Hayfield Secondary AP Summer Assignment Cover

Hayfield Secondary

7630 Telegraph Road, Alexandria, VA 22315 • Phone: (703) 924-7400 • FAX (703) 924-7497

Sheet

Course	AP Chemistry
Teacher Names & Email Addresses	Julia Riley jsriley@fcps.edu
Assignment Title	AP Chemistry
Date Assigned	June
Date Due	Second Day of Class
Objective/Purpose of Assignment	Students will continue to practices and reinforce basic chemistry knowledge that is essential to be successful in AP Chemistry
Description of how Assignment will be Assessed	The assignment will be checked for completion and assessed as part of the Unit 1 test which will be the 3rd or 4th class.
Grade Value of Assignment	**20 points**
Tools/Resources Needed to Complete Assignment	Chemistry tables located at the back of this packet https://www.khanacademy.org/
Estimated Time Needed to Complete Assignment	**five to ten hours**

AP Chemistry Summer Packet 2017
Hayfield Secondary School

Supply List

1. 2-inch 3-ring binder with dividers
2. Composition book with grid/graph paper
3. Graphing calculator
4. It is suggested that you purchase a AP Chemistry **review book (est. cost $10-20)** and start working through it starting at the beginning of the year.

Summer Assignment

You must complete this review packet and turn it in on your second day of AP Chemistry. ***This is not optional. It is required and taken for your first grade. For students enrolled as of June 1st, late assignments will not be accepted after the first Unit test!***

The material is divided into seven weeks as provided. Should you choose to follow this pacing the workload will not feel daunting. If you choose to wait until the night before school starts to complete this packet, you may feel differently.

Assessment on Summer Material

You will have a test on this material the third class. This will cover:

- All Prior Knowledge that should be Memorized (see next pages)
- All General Chemistry content covered in this review packet

AP Chemistry is a difficult course and having the following pages of material memorized is **essential** for success in learning the concepts covered in the course. Make flashcards, have your friends and family quiz you, take lists with you on vacation, or do whatever it takes to get this information firmly planted in your head. **Do not wait until the night before school begins.**

Prior Knowledge that should be Memorized

At the end of this packet we have provided you with Reference Tables to assist with your summer assignment. You do need to memorize the following Tables:

Table E	Selected Polyatomic Ions
Table F	Solubility Guidelines
Table P	Organic Prefixes
Table Q	Homologous Series of Hydrocarbons
Table R	Organic Functional Groups
Table T	Important Formulas and Equations

Oxidation Numbers

An oxidation number is a number assigned to an atom in a molecular compound or molecular ion that indicates the general distribution of electrons among the bonded atoms.

1. The oxidation number of any free, uncombined element is 0.
2. The oxidation number of a monatomic ion equals the charge on the ion.
3. The more electronegative element in a binary compound is assigned the number equal to the charge it would have if it were an ion.
4. The oxidation number of fluorine in a compound is always -1.
5. Oxygen has an oxidation number of -2 unless it is combined with F, in which case it is +2, or it is in a peroxide, in which case it is -1.
6. The oxidation state of hydrogen in most of its compounds is +1 unless it is combined with a metal, in which case it is -1.
7. In compounds, elements of Groups 1 and 2 as well as aluminum have oxidation numbers of +1, +2, and +3, respectively.
8. The sum of oxidation numbers of all atoms in a neutral compound is zero.
9. The sum of the oxidation number of all atoms in a polyatomic ion equals the charge of the ion.

Strong Acids and Bases

Acids	Bases
HF – weak	LiOH – strong
HCl – strong	NaOH– strong
HBr – strong	KOH – strong
HI – strong	RbOH– strong
H_2SO_4 – strong	CsOH– strong
HNO_3 – strong	$Ca(OH)_2$ – strong
$HClO_3$ – strong	$Ba(OH)_2$ – strong
$HClO_4$ – strong	$Sr(OH)_2$ – strong
	NH_3 – weak
All other acids are weak	
$H_2CO_3 \rightarrow H_2O + CO_2$ (very weak acid-breaks down!)	

Polyatomic Ions – Cut These Out to Make Flashcards!

Bromide	Br^{1-}	Dichromate	$Cr_2O_7^{2-}$	Iodate (VII) (Periodate)	IO_4^{1-}
Bromate (I) (Hypobromite)	BrO^{1-}	Dihydrogen Phosphate	$H_2PO_4^{1-}$	Manganate (VII) (Permanganate)	MnO_4^{1-}
Bromate (III) (Bromite)	BrO_2^{1-}	Ethanoate (Acetate)	$C_2H_3O_2^{1-}$	Nitrate	NO_3^{1-}
Bromate (V) (Bromate)	BrO_3^{1-}	Hydrogen Carbonate (Bicarbonate)	HCO_3^{1-}	Nitrite	NO_2^{1-}
Bromate (VII) (Perbromate)	BrO_4^{1-}	Hydrogen Phosphate	HPO_4^{2-}	Oxalate	$C_2O_4^{2-}$
Carbonate	CO_3^{2-}	Hydrogen Sulfate (Bisulfate)	HSO_4^{1-}	Peroxide	O_2^{2-}
Chlorate (I) (Hypochlorite)	ClO^{1-}	Hydrogen Sulfide (Bisulfide)	HS^{1-}	Phosphate	PO_4^{3-}
Chlorate (III) (Chlorite)	ClO_2^{1-}	Hydrogen Sulfite (Bisulfite)	HSO_3^{1-}	Phosphite	PO_3^{3-}
Chlorate (V) (Chlorate)	ClO_3^{1-}	Hydroxide	OH^{1-}	Sulfate	SO_4^{2-}
Chlorate (VII) (Perchlorate)	ClO_4^{1-}	Iodate (I) (Hypoiodite)	IO^{1-}	Sulfite	SO_3^{2-}
Chromate	CrO_4^{2-}	Iodate (III) (Iodite)	IO_2^{1-}	Thiosulfate	$S_20_3^{2-}$
Cyanide	CN^{1-}	Iodate (V) (Iodate)	IO_3^{1-}	Thiocyanate	SCN^{1-}

Week #1

Significant Figures

1. Give the number of sig figs in each of the following numbers:

a. 123
b. 0.078
c. 89007
d. 12,000
e. 1,000,000,000.0
f. 0.009
g. 23,000.
h. 34,000
i. 34.89
j. 101

2. Do the following calculations giving the answer in the appropriate number of sig figs:

a. 1.23 + 75
b. 1.89 - .20
c. 45.6 x 8.2
d. 234/0.298
e. 0.887 + 0.3
f. 2340 - 100
g. 12.45 x 3
h. 25,600/ 3.0

3. Do the following calculations giving the answer in the appropriate number of sig figs:

a. 45.0 x 9.0 + 89.22/ 75
b. (2.88 + .5) x (23,000 - 0.11)
c. 0.8897 x 2.15 + 0.002/.1
d. (8 + 9)/(34.0 – 20.)

