Academy for Advance Studies
AP Chemistry Pre-AP Assignment

AP Chemistry is an extremely fast paced course and it is necessary that you come to this course ready to work from Day 1. It will be very important for you to **read each and every chapter** several times in order to get the maximum benefit out of this course. We will begin by reviewing what you have done in Chemistry I. This is basically the first three chapters of the book. I will ask that you thoroughly read and take notes on the first three chapters prior to the first day of class, so that you are well prepared to take on even more challenges as the days and weeks go on. Note-cards can be a valuable tool as you begin to get into college level work. These cards should contain important notes and explanations on one side, with key words on the other.

In AP Chemistry tt is important that you be able to explain processes as well as solve problems. In addition, you may want to review your Chemistry I notes pertaining to each section and place these on note cards as well (I strongly encourage you to do this, since it will be expected that you remember details that were covered in Chem. I).

The following assignment will be reviewed in class beginning on the first day of school. I will take questions on any problems you may have had from this assignment on the first few days of class. Therefore, you need to have your material with you on the first day. Please come prepared. Due dates listed below may be adjusted based on class needs and experiences. Students are suggested to complete as much of the summer assignment as they can prior to the start of the school year.

If you have any questions, please email me at charlena.raines@henry.k12.ga.us or send questions through the AP chemistry remind [**text @ap-chemaas to 81010**]. Do not wait until the last minute to do these assignment as it will take a while to complete. If you would like to schedule virtual tutoring prior to the start of the school year please reach out through email or remand.

Optional Mental Math Practice [by Aug 28th]

Note that calculators are not allowed for multiple choice questions. Students need to be able to do basic mental math and estimate. There is an optional mental math posted on Ms. Raines web page in addition to an online AP Chemistry textbook. https://schoolwires.henry.k12.ga.us/Page/110741

Items to Memorize: [by Aug 28th]

Name and charges for elements in the following groups.

Group 1: Alkali Metals all have +1 charge but Hydrogen can be +1 or -1

Group 2: Alkaline Earth Metals all have +2 charge

Group 17 Halogens all have -1 charge, and name ends in –ide [example: Chloride is Cl^{-1}]

Group 18: Noble Gases

Strong Acids and Strong Bases (shown in table on last page)

Solubility Rules

- **Group 1 (Alkali Metals) always soluble**
- **Nitrates, acetates, and ammonium always soluble**
- **Precipitates to know: $BaSO_4$, AgCl, PbI_2**

Required Pre-AP Assignment. For any items, involving calculations show ALL calculations with units and chemical formulas. Students need to use dimensional analysis (factor label method) on any and ALL conversions.

I. Significant Figures [checked Aug 5th]

How many significant figures are in each of the following?

Reference video: https://www.youtube.com/watch?v=7b60RZqut0U

1) 1.92 mm
2) 0.030100 kJ
3) 6.022×10^{23} atoms
4) 460.00 L
5) 0.00036 cm^3
6) 100
7) 1001
8) 0.001
9) 0.0101
10) 0.010100

Calculate the following to the correct number of significant figures.

Reference video 1: https://www.youtube.com/watch?v=o5BmoMDJLRY [multiplication and division]

Reference video 2: https://www.youtube.com/watch?v=2eXC6s9X6Wc [addition and subtraction]

Reference video 3: https://www.youtube.com/watch?v=Ma4nDAOP6Gk [counted quantities]

