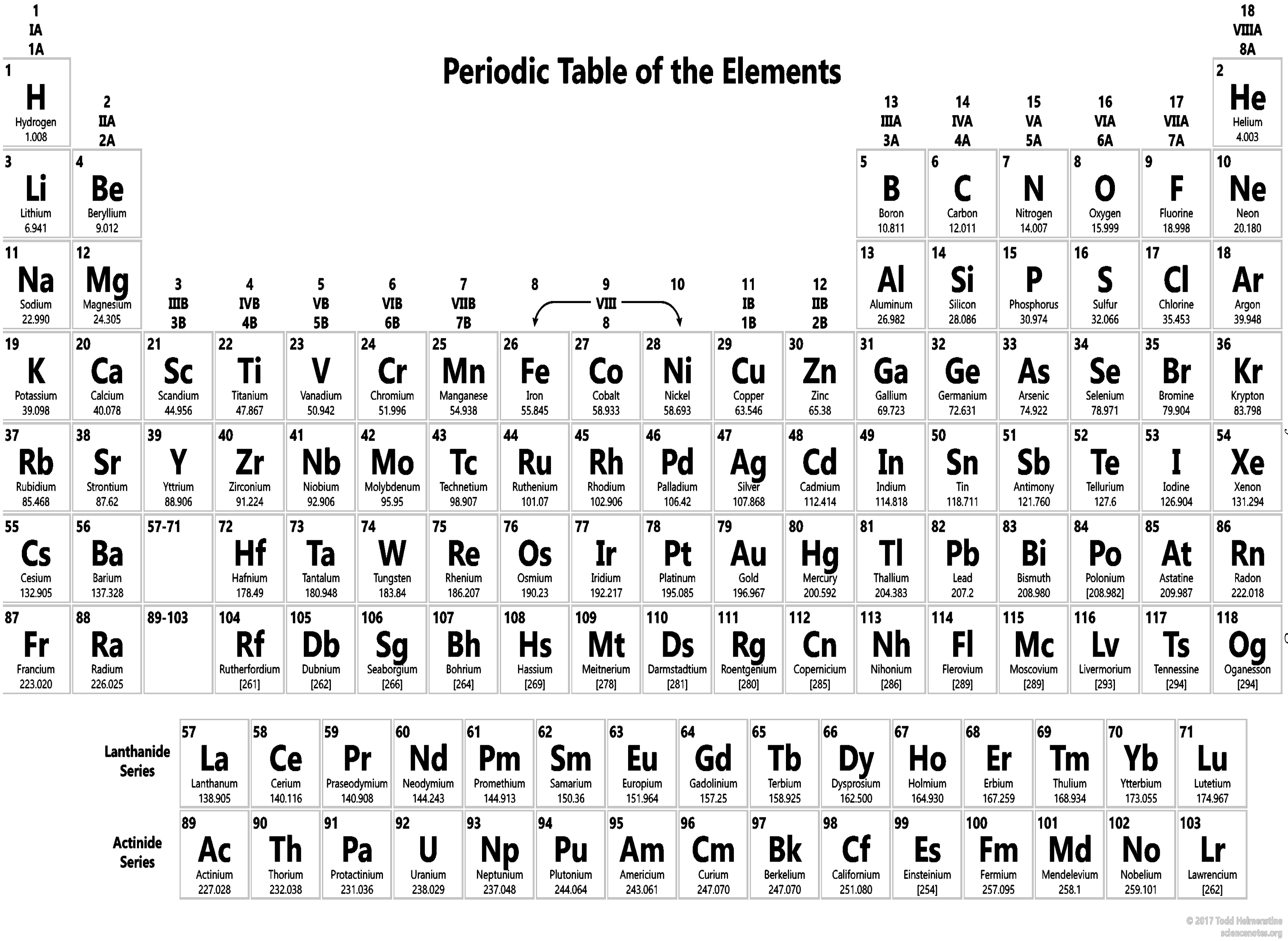
FIGURE I.1
Common glassware and equipment.




Double buret clamp
Büchner funnel
Filter paper
Funnels
Iron ring
Wire gauze
Clay triangle
Watch glasses
Crucible and lid
Crucible tongs
Ring stand
Pinch clamp
Utility clamp
Rubber tubing
Bunsen burner
Extension clamp
Clamp holder

Periodic table from ScienceNotes.org



Periodic Table of the Elements

1 IA 1A																	18 VIIIA 8A
1 **H** Hydrogen 1.008	2 IIA 2A											13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012											5 **B** Boron 10.811	6 **C** Carbon 12.011	7 **N** Nitrogen 14.007	8 **O** Oxygen 15.999	9 **F** Fluorine 18.998	10 **Ne** Neon 20.180
11 **Na** Sodium 22.990	12 **Mg** Magnesium 24.305	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 **Al** Aluminum 26.982	14 **Si** Silicon 28.086	15 **P** Phosphorus 30.974	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.453	18 **Ar** Argon 39.948
19 **K** Potassium 39.098	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.956	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.942	24 **Cr** Chromium 51.996	25 **Mn** Manganese 54.938	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933	28 **Ni** Nickel 58.693	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.38	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.631	33 **As** Arsenic 74.922	34 **Se** Selenium 78.971	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.798
37 **Rb** Rubidium 85.468	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.906	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.906	42 **Mo** Molybdenum 95.95	43 **Tc** Technetium 98.907	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.906	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.868	48 **Cd** Cadmium 112.414	49 **In** Indium 114.818	50 **Sn** Tin 118.711	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.6	53 **I** Iodine 126.904	54 **Xe** Xenon 131.294
55 **Cs** Cesium 132.905	56 **Ba** Barium 137.328	57-71	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.948	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.085	79 **Au** Gold 196.967	80 **Hg** Mercury 200.592	81 **Tl** Thallium 204.383	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.980	84 **Po** Polonium [208.982]	85 **At** Astatine 209.987	86 **Rn** Radon 222.018
87 **Fr** Francium 223.020	88 **Ra** Radium 226.025	89-103	104 **Rf** Rutherfordium [261]	105 **Db** Dubnium [262]	106 **Sg** Seaborgium [266]	107 **Bh** Bohrium [264]	108 **Hs** Hassium [269]	109 **Mt** Meitnerium [278]	110 **Ds** Darmstadtium [281]	111 **Rg** Roentgenium [280]	112 **Cn** Copernicium [285]	113 **Nh** Nihonium [286]	114 **Fl** Flerovium [289]	115 **Mc** Moscovium [289]	116 **Lv** Livermorium [293]	117 **Ts** Tennessine [294]	118 **Og** Oganesson [294]

Lanthanide Series	57 **La** Lanthanum 138.905	58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.908	60 **Nd** Neodymium 144.243	61 **Pm** Promethium 144.913	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.925	66 **Dy** Dysprosium 162.500	67 **Ho** Holmium 164.930	68 **Er** Erbium 167.259	69 **Tm** Thulium 168.934	70 **Yb** Ytterbium 173.055	71 **Lu** Lutetium 174.967
Actinide Series	89 **Ac** Actinium 227.028	90 **Th** Thorium 232.038	91 **Pa** Protactinium 231.036	92 **U** Uranium 238.029	93 **Np** Neptunium 237.048	94 **Pu** Plutonium 244.064	95 **Am** Americium 243.061	96 **Cm** Curium 247.070	97 **Bk** Berkelium 247.070	98 **Cf** Californium 251.080	99 **Es** Einsteinium [254]	100 **Fm** Fermium 257.095	101 **Md** Mendelevium 258.1	102 **No** Nobelium 259.101	103 **Lr** Lawrencium [262]

Parts per Thousand (ppt) Guide

Parts per thousand (ppt), also known as the "relative standard deviation", is useful when comparing the uncertainty between different measurements of varying magnitude (i.e. it is a measure of the ***precision*** within an experiment.) **Parts per thousand can be applied to any set of data** where more than one experimental value has been applied – i.e. volumes, percentages, concentrations, etc. We will use parts per thousand often this year, so knowledge of how it works is critical for the successful student.

For the values x_1*,* x_2 *and* x_3*:*

- Take the **average** of the values

$$\text{average} = \frac{\text{sum}}{\#\ \text{of values}} = \frac{x_1 + x_2 + x_3}{3}$$

- Find the **deviation** of each value relative to the average

$$\text{deviation}_1 = \text{absolute value } (\text{average} - x_1) = |\ \text{average} - x_1\ |$$
$$\text{deviation}_2 = |\ \text{average} - x_2\ |$$
$$\text{deviation}_3 = |\ \text{average} - x_3\ |$$

- Find the **average deviation** of the deviations

$$\text{average deviation} = \frac{\text{sum of deviations}}{\#\ \text{of values}} = \frac{deviation_1 + deviation_2 + deviation_3}{3}$$

- Calculate the **parts per thousand (ppt)** for the values

$$\text{ppt} = \frac{\text{average deviation}}{\text{average}} * 1000$$

Example: Calculate the parts per thousand for the values 35.72%, 35.92% and 36.02%

- Average = $\frac{35.72 + 35.92 + 36.02}{3}$ = **35.89 %**
- Deviation$_1$ = | 35.89 – 35.72 | = 0.17
- Deviation$_2$ = | 35.89 – 35.92 | = 0.03
- Deviation$_3$ = | 35.89 – 36.02 | = 0.13
- average deviation = $\frac{0.17 + 0.03 + 0.13}{3}$ = **0.11 %**
- parts per thousand = $\frac{0.11}{35.89} * 1000$ = **3.1** *unitless*

Parts per thousand relates the deviation to the magnitude of the experimental data. Consider these two sets of data each with an average deviation of ±0.010:

> *Data set 1:* 0.250 ± 0.010, ppt = (0.010/0.250) x 1000 = 40 ppt (not very good precision).
> *Data set 2:* 4.50 ± 0.010, ppt = (0.010/4.50) x 1000 = 2 ppt (excellent precision)

Although both scenarios have the same deviation, the relative deviation compared to the data gives very different results. Patience and focus is a virtue in this lab.

Summer 2024 Chemistry 151 *with* Dr. Michael A. Russell

CH 151, Mt. Hood Community College, Gresham, Oregon, USA 97030

Office: **AC 2568** *Phone:* **(503) 491-7348**

Email: **mike.russell@mhcc.edu**

Office Hours: Held on ***Discord*** *at* **https://discord.gg/QRcwa5P3Y4***, M and W from 10 AM - noon*

Chemistry 151 website:
http://mhchem.org/151

Required/Recommended Materials*:*

* "Chemistry" *by* The OpenStax College (978-1-947172-62-3),
available here for free: **http://mhchem.org/text/OpenStaxChem.pdf**
* *The* **Chemistry 151 Companion**, *purchase here:* **http://mhcc.edu/bookstore**
* Calculator with at least EXP or EE *(such as the TI-83, TI-89, etc.)*

Course Description: CH 151 is a basic course designed for students who want to take the CH 221/222/151 sequence but lack sufficient math and/or chemistry background. This one-term course includes mathematical applications appropriate for the first term of the above chemistry sequence, as well as an introduction to classification of matter, atomic theory, stoichiometry and nomenclature. **Prerequisite**: RD090, WR090, each with a grade of "C" or better; or placement above levels. **Co-requisite**: MTH 095 or higher.

Course Philosophy: To be successful, students enrolled in this summer accelerated chemistry course should complete all assignments before coming to class, attend classes regularly, participate in discussions, and think critically to discover the fundamental theories inherent to this course. All homework assignments represent the *minimum* requirement for understanding the principles of chemistry. It is assumed that A and B students will perform enough *unassigned* exercises to master the concepts.

I encourage questions in this class. If you contact me by email, I will respond to you normally within 24 hours..

The Honor Principle: All students will be expected to behave with the highest moral and academic integrity while enrolled in this class. Plagiarism, cheating or sharing information on tests or laboratory reports, disruptive behavior, and other related offenses will be dealt with according to the directives stated in the current *Mt. Hood Community College Student Guide*. Offering, asking for, giving or receiving help from a person or website without instructor consent is cheating. Copying and/or sharing any course materials outside this class is not allowed and illegal due to copyright laws.

Grading:	Midterm Exam	140 points	*23.3% of total points*
	Quizzes (4 total, 20 points each)	80 points	*13.3%*
	Final Exam	200 points	*33.3%*
	Problem sets (4 total)	40 points	*6.7%*
	Seven lab experiments (20 points each)	140 points	*23.3%*
	Total points:	**600** points	***100%*** *(99.9%)*

Tentative grading distribution: **A**: 90-100% **B**: 80-89% **C**: 65-79% **D**: 50-64% **F**: less than 50%

Problem Sets should include your name, the problem assignment, the setup for the problem (with units), and a circled final answer. Your **problem set grade** will be one of four possibilities: a check plus (10 points, indicates completion of the assignment with *most* of the answers correct), a check (7 points, indicates partial or total completion of the assignment with *some* answers correct), a check minus (3 points, indicates an incomplete or late assignment) and a zero for assignments not turned in. Late assignments are worth a maximum of three points.

Exams, Quizzes, Problem Sets and Labs will be completed on your own and submitted via email to the instructor by 9 AM Friday. Assignments should be submitted as PDF, Word or Google Documents format, and each assignment must be submitted as one file (i.e. if an assignment has five pages, you must submit it as a single file and not as five separate pages.) Details regarding grading will be discussed during the first week of the term.

Late Assignments will suffer a point penalty. **Quizzes, the midterm and the lecture final** *must* be turned in on time, otherwise the assigned score will be a zero - these will not be accepted late for credit.

"What's Due This Week" Schedule for CH 151 Summer 2024

***All assignments** (problem sets, quizzes, labs, etc.) can be found on the **Chemistry 151 website** (http://mhchem.org/151)*

Week	**Dates**	**Assignment**
1	6/24 - 6/28	*Begin:* Problem Set #1, Introduce Yourself Lab, Quiz #1, Problem Solving Lab
	6/26	*Due:* Problem Set #1 *Chapter 1 by Wednesday, June 26 by 11:59 PM via email*
	6/26	*Due:* Introduce Yourself Lab (Lab #1) *by Wednesday, June 26 by 11:59 PM via email*
	6/28	*Due:* Quiz #1 *available late 6/26, due by Friday, June 28 at 9 AM via email*
	6/28	*Due:* Problem Solving Lab (Lab #2) *by Friday, June 28 at 9 AM via email*
2	7/1 - 7/5	*Begin:* Problem Set #2, Nomenclature Lab, Quiz #2, Density Lab
	7/3	*Due:* Problem Set #2 *Chapter 2 and 3 by Wednesday, July 3 by 11:59 PM via email*
	7/3	*Due:* Nomenclature Lab (Lab #3) *by Wednesday, July 3 by 11:59 PM via email*
	7/5	*Due:* Quiz #2 *available late 7/3, due by Friday, July 5 at 9 AM via email*
	7/5	*Due:* Density Lab (Lab #4) *by Friday, July 5 at 9 AM via email*
	7/5 - 7/7	*Begin:* Midterm Exam *(available late July 5, due Sunday by 11:59 PM)*
		Due: **MIDTERM EXAM** *by Sunday, July 7 at 11:59 PM via email*
3	7/8 - 7/12	*Begin:* Problem Set #3, Crossword Lab, Quiz #3, Chemical Equations and Reaction Types Lab
	7/10	*Due:* Problem Set #3 *Chapter 4 by Wednesday, July 10 by 11:59 PM via email*
	7/10	*Due:* Crossword Lab (Lab #6) *by Wednesday, July 10 by 11:59 PM via email*
	7/12	*Due:* Quiz #3 *available late 7/10, due by Friday, July 12 at 9 AM via email*
	7/12	*Due:* Chemical Equations and Reaction Types Lab (Lab #5) *by Friday, July 12 at 9 AM via email*
4	7/15 - 7/19	*Begin:* Problem Set #4, Quiz #4, Percent Potassium Chlorate Lab, Final Exam
	7/17	*Due:* Problem Set #4 *Chapter 4 and Chapter 6 by Wednesday, July 17 by 11:59 PM via email*
	7/17	*Due:* Quiz #4 *available late 7/15, due by Wednesday, July 17 by 11:59 PM via email*
	7/17	*Due:* Percent Potassium Chlorate Lab (Lab #7) *by Wednesday, July 17 by 11:59 PM via email*
	7/19	*Due:* **FINAL EXAM** *available late 7/17, due by Friday, July 19 at 9 AM via email*

All assignments due to the instructor via email (mike.russell@mhcc.edu) on the date and time listed above.

*The **textbook** for this class is **free** and **available here**: https://mhchem.org/text/OpenStaxChem.pdf*

Assignments received past the deadline will be considered late with the exception of quizzes, the Midterm Exam and Final Exam; these will receive a grade of zero.

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Rules for Turning in Assignments to the Instructor this Quarter

All problem sets, labs, quizzes, exams, and other work must be submitted to the instructor via email to mike.russell@mhcc.edu.

Assignments ***must*** be contained within one file only. If an assignment consists of multiple pages, you must combine the individual pages into a single file before submitting to the instructor.

Acceptable file formats this quarter include PDF (preferred), Word documents (.doc or .docx) and Google Documents shared files… you select the file format which is easiest for you.

Getting the assignment into a PDF, Word or Google Document is not difficult. Here are four common approaches used by students in previous classes… feel free to use all of just one of them, or if you find an alternative method, let the instructor know! :)

1 - **If you have a printer and wish to complete the work "by hand".**

- print the assignment and fill out as usual. You cannot print at MHCC currently so this must be done on your own.
- On your **phone** (Android or iPhone), use a free program like **CamScanner** to make pdf scans and combine into one file
- email to the instructor! done!

2 - if you have a tablet (iPad, Surface, etc.) and can write directly on the screen:

- Download the PDF file (to the desktop, Google Drive, etc.)
- Use a program which allows you to import the PDF and write directly on the tablet. Examples include (but are not limited to): GoodNotes (my current favorite), Notability, Apple Notes, Evernote, OneNote, Google Keep, Typora or Microsoft OneNote Some of these programs might have a cost associated with them.
- Email the completed PDF assignment to the instructor... you're done!

3 - If you wish to complete assignments in Microsoft Word: *(Note:* as a MHCC student, you can **access Microsoft Office for free** *on both Windows and Mac platforms. More info:* **https://mhcc.edu/OfficeInstall/***)*

- Open the PDF file in Word. Modern versions of Word will convert the file for you so you can complete the work within the Word program.
- To Save your work as a PDF:
  - On Mac: File -> Print -> PDF -> Save as PDF
  - In Windows (Windows 10): File -> Print -> Microsoft Print to PDF (More info for Windows users: https://www.howtogeek.com/361612/how-to-create-a-pdf-file-in-windows/)

- Email the completed PDF assignment to the instructor... you're done!

Please note that the formatting of the original PDF file does not have to be maintained. Using Word files can alter the formatting.... but as long as the question order is maintained, and I can see which question you're answering, etc. all will be well.

4 - If you wish to complete assignments in Google Documents:

- Save the assignment to your Google Drive.
- Right click/Control click on the PDF file, then Open with Google Docs
- Complete the assignment
- To Save your work as a PDF file:
  - On Mac: File -> Print -> Print from my Computer, then File -> Print -> PDF -> Save as PDF
  - In Windows: File -> Download -> PDF Document (.pdf)
- Email the completed PDF assignment to the instructor... you're done!

Please note that the formatting of the original PDF file does not have to be maintained. Using Google Doc files can alter the formatting.... but as long as the question order is maintained, and I can see which question you're answering, etc. all will be well.

Getting Started in Chemistry 151

Welcome to Chemistry 151! I am glad to have you enrolled in CH 151! Here are some hints on how to get started in the class:

- First, **know that I am here to help you succeed in this class**. If you have any questions, please email me (mike.russell@mhcc.edu). I try to respond to student inquiries within 24 hours.

- **All relevant assignments** (problem sets, papers, etc.) as well as assessments (quizzes, etc.) will be **due at the time and date listed on the second page of the syllabus ("What's Due This Week".)** This applies to all students in all sessions. Assignments must be emailed in a suitable format (PDF, Word document, shared Google drive, etc.) for credit, and if the assignment is late, even for technology reasons, a point penalty will apply. I prefer that you email the assignments to me at mike.russell@mhcc.edu.

- **All assignments must be submitted in one single file**. If an assignment has five pages, do ***NOT*** send me five individual files. You are responsible for getting the separate pages into one file. The process is not hard; see page 3 of the syllabus for methods used successfully by students in the past, and email the instructor if you have any questions. If multiple assignments are due (i.e. a problem set, lab and quiz), I prefer that these be submitted individually (don't combine these in to one file.)

- You can **get the assignments** (problem sets, quizzes, labs, exams, etc.) **from the Chemistry 151 website** (see below.) If you need to save a copy of the assignment to your computer, "right click" (or control-click on a Mac) followed by "Download the file" or "Save the file"

- The **"What's Due This Week" Schedule for CH 151** located on page 2 of your syllabus **lists all the problem set due dates, assignment deadlines, labs performed, exam/quiz dates, and related information for this term**. You can plan your term by referencing this handout. I will also send out frequent email messages… follow my emails closely!

- The **Chemistry 151 website** is worth exploring. The Chemistry 151 website has a host of learning opportunities waiting for you. You can download and/or print copies of the syllabus, problem sets, quizzes and exams, labs, quiz answers, and more. The website is:

  http://mhchem.org/151

- The **Chemistry 151 Textbook** is **free** and **legal to download** from our website: http://mhchem.org/text/OpenStaxChem.pdf

- **Office hours will be held on the CH 151 Discord server (https://discord.gg/QRcwa5P3Y4)**. I will always be there Mondays (10 AM - noon) and Wednesday (10 AM - noon). ***There will be no "face to face" office hours at MHCC this term.*** Also: you can receive free and chemistry-specific help from the **AVID/Learning Success Center** at MHCC via Zoom - view their **website** (**https://www.mhcc.edu/lsc/**) for more information.

- You can **download** the entire **Microsoft Office** suite of programs (Word, Excel, PowerPoint, etc.) **for free**… see this link for information: **https://mhcc.edu/OfficeInstall/**

Again, welcome to Chemistry 151! Let me know if I can make your learning experience better in any way, and I look forward to working with you this term!

Peace, Dr. Michael Russell (mike.russell@mhcc.edu, 503.491.7348, AC 2568)

“Introduce Yourself” Lab for Chemistry 151 Section W1

***Create a video, sign the form below** and turn in everything via email to mike.russell@mhcc.edu by **11:59 PM, Wednesday, June 26**. Turn in the video link **and** Memorandum form as a PDF file.*

Welcome to Chemistry 151! I am glad you enrolled in CH 151 this quarter, and I look forward to an exciting term with you!

Section W1 of this class will be taught exclusively online; there will be no “face to face” lectures, labs, office hours, exams, etc. So…. let’s do this! :)

The goal of this “lab” is to “meet you.” I want to know a bit about you, so **I want you to make a short (about 3 minutes or so) video on YouTube (or something similar) about yourself**. Show yourself talking (no pictures, etc. - just show you!) and tell me a bit about yourself. Maybe you could tell me about your college goals - why are you taking CH 151? Or maybe you could tell me about a cool movie you watched, or a book you read, or a music band you’re enjoying…. it’s totally up to you, but it will help me get a better idea as to “who you are”, and this is important to me! **Email me a link to the video by Wednesday, June 26 by 11:59 PM**.

I also want you to read the “Memorandum” page (which is found below), then **initial, sign and return the “Memorandum” page** (page Ib-1-4) **to me electronically** (i.e. email to mike.russell@mhcc.edu) **by Wednesday, June 26 at 11:59 PM**.

I have suggestions for completing both assignments on the next several pages.

How to Create a Video for this Assignment:

Making a video should not be a difficult assignment for you. I do not expect a “Hollywood quality” video; instead, I just want to see YOU and hear some of your stories.

To create the video, I recommend creating a video on your phone, then using the YouTube app to upload the video. Connect your gmail/Google account in YouTube, select the “plus” symbol (which is at the bottom middle of the screen) to start uploading the video (and make sure you set the video to “**unlisted**”, *not* “private”.) Once ready, email me a link (use the “Share” - “Copy Link” function)... and then you’re done!

You do not have to edit your video - your submitted video can be pretty rough! On the other hand, if you don't like the way the video is going, stop the recording, delete it, and start again.

How to Fill Ou the "Memorandum" for this Assignment:

The final page of this assignment has the "Memorandum" which I also want you to submit to me via email. **All assignments must be submitted to the instructor via email** (mike.russell@mhcc.edu) this quarter, and **only in one file** (i.e. if the assignment is five pages, submit all five pages as one file and not five individual files.)

How you do this depends on you… here are some suggestions:

1 - **If you have a printer and wish to complete the work "by hand".**

- print the assignment and fill out as usual. You cannot print at MHCC currently so this must be done on your own.
- On your **phone** (Android or iPhone), use a free program like **CamScammer** to make pdf scans and combine into one file
- email to the instructor! done! (I really like CamScanner - check it out! - but use the free version, don't pay for any upgrades!)

2 - if you have a tablet (iPad, Surface, etc.) and can write directly on the screen:

- Download the PDF file (to the desktop, Google Drive, etc.)
- Use a program which allows you to import the PDF and write directly on the tablet. Examples include (but are not limited to): GoodNotes (my current favorite), Notability, Apple Notes, Evernote, OneNote, Google Keep, Typora or Microsoft OneNote Some of these programs might have a cost associated with them.
- Email the completed PDF assignment to the instructor... you're done!

3 - If you wish to complete assignments in Microsoft Word: *(Note:* as a MHCC student, you can **access Microsoft Office for free** *on both Windows and Mac platforms. More info:* **https://mhcc.edu/OfficeInstall/***)*

- Open the PDF file in Word. Modern versions of Word will convert the file for you so you can complete the work within the Word program.
- To Save your work as a PDF:
  - On Mac: File -> Print -> PDF -> Save as PDF
  - In Windows (Windows 10): File -> Print -> Microsoft Print to PDF (More info for Windows users: https://www.howtogeek.com/361612/how-to-create-a-pdf-file-in-windows/)

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- Right click/Control click on the PDF file, then Open with Google Docs
- Complete the assignment
- To Save your work as a PDF file:
    - On Mac: File -> Print -> Print from my Computer, then File -> Print -> PDF -> Save as PDF
    - In Windows: File -> Download -> PDF Document (.pdf)
- Email the completed PDF assignment to the instructor... you're done!

Please note that the formatting of the original PDF file does not have to be maintained. Using Google Doc files can alter the formatting.... but as long as the question order is maintained, and I can see which question you're answering, etc. all will be well.

Again, *you* pick which of these methods works well for you, and use it complete all assignments in CH 151 this quarter.

And if you have questions on anything, please email me (**mike.russell@mhcc.edu**) - I'm happy to help!

Good luck, and I look forward to having you in my classroom this quarter!

Peace, Michael

p.s. Want to know more about me? https://mhchem.org/221/russellm/index.htm

Memorandum for Chemistry 151

***Create a video, sign the form below** and turn in everything via email to mike.russell@mhcc.edu*
by **11:59 PM, Wednesday, June 26**.
Also remember to turn in the video link to me as well!

---

* **I, the undersigned, agree to turn in all assignments via email only using** PDF, Word/Excel files, and Google shared documents. All assignments will be **submitted as a single file** (do not submit one assignment as multiple files.) This class will be taught exclusively online, and there will be no face-to-face office hours, labs, lectures, quizzes, exams, etc.

* **I understand that problem sets, labs, quizzes and most assignments are due on Wednesdays by 11:59 PM *or* Fridays by 9 AM via email** (check the syllabus for exact due dates.) **Late assignments (even due to technology reasons) will incur a point penalty. Quizzes and exams will be worth zero points if turned in late.** Email assignments early if you worry about the quality of your internet connection.

* **I understand that all assignments will be returned via email to the email address listed below**. This address will be used to discus items related to our class during the term. **The email address I include below can be shown to other students** in a public CH 151 email message**.**

* **I will try to have a sense of humor** as the instructor frantically tries to keep up with the changes of this class :). **I will email the instructor** if I have any questions!

* **I have read this document and will stay informed with the class through the instructor's email.**

____

Signature

____

Printed name

____

Date

The instructor will return corrected assignments to you using your MHCC @saints email address unless I hear differently from you (ie email me!)

CH 151 Summer 2024: **"Problem Solving"** *(online)* ***Lab** - Instructions*

Step One:

Watch the lab video for the "Problem Solving" lab, found here:
http://mhchem.org/t/g.htm
There is no data to record in this lab video.

Step Two:

Complete pages Ib-2-3 through Ib-2-12 using the "Problem Solving" video and the actual lab instructions on pages Ib-2-3 through Ib-2-11. Include your name on page Ib-2-3!

Step Three:

Submit your lab (pages Ib-2-3 through Ib-2-11 *only* to avoid a point penalty**) as a *single* PDF file to the instructor via email (mike.russell@mhcc.edu) on Friday, June 28 by 9 AM.** I recommend a free program (ex: CamScanner, https://camscanner.com) or a website (ex: CombinePDF, https://combinepdf.com) to convert your work to a PDF file.

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

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Problem Solving (online) **Lab**

Name:

Being able to convert units is essential to chemistry and all of the sciences. We will use the example of the **mole** to demonstrate the usefulness of both the dimensional analysis method (also known as "factor label method") and significant figures ("sig figs".)

The mole started with an inspiration from Amadeos Avogadro. He knew that an atom of oxygen (16 amu where 1 amu is very very small unit of mass) had sixteen times the amount of mass as hydrogen (1 amu). He reasoned that 16 grams of oxygen would have the same number of atoms as 1 gram of hydrogen. He called that amount of atoms a **mole**.

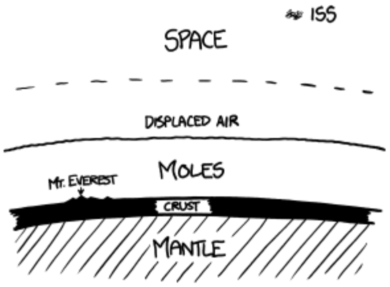
One mole of any substance = **6.022 x 10^{23}** particles

6.02 x 10^{23} is called **Avogadro's number**. If you wrote the entire number out, it would be 602,200,000,000,000,000,000,000! This is about 600 billion trillion!

Avogadro's number is greater than…

- The entire human population (about 7 billion or 7.0x10^{9})
- Jeff Bezos, the world's richest man's net worth: $114 billion (1.14x$10^{11}$) (in 2020)
- All the grains of sand present on the Earth. (est. 7.5x10^{18})

A mole of any substance contains a massive number of particles. As a visual, XKCD.com estimated that if you dropped a *mole of moles* on the Earth's surface, it would form a layer about 80 kilometers thick – about the same as the thickness of our entire atmosphere!



Numbers this big are expressed using **scientific notation.** Large numbers are reduced to something between 0-9, and the number of decimal places afterwards are indicated by powers of 10.

Convert each of these to scientific notation:

1. 45,000 ___________________

2. 138,000,000 ___________________

3. 305 ___________________

4. 720,000,000,000 ___________________

To use these numbers in your calculator, ***use the EE button*** *in place of the (x10) part. For example, 6.022x10^{23} would appear in your calculator like this:* ***6.022E23****.*

Numbers that are very small can also be expressed using **scientific notation.** Small numbers are reduced to something between 0-9, and the number of decimal places you move are indicated by a negative power of 10. 0.0035 would be represented by $3.5x10^{-3}$.

Convert each of these to scientific notation:

5. 0.010 ____________________

6. 0.0000473 ____________________

7. 0.00202 ____________________

8. 0.00044 ____________________

Practice

Convert each of these to scientific notation. Indicate whether this amount is **greater than** or **less than** a mole.

9. The total width of the United States is about 2,680 miles.

Scientific Notation: _________________ (Greater Than / Less Than) one mole.

10. The distance from the Earth to the Sun is about 93,000,000 miles.

Scientific Notation: _________________ (Greater Than / Less Than) one mole.

11. The Earth has a mass of 5,970,000,000,000,000,000,000,000 kg.

Scientific Notation: _________________ (Greater Than / Less Than) one mole.

12. The Moon has a mass of 73,500,000,000,000,000,000,000 kg.

Scientific Notation: _________________ (Greater Than / Less Than) one mole.

13. There are about 31,500,000 seconds in one year.

Scientific Notation: _________________ (Greater Than / Less Than) one mole.

14. The total number of humans that ever existed is estimated to be about 108,000,000,000.

Scientific Notation: _________________ (Greater Than / Less Than) one mole.

15. The Earth is estimated to be 4,540,000,000 years old.

Scientific Notation: ________________ (Greater Than / Less Than) one mole.

16. The Universe is estimated to be 13,800,000,000 years old.

Scientific Notation: ________________ (Greater Than / Less Than) one mole.

17. A typical adult human contains about 37,000,000,000,000 cells.

Scientific Notation: ________________ (Greater Than / Less Than) one mole.

18. The body of a 155-pound person has about 7,000,000,000,000,000,000,000,000,000 atoms.

Scientific Notation: ________________ (Greater Than / Less Than) one mole.

Dimensional Analysis

To solve problems in science, you will often need to use **Dimensional Analysis** to convert one type of unit into another.

You often do this in your life without thinking about it; for example, 12 hours is half a day, but to determine this formally, you would:

12 hours * (1 day / 24 hours) = 0.5 days

The "1 day / 24 hours" is called a "**conversion unit**" and it is essential if you wish to convert hours into days. There are many kinds of conversion units: four quarters per dollar, 60 seconds per minute, and 12 donuts per 1 dozen donuts. We will use different kind of conversion units in chemistry as we proceed through the course.

Conversion units can be "flipped" to find different quantities. Instead of writing "1 day / 24 hours" you could write "24 hours / 1 day" if you wanted to convert days into hours.

"Dimensional Analysis" means, essentially, to "watch your units". You want to convert your original unit (hours) into a new type of unit (days). Remember that you can "flip" your conversion unit as necessary.

Time for some practice!

Solve each of these problems using scientific notation and dimensional analysis.

19. There are about $1x10^{12}$ stars in our galaxy. There are about $10x10^{12}$ galaxies in the universe. Assuming each galaxy has the same number of stars, how many total stars are there in the universe?

20. There are about 7 billion people ($7x10^{9}$) on the Earth. Assuming that each person has the number of atoms indicated in question #18 earlier, how many total atoms are present in all of humanity?

21. How many days are in a millennium (1000 years)?

22. How many nickels could be had for $24,305?

Significant Figures

In chemistry, **significant figures** ("sig figs" for short) are the digits of value which carry meaning in a measurement. Experimental measurements always have a level of uncertainty associated with them; better experiments create better experimental values (and lower quality experiments will create inferior numbers.) In order to ensure precision and accuracy in measurements, a fixed method to compensate for these uncertainties has been developed…. hence, significant figures!

To tell how many significant figures a number has, keep these things in mind:

- all non-zero numbers are significant
- zeroes between non-zero numbers are significant
- a trailing zero or final zero in the decimal portion only as significant

You can probably see that zeroes are weird! :) So let's see some examples:

- Those digits which are non-zero are significant. For example, in **6575** cm there are **four** significant figures and in **0.543** there are **three** significant figures.

- If any zero precedes the non-zero digit then it is not significant. The preceding zero indicates the location of the decimal point; so, in **0.005** there is only **one** sig fig and the number **0.00232** has **3** sig figs.
- If a dot follows a large number ending in zero(es), the zeroes are significant; so 120. would be 3 sig figs (the dot means "the zero is significant") while 120 would be 2 sig figs (the zero is not meaningful.)
- If there is a zero between two non-zero digits then it is also a significant figure. For example; **4.5006** have **five** significant figures.
- Zeroes at the end or on the right side of the number are also significant. For example; **0.500** has **three** significant figures.
- Counting the number of objects (i.e. 5 bananas or 10 oranges) have **infinite** significant figures as these are exact numbers. Some definitions are also considered exact (i.e. 10 mm = 1 cm) and are considered to have infinite sig figs (so don't base your sig fig calculations on them, see below.)

Let's try some examples!

Tell how many significant figures are in each of these numbers:

23. 45,000 ___________________

24. 4308 ___________________

25. 4.00 ___________________

26. 0.00500 ___________________

27. 40.05 ___________________

Multiplying and dividing using significant figures is very important in chemistry. Most of the calculations that chemists do invoke Dimensional Analysis, which is essentially multiplying and dividing of numbers.

When you multiply or divide numbers in chemistry, the answer must reflect the smaller number of significant figures. So if you multiply two numbers with three sig figs each, the answer should have 3 sig figs. However, if you multiply two numbers, one with 2 sig figs and the other with 3 sig figs, the answer should have only 2 significant figures…. the smaller number of sig figs is carried through to the final answer. This is why it is critical to use the best sig figs possible in order to get better answers!

Here are some examples of multiplying and dividing numbers using significant figures:

3.0 x 4.0 = **12** (both 3.0 and 4.0 are 2 sig figs, so the answer must have only 2 sig figs)

3 x 4 = **10** (both 3 and 4 are 1 sig fig, so the final answer should have only 1 sig fig. 12 rounded to one sig fig is 10 (the zero does not count)…. this is not practical in the "real world", but it does provide a good example of how sig figs work.)

2.5 x 3.42 = **8.6** (in the calculator, the number is 8.55 but we **round up** to 8.6 - two sig figs since the 2.3 is a 2 sig fig number. **Round up only if the first number dropped is between 5 and 9**.)

2.5 x 3.41 = **8.5** (in the calculator, the number is 8.525 but we do not round up to 8.6 since the first number dropped (2) is not between 5 and 9.)

4.52x10^4 x 3.980x10^6 = **1.80x10^{11}** (in scientific notation, all showing numbers are significant, so 4.52 would be 3 sigs and 3.980 would be 4 sigs. The number from the calculator (1.79896x10^{11}) is rounded up to 1.80x10^{11} because the first digit dropped (and 8) is between 5 and 9… so 1.79 becomes 1.80)

Time for some practice!