Dimensional Analysis

4. Convert the following measurements to the desired unit:

a. 0.050 cm = ______ mm
b. 1872 mg = _______ kg
c. 1.9 dL = ________ cL
d. $3.4x10^{-3}$ ks = ________ cs

5. An aluminum block has a density of 2.70 g/mL. If the mass of the block is 24.60 g, find the volume of the substance.

6. A student can eat 4.0 M&Ms every 1.00 seconds. If an M&M has a mass of 63 mg, determine how many kilograms of M&Ms can be eaten by a class of 20 students in 3.75 hours.

Week #2

Naming Compounds– Using your memorized ions!

Formula	Name
1. P4O10	________
2. $ZnBr_2$	________
3. SBr_6	________
4. CaF_2	________
5. P_2S_3	________
6. ________	carbon monoxide
7. ________	sodium hydride
8. ________	aluminum selenide
9. ________	xenon hexafluoride
10. ________	dinitrogen monoxide
11. $KClO_3$	________
12. $Pb(OH)_2$	________
13. $Ca(MnO_4)_2$	________
14. N_2O_4	________
15. $FeCl_2$	________
16. ________	manganese (VII) oxide
17. ________	francium dichromate
18. ________	copper (II) phosphide
19. ________	silver nitrate
20. ________	ammonium oxalate
21. $(NH_4)_2SO_3$	________
22. $Ni_3(PO_4)_2$	________
23. $Fe(ClO_2)_3$	________
24. $NaBrO_3$	________
25. H_3PO_4	________
26. ________	sulfurous acid
27. ________	hydroiodic acid
28. ________	mercury (I) nitrate
29. ________	vanadium (V) oxide
30. ________	tetraphosphorous decoxide

Electron Configuration & Periodicity

1. Draw the orbital notation for nickel.
2. How many unpaired electrons are in arsenic?
3. Write the electron configuration for palladium.
4. How many valence electrons are in mercury?
5. Write the electron configuration for uranium.
6. Write the noble gas electron configuration for lead.
7. Which is more electronegative, sulfur or chlorine, and why?
8. Which has a larger atomic radius, potassium or bromine, and why?
9. Which has the smaller ionization energy, nitrogen or phosphorus, and why?
10. Write the noble gas electron configuration for copper.

Lewis Structures and VSEPR Theory

For the following questions, draw the Lewis Structure and the name of the shape the molecule will form.

1. $SeCl_2$
2. OF_2
3. BF_3
4. CO_2
5. CH_3NH_2
6. HCOOH
7. HCN

Week #3

Atomic Structure

1. Fill in the table below based on the given isotopes.

Isotope	Protons	Neutrons	Electrons
^{13}C			
^{31}P			
^{232}U			

Average Atomic Mass

2. Given the data below determine the average atomic mass

	Isotope % Abundance	Isotopic Mass	Average Atomic Mass
Question A.	Sb-121 57.25%	120.9038 amu	
	Sb-123 42.75%	122.0041 amu	
Question B.	Ag-107 51.82%	106.90509 amu	
	Ag-109 48.18%	108.9047 amu	

The Mole

3. Convert each of the following to moles.

a. 12.64 g NaOH

b. 3.00×10^{24} atoms Au

c. 40.0 L of Ne gas

d. 800. g $CaBr_2$

e. 3.011×10^{22} molecules H_2O

f. 6.78 L of Ar gas

4. Given 0.250 moles of krypton determine:
   a. the mass
   b. the number of atoms
   c. the volume at STP

5. Given 0.750 moles of oxygen determine"
   a. the mass
   b. the number of atoms
   c. the volume at STP

Percent Composition

6. Calculate the percent composition by mass of each element in K_2CrO_4.

Empirical and Molecular Formulas

7. Find the empirical and molecular formulas for a compound containing 11.66 g iron and 5.01 g oxygen if the molar mass of the compound is 320 g/mol.

8. Find the empirical and molecular formulas for a compound containing 5.28 g of tin and 3.37 g of fluorine if the molar mass of the compound is 584.1 g/mol.

Week #4

Balancing Chemical Equations

1. Balance the following equations:

   a. _____$Cu_{(s)}$ + _____$HNO_{3\,(aq)}$ → _____$NO_{2\,(g)}$ + _____$Cu(NO_3)_{2\,(aq)}$ + 2 $H_2O_{(l)}$

   b. _____$Fe_{(s)}$ + _____$H_2O_{(l)}$ → _____$Fe_3O_{4\,(s)}$ + _____$H_{2\,(g)}$

   c. _____$C_2H_{6\,(g)}$ + _____$O_{2\,(g)}$ → _____$CO_{2\,(g)}$ + _____$H_2O_{(l)}$

2. Write and balance the following equations:
   a. Iron metal reacts with oxygen to form solid rust, iron (III) oxide.

   b. Calcium metal reacts with water to produce aqueous calcium hydroxide and hydrogen gas.

   c. Aqueous barium hydroxide reacts with aqueous sulfuric acid to produce solid barium sulfate and water.

Stoichiometry

3. 30.5 g of sodium metal reacts with a solution of excess lithium bromide. How many grams of lithium metal are produced?

   _____$Na_{(s)}$ + _____$LiBr_{(aq)}$ → _____$Li_{(s)}$ + _____$NaBr_{(aq)}$

4. Propane, C_3H_8, undergoes combustion. How many grams of propane are needed to produce 45.9 g of water?

   _____$C_3H_{8\,(g)}$ + _____$O_{2\,(g)}$ → _____$CO_{2\,(g)}$ + _____$H_2O_{(l)}$

5. A solution of 3.50 g of sodium phosphate is mixed with a solution containing 6.40 g of barium nitrate. How many grams of barium phosphate can be formed?

$$\_\_\_\_ Na_3PO_{4\,(aq)} + \_\_\_\_ Ba(NO_3)_{2\,(aq)} \rightarrow \_\_\_\_ Ba_3(PO_4)_{2\,(s)} + \_\_\_\_ NaNO_{3\,(aq)}$$

6. Octane, C_8H_{18}, undergoes combustion. How many grams of oxygen are needed to burn 10.0 g of octane?

7. Sodium azide, NaN_3, decomposes into its elements. How many grams of sodium azide are required to form 34.8 g of nitrogen gas?

8. Ammonia reacts with oxygen gas to form nitrogen monoxide and water. How many grams of nitrogen monoxide are formed when 1.50 g of ammonia react with 2.75 g of oxygen gas?

Week #5

Reactions

Please review the following material:

- There are three main classifications of reactions: precipitation, acid-base, or redox (reduction-oxidation…like, synthesis, decomposition, and single displacement).

- Any ion has an aqueous state of matter.