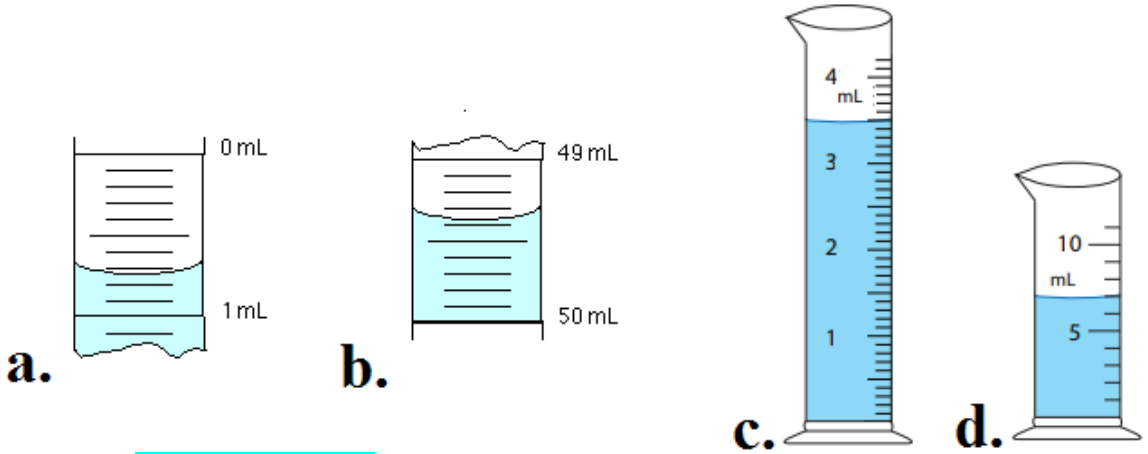
1) 1.27 / 5.296
2) 12.235 / 1.01
3) 12.2 + 0.38
5) 2.1 x 3.21
6) 200.1 x 120
7) 17.6 + 2.838 + 2.3 + 110.77

4) 17.3 + 2.785 8) 3.28 (2.45 – 6.6)

Record the following measurements to the correct Significant figures.

Reference video: https://www.youtube.com/watch?v=gzvzvDv_BnA [burette]

Reference video: https://www.youtube.com/watch?v=7ewRaV5baik [graduated cylinder]



II. Scientific Notation [checked Aug 5th]

Reverence video: https://www.youtube.com/watch?v=Dme-G4rc6NI&t=328s

Record the following in correct scientific notation:

1) 350,000,000 cal
2) 0.0000721 mol
3) 0.0000000809 Å
4) 765,400,000,000 atoms

Performing the following calculations (without calculator) and write the answers using scientific notation

Reference video: https://www.youtube.com/watch?v=ciFOlirz4Js

1) $(5.3 \times 10^3) \times (2.0 \times 10^4)$
2) $(8.4 \times 10^6) / (2.0 \times 10^4)$
3) $(1.3 \times 10^4) \times (3.1 \times 10^4)$
4) $(8.8 \times 10^3) / (4.4 \times 10^8)$

III. Metric & time Conversions [checked Aug 5th]

Use factor labeling method to convert the following: Must show your work using dimensional analysis

Reference video: https://www.youtube.com/watch?v=lYgTiQ-ZIf0

Equalities you MUST know. base to mili, base to kilo, base to nano, base to centi, and time

1. 515 m = ___ nm (nanometers)
2. 200 mm (millimeter) = ____ meters
3. 325 hours = _____ seconds.
4. 200.0 centijoule (cJ) = _____ kilojoule (kJ)
5. 10 kilometers into meters
6. 15,050 milligrams into grams
7. 3,264 milliliters into liters
8. 9,674,444 grams into kilograms

IV. Matter [due no later than Aug 10th, recommend early submission]

Describe each of the following AND give at least **one example**

1. States of matter
   a. Solid
   b. Liquid
   c. gas
2. classification of matter
   a. pure substance
   b. element
   c. compound
   d. mixture
   e. homogeneous mixture
   f. heterogeneous mixture
   g. solution
3. changes
   a. describe:
      i. endothermic
      ii. exothermic
   b. Describe: physical change
   c. Give three 3 examples of physical changes
   d. For each phase change below give the states of matter it is occurring between and specific if it is an endothermic or exothermic process
      i. melting
      ii. Boiling
      iii. Condensation
      iv. Freezing
      v. Sublimation
      vi. deposition
   e. describe each of the following separation techniques
      i. manual separation
      ii. distillation
      iii. Filtration
      iv. Evaporation
      v. Paper chromatography
   f. Describe chemical change
   g. Give 3 examples of chemical changes