Perform the calculation and express the answer to the correct number of significant figures:

28. 6.0 x 7.0 ____________________

29. 6 x 7 ____________________

30. 7 x 7 ____________________

31. 37.41 x 8.3001 ____________________

32. (3.4617 x 10^7) ÷ (5.61 x 10^{-4}) ____________________

Adding and subtracting using significant figures is different from multiplying and dividing. In chemistry, add or subtract in the normal fashion, then round the answer to the LEAST number of places to the decimal point of any number in the problem. The last significant figure is called the "doubtful digit", so you essentially wish to cut the answer off at the "largest doubtful digit".

Here are some examples:

3.52 - 1.47 = **2.05** (all digits stop at the "hundredths spot" (the doubtful digit), so the answer stops at the hundredths spot as well.)

1.2 + 1.135 = **2.3** (1.2 stops at the "2" (the "tenths spot") while 1.135 stops at the "thousandths spot" (the 5). In sig figs, stop the answer at the largest doubtful digit (only one place to the right of the decimal), so 2.335 (the calculator answer) is rounded to 2.3. We did not round up because the first digit dropped (a 3) is not between 5 and 9.)

1520 + 0.1 - 0.001 = **1520** (the 1520 has a doubtful digit of tens (the "2") - this is the largest doubtful digit, so the answer stops there. the calculator reports 1520.099, but we stop the value at 1520 due to the sig figs.)

Perform these calculations and express the answer to the correct number of significant figures:

33. 32500 + 1424 + 120 ____________________

34. 1.55 - 0.2245 ____________________

35. 120 + 241 - 13.5 ____________________

36. 121.1 + 3.22 ____________________

37. 1.0 x 10^3 + 111.5 ____________________

The Metric System

Most of the world uses the metric system to express quantities of mass, volume, distance, and much more. The metric system is based upon powers of ten, each of which has its own prefix, and these are related back to the "base unit" (m for length, g for mass, etc.) For example, the metric prefixes we will use in chemistry are mostly these five:

kilo (k)	10^3
centi (c)	10^{-2}
milli (m)	10^{-3}
micro (μ)	10^{-6}
nano (n)	10^{-9}

For length, the "base unit" is the meter (m). You write the base unit name after the metric prefix and the unit (m) after the number; so re-writing the above for length, we get:

kilometer = km = 10^3 m
centimeter = cm = 10^{-2} m
millimeter = mm = 10^{-3} m
micrometer = µm = 10^{-6} m
nanometer = nm = 10^{-9} m

Since 10^3 is 1000, we can say that 1 km = 1000 m! Pretty easy!

Conversions between metric prefixes are consider exact (unlimited sig figs), so they are not used when calculating the number of sig figs. Example:

422 m * (1 km / 1000 m) = 0.422 km (3 sig figs due to 3 sigs in 422)

Time for some practice!

Perform these calculations and express the answer to the correct number of significant figures:

38. 1300 m to km ____________________

39. 462 g to µg ____________________

40. 3.75 L to mL ____________________

41. 469.5 nm to m ____________________

42. 3.7 x 10^3 cm to km ____________________

Final Practice!

Perform the following calculations. Express the answer to the correct number of significant figures and in scientific notation.

43. The average female has 4500 mL of blood. What is this volume in gallons? (1 gallon = 3.7856 L)

44. How many mg in 33 kg?

45. You need to make 2,125 copies of a sporting event flyer, and copies cost 5.0 cents. How many dollars ($) will it take to make this many copies?

46. If a bumblebee weighs 0.0022 kg, how many bees weigh 5.0 lb? (453.6 g = 1.0 lb)

47. How many quarters would you need to travel 495 miles? Gas costs $2.65 per gallon, and your vehicle gets 22 miles per gallon.

You're done! Way to go! Email this assignment to mike.russell@mhcc.edu.

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CH 151 Summer 2024:
“Nomenclature” *(online)*
***Lab** - Instructions*

Step One:

Watch the lab video for the “Nomenclature” lab, found here: **http://mhchem.org/t/h.htm**
There is no data to record in this lab video.

Step Two:

Complete pages Ib-3-5 through Ib-3-8 using the “Nomenclature” video and the actual lab instructions on pages Ib-3-3 through Ib-3-4. Include your name on page Ib-3-5!

Step Three:

Submit your lab (pages Ib-3-5 through Ib-3-8 *only* to avoid a point penalty**) as a *single* PDF file to the instructor via email (mike.russell@mhcc.edu) on Wednesday, July 3 by 11:59 PM.** I recommend a free program (ex: CamScanner, https://camscanner.com) or a website (ex: CombinePDF, https://combinepdf.com) to convert your work to a PDF file.

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

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Nomenclature: The Language of Chemistry

Systematic chemical names of inorganic compounds were developed by a group of scientists who were part of the International Union of Pure and Applied Chemistry (IUPAC) which first met in 1921. Elements are represented by symbols which are the first, first two, or first and third letters from the name of the element. There are some notable exceptions, where the symbols appear to have no connection to the name of the element. These symbols are derived from early names for these elements. The table below illustrates some of these.

Present Name	Symbol	Former Name
Antimony	Sb	Stibium
Copper	Cu	Cuprum
Gold	Au	Aurum
Iron	Fe	Ferrum
Lead	Pb	Plumbum
Potassium	K	Kalium
Silver	Ag	Argentum
Sodium	Na	Natrium
Tin	Sn	Stanum
Tungsten	W	Wolfram

The names of inorganic compounds are constructed so that every compound can be named from its formula and each formula has a name unique to that formula. For the purpose of clarity, we will divide the formulas into the following categories:

1) Binary compounds of nonmetals (covalent molecules)
2) Binary compounds of a metal and nonmetal (ionic compounds)
3) Ternary and higher compounds (polyatomic ions and acids)

I. Binary Covalent Compounds: two nonmetals

1. Name first element, preceded by Greek prefix for number of atoms. If one, omit mono.
2. Name the second element, preceded by Greek prefix for number of atoms even if one.

The ending of the second element is -ide.

Greek Prefixes:					
	1 = mono	2 = di	3 = tri	4 = tetra	5 = penta
	6 = hexa	7 = hepta	8 = octa	9 = nona	10 = deca

Examples:	Formula	Name
	PCl_3	Phosphorous trichloride
	SO_2	Sulfur dioxide
	CO	Carbon monoxide
	N_2O	Dinitrogen monoxide

II. Ionic Compounds: metal + nonmetal - A. Metal with a fixed charge

1. Name metal (cation) first - **only** for metals in Groups IA, IIA and the "stairs"
2. Name nonmetal (anion) with the ending changed to -ide. Charge = **group number - 8**

Ex:	Formula	Name	**Fixed Charge Cations**
	KCl	Potassium chloride	IA = +1
	Na_2S	Sodium sulfide	IIA = +2
	Al_2S_3	Aluminum sulfide	IIIA = +3 one of the 'stairs' (*video*)

In ionic compounds, the metal and nonmetal must combine in a ratio to give an overall neutral charge. To write formulas based on name, first write the symbol with the correct charge for the cation and anion. Then determine the lowest ratio for a neutral compound.

B. Metals with variable charge (transition metals, lanthanides, actinides, etc.)

1. Name metal. In parentheses write the charge of the metal in Roman numerals.
   The charge is determined based on the fixed charge of the nonmetal.
   [Fixed charges of nonmetal: VIIA = -1; VIA = -2; VA = -3]
2. Name nonmetal with the ending -ide. Charge = **group number - 8**

Examples:	Formula	Name	Old Method – ***do NOT use!***
	CuCl	Copper(I) chloride	*Cuprous chloride*
	$CuCl_2$	Copper(II) chloride	*Cupric chloride*
	FeO	Iron(II) oxide	*Ferrous oxide*
	Fe_2O_3	Iron(III) oxide	*Ferric oxide*

III. Polyatomic Anions and Acids

When writing names of ionic compounds composed of polyatomic anions or of acids, you must first learn the name, number of oxygens, and charge of the most common polyatomics (listed below). Then add the following rules for naming polyatomics and acids with differing number of oxygens. Notice that as oxygens are added/ subtracted, the polyatomic charge remains the same. **Common polyatomic ions** include:

CO_3^{-2}	carbonate	ClO_3^{-1}	chlorate	OH^{-1}	hydroxide
NO_3^{-1}	nitrate	BrO_3^{-1}	bromate	NH_4^{+1}	ammonium
PO_4^{-3}	phosphate	IO_3^{-1}	iodate	HCO_3^{-1}	bicarbonate
SO_4^{-2}	sulfate	MnO_4^{-1}	permanganate	$Cr_2O_7^{2-}$	dichromate
$C_2H_3O_2^{-1}$ - acetate					

# Oxygens	***Anion***	***Example***	***Acid***	***Example***
+1 Oxygen	per-ate	perchlorate, ClO_4^-	per-ic	perchloric acid, $HClO_4$
common	-ate	chlorate, ClO_3^-	-ic	chloric acid, $HClO_3$
-1 Oxygen	-ite	chlorite, ClO_2^-	-ous	chlorous acid, $HClO_2$
-2 Oxygen	hypo-ite	hypochlorite, ClO	hypo-ous	hypochlorous acid, HClO
No Oxygen	-ide	chloride, Cl	hydro-ic	hydrochloric acid, HCl

For more polyatomic / acid help, see the "**Common Polyatomic Ions and the Corresponding Acids**" handout in your lab manual under "Learning Resources"

Nomenclature (online) **Lab** **Name:**

1a. Ionic Compounds (metal + nonmetal)

	FORMULA	**CATION**	**ANION**	**NAME**
Ex.	$CaBr_2$	Ca^{2+}	Br^{1-}	Calcium bromide
1				**Magnesium nitride**
2		$\mathbf{K^{+}}$	$\mathbf{S^{2-}}$	
3	**ZnO**			
4		$\mathbf{Sn^{4+}}$	$\mathbf{O^{2-}}$	
5	$\mathbf{Cr_2S_3}$			
6				**Copper(I) phosphide**
7	**RbI**			
8				**Calcium nitride**
9				**Titanium(IV) chloride**
10	**SrS**			
11	$\mathbf{Au_2O_3}$			
12				**Cadmium phosphide**

1b. Covalent Compounds (nonmetal + nonmetal)

1. SF_6 ________________________
2. IBr ________________________
3. ______________________________ Carbon monoxide
4. __________________________ Dinitrogen pentoxide

2. Name the following: (Hint: First identify if the compound is ionic or covalent)

a. NaF

b. PbS

c. TiO_2

d. Cr_2O_3

e. Zn_3P_2

f. MnO_2

g. PI_3

h. S_2Br_2

i. IBr_5

j. XeF_4

3. Write formulas for the following compounds: (See hint above!)

a. Barium iodide

b. Palladium(II) bromide

c. Zinc arsenide

d. Gold(III) oxide

e. Lead(IV) oxide

f. Copper(I) sulfide

g. Sulfur hexafluoride

h. Nitrogen trichloride

i. Chlorine dioxide

Nomenclature (online) Lab
Polyatomic Anions and Acids

4. Write the names for the following compounds. If the compound is an **acid**, name as an acid and not an ionic compound to receive full credit.

a. Na_2SO_4

b. $Ca(ClO)_2$

c. $Ba(NO_3)_2$

d. $Al(OH)_3$

e. $Fe(NO_2)_3$

f. $CuSO_3$

g. Cu_2CO_3

h. NH_4ClO

i. $Ni_3(PO_4)_2$

j. $Pb(OH)_2$

l. $HBrO_3$

m. $HBrO_2$

n. $HBrO$

o. HBr

p. $HBrO_4$

q. H_2SO_4

r. HNO_3

s. H_3PO_3

5. Write the chemical formulas for the following compounds.

a. sodium phosphate

b. iron(II) sulfate

c. calcium bromate

d. aluminum nitrate

e. zinc(II) sulfite

f. copper(I) chlorite

g. ammonium hydroxide

h. silver nitrite

i. lead(II) phosphate

j. potassium bicarbonate

k. iodic acid

l. hypoiodous acid

m. periodic acid

n. iodous acid

o. hydroiodic acid

p. sulfurous acid

q. nitric acid

r. nitrous acid

s. phosphoric acid

t. acetic acid

u. carbonic acid

CH 151 Summer 2024: **“Density”** *(online)* ***Lab*** **-** *Instructions*

Step One:

Watch the lab video for the “Density” lab, found here:
http://mhchem.org/t/j.htm
Record the data found at the ***end*** of the lab video on page Ib-4-5.

Step Two:

Complete pages Ib-4-5 through Ib-4-9 using the “Density” video and the actual lab instructions on pages Ib-3-3 through Ib-3-4. Include your name on page Ib-4-5!

Step Three:

Submit your lab (pages Ib-4-5 through Ib-4-9 *only* to avoid a point penalty**) as a *single* PDF file to the instructor via email (mike.russell@mhcc.edu) on Friday, July 5 by 9:00 AM.** I recommend a free program (ex: CamScanner, https://camscanner.com) or a website (ex: CombinePDF, https://combinepdf.com) to convert your work to a PDF file.

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

Density (online) **Lab**

Introduction

Density, like color, odor, melting point, and boiling point, is a physical property of matter. Therefore, density may be used in identifying matter. Every substance (element, compound, alloy, etc.) has a distinct density. **Density** is defined as **mass per unit volume** and is expressed mathematically as **$d = m/V$** (d is density, m is mass, and V is volume). Density is essentially a measurement of how tightly matter is packed together.

Density is an important concept in a wide range of fields including chemistry, physics, material science, engineering, geology, meteorology, biology and medicine. For example, a bone density test uses X-rays to determine how much calcium and minerals are packed into a segment of bone. You may also be familiar with different types of plastics, including high-density polyethylene (HDPE, #2, used for milk jugs, hula hoops, and breast implants) and low-density polyethylene (LDPE, #4 used mostly for plastic bags.) The difference between these plastics depends on how tightly the polyethylene molecules are packed together during synthesis.

The **density of water** is 1.00000 g/cm^3 at 4 °C and is slightly less at room temperature. In lab today, you will be using the *Handbook of Chemistry and Physics* to determine the exact density of water at a specific temperature. The density of various materials ranges significantly from less than water (styrofoam's density is about 0.1 g/cm^3) to much greater (Osmium has a density of 22.6 g/cm^3.) For example, aluminum has a density of 2.70 g/cm^3 whereas a sample of lead has a density of 11.2 g/cm^3. The same volume of lead will have a mass over four times that of aluminum! That is why lead is used to shield against X-rays whereas aluminum would be ineffective. Aluminum atoms are not only smaller but also packed so that there is more space between atoms.

The SI unit (International System of Units) for density is kg/m^3 and is typically used by physicists and engineers. Because chemists work with much smaller masses and volumes, traditional metric units of **g/cm^3** or **g/mL** are the preferred units of measurement (note that **1 mL = 1 cm^3**). Liquids are usually measured in g/mL while solids are measured in g/cm^3. Gases are much less dense, so their density is measured in **g/L**.

Density is often represented as a relative density or ***specific gravity,*** a dimensionless quantity that expresses density as a multiple of a given standard (such as water or a gas.) For example, gasoline has a density of 0.67 g/cm^3. Its specific gravity, relative to water, is 0.67. Specific gravity is used in many fields from chemical engineers studying concrete to food scientists testing the alcohol content of a microbrew.

To determine density, mass and volume must both be determined. The **mass** can easily be found using a balance. Determining the **volume** is more ambiguous. The volume of a liquid can be determined using a calibrated container such as a graduated cylinder or graduated flask. The volume of a solid sample with a regular geometric shape can be determined by direct measurement. However, most solids have an irregular shape. The volume can be determined by immersing the solid in a known volume of liquid and measuring the volume of liquid displaced.

This is similar to the method utilized in the ancient tale of **Archimedes** to prove that King Hiero II's crown was not real gold. Archimedes is alleged to have come upon the liquid displacement method while bathing and noticing the rise in his bath water. He then ran through the streets shouting "Eureka!" (I found it!), so excited that he forgot his bathrobe. After dressing, he then proved that the king's crown did not displace the same amount of water as a piece of gold of the same mass. This method is called the "**displacement method**" and can be used with a variety of liquids in order to find the density of various materials.

All measurements are approximations. **Significant figures** ("**sig figs**") are those digits that carry meaning which contributes to precision. The uncertainty is in the last digit and determined by the device. For example, when reading a graduated cylinder, the number of sig figs is estimated one digit beyond the gradations. For the *example pictured on the right,* the bottom of the meniscus is between the 8.4 mL and 8.5 mL markings. You can estimate to the hundredth place or 8.45 mL. Reading a meniscus is subjective and takes practice. In this experiment, you will use the mass and density of water to find the volume of a flask more precisely and reduce human bias.

Mass versus Weight: When determining density, you must determine the mass of the sample. The terms *mass* and *weight* are easily confused. The ***mass*** of a substance is how much matter it is composed of. Units of mass are grams and kilograms. The mass of an object is the same on earth or on the moon. ***Weight*** is a measure of the force of gravity acting on the object. Pounds (units = lb) is a unit of weight, a force. The weight of an object is variable depending on the location of the object. If Joe weighs 220 Ibs at the North Pole, he would weigh only 219 Ibs at the equator due to the bulge of the earth. He weighs only 37 Ibs on the moon. In outer space, an astronaut is weightless but never massless. A great blue whale is weightless in space, but it would still cause damage to your spaceship if you bumped into it.

Accuracy and Precision: Accuracy is how close a measurement, or average of measurements, come to the actual or accepted value. Accuracy is often compared to hitting the bull's eye on a target. In a chemistry lab, accuracy is how close the final calculated answer is to the accepted book value. When working with an unknown, students are graded on their accuracy, how close their answer is to the actual value. Accuracy is determined by calculating the percent error: **percent error = [(|actual value - experimental value|)/actual value] * 100%** (notice the absolute value in the numerator; percent error should be a positive number.) We will use percent error in an upcoming lab. A "good" percent error varies depending on the experiment, the equipment used, and the technician's experience.

Precision is how close multiple measurements of the same quantity come to each other. Precision is a measure of *consistency in lab technique*; is the data reproducible? One method to determine precision is to calculate **parts per thousand** (see the handout in the "Lab Notes" of your Companion, or ask the instructor.) We will calculate parts per thousand in future labs. The term **precision** also refers to the number of significant digits in a measurement. For example, the balances (scales) that will be used in this lab allow measurements to 1 mg (0.001 g). An analytical balance allows mass.to be determined to 0.1 mg (0.0001 g) and so is more precise. The technique used in this lab for determining volume allows for more significant figures and, hence, is more precise than simply using a graduated cylinder.

Random Error and Systematic Error: Random errors originate from uncontrollable variables in an experiment. Momentary fluctuations in air currents can affect balance reading. A student who rushes through the lab and follows directions haphazardly will perform many random errors. Random errors affect the precision of measurements and the overall experiment. **Systematic errors** are controllable or repeated errors in an experiment. A miscalibrated scale will result in all mass measurements being erroneous by the same factor. A student consistently misreading an instrument is a systematic error. Because a systematic error is consistent throughout the experiment, it does not affect the precision but can significantly affect the accuracy.

In this experiment you will determine densities of an unknown liquid and solid by measuring their mass with a balance and their volume. First, you will determine the exact volume of a flask using water. You will determine the density of a solid by displacement of a known quantity of water.

***PROCEDURE*:** (this is what we would have done in the lab room under "normal" circumstances)

Part A: Density of a Liquid *All mass measurements should be recorded to the milligram (0.001 g.)*

1. Clean a 10 mL volumetric flask with soap and water. Dry with a small amount of acetone in the hood and by gently blowing compressed air into it. Determine and record the mass (to the nearest mg) of the *clean* and *dry* 10 mL volumetric flask with a stopper in it.
2. Fill this 10 mL volumetric flask with deionized water. Insert stopper so no air remains in flask. Dry the outside of the volumetric flask. Record the mass to the nearest 0.001 grams.
3. Calculate the mass of the water in the flask. Remember to show all calculation steps in your lab report.
4. Determine the temperature of the water to the tenths place. Use the *Handbook of Chemistry and Physics* to find the density of water at this temperature. Calculate the volume of this volumetric flask. Remember significant digits!
5. Dry the volumetric flask. Obtain an unknown liquid and record the identification number. Fill the volumetric flask with the unknown liquid, stopper and record the mass.
6. Calculate the mass of the unknown liquid added. Calculate the density of the unknown liquid in g/mL to the correct number of significant digits.

Part B: Density of a Solid *All mass measurements should be recorded to the milligram (0.001 g.)*

1. Select an unknown metal and record its identifier.
2. Clean and dry a 50 mL Erlenmeyer flask that will fit your metal sample. Record the mass of the dry flask and stopper. Fill the flask with water. Record the mass.
3. Determine the volume of the Erlenmeyer flask as in part A.
4. Empty and dry the flask thoroughly. Add small chunks of a dry metal sample to the flask until the flask is at least half full. Weigh the flask, with its stopper and the metal, to the nearest milligram. You should have about 50 g of metal in the flask (more is better!)
5. Determine the mass of metal added.
6. Leaving the metal in the flask, fill the flask with water and replace the stopper. Roll the metal around in the flask to make sure that no air is trapped between the metal pieces. Refill the flask if necessary, and then weigh the stoppered flask full of water plus the metal sample.
7. Calculate the mass of water added.
8. Calculate the volume of water added based on its density and mass.
9. Calculate the volume of metal added. Use this value to calculate the density (in g/cm^3) of the metal.
10. Pour the water from the flask. Dry the metal before returning to its container.

Density (online) **Lab**

YOUR NAME: ____

DATA: *Watch the video (***http://mhchem.org/t/j.htm***) to acquire these values using the data at the very end:*

Part A

empty flask (g): ____________________

flask + water (g): ____________________

water temperature (°C): ____________________

density of water (g/mL): ____________________

flask + unknown (g): ____________________

Part B

empty flask (g): ____________________

flask + water (filled) (g): ____________________

water temperature (°C): ____________________

density of water (g/mL): ____________________

flask + metal (g): ____________________

flask + metal + water (g): ____________________

Part A Calculations: *Determining the Density of an Unknown Liquid*

Show all work, use significant figures and circle the final answer for full credit.

1. Using the data from the video, calculate the mass (g) of water in the flask for Part A.

2. Using the mass of water in the flask (above) and the given density from the video, calculate the volume (mL) of the water in the flask.

3. Assuming that the water *completely* filled the flask (and it did!), determine the volume (mL) of the flask. Explain your answer.

4. Using the data from the video, calculate the mass (g) of the unknown in the flask.

5. Using the mass of the unknown in the flask (g), and assuming the unknown completely filled the flask (it did!), determine the density (g/mL) of the unknown liquid.

Part B Calculations: ***Determining the Density of an Unknown Solid***

Show all work, use significant figures and circle the final answer for full credit.

1. Using the data from the video, calculate the mass (g) of water in the flask for Part B.

2. Using the mass of water in the flask (above) and the given density from the video, calculate the volume (mL) of the water in the flask.

3. Assuming that the water *completely* filled the flask (and it did!), determine the volume (mL) of the flask. Explain your answer.

4. Using the data from the video, calculate the mass (g) of the unknown metal in the flask.

5. Using the data from the video, calculate the mass (g) of water in the flask when the metal was present. *This is a different value from step 1 of part B!*

6. Convert the grams of water in the flask when the metal was present (step 5, above) into the volume of water (mL) present. Use the density from step 2, above.

Part B Calculations: *Continued*

7. Find the volume of the metal (cm^3) using the volume of the flask (step 3) and the volume of water present with the metal (step 6.)

8. Using the mass of the metal in the flask (g, step 1) and the volume of the metal (step 7), determine the density (g/cm^3) of the unknown metal.

Postlab Questions:

Show all work, use significant figures and circle the final answer for full credit.

1. In the original Indiana Jones movie, our hero is attempting to claim a precious ancient gold relic from a poor third world country. He estimates the size of his prize and carefully adjusts the *volume* of sand in his bag to equal that of the gold relic. With the dexterity that only Indiana Jones possesses, he swiftly but delicately swaps the sand for the gold. After a moment of delight, our hero realizes he has misjudged and the ancient tomb is not fooled. What went wrong? *You do not have to watch the Indiana Jones movie to answer this question!* ☺

2. Using the techniques covered in this lab, how can the volume of an irregularly shaped object that is less dense than water be found? Assume the object's density is unknown, and “forced submersion” or "weighted submersion" answers will not get credit.

Postlab Questions: ***Continued***

3. While panning for gold, you find a nugget that looks like gold. You find its mass to be 1.25g. You know that the density of pure gold is about 20.0 g/cm^3 and that the density of iron pyrite (fool's gold) is 5.0 g/cm^3. Determine if a cubic nugget about 0.40 cm on each side is fool's gold or pure gold. (Show all work)

4. Dennis obtained a clean, dry stoppered flask. He determined the mass of the flask and stopper to be 32.634 g. He then filled the flask with water and determined the mass of the full stoppered flask to be 59.479 g. Based on the temperature of the water, Dennis found the density of water in the *Handbook of Chemistry and Physics* to be 0.998730 g/cm^3. Calculate the volume of the flask.

5. Dennis emptied the flask from question #4, dried it and filled it with an unknown liquid. The mass of the stoppered flask when completely filled with liquid was 50.376 g. Calculate the density of the unknown liquid.

6. Dennis emptied the flask from question #4 and #5 and dried it again. He added an unknown metal to the flask. He determined the mass of the stoppered flask and metal to be 152.047 g. He then filled the flask with water, stoppered it and obtained a total mass of 165.541 g. Calculate the volume of metal added and the density of the unknown metal.

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CH 151 Summer 2024:
"Chemical Equations & Reaction Types" *(online)* ***Lab - Instructions***

Step One:

Watch the lab video for the "Nomenclature" lab, found here:

http://mhchem.org/t/k.htm

There is no data to record in this lab video.

Step Two:

Complete pages Ib-5-5 through Ib-5-8 using the "Chemical Equations & Reaction Types" video and the actual lab instructions on pages Ib-5-3 through Ib-5-4. Include your name on page Ib-5-5!

Step Three:

Submit your lab (pages Ib-5-5 through Ib-5-8 *only* to avoid a point penalty**) as a *single* PDF file to the instructor via email (mike.russell@mhcc.edu) on Friday, July 12 by 9:00 AM.** I recommend a free program (ex: CamScanner, https://camscanner.com) or a website (ex: CombinePDF, https://combinepdf.com) to convert your work to a PDF file.

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

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Chemical Equations & Reaction Types (online) **Lab**

The purpose of this laboratory exercise is to develop skills in writing and balancing chemical equations. The relevance of this exercise is illustrated by a series of demonstration reactions, performed by your lab instructor, which will provide a model to enable the student to predict the products and write balanced chemical equations for a series of similar reactions.

In order to write a balanced chemical reaction, two skills must be mastered.

1) Describe the chemical process: write correct chemical formulas for reactants, predict products and write correct chemical formulas for the products of the chemical reaction.
2) Balance the chemical equation.

A chemical equation is a shorthand way of expressing a chemical change in terms of symbols and formulas. An equation for a reaction cannot be written unless the substances that are reacting and being formed are both known. For an equation to be considered correct, it must be balanced. That is, the number of atoms of each element on the left side of the equation must equal the number of atoms of the same element on the right side. This is an application of the Law of Conservation of Mass. Equations may be written in two general ways: as molecular equations and as ionic equations. We shall only consider molecular equations in this exercise.

There are several conventions which are used in writing chemical equations:

1) The reactants are placed on the left side of the equation and the products on the right side with a single arrow separating the reactants from the products.
2) A plus sign (+) separates each reactant or each product.
3) The physical state of the chemical is often listed as a subscript. (i.e. $H_2O_{(l)}$ and $NaCl_{(s)}$)
4) A symbol may be placed above the arrow to indicate conditions needed for the reaction to occur; for example: Δ indicates that heat must be applied.

Guidelines for balancing chemical equations

The chemical equations we will encounter in this exercise are balanced "by inspection". The following guidelines are just helpful suggestions to facilitate the balancing process.

1) Determine the type of reaction (i.e. combination, decomposition, replacement, etc.)
2) Write the correct formula for reactants. Once the correct formula is written it must not be changed during the subsequent balancing operation.

*Note: The seven diatomic elements, when uncombined, are written with subscripts of 2 (H_2; O_2; etc.)

3) Determine the products and write the correct formula for each product. Once the correct formula is written it must not be changed during the subsequent balancing operation.
4) Balance the chemical equation. Do NOT change any chemical formulas while balancing.
    a) Choose the compound with the greatest number of atoms (excluding H and O) and balance the number of atoms of that element on both sides of the equation. This is done by placing the appropriate coefficient in <u>front</u> of the formula of the element or compound on the other side of the arrow that contains that same element. The coefficient is chosen so that when the coefficient is multiplied by the subscript for that element, the number of atoms of that element is equal to the number of atoms of the same element on the other side of the arrow.
    b) Continue until the number of atoms of each element is the same on both sides of the arrow.
    c) Check all coefficients to see that they are whole numbers and the lowest possible ratio.

The following example illustrates these guidelines.

$$Ca(OH)_2 + H_3PO_4 \rightarrow Ca_3(PO_4)_2 + H_2O$$

Start by balancing the calcium atoms in calcium phosphate first, since calcium phosphate contains the most atoms of an element other than H or O. This requires a coefficient of 3 to be placed in front of $Ca(OH)_2$ on the other side of the arrow.

$$3\ Ca(OH)_2 + H_3PO_4 \rightarrow Ca_3(PO_4)_2 + H_2O$$

Next balance the phosphate (if a polyatomic is found on both sides of the equation, it is easier to balance for the polyatomic than as each type of element) by putting a 2 in front of H_3PO_4.

$$3\ Ca(OH)_2 + 2\ H_3PO_4 \rightarrow Ca_3(PO_4)_2 + H_2O$$

The hydrogen atoms now total 12 on the left side, 6 from the 3 $Ca(OH)_2$ "molecules" and 6 from 2 H_3PO_4 molecules. Therefore, place a 6 in front of the formula for water and the equation will be balanced.

$$3\ Ca(OH)_2 + 2\ H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6\ H_2O$$

All coefficients should be **whole numbers** and the **lowest possible ratio**.

Categories of Chemical Reactions:

Most chemical reactions can be grouped into one of four categories:

1) **Combination reactions** $A + B \rightarrow X$

2) **Decomposition reactions** $X \rightarrow A + B$

3) **Single replacement reactions** $A + BX \rightarrow AX + B$
(Metal replace metals; non-metals replace non-metals.)

4) **Double displacement reactions** $AX + BY \rightarrow AY + BX$
   a) Precipitation (solid forms)
   b) Acid/Base (water is formed) [sometimes called neutralization]

Knowledge of the kind of reaction is useful in predicting the products in a particular reaction. Your instructor will demonstrate several reactions of each category, predicting the products, writing and balancing the chemical equation in each case. Using these as models, you will write and balance chemical equations of similar reactions.

Chemical Equations & Reaction Types (online) Lab

Name:

Write balanced chemical equations for each reaction below. *Remember the seven diatomics!*

A. COMBINATION: A + B → X

1) Magnesium metal burning in air.

2) The reaction of iron with oxygen to yield iron(III) oxide.

3) The reaction of sodium metal with chlorine gas.

4) The reaction of calcium with fluorine gas.

5) The reaction of ammonia (NH_3) with hydrogen monochloride to yield ammonium chloride.

B. DECOMPOSITION: $X \rightarrow A + B$

1) The decomposition of ammonium dichromate, $(NH_4)_2Cr_2O_7$, into nitrogen, water, and chromium(III) oxide.

2) The decomposition of nitrogen triiodide into its elements.

3) The decomposition of potassium chlorate to potassium chloride and oxygen.

4) The thermal decomposition of ammonium carbonate into ammonia, carbon dioxide and water

5) The decomposition of lead(IV) oxide into its elements.

C. SINGLE REPLACEMENT: $AX + B \rightarrow BX + A$

1) The reaction of a solution of silver nitrate with copper metal (copper(II) nitrate is a product).

2) The reaction of sodium metal with water to create hydrogen gas and sodium hydroxide.

3) Zinc metal with sulfuric acid (zinc sulfate is a product).

4) Chlorine with aqueous sodium bromide.

5) Aluminum metal with aqueous copper(II) sulfate.

D. DOUBLE DISPLACEMENT: AX + BY → AY + BX

1) The reaction of aqueous solution of calcium chloride with ammonium carbonate.

2) The action of vinegar (dilute acetic acid) on sodium bicarbonate.

3) The reaction of dihydrogen monosulfide on a solution of lead(II) nitrate.

4) The reaction of solutions of sodium chloride with silver nitrate.

5) The reaction of magnesium chloride with sulfuric acid.

POSTLAB QUESTIONS: Write balanced equations and classify the type of reaction.

1. Calcium reacts with chlorine

2. Sodium chloride is mixed with lead(II) nitrate

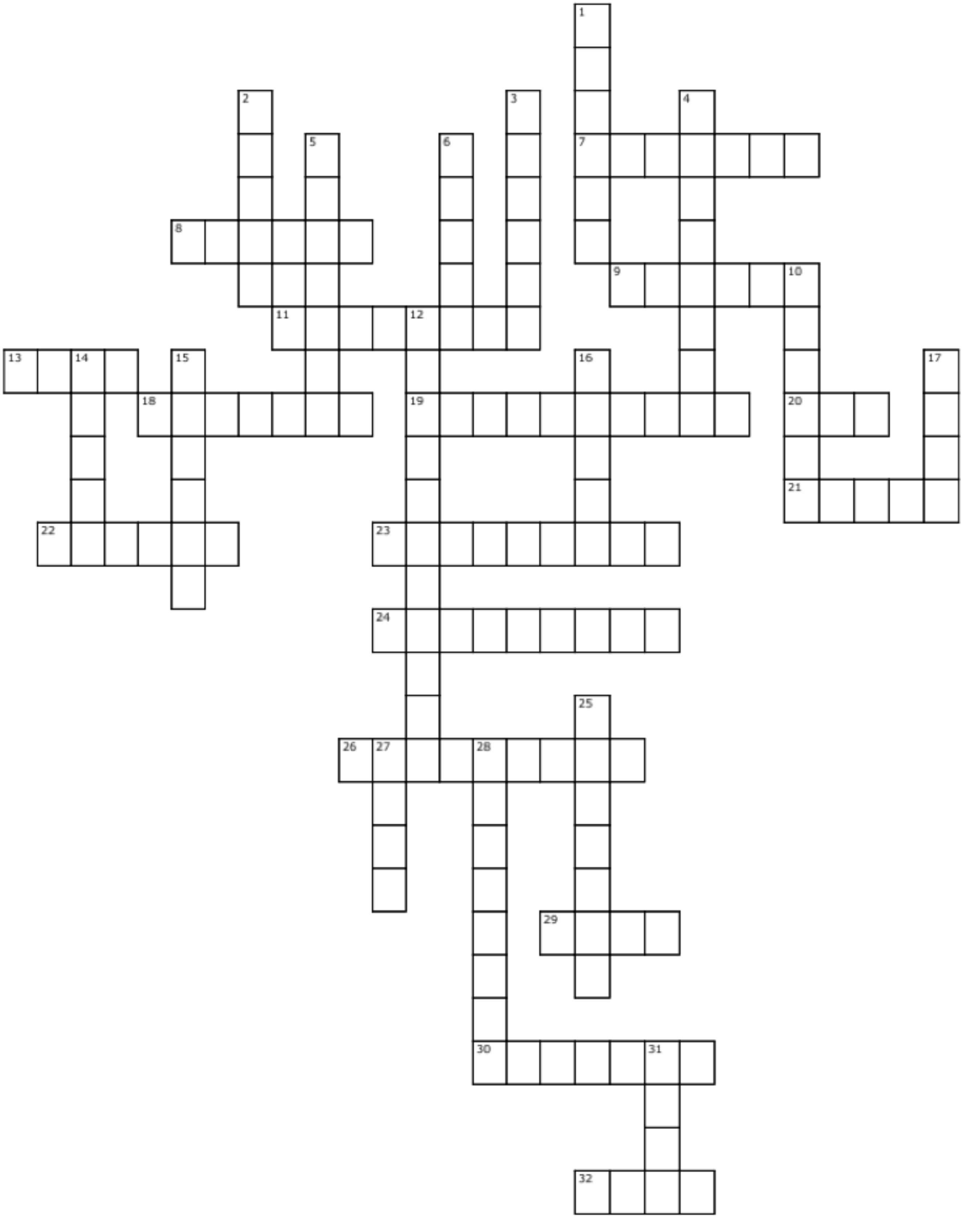
3. Sodium reacts with zinc sulfate

4. Diphosphorus pentoxide breaks down into its elements.

5. Metallic aluminum reacts with nickel(II) nitrate

Chemistry 151 Section W1: Crossword Puzzle **Name:**

Due by 11:59 PM Wed, July 10 via email



The Crossword Puzzle Hints:

Across

7. Protons and neutrons in the atom

8. Positive subatomic particle

9. Paper used to measure pH

11. Solute plus solvent equals a _______

13. Produces OH- ions in solution

18. Eye protection

19. A test in the laboratory

20. An atom or molecule with an electric charge

21. Metric prefix 10^{-6}

22. Cylindrical glass container

23. K

24. Heavy hydrogen

26. Measures the pressure

29. 6.022×10^{23}

30. A substance which cannot be broken down by chemical means

32. A nucleus orbited by electrons

Down

1. Bunsen _______

2. Negatively charged particle

3. Positively charged particle

4. Negative subatomic particle

5. Same element but different number of neutrons

6. Metric prefix 10^{-2}

10. Na

12. Might be calibrated in Fahrenheit or Celsius

14. Used to measure mass

15. Cu

16. Metric prefix 10^{-3}

17. Metric prefix 10^{3}

25. Neutral subatomic particle

27. Produces H+ ions in solution

28. Combination of two or more atoms

31. Metric prefix 10^{-9}

CH 151 Summer 2024:
“Percent Potassium Chlorate”
(online) ***Lab*** *- Instructions*

Step One:

Watch the lab video for the “Percent Potassium Chlorate” lab, found here:
http://mhchem.org/t/m.htm
Record the data found at the ***end*** of the lab video on page Ib-7-3.