- For acid-base reactions, strong acids (HCl, HBr, HI, H_2SO_4, $HClO_3$, $HClO_4$, and HNO_3) and strong bases (metal ions in Groups 1 and 2 paired with hydroxide) completely dissociate. Weak acids and bases do not.

- For precipitation (and some redox) reactions, use the solubility rules in your memorization material to determine which salts are soluble (aqueous) or insoluble (solid). Only aqueous solutions can dissociate…solids, liquids, and gases cannot.

Acid-Base Example: *Hydrochloric acid is added to a solution of zinc hydroxide.*

*First, write a molecular equation.

$HCl + Zn(OH)_2 \rightarrow ZnCl_2 + H_2O$

Acid Base Salt Water

*Next, you need to see what dissociates and what does not. Hydrochloric acid is a strong acid, so it will completely dissociate into its ions while zinc hydroxide is a weak base, so it will not dissociate. Zinc chloride is a soluble salt according to the solubility rules above, so it will also dissociate into its ions.

*Wait to balance the reaction until the end.

$H^+ + Cl^- + Zn(OH)_2 \rightarrow Zn^{+2} + Cl^- + H_2O$

*Last, you need to see what can be cancelled out. Species that are identical on both sides of the reaction, called spectator ions, can be cancelled out. Cl^- is present on both sides of the reaction and therefore can be cancelled out…giving you your net ionic reaction that you'll now balance and put back on states of matter.

$2\ H^+\ (aq) + Zn(OH)_2\ (aq) \rightarrow Zn^{+2}\ (aq) + 2\ H_2O\ (l)$

Redox Example: *Silver metal reacts with a solution of sodium nitrate.*

$Ag + NaNO_3 \rightarrow Na + AgNO_3$

*Ag is a solid. $NaNO_3$ is a soluble salt according to the solubility rules above, so it will dissociate into its ions. Na is a solid. $AgNO_3$ is also a soluble salt and will dissociate.

$Ag + Na^+ + NO_3^- \rightarrow Na + Ag^+ + NO_3^-$

*NO_3^- is a spectator ion.

$Ag\ (s) + Na^{+}\ (aq) \rightarrow Na\ (s) + Ag^{+}\ (aq)$

Precipitation Example: *Barium acetate is mixed with potassium sulfate.*

$Ba(C_2H_3O_2)_2 + K_2SO_4 \rightarrow BaSO_4 + KC_2H_3O_2$

*According to the solubility rules, barium sulfate is the only insoluble salt. So, everything else will dissociate.

COMPLETE IONIC EQUATION

$Ba^{+2} + C_2H_3O_2^{-} + K^{+} + SO_4^{-2} \rightarrow BaSO_4 + K^{+} + C_2H_3O_2^{-}$

*The potassium ions and acetate ions are spectator ions and can be cancelled out.

NET IONIC EQUATION

$Ba^{+2}\ (aq) + SO_4^{-2}\ (aq) \rightarrow BaSO_4\ (s)$

Please write ***net ionic*** balanced reactions (with states of matter included) for the following questions. It may be helpful to first identify the type of reaction.

1. Solid sodium bicarbonate is mixed with copper (II) nitrate.
2. Magnesium oxide is heated.
3. Acetic acid is added to a solution of ammonia.
4. Iron (III) chloride is mixed with silver sulfite.
5. A solid piece of aluminum is put into a solution of nickel (II) chloride.
6. A solution of lithium chloride is added to a solution of lead (IV) nitrite.
7. Sulfuric acid is added to a solution of aluminum hydroxide.
8. Cadmium nitrate is added to sodium sulfide.
9. Chromium (III) sulfate is added to ammonium carbonate.
10. Methane combusts in air.

Week #6

Short Answer AP Questions

1. The reaction between silver ion and solid zinc is represented by the following equation:

$$2Ag^{+}_{(aq)} + Zn_{(s)} \rightarrow Zn^{+2}_{(aq)} + 2Ag_{(s)}$$

A 1.50 g sample of Zn is combined with 250 mL of 0.110 M $AgNO_3$ at 25°C.

e. Identify the limiting reagent. Show calculations to support your answer.

f. On the basis of the limiting reactant that you identified in part (i), determine the concentration of Zn^{+2} after the reaction is complete.

2. Consider the hydrocarbon pentane, C_5H_{12} (molar mass 72.15 g/mol).

   a. Write the balanced equation for the combustion of pentane to yield carbon dioxide and water.

   b. What volume of dry carbon dioxide, measured at 25°C and 785 mmHg, will result from the complete combustion of 2.50 g pentane?

3. Find the mass percent of nitrogen in each of the following compounds:

   a. NO

   b. NO_2

   c. N_2O_4

   d. N_2O

4. Benzene contains only carbon and hydrogen and has a molar mass of 78.1 g/mol. Analysis shows the compound to be 7.74% H by mass. Find the empirical and molecular

formulas of benzene.

5. Calcium carbonate decomposes upon heating, producing calcium oxide and carbon dioxide gas.

   a. Write a balanced chemical equation for this reaction.

   b. How many grams of calcium oxide will be produced after 12.25 g of calcium carbonate is completely decomposed?

   c. What volume of carbon dioxide gas is produced from this amount of calcium carbonate, at STP?

Week #7

More Short Answer AP Questions

1. Hydrogen gas and bromine gas react to form hydrogen bromide gas.

   a. Write a balanced chemical equation for this reaction.

   b. 3.2 g of hydrogen gas and 9.5 g of bromine gas react. Which is the limiting reagent?

   c. How many grams of hydrogen bromide gas can be produced using the amounts in (b)?

   d. How many grams of the excess reactant is left unreacted?

   e. What volume of HBr, measured at STP, is produced in (b)?

2. When ammonia gas, oxygen gas and methane gas (CH_4) are combined, the products are hydrogen cyanide gas and water.

   a. Write a balanced chemical equation for this reaction.

   b. Calculate the mass of each product produced when 225 g of oxygen gas is reacted with an excess of the other two reactants.

   c. If the actual yield of the experiment in (b) is 105 g of HCN, calculate the percent yield.

3. When solutions of potassium iodide and lead (II) nitrate are combined, the products are potassium nitrate and lead (II) iodide.

   a. Write a balanced equation for this reaction, including (aq) and (s).

   b. Calculate the mass of precipitate produced when 50.0mL of 0.45M potassium iodide solution and 75mL of 0.55M lead (II) nitrate solution are mixed.

   c. Calculate the volume of 0.50M potassium iodide required to react completely with 50.0mL of 0.50M lead (II) nitrate.