Step Two:

Complete pages Ib-7-3 through Ib-7-6 using the “Percent Potassium Chlorate” video and the actual lab instructions on page Ib-7-2. Include your name on page Ib-7-3!

Step Three:

Submit your lab (pages Ib-7-3 through Ib-7-6 *only* to avoid a point penalty**) as a *single* PDF file to the instructor via email (mike.russell@mhcc.edu) on Wednesday, July 17 by 11:59 PM.** I recommend a free program (ex: CamScanner, https://camscanner.com) or a website (ex: CombinePDF, https://combinepdf.com) to convert your work to a PDF file.

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

Percent Potassium Chlorate (online) Lab

Potassium chlorate ($KClO_3$) decomposes on heating to produce potassium chloride and oxygen. In this experiment, you will begin with a sample that is a mixture of potassium chlorate and potassium chloride. Your objective is to determine the percentage by mass of potassium chlorate in the original mixture. Upon heating, only the potassium chlorate will decompose. Using the balanced equation and the fact that all the mass that is lost is oxygen gas, you can use stoichiometry to calculate the mass of potassium chlorate in the original mixture.

A catalyst, manganese(IV) oxide, is added to the reaction mixture in order to speed up the reaction. Like all catalysts, the same amount of catalyst is present at the end of the reaction as in the beginning. Therefore, we will include the mass of the catalyst in with the mass of the crucible.

To ensure that the decomposition is complete, the product must be heated to a constant weight. After the first heating, cooling and weighing, the sample must be heated again, cooled and reweighed. This process is continued until two successive weights are within 5 mg of each other (up to four heating cycles.)

PROCEDURE (this is what we would do in the lab room under "normal" circumstances)**:** - *You must wear safety goggles while performing this lab! **All** mass measurements should be recorded to the milligram (0.001 g.)*

1. Set up a ring stand with a triangle as demonstrated by your teacher. The small white crucible should fit inside the triangle.

2. Place about 0.5 g of manganese(IV) oxide into a clean, dry small white crucible. Heat the crucible and catalyst with a Bunsen burner for about 3 minutes to drive off any moisture that may be in the catalyst or crucible. Wear safety glasses at all times if a Bunsen burner is operational at your lab bench!

3. When the crucible is cool enough to touch, record the entire mass to the nearest 0.001g.

4. Add between 2.0 to 2.5 grams of the unknown mixture to the crucible. Mix the contents to obtain a somewhat uniform mixture. Record the mass of the crucible plus catalyst plus mixture to the nearest 0.001 g. Be sure to also record your unknown number!

5. Begin heating the crucible gently at first followed by a more aggressive treatment for a total of 10 minutes. Be aware that the sample may begin to bubble and spurt; if this happens, turn the flame down a bit.

6. Allow the sample to cool to room temperature. Record the mass to the nearest 0.001 g.

7. Reheat your sample for 5 minutes. Cool and record the mass. If your mass is within 0.005 g of the mass after the previous heating with the unknown sample, congratulations, you can move on to calculations. If not, you should reheat, cool, and weigh until you have two successive masses within 0.005 g of each other. Clean up and put away your equipment (all waste in this lab can be washed down the drain with water.)

Percent Potassium Chlorate (online) **Lab**

***YOUR NAME:* ____**

DATA: *Watch the video (***http://mhchem.org/t/m.htm***) to acquire these values:*

mass of empty crucible (g): ______________________

crucible after heating with MnO_2 (g): ______________________

crucible, MnO_2 & $KClO_3$ mixture before heating (g): ______________________

crucible, MnO_2 & $KClO_3$ mixture after heating for ten minutes (g): ______________________

crucible, MnO_2 & $KClO_3$ mixture after heating for additional ten minutes (g):

____

CALCULATIONS: *The video (***http://mhchem.org/t/m.htm***) might help you with these calculations. Clearly* ***show all work*** *in the area provided,* ***watch significant figures*** *and circle final answers*

1. Write a balanced equation for the decomposition of potassium chlorate into potassium chloride and oxygen gas.

2. Using the data from the video, determine the **mass of the mixture** used in this experiment. *Remember:* do ***not*** include the catalyst!

3. Using the data from the video, determine the **mass of oxygen lost** upon heating the mixture. This answer will be the **α** (below) in the equation.

4. Determine the **molar mass** of **oxygen** (**O_2**) to 0.01 g/mol. This answer will be the **β** (below) in the equation.

5. Determine the **molar mass** of **potassium chlorate** (**$KClO_3$**) to 0.01 g/mol. This answer will be the **δ** (below) in the equation.

6. Use the balanced equation and your values of **α** (the mass of oxygen lost), **β** (the molar mass of oxygen) and **δ** (the molar mass of potassium chlorate) to **determine the mass of potassium chlorate present in the original mixture** (this is the $KClO_3$ that decomposed in this experiment and is represented by **λ**, below, in the equation.) *Show your work!* The equation to use:

$$\lambda \text{ g KClO}_3 = \left(\alpha \text{ g O}_2 \text{ lost}\right) * \left(\frac{\text{mol O}_2}{\beta \text{ g O}_2}\right) * \left(\frac{2 \text{ mol KClO}_3}{3 \text{ mol O}_2}\right) * \left(\frac{\delta \text{ g KClO}_3}{1 \text{ mol KClO}_3}\right)$$

7. **Determine the percentage of potassium chlorate in the original white mixture** using your answers from step 6 (the pure $KClO_3$) and step 2 (the mass of the original mixture.)

POSTLAB QUESTIONS:

1. A white powder is a mixture of magnesium carbonate and magnesium oxide. Upon heating, the magnesium carbonate decomposes into magnesium oxide and carbon dioxide. If you have 1.897 g of the mixture and after heating are left with 1.494 g of magnesium oxide, calculate the weight percent of magnesium carbonate in the original mixture. *Hint:* Start by writing a balanced reaction, and remember the 1.897 g value is not pure!

2. Calculate the % oxygen by mass for the following (show calculations): a) $LiNO_3$ b) $NaHCO_3$ *Hint:* first find the molar mass (to 0.01 g/mol) of the compound!

3. If we had doubled the mass of the original mixture and completed the lab as written, would the calculated $\%KClO_3$ have changed? Explain.

CH 151 Summer 2024:

Problem Set #1

Instructions

Step One:

- **Learn the material** for Problem Set #1 by **reading Chapter 1 and Chapter 2** of the textbook and/or by watching the videos found on the website (https://mhchem.org/151)
- **Try the problems** for Problem Set #1 found on the next pages on your own first. Use separate paper and write out your answers, showing all of your work. If you write the answers on the problem set itself, you will receive fewer points. Include your name on your problem set!

Step Two:

Watch the recitation video for Problem Set #1:
http://mhchem.org/t/n.htm

- **Self correct *all* of the problems** while viewing the video. Mark correct problems with a star (or other similar mark), and correct all incorrect problems (show the correct answer and the steps required to achieve it.)
- **Submit Problem Set #1 via email (mike.russell@mhcc.edu) as a single PDF file** (use CamScanner (https://camscanner.com), CombinePDF (https://combinepdf.com), etc.) **by 11:59 PM Wednesday, June 26.**

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

CH 151 Problem Set #1

* Complete problem set on separate pieces of paper showing all work, circling final answers, etc.
* Self correct your work before turning it in to the instructor.

Covering: **Chapter One** *and* **Chapter Two**
Important Tables and/or Constants: 1 cm^3 = 1 mL; k = 10^3; c = 10^{-2}; m = 10^{-3}; μ = 10^{-6}; n = 10^{-9}; **273.15**, periodic table (http://mhchem.org/pertab)

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1. Determine the number of significant figures in each of the following measured values:
   a. 0.1111010
   b. 0.0000007
   c. 4000
   d. 4000.
   e. 0.0040
   f. 67,000,100
2. Round off each of the following numbers to the number of significant figures indicated in parentheses.
   a. 3883 (two)
   b. 0.00003011 (two)
   c. 4.4050 (three)
   d. 2.1000 (three)
3. Carry out the following mathematical operations, expressing your answers to the correct number of significant figures. Assume that all numbers are measured quantities.
   a. 3.33 x 3.03 x 0.0333
   b. 300,003 x 20,000 x 1.33333
   c. (2.322 + 4.00) / (3.200 + 6.73)
   d. 7.403 / (3.220 x 5.000)
   e. (5600 x 300) / (22 x 97.1)
4. Carry out the following mathematical operations, expressing your answers to the correct number of significant figures. Assume that all numbers are measured quantities.
   a. 237 + 37 + 7
   b. 3.111 + 3.11 + 3.1
   c. 235.45 + 37 + 36.4
   d. 4.72 - 3.908
   e. 46,230 + 325 + 45
5. Express the following numbers in scientific notation.
   a. 787.6
   b. 0.01798
   c. 40.0
   d. 675,000
6. Identify the metric prefixes corresponding to each of the following powers of ten, or vice versa.
   a. 10^{-3} b. 10^{-9} c. 10^3 d. micro e. centi

Problem Set #1 continues on the next page

Problem Set #1, Continued from previous page

7. Calculate the volume of each of the following objects, each of which has a regular geometrical shape.
    a. a cube of steel whose edge is 3.5175 mm ($V = s^3$)
    b. a spherical marble with a radius of 1.212 cm ($V = {}^4/_3\pi r^3$)
    c. a bar of iron 6.0 m long, 0.10 m wide and 0.20 m high ($V = l * w * h$)
    d. a cylindrical rod of copper with radius = 3.2 mm and length = 62 mm ($V = \pi r^2 L$)
8. A piece of metal weighing 187.6 g is placed in a graduated cylinder containing 225.2 mL of water. The combined volume of solid and liquid is 250.3 mL. What is the volume (in cm^3) and density (in grams per milliliter) of the metal?
9. A pediatric dosage of a certain analgesic is 225 mg/kg of body weight per day. How much analgesic, in milligrams per day, should be administered to a child who weighs 12.3 kg?
10. A 2004 US penny (zinc plated with a thin layer of copper) with a mass of 2.552 g contains 2.448 g of zinc. What is the mass percentage in the penny of copper? of zinc?
11. Carry out the following temperature scale conversions. **T(K) = T(°C) + 273.15**
    a. Mercury freezes at 234.3 K. What is this temperature in degrees Celsius?
    b. Normal body temperature for a chickadee is 41.0 °C. What is this temperature in Kelvin?
    c. A recommended temperature setting for household hot water heaters is 60. °C. What is this temperature in degrees Fahrenheit? T(°F) = 1.8*T(°C) + 32
12. What should the recorded uncertainty be (±0.1 unit, ±0.01 unit, etc.) for measurements made using the following measuring device scales?
    a. a graduated cylinder scale with markings in 10 mL intervals
    b. a meter stick scale with markings in 1 cm intervals
    c. a buret (a volumetric device) scale with markings in 0.1 mL intervals
    d. a double pan mass balance scale with markings in 100 g intervals
13. With a high grade measuring device, the length of an object is determined to be 13.452 mm. Three students are asked to determine the length of the same object using a lower grade measuring device. How do you evaluate the following work of the three students with regard to accuracy and precision?

Trial	Student A	Student B	Student C
1	13.6 mm	13.4 mm	13.9 mm
2	13.9 mm	13.5 mm	13.9 mm
3	13.3 mm	13.5 mm	14.0 mm
4	13.6 mm	13.4 mm	14.1 mm

14. The accepted value for the normal boiling point of benzaldehyde, a substance used as an almond flavoring, is 178 °C. In a laboratory setting, three students are asked to experimentally determine the normal boiling point of benzaldehyde. Their results are:

    Student 1: 175 °C *Student 2:* 190. °C *Student 3*: 181 °C

    Calculate the percent error associated with each student's reported boiling point. *Helpful formula:* **% error = absolute value |(difference)| / (accepted) * 100%**

Problem Set #1 continues on the next page

Problem Set #1, Continued from previous page

15. The following are properties of the metal beryllium. Classify them as **physical** or **chemical**.
    a. In powdered form, it burns brilliantly on ignition.
    b. Bulk metal melts at 1287 °C
    c. It has a density of 1.85 g/cm^3 at 20 °C.
    d. It is a relatively soft silvery white metal.
16. Consider the following classifications of matter: **heterogeneous mixture**, **homogeneous mixture** and **pure substance**
    a. In which of these classifications must the composition be constant?
    b. In which of these classifications is separation into simpler substances using physical means possible?
17. Based on the information given, classify each of the pure substances A through D as **elements** or **compounds**, or indicate that no such classification is possible because of insufficient information.
    a. Substance A cannot be broken down into simpler substances by chemical means
    b. Substance B cannot be broken down into simpler substances by physical means
    c. Substance C readily dissolves in water
    d. Substance D readily reacts with the element chlorine
18. Indicate whether each of the following statements is **true** or **false**.
    a. Compounds can be separated into their constituent elements using chemical means.
    b. Elements can be separated into their constituent compounds using physical means.
    c. A compound must contain at least two elements.
    d. A compound is a physical mixture of different elements
19. Give the name of the element associated with each of the following chemical symbols, or vice versa.
    a. Li
    b. He
    c. F
    d. Zn
    e. mercury
    f. chlorine
    g. gold
    h. selenium
20. Write the chemical symbol for each member of the following pairs of elements:
    a. copper and cobalt
    b. potassium and phosphorus
    c. iron and iodine
    d. silicon and silver

CH 151 Summer 2024:

Problem Set #2

Instructions

Step One (all sections):

- **Learn the material** for Problem Set #2 by **reading Chapter 2 and Chapter 3** of the textbook and/or by watching the videos found on the website (https://mhchem.org/151)
- **Try the problems** for Problem Set #2 found on the next pages on your own first. Use separate paper and write out your answers, showing all of your work. If you write the answers on the problem set itself, you will receive fewer points. Include your name on your problem set!

Step Two:

Watch the recitation video for Problem Set #2:
http://mhchem.org/t/b.htm

- **Self correct *all* of the problems** while viewing the video. Mark correct problems with a star (or other similar mark), and correct all incorrect problems (show the correct answer and the steps required to achieve it.)
- **Submit Problem Set #2 via email (mike.russell@mhcc.edu) as a single PDF file** (use CamScanner (https://camscanner.com), CombinePDF (https://combinepdf.com), etc.) **by 11:59 PM Wednesday, July 3.**

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

CH 151 Problem Set #2

* Complete problem set on separate pieces of paper showing all work, circling final answers, etc.

* Self correct your work before turning it in to the instructor.

Covering: **Chapter Two** *and* **Chapter Three**

Important Tables and/or Constants: 1 mol = 6.022×10^{23}, periodic table (http://mhchem.org/pertab)

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1. On the basis of its formula, classify each of the following substances as an element or a compound.
   a. AlN
   b. CO_2
   c. Co
2. Match the terms **proton neutron**, and **electron** to each of the following subatomic particle descriptions. It is possible that more than one term may apply in a given situation.
   a. has no charge
   b. has a charge equal to but opposite in sign to that of an electron
   c. is not found in the nucleus
   d. has a positive charge
3. Indicate whether each of the following statements about the nucleus of an atom is true or false.
   a. The nucleus accounts for almost all the volume of an atom.
   b. The nucleus can be positively or negatively charged, depending on the identity of the atom.
   c. The nucleus of an atom contains an equal number of protons, neutrons and electrons.
   d. The nucleus of an atom is always positively charged.
4. What is the complete symbol ($^{A}_{Z}X$) for neutral atoms composed of the following sets of subatomic particles?
   a. 4 protons, 4 electrons and 5 neutrons
   b. 7 protons, 7 electrons and 8 neutrons
   c. 15 protons, 15 electrons and 16 neutrons
   d. 20 protons, 20 electrons and 28 neutrons
5. Determine the number of protons, electrons, and neutrons in each of the following neutral atoms.
   a. $^{35}_{17}Cl$
   b. $^{55}_{25}Mn$
   c. $^{127}_{53}I$
   d. $^{209}_{83}Bi$
6. Four naturally occurring isotopes of the element strontium exist. Knowing that the lightest isotope has a mass number of 84 and that the other isotopes have, respectively, 2, 4, and 5 more neutrons, write the complete symbol ($^{A}_{Z}X$) for each of the four isotopes.

Problem Set #2 continues on the next page

Problem Set #2, Continued from previous page

7. Each of the following elements has only two naturally occurring isotopes. Determine, in each case, which isotope is more abundant, using only the atomic mass value for the element that is listed on the periodic table.
    a. $^{10}_{5}B$ and $^{11}_{5}B$
    b. $^{69}_{31}Ga$ and $^{71}_{31}Ga$
    c. $^{107}_{47}Ag$ and $^{109}_{47}Ag$
    d. $^{203}_{81}Tl$ and $^{205}_{81}Tl$
8. Calculate the atomic mass of copper on the basis of the following percent composition and isotopic mass data for the naturally occurring isotopes: **copper-63** : 69.09% (62.9298 amu) , and **copper-65** : 30.91% (64.9278 amu)
9. Name each of the following fixed-charge binary ionic compounds.
    a. BeS
    b. $GaCl_3$
    c. CaO
10. Name each compound in the following pairs of variable-charge binary ionic compounds.
    a. $SnCl_4$ and $SnCl_2$
    b. FeS and Fe_2S_3
    c. AuI and AgI
11. Write chemical formulas for both ions in each of the following pairs of polyatomic ions.
    a. nitrate and nitrite
    b. chlorate and perchlorate
    c. phosphate and phosphite
12. In which of the following pairs of compounds are polyatomic ions present in both members of the pair?
    a. SO_3 and $CaSO_4$
    b. NH_4Br and KClO
13. Name each compound in the following pairs of polyatomic ion containing compounds.
    a. $CuNO_3$ and $Cu(NO_3)_2$
    b. $Pb_3(PO_4)_2$ and $Pb_3(PO_4)_4$
14. Name the following binary molecular compounds.
    a. S_4N_2
    b. SO_3
15. Write chemical formulas for the following binary molecular compounds.
    a. disulfur monoxide
    b. tetraphosphorus hexoxide
    c. carbon dioxide
16. Name each of the following compounds as acids.
    a. $HClO_4$
    b. $HClO_3$
    c. $HClO_2$
    d. HClO
    e. HCl

Problem Set #2 continues on the next page

Problem Set #2, Continued from previous page

17. Calculate the molar mass (to 0.01 g/mol) of each of the following substances.
    a. $NaHCO_3$ (baking soda, or sodium bicarbonate)
    b. Tl_2SO_4 (thallium(I) sulfate, a rat and ant poison)
18. Calculate the percent element composition for each of the following compounds. (Round off all atomic masses to 0.01 g/mol before using them.)
    a. $C_{10}H_8$ (naphthalene, ingredient in some mothballs)
    b. NaCN (sodium cyanide, used to extract gold from ores)
19. Calculate the number of molecules or atoms present in each of the following:
    a. 4.69 moles CO
    b. 3.752 g of Li
20. Calculate the mass, in grams, of 0.981 mole of each of the following compounds.
    a. SO_2
    b. S_4N_4
21. Each of the following is a correctly written molecular formula. In each case write the empirical formula for the substance.
    a. As_4O_6
    b. Pb_3S_4
    c. C_4H_8
22. Given the following percent element composition, determine the empirical formula: **47.26% Cu and 52.74% Cl**
23. Determine the molecular formulas of compounds with the following empirical formulas and molecular masses.
    a. CB_2H_3, 73.3 amu
    b. $C_5H_{10}O_2$, 102 amu
24. Adipic acid, a compound used in the manufacture of nylon, has a molecular mass of 146 g/mol. Its percent composition by mass is 49.30% C, 6.91% H, and 43.79% O. Determine the molecular formula of adipic acid.

CH 151 Summer 2024:

Problem Set #3

Instructions

Step One (all sections):

- **Learn the material** for Problem Set #3 by **reading Chapter 4** of the textbook and/or by watching the videos found on the website (https://mhchem.org/151)
- **Try the problems** for Problem Set #3 found on the next pages on your own first. Use separate paper and write out your answers, showing all of your work. If you write the answers on the problem set itself, you will receive fewer points. Include your name on your problem set!

Step Two:

Watch the recitation video for Problem Set #3:
http://mhchem.org/t/c.htm

- **Self correct *all* of the problems** while viewing the video. Mark correct problems with a star (or other similar mark), and correct all incorrect problems (show the correct answer and the steps required to achieve it.)
- **Submit Problem Set #3 via email (mike.russell@mhcc.edu) as a single PDF file** (use CamScanner (https://camscanner.com), CombinePDF (https://combinepdf.com), etc.) **by 11:59 PM Wednesday, July 10.**

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

CH 151 Problem Set #3

* Complete problem set on separate pieces of paper showing all work, circling final answers, etc.
* Self correct your work before turning it in to the instructor.

Covering: **Chapter Four**
* *Important Tables and/or Constants:* periodic table (http://mhchem.org/pertab)

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1. What do the symbols in parentheses stand for in the following equations?
    a. $PCl_3(l) + Cl_2(g) \rightarrow PCl_5(s)$
    b. $NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$
2. For each of the following balanced equations, indicate how many atoms of each element are present on the reactant and product sides of the chemical equation.
    a. $4\,Al + 3\,O_2 \rightarrow 2\,Al_2O_3$
    b. $2\,Na + 2\,H_2O \rightarrow 2\,NaOH + H_2$
    c. $2\,Co + 3\,HgCl_2 \rightarrow 2\,CoCl_3 + 3\,Hg$
    d. $H_2SO_4 + 2\,NH_3 \rightarrow (NH_4)_2SO_4$
3. Balance the following chemical equations.
    a. $Fe + O_2 \rightarrow Fe_2O_3$
    b. $NaClO_3 \rightarrow NaCl + O_2$
    c. $Au_2S_3 + H_2 \rightarrow H_2S + Au$
    d. $NH_3 + O_2 \rightarrow N_2O + H_2O$
4. Balance the following combustion equations.
    a. $C_2H_4 + O_2 \rightarrow CO_2 + H_2O$
    b. $C_6H_{12} + O_2 \rightarrow CO_2 + H_2O$
    c. $C_3H_6O + O_2 \rightarrow CO_2 + H_2O$
    d. $C_5H_{10}O_2 + O_2 \rightarrow CO_2 + H_2O$
5. Balance the following chemical equations.
    a. $Al + Sn(NO_3)_2 \rightarrow Al(NO_3)_3 + Sn$
    b. $Na_2CO_3 + Mg(NO_3)_2 \rightarrow MgCO_3 + NaNO_3$
    c. $Al(NO_3)_3 + H_2SO_4 \rightarrow Al_2(SO_4)_3 + HNO_3$
    d. $Ba(C_2H_3O_2)_2 + (NH_4)_3PO_4 \rightarrow Ba_3(PO_4)_2 + NH_4C_2H_3O_2$
6. Classify each of the following chemical reactions as precipitation, decomposition, single-replacement, combustion, acid-base or combination.
    a. $3\,CuSO_4 + 2\,Al \rightarrow Al_2(SO_4)_3 + 3\,Cu$
    b. $K_2CO_3 \rightarrow K_2O + CO_2$
    c. $2\,AgNO_3 + K_2SO_4 \rightarrow Ag_2SO_4(s) + 2\,KNO_3$
    d. $2\,SO_2 + O_2 \rightarrow 2\,SO_3$
    e. $H_2SO_4 + 2\,KOH \rightarrow 2\,H_2O + K_2SO_4$
    f. $CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$

Problem Set #3 continues on the next page

Problem Set #3, Continued from previous page

7. Identify the products of, and then write a balanced chemical equation for, each of the following chemical reactions.
    a. $AlCl_3 \rightarrow ? + ?$ (decomposition reaction into elements)
    b. $HNO_3 + NaOH \rightarrow ? + ?$ (acid-base reaction)
    c. $Al + Ni(NO_3)_2 \rightarrow ? + ?$ (single replacement reaction)
    d. $Be + N_2 \rightarrow ?$ (combination reaction)
8. Write a balanced chemical equation for the thermal decomposition of each of the following metal carbonates to its metal oxide and carbon dioxide.
    a. $BeCO_3$
    b. Li_2CO_3
    c. $ZnCO_3$
    d. Cs_2CO_3
9. Write a balanced chemical equation for the combustion of each of the following hydrocarbons in air.
    a. C_5H_{12}
    b. C_4H_6
    c. C_7H_8
    d. C_8H_{18}
10. Write a balanced chemical equation for the combustion of each of the following hydrocarbons in air.
    a. C_2H_4O
    b. $C_5H_{10}O$
    c. $C_2H_4O_2$
    d. $C_3H_6O_2$
11. Balance the following chemical equations.
    a. $NH_3 + O_2 + CH_4 \rightarrow HCN + H_2O$
    b. $KClO_3 + HCl \rightarrow KCl + Cl_2 + H_2O$

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CH 151 Summer 2024:

Problem Set #4

Instructions

Step One (all sections):

- **Learn the material** for Problem Set #4 by **reading Chapter 4 and Chapter 6** of the textbook and/or by watching the videos found on the website (https://mhchem.org/151)
- **Try the problems** for Problem Set #4 found on the next pages on your own first. Use separate paper and write out your answers, showing all of your work. If you write the answers on the problem set itself, you will receive fewer points. Include your name on your problem set!

Step Two:

Watch the recitation video for Problem Set #4:
http://mhchem.org/t/d.htm

- **Self correct *all* of the problems** while viewing the video. Mark correct problems with a star (or other similar mark), and correct all incorrect problems (show the correct answer and the steps required to achieve it.)
- **Submit Problem Set #4 via email (mike.russell@mhcc.edu) as a single PDF file** (use CamScanner (https://camscanner.com), CombinePDF (https://combinepdf.com), etc.) **by 11:59 PM Wednesday, July 17.**

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

CH 151 Problem Set #4

* Complete problem set on separate pieces of paper showing all work, circling final answers, etc.
* Self correct your work before turning it in to the instructor.

Covering: **Chapter Four and Chapter 6**
Important Tables and/or Constants: periodic table (http://mhchem.org/pertab)

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1. For the chemical reaction: **$4\ FeS_2(s) + 11\ O_2(g) \rightarrow 2\ Fe_2O_3(s) + 8\ SO_2(g)$**
   a. How many moles of O_2 are needed to produce 3.50 moles of SO_2?
   b. How many moles of Fe_2O_3 will be produced from 1.02 mole of FeS_2?
   c. How many moles of FeS_2 are needed to react with 5.40 moles of O_2?
   d. How many moles of Fe_2O_3 are produced at the same time that 0.908 moles of SO_2 are produced?
2. In the atmosphere, the air pollutant nitrogen dioxide (NO_2) reacts with water to produce nitric acid (HNO_3). The reaction for the formation of nitric acid is:
   $3\ NO_2(g) + H_2O(l) \rightarrow 2\ HNO_3(aq) + NO(g)$
   a. How many grams of NO_2 are needed to react with 2.30 moles of H_2O?
   b. How many grams of NO are produced when 2.04 moles of H_2O react?
   c. How many grams of HNO_3 are produced at the same time that 0.500 mole of NO are produced?
   d. How many grams of NO_2 must react in order to produce 1.23 moles of HNO_3?
3. Potassium thiosulfate, $K_2S_2O_3$, is used to remove any excess chlorine from fibers and fabrics that have been bleached with that gas. The reaction:
   $K_2S_2O_3 + 4\ Cl_2 + 5\ H_2O \rightarrow 2\ KHSO_4 + 8\ HCl$
   a. How many moles of $K_2S_2O_3$ must react to produce 2.500 g of HCl?
   b. How many grams of Cl_2 must react to produce 20.00 g of $KHSO_4$?
   c. How many molecules of HCl are produced at the same time that 2.000 g of $KHSO_4$ is produced?
   d. How many milliliters of H_2O are consumed as 12.50 g of Cl_2 reacts? d(H_2O) = 0.9978 g/mL
4. If 70.0 g of $TiCl_4$ and 16.0 g of Ti are present in a reaction mixture, determine how many grams of each reactant will be left unreacted upon completion of the following reaction:
   $3\ TiCl_4 + Ti \rightarrow 4\ TiCl_3$
5. Aluminum and oxygen react to form aluminum oxide. In a certain experiment, 125 g of Al_2O_3 are produced from 75.0 g of Al and 200.0 g of O_2. What is the theoretical yield and percent yield of Al_2O_3? The equation: **$4\ Al + 3\ O_2 \rightarrow 2\ Al_2O_3$**
6. For each of the following sets of elements, choose the two that would be expected to have similar chemical properties.
   a. ${}_{11}Na$, ${}_{14}Si$, ${}_{23}V$, ${}_{55}Cs$
   b. ${}_{13}Al$, ${}_{19}K$, ${}_{32}Ge$, ${}_{50}Sn$
   c. ${}_{37}Rb$, ${}_{38}Sr$, ${}_{54}Xe$, ${}_{56}Ba$
   d. ${}_{2}He$, ${}_{6}C$, ${}_{8}O$, ${}_{10}Ne$

Problem Set #4 continues on the next page

7. Give the maximum number of electrons that can occupy each of the following electron ***subshells***.
   a. 6*p* b. 1*s* c. 5*f* d. 4*d*
8. Give the maximum number of electrons that can occupy each of the following electron ***orbitals***.
   a. 1*s* b. 3*d* c. 5*p* d. 4*d*
9. Which of the following electron subshell and electron orbital designations is not allowed?
   a. 2*d* subshell
   b. 4*s* orbital
   c. 3*p* subshell
   d. 2*f* orbital
10. With the help of an Aufbau diagram, write the complete electron configuration for each of the following atoms.
   a. $_6$C b. $_{10}$Ne c. $_{15}$P d. $_{36}$Kr
11. With the help of an Aufbau diagram, write the complete electron configuration for each of the following atoms.
   a. $_{31}$Ga
   b. $_{38}$Sr
   c. $_{48}$Cd
   d. $_{88}$Ra
12. Based on total number of electrons present, identify the neutral element represented by each of the following electron configurations.
   a. $1s^2\ 2s^2\ 2p^2$
   b. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$
   c. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$
   d. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$
13. Determine how many unpaired electrons there are in an atom of the following elements. Indicate whether the elements are **paramagnetic** or **diamagnetic**.
   a. lithium
   b. aluminum
   c. calcium
   d. bromine
14. Using the periodic table as a guide, indicate the number of:
   a. 3*s* electrons and valence electrons in a $_{12}$Mg atom
   b. 4*p* electrons and valence electrons in a $_{32}$Ge atom
   c. 3*d* electrons in a $_{47}$Ag atom
   d. 4*p* electrons and valence electrons in a $_{15}$P atom
15. How many elements are there that have the following generalized condensed electron configurations?
   a. [noble gas]ns^1
   b. [noble gas]$ns^2\ np^2$
16. Write the electron configuration for each of the following ions.
   a. S^{2-} b. P^{3-} c. Be^{2+} d. Na^{+1}

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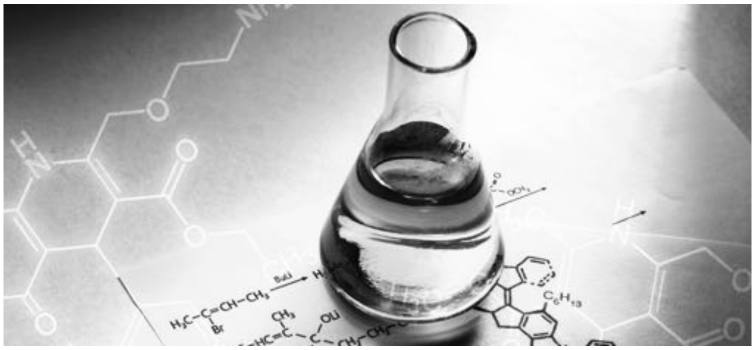
Chemistry 151: Basic Chemistry

Welcome! & Chapter 1



Welcome to Chemistry 151!

Chemistry 151 is the gateway to a successful experience in the "majors level" chemistry classes (Chemistry 221, Chemistry 222 and Chemistry 223 at Mt. Hood Community College)

CH 151 offers students the chance to acquaint themselves with chemistry, math and more before tackling the higher level (and faster paced) classes.

The *goals* of CH 151: learn chemistry, understand sig figs and dimensional analysis, explore math skills needed for chemistry, and have fun! :)

MAR

What is Chemistry?

- "Keme" (earth)
- "Kehmeia" (transmutation)
- "Al-Khemia" (Arabic)
- "alchemy" (Europe's Dark Age)
- "chymistry" (Boyle's 1661 publication)
- "chemistry" (modern)

Khemeia - ancient Egyptian processes for embalming the dead, later extended to metallurgy

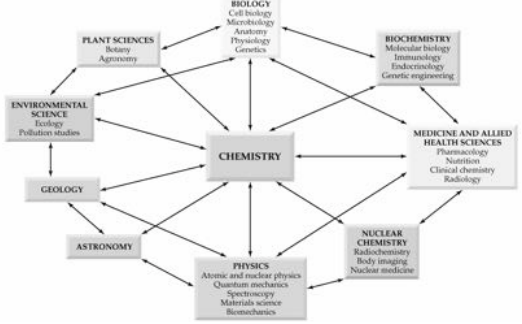
Chemistry is the study of matter and energy

Khemeia (and later chemistry) seen as "occult" by laymen, extended to modern age

MAR

Chemistry: The Central Science

Chemistry is often referred to as “***The Central Science***” because it is crucial to all other sciences.



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The Branches of Chemistry

- **Organic - carbon, nitrogen, oxygen**
- **Inorganic - metals, everything “non-carbon”**
- **Analytical - Spectroscopy, “how much”, “what kind”**
- **Physical - measurement, where physics meets chemistry**
- **Biochemical - the chemistry of life**
- **also: geochemistry, astrochemistry, radiochemistry, medicinal chemistry, etc.**

MAR

Metric System

Scientists use the metric system to record measurements (length, mass, volume, temperature, etc.) The metric system uses prefixes which correspond to a power of ten:

COMMON METRIC PREFIXES

PREFIX	ABBREV.	MEANING	NUMERICAL VALUE	
mega-	M	one million	1,000,000	(10^6)
kilo-	k	one thousand	1,000	(10^3)
deci-	d	one tenth	0.1	(10^{-1})
centi-	c	one hundredth	0.01	(10^{-2})
milli-	m	one thousandth	0.001	(10^{-3})
micro-	μ	one millionth	0.000001	(10^{-6})
nano-	n	one billionth	0.000000001	(10^{-9})

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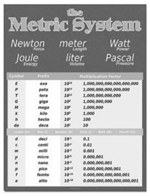
Metric System



The same prefixes are used with different types of measurements.

Length	**Mass**	**Volume**	**Time**
(meter, m)	**(gram, g)**	**(liter, L)**	**(second, s)**
megameter	megagram	megaliter	megasecond
kilometer	kilogram	kiloliter	kilosecond
decimeter	decigram	deciliter	decisecond
centimeter	centigram	centiliter	centisecond
millimeter	milligram	milliliter	millisecond
micrometer	microgram	microliter	microsecond
nanometer	nanogram	nanoliter	nanosecond

...and many more!

MAR

Metric System

Relationships can be obtained from prefix meanings; just replace the prefix with its numerical equivalent

1 **kilo**meter = **1000** meters *(kilo = 10^3 or 1000)*

1 **deci**meter = **0.1** meters *(deci = 10^{-1} or 0.1)*

1 **centi**meter = **0.01** meters (*centi = 10^{-2} or 0.01 - note that this is equivalent to saying* **100 cm = 1 meter**)

MA

Metric System

Common "Bridges" Between English and Metric Systems

QUANTITY	BRIDGE
Length	2.54 cm = 1.00 in 1.61 km = 1.00 mile
Mass	454 g = 1.00 lb
Volume	1.00 L = 1.06 qts

Try to use the metric system at all times!

MAR

Physical Quantities

Measurable physical properties such as height, volume, and temperature are called ***Physical quantity***. A number and a unit of defined size is required to describe physical quantity.

Number Unit

61.2 kilograms

MAR

Physical Quantities

A number alone doesn't say much!

Say an average textbook weighs 1.

The question would then be asked 1 what? 1 pound? 1 kilogram? 1 ounce?

You have to mention the unit of mass *along with the number* for the statement to be meaningful.

MAR

Physical Quantities

Physical quantities measured using many different units. Mass can be measured in pounds, kilograms, ounces, etc.

To avoid confusion, scientists around the world have agreed to use a set of standard units known as the ***International System of Units*** or ***SI units*** for some common physical quantities.

MAR

SI Units

In **SI Units**,

- mass measured in kilograms (kg)
- length measured in meters (m)
- volume measured in cubic meters (m^3)
- time measured in seconds (s).

Many other units derived from SI units.

- speed measured in meters per second (m/s)
- density measured in grams per cubic centimeter (g/cm^3).

Measuring Mass

Mass is a measure of amount of matter in an object.

Weight is a measure of gravitational pull on an object.

At the same location, two objects with *identical masses* have *identical weights* (gravity pulls them equally).

Thus masses of objects determined by comparing the weight of the object to the weight of a known reference.

Measuring Length

The Meter (m) is the standard measure of length or distance in both SI and metric system. One meter is 39.37 inches.

Centimeter (cm; $^1/_{100}$ m) and millimeter (mm; $^1/_{1000}$ m) commonly used for most measurements in chemistry and medicine.

Measuring Volume

Volume is the amount of space occupied by an object.

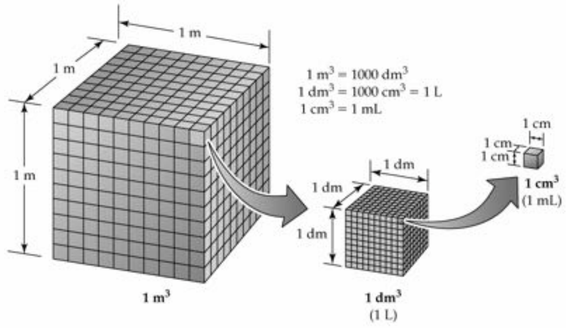
SI unit for volume is the cubic meter (m^3)

Liter (L) is commonly used in chemistry.

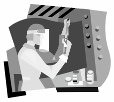
1 L = 0.001 m^3 = 1000 mL

A milliliter is often called a cubic centimeter

1 mL = 1 cm^3



Scientific Notation



Scientific notation used by scientists to express very large and very small numbers in a compact fashion.

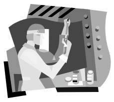
To express a number in scientific notation we rewrite the quantity as a number (between 1 and 9) multiplied by 10 raised to a power (exponent) that tells us how we moved the decimal point.

- Multiply the number by 10^0. (*Remember* $10^0 = 1$)
- Move the decimal point to give a number between 1 and 10.
- Every time we shift the decimal point to the left by one place we increase the value of the exponent by one.
- Every time we shift the decimal point to the right by one place we reduce the value of the exponent by one.

$$215. = 2.15 \times 10^2$$

Decimal point is moved two places to the left, so exponent is 2.

Scientific Notation



Example: Write 120,000 in scientific notation.

$120,000 = 120,000 \times 10^0 = 1.2 \times 10^5$

Example: Write 0.0000012 in scientific notation.

$0.0000012 = 0.0000012 \times 10^0 = 1.2 \times 10^{-6}$

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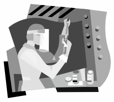
Scientific Notation



To express a scientific notation number as a non-exponential "regular" number:

- Move the decimal point the same number of places as the value of the exponent and eliminate the exponential part of the number.
- If the exponent is positive, we move the decimal to the right, to the same number of places as the value of the exponent. (The result should be a number greater than 1.)
- If the exponent is negative, we move the decimal to the left, to the same number of places as the value of the exponent. (The result should be a number less than 1.)

$1.56 \times 10^{-8} = 0.000\,000\,015\,6$

Negative exponent of –8,
so decimal point is moved to the left eight places.

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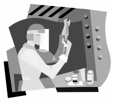
Scientific Notation



Example: Write 1.23 x 10^6 in non-exponential form.

$1.23 \times 10^6 = 1,230,000$

Example: Write 1.11 x 10^-5 in non-exponential form.

$1.11 \times 10^{-5} = 0.0000111$

Remember: If we make the exponent larger we must make the number part smaller, and if we make the exponent smaller we must make the number part larger.

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Calculations Using Scientific Notation on Your Calculator

Let's see how you are at using your calculators. Try the following and don't forget about cancelling units where appropriate. Record your answers in scientific notation, rounded to one digit past the decimal. (**Rounding rule: 5 or bigger, round up**.)

1. $(1.5 \times 10^5\ \text{in}^2)(1.2 \times 10^{-2}\ \text{in}) = ?$

(It saves time to use your exponent button. EE, exp, 10^x)

1.5EE5x1.2EE(-)2 [Enter] = 1800 in^3 = $1.8 \times 10^3\ \text{in}^3$ *1800 exact*

2. $4.3 \times 10^5\ \text{ft} / 5.1 \times 10^{-6}\ \text{ft} = ?$ (try this yourself!)

$= 8.4 \times 10^{10}$ *8.43137.... E10*

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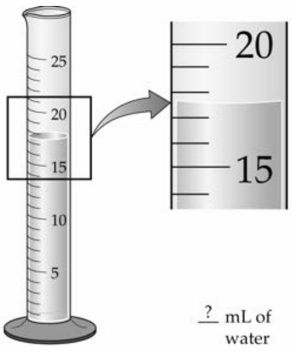
Measurement and Significant Figures

Every experimental measurement, no matter how precise, has a degree of uncertainty because there is a limit to the number of digits that can be determined.



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Measurement and Significant Figures

To indicate the precision of the measurement, the value recorded should use all the digits known with certainty *plus* one additional estimated digit ("doubtful digit") that usually is considered *uncertain* by plus or minus 1 (± 1)

The total number of digits used to express such a measurement is called the number of ***significant figures***.

Example: The quantity 65.07 g has four significant figures and 7 is the "doubtful digit"

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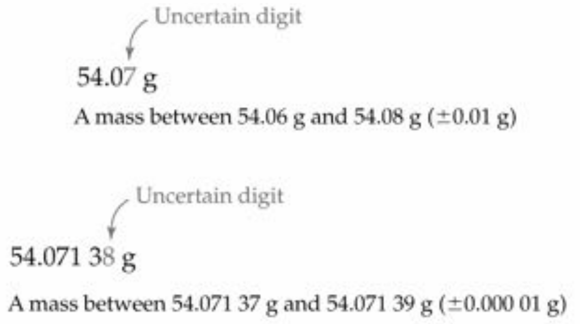
Measurement and Significant Figures



A mass between 54.06 g and 54.08 g (±0.01 g)

A mass between 54.071 37 g and 54.071 39 g (±0.000 01 g)

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Rules for Determining Significant Figures

1. Zeroes in the middle of a number are significant. 69.08 g has four significant figures, 6, 9, 0, and 8.
2. Zeroes at the beginning of a number are not significant. 0.0089 g has two significant figure, 8 and 9.
3. Zeroes at the end of a number and after the decimal points are significant. 2.50 g has three significant figures 2, 5, and 0. 25.00 m has four significant figures 2, 5, 0, and 0.

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Significant Figures often abbreviated as "sig figs"

Rules for Determining Significant Figures

4. Zeroes at the end of a number and before an implied decimal points may or may not be significant. 1500 kg may have two, three, or four significant figures. Zeroes here may be part of the measurements or for simply to locate the unwritten decimal point.

MAR

Test Yourself: How Many Significant Figures?

94.072 g
0.0834 cm
0.02907 mL
138.200 m
23,000 kg

23,000. kg

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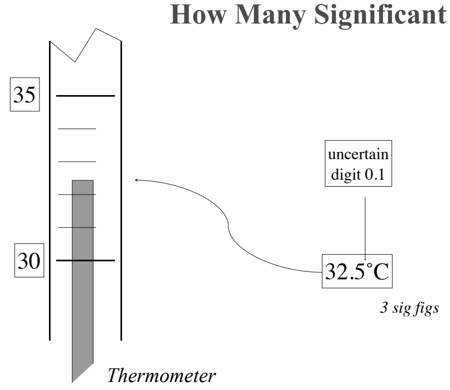
How Many Significant Figures?



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Rounding off Numbers

Often calculators produce large numbers as a result of a calculation *although* the number of significant figures is good only to a few numbers, less than the calculator has produced

In this case the large number may be rounded off to a smaller number *keeping only significant figures*.

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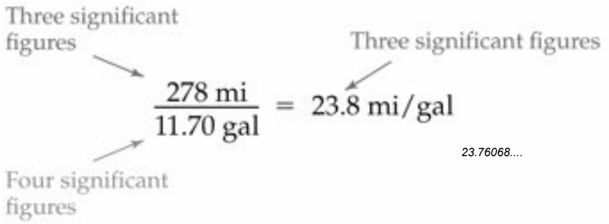
Rules for Rounding off Numbers

Rule 1 (For multiplication and divisions): The answer can't have more significant figures than either of the original numbers.



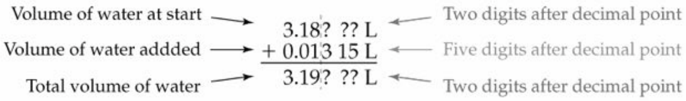
$$\frac{278 \text{ mi}}{11.70 \text{ gal}} = 23.8 \text{ mi/gal}$$

23.76068....

MAR

Rules for Rounding off Numbers

Rule 2 (For addition and subtraction): The number can't have more digits after the decimal point than either of the original numbers.



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Rules for Rounding off Numbers

Rule 3: Once you decide how many numbers to keep, you *may* need to round off your answer:

If the first digit you remove is between 0 and 4, drop it and all remaining digits.

If the first digit you remove is between 5 and 9, round the number up by adding 1 to the digit to the left of the one you drop

Example: **2.4271** becomes **2.4** when rounded to two significant figures

Example: **4.5816** becomes **4.6** when rounded to two significant figures

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Factor-Label Method of Unit Conversions

Quantities measured in the lab usually have **units (labels)** which tell us the type of measurement made.

For example:

5.2 cm - the unit (cm) tells us the type of measurement made is length.
16.237 g - the unit (g) tells us the type of measurement made is mass.

Often we must convert one kind of unit for a measurement to a different kind. For example, we may need to convert 28 inches into a certain number of feet. The **factor-label** method (also known as the *dimensional analysis* method) uses **conversion factors** and units (**labels**) to solve problems of this type.

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Factor-Label Method of Unit Conversions

Conversion factors are fractions that relate two kinds of units. One way in which they may be obtained is from equalities.

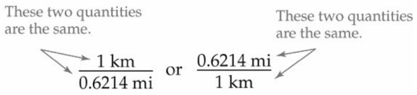
For example: 12 in = 1 ft is an equality which leads to two equivalent fractions (conversion factors) generated by dividing one side of the equality by the other side.

$$\frac{12 \text{ in}}{1 \text{ ft}} \qquad \frac{1 \text{ ft}}{12 \text{ in}}$$

Another common conversion factor: there are 4 quarters in a dollar ($):

$$\frac{4 \text{ quarters}}{1 \text{ \$}} \qquad \frac{1 \text{ \$}}{4 \text{ quarters}}$$

And:



$$\frac{1 \text{ km}}{0.6214 \text{ mi}} \text{ or } \frac{0.6214 \text{ mi}}{1 \text{ km}}$$

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Factor-Label Method of Unit Conversions

And yet another common example:

60 min = 1 hr is an equality which leads to two equivalent conversion factors.

$$\frac{60 \text{ min}}{1 \text{ hr}} \qquad \frac{1 \text{ hr}}{60 \text{ min}}$$

Other forms : $\frac{60 \text{ min}}{\text{per hr}}$ = 60 min/hr = $\frac{60 \text{ min}}{1 \text{ hr}}$

When you are new to the factor-label method, it is most helpful to use the form that has a numerator and denominator term (and not 60 min/hr)

Some conversion factors are considered *exact* and have *unlimited sig figs,* but most conversion factors obey sig fig rules.

MAR

When solving a problem, set up an equation so that all unwanted units cancel, leaving only the desired unit. *For example*, we want to find out how many kilometers are there in 26.22 miles. We will get the correct answer if we multiply 26.22 mi by the conversion factor km/mi.

$$\underset{\text{Starting quantity}}{26.22\ \cancel{\text{mi}}} \times \underset{\text{Conversion factor}}{\frac{1\ \text{km}}{0.6214\ \cancel{\text{mi}}}} = \underset{\text{Equivalent quantity}}{42.20\ \text{km}}$$

42.195043....

MAR

Some Exact Conversions

Length
1 km = 1000 m = 10^5 cm = 10^{12} nm
12 in = 1 ft 5280 ft =1 mile
1 in = 2.54 cm

Volume
1 cm^3 = 1 mL 1000 mL = 1 L

Mass
1 g = 1000 mg 1 kg = 1000 g

These conversions have ***unlimited*** sig figs by definition.
Most other conversions inexact… and follow sig fig rules!

MAR

Test yourself: How many hours in 3.5 weeks?

MAR

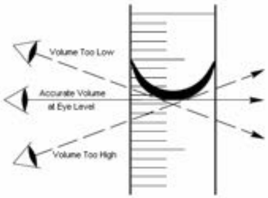
Test yourself: How many quarters will a tourist need to travel 555 km? Car: 22 miles per gallon, gas: $1.37/gallon, 1.61 km = 1 mile

MAR

How do we measure the volume of a liquid?

volumetric flasks

Beaker (left), graduated cylinder (right)



read volume from bottom of meniscus at eye level

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Density

Density relates the mass of an object with its volume.
Density is usually expressed in:

- Gram per cubic centimeter (g/cm^3) (solids)
- Gram per milliliter (g/mL) (liquids)

$$\text{Density} = \frac{\text{Mass (g)}}{\text{Volume (mL or cm}^3\text{)}}$$

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Test yourself: Mercury has a density of 13.6 g/mL. How many L of Hg are there in 42.7 kg of Hg?

MAR

Measuring Temperature

Temperature, the measure of how hot or cold an object is, is commonly reported either in Fahrenheit (^{o}F) or Celsius (^{o}C). The SI unit of temperature is, however, the Kelvin (K).

Kelvin temperatures are ***always positive*** and they do not use the degree (^{o}) symbol.

Kelvin used in calculations, Celsius in the lab.

Temperature in K = Temperature in ^{o}C + 273.15

Temperature in ^{o}C = Temperature in K - 273.15

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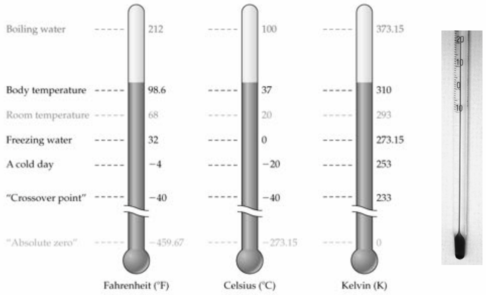

Comparison of the Fahrenheit, Celsius, and Kelvin Scales

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Converting between Fahrenheit and Celsius scales is similar to converting between different units of length or volume.

The following formulas can be used for the conversion:

^{o}F = 1.8 x ^{o}C + 32 ^{o}F

^{o}C = (^{o}F – 32 ^{o}F) / 1.8

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Test yourself: Mars often has temperatures around -70. °C. Express this in K and °F.

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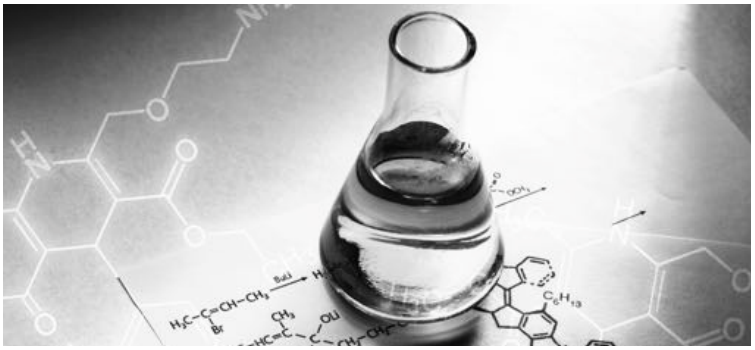
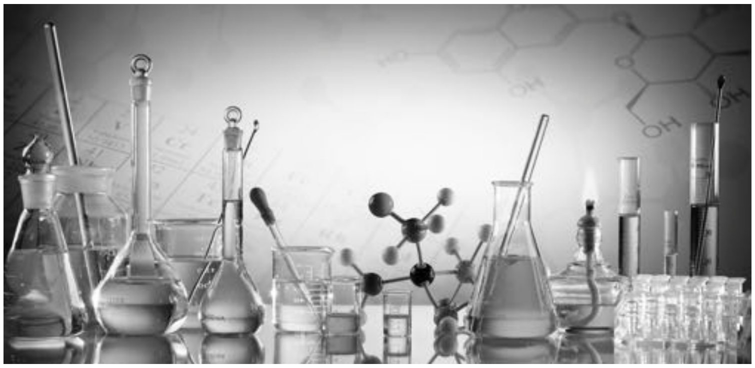
End of Chapter 1



Chemistry 151: Basic Chemistry

Chapter 2



Basic Terms of Chemistry

Matter: Anything that has mass and occupies space – things you can see, touch, taste, or smell.

Property: a characteristic that can be used to describe a substance.

Size, color, temperature are familiar properties of matter. Less familiar properties include:

Chemical composition: what matter is made of.

Chemical Reactivity: how matter behaves, *reactions*.

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Physical and Chemical Change

A Physical Change does not alter the chemical makeup of a substance. Change is reversible.

Example: Melting of solid ice; only change in form takes place and change is reversible.

A Chemical Change alters chemical composition of a substance. Change is irreversible.

Example: Rusting of iron; iron combines with oxygen and produces a new substance (rust).

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States of Matter

Matter exist in three forms: *solid*, *liquid*, and *gas*.

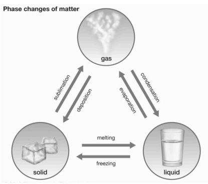
Solids have definite shape and volume.

Liquids have definite volume but changes shape to fill containers.

Gases have neither definite volume or definite shape.

Most substances, such as **water**, can exist in all three states depending on the temperature.

The conversion of a substance from one state into another is known as *change of state*.



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The **solid, liquid** and **gaseous** states of water are shown below:

(a) Ice: A solid has a definite volume and a definite shape independent of its container.

(b) Water: A liquid has a definite volume but a variable shape that depends on its container.

(c) Steam: A gas has both variable volume and shape that depend on its container.

MAR

More on the Kinetic Molecular Theory (KMT) of Matter in CH 221!

Classification of Matter

Pure Substance: Uniform in its chemical composition and properties. Sugar (a compound) and water (compound) are pure substances.

Elements and **Compounds** can be pure.

Mixture: Composition and properties may vary. Different amounts of sugar dissolved in water will determine sweetness of water.

Mixtures can be **heterogeneous** (single phase) or **homogeneous** (single phase)

Sugar water is a homogeneous mixture, sand is a heterogeneous mixture

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Elements and Compounds

Elements cannot be broken down chemically into simpler substances, "building blocks" of nature.

Hydrogen, oxygen, and nitrogen are example of elements.

Chemical Compounds can be broken down into elements or other compounds.

Water is a chemical compound since it can be broken down into hydrogen and oxygen.

MAR

Mixtures and compounds contain more than one substance. What's the difference?

Mixture:

$$\underset{\text{(variable proportions)}}{\text{Sugar water}} \xrightarrow[\text{change}]{\text{physical}} \underset{\text{compound}}{\text{Sugar}} + \underset{\text{compound}}{\text{Water}}$$

Mixtures broken down to compounds or elements by physical changes

Compound:

$$\underset{\text{(fixed proportions)}}{\text{Water}} \xrightarrow[\text{change}]{\text{chemical}} \underset{\text{element}}{\text{hydrogen}} + \underset{\text{element}}{\text{oxygen}}$$

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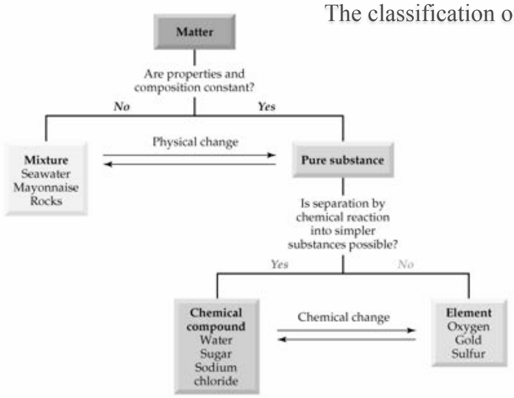
Compounds broken down to elements by chemical changes

The classification of matter scheme:



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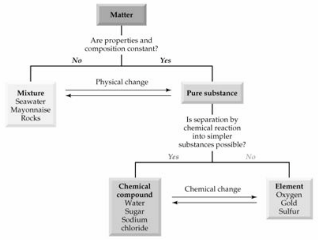
Test yourself:



pizza
Coke
water
silicon
iron
rust

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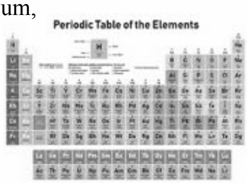
Chemical Elements and Symbols

Approximately 118 Elements are known - they are listed on the periodic table.

Only 90 of these elements occur naturally, remaining elements synthesized in lab.

Some familiar elements are iron, tin, carbon, oxygen, hydrogen, sulfur, etc.

Some possibly unfamiliar elements are niobium, rhodium, thulium, californium, etc.



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Chemical Symbols

Each element has its own unique *symbol*.

One or *two* letter symbols are used to represent elements.

First letter is always *capitalized* and the second letter is always a *lower case*.

Some symbols came from elements' modern names such as 'H' for hydrogen, 'O' for oxygen, 'N' for nitrogen, etc.

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Chemical Symbols

A few symbols for elements from their *Latin* names. *Example:* ‘Na’ for sodium from Latin *Natrium*.

Naturally occurring elements are not equally abundant. Oxygen and silicon together: 75% of earth’s crust.

Chemical Formula: A notation for a chemical compound using element symbols and subscripts to show how many atoms of each element are present.

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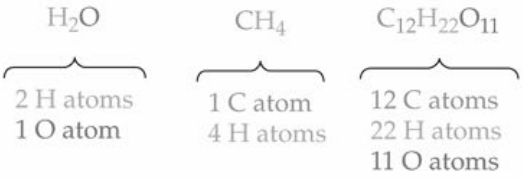
The formula for water is H_2O.

H_2O indicates that two hydrogens and one oxygen combined together to produce water.

Every formula described similarly



H_2O: 2 H atoms, 1 O atom

CH_4: 1 C atom, 4 H atoms

$C_{12}H_{22}O_{11}$: 12 C atoms, 22 H atoms, 11 O atoms

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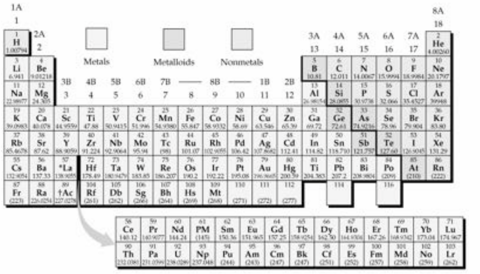
Elements and the Periodic Table



Metals, nonmetals and metalloids appear in distinct places on the periodic table

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Metals (left side)

- Solids at room temperature (except Hg)
- Good conductor of heat & electricity
- Malleable, give up electrons

Nonmetals (right side)

- Eleven gases, five solids, one liquid (Br)
- Like to absorb electrons generally

Metalloids (between)

- Properties between metals and nonmetals
- Used in semi-conductors

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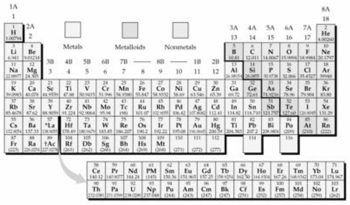
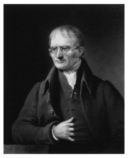
Test yourself:



Metal, Metalloid or Nonmetal:

Li
Au
Si
Se
Cl
Ne

MAR



John Dalton

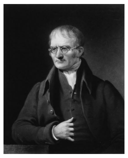
John Dalton's Atomic Theory

Chemistry founded on four fundamental assumptions about **atoms** and **matter** which make up the modern **Atomic Theory**:

1. All matter is composed of atoms.
2. The atoms of an element differ from the atoms of all other elements.
3. Chemical compounds consist of atoms combined in specific ratios.
4. Chemical reactions change only the way the atoms are combined in compounds; the atoms themselves are unchanged.

MAR

John Dalton's Atomic Theory


John Dalton

Atoms are the smallest pieces of elements.

You can divide an element down to the atom... but if you divide an atom, it will no longer be the same element.

Molecules are the smallest pieces of compounds.

You can divide compounds down to the molecule... but if you divide a molecule, it will break into individual atoms (or smaller molecules.)

MAR

Atomic Theory

Atoms are composed of tiny **subatomic particles** called **protons, neutrons,** and **electrons.**

Since the masses of atoms are so small, their masses are expressed on a *relative mass scale*. That is, one atom is assigned a mass, and all others are measured relative to it.

Relative atomic mass scale based on carbon atoms with 6 protons and 6 neutrons. This carbon atom is assigned a mass of *exactly* 12 atomic mass units (**amu**). **1 amu = 1.66 * 10^{-24} g**

Mass of proton = 1.007 amu

Mass of oxygen = 16.00 amu

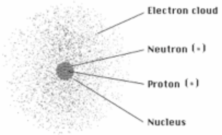
MAR

Atomic Theory

Subatomic particles not distributed randomly throughout atoms.

Protons and **neutrons** packed closely together in a dense core called the **nucleus**.

Electrons move about rapidly around core through a large, mostly empty volume of space in atom.



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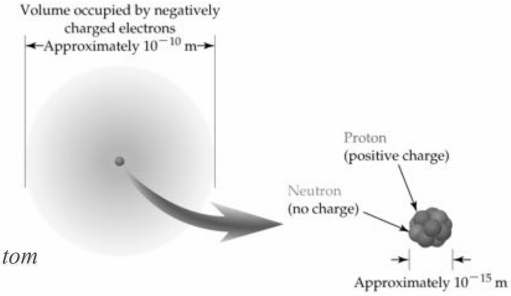
Diameter of a <u>nucleus</u> is only about 10^{-15} m.

Diameter of an <u>atom</u> is only about 10^{-10} m.



The Structure of an Atom

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The modern view of the atom was developed by Ernest Rutherford in 1910.


Rutherford Experiment: Nuclear Atom

Low density atom with a highly dense, positively charged nucleus

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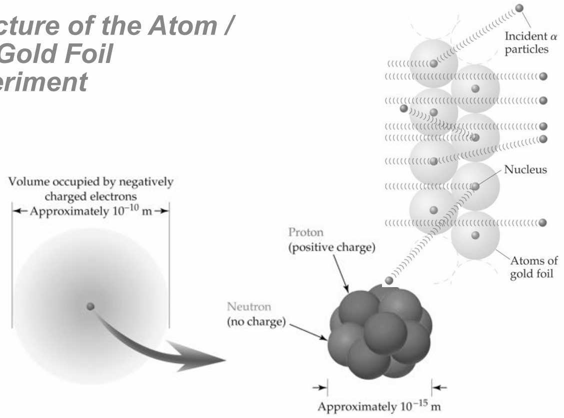
Structure of the Atom / The Gold Foil Experiment



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Attraction / Repulsion

Structure of atoms determined by an interplay of different **attractive** and **repulsive forces**.

Unlike charges attract - the *negatively charged electrons* held close to nucleus by attraction to *positively charged protons*

Protons and electrons attract one another

MAR

Attraction / Repulsion

Like charges repel each other - *negatively charged electrons* try to get as far apart as possible

Positively charged protons in nucleus also repel, but they are held together by a unique attraction called *nuclear strong force (Chemistry 222)*

Electrons repel one another

Protons repel one another

MAR

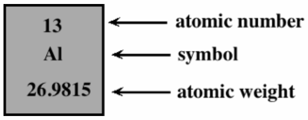
Element and Atomic Number

Atomic Number (Z): Number of protons in an atom

Elements defined by number of protons in the nucleus.

Atoms are neutral overall with no net charge; hence, number of positive protons equals number of negative electrons in the atom.

Mass Number (A): The total number of protons *and* neutrons in an atom.



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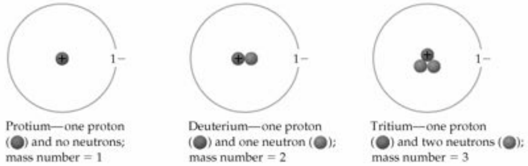
Isotopes and Atomic Weight

Isotopes are atoms with identical atomic numbers (Z) but different mass numbers (A)

Protium, deuterium, and tritium are isotopes of hydrogen.

- Protium: one proton (Z=1) and no neutrons (A=1)
- Deuterium: one proton (Z=1) and one neutron (A=2)
- Tritium: one proton (Z=1) and two neutrons (A=3)



Protium—one proton (●) and no neutrons; mass number = 1

Deuterium—one proton (●) and one neutron (●); mass number = 2

Tritium—one proton (●) and two neutrons (●); mass number = 3

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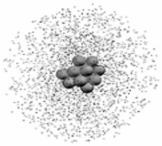
Atomic and Mass Numbers

Atomic Number, Z

Z = # protons *(defines element)*

Mass Number, A

A = # protons + # neutrons

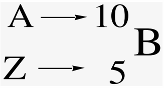


Boron-10, ^{10}B

A boron atom can have

A = 5 p + 5 n = 10 amu

Method to display A, Z and element symbol:



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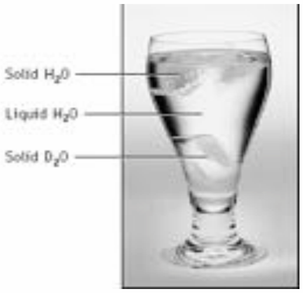
Hydrogen Isotopes

Hydrogen has *three* isotopes

$^{1}_{1}H$ **1 proton and 0 neutrons,** protium

$^{2}_{1}H$ **1 proton and 1 neutron,** deuterium

$^{3}_{1}H$ **1 proton and 2 neutrons,** tritium **radioactive**



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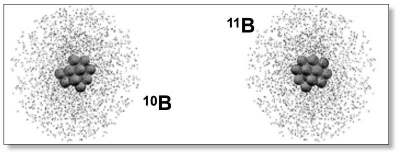
Isotopes Overview

Atoms of the same element (same Z) but different mass number (A).

Boron-10 has 5 p and 5 n: $^{10}_{5}B$

Boron-11 has 5 p and 6 n: $^{11}_{5}B$



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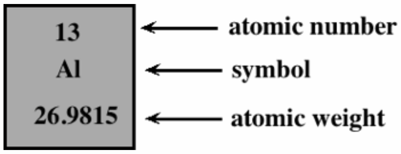
Atomic Weight: The weighted average mass of an element's atoms in a large sample that includes all naturally occurring isotopes of that atom.

Atomic number and atomic weight displayed in periodic table *(but not mass number!)*



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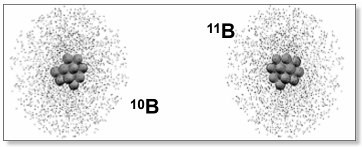
Isotopes



Because of the existence of isotopes, the mass of a collection of atoms has an average value.

Average mass = ATOMIC WEIGHT

Boron is 20% ^{10}B and 80% ^{11}B. That is, ^{11}B is 80 percent abundant on earth.

For boron atomic weight

= 0.20 (10 amu) + 0.80 (11 amu) = 10.8 amu

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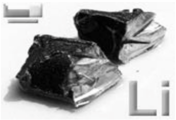
Isotopes & Atomic Weight

Because of the existence of isotopes, the mass of a *collection* of atoms has an average value.



^{6}Li = 7.5% abundant and ^{7}Li = 92.5%

Atomic weight of Li = ______________

^{28}Si = 92.23%, ^{29}Si = 4.67%, ^{30}Si = 3.10%

Atomic weight of Si = ______________

MAR

Isotopes

Example: **Nitrogen has two main isotopes, ^{14}N (14.0031 amu, 99.6299%) and ^{15}N (15.0001 amu, 0.3701%). Calculate the average atomic mass.**

Solution

Average atomic mass =

= (0.996299*14.0031) + (0.003701*15.0001)

= 13.9512745 + 0.05551537

= 14.0068 amu

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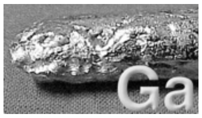
Isotopes



Example: **Gallium has two main isotopes, ^{69}Ga (68.9257 amu) and ^{71}Ga (70.9249 amu) with an average atomic mass of 69.723. Calculate the % abundance of each isotope.**

Solution

Average atomic mass =

69.723 = *x*(^{69}Ga)*68.9257 + *y*(^{71}Ga)*70.9249

but also

1 = *x*(^{69}Ga) + *y*(^{71}Ga) *(2 percentages equal 100%)*

so y(^{71}Ga) = 1 - x(^{69}Ga)

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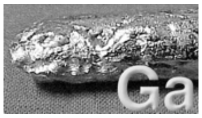
Isotopes



Example: **Gallium has two main isotopes, ^{69}Ga (68.9257 amu) and ^{71}Ga (70.9249 amu) with an average atomic mass of 69.723. Calculate the % abundance of each isotope.**

Solution

69.723 = *x*(^{69}Ga)*68.9257 + *y*(^{71}Ga)*70.9249, *or*

69.723 = x*68.9257 + (1 - x)*70.9249

69.723 = x*68.9257 + 70.9249 - 70.9249x

Solve for x, get:

***x*(^{69}Ga) = 0.6012 (60.12%)**

***y*(^{71}Ga) = 1 - x = 0.3988 (39.88%)**

MAR

Isotopes

Antimony has two main isotopes:

^{121}Sb (120.9038 amu, 57.20%) *and*

^{123}Sb (122.9042 amu, 42.80%)

Average atomic mass of Sb: **121.760**

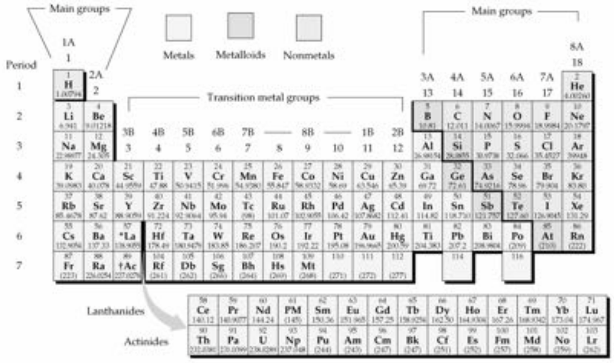
Will you have <u>one atom</u> of antimony with 121.760 amu?

No!

One atom of antimony will have a mass of 120.9038 amu 57.20% of the time

One atom of antimony will have a mass of 122.9042 amu 42.80% of the time

MAR



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The Periodic Table

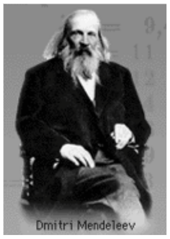
The Periodic Table

Beginning in upper left corner, elements are arranged by increasing atomic number

Seven horizontal rows called ***periods***

Eighteen vertical columns called ***groups***.

Elements in a given group have similar chemical properties (i.e. lithium, sodium, potassium, etc. in group 1A have similar properties)



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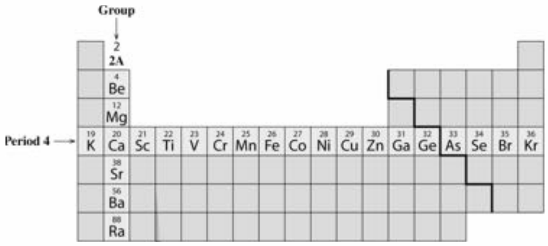
Groups and Periods



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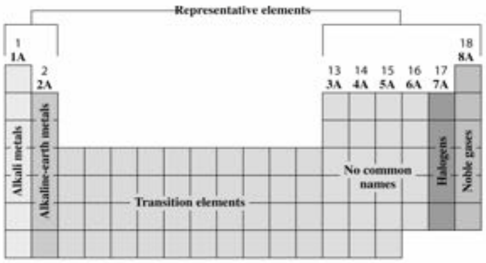
Groups on the Periodic Table

Several groups of elements are known by common names.



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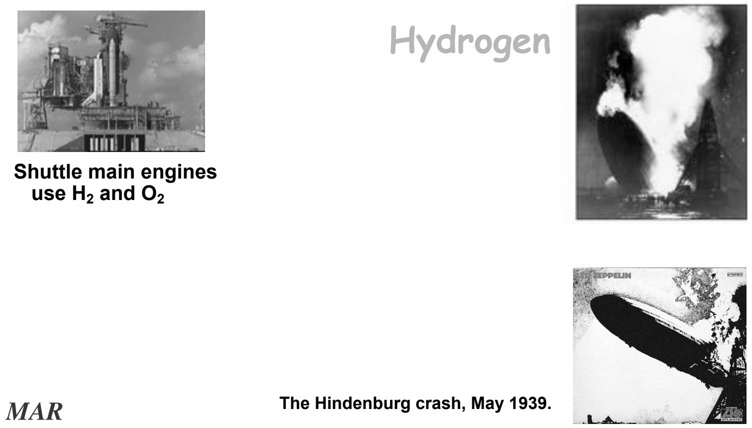
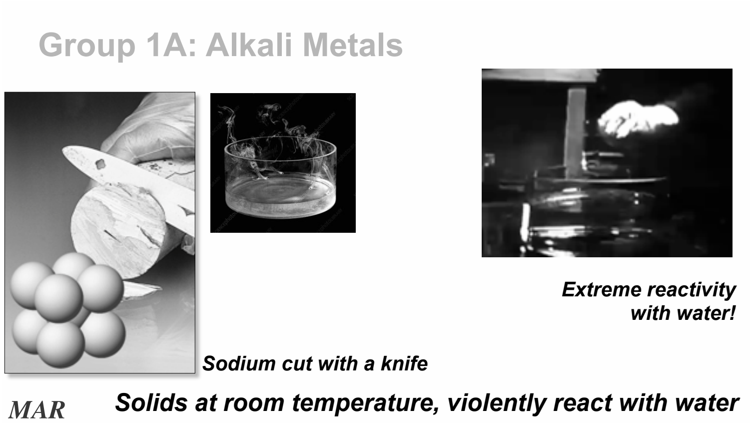


Hydrogen

Shuttle main engines use H_2 and O_2

The Hindenburg crash, May 1939.