C

THE UNIVERSITY OF THE STATE OF NEW YORK • THE STATE EDUCATION DEPARTMENT • ALBANY, NY 12234

Reference Tables for Physical Setting/CHEMISTRY

2011 Edition

Table A
Standard Temperature and Pressure

Name	Value	Unit
Standard Pressure	101.3 kPa 1 atm	kilopascal atmosphere
Standard Temperature	273 K 0°C	kelvin degree Celsius

Table B
Physical Constants for Water

Heat of Fusion	334 J/g
Heat of Vaporization	2260 J/g
Specific Heat Capacity of $H_2O(\ell)$	4.18 J/g•K

Table C
Selected Prefixes

Factor	Prefix	Symbol
10^{3}	kilo-	k
10^{-1}	deci-	d
10^{-2}	centi-	c
10^{-3}	milli-	m
10^{-6}	micro-	μ
10^{-9}	nano-	n
10^{-12}	pico-	p

Table D
Selected Units

Symbol	Name	Quantity
m	meter	length
g	gram	mass
Pa	pascal	pressure
K	kelvin	temperature
mol	mole	amount of substance
J	joule	energy, work, quantity of heat
s	second	time
min	minute	time
h	hour	time
d	day	time
y	year	time
L	liter	volume
ppm	parts per million	concentration
M	molarity	solution concentration
u	atomic mass unit	atomic mass

Table E
Selected Polyatomic Ions

Formula	Name	Formula	Name
H_3O^+	hydronium	CrO_4^{2-}	chromate
Hg_2^{2+}	mercury(I)	$Cr_2O_7^{2-}$	dichromate
NH_4^+	ammonium	MnO_4^-	permanganate
$C_2H_3O_2^-$ / CH_3COO^-	acetate	NO_2^-	nitrite
		NO_3^-	nitrate
CN^-	cyanide	O_2^{2-}	peroxide
CO_3^{2-}	carbonate	OH^-	hydroxide
HCO_3^-	hydrogen carbonate	PO_4^{3-}	phosphate
$C_2O_4^{2-}$	oxalate	SCN^-	thiocyanate
ClO^-	hypochlorite	SO_3^{2-}	sulfite
ClO_2^-	chlorite	SO_4^{2-}	sulfate
ClO_3^-	chlorate	HSO_4^-	hydrogen sulfate
ClO_4^-	perchlorate	$S_2O_3^{2-}$	thiosulfate

Table F
Solubility Guidelines for Aqueous Solutions

Ions That Form *Soluble* Compounds	Exceptions
Group 1 ions (Li^+, Na^+, etc.)	
ammonium (NH_4^+)	
nitrate (NO_3^-)	
acetate ($C_2H_3O_2^-$ or CH_3COO^-)	
hydrogen carbonate (HCO_3^-)	
chlorate (ClO_3^-)	
halides (Cl^-, Br^-, I^-)	when combined with Ag^+, Pb^{2+}, or Hg_2^{2+}
sulfates (SO_4^{2-})	when combined with Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, or Pb^{2+}

Ions That Form *Insoluble* Compounds*	Exceptions
carbonate (CO_3^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
chromate (CrO_4^{2-})	when combined with Group 1 ions, Ca^{2+}, Mg^{2+}, or ammonium (NH_4^+)
phosphate (PO_4^{3-})	when combined with Group 1 ions or ammonium (NH_4^+)
sulfide (S^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
hydroxide (OH^-)	when combined with Group 1 ions, Ca^{2+}, Ba^{2+}, Sr^{2+}, or ammonium (NH_4^+)