MAR



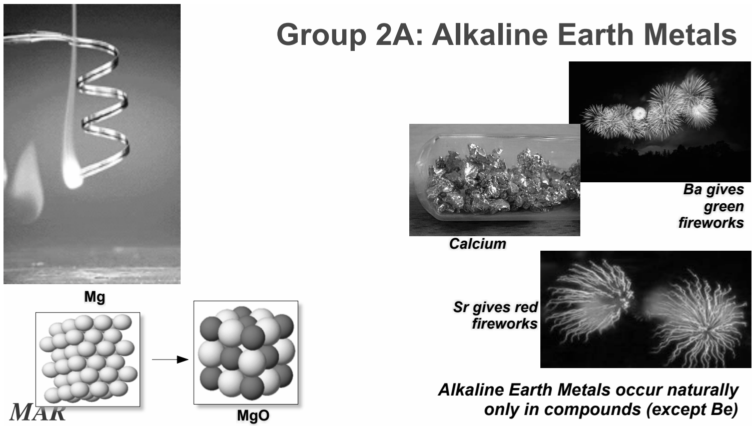
Group 1A: Alkali Metals

Sodium cut with a knife

Extreme reactivity with water!

Solids at room temperature, violently react with water

MAR



Group 2A: Alkaline Earth Metals

Mg

MgO

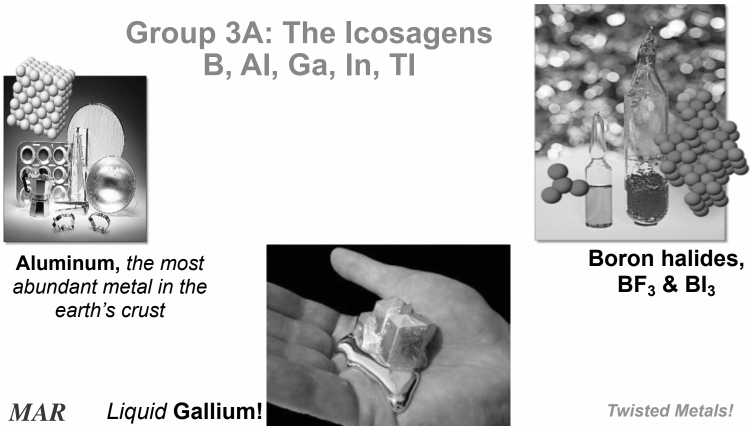
Calcium

Ba gives green fireworks

Sr gives red fireworks

Alkaline Earth Metals occur naturally only in compounds (except Be)

MAR



Group 3A: The Icosagens
B, Al, Ga, In, Tl

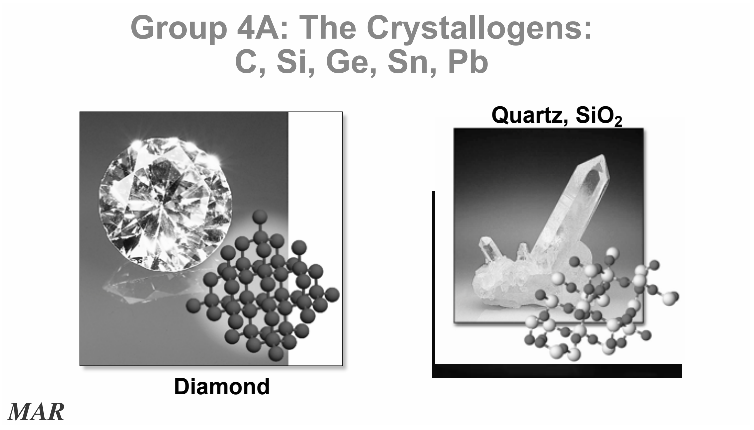
Aluminum, *the most abundant metal in the earth's crust*

Boron halides, BF_3 & BI_3

Liquid **Gallium!**

Twisted Metals!

MAR



Group 4A: The Crystallogens:
C, Si, Ge, Sn, Pb

Diamond

Quartz, SiO_2

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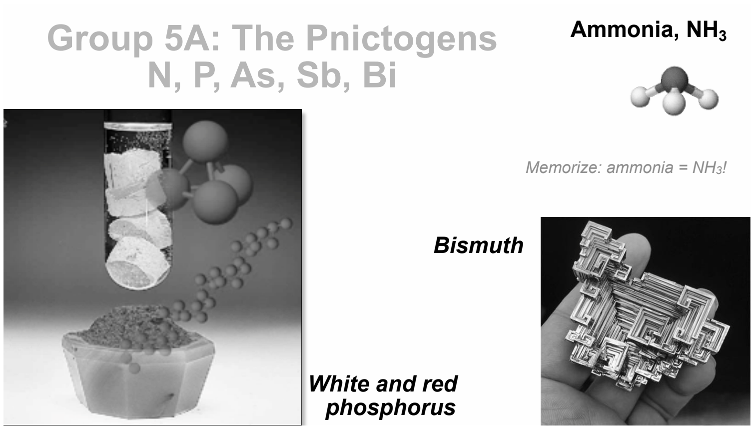


Group 5A: The Pnictogens
N, P, As, Sb, Bi

Ammonia, NH_3

Memorize: ammonia = NH_3!

Bismuth

White and red phosphorus

Phosphorus

Red and white phosphorus ignite in air to make P_4O_{10}

Phosphorus first isolated by Brandt from urine (!) in 1669

Most chemists' jobs are not so "demanding"!!!

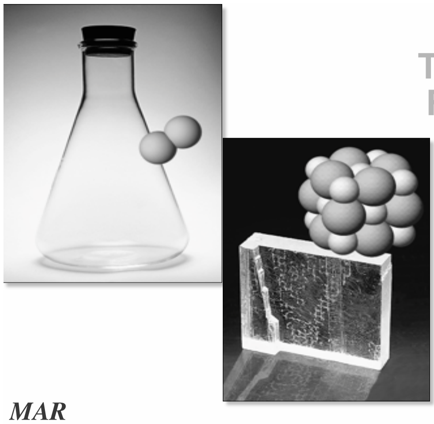
Group 6A: The Chalcogens O, S, Se, Te, Po

Sulfuric acid dripping from a cave in Mexico

Sulfur from a volcano

MAR

Group 7A: The Halogens F, Cl, Br, I, At



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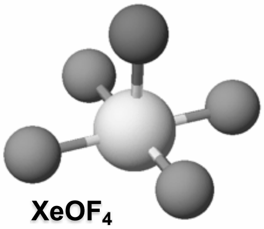
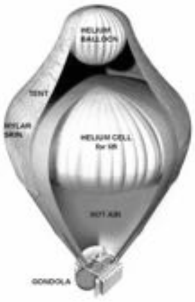
Group 8A: Noble Gases He, Ne, Ar, Kr, Xe, Rn

All gases at room temperature; considered unreactive until 1962



$XeOF_4$



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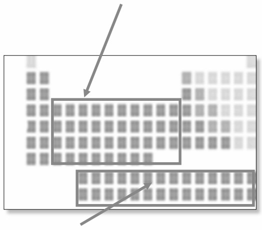
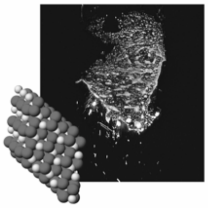
Transition Metals



Lanthanides and actinides



Iron in air gives iron(III) oxide

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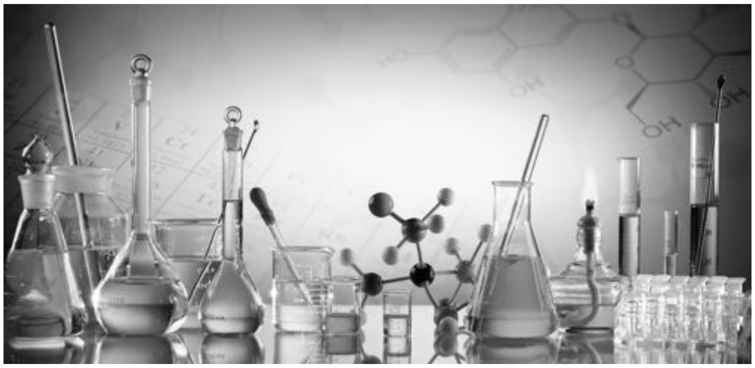
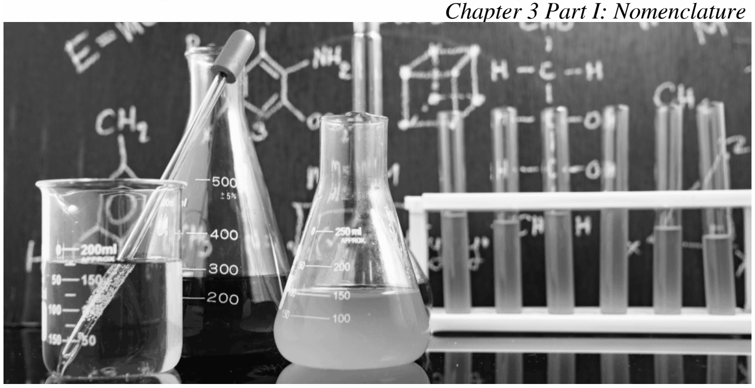
End of Chapter 2



Chemistry 151: Basic Chemistry

Chapter 3 Part I: Nomenclature



Time For a (*relevant*) Joke!

Two chemists walk into a bar.
The first chemist says, "I'll have some H Two O"
A clear liquid in a glass arrives...
They drink it down... very satisfying.

i.e. H_2O, water

The second chemist says, "I'll have some H Two O Too"
A clear liquid in a glass arrives...
They drink it down....
...and die!

i.e. H_2O_2

H_2O = water, good to drink!
H_2O_2 = hydrogen peroxide, looks like water, dangerous / deadly to drink

One extra atom affects the reactivity!
Nomenclature very important!

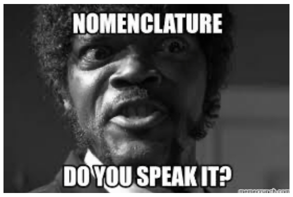
MAR

Nomenclature

Nomenclature: a set of rules used to generate names for chemical compounds - or, being able to "talk the talk" of chemistry

Important to describe H_2O (essential to life) versus H_2O_2 (deadly oxidizing agent) - one atom (more or less) makes a huge difference

This is arguably the most important chapter of CH 151!



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Compounds and Molecules

COMPOUNDS are a combination of 2 or more elements in definite ratios by mass.

The character of each element is lost when forming a compound.

MOLECULES are the smallest unit of a compound that retains the characteristics of the compound.

MAR

Chemical Bond

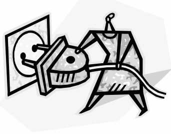
008

Bonding, the way **atoms** are attracted to each other to form **molecules**, determines nearly all of the chemical properties. We shall see later that the number "8" is very important to chemical bonding.

Bonding can be **ionic** or **covalent**.

MAR

Ions



Atoms are electrically neutral because
number of protons = number of electrons

By gaining or losing electrons an atom can be converted into a charged particle called an ***ion***.

Loss of one or more electrons gives positively charged ion called a ***cation***.

Gaining one or more electrons gives negatively charged ion called a ***anion***.

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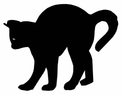
IONS AND IONIC COMPOUNDS

CATIONS have protons > electrons

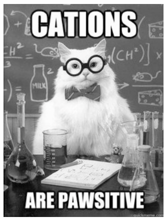


ANIONS have electrons > protons

Remember:

CATS have PAWS

CATions are PAWSitive



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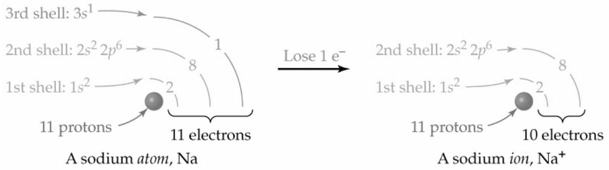
Cations

The symbol for a cation is written by adding a positive charge as a superscript to the symbol for the element.

For example, Na loses an electron to make the sodium cation (Na^+).



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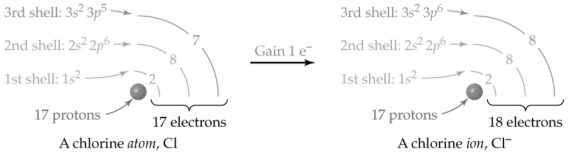
Anions

The symbol for a anion is written by adding a negative charge as a superscript to the symbol for the element.

For example, Cl gains an electron to make the chloride anion (Cl^-).



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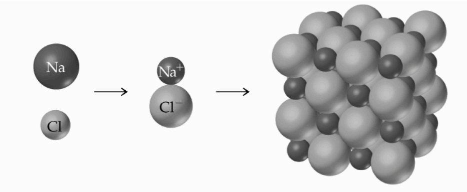
Ionic Bonds

Opposite electrical charges *attract*

When sodium combines with chlorine, sodium transfers electron to chlorine forming Na^+ and Cl^- ions.

The oppositely charged Na^+ and Cl^- ions are held together by a *ionic bond*, making an *ionic compound*.



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Formation of NaCl

Formation of
Sodium Chloride

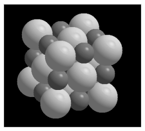
MAR

Ionic Compounds

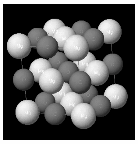
Ionic compounds *usually* form crystalline solids

Ions vary in size and charge.

Ionic compounds have high melting and boiling points.



NaCl, Na^+ and Cl^-, m.p. 804 ^oC



MgO, Mg^{2+} and O^{2-} m.p. 2800 ^oC

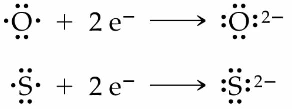
MAR

Ions of Some Common Elements

Metals of group 1A and 2A form *only* +1 and +2 ions. Ions of these elements all have a noble gas configuration through *electron loss* from their outermost shell.

Group 6A and 7A elements attain noble gas configuration by *gaining* 1 or 2 electrons.

Group 6A:



"noble gas configuration" means 8 electrons

MAR

Ions and the Octet Rule

Octet Rule: Main group elements undergo reactions that leave them with 8 valence electrons or a noble gas configuration - **isoelectronic** (same number of electrons) with noble gases.

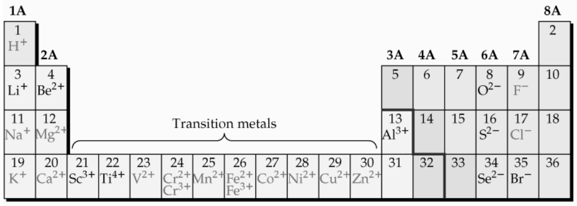
All noble gases (except helium) have 8 electrons in their valence shell.

For example, in NaCl, Na^+ and Cl^- have the following electron configurations:

$$\underset{1s^2\,2s^2\,2p^6\,3s^1}{\text{Na}} + \underset{1s^2\,2s^2\,2p^6\,3s^2\,3p^5}{\text{Cl}} \longrightarrow \underset{\underbrace{1s^2\,2s^2\,2p^6}_{\text{Neon configuration}}}{\text{Na}^+} + \underset{\underbrace{1s^2\,2s^2\,2p^6\,3s^2\,3p^6}_{\text{Argon configuration}}}{\text{Cl}^-}$$

MAR

Common ions formed by elements in the first four periods



Groups IA - IIIA: ion usually gets a positive charge equal to the group number

Groups VA - VIIA: ion usually gets a negative charge equal to the group number minus eight

Ex: Aluminum makes the Al^{3+} ion

Ex: Nitrogen makes the N^{3-} ion

MAR

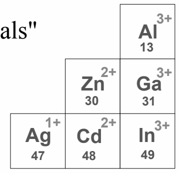
Naming Fixed Charge Cations

Main group metal cations (Groups 1A, 2A, and "the stairs") named by identifying the metal, followed by the word "ion":

K^+	Potassium ion
Mg^{2+}	Magnesium ion
Al^{3+}	Aluminum ion

These metals are called "fixed charge metals"

the stairs:



MAR

Naming Anions

Main group nonmetal anions (Groups VA, VIA, and VIIA) named by identifying the nonmetal and *changing ending to "ide"* followed by the word "ion":

Cl^-	Chloride ion
O^{2-}	Oxide ion
P^{3-}	Phosphide ion
C^{4-}	Carbide ion

MAR

Naming Variable Charge Cations

Many metals (transition, lanthanide, actinide, etc.) can often form more than one type of cation. Use Roman number to describe charge on metal:

Cr^{2+}	Cr^{3+}
Chromium(II) ion	Chromium(III) ion

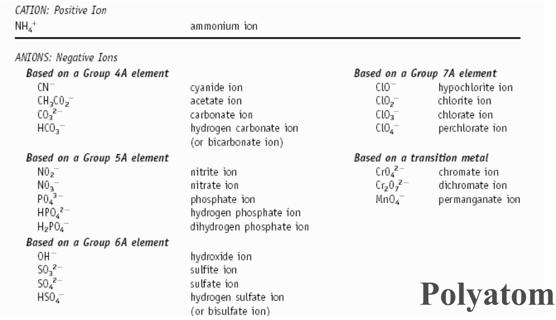
Roman numeral indicates charge on cation:

iron(III) would be Fe^{3+}

MAR

A *Polyatomic ion* is an ion composed of more than one atom. Formula for polyatomic ions shown by subscripts. *Example:* SO_4^{2-} ion has one sulfur atom, four oxygen atoms and a -2 charge

Many polyatomic ions known - *memorize*!



CATION: Positive Ion

NH_4^+	ammonium ion

ANIONS: Negative Ions

Based on a Group 4A element		***Based on a Group 7A element***	
CN^-	cyanide ion	ClO^-	hypochlorite ion
$CH_3CO_2^-$	acetate ion	ClO_2^-	chlorite ion
CO_3^{2-}	carbonate ion	ClO_3^-	chlorate ion
HCO_3^-	hydrogen carbonate ion (or bicarbonate ion)	ClO_4^-	perchlorate ion
Based on a Group 5A element		***Based on a transition metal***	
NO_2^-	nitrite ion	CrO_4^{2-}	chromate ion
NO_3^-	nitrate ion	$Cr_2O_7^{2-}$	dichromate ion
PO_4^{3-}	phosphate ion	MnO_4^-	permanganate ion
HPO_4^{2-}	hydrogen phosphate ion		
$H_2PO_4^-$	dihydrogen phosphate ion		
Based on a Group 6A element			
OH^-	hydroxide ion		
SO_3^{2-}	sulfite ion		
SO_4^{2-}	sulfate ion		
HSO_4^-	hydrogen sulfate ion (or bisulfate ion)		

Polyatomic Ions

MAR

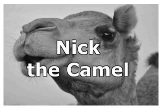
Introducing: Nick the Camel!

Nick *the* Camel Brat *ate* Icky Clam *for* Supper *in* Phoenix

MAR

Nick the Camel

Nick *the* Camel Brat *ate* Icky Clam *for* Supper *in* Phoenix



	Consonants = Oxygen	Vowels = Charge	Polyatomic Ion
Nick = Nitrate	3	-1	$NO_3^{\ -}$
Camel = Carbonate	3	-2	$CO_3^{\ 2-}$
Brat = Bromate	3	-1	$BrO_3^{\ -}$
Icky = Iodate	3	-1	$IO_3^{\ -}$
Clam = Chlorate	3	-1	$ClO_3^{\ -}$
Supper = Sulfate	4	-2	$SO_4^{\ 2-}$
Phoenix = Phosphate	4	-3	$PO_4^{\ 3-}$
Did Nick have Crepes for dessert too? :)			
Crepes = chromate	4	-2	$CrO_4^{\ 2-}$

MAR

Naming Ionic Compounds

Ionic compounds are named by citing first the cation and then the anion with a space between the words. For example:

$NaBr$ – Sodium bromide

$MgSO_4$ – Magnesium sulfate

$SnCl_2$ – Tin(II) chloride

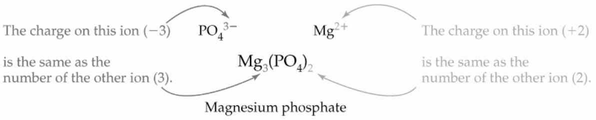
$SnCl_4$ – Tin(IV) chloride

Al_2O_3 – Aluminum oxide

MAR

Formulas of Ionic Compounds

Formula of an ionic compound shows the *lowest possible ratio* of atoms in the compound.



The charge on this ion (−3) PO_4^{3-} is the same as the number of the other ion (3).

Mg^{2+} The charge on this ion (+2) is the same as the number of the other ion (2).

$Mg_3(PO_4)_2$

Magnesium phosphate

Practice, practice, practice!!!

MAR

Formulas of Ionic Compounds

$Na^+ + Cl^- = NaCl$

$Ca^{+2} + O^{-2} = CaO$

$Al^{+3} + S^{-2} = Al_2S_3$

$Li^+ + Br^- =$ $LiBr$

$Al^{+3} + I^- =$ AlI_3

$Sr^{+2} + P^{-3} =$ Sr_3P_2

$Ca^{+2} + Cl^- = CaCl_2$

$Na^+ + O^{-2} = Na_2O$

$Ca^{+2} + N^{-3} = Ca_3N_2$

$Mg^{+2} + F^- =$ MgF_2

$NH_4^+ + PO_4^{-3} =$ $(NH_4)_3PO_4$

Not $NH_{43}PO_4$

$K^+ + Cl^- =$ KCl

Make final compound neutral

MAR

Learning Check

Write the formulas and names for compounds of the following ions:

	Br^-	S^{2-}	N^{3-}
Na^+			
Al^{3+}			
Sn^{2+}			
Sn^{4+}			

Remember: To write formulas, cross the charge. To write the name, name the cation (Roman numeral if necessary) then the anion.

MAR

Learning Check - *Answers*

Write the formulas and names for compounds of the following ions:

	Br^-	S^{2-}	N^{3-}
Na^+	NaBr sodium bromide	Na_2S sodium sulfide	Na_3N sodium nitride
Al^{3+}	$AlBr_3$ aluminum bromide	Al_2S_3 aluminum sulfide	AlN aluminum nitride
Sn^{2+}	$SnBr_2$ tin(II) bromide	SnS tin(II) sulfide	Sn_3N_2 tin(II) nitride
Sn^{4+}	$SnBr_4$ tin(IV) bromide	SnS_2 tin(IV) sulfide	Sn_3N_4 tin(IV) nitride

MAR

Learning Check

Write formulas and names for compounds of the following ions.

	OH^-	CO_3^{2-}	PO_4^{3-}
NH_4^+			
Ca^{2+}			

Remember: To write formulas, cross the charges. To name an ionic compound, name the cation (with Roman numeral if necessary), then the anion. If you need more than one polyatomic ion, use parentheses with the number of ions as a subscript.

MAR

Learning Check - Answers

Write formulas and names for compounds of the following ions.

	OH^-	CO_3^{2-}	PO_4^{3-}
NH_4^+	NH_4OH ammonium hydroxide	$(NH_4)_2CO_3$ Ammonium carbonate	$(NH_4)_3PO_4$ ammonium phosphate
Ca^{2+}	$Ca(OH)_2$ Calcium hydroxide	$CaCO_3$ Calcium carbonate	$Ca_3(PO_4)_2$ calcium phosphate

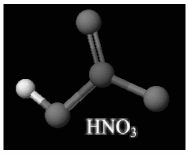
MAR

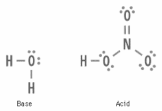
H^+ and Acids

The *Hydrogen cation* (H^+) contains only a proton (no electrons or neutrons).

Acids are substances that provide H^+ ions in water; for example, HCl, H_2SO_4, HNO_3.

HCl dissolved in water → $H^+ + Cl^-$





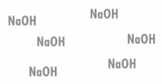
MAR

OH^- Ions and Bases

The *Hydroxide anion* (OH^-) is a polyatomic ion with a -1 charge.

Bases are substances that provide OH^- ions in water; for example, NaOH, KOH, $Ba(OH)_2$.

NaOH dissolved in water → $Na^+ + OH^-$



MAR

Test Yourself: Ionic Compounds

Give the names for the following formulas:

$NaCl$
$CaBr_2$
MnF_2
$Ga_2(SO_4)_3$
$Cr(NO_3)_3$

Give the formulas for the following names:

hydrochloric acid
iron(III) oxide
potassium hydroxide
chromium(III) iodide

MAR

Practice, practice, practice!

Covalent Bonds

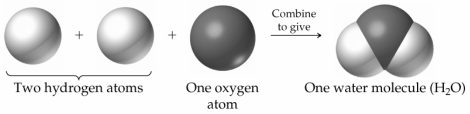
A ***covalent bond*** is a bond formed by sharing electrons between atoms.

A ***molecule*** is a group of atoms held together by covalent bonds.

Nonmetals form covalent bonds with nonmetals. They reach the Noble Gas configuration by *sharing* an appropriate number of electrons.

MAR

A water molecule results when two hydrogen atoms and one oxygen atom are covalently bonded:



MAR

Test Yourself

Are these compounds bonded through ionic or covalent bonding?

PCl_5
Na_2O
SO_3
$CaSO_3$
$SbAs$

Nomenclature of covalent compounds different from ionic compounds; important to know the difference

MAR

Naming Molecular Compounds

When two or more nonmetal elements combine they form *covalent compounds*.

The formulas of covalent compounds are written with the less electronegative (*i.e. more metal-like*) element first.

More electronegative element gets *-ide* suffix

Use Greek Prefixes to indicate number of atoms present.

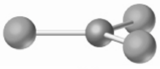
MAR

Greek Prefixes

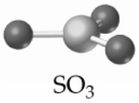
1	***mono***	**6**	***hexa***
2	***di***	**7**	***hepta***
3	***tri***	**8**	***octa***
4	***tetra***	**9**	***nona***
5	***penta***	**10**	***deca***

MAR

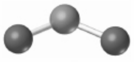
Covalent compounds and nomenclature:



BCl_3 boron trichloride



SO_3 sulfur trioxide



NO_2 nitrogen dioxide

MAR

Test Yourself - Covalent Bonding

Give the names for the following formulas:

N_2O_5
SO_2
OF_2
P_2O_3
NO

Give the formulas for the following names:

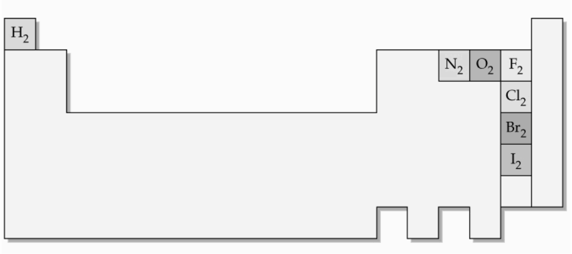
tetraphosphorus decaoxide
carbon dioxide
carbon monoxide
nitrogen dioxide

Practice, practice, practice!

MAR

Most elements exist as individual atoms.

Seven elements *always* exist as diatomic molecule - the seven diatomics



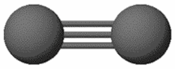
HONCl BrIF

MAR

Elements that Exist as Diatomic Molecules

Have
No
Fear
Of
Ice
Clear
Brew

"HONCl BrIF"



Nitrogen, N_2

MAR

End of Chapter 3 Part I

Chemistry 151: Basic Chemistry

Chapter 3 Part II: The Power of the Chemical Formula

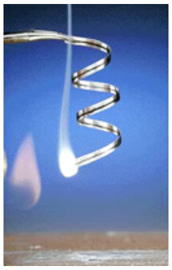
The Power of the Chemical Formula

A **chemical formula** provides a lot of information to the chemist.

We will explore the value of **molar mass**, **Avogadro's number** and **percent composition** in order to find the **empirical formula** and **molecular formula**.

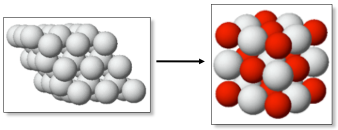
MAR

Counting Atoms



Mg burns in air (O_2) to produce white magnesium oxide, MgO.

How can we figure out how much oxide is produced from a given mass of Mg?



MAR

Counting Atoms

Chemistry is a quantitative science - we need a "counting unit."

The MOLE!

A mole is similar to a *dozen* - you can have a dozen roses, a dozen donuts - you can also have a mole of roses, or a mole of donuts

MAR

Particles in a Mole

Avogadro's Number (N_A), *named for* **Amedeo Avogadro,** *1776-1856*

$6.02214076 \times 10^{23}$

A mole is the amount of *any* substance containing 6.022×10^{23} particles

$$\frac{6.022 \times 10^{23}\ \text{Cu atoms}}{1\ \text{mole Cu}} \qquad \frac{1\ \text{mole}\ CO_2}{6.022 \times 10^{23}\ \text{molecules}\ CO_2}$$

MAR

How Big is a Mole?

If you distribute equally 6×10^{23} dollars to every human being on the planet and spend a million dollars an hour it would would take more than 10,000 years to spend your share!

Traveling at the speed of light it would take more than a 100 billion years to travel 6×10^{23} miles!

A stack of 6×10^{23} pennies would be so tall that it would take 100,000 years traveling at the speed of light to go from one end of the stack to the other!

It would take more than a 100 trillion years to print 6×10^{23} dollars at a rate of 100 dollars per second!

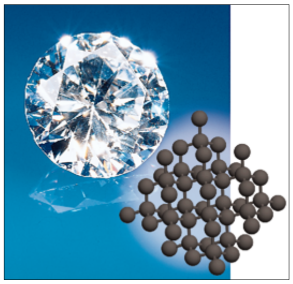
MAR

Molar Mass

1 mol of ^{12}C
= 12.00 g of C
= 6.022 x 10^{23} atoms of C

12.00 g of ^{12}C is its MOLAR MASS

Taking into account all of the isotopes of C, the molar mass of C is 12.011 g/mol



MAR

Molar Mass

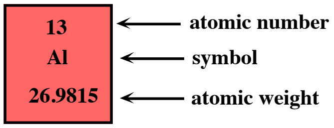
1 mol of Al = 26.9815 g of Al

1 mol of Al = 6.022 x 10^{23} atoms of Al

26.9815 g of Al is its MOLAR MASS

We will write this as: **26.9815 g Al / 1 mol Al**

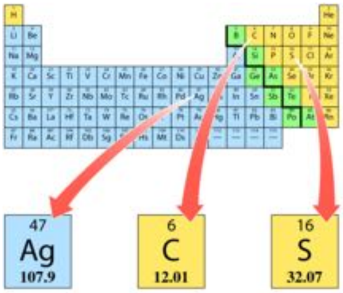
Find molar mass from periodic table



MAR

Molar Mass From the Periodic Table

Molar mass is the atomic weight expressed in grams per mol (g/mol), and these values come directly from the periodic table



1 mole Ag = 107.9 g

1 mole C = 12.01 g

1 mole S = 32.07 g

Molar mass of Ag = 107.9 g/mol

MAR

One mole Amounts

63.5 g Cu

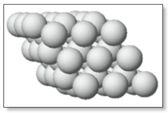
32.1 g S

24.3 g Mg

118.7 g Sn

28.1 g Si

MAR



PROBLEM: What amount of Mg is represented by 0.200 g? How many atoms?

Mg has a molar mass of 24.3050 g/mol.

$$0.200\ \text{g} \bullet \frac{1\ \text{mol}}{24.31\ \text{g}} = 8.23 \text{ x } 10^{-3}\ \text{mol}$$

How many atoms in this piece of Mg?

$$8.23 \text{ x } 10^{-3}\ \text{mol} \bullet \frac{6.022 \text{ x } 10^{23}\ \text{atoms}}{1\ \text{mol}}$$

= 4.96 x 10^{21} atoms Mg

MAR

Atomic Weight

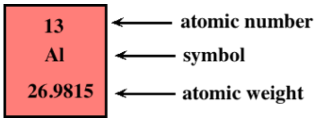
***Atomic Weight*:** The weighted average mass of an element's atoms in a large sample that includes all naturally occurring isotopes of that atom.

Atomic number and atomic weight displayed in periodic table

Atomic weight (amu) and **molar mass** (g/mol): *same number, different units!*

** Atomic weight for* ***one*** *atom*

** Molar mass for grams in a mole (**6.022x10^{23} atoms**)*



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Molecular weight: The sum of atomic weights for all atoms in a molecule

Example (use a periodic table):

- **Carbon**: **12.01 amu** *(the **atomic weight**)*
- **Oxygen**: **16.00 amu** *(the **atomic weight**)*
- **Carbon monoxide (CO)**: **28.01 amu** = 12.01 + 16.00 *(28.01 is the **molecular weight** for CO)*
- 28.01 *is also the* molar mass *of CO (in* g/mol*) - the mass in grams of* $6.022x10^{23}$ *molecules of CO)*

Molecular weight and molar mass: same number, different units (and uses)

Molecular Weight

MAR

Molar Mass

Example: Find the molar mass of H_2O.

Water has 2 H and 1 O

2*H = 2*1.008 = 2.016 *grams*

1*O = 1*15.999 = 15.999 *grams*

so: Molar mass =

15.999 + 2.016 = **18.015 *grams per mole***

This means that in 18.015 grams of water we have one mole of molecules of water

One mole of water molecules equals $6.022*10^{23}$ molecules of water

MAR

We can convert mol of water to g and g of water to mol using "18.0 g / mol" and dimensional analysis:

Molar mass used as conversion factor

$$0.25\ \cancel{\text{mol H}_2\text{O}} \times \frac{18.0\ \text{g H}_2\text{O}}{1\ \cancel{\text{mol H}_2\text{O}}} = 4.5\ \text{g H}_2\text{O}$$

Molar mass used as conversion factor

$$27\ \cancel{\text{g H}_2\text{O}} \times \frac{1\ \text{mol H}_2\text{O}}{18.0\ \cancel{\text{g H}_2\text{O}}} = 1.5\ \text{mol H}_2\text{O}$$

MAR

Molar Mass

What is the molar mass of Urea, $(NH_2)_2CO$?

Solution:

2 x N = 2 x 14.0067 = 28.0134

1 x C = 1 x 12.0111 = 12.0111

4 x H = 4 x 1.00794 = 4.03176

1 x O = 1 x 15.9994 = 15.9994

TOTAL = 60.0556 g/mol

MAR

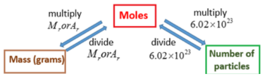
Test Yourself Part 1

What is the molar mass of potassium dichromate, $K_2Cr_2O_7$?

MAR

Test Yourself Part 2

How many moles in 35.013 g of $K_2Cr_2O_7$?



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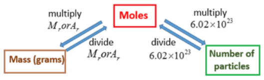
Test Yourself Part 3



How many molecules of $K_2Cr_2O_7$ in 35.013 g?

MAR

Percent Composition

Chemists wish to determine the elements present in a compound and their **percent by mass**.

- Percent by mass also known as "percent by weight"

Example: A 100g sample of a new compound contains 55 g of element X and 45 g of element Y

Percent by mass can be calculated using:

$$\frac{\textit{Mass of element}}{\textit{Mass of compound}} \textit{ X 100} = \textbf{percent by mass}$$

55% X and 45% Y

Percents of all elements in compound must equal 100%

MAR

Percent Composition from the Chemical Formula

If you know the chemical formula for a compound, you can calculate its percent composition:

1. Calculate the molar mass of each element in the compound formula unit
   a. Assume sample size is one mole
   b. Multiply the molar mass of the element by its subscript in the chemical formula
2. Divide the mass of the element by the molar mass of the compound unit and multiply by 100

MAR

Percent Composition from the Chemical Formula

Example: Find the percent composition of **water, H_2O**

- Hydrogen – 1.01 x 2 = 2.02 g H in water
  Oxygen – 16.00 x 1 = 16.00 g O in water
  Molar mass = 2.02 + 16.00 = 18.02 g/mol of H_2O
- % of H: $\frac{2.02 \text{ g H}}{18.02 \text{ g } H_2O}$ x 100% = **11.2 %H in Water**
  % of O: $\frac{16.00 \text{ g O}}{18.02 \text{ g } H_2O}$ x 100% = **88.79 %O in Water**

Water is 11.2% H and 88.79% O

Check: 11.2 + 88.8 = 99.99% :)

MAR

Percent Composition from the Chemical Formula

Determine the percent composition of Sodium Hydrogen Carbonate ($NaHCO_3$)

First find molar mass (g/mol)

Na = 1* 22.99 g = 22.99 g Na

H = 1* 1.01 g = 1.01 g H

C = 1* 12.01 g = 12.01 g C

O = 3* 16.00 g = <u>48.00 g O</u>

84.01 g/mol $NaHCO_3$

MAR

Percent Composition from the Chemical Formula

Sodium: $\frac{22.99 \text{ g Na}}{84.01 \text{ g } NaHCO_3}$ x 100% = **27.37 % Na**

Hydrogen: $\frac{1.01 \text{ g H}}{84.01 \text{ g } NaHCO_3}$ x 100% = **1.20 % H**

Carbon: $\frac{12.01 \text{ g C}}{84.01 \text{ g } NaHCO_3}$ x 100% = **14.30 % C**

Oxygen: $\frac{48.00 \text{ g O}}{84.01 \text{ g } NaHCO_3}$ x 100% = **57.14 % O**

check: 27.37% + 1.20% + 14.30% + 57.14% = 100.01%

MAR

Empirical Formula (EF) and Molecular Formula (MF)

Finding the molecular formula (MF) is a "holy grail" for chemists. If they can determine the MF, they know what the compound is, etc.

To find the MF, chemists first have to find the empirical formula (EF), then compare the EF to the molar mass.

MAR

Empirical Formula (EF) and Molecular Formula (MF)

Molecular formula: the true number of atoms of each element in the formula of a compound.

Empirical formula: the lowest whole number ratio of atoms in a compound.

molecular formula = (empirical formula)$_n$

molecular formula = C_6H_6 = $(CH)_6$

empirical formula = CH

MAR

Empirical Formula (EF) and Molecular Formula (MF)

Formulas for ionic compounds are **ALWAYS** empirical (lowest whole number ratio).

Examples:

$NaCl$ $Al_2(SO_4)_3$

$MgCl_2$ K_2CO_3

MAR

Empirical Formula (EF) and Molecular Formula (MF)

Formulas for molecular compounds *MIGHT* be empirical (lowest whole number ratio).

Molecular: H_2O $C_6H_{12}O_6$ $C_{12}H_{22}O_{11}$

$\downarrow$ $\downarrow$ $\downarrow$

Empirical: H_2O CH_2O $C_{12}H_{22}O_{11}$

MAR

Empirical Formula (EF) and Molecular Formula (MF)

Molecular Formula	Empirical Formula
N_2O	N_2O
$C_2H_4O_2$	CH_2O
$C_2H_6O_2$	CH_3O
N_2O_4	NO_2

Notice:

1. The molecular formula and the empirical formula *can* be identical
2. You scale up from the empirical formula to the molecular formula by a whole number factor

MAR

Empirical Formula via Mass Percentages

To find the Empirical Formula from mass percentages:

1. Assume 100 grams of the substance and convert % into grams.
2. Convert grams to moles by dividing the amount in grams by the molar mass of that element.
3. Select the SMALLEST mole value and divide ALL mole values by this smallest one.
4. The results of Step 3 will either be VERY close to whole numbers or will be recognizable mixed number fractions If any result from Step 3 is a decimal mixed number, you must multiply ALL values by some number to make it a whole number. Ex: 1.33 x 3, 2.25 x 4, 2.50 x 2, etc.

MAR

Let's see some examples

Empirical Formula via Mass Percentages

Example: The percent composition of a sulfur oxide is 40.05 % S and 59.95 % O. Find the empirical formula.

Step 1: Convert % to grams (assume 100 g), then find moles of each element

$$\frac{40.05 \text{ g S}}{32.07 \text{ g/mol S}} = 1.249 \text{ mol S}$$

$$\frac{59.95 \text{ g O}}{16.00 \text{ g/mol O}} = 3.747 \text{ mol O}$$

MAR

Empirical Formula via Mass Percentages

Example: The percent composition of a sulfur oxide is 40.05 % S and 59.95 % O. Find the empirical formula.

Step 2: Divide the mole values by the value of the element with the *smallest* number of moles (sulfur).

$$\frac{1.249 \text{ mol S}}{1.249} = 1 \text{ mol S}$$

$$\frac{3.747 \text{ mol O}}{1.249} = 3 \text{ mol O}$$

Empirical Formula = SO_3

MAR

Empirical Formula via Mass Percentages

In this example, the simplest whole number mole ratio of S atoms to O atoms is 1:3. The empirical formula for the oxide of sulfur is **SO_3**

Note that the calculated mole values may not always be whole numbers.

In these cases all the mole values must be multiplied by the smallest factor that will make them whole numbers

MAR

Practice Problem

Butene is hydrocarbon, a compound composed only of carbon and hydrogen. It is 85.63% carbon and 14.37% hydrogen. What is the empirical formula?

Assume 100 g total.

85.63 g C * (mol C / 12.01 g C) = 7.130 mol C

14.37 g H * (mol C / 1.008 g H) = 14.26 mol H

14.26 / 7.130 = 2.000 mol H

7.130 / 7.130 = 1.000 mol C

Empirical Formula = CH_2

MAR

Molecular Formulas

Two or more substances with distinctly different properties can have the same percent composition and the same empirical formula

Example: NO_2 and N_2O_4: same EF, different compounds

Example: C_2H_4 and C_4H_8: same EF, different compounds

Empirical formulas do not always indicate the actual moles in the compound! Chemists need a molecular formula to fully describe a compound.

MAR

Determining Molecular Formulas

A molecular formula specifies the actual number of atoms of each element in one molecule or formula unit of the substance

The **molar mass** must be determined through a separate experiment *(mass spectrometer)* and compared with the empirical formula to find the molecular formula.

Let's see an example!

MAR

Determining Molecular Formulas

Example: The molar mass of a compound is 181.50 g/mol and the empirical formula is C_2HCl. What is the molecular formula?

First, find molar mass of empirical formula (C_2HCl):

$2*C + 1*H + 1*Cl = 2*12.01 + 1*1.01 + 1*35.45$

= 60.48 g/mol for C_2HCl

Now compare molar mass of compound (181.50) to molar mass of EF (60.48) - should always get a whole number!

181.50 / 60.48 = 3.001 which is essentially 3

Multiply this ratio by the EF to get the MF:

Molecular Formula = $(C_2HCl)_3$ = $\mathbf{C_6H_3Cl_3}$

MAR

Test Yourself!

Analysis of a weak acid finds a chemical composition of 49.32 %C, 6.85 %H, and 43.84 %O. The molar mass is 146 g/mol. Determine the empirical and molecular formulas.

Steps:

- assume 100 g, so %s equal g of the element
- turn g of element into moles
- divide moles by smallest number to find EF
- turn EF into a molar mass
- compare molar mass of compound (146) to EF molar mass to find ratio, then MF

MAR

Test Yourself!

Analysis of a weak acid finds a chemical composition of 49.32 %C, 6.85 %H, and 43.84 %O. The molar mass is 146 g/mol. Determine the empirical and molecular formulas.

49.32 %C = 49.32 g of C, etc. *Turn to moles:*

49.32 g C * (mol C / 12.01 g C) = 4.107 mol C

6.85 g H * (mol H / 1.01 g H) = 6.78 mol H

43.84 g O * (mol C / 16.00 g O) = 2.740 mol O

2.740 is smallest, so find EF:

C(4.107/2.740) H(6.78/2.740) O(2.740/2.740)

C(1.499) H(2.47) O(1.000) ≈ $C_{1.5}$ $H_{2.5}$ O_1

Multiply by 2 to eliminate fraction:

$(C_{1.5}\ H_{2.5}\ O_1)_2$ = $\mathbf{C_3H_5O_2}$ = *Empirical Formula*

MAR

Test Yourself!

Analysis of a weak acid finds a chemical composition of 49.32 %C, 6.85 %H, and 43.84 %O. The molar mass is 146 g/mol. Determine the empirical and molecular formulas. (EF = $C_3H_5O_2$ via previous page)

To find MF, *find molar mass of EF ($C_3H_5O_2$) and compare to 146 g/mol:*

(3C*12.01 g/mol) + (5H*1.01 g/mol) + (2O*16.00 g/mol) = 73.07 g/mol *(molar mass of EF)*

146 / 73.07 = 2.00 *ratio should always be whole number*

$(C_3H_5O_2)_2$ = $\mathbf{C_6H_{10}O_4}$ = **molecular formula (MF)**

This is adipic acid!

MAR

Test Yourself!

A colorless liquid composed of 46.68% nitrogen and 53.32% oxygen has a molar mass of 60.01 g/mol. What is the molecular formula?

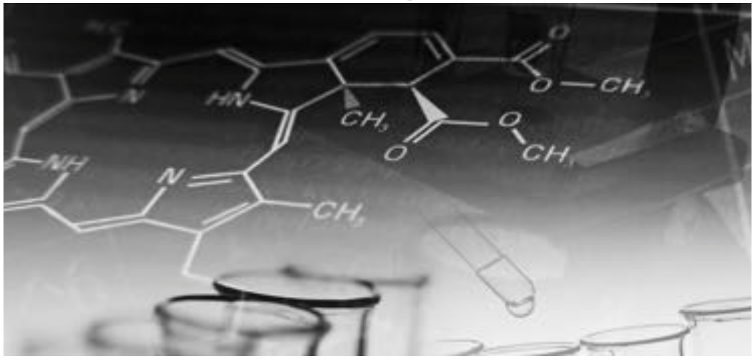
Answers: EF = NO, MF = N_2O_2

MAR

End of Chapter 3 Part II

Chemistry 151: Basic Chemistry

Chapter 4 Part I: The Chemical Reaction

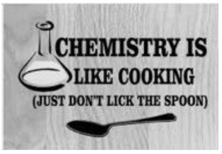


Chemical Equations

Chemical equations are like recipes in cooking: They tell a chemist how to make something ("products") and what you'll need to make it ("reactants")

Having balanced amounts critical in cooking: too much flour can make a cake dry, and too little flour can prevent the cake from forming. Same in chemistry!

We will learn how to create a balanced chemical equation in this chapter, and in the next section, we will explore the quantities needed to actually make the products.



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Chemical Equations

***Chemical equation**:* An expression in which symbols and formulas are used to represent a chemical reaction.

***Reactant**:* A substance that undergoes change in a chemical reaction; written on *left side* of the reaction arrow

***Product**:* A substance that is formed in a chemical reaction; written on *right side* of reaction arrow

$$\underbrace{2\,NaHCO_3}_{\text{Reactant}} \xrightarrow{\text{Heat}} \underbrace{Na_2CO_3 + H_2O + CO_2}_{\text{Products}}$$

MAR

Chemical Equations

Equations depict the *kind* of reactants and products and their relative amounts in a reaction.

$$\mathbf{4\ Al(s)\ +\ 3\ O_2(g)\ \text{--->}\ 2\ Al_2O_3(s)}$$

The numbers in the front are called

stoichiometric coefficients

The letters (s), (g), (l) and (aq) are the physical states of compounds:

s = solid, g = gas, l = liquid,

aq = solution in water (aqueous)

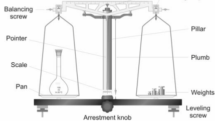
MAR

The ***Law of conservation of mass*** states that matter cannot be created or destroyed in any chemical reaction

The bonds between atoms in the reactants are rearranged to form new compounds, but none of the atoms disappear, and no new atoms are formed.

So: Chemical equations must be *balanced*, meaning the numbers and kinds of atoms must be the same on both sides of the reaction arrow.

The numbers placed in front of formulas to balance equations are called *coefficients*, and they multiply all the atoms in the chemical formula.



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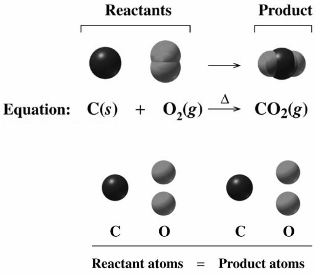
Chemical Equations are Balanced

In a **balanced chemical reaction:**

- atoms are not gained or lost.
- the number of reactant atoms is equal to the number of product atoms.



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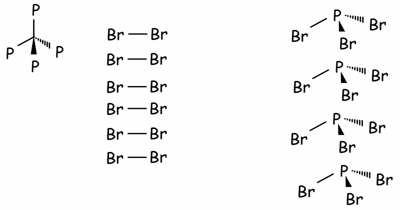
$P_4 + 6\ Br_2 \longrightarrow 4\ PBr_3$



Balance Sheet:

$4\ P + 12\ Br \longrightarrow 4\ P + 12\ Br$

MAR

Balancing Chemical Equations

The following four steps can be used as a guide to balance chemical equations.

Example: Sulfuric acid reacts with sodium hydroxide to create sodium sulfate and water. Balance this chemical reaction.

Step 1: Write an unbalanced equation, using correct formulas for all reactants and products.

$H_2SO_4 + NaOH \longrightarrow Na_2SO_4 + H_2O$ (Unbalanced)

MAR

Step 2: Add appropriate coefficients to balance the numbers of atoms of each element.

$H_2SO_4 + 2\ NaOH \longrightarrow Na_2SO_4 + H_2O$ (Balanced for Na)

Add this coefficient . . . . . . to balance these 2 Na.

$H_2SO_4 + 2\ NaOH \longrightarrow Na_2SO_4 + H_2O$ (Balanced for Na and sulfate)

One sulfate here . . . . . . and one here.

Step 3: Check the equation to make sure the numbers and kinds of atoms on both sides of the equation are same.

$H_2SO_4 + 2\ NaOH \longrightarrow Na_2SO_4 + 2\ H_2O$ (Completely balanced)

4 H and 2 O here. 4 H and 2 O here.

Step 4: Make sure the coefficients are reduced to their lowest whole-number value (ok here).

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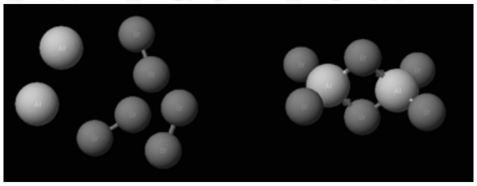
Balancing Equations

_ Al(s) + _ Br_2(liq) ---> _ Al_2Br_6(s)



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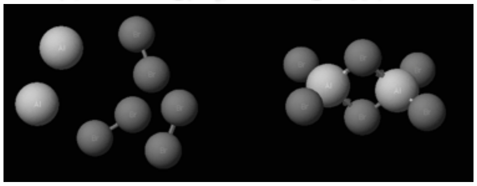
Balancing Equations

2 Al(s) + 3 Br_2(liq) ---> Al_2Br_6(s)



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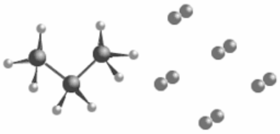
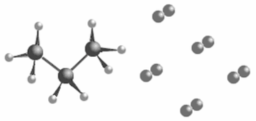


Balancing Equations

____C_3H_8(g) + _____ O_2(g) -->

_____CO_2(g) + _____ H_2O(g)

MAR



Balancing Equations

$C_3H_8(g)$ + 5 $O_2(g)$ ---->

3 $CO_2(g)$ + 4 $H_2O(g)$

MAR

Balancing Equations

Balance the following:

Calcium + nitrogen → Calcium nitride

MAR

Balancing with Polyatomic Ions

Magnesium chloride + sodium phosphate →
magnesium phosphate + sodium chloride

$MgCl_2(aq) + Na_3PO_4(aq) \rightarrow NaCl(aq) + Mg_3(PO_4)_2(s)$

Leave polyatomic ions as "units", don't break up when balancing, usually balance them first before other atoms

$MgCl_2(aq) + 2Na_3PO_4(aq) \rightarrow NaCl(aq) + Mg_3(PO_4)_2(s)$

$3MgCl_2(aq) + 2Na_3PO_4(aq) \rightarrow 6NaCl(aq) + Mg_3(PO_4)_2(s)$

$2\ PO_4^{3-} = 2\ PO_4^{3-}$

$3\ Mg^{2+} = 3\ Mg^{2+}$

$6\ Na^{+} = 6\ Na^{+}$

$6\ Cl^{-} = 6\ Cl^{-}$

Balanced!

MAR

Balancing Equations

Balance the following. To save time, balance polyatomic ions as units (not individual atoms):

$BaCl_2 + Na_3PO_4 \rightarrow Ba_3(PO_4)_2 + NaCl$

MAR

Balancing Equations - Hints

- Balance those atoms which occur in only one compound on each side
- Balance the remaining atoms
- Reduce coefficients to smallest whole integers
- Check your answer
- *Remember the seven diatomics! HONCl BrIF*

MAR

Test Yourself

Balance the following reactions:

$K_{(s)} + H_2O_{(l)} \rightarrow H_{2(g)} + KOH_{(aq)}$

$Ba_{(s)} + H_3AsO_{4(aq)} \rightarrow H_{2(g)} + Ba_3(AsO_4)_{2(aq)}$

$PCl_{5(s)} + H_2O_{(l)} \rightarrow H_3PO_{4(aq)} + HCl_{(aq)}$

$KClO_{3(s)} \rightarrow KCl_{(s)} + O_{2(g)}$

MAR *practice, practice, practice!*

Types of Reactions

Most chemical reactions can be grouped into one of these six categories:

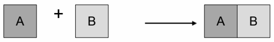
1. **Combination** $A + B \rightarrow AB$
2. **Decomposition** $AB \rightarrow A + B$
3. **Single Replacement** $AB + C \rightarrow CB + A$ *or* $MY + X \rightarrow MX + Y$

(Metals replace metals; nonmetals replace nonmetals)

4. **Combustion** $C_xH_y + O_2 \rightarrow CO_2 + H_2O$
5. **Acid-Base** $HX + MOH \rightarrow MX + H_2O$
6. **Precipitation** $AX + BY \rightarrow AY(s) + BX$

Combination (Addition)

In a **combination reaction**, two or more reactants form one product or simple compounds combine to form one product.



$2\,Mg(s) + O_2(g) \longrightarrow 2\,MgO(s)$

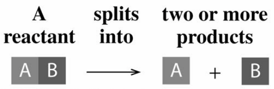
$2\,Na(s) + Cl_2(g) \longrightarrow 2\,NaCl(s)$

$SO_3(g) + H_2O(l) \longrightarrow H_2SO_4(aq)$

Combination reactions are also known as **addition reactions.**

Decomposition

In a **decomposition reaction**, one substance splits into two or more simpler substances.



$2\,HgO(s) \longrightarrow 2\,Hg(l) + O_2(g)$

$2\,KClO_3(s) \longrightarrow 2\,KCl(s) + 3\,O_2(g)$

Learning Check

Classify the following reactions as combination or decomposition.

$H_2(g) + Br_2(g) \longrightarrow 2\,HBr(l)$ *Combination*

$Al_2(CO_3)_3(s) \longrightarrow Al_2O_3(s) + 3\,CO_2(g)$ *Decomposition*

$4\,Al(s) + 3\,C(s) \longrightarrow Al_4C_3(s)$ *Combination*

Single Replacement Reactions

Single replacement reactions:

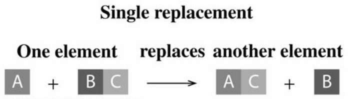
$A + BC \rightarrow AC + B$

$X + BY \rightarrow BX + Y$

Metal (A and B) replace metals;
Non-metals (X and Y) replace non-metals

Single Replacement

In a **single replacement** reaction, one element takes the place of a different element in a reacting compound.



Metals (Zn and Ag) replacing metals:

$Zn(s) + 2\,AgCl(aq) \longrightarrow ZnCl_2(aq) + 2\,Ag(s)$

Nonmetals (Br and Cl) replacing nonmetals:

$Br_2(g) + 2\,NaCl(aq) \longrightarrow 2\,NaBr(aq) + Cl_2(g)$

Learning Check

Complete and balance the following single replacement equation:

Metals replace metals:
zinc + silver nitrate →

Non-metals replace non-metals:
chlorine + sodium iodide →

MAR

Combustion Reactions

In a combustion reaction, a hydrocarbon (containing C, H and/or O) reacts with oxygen (O_2) to make carbon dioxide and water. These are very common in organic chemistry (and in your combustion gasoline car!)

$$\mathbf{C_2H_4(g) + 3\ O_2(g) \rightarrow 2\ H_2O(g) + 2\ CO_2(g)}$$

$$\mathbf{C_6H_{12}(g) + 9\ O_2(g) \rightarrow 6\ CO_2(g) + 6\ H_2O(g)}$$

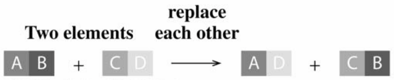
$$\mathbf{2\ C_2H_4O(g) + 5\ O_2(g) \rightarrow 4\ CO_2(g) + 4\ H_2O(g)}$$

MAR

Acid-Base Reactions

In an acid-base reaction, an acid (H listed first) reacts with a base (metal hydroxide) to create water and a "salt"

Double replacement



$$\underset{acid}{HNO_3(aq)} + \underset{base}{NaOH(aq)} \longrightarrow \underset{water}{H_2O(l)} + \underset{salt}{NaNO_3(aq)}$$

Acid-Base reactions are also a type of **double displacement** or **exchange reactions**

MAR

Acid-Base Reactions

When equal amounts (moles) of acids (H^+) and bases (OH^-) are mixed together, both acidic and basic properties disappear because of a neutralization reaction. The neutralization reaction produces water and a salt.

Example: $\underset{acid}{HCl_{(aq)}} + \underset{base}{NaOH_{(aq)}} \rightarrow \underset{water}{H_2O_{(l)}} + \underset{salt}{NaCl_{(aq)}}$

MAR

Acid-Base Reactions

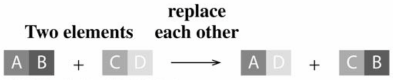
Example: $\underset{acid}{HCl_{(aq)}} + \underset{base}{NaOH_{(aq)}} \rightarrow \underset{water}{H_2O_{(l)}} + \underset{salt}{NaCl_{(aq)}}$

MAR

Precipitation Reactions

In a precipitation reaction, reactants exchange cations, and at least one of the products is a solid (a *precipitate*)

Double replacement



$$AgNO_3(aq) + NaCl(aq) \longrightarrow \underset{precipitate}{AgCl(s)} + NaNO_3(aq)$$

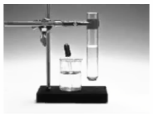
Precipitation reactions are also a type of **double displacement** or **exchange reactions**

MAR

Precipitation Reactions

Solubility: The amount of a compound that will dissolve in a given amount of solvent at a given temperature.

When solubility exceeded, precipitates form



$Pb(NO_3)_2(aq) + 2\ KI(aq) \rightarrow PbI_2(s) + 2\ KNO_3(aq)$

MAR

Test Yourself

Balance and classify the following reactions:

$C_5H_{12}(l) + O_2(g) \rightarrow$

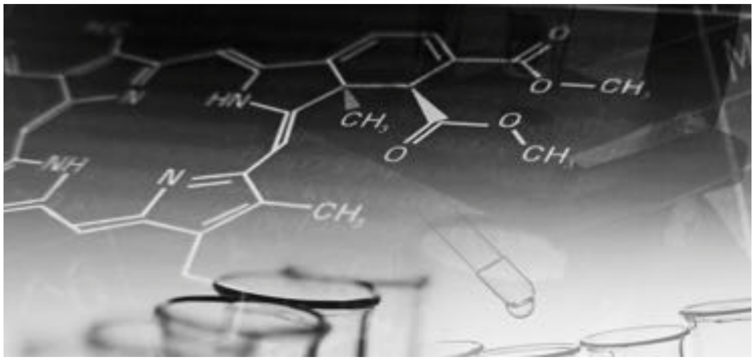
$HCl(aq) + Pb(NO_3)_2(aq) \rightarrow$ *$PbCl_2(s)$ is a product*

$HI(aq) + LiOH(aq) \rightarrow$

practice, practice, practice!

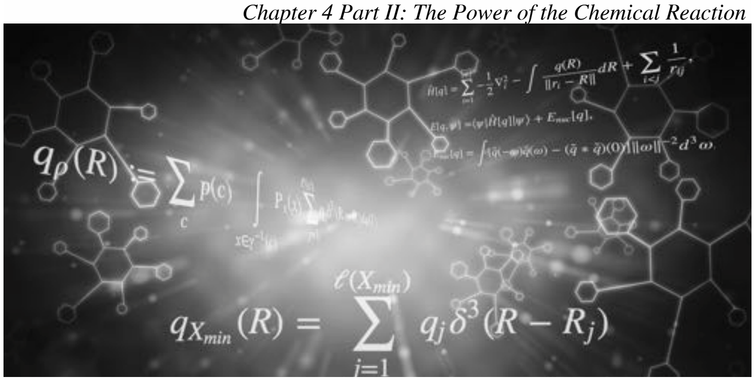
MAR

End of Chapter 4 Part I



Chemistry 151: Basic Chemistry

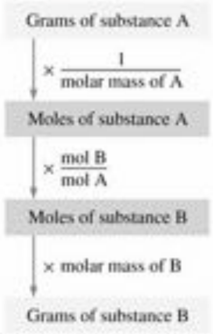
Chapter 4 Part II: The Power of the Chemical Reaction



The Power of Chemical Reactions

A balanced chemical reaction will show the relative amounts of reactants and products. In this section we will apply the balanced reaction to "real world" situations whereby quantities of products created or reactants needed can be predicted... and more!

This section exemplifies why chemists get paid: bosses want to know 'how much' plastic will be made for cell phones, they do not care about moles *(lol)*.... this is an important chapter!



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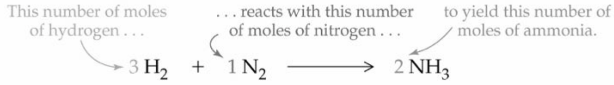
Coefficients in Chemical Equations

Coefficients in a *balanced* chemical equation tell how many molecules (and thus how many moles) of each reactant are needed *and* how many molecules (and thus moles) of each product are formed.



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Coefficients in Chemical Equations

In the equation:

$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$

this equation means

1 mole C_3H_8 + 5 moles O_2 →
3 moles CO_2 + 4 moles H_2O

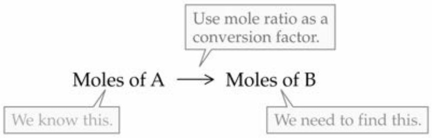
OR

1 molecule C_3H_8 + 5 molecules O_2 →
3 molecules CO_2 + 4 molecules H_2O

MAR

Converting Moles in Equations

We can use a mole ratio from a chemical equation to convert mol (*or g*) of A into mol (*or g*) of B

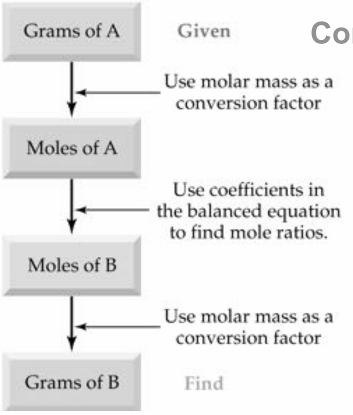


This is useful in determining how much product is created from so much reactant

Also used for determining how much reactant necessary to create so much product

MAR

Conversions



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Example

Nitrogen and oxygen gases combine to give nitrogen dioxide. How many grams of oxygen are consumed and how many grams of nitrogen dioxide can be formed by the reaction of 133 g of nitrogen in excess oxygen?

MAR

Example

Nitrogen and oxygen gases combine to give nitrogen dioxide. How many grams of oxygen are consumed and how many grams of nitrogen dioxide can be formed by the reaction of 133 g of nitrogen in excess oxygen?

Translate Word Equation

Nitrogen + **Oxygen** → **Nitrogen dioxide**

$$\downarrow \qquad \downarrow \qquad \downarrow$$

N_2 O_2 NO_2

MAR

Example

Nitrogen and oxygen gases combine to give nitrogen dioxide. How many grams of oxygen are consumed and how many grams of nitrogen dioxide can be formed by the reaction of 133 g of nitrogen in excess oxygen?

Translate Word Equation

$$N_2 + O_2 \rightarrow NO_2$$

…but note that there are 2 N and 2 O reactants with only 1 N and 2 O products; need to *balance* equation

MAR

Example

Nitrogen and oxygen gases combine to give nitrogen dioxide. How many grams of oxygen are consumed and how many grams of nitrogen dioxide can be formed by the reaction of 133 g of nitrogen in excess oxygen?

Balance the equation

$$N_2 + O_2 \rightarrow NO_2$$

Now there are 2 N and 4 O reactants with 2 N and 4 O products; equation is *balanced*

MAR

Example:

Nitrogen and oxygen gases combine to give nitrogen dioxide. How many grams of oxygen are consumed and how many grams of nitrogen dioxide can be formed by the reaction of 133 g of nitrogen in excess oxygen?

Convert mass of compound available (nitrogen) to moles.

$$133\ \cancel{\text{g N}_2} * \frac{1\text{ mol N}_2}{28.0\ \cancel{\text{g N}_2}} = 4.75\text{ mol N}_2$$

MAR

Example:

Nitrogen and oxygen gases combine to give nitrogen dioxide. How many grams of oxygen are consumed and how many grams of nitrogen dioxide can be formed by the reaction of 133 g of nitrogen in excess oxygen?

Now relate the moles of nitrogen available to moles of oxygen required.

Equation: $N_2 + 2 O_2 \rightarrow 2 NO_2$

$$4.75\ \cancel{\text{mol N}_2} * \frac{2\text{ mol O}_2\text{ required}}{1\ \cancel{\text{mol N}_2}\text{ available}} =$$

MAR

9.50 mol O_2 required

Example:

Nitrogen and oxygen gases combine to give nitrogen dioxide. How many grams of oxygen are consumed and how many grams of nitrogen dioxide can be formed by the reaction of 133 g of nitrogen in excess oxygen?

Convert moles of oxygen consumed to grams.

$$9.50\ \cancel{\text{mol O}_2}\ \text{required} * \frac{32.0\ \text{g O}_2}{1\ \cancel{\text{mol O}_2}} =$$

304 g O_2 required to combust 133 g N_2

MAR

Example:

Nitrogen and oxygen gases combine to give nitrogen dioxide. How many grams of oxygen are consumed and how many grams of nitrogen dioxide can be formed by the reaction of 133 g of nitrogen in excess oxygen?

Relate the moles of nitrogen available to moles of NO_2 produced.

Equation: $N_2 + 2\ O_2 \rightarrow 2\ NO_2$

$$4.75\ \cancel{\text{mol N}_2} * \frac{2\ \text{mol NO}_2\ \text{produced}}{1\ \cancel{\text{mol N}_2}\ \text{available}} =$$

9.50 mol NO_2 produced

MAR

Example:

Nitrogen and oxygen gases combine to give nitrogen dioxide. How many grams of oxygen are consumed and how many grams of nitrogen dioxide can be formed by the reaction of 133 g of nitrogen in excess oxygen?

Convert moles of NO_2 produced to grams.

$$9.50\ \cancel{\text{mol NO}_2} * \frac{46.0\ \text{g NO}_2}{1\ \cancel{\text{mol NO}_2}} =$$

437g NO_2 created when 133 g N_2 burned in O_2

MAR

Test Yourself

How many grams of water will be produced if $6.000*10^9$ molecules of sulfur dioxide are created? The equation:

$$2\ H_2SO_4 + Cu \rightarrow SO_2 + 2\ H_2O + CuSO_4$$

MAR

Percent Yield

Actual yield - The quantity of product (g) actually obtained in a reaction.

Theoretical yield - The quantity of product (g) that is expected from a chemical reaction.

$$\%\ \text{yield} = \frac{\text{actual yield}}{\text{theoretical yield}}\ \text{X}\ 100$$

MAR

Example - Percent Yield

Nitrogen and oxygen gases combine to give nitrogen dioxide. How many grams of oxygen are consumed and how many grams of nitrogen dioxide can be formed by the reaction of 133 g of nitrogen in excess oxygen?

The theoretical yield of NO_2 was 437 g (see previous example)

In the actual experiment, only 247 g of NO_2 was recovered; this is the actual yield

Percent yield = (actual / theoretical) * 100%

= (247 / 437) * 100%

= 56.5%

MAR

Practice, practice, practice!

Limiting Reactant

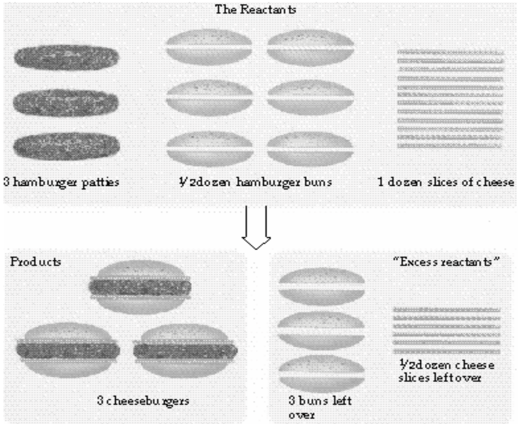
Most of the time, one reactant limits how much product can be produced.

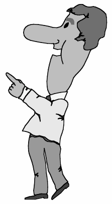
This reactant is called the **limiting reactant**, and the other reactant(s) is called the **reactant in excess** or **excess reactant**.

The limiting reactant ***limits*** the **amount of product** that can be made and hence controls the reaction.

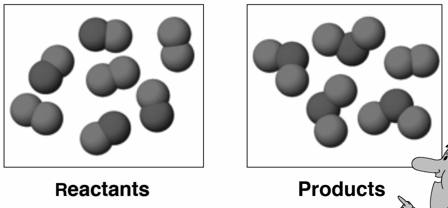
MAR

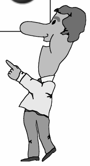
Limiting Reactant





Limiting Reactant





$2 NO(g) + O_2 (g) \longrightarrow 2 NO_2(g)$

Limiting reactant = ___________

Excess reactant = ____________

MAR

Example - Limiting Reactant

Zinc metal (7.00 g) reacts with 0.100 mol HCl to make $ZnCl_2$ and H_2 gas. Find the limiting reactant, the reactant in excess, and find the theoretical yield of $ZnCl_2$.

balanced chemical equation:

$$Zn_{(s)} + 2 HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$

MAR

Example - Limiting Reactant

Zinc metal (7.00 g) reacts with 0.100 mol HCl to make $ZnCl_2$ and H_2 gas. Find the limiting reactant, the reactant in excess, and find the theoretical yield of $ZnCl_2$.
$Zn_{(s)} + 2 HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$

First, convert Zn to mol to use mol ratio:

7.00 g Zn * (mol Zn / 65.4 g Zn) = 0.107 mol Zn

Second, convert mol Zn and mol HCl to mol $ZnCl_2$.

0.107 mol Zn * (mol $ZnCl_2$ / mol Zn) =
0.107 mol $ZnCl_2$

0.100 mol HCl * (mol $ZnCl_2$ / 2 mol HCl) =
0.0500 mol $ZnCl_2$

Notice unequal quantities of $ZnCl_2$ created!

MAR

Example - Limiting Reactant

Zinc metal (7.00 g) reacts with 0.100 mol HCl to make $ZnCl_2$ and H_2 gas. Find the limiting reactant, the reactant in excess, and find the theoretical yield of $ZnCl_2$.
$Zn_{(s)} + 2 HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$

Third, compare $ZnCl_2$ quantities:

7.00 g Zn = 0.107 mol Zn which gives 0.107 mol $ZnCl_2$

0.100 mol HCl gives 0.0500 mol $ZnCl_2$

HCl gives *less* $ZnCl_2$ than Zn! Hence, HCl is *limiting* how much product can be made, and **HCl is the limiting reactant**.

Zn could produce a lot more $ZnCl_2$ than HCl, but HCl cannot keep up. Hence, **Zn is the reactant in excess**.

MAR

Example - Limiting Reactant

Zinc metal (7.00 g) reacts with 0.100 mol HCl to make $ZnCl_2$ and H_2 gas. Find the limiting reactant, the reactant in excess, and find the theoretical yield of $ZnCl_2$.

$Zn_{(s)} + 2\ HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$

Fourth, find theoretical yield of $ZnCl_2$.

Need to use limiting reactant to calculate theoretical yield of $ZnCl_2$.

0.0500 mol $ZnCl_2$ * (136.3 g $ZnCl_2$ / mol $ZnCl_2$) =

6.82 g $ZnCl_2$, the **theoretical yield**

If we used the 0.107 mol $ZnCl_2$ from Zn:

0.107 mol $ZnCl_2$ * (136.3 g $ZnCl_2$ / mol $ZnCl_2$) =

14.6 g $ZnCl_2$, *which is not possible!*

MAR

Practice, practice, practice!

Test Yourself Part 1

Write a balanced reaction for the formation of gaseous antimony(III) chloride from gaseous antimony and chlorine gas.

MAR

Test Yourself Part 2

Determine the limiting reactant and theoretical yield of $SbCl_3$ if 129 g of Sb and 106 g of Cl_2 are mixed.

$2\ Sb_{(g)} + 3\ Cl_{2(g)} \rightarrow 2\ SbCl_{3(g)}$

MAR

Test Yourself Part 3

Only 113.5 g of $SbCl_3$ were collected. Calculate the percent yield for the reaction. (Theoretical yield = 227 g)

$2\ Sb_{(g)} + 3\ Cl_{2(g)} \rightarrow 2\ SbCl_{3(g)}$

MAR

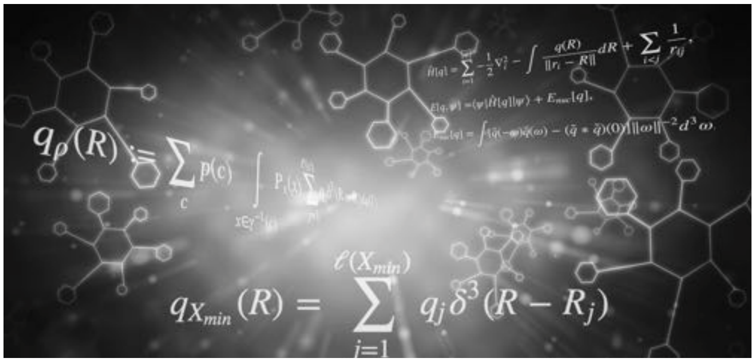
Test Yourself Part 4

How much excess reactant is left at the end of the reaction if 129 g of Sb and 106 g of Cl_2 are mixed? $2\ Sb_{(g)} + 3\ Cl_{2(g)} \rightarrow 2\ SbCl_{3(g)}$

Practice, practice, practice!

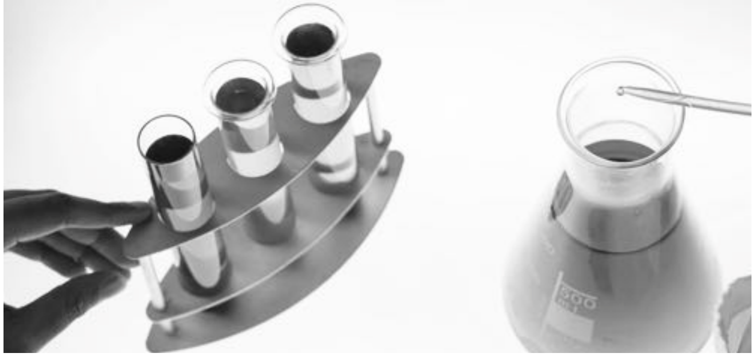
MAR

End of Chapter 4 Part II



Chemistry 151: Basic Chemistry

Chapter 6: Understanding Electrons

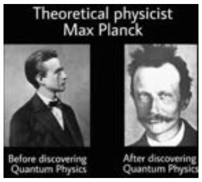


Electrons in Atoms

From previous sections, we know that protons and neutrons are in the nucleus... but what about the electrons?