*compounds having very low solubility in H_2O

Table G
Solubility Curves at Standard Pressure

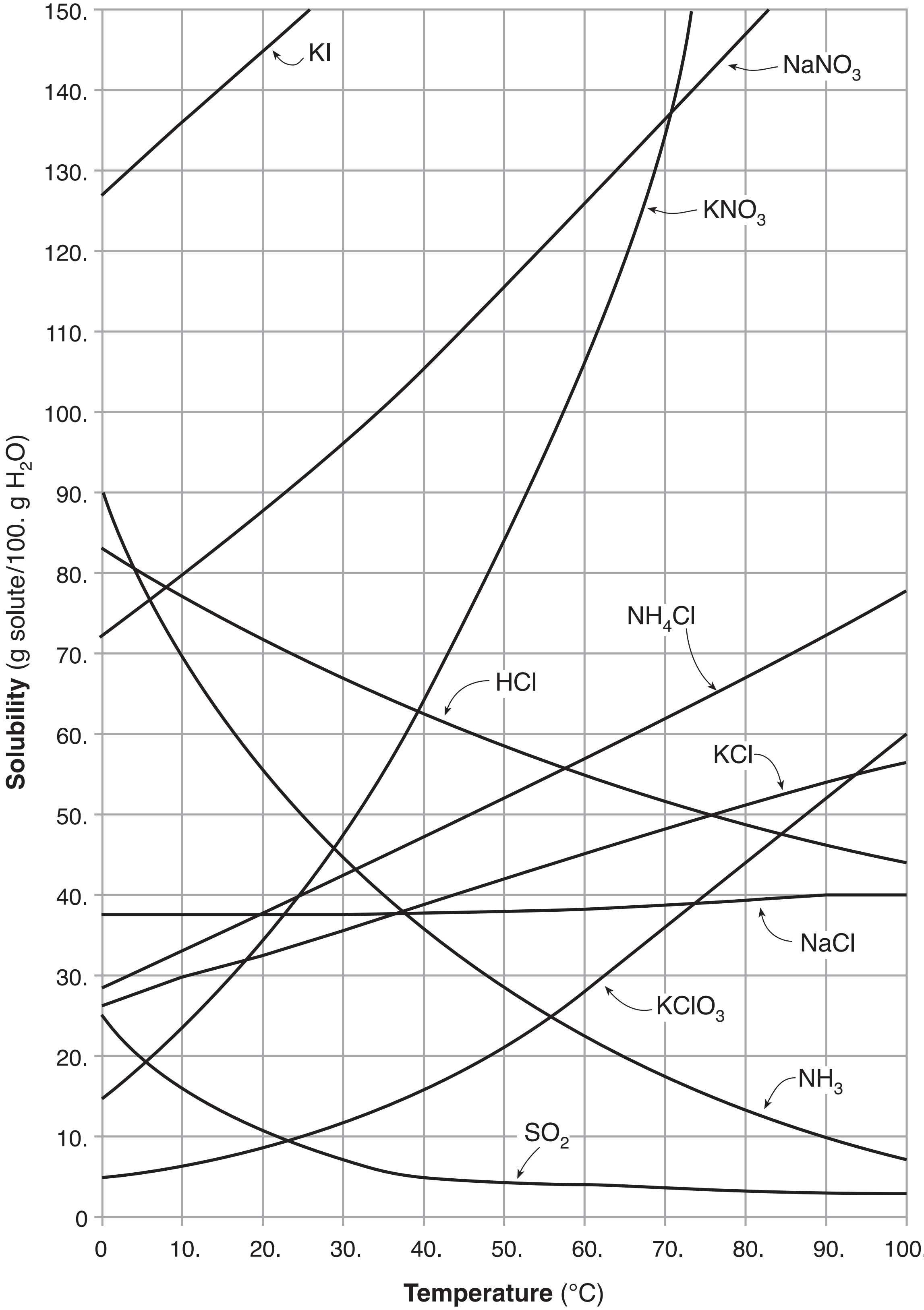


Table H
Vapor Pressure of Four Liquids

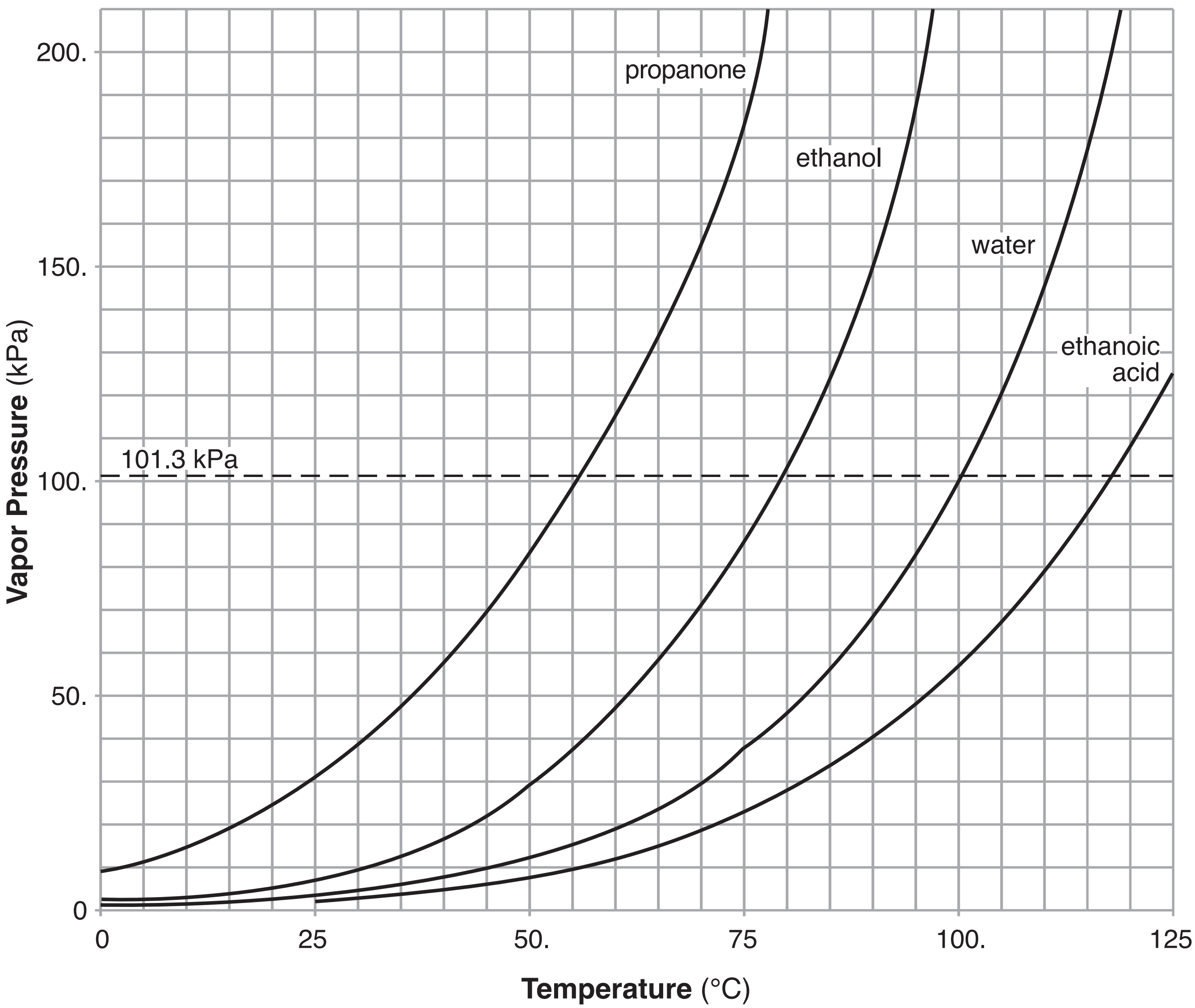


Table I
Heats of Reaction at 101.3 kPa and 298 K

Reaction	ΔH (kJ)*
$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(\ell)$	–890.4
$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(\ell)$	–2219.2
$2C_8H_{18}(\ell) + 25O_2(g) \longrightarrow 16CO_2(g) + 18H_2O(\ell)$	–10943
$2CH_3OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(\ell)$	–1452
$C_2H_5OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(\ell)$	–1367
$C_6H_{12}O_6(s) + 6O_2(g) \longrightarrow 6CO_2(g) + 6H_2O(\ell)$	–2804
$2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$	–566.0
$C(s) + O_2(g) \longrightarrow CO_2(g)$	–393.5
$4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$	–3351
$N_2(g) + O_2(g) \longrightarrow 2NO(g)$	+182.6
$N_2(g) + 2O_2(g) \longrightarrow 2NO_2(g)$	+66.4
$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$	–483.6
$2H_2(g) + O_2(g) \longrightarrow 2H_2O(\ell)$	–571.6
$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$	–91.8
$2C(s) + 3H_2(g) \longrightarrow C_2H_6(g)$	–84.0
$2C(s) + 2H_2(g) \longrightarrow C_2H_4(g)$	+52.4
$2C(s) + H_2(g) \longrightarrow C_2H_2(g)$	+227.4
$H_2(g) + I_2(g) \longrightarrow 2HI(g)$	+53.0
$KNO_3(s) \xrightarrow{H_2O} K^+(aq) + NO_3^-(aq)$	+34.89
$NaOH(s) \xrightarrow{H_2O} Na^+(aq) + OH^-(aq)$	–44.51
$NH_4Cl(s) \xrightarrow{H_2O} NH_4^+(aq) + Cl^-(aq)$	+14.78
$NH_4NO_3(s) \xrightarrow{H_2O} NH_4^+(aq) + NO_3^-(aq)$	+25.69
$NaCl(s) \xrightarrow{H_2O} Na^+(aq) + Cl^-(aq)$	+3.88
$LiBr(s) \xrightarrow{H_2O} Li^+(aq) + Br^-(aq)$	–48.83
$H^+(aq) + OH^-(aq) \longrightarrow H_2O(\ell)$	–55.8

*The ΔH values are based on molar quantities represented in the equations. A minus sign indicates an exothermic reaction.