Most of chemical reactions involve transferring electrons from reactant(s) to product(s), so knowledge of their location is critical.

Quantum physics delivers us answers... but they might make you think twice about the nature of our reality!



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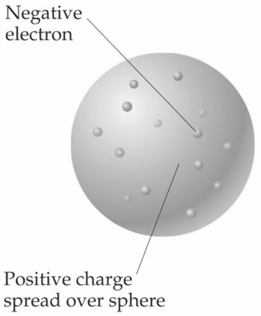
The Plum Pudding Model of the Atom

JJ Thomson (discoverer of the electron) proposed the "plum pudding" model for the atom (and electrons) in 1904.

Large volume, negative "spheres" in a positive "cloud" of low density

Rutherford's Gold Foil Experiment proposed the correct (current) model *for the nucleus*



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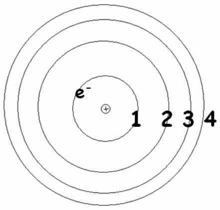
The Bohr Model of the Atom

Niels Bohr proposed electrons exist in "orbits" - *shells* - around an atom

Electrons want to have the lowest energy possible, thus will occupy orbits closest to the nucleus (the ground state) – unless energy is added to the atom.



Ground state (lowest energy electronic configuration) for the Hydrogen atom.

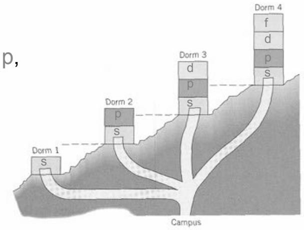
MAR

Limitations of the Bohr Model

Bohr model worked great for H, not so great for other atoms

Schrödinger and others built a better model: **quantum mechanics**, where energy levels are split into *subshells* labeled s, p, d, and f.

The maximum number of sub-levels per energy level = energy level number



Floors within a Dorm

The floors represent different subdivisions of energy within each dorm, analogous to the subshells within each shell

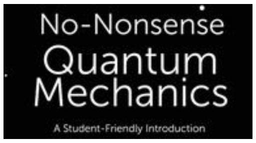
MAR

Electronic Structure of Atoms

Quantum mechanical model of atomic structure gives info on electrons

Electrons *restricted* to moving within a certain region of space in atom - not free to "move about".

Position depends on the amount of energy the electron has.



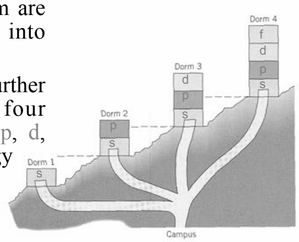
MAR

Electronic Structure of Atoms

Energies of electrons are quantized, or restricted to having only certain values.

This means that electrons in an atom are grouped around the nucleus into shells.

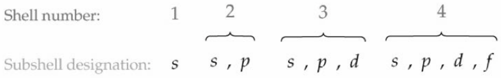
Within the shells, electrons are further grouped into **subshells** of four different types, identified as s, p, d, and f, in order of increasing energy



Floors within a Dorm

The floors represent different subdivisions of energy within each dorm, analogous to the subshells within each shell

MAR



Shell number:	1	2	3	4
Subshell designation:	*s*	*s* , *p*	*s* , *p* , *d*	*s* , *p* , *d* , *f*

From quantum mechanics we find:

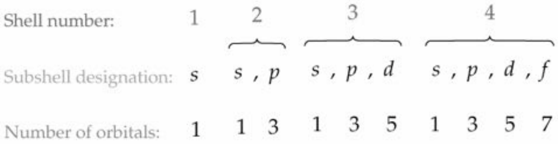
- The first shell has only a *s* subshell
- The second shell has a *s* and *p* subshell
- The third shell has a *s*, *p* and *d* subshell.
- The fourth shell has a *s*, *p*, *d*, and *f* subshell.

MAR

The number of subshells is equal to the shell number (*ex:* shell number 3 has 3 subshells)

Within each subshell, electrons are further grouped into *orbitals*, regions of space within an atom where the electrons are likely to be found. Each orbital holds *two electrons*.

There are different numbers of orbitals within the various subshells:



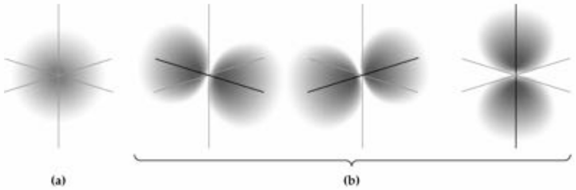
Shell number:	1	2		3			4			
Subshell designation:	*s*	*s*	*p*	*s*	*p*	*d*	*s*	*p*	*d*	*f*
Number of orbitals:	1	1	3	1	3	5	1	3	5	7

MAR

Shapes of Orbitals

Orbitals have different shapes:

- Orbitals in *s* subshells are spherical (a, below)
- Orbitals in *p* subshells are roughly dumbbell / infinity shaped (b, below)



MAR

The overall electron distribution within an atom:

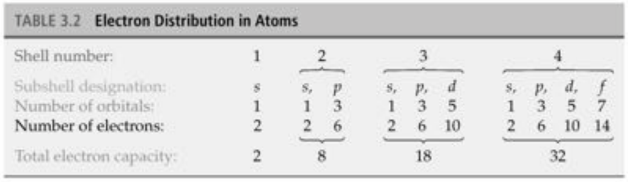


TABLE 3.2 Electron Distribution in Atoms

Shell number:	1	2		3			4			
Subshell designation:	*s*	*s*,	*p*	*s*,	*p*,	*d*	*s*,	*p*,	*d*,	*f*
Number of orbitals:	1	1	3	1	3	5	1	3	5	7
Number of electrons:	2	2	6	2	6	10	2	6	10	14
Total electron capacity:	2	8		18			32			

MAR

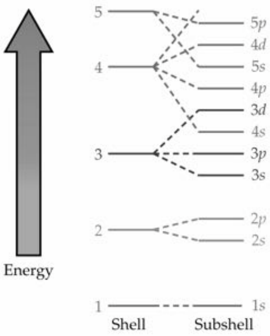
Electron Configurations

Electron Configuration: The *exact* arrangement of electrons in atom’s shells and subshells. ***Rules to predict electron configurations:***

- Electrons occupy the lowest-energy orbitals available, beginning with 1s and continuing in order shown on the next slide
- Each orbital holds only two electrons which must have *opposite spin* ("up" and "down")
- *If two or more orbitals with the same energy:* each orbital gets one electron before any orbital gets two.

MAR

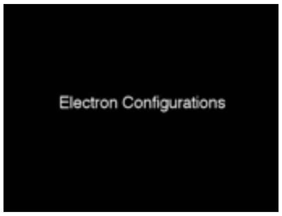
Notice *order* of electron filling… *important!*
Each orbital holds *only* two electrons



Order of Orbital Energy Levels

MAR

Electron Configurations - *Overview*



MAR

Ground State Electron Configurations

Fill electrons into the lowest energy sublevels first.

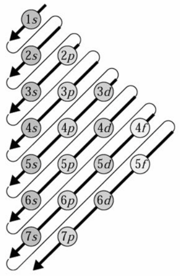
Relative energy of sublevels:
1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p < 6s

Procedure:
Start with a bare nucleus and fill electrons into the lowest energy sublevel first (1s), then moving on when each sublevel reaches its maximum number of electrons. Stop when you run out of electrons.
Each s subshell holds 2 electrons; each p subshell holds 6, d holds 10, f holds 14, etc.

This means that 1s, 2s, 3s, 4s, etc. - each of them holds only 2 electrons!
Likewise 2p, 3p, 4p, etc. holds 6 electrons, etc.

MAR

The Aufbau Diagram



Aufbau diagram shows electron filling order (start at 1s and move down by arrow)

Each *s* orbital holds 2 electrons

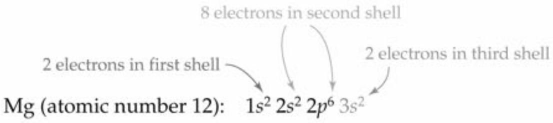
Each *p* orbital holds 6 electrons

Each *d* orbital holds 10 electrons

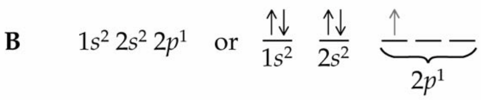
Each *f* orbital holds 14 electrons

MAR

Electronic configuration of Magnesium:
Magnesium (Z=12) has 12 protons and 12 electrons



Electronic configuration of Boron:
Boron (Z=5) has 5 protons and 5 electrons



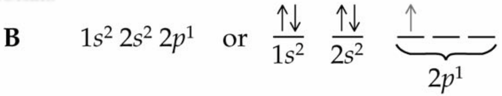
MAR

Orbital Box Notation

Boron shown with "spectroscopic" *($1s^2\ 2s^2\ 2p^1$)* and orbital box notation (on the right)

Orbital box shows if atoms are **paramagnetic** (odd electron by itself) or **diamagnetic** (every up electron has a down electron.)

When filling in electrons, use 1 electron per box in a subshell, only pair when no more empty orbitals



Boron is paramagnetic (up electron without down)

MAR

Orbital Box Notation

Boron is *paramagnetic* (one unpaired single electron in 2p subshell)

B $1s^2\,2s^2\,2p^1$ or $\underset{1s^2}{\underline{\uparrow\downarrow}}\quad \underset{2s^2}{\underline{\uparrow\downarrow}}\quad \underbrace{\underline{\uparrow}\ \underline{\ \ }\ \underline{\ \ }}_{2p^1}$

Magnesium is *diamagnetic* (every "up" electron has a "down" electron, no unpaired electrons)

Mg $\underset{1s^2}{\underline{\uparrow\downarrow}}\quad \underset{2s^2}{\underline{\uparrow\downarrow}}\quad \underbrace{\underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}}_{2p^6}\quad \underset{3s^2}{\underline{\uparrow\downarrow}}$

Paramagnetic species affected by magnetic fields, more reactive

MAR

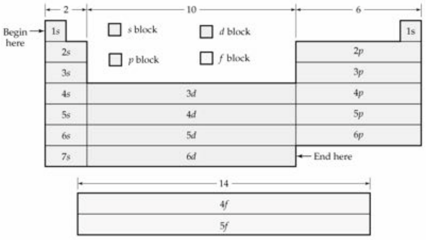
paramagnetic

C $1s^2\,2s^2\,2p^2$ or $\underset{1s^2}{\underline{\uparrow\downarrow}}\quad \underset{2s^2}{\underline{\uparrow\downarrow}}\quad \underbrace{\underline{\uparrow}\ \underline{\uparrow}\ \underline{\ \ }}_{2p^2}$

MAR

Electron Configurations and the Periodic Table

The periodic table can be divided into four regions or blocks of elements according to the shells and subshells as shown on next slide:



MAR

Test Yourself: Electron Configurations

H: $1s^1$
He: $1s^2$
Li: $1s^2 2s^1$
Be: $1s^2 2s^2$

These are "s-block" elements

B:
C:
N:
O:
F:
Ne:

MAR

For Sodium:

Group 1A

Atomic number = 11

$1s^2\,2s^2\,2p^6\,3s^1$ *or*

"neon core" + $3s^1$

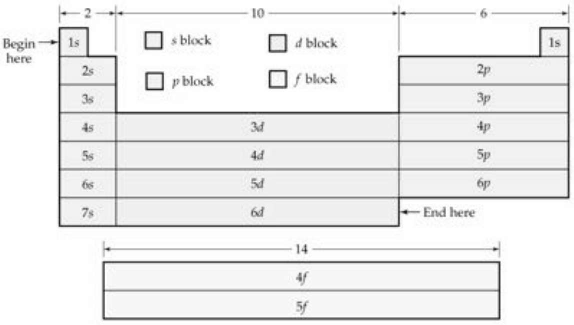
[Ne] **$3s^1$** *(uses noble gas notation)*

Sodium

All Group 1A elements have [core] ns^1 *configurations:*

- **K:** [Ar] **$4s^1$**
- **Rb:** [Kr] **$5s^1$**
- **Cs:** [Xe] **$6s^1$**

MAR



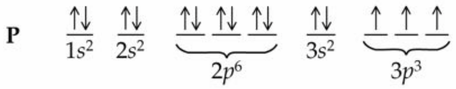
Electron configurations and the periodic table

MAR

Valence Shell and Electrons

Valence Shell: Outermost shell of an atom.

Valence electrons: Electrons in the outermost shell of an atom. These electrons are loosely held and are most important in determining an element's properties and reactivities. *Example:*



P has five valence electrons ($3s^2 3p^3$) in the 3rd valence shell

MAR

Valence Electrons

Valence electrons are those in the outermost energy level (the highest main energy level) in an atom. These are the most reactive elements in an atom!

Shortcut: the number of valence electrons = the group number

Ex: Carbon - Group IV - 4 valence electrons

Ex: Bromine - Group VII - 7 valence electrons

MAR

Test Yourself

What is the electron configuration for As?

How many valence electrons in As?

What is the electron configuration for Ca? How many valence electrons in Ca?

MAR

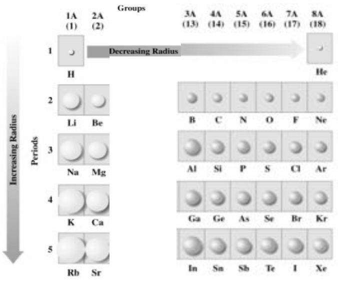
Periodic Properties: Atomic Size

Periodic Properties: properties of elements that repeat in a regular fashion as atomic number increases.

Atomic Size

Atomic size is described using the **atomic radius**; the distance from the nucleus to the valence electrons.

Size gets bigger as you go left and down the periodic table



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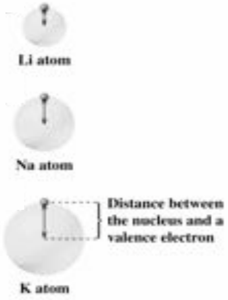
Atomic Radius Within A Group

Atomic radius *increases* going down each group of representative elements.



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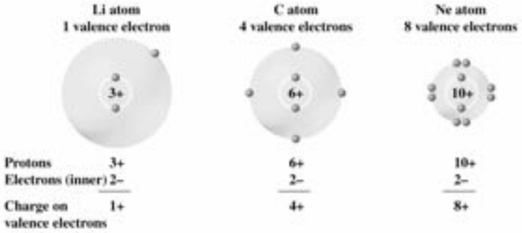
Atomic Radius Across a Period

Going across a period left to right,

- an increase in number of protons increases attraction for valence electrons.
- atomic radius *decreases*.



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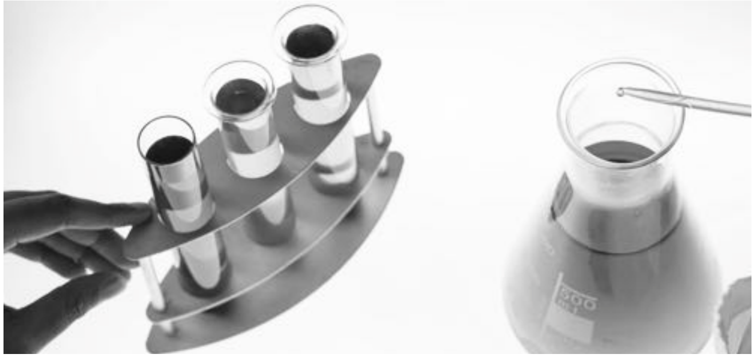
Test Yourself

Which neutral atom is larger: calcium or bromine?

Which neutral atom is larger: calcium or radium?

MAR

End of Chapter 6



CH 151 Name: ____________________

Dimensional Analysis Worksheet

Directions: You must show all work and it must be presented in a neat and orderly fashion. The numbers in your setups and answers must include proper units and significant figures. You must use proper dimensional analysis technique, which means use one continuous conversion. **Answers appear immediately following the problems.**

---

1. Convert 124.0 days into seconds.

2. Convert 9.75 x 10^7 fluid ounces of water (density = 0.99998 g/mL) into metric tons.

3. Convert 3.87 x10^{-8} km into cm.

4. Convert 67 U.S. quarts into kL.

5. Convert 6.5 pounds into cups if the density of the liquid is 2.03 g/L.

6. Convert 3.409 miles per hour into km per minute.

7. Convert 56.2 m^3 into yd^3.

8. What is the density of a mystery liquid in g per mL if 65.0 fluid ounces weighs 202 mass ounces?

9. A piece of gold leaf (density 19.3 g/cm^3) weighs 1.93 mg. What is the volume in mm^3?

10. What is a better deal, a one gallon gasoline for $2.89 or one liter of gasoline for $0.75? Support you answer using calculations.

11. A car travels at a rate of 65 miles per hour. If the car gets 33.5 miles to the gallon, how many hours can a car travel on 25.0 pounds of fuel? (density of fuel is 6.50 pounds/gallon)

12. The recommended dose of a medication is 5 mg/kg body weight. You have a patient whose weight is 125 pounds. The pharmacy offers three different oils containing 500 mg, 250 mg, and 100 mg of medication. Which pill should you give your patient?

13. The bromine content of the ocean is about 65 grams of bromine per million grams of sea water. How many cubic meters of ocean must be processed to recover 1.0 pounds of bromine if the density of sea water is 1.0×10^3 kg/m^3?

14. An average man is requires about 2.00 mg of fiboflavin (vitamin B2) per day. Cheese contains 5.5μg of riboflavin per gram of cheese. How many pounds of cheese would a man have to eat per day if this is his only source of riboflavin?

15. Alan is going to the Boy Scouts Jamboree in D.C. next summer and he has been asked to bring the smores supply for all the boys going from the district in Oregon. Each giant chocolate bar makes 16 smores. Each boy will be limited to exactly 3 smores. The problem is that he has to buy the chocolate once he gets to D.C. because there will be too many of them and they may melt in the summer heat. On average, the stores only carry 25 of these giant chocolate bars in stock. How many stores will he have to visit if there are 2,225 boys?

16. In the yearly fundraiser at school, kids can earn a hamburger phone if they raise at least $250 in donations. Aaron was able to get all of his family and family friends to pledge enough money that he will earn $35 for each mile he runs. The problem is he runs very slowly, 88 inches per second. How many hours will it take him to run just long enough to earn the hamburger phone?

Answers to the Dimensional Analysis Worksheet:

1. $1.071 * 10^7$ s
2. $2.88 * 10^3$ tons
3. $3.87 * 10^{-3}$ cm
4. $6.3 * 10^{-2}$ kL
5. $6.1 * 10^3$ cups
6. $9.142 * 10^{-2}$ km
7. 73.6 yd^3
8. 2.98 g/mL
9. 0.100 mm^3
10. $0.75/L (which equals $2.84 / gallon)
11. 2.0 hr
12. Use 250 mg pill (answer = 300 mg)
13. 7.0 m^3
14. 0.80 lb
15. 17 stores
16. 1.4 hr

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Common Polyatomic Ions and the Corresponding Acids

There is a pattern associated with many of the polyatomic ions in chemistry that can aid you when learning names and the relationships with the corresponding acids. Some combinations of a central atom with oxygen are found more often in nature, and they are designated the “common” form of the polyatomic... yet due to oxygen’s “social nature”, several other combinations of the central atom with oxygen can exist. A pattern exists which relates the number of oxygen atoms relative to the “common” form... and this pattern can be extended to a host of oxygen-containing acids.

First, remember this phrase:

“**Nick** the **Camel Brat** ate **Icky Clam** for **Supper** in **Phoenix**”

This phrase helps you remember the **central atom**, the **number of oxygen atoms in the “common” form** of the polyatomic, and the **charge** on the polyatomic ion. ***All of the common form polyatomic ions get an “ate” suffix.***

- The **number of consonants** = the **number of oxygen atoms** in the common form of the polyatomic ion
- The **number of vowels** = the **negative charge** on the polyatomic ion

Nick = **nitr**ate, NO_3^{-1}
Camel = **carb**onate, CO_3^{-2}
Brat = **brom**ate, BrO_3^{-1}
Icky = **iod**ate, IO_3^{-1} *(note that **y** is a consonant and not a vowel in this context!)*
Clam = **chlor**ate, ClO_3^{-1}
Supper = **sulf**ate, SO_4^{-2}
Phoenix = **phosph**ate, PO_4^{-3}

- Polyatomic ions in the **common** form have an “**ate**” suffix (i.e. chlor**ate**, ClO_3^{-1})
- Polyatomic ions with **one more oxygen** than the common form get a “**per**” prefix and an “**ate**” suffix (i.e. **per**chlor**ate**, ClO_4^{-1})
- Polyatomic ions with **one less oxygen** than the common form get an “**ite**” ending (i.e. chlor**ite**, ClO_2^{-1})
- Polyatomic ions with **two less oxygen atoms** than the common form get a “**hypo**” prefix and the “**ite**” suffix (i.e. **hypo**chlor**ite**, ClO^{-1})

The following table shows the various polyatomic ions and all of their known variations:

	nitrogen	*carbon*	*bromine*	*iodine*	*chlorine*	*sulfur*	*phosphorus*
-2 oxygen	-	-	**hypo**brom**ite**, BrO^{-1}	**hypo**iod**ite**, IO^{-1}	**hypo**chlor**ite**, ClO^{-1}	-	-
-1 oxygen	nitr**ite**, NO_2^{-1}	-	brom**ite**, BrO_2^{-1}	iod**ite**, IO_2^{-1}	chlor**ite**, ClO_2^{-1}	sulf**ite**, SO_3^{-2}	phosph**ite**, PO_3^{-3}
common	nitr**ate**, NO_3^{-1}	carbon**ate**, CO_3^{-2}	brom**ate**, BrO_3^{-1}	iod**ate**, IO_3^{-1}	chlor**ate**, ClO_3^{-1}	sulf**ate**, SO_4^{-2}	phosph**ate**, PO_4^{-3}
+1 oxygen	-	-	**per**brom**ate**, BrO_4^{-1}	**per**iod**ate**, IO_4^{-1}	**per**chlor**ate**, ClO_4^{-1}	-	-

Entries with a “-“ are not known to exist and can be ignored.

Polyatomic ions readily make acids. An acid is a compound with a hydrogen atom that reacts readily with other substances. In chemistry, we list the acidic hydrogen first to designate its reactivity.

As before, a naming pattern exists for acids containing an oxygenated polyatomic ion:

- Acidic polyatomic ions in the **common** form have an "**ic acid**" suffix (i.e. chlor**ic acid**, $HClO_3$)
- Acidic polyatomic ions with **one more oxygen** than the common form get a "**per**" prefix and an "**ic acid**" suffix (i.e. **per**chlor**ic acid**, $HClO_4$)
- Acidic polyatomic ions with **one less oxygen** than the common form get an "**ous acid**" ending (i.e. chlor**ous acid**, $HClO_2$)
- Acidic polyatomic ions with **two less oxygen atoms** than the common form get a "**hypo**" prefix and the "**ous acid**" suffix (i.e. **hypo**chlor**ous acid**, $HClO$)
- Acidic polyatomic ions with **no oxygen atoms** get a "**hydro**" prefix and the "**ic acid**" suffix (i.e. **hydro**chlor**ic acid**, HCl)

The following table shows the acidic form of the polyatomic ions with all of their known variations:

	nitrogen	*carbon*	*bromine*	*iodine*	*chlorine*	*sulfur*	*phosphorus*
no oxygen	-	-	**hydro**brom**ic** **acid**, HBr	**hydro**iod**ic** **acid**, HI	**hydro**chlor**ic** **acid**, HCl	**hydro**sulfur**ic** **acid**, H_2S	-
-2 oxygen	-	-	**hypo**brom**ous** **acid**, $HBrO$	**hypo**iod**ous** **acid**, HIO	**hypo**chlor**ous** **acid**, $HClO$	-	-
-1 oxygen	nitr**ous** **acid**, HNO_2	-	brom**ous** **acid**, $HBrO_2$	iod**ous** **acid**, HIO_2	chlor**ous** **acid**, $HClO_2$	sulfur**ous** **acid**, H_2SO_3	phosphor**ous** **acid**, H_3PO_3
common	nitr**ic** **acid**, HNO_3	carbon**ic** **acid**, H_2CO_3	brom**ic acid**, $HBrO_3$	iod**ic acid**, HIO_3	chlor**ic acid**, $HClO_3$	sulfur**ic acid**, H_2SO_4	phosphor**ic** **acid**, H_3PO_4
+1 oxygen	-	-	**per**brom**ic** **acid**, $HBrO_4$	**per**iod**ic** **acid**, HIO_4	**per**chlor**ic** **acid**, $HClO_4$	-	-

Finally, please note that this list is not 100% inclusive... but similar patterns can be applied to polyatomic ions not on this list. For example,

- H_2SeO_4 = selenic acid *and* H_2SeO_3 = selenous acid
- AsO_4^{-3} = arsenate ion *and* AsO_3^{-3} = arsenite ion

And if you cannot get enough polyatomic ions… here's another useful phrase:

"**Simon** and **Bonnie** **Aspired** to **Search** the **Creepy** **Count** for the **Icky** **Clam**"

Simon = SiO_3^{2-} = silicate
Bonnie = BO_3^{3-} = borate
Aspired = AsO_4^{2-} = arsenate
Search = SeO_4^{2-} = selenate
Creepy = CrO_4^{2-} = chromate
Count = CO_3^{2-} = carbonate
Icky = IO_3^{1-} = silicate
Clam = ClO_3^{1-} = chlorate

CH 151 Nomenclature
Self Quiz Name: ______________________________ Lab Section: _______

This is a sample quiz for CH 151 providing examples of nomenclature. Answers are provided at the end of this handout. *Good luck!*

Provide names or formulas for the following compounds:

nitrogen trifluoride	nitrogen monoxide	nitrogen dioxide
dinitrogen tetroxide	dinitrogen monoxide	phosphorus trichloride
phosphorus pentachloride	sulfur hexafluoride	disulfur decafluoride
xenon tetrafluoride	CCl_4	P_4O_{10}
ClF_3	BCl_3	SF_4
HBr(g)	N_2F_2	XeF_3
PI_3	SCl_2	S_2Cl_2
OF_2	NCl_3	$AsCl_5$

CH 151 Nomenclature
Self Quiz Name: ____ Lab Section: _______

This is a sample quiz for CH 151 providing examples of nomenclature. Answers are provided at the end of this handout. *Good luck!*

Provide a formula for the following combinations of cation and anion:

	Cl^-	NO_3^-	S^{2-}	CO_3^{2-}	N^{3-}	PO_4^{3-}	OH^-
Na^+							
NH_4^+							
Sn^{2+}							
Hg_2^{2+}							
Al^{3+}							
Sn^{4+}							

Provide the formula and name for the following combinations of cations and anions:

Cation	**Anion**	**Formula**	**Name**
Cu^{2+}	OH^-		
Ba^{2+}	SO_4^{2-}		
NH_4^+	$Cr_2O_7^{2-}$		
Ag^+	$C_2H_3O_2^-$		
Fe^{3+}	S^{2-}		

Provide names and/or formulas for the following:

Formula	**Name**
$HCl(aq)$	
$HBrO_2(aq)$	
$H_2SO_4(aq)$	
$HNO_2(aq)$	
$HIO(aq)$	
$HIO_4(aq)$	
$NaOH$	
$LiOH$	
NH_4OH	
$Mg(OH)_2$	

Formula	**Name**
	hydrobromic acid
	chlorous acid
	sulfurous acid
	hydrosulfuric acid
	nitric acid
	phosphoric acid
	phosphorous acid
	potassium hydroxide
	calcium hydroxide
	dihydrogen monoxide

nitrogen trifluoride **NF_3**	nitrogen monoxide **NO**	nitrogen dioxide **NO_2**
dinitrogen tetroxide **N_2O_4**	dinitrogen monoxide **N_2O**	phosphorus trichloride **PCl_3**
phosphorus pentachloride **PCl_5**	sulfur hexafluoride **SF_6**	disulfur decafluoride **S_2F_{10}**
xenon tetrafluoride **XeF_4**	CCl_4 **carbon tetrachloride**	P_4O_{10} **tetraphosphorus decaoxide**
ClF_3 **chlorine trifluoride**	BCl_3 **boron trichloride**	SF_4 **sulfur tetrafluoride**
HBr(g) **hydrogen monobromide** *(not an acid)*	N_2F_2 **dinitrogen difluoride**	XeF_3 **xenon trifluoride**
PI_3 **phosphorus triiodide**	SCl_2 **sulfur dichloride**	S_2Cl_2 **disulfur dichloride**
OF_2 **oxygen difluoride**	NCl_3 **nitrogen trichloride**	$AsCl_5$ **arsenic pentachloride**

CH 151 Nomenclature *Self Quiz* - **ANSWERS APPEAR IN BOLD**

Provide a formula for the following combinations of cation and anion:

	Cl^-	NO_3^-	S^{2-}	CO_3^{2-}	N^{3-}	PO_4^{3-}	OH^-
Na^+	**$NaCl$**	**$NaNO_3$**	**Na_2S**	**Na_2CO_3**	**Na_3N**	**Na_3PO_4**	**$NaOH$**
NH_4^+	**NH_4Cl**	**NH_4NO_3**	**$(NH_4)_2S$**	**$(NH_4)_2CO_3$**	**$(NH_4)_3N$**	**$(NH_4)_3PO_4$**	**NH_4OH**
Sn^{2+}	**$SnCl_2$**	**$Sn(NO_3)_2$**	**SnS**	**$SnCO_3$**	**Sn_3N_2**	**$Sn_3(PO_4)_2$**	**$Sn(OH)_2$**
Hg_2^{2+}	**Hg_2Cl_2**	**$Hg_2(NO_3)_2$**	**Hg_2S**	**Hg_2CO_3**	**$(Hg_2)_3N_2$**	**$(Hg_2)_3(PO_4)_2$**	**$Hg_2(OH)_2$**
Al^{3+}	**$AlCl_3$**	**$Al(NO_3)_3$**	**Al_2S_3**	**$Al_2(CO_3)_3$**	**AlN**	**$AlPO_4$**	**$Al(OH)_3$**
Sn^{4+}	**$SnCl_4$**	**$Sn(NO_3)_4$**	**SnS_2**	**$Sn(CO_3)_2$**	**Sn_3N_4**	**$Sn_3(PO_4)_4$**	**$Sn(OH)_4$**

Provide the formula and name for the following combinations of cations and anions:

Cation	**Anion**	**Formula**	**Name**
Cu^{2+}	OH^-	**$Cu(OH)_2$**	**copper(II) hydroxide**
Ba^{2+}	SO_4^{2-}	**$BaSO_4$**	**barium sulfate**
NH_4^+	$Cr_2O_7^{2-}$	**$(NH_4)_2Cr_2O_7$**	**ammonium dichromate**
Ag^+	$C_2H_3O_2^-$	**$AgC_2H_3O_2$**	**silver(I) acetate**
Fe^{3+}	S^{2-}	**Fe_2S_3**	**iron(III) sulfide**

Provide names and/or formulas for the following:

Formula	**Name**
$HCl(aq)$	**hydrochloric acid**
$HBrO_2(aq)$	**bromous acid**
$H_2SO_4(aq)$	**sulfuric acid**
$HNO_2(aq)$	**nitrous acid**
$HIO(aq)$	**hypoiodous acid**
$HIO_4(aq)$	**periodic acid**
$NaOH$	**sodium hydroxide**
$LiOH$	**lithium hydroxide**
NH_4OH	**ammonium hydroxide**
$Mg(OH)_2$	**magnesium hydroxide**

Formula	**Name**
$HBr(aq)$	hydrobromic acid
$HClO_2(aq)$	chlorous acid
$H_2SO_3(aq)$	sulfurous acid
$H_2S(aq)$	hydrosulfuric acid
$HNO_3(aq)$	nitric acid
$H_3PO_4(aq)$	phosphoric acid
$H_3PO_3(aq)$	phosphorous acid
KOH	potassium hydroxide
$Ca(OH)_2$	calcium hydroxide
H_2O	dihydrogen monoxide

CH 151 "Mass, Moles, Atoms" Study Questions

1. What is the molar mass of ammonium sulfate?
2. What is the molar mass of cobalt(II) iodide hexahydrate?
3. Calculate the number of moles in 0.41 g of titanium.
4. What is the mass of $1.0 * 10^9$ carbon atoms?
5. The density of carbon tetrachloride is 1.59 g/mL. How many Cl atoms are present in 55 mL of carbon tetrachloride?
6. The molar mass of cesium is 132.9 g/mol. What is the mass of a single Cs atom?
7. The density of lithium is 0.546 g/cm^3. What volume is occupied by 1.96×10^{23} atoms of Li?
8. What is the mass percentage of oxygen in acetic acid, HCH_3CO_2?
9. Which of the following could be an empirical formula? C_6H_{10}, B_4H_{10}, NO_3, $AsCl_5$.
10. Benzene has an empirical formula of CH. If the molar mass of benzene is 78.11 g/mol, what is the molecular formula for benzene?
11. Toluene is 91.25% C and 8.75% H. Determine the empirical formula for toluene. *Hint:* 8/7 = 1.14
12. The compound azulene is 93.71%C with the remainder hydrogen, and it has a molar mass of 128.16 g/mol. Calculate the empirical formula and molecular formula for azulene. *Hint:* 5/4 = 1.25

Answers appear on the next page

CH 151 “Mass, Moles, Atoms” Study Questions - *Answers*

1. 132.1 g/mol
2. 420.8 g/mol
3. 8.6×10^{-3} mol
4. 2.0×10^{-14} g
5. 1.4×10^{24} atoms
6. 2.207×10^{-22} g
7. 4.14 cm^3
8. 53.29%
9. NO_3 and $AsCl_5$ could be empirical formulas.
10. C_6H_6
11. C_7H_8
12. C_5H_4 (EF) and $C_{10}H_8$ (MF)

CH 151 Name: ____________________

Chemical Reactions Worksheet

Directions: Balance the following chemical reactions using the given information. In addition, ***classify*** each chemical reaction. **Answers appear immediately following the problems.**

---

1. Hypochlorous acid decomposes into water and dichlorine monoxide.

Reaction classification: _______________

---

2. Acetic acid is burned.

Reaction classification: _______________

---

3. Solid magnesium fluoride appears upon mixing magnesium chloride and sodium fluoride.

Reaction classification: _______________

---

4. Phosphorus (P_4) and oxygen produce tetraphosphorus decaoxide.

Reaction classification: _______________

---

5. Calcium and hydrochloric acid create a gas. Identify the gas through the balanced equation.

Reaction classification: _______________

---

6. Calcium hydroxide is added to perchloric acid..

Reaction classification: _______________

***Answers* to the Chemical Reactions Worksheet:**

---

1. Hypochlorous acid decomposes into water and dichlorine monoxide.

$2\ HClO(aq) \rightarrow H_2O(l) + Cl_2O(aq)$ *Classification:* **Decomposition**

2. Acetic acid is burned.

$HC_2H_3O_2(aq) + 2\ O_2(g) \rightarrow 2\ CO_2(g) + 2\ H_2O(l)$ *Classification:* **Combustion / Burning**

3. Solid magnesium fluoride appears upon mixing magnesium chloride and sodium fluoride.

$MgCl_2(aq) + 2\ NaF(aq) \rightarrow MgF_2(s) + 2\ NaCl(aq)$ *Classification:* **Precipitation**

4. Phosphorus (P_4) and oxygen produce tetraphosphorus decaoxide.

$P_4(s) + 5\ O_2(g) \rightarrow P_4O_{10}(s)$ *Classification:* **Combination**

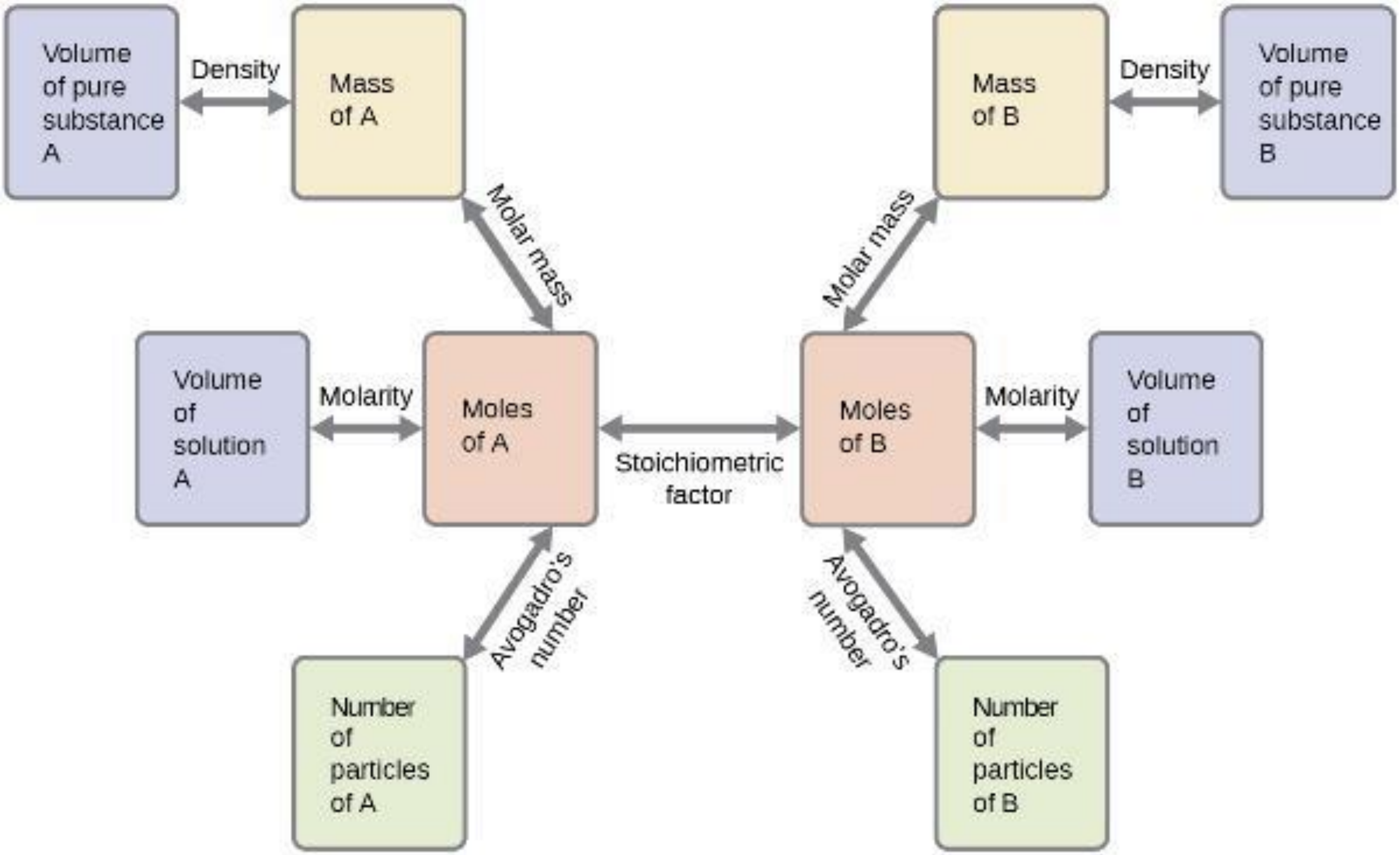
5. Calcium and hydrochloric acid create a gas. Identify the gas through the balanced equation.

$Ca(s) + 2\ HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$ *Classification:* **Single Replacement**

6. Calcium hydroxide is added to perchloric acid..

$Ca(OH)_2(aq) + 2\ HClO_4(aq) \rightarrow Ca(ClO_4)_2(aq) + 2\ H_2O(l)$ *Classification:* **Acid/Base**

CH 151 Stoichiometry Guide



The power of the balanced chemical reaction!

CH 151 Limiting Reactant Example

Hexane (C_6H_{14}) burns in air (O_2) to give CO_2 and H_2O.

- Write a balanced equation for this reaction.
- If 215 g of C_6H_{14} is mixed with 215 g of O_2, what masses of CO_2 and H_2O are produced in the reaction?
- What mass of excess reactant remains at the end of the reaction?
- If 151.3 g of CO_2 are collected, what is the percent yield of CO_2?

$2\ C_6H_{14}(\ell) + 19\ O_2(g) \rightarrow 12\ CO_2(g) + 14\ H_2O(g)$

215 g C_6H_{14} * (mol/86.18 g) * (12 mol CO_2 / 2 mol C_6H_{14}) * 44.01 g/mol = 658 g CO_2

215 g O_2 * (mol/32.00 g) * (12 mol CO_2 / 19 mol O_2) * 44.01 g/mol = 187 g CO_2 **(Theo. yield)**

Excess Reactant = C_6H_{14}*,* ***Limiting Reactant =*** O_2

$$215\ \text{g}\ O_2 * (\text{mol}/32.00\ \text{g}) \cdot \frac{12\ \text{mol}\ CO_2}{19\ \text{mol}\ O_2} \cdot \frac{44.01\ \text{g}}{1\ \text{mol}\ CO_2} = \mathbf{187\ g\ CO_2}$$

$$215\ \text{g}\ O_2 * (\text{mol}/32.00\ \text{g}) \cdot \frac{14\ \text{mol}\ H_2O}{19\ \text{mol}\ O_2} \cdot \frac{18.02\ \text{g}}{1\ \text{mol}\ H_2O} = \mathbf{89.2\ g\ H_2O}$$

$$215\ \text{g}\ O_2 * (\text{mol}/32.00\ \text{g}) \cdot \frac{2\ \text{mol}\ C_6H_{14}}{19\ \text{mol}\ O_2} \cdot \frac{86.18\ \text{g}}{1\ \text{mol}\ C_6H_{14}} = \mathbf{60.9\ g\ C_6H_{14}\ used}$$

215 g C_6H_{14} available – 60.9 g C_6H_{14} used = **154 g C_6H_{14} remains**

%yield = (151.3 / 187) * 100% = **80.9% CO_2**

Try it yourself:

Calcium oxide and ammonium chloride can be combined to give ammonia (NH_3), water and calcium chloride.

- Write a balanced equation for this reaction.
- If 112 g of calcium oxide is mixed with 224 g of ammonium chloride, what mass of NH_3 should be produced in the reaction?
- What mass of excess reactant remains at the end of the reaction?
- If only 16.3 g of NH_3 are collected, what is the percent yield of NH_3?

Answers appear on the next page.

CH 151 Limiting Reactant Example - *Answers*

Calcium oxide and ammonium chloride can be combined to give ammonia (NH_3), water and calcium chloride.

- Write a balanced equation for this reaction.

  $CaO(s) + 2\ NH_4Cl(aq) \rightarrow 2\ NH_3(g) + H_2O(g) + CaCl_2(s)$

- If 112 g of calcium oxide is mixed with 224 g of ammonium chloride, what mass of NH_3 should be produced in the reaction?

  Theoretical yield of NH_3 = 68.0 g

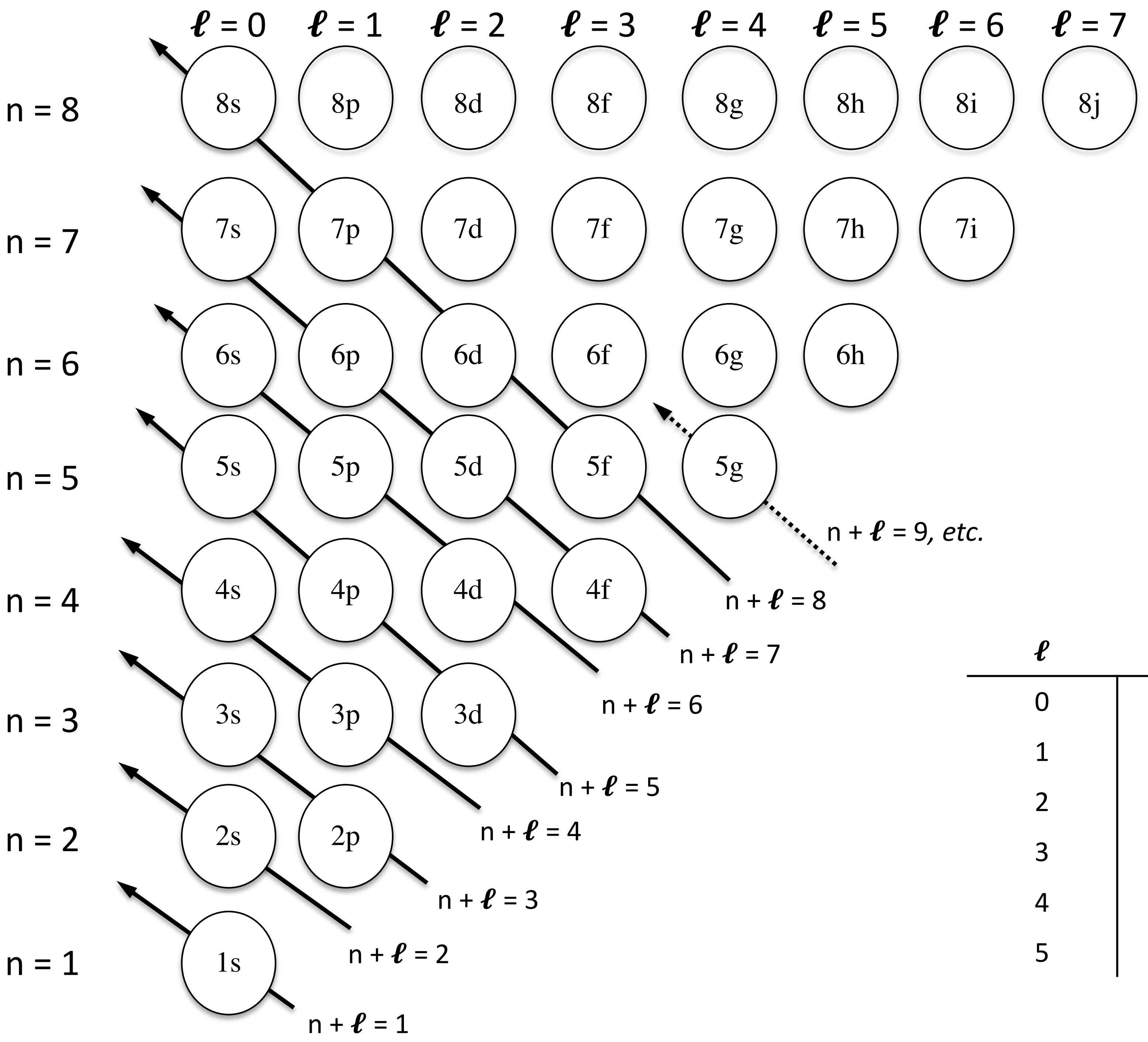
- What mass of excess reactant remains at the end of the reaction?

  10. g of excess reactant remains at the end of the reaction.

- If only 16.3 g of NH_3 are collected, what is the percent yield of NH_3?

  Percent yield = 24.0%

Aufbau Diagram



ℓ	*letter*	
0	s	*stupid*
1	p	*people*
2	d	*drive*
3	f	*freakin'*
4	g	*gas*
5	h	*hogs*

1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s 4f 5d 6p 7s 5f 6d 7p...

Predicting Atomic Electron Configurations

1) Electrons occupy the lowest energy orbitals available - *the **n+l Rule***
Begin assigning electrons at **1s** and continue in the following order:

1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s 4f 5d 6p *etc.*

Examples: **Li**: $1s^22s^1$ **Na**: $1s^22s^22p^63s^1$ **Ca**: $1s^22s^22p^63s^23p^64s^2$

2) **s** orbitals have one subshell; **p** orbitals have three subshells; **d** orbitals have five subshells; **f** orbitals have seven subshells. Or:

Number of subshells = 2l+1

where $m_l = \{l, (l-1), \ldots, 0, \ldots, (-l+1), -l\}$ … *and* $l = \{0, 1, \ldots n - 1\}$

3) No two electrons in an atom can have the same set of four quantum numbers - ***Pauli Exclusion Principle***. Each subshell can hold only two electrons, and the two electrons must have opposite values of spin (i.e. m_s).

4) The most stable arrangement of electrons is that with the maximum number of unpaired electrons - ***Hund's Rule***. Single electrons must occupy every subshell in an orbital before they "pair up" or are "spin paired".

Example: **Ti**: $[Ar]3d^24s^2$ Titanium has two unpaired electrons

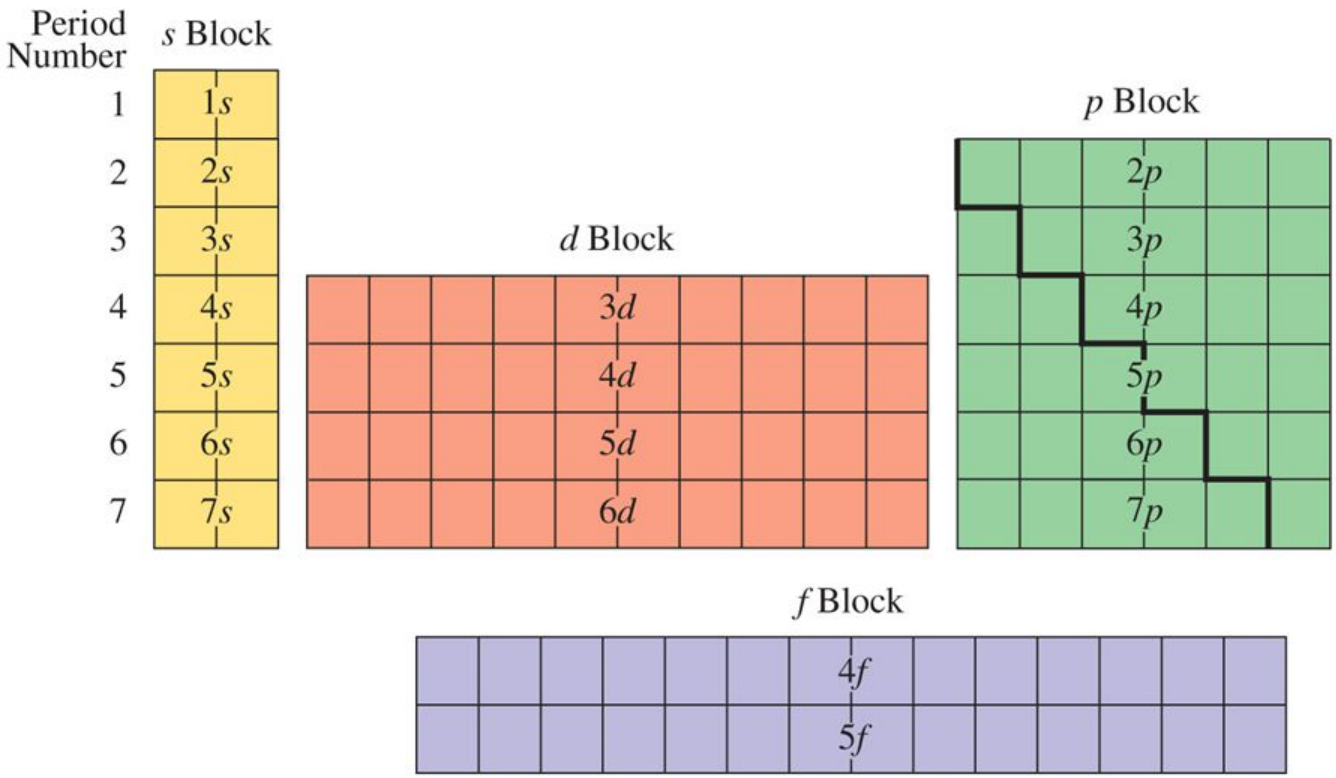
5) ***Paramagnetic*** compounds contain unpaired electrons.
Diamagnetic compounds contain electrons that are exclusively "spin paired." No unpaired electrons exist in diamagnetic compounds.

Examples: **Zn**: $[Ar]3d^{10}4s^2$ *(diamagnetic)* **Li**: $[He]2s^1$ *(paramagnetic)*

6) ***Atomic ion configurations*** can be assigned using the rules given above and while remembering that the electrons easiest to remove will generally come from the highest energy orbital available.

Examples: **Cu**: $[Ar]3d^{10}4s^1$ **Cu^{2+}**: $[Ar]3d^9$

Periodic Table Blocks



CH 151 Study Questions for the Final Exam

1. If 97.0 grams of aluminum oxide is produced from the reaction of 65.0 grams of aluminum with unlimited oxygen, what is the theoretical yield of aluminum oxide and the percent yield?
2. If 0.885 g of CO react with 0.352 g of H_2 to form CH_3OH, what is the limiting reactant? What is the theoretical yield of CH_3OH? What mass of excess reactant is left at the end of the reaction?
3. How many grams are there in 5.62×10^{13} molecules of $C_8H_{18}O_4$?
4. How many atoms of nitrogen are in 6.5×10^6 g of $Al(NO_3)_3$?
5. How many atoms of chlorine are there in 943.1 g of chlorine (Cl_2)?
6. Gallium reacts with iodine to make gallium iodide. Write the balanced equation.
7. Lead(II) nitrate reacts in a double displacement reaction with sodium iodide. Write the balanced equation.
8. Write the electron configuration for the following atoms: Ne, Mg, Cl, Ca, V, Kr
9. Write the electron configuration for the following ions: Na^+, Al^{3+}, F^{-1}, Cr^{5+}.
10. In questions #8 and #9, above, which atoms and ions are paramagnetic? Which atom or ion is the *most* paramagnetic?
11. In questions #8 and #9, above, which atoms and ions are isoelectronic? How many valence electrons do the isoelectronic atoms and/or ions possess?

Answers appear on the next page

CH 151 Study Questions for the Final Exam - *Answers*

1. 123 g Al_2O_3, 78.9% yield
2. CO limiting reactant, 1.01 g = theoretical yield, 0.224 g excess reactant unused
3. $1.66 * 10^{-8}$ g
4. $5.5 * 10^{28}$ atoms N
5. $1.602 * 10^{25}$ atoms Cl
6. $2\ Ga + 3\ I_2 \rightarrow 2\ GaI_3$
7. $Pb(NO_3)_2 + 2\ NaI \rightarrow 2\ NaNO_3 + PbI_2$
8. Ne: $1s^22s^22p^6$, Mg: $[Ne]3s^2$, Cl: $[Ne]3s^23p^5$, Ca: $[Ar]4s^2$, V: $[Ar]4s^23d^3$, Kr: $[Ar]4s^23d^{10}4p^6$
9. Na^+: [Ne], Al^{3+}: [Ne], F^{-1}: [Ne], Cr^{5+}: $[Ar]3d^1$
10. *Paramagnetic:* Cl (1 unpaired electrons), Vanadium (3 unpaired electrons), chromium(V) (1 unpaired electron). Vanadium is the most paramagnetic.
11. *Isoelectronic:* Ne, Na^+, Al^{3+}, F^{-1}. These species have zero valence electrons.

CH 151 Sample Quiz #1 Name: ____

Be sure to show all work, use the correct number of significant figures, circle final answers and use correct units in all problems.

---

1. Automotive batteries generally are filled with sulfuric acid. If a battery has a volume of 1.86 L and contains 3.42 x 10^6 mg of sulfuric acid, what is the density of sulfuric acid in g/mL? (5 points)

2. A child's fever medicine has a concentration of 250 mg/mL. If a child receives 2.0 teaspoons of this medicine, how many mg of medicine is being received? (1 teaspoon = 4.93 mL) (5 points)

3. Perform the following calculations. Report the answer to the correct number of significant digits. (5 points)

110.23 cm + 0.989 cm + 1.20 cm ______________

$$\frac{\left(2.34 \text{ x } 10^{3}\text{ cm}\right)\left(4.2021 \text{ x } 10^{-6}\text{ cm}\right)}{\left(8.7 \text{ x } 10^{3}\text{s}\right)}$$ ______________

154.0 = 3.76 x Q Q = ______________

4. Convert the following quantities: (5 points) Watch sig figs!

157.7 K to **°C**.

9.22 g/cm^3 to **g/mm^3**

7.360 cg to **ng**

CH 151
Sample Quiz #1 Name: ____ Lab Section: _______
Answers

---

1. Automotive batteries generally are filled with sulfuric acid. If a battery has a volume of 1.86 L and contains 3.42 x 10^6 mg of sulfuric acid, what is the density of sulfuric acid in g/mL? (5 points)

   1.84 g/ mL

2. A child's fever medicine has a concentration of 250 mg/mL. If a child receives 2.0 teaspoons of this medicine, how many mg of medicine is being received? (1 teaspoon = 4.93 mL) (5 points)

   2500 mg

3. Perform the following calculations. Report the answer to the correct number of significant digits. (5 points)

110.23 cm + 0.989 cm + 1.20 cm	***<u>112.42 cm</u>***
$\frac{\left(2.34 \times 10^{3}\ \text{cm}\right)\left(4.2021 \times 10^{-6}\ \text{cm}\right)}{\left(8.7 \times 10^{3}\text{s}\right)}$	**$1.1 \times 10^{-6}\ \text{cm}^2 / \text{s}$**
154.0 = 3.76 x Q	Q = **41.0**

4. Convert the following quantities: (5 points) Watch sig figs!

157.7 K to **°C**.	**-115.5 °C**
9.22 g/cm^3 to **g/mm^3**	**9.22 x 10^{-3} g/mm^3**
7.360 cg to **ng**	**7.360 x 10^7 ng**

CH 151 Sample Quiz #2 Name: ______________________________

Be sure to show all work, use the correct number of significant figures, circle final answers and use correct units in all problems.

---

1. Match the term on the left with the correct phrase on the right (7 points)

A. Isotope	__	Smallest subatomic particle; negative charge
B. Atomic Number	__	Same atomic number, different mass number
C. Neutron	__	Positive subatomic particle
D. Mass Number	__	Same mass number, different atomic number
E. Proton	__	Largest subatomic particle
F. Electron	__	Number of protons
G. Isobar	__	Number of protons and neutrons

2. Calculate the atomic number and mass number for an atom with 30 protons, 34 neutrons and 28 electrons. What element is it? What is the atom's symbol? Give the symbol for this isotope in the form ${}^{A}_{Z}X$. (5 points)

3. Classify each of the statements below as being True (**T**) or false (**F**). (1 point each, 8 points total)

An elemental symbol contains a capital letter followed by a small letter __

The properties of elements are always different from the properties of the compounds they formed __

Two objects, both having a negative charge, attract each other __

Two atoms of silicon each with a different number of electrons will always have the same mass number __

The mass number for each isotope of an element will be different __

Protons and electrons act like a type of "glue" that holds the atom together __

Democritus determined that most of the atom was empty __

An isotope of neptunium with 93 neutrons is written as neptunium-93 __

CH 151
Sample Quiz #2 Name: ____ Lab Section: _______
Answers

---

1. Match the term on the left with the correct phrase on the right (7 points)

A. Isotope	**F**	Smallest subatomic particle; negative charge
B. Atomic Number	**A**	Same atomic number, different mass number
C. Neutron	**E**	Positive subatomic particle
D. Mass Number	**G**	Same mass number, different atomic number
E. Proton	**C**	Largest subatomic particle
F. Electron	**B**	Number of protons
G. Isobar	**D**	Number of protons and neutrons

2. Calculate the atomic number and mass number for an atom with 30 protons, 34 neutrons and 28 electrons. What element is it? What is the atom's symbol? Give the symbol for this isotope in the form $^{A}_{Z}X$. (5 points)

This is zinc-64, or ${}_{30}{}^{64}\mathbf{Zn}^{2+}$

3. Classify each of the statements below as being True (**T**) or false (**F**). (1 point each, 8 points total)

An elemental symbol contains a capital letter followed by a small letter	**F**
The properties of elements are always different from the properties of the compounds they formed	**T**
Two objects, both having a negative charge, attract each other	**F**
Two atoms of silicon each with a different number of electrons will always have the same mass number	**F**
The mass number for each isotope of an element will be different	**T**
Protons and electrons act like a type of "glue" that holds the atom together	**T**
Democritus determined that most of the atom was empty	**F**
An isotope of neptunium with 93 neutrons is written as neptunium-93	**F**

CH 151 Sample Quiz #3 Name: ____

Be sure to show all work, use the correct number of significant figures, circle final answers and use correct units in all problems.

---

1. Write the names of the following compounds. Use acid names where appropriate. (1 point each)

P_2S_3

$Mg(NO_2)_2$

$HBrO$

Cu_2S

$CaCl_2$

N_2O_4

V_2O_3

$SnCl_3$

SiO_2

HI

2. Write the correct formula for each of the following compounds: (1 point each)

potassium bromide

nickel(IV) oxide

sulfur difluoride

galium oxide

nitric acid

iron(II) hydroxide

periodic acid

sodium iodide

sulfur hexafluoride

titanium(II) sulfate

CH 151
Sample Quiz #3 Name: ____ Lab Section: _______
Answers

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1. Write the names of the following compounds. Use acid names where appropriate. (1 point each)

P_2S_3	**diphosphorus trisulfide**
$Mg(NO_2)_2$	**magnesium nitrite**
$HBrO$	**hypobromous acid**
Cu_2S	**copper(I) sulfide**
$CaCl_2$	**calcium chloride**
N_2O_4	**dinitrogen tetraoxide**
V_2O_3	**vanadium(III) oxide**
$SnCl_3$	**tin(III) chloride**
SiO_2	**silicon dioxide (silicon(IV) oxide ok)**
HI	**hydroiodic acid**

2. Write the correct formula for each of the following compounds: (1 point each)

potassium bromide	**KBr**
nickel(IV) oxide	**NiO_2**
sulfur difluoride	**SF_2**
galium oxide	**Ga_2O_3**
nitric acid	**HNO_3**
iron(II) hydroxide	**$Fe(OH)_2$**
periodic acid	**HIO_4**
sodium iodide	**NaI**
sulfur hexafluoride	**SF_6**
titanium(II) sulfate	**$TiSO_4$**

CH 151 Sample Quiz #4 Name: ____

Be sure to show all work, use the correct number of significant figures, circle final answers and use correct units in all problems.

---

1. Write and balance the following reactions: (14 points)

   a. Calcium iodide is formed from its elements

   b. Molybdenum(III) selenide decomposes to its elements

   c. Combustion of butane, C_4H_{10}.

   d. Gallium reacts with a solution of zinc(II) nitrate.

   e. A bright white precipitate forms when solutions of silver(I) nitrate and potassium iodide react.

   f. Sodium hydroxide neutralizes hydrochloric acid.

2. Classify each of the above reactions: (1 point each)

   a.

   b.

   c.

   d.

   e.

   f.

CH 151
Sample Quiz #4 Name: ____ Lab Section: _______
Answers

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1. Write and balance the following reactions: (14 points)

a. Calcium iodide is formed from its elements **$Ca + I_2 \rightarrow CaI_2$**

b. Molybdenum(III) selenide decomposes to its elements **$Mo_2Se_{3(s)} \rightarrow 2\ Mo + 3\ Se$**

c. Combustion of butane, C_4H_{10}. **$2\ C_4H_{10(g)} + 13\ O_{2(g)} \rightarrow 8\ CO_{2(g)} + 10\ H_2O_{(g)}$**

d. Gallium reacts with a solution of zinc(II) nitrate. **$2\ Ga + 3\ Zn(NO_3)_2 \rightarrow 2\ Ga(NO_3)_3 + 3\ Zn$**

e. A bright white precipitate forms when solutions of silver(I) nitrate and potassium iodide react.
$AgNO_{3(aq)} + KI_{(aq)} \rightarrow KNO_{3(aq)} + AgI_{(s)}$

f. Sodium hydroxide neutralizes hydrochloric acid. **$NaOH_{(aq)} + HCl_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$**

2. Classify each of the above reactions: (1 point each)

a. **combination**

b. **decomposition**

c. **combustion** *or* **burning**

d. **single replacement**

e. **precipitation**

f. **acid-base** *or* **neutralization**

CH 151 Sample Quiz #5 Name: ____

Be sure to show all work, use the correct number of significant figures, circle final answers and use correct units in all problems.

---

1. How many grams of carbon monoxide will be produced if $3.303*10^{10}$ molecules of chromium(III) oxide are consumed? (5 points)

$$Cr_2O_3 + 3\ C \rightarrow 3\ CO + 2\ Cr$$

2. For the balanced equation shown below, if 93.8 grams of PCl_5 were reacted with 20.3 grams of H_2O, how many grams of H_3PO_4 would be produced? (5 points)

$$PCl_5 + 4\ H_2O \rightarrow H_3PO_4 + 5\ HCl$$

3. Using the information in problem #2, above, calculate the percent yield for the reaction if 20.2 g of H_3PO_4 are actually produced. (4 points)

4. The poison phosgene ($COCl_2$) can be neutralized with sodium hydroxide (NaOH) to produce salt (NaCl), water and carbon dioxide by the reaction: **$COCl_2 + 2\ NaOH \rightarrow 2\ NaCl + H_2O + CO_2$**

   If 9.5 grams of phosgene and 9.5 grams of sodium hydroxide are reacted, what is the theoretical yield of NaCl? If only 1.1 g of NaCl are collected, what is the percent yield of NaCl? (6 points)

CH 151
Sample Quiz #5 Name: ____ Lab Section: _______
Answers

---

1. How many grams of carbon monoxide will be produced if $3.303*10^{10}$ molecules of chromium(III) oxide are consumed? (5 points)

$$Cr_2O_3 + 3\ C \rightarrow 3\ CO + 2\ Cr$$

4.609×10^{-12} g CO

2. For the balanced equation shown below, if 93.8 grams of PCl_5 were reacted with 20.3 grams of H_2O, how many grams of H_3PO_4 would be produced? (5 points)

$$PCl_5 + 4\ H_2O \rightarrow H_3PO_4 + 5\ HCl$$

Theoretical yield = 27.6 g H_3PO_4, limiting reactant = water

3. Using the information in problem #2, above, calculate the percent yield for the reaction if 20.2 g of H_3PO_4 are actually produced. (4 points)

73.2%

4. The poison phosgene ($COCl_2$) can be neutralized with sodium hydroxide (NaOH) to produce salt (NaCl), water and carbon dioxide by the reaction: **$COCl_2 + 2\ NaOH \rightarrow 2\ NaCl + H_2O + CO_2$**

If 9.5 grams of phosgene and 9.5 grams of sodium hydroxide are reacted, what is the theoretical yield of NaCl? If only 1.1 g of NaCl are collected, what is the percent yield of NaCl? (6 points)

Theoretical yield = 11 g NaCl, LR = $COCl_2$
% yield = 10. %

CH 151 Midterm Exam Cover Sheet

Sample Exam

Name: ____

This sample exam consists of four (4) double-sided pages (including this sheet) with twenty-five (25) multiple choice questions, six (6) short answer questions, and one (1) five point extra credit question.

Point values are summarized on the next page.

A periodic table and scratch paper are available for you to use on this exam.

Before you start:

- Verify that you have all four (4) double-sided pages
- Write your name in the space above

At the conclusion of the exam:

- Sign the integrity statement below. **Failing to sign the integrity statement on this exam imparts an immediate grade of zero.**
- Ensure that all multiple choice answers are clearly marked
- Turn in the exam, the periodic table and all scratch paper used

---

Integrity statement:

I have neither given nor received aid on this exam.

____

Your signature

CH 151 Midterm Exam Point Distribution Sheet

Sample Exam

Multiple choice questions:

________ X *4 points per question* = _________ points

number of multiple choice questions correct

Short answer questions and extra credit:

_________ points

Total points on this exam: _________ points

Grade	***Percentage***	***Points on This Exam***
A	90% - 100%	117 - 130
B	80% - 89%	104 - 116
C	65% - 79%	84 - 103
D	50% - 64%	65 - 83
F	0% - 49%	0 - 64

CH 151 Sample Midterm Exam   Name: ______________________________

Part I: Multiple Choice Questions (100 Points) There is *only* one best answer for each question.

---

1. There are _____ ng in a pg. (n = 10^{-9}, p = 10^{-12})

   a. 0.001
   b. 1000
   c. 0.01
   d. 100
   e. 10

2. Express the temperature 422.35 K in degrees Celsius.

   a. 792.23 °C
   b. 149.20 °C
   c. 692.50 °C
   d. 50.89 °C
   e. 22.78 °C

3. Which group in the periodic table contains only nonmetals?

   a. IA
   b. IIA
   c. VA
   d. VIIB
   e. VIIIA

4. The recommended adult dose of Elixophyllin®, a drug used to treat asthma, is 6.00 mg/kg of body mass. Calculate the dose in milligrams for a 115-lb person. 1 lb = 453.59 g.

   a. 24
   b. 1,521
   c. 1.5
   d. 313
   e. 3.1 x 10^5

5. Convert $5.01*10^3$ cm to km, m and mm

   a. $5.01*10^{-2}$ km, $5.01*10^1$ m, $5.01*10^4$ mm
   b. $5.01*10^{-2}$ km, $5.01*10^1$ m, $5.01*10^3$ mm
   c. $5.01*10^{-2}$ km, $5.01*10^5$ m, $5.01*10^8$ mm
   d. $5.01*10^4$ km, $5.01*10^1$ m, $5.01*10^{-2}$ mm
   e. $5.01*10^8$ km, $5.01*10^5$ m, $5.01*10^2$ mm

6. Which of the numbers has the *most* significant figures?

   a. $32,769,100*10^{-6}$ pg
   b. $12.19*10^{-3}$ g
   c. 9,241,000 J
   d. 0.00163 s
   e. 1,200,000.00 kWh

7. Elements in Group 7A are known as the

   a. alkali metals
   b. chalcogens
   c. alkaline earth metals
   d. halogens
   e. noble gases

8. Calcium forms an ion with a charge of

   a. +2
   b. +1
   c. -1
   d. -2
   e. unknown; it is a variable charge metal

9. Which of the following is a chemical property?

   a. Combustibility
   b. Boiling Point
   c. Density
   d. Melting Point
   e. Index of refraction

10. Which of the following is *true*?

    a. Two objects, both having positive charges, repel each other
    b. Two objects having opposite charges attract each other
    c. Electrostatic forces are responsible for the energy absorbed or released in chemical changes
    d. The number of neutrons in an atom of an element is variable depending on the isotope
    e. All of the above are true

11. Which of the following symbol/name pairs are correctly matched?

    a. Fl, Fluorine
    b. Ca, Carbon
    c. S, Silicon
    d. Ir, Iron
    e. Na, Sodium

12. Isobars of an element have similar

    a. protons
    b. neutrons
    c. electrons
    d. atomic numbers
    e. mass numbers

13. Which of the following masses is closest to the mass of one atomic mass unit (amu)?

    a. 12 g
    b. 1.66 g
    c. 1 g
    d. $^{1}/_{12}$ g
    e. 10^{-24} g

14. Which of the following is correct for the third period element in Group 4A?

	Z	**Chemical Symbol**	**Atomic Mass**
a.	31	Ga	69.72
b.	69.72	Ga	31
c.	14	Si	28.09
d.	28.09	Si	14
e.	21	Sc	44.96

15. Which of the following is correct?

a. The element H is in both the first period and the seventh period
b. The element Na is in Group 2A
c. The element Ge is in the fourth period and Group 4A
d. The element Cr is in the third period and Group 6B
e. More than one of the statements above are correct

16. Which of the following name/formula pairs is correct?

a. phosphoric acid, H_3PO_3
b. sulfate ion, SO_3^{2-}
c. bromate ion, BrO_3^{-1}
d. hydrochlorous acid, HCl
e. carbonate ion, CO_3^{-1}

17. What is the name of $Cu(ClO_3)_2 \cdot 2\ H_2O$?

a. copper chlorate terthydrate
b. copper(II) chlorate dihydrate
c. copper chlorate terhydrate
d. copper(II) chlorate terhydrate
e. copper chlorate trihydrate

18. Which of the following is the correct name for the ammonium ion?

a. NH_4
b. NH_4^+
c. NH_3^+
d. NH_3
e. NH_2^{-1}

19. What are the formulas of the compounds calcium periodate and potassium nitrate?

a. $Ca(IO_4)_2$, KNO_2
b. $Ca(IO_3)_2$, KNO_2
c. $Ca(IO_4)_2$, KNO_3
d. $Ca(IO_3)_2$, KNO_3
e. $CaIO_4$, KNO_3

20. Identify the element below which does *not* form stable diatomic molecules:

a. nitrogen
b. hydrogen
c. chlorine
d. bromine
e. carbon

21. How many molecules are in 0.105 mol of N_2H_4?

    a. $6.32*10^{22}$
    b. $5.73*10^{2\backslash 4}$
    c. $1.74*10^{-25}$
    d. $1.58*10^{-23}$
    e. 1.79

22. Calculate the molar mass of gallium carbonate

    a. 129.7 g/mol
    b. 154.3 g/mol
    c. 189.7 g/mol
    d. 319.5 g/mol
    e. 334.6 g/mol

23. Calculate the percent composition of gallium selenide.

    a. 37.1% Ga, 62.9% Se
    b. 42.3% Ga, 57.7% Se
    c. 44.1% Ga, 55.9% Se
    d. 46.7% Ga, 53.3% Se
    e. 50.0% Ga, 50.0% Se

24. From the following, pick the compound that could be an empirical formula:

    a. C_4H_8
    b. NH_3
    c. Al_2Br_6
    d. N_2O_4
    e. more than one of the above could be an empirical formula

25. How many grams of oxygen are in 8.50 g of potassium sulfite, K_2SO_3?

    a. 2.12 g
    b. 2.58 g
    c. 4.25 g
    d. 4.53 g
    e. 16.0 g

Part II: Short Answer / Calculation, 30 points total. *Show all work!*

1. A new compound called Chemane is composed of 40.00% C, 6.72% H, and the remainder oxygen. Calculate the empirical formula of Chemane. (8 points)

2. If the molar mass of Chemane in problem #1, above, is found to be 180.18 g/mol, calculate the molecular formula of Chemane. (6 points)

3. Provide the appropriate chemical formula or name to the following. Use acid names if appropriate. (1 point each)

phosphorus tribromide

SCl_4

sodium iodate

$Fe(ClO_2)_5$

calcium iodide

chromium(III) nitrate

$(NH_4)_2SO_4$

potassium phosphide

$HNO_3(aq)$

$Ca(OH)_2$

4. Find the mass of 115.7 cm^3 benzene in pounds. (density = 0.779 g/mL, 454 g = 1 pound) (4 points)

5. What is the **formula** and **molar mass** of calcium nitrate? (4 points)

6. Convert 4.2 K to °C and °F. (3 points)

CH 151 Sample Exam
Exam I Name: ____ Lab Section: ______
Answers

<u>Part I</u>: Multiple Choice Questions

1. A
2. B
3. E
4. D
5. A
6. E

7. D
8. A
9. A
10. E
11. E
12. E
13. E

14. C
15. C
16. C
17. B
18. B
19. C
20. E

21. A
22. D
23. A
24. B
25. B

<u>Part II</u>: Short Answer / Calculation.

1. CH_2O
2. $C_6H_{12}O_6$
3. *Names/formulas:*
    PBr_3
    sulfur tetrachloride
    $NaIO_3$
    iron(V) chlorite
    CaI_2
    $Cr(NO_3)_3$
    ammonium sulfate
    K_3P
    nitric acid
    calcium hydroxide
4. 0.199 lbs
5. $Ca(NO_3)_2$, 164.09 g/mol
6. -269.0 °C, -452.1 °F