Table J
Activity Series**

Most Active ↓ Least Active

Metals	Nonmetals
Li	F_2
Rb	Cl_2
K	Br_2
Cs	I_2
Ba	
Sr	
Ca	
Na	
Mg	
Al	
Ti	
Mn	
Zn	
Cr	
Fe	
Co	
Ni	
Sn	
Pb	
H_2	
Cu	
Ag	
Au	

**Activity Series is based on the hydrogen standard. H_2 is *not* a metal.

Table K
Common Acids

Formula	Name
$HCl(aq)$	hydrochloric acid
$HNO_2(aq)$	nitrous acid
$HNO_3(aq)$	nitric acid
$H_2SO_3(aq)$	sulfurous acid
$H_2SO_4(aq)$	sulfuric acid
$H_3PO_4(aq)$	phosphoric acid
$H_2CO_3(aq)$ or $CO_2(aq)$	carbonic acid
$CH_3COOH(aq)$ or $HC_2H_3O_2(aq)$	ethanoic acid (acetic acid)

Table L
Common Bases

Formula	Name
$NaOH(aq)$	sodium hydroxide
$KOH(aq)$	potassium hydroxide
$Ca(OH)_2(aq)$	calcium hydroxide
$NH_3(aq)$	aqueous ammonia

Table M
Common Acid–Base Indicators

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.1–4.4	red to yellow
bromthymol blue	6.0–7.6	yellow to blue
phenolphthalein	8–9	colorless to pink
litmus	4.5–8.3	red to blue
bromcresol green	3.8–5.4	yellow to blue
thymol blue	8.0–9.6	yellow to blue

Source: *The Merck Index*, 14^{th} ed., 2006, Merck Publishing Group

Table N
Selected Radioisotopes

Nuclide	Half-Life	Decay Mode	Nuclide Name
^{198}Au	2.695 d	β^-	gold-198
^{14}C	5715 y	β^-	carbon-14
^{37}Ca	182 ms	β^+	calcium-37
^{60}Co	5.271 y	β^-	cobalt-60
^{137}Cs	30.2 y	β^-	cesium-137
^{53}Fe	8.51 min	β^+	iron-53
^{220}Fr	27.4 s	α	francium-220
^{3}H	12.31 y	β^-	hydrogen-3
^{131}I	8.021 d	β^-	iodine-131
^{37}K	1.23 s	β^+	potassium-37
^{42}K	12.36 h	β^-	potassium-42
^{85}Kr	10.73 y	β^-	krypton-85
^{16}N	7.13 s	β^-	nitrogen-16
^{19}Ne	17.22 s	β^+	neon-19
^{32}P	14.28 d	β^-	phosphorus-32
^{239}Pu	2.410×10^4 y	α	plutonium-239
^{226}Ra	1599 y	α	radium-226
^{222}Rn	3.823 d	α	radon-222
^{90}Sr	29.1 y	β^-	strontium-90
^{99}Tc	2.13×10^5 y	β^-	technetium-99
^{232}Th	1.40×10^{10} y	α	thorium-232
^{233}U	1.592×10^5 y	α	uranium-233
^{235}U	7.04×10^8 y	α	uranium-235
^{238}U	4.47×10^9 y	α	uranium-238

Source: *CRC Handbook of Chemistry and Physics*, 91^{st} ed., 2010–2011, CRC Press

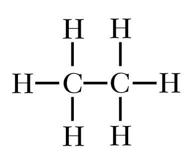
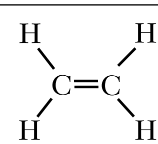
Table O
Symbols Used in Nuclear Chemistry

Name	Notation	Symbol
alpha particle	$^{4}_{2}He$ or $^{4}_{2}\alpha$	α
beta particle	$^{0}_{-1}e$ or $^{0}_{-1}\beta$	β^{-}
gamma radiation	$^{0}_{0}\gamma$	γ
neutron	$^{1}_{0}n$	n
proton	$^{1}_{1}H$ or $^{1}_{1}p$	p
positron	$^{0}_{+1}e$ or $^{0}_{+1}\beta$	β^{+}

Table P
Organic Prefixes

Prefix	Number of Carbon Atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

Table Q
Homologous Series of Hydrocarbons

Name	General Formula	Examples	
		Name	Structural Formula
alkanes	C_nH_{2n+2}	ethane	
alkenes	C_nH_{2n}	ethene	
alkynes	C_nH_{2n-2}	ethyne	H—C≡C—H

Note: n = number of carbon atoms

Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	—F (fluoro-) —Cl (chloro-) —Br (bromo-) —I (iodo-)	$R-X$ (X represents any halogen)	$CH_3CHClCH_3$ 2-chloropropane
alcohol	—OH	$R-OH$	$CH_3CH_2CH_2OH$ 1-propanol
ether	—O—	$R-O-R'$	$CH_3OCH_2CH_3$ methyl ethyl ether
aldehyde	$-\overset{\text{O}}{\overset{\Vert}{\text{C}}}-\text{H}$	$R-\overset{\text{O}}{\overset{\Vert}{\text{C}}}-\text{H}$	$CH_3CH_2\overset{\text{O}}{\overset{\Vert}{\text{C}}}-H$ propanal
ketone	$-\overset{\text{O}}{\overset{\Vert}{\text{C}}}-$	$R-\overset{\text{O}}{\overset{\Vert}{\text{C}}}-R'$	$CH_3\overset{\text{O}}{\overset{\Vert}{\text{C}}}CH_2CH_2CH_3$ 2-pentanone
organic acid	$-\overset{\text{O}}{\overset{\Vert}{\text{C}}}-\text{OH}$	$R-\overset{\text{O}}{\overset{\Vert}{\text{C}}}-\text{OH}$	$CH_3CH_2\overset{\text{O}}{\overset{\Vert}{\text{C}}}-OH$ propanoic acid
ester	$-\overset{\text{O}}{\overset{\Vert}{\text{C}}}-\text{O}-$	$R-\overset{\text{O}}{\overset{\Vert}{\text{C}}}-\text{O}-R'$	$CH_3CH_2\overset{\text{O}}{\overset{\Vert}{\text{C}}}OCH_3$ methyl propanoate
amine	$-\overset{\vert}{\text{N}}-$	$R-\overset{R'}{\overset{\vert}{\text{N}}}-R''$	$CH_3CH_2CH_2NH_2$ 1-propanamine
amide	$-\overset{\text{O}}{\overset{\Vert}{\text{C}}}-\overset{\vert}{\text{N}}\text{H}$	$R-\overset{\text{O}}{\overset{\Vert}{\text{C}}}-\overset{R'}{\overset{\vert}{\text{N}}}\text{H}$	$CH_3CH_2\overset{\text{O}}{\overset{\Vert}{\text{C}}}-NH_2$ propanamide

Note: R represents a bonded atom or group of atoms.

Periodic Table of the Elements

KEY

Atomic Mass →	12.011
Symbol →	C
Atomic Number →	6
Electron Configuration →	2-4
← Selected Oxidation States	−4 +2 +4

Relative atomic masses are based on ^{12}C = 12 (exact)

Note: Numbers in parentheses are mass numbers of the most stable or common isotope.

Period	Group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1.00794 +1 −1 **H** 1 1																	4.00260 0 **He** 2 2
2	6.941 +1 **Li** 3 2-1	9.01218 +2 **Be** 4 2-2											10.81 +3 **B** 5 2-3	12.011 −4 +2 +4 **C** 6 2-4	14.0067 −3 −2 −1 +1 +2 +3 +4 +5 **N** 7 2-5	15.9994 −2 **O** 8 2-6	18.9984 −1 **F** 9 2-7	20.180 0 **Ne** 10 2-8
3	22.98977 +1 **Na** 11 2-8-1	24.305 +2 **Mg** 12 2-8-2											26.98154 +3 **Al** 13 2-8-3	28.0855 −4 +2 +4 **Si** 14 2-8-4	30.97376 −3 +3 +5 **P** 15 2-8-5	32.065 −2 +4 +6 **S** 16 2-8-6	35.453 −1 +1 +5 +7 **Cl** 17 2-8-7	39.948 0 **Ar** 18 2-8-8
4	39.0983 +1 **K** 19 2-8-8-1	40.08 +2 **Ca** 20 2-8-8-2	44.9559 +3 **Sc** 21 2-8-9-2	47.867 +2 +3 +4 **Ti** 22 2-8-10-2	50.9415 +2 +3 +4 +5 **V** 23 2-8-11-2	51.996 +2 +3 +6 **Cr** 24 2-8-13-1	54.9380 +2 +3 +4 +7 **Mn** 25 2-8-13-2	55.845 +2 +3 **Fe** 26 2-8-14-2	58.9332 +2 +3 **Co** 27 2-8-15-2	58.693 +2 +3 **Ni** 28 2-8-16-2	63.546 +1 +2 **Cu** 29 2-8-18-1	65.409 +2 **Zn** 30 2-8-18-2	69.723 +3 **Ga** 31 2-8-18-3	72.64 +2 +4 **Ge** 32 2-8-18-4	74.9216 −3 +3 +5 **As** 33 2-8-18-5	78.96 −2 +4 +6 **Se** 34 2-8-18-6	79.904 −1 +1 +5 **Br** 35 2-8-18-7	83.798 0 +2 **Kr** 36 2-8-18-8
5	85.4678 +1 **Rb** 37 2-8-18-8-1	87.62 +2 **Sr** 38 2-8-18-8-2	88.9059 +3 **Y** 39 2-8-18-9-2	91.224 +4 **Zr** 40 2-8-18-10-2	92.9064 +3 +5 **Nb** 41 2-8-18-12-1	95.94 +6 **Mo** 42 2-8-18-13-1	(98) +4 +6 +7 **Tc** 43 2-8-18-13-2	101.07 +3 **Ru** 44 2-8-18-15-1	102.906 +3 **Rh** 45 2-8-18-16-1	106.42 +2 +4 **Pd** 46 2-8-18-18	107.868 +1 **Ag** 47 2-8-18-18-1	112.41 +2 **Cd** 48 2-8-18-18-2	114.818 +3 **In** 49 2-8-18-18-3	118.71 +2 +4 **Sn** 50 2-8-18-18-4	121.760 −3 +3 +5 **Sb** 51 2-8-18-18-5	127.60 −2 +4 +6 **Te** 52 2-8-18-18-6	126.904 −1 +1 +5 +7 **I** 53 2-8-18-18-7	131.29 0 +2 +4 +6 **Xe** 54 2-8-18-18-8
6	132.905 +1 **Cs** 55 2-8-18-18-8-1	137.33 +2 **Ba** 56 2-8-18-18-8-2	138.9055 +3 **La** 57 2-8-18-18-9-2	178.49 +4 **Hf** 72 *18-32-10-2	180.948 +5 **Ta** 73 -18-32-11-2	183.84 +6 **W** 74 -18-32-12-2	186.207 +4 +6 +7 **Re** 75 -18-32-13-2	190.23 +3 +4 **Os** 76 -18-32-14-2	192.217 +3 +4 **Ir** 77 -18-32-15-2	195.08 +2 +4 **Pt** 78 -18-32-17-1	196.967 +1 +3 **Au** 79 -18-32-18-1	200.59 +1 +2 **Hg** 80 -18-32-18-2	204.383 +1 +3 **Tl** 81 -18-32-18-3	207.2 +2 +4 **Pb** 82 -18-32-18-4	208.980 +3 +5 **Bi** 83 -18-32-18-5	(209) +2 +4 **Po** 84 -18-32-18-6	(210) **At** 85 -18-32-18-7	(222) 0 **Rn** 86 -18-32-18-8
7	(223) +1 **Fr** 87 -18-32-18-8-1	(226) +2 **Ra** 88 -18-32-18-8-2	(227) +3 **Ac** 89 -18-32-18-9-2	(261) +4 **Rf** 104	(262) **Db** 105	(266) **Sg** 106	(272) **Bh** 107	(277) **Hs** 108	(276) **Mt** 109	(281) **Ds** 110	(280) **Rg** 111	(285) **Cn** 112	(284) **Uut** 113**	(289) **Uuq** 114	(288) **Uup** 115	(292) **Uuh** 116	(?) **Uus** 117	(294) **Uuo** 118

140.116 +3 +4 **Ce** 58	140.908 +3 **Pr** 59	144.24 +3 **Nd** 60	(145) +3 **Pm** 61	150.36 +2 +3 **Sm** 62	151.964 +2 +3 **Eu** 63	157.25 +3 **Gd** 64	158.925 +3 **Tb** 65	162.500 +3 **Dy** 66	164.930 +3 **Ho** 67	167.259 +3 **Er** 68	168.934 +3 **Tm** 69	173.04 +2 +3 **Yb** 70	174.9668 +3 **Lu** 71
232.038 +4 **Th** 90	231.036 +4 +5 **Pa** 91	238.029 +3 +4 +5 +6 **U** 92	(237) +3 +4 +5 +6 **Np** 93	(244) +3 +4 +5 +6 **Pu** 94	(243) +3 +4 +5 +6 **Am** 95	(247) +3 **Cm** 96	(247) +3 +4 **Bk** 97	(251) +3 **Cf** 98	(252) +3 **Es** 99	(257) +3 **Fm** 100	(258) +2 +3 **Md** 101	(259) +2 +3 **No** 102	(262) +3 **Lr** 103

*denotes the presence of (2-8-) for elements 72 and above

**The systematic names and symbols for elements of atomic numbers 113 and above will be used until the approval of trivial names by IUPAC.

Source: *CRC Handbook of Chemistry and Physics*, 91st ed., 2010–2011, CRC Press

Table S
Properties of Selected Elements

Atomic Number	Symbol	Name	First Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling* Point (K)	Density** (g/cm^3)	Atomic Radius (pm)
1	H	hydrogen	1312	2.2	14	20.	0.000082	32
2	He	helium	2372	—	—	4	0.000164	37
3	Li	lithium	520.	1.0	454	1615	0.534	130.
4	Be	beryllium	900.	1.6	1560.	2744	1.85	99
5	B	boron	801	2.0	2348	4273	2.34	84
6	C	carbon	1086	2.6	—	—	—	75
7	N	nitrogen	1402	3.0	63	77	0.001145	71
8	O	oxygen	1314	3.4	54	90.	0.001308	64
9	F	fluorine	1681	4.0	53	85	0.001553	60.
10	Ne	neon	2081	—	24	27	0.000825	62
11	Na	sodium	496	0.9	371	1156	0.97	160.
12	Mg	magnesium	738	1.3	923	1363	1.74	140.
13	Al	aluminum	578	1.6	933	2792	2.70	124
14	Si	silicon	787	1.9	1687	3538	2.3296	114
15	P	phosphorus (white)	1012	2.2	317	554	1.823	109
16	S	sulfur (monoclinic)	1000.	2.6	388	718	2.00	104
17	Cl	chlorine	1251	3.2	172	239	0.002898	100.
18	Ar	argon	1521	—	84	87	0.001633	101
19	K	potassium	419	0.8	337	1032	0.89	200.
20	Ca	calcium	590.	1.0	1115	1757	1.54	174
21	Sc	scandium	633	1.4	1814	3109	2.99	159
22	Ti	titanium	659	1.5	1941	3560.	4.506	148
23	V	vanadium	651	1.6	2183	3680.	6.0	144
24	Cr	chromium	653	1.7	2180.	2944	7.15	130.
25	Mn	manganese	717	1.6	1519	2334	7.3	129
26	Fe	iron	762	1.8	1811	3134	7.87	124
27	Co	cobalt	760.	1.9	1768	3200.	8.86	118
28	Ni	nickel	737	1.9	1728	3186	8.90	117
29	Cu	copper	745	1.9	1358	2835	8.96	122
30	Zn	zinc	906	1.7	693	1180.	7.134	120.
31	Ga	gallium	579	1.8	303	2477	5.91	123
32	Ge	germanium	762	2.0	1211	3106	5.3234	120.
33	As	arsenic (gray)	944	2.2	1090.	—	5.75	120.
34	Se	selenium (gray)	941	2.6	494	958	4.809	118
35	Br	bromine	1140.	3.0	266	332	3.1028	117
36	Kr	krypton	1351	—	116	120.	0.003425	116
37	Rb	rubidium	403	0.8	312	961	1.53	215
38	Sr	strontium	549	1.0	1050.	1655	2.64	190.
39	Y	yttrium	600.	1.2	1795	3618	4.47	176
40	Zr	zirconium	640.	1.3	2128	4682	6.52	164

Atomic Number	Symbol	Name	First Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling* Point (K)	Density** (g/cm^3)	Atomic Radius (pm)
41	Nb	niobium	652	1.6	2750.	5017	8.57	156
42	Mo	molybdenum	684	2.2	2896	4912	10.2	146
43	Tc	technetium	702	2.1	2430.	4538	11	138
44	Ru	ruthenium	710.	2.2	2606	4423	12.1	136
45	Rh	rhodium	720.	2.3	2237	3968	12.4	134
46	Pd	palladium	804	2.2	1828	3236	12.0	130.
47	Ag	silver	731	1.9	1235	2435	10.5	136
48	Cd	cadmium	868	1.7	594	1040.	8.69	140.
49	In	indium	558	1.8	430.	2345	7.31	142
50	Sn	tin (white)	709	2.0	505	2875	7.287	140.
51	Sb	antimony (gray)	831	2.1	904	1860.	6.68	140.
52	Te	tellurium	869	2.1	723	1261	6.232	137
53	I	iodine	1008	2.7	387	457	4.933	136
54	Xe	xenon	1170.	2.6	161	165	0.005366	136
55	Cs	cesium	376	0.8	302	944	1.873	238
56	Ba	barium	503	0.9	1000.	2170.	3.62	206
57	La	lanthanum	538	1.1	1193	3737	6.15	194
Elements 58–71 have been omitted.								
72	Hf	hafnium	659	1.3	2506	4876	13.3	164
73	Ta	tantalum	728	1.5	3290.	5731	16.4	158
74	W	tungsten	759	1.7	3695	5828	19.3	150.
75	Re	rhenium	756	1.9	3458	5869	20.8	141
76	Os	osmium	814	2.2	3306	5285	22.587	136
77	Ir	iridium	865	2.2	2719	4701	22.562	132
78	Pt	platinum	864	2.2	2041	4098	21.5	130.
79	Au	gold	890.	2.4	1337	3129	19.3	130.
80	Hg	mercury	1007	1.9	234	630.	13.5336	132
81	Tl	thallium	589	1.8	577	1746	11.8	144
82	Pb	lead	716	1.8	600.	2022	11.3	145
83	Bi	bismuth	703	1.9	544	1837	9.79	150.
84	Po	polonium	812	2.0	527	1235	9.20	142
85	At	astatine	—	2.2	575	—	—	148
86	Rn	radon	1037	—	202	211	0.009074	146
87	Fr	francium	393	0.7	300.	—	—	242
88	Ra	radium	509	0.9	969	—	5	211
89	Ac	actinium	499	1.1	1323	3471	10.	201
Elements 90 and above have been omitted.								

*boiling point at standard pressure

**density of solids and liquids at room temperature and density of gases at 298 K and 101.3 kPa

— no data available

Source: *CRC Handbook for Chemistry and Physics*, 91st ed., 2010–2011, CRC Press

Table T
Important Formulas and Equations

Density	$d = \frac{m}{V}$	d = density m = mass V = volume
Mole Calculations	$\text{number of moles} = \frac{\text{given mass}}{\text{gram-formula mass}}$	
Percent Error	$\text{\% error} = \frac{\text{measured value} - \text{accepted value}}{\text{accepted value}} \times 100$	
Percent Composition	$\text{\% composition by mass} = \frac{\text{mass of part}}{\text{mass of whole}} \times 100$	
Concentration	$\text{parts per million} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 1\,000\,000$	
	$\text{molarity} = \frac{\text{moles of solute}}{\text{liter of solution}}$	
Combined Gas Law	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	P = pressure V = volume T = temperature
Titration	$M_AV_A = M_BV_B$	M_A = molarity of H^+ M_B = molarity of OH^- V_A = volume of acid V_B = volume of base
Heat	$q = mC\Delta T$ $q = mH_f$ $q = mH_v$	q = heat H_f = heat of fusion m = mass H_v = heat of vaporization C = specific heat capacity ΔT = change in temperature
Temperature	K = °C + 273	K = kelvin °C = degree Celsius