4. Density Solve the following density problems [Density = mass/ volume]
    a. Mercury metal is poured into a graduated cylinder that holds exactly 22.5 mL. The mercury used to fill the cylinder weighs 306.0 g. From this information, calculate the density of mercury.
    b. What is the mass of the ethyl alcohol that exactly fills a 200.0 mL container? The density of ethyl alcohol is 0.789 g/mL.
    c. A rectangular block of copper metal weighs 1896 g. The dimensions of the block are 8.4 cm by 5.5 cm by 4.6 cm. From this data, what is the density of copper?
    d. What volume of silver metal will weigh exactly 2500.0 g. The density of silver is 10.5 g/cm^3.
    e. What is the density of CO gas if 0.196 g occupies a volume of 100 ml?
    f. Find the mass of 250.0 mL of benzene. The density of benzene is 0.8786 g/mL
    g. Given that the density of Hg is about 16.5 $g\ mL^{-1}$, what is the volume of one mole of Hg?
    h. What is the density of oxygen gas at STP (standard temperature and pressure)? [HINT: use molar mass and molar volume]

V. Electron Structure and Periodicity **[due no later than Aug 10th, recommend early submission]**

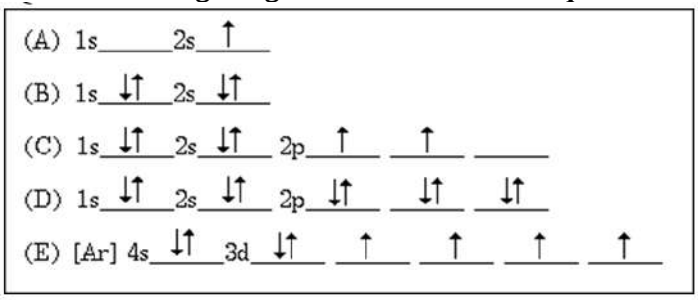
1. Draw the orbital (arrow) notation for nickel.
2. How many unpaired electrons are in arsenic?
3. Write the electron configuration for palladium.
4. How many valence electrons are in mercury?
5. Write the noble gas electron configuration for californium (Cf).
6. Write the noble gas electron configuration 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 nickel

Use these answers for the next 4 questions

(A) $1s^2\ 2s^2 2p^5\ 3s^2 3p^5$ (B) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6$ (C) $1s^2\ 2s^2 2p^6 2d^{10}\ 3s^2 3p^6$
(D) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^5$ (E) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^3\ 4s^2$

11. An impossible electronic configuration
12. The ground-state configuration for the atoms of a transition element
13. The ground-state configuration of a negative ion of a halogen
14. The ground-state configuration of a common ion of an alkaline earth element

Use the following image to answer the next 4 questions



15. Represents an atom that is chemically unreactive
16. Represents an atom in an excited state
17. Represents an atom that has four valence electrons.
18. Represents an atom of a transition metal.
19. What is the average atomic mass of silicon given the following abundance information on the isotopes of silicon in the table to the right? →

Mass number	Abundance
Si-28	92.21 %
Si-29	4.70 %
Si-30	3.09 %

20. Given the data below determine the average atomic mass

Isotope % Abundance	Isotopic Mass
Sb-121 57.25%	120.9038 amu
Sb-123 42.75%	122.0041 amu

VI. Reactions [due no later than Aug 17th, recommend early submission]

In each of the equations below, the reactants are written correctly. You must write the correct products and then balance the equation. Identify the type of chemical reaction before writing the products.

1. $CaCO_3 \rightarrow$
2. $Al + O_2 \rightarrow$
3. $Fe + CuSO_4 \rightarrow$
4. $C_6H_{12} + O_2 \rightarrow$
5. $Zn + H_2SO_4 \rightarrow$
6. $Cl_2 + MgI_2 \rightarrow$
7. $NaOH \rightarrow$
8. $Fe + HCl \rightarrow$
9. $NaOH + H_3PO_4 \rightarrow$
10. $(NH_4)_2SO_4 + Ca(OH)_2 \rightarrow$
11. $AgNO_3 + K_2SO_4 \rightarrow$
12. $Mg(OH)_2 + H_3PO_4 \rightarrow$
13. $Na + H_2O \rightarrow$
14. $KClO_3 \rightarrow$
15. $Al_2(SO_4)_3 + Ca_3(PO_4)_2 \rightarrow$
16. $SO_2 + H_2O \rightarrow$
17. $(NH_4)_3PO_4 + Ba(OH)_2 \rightarrow$
18. $Ca(OH)_2 + HNO_3 \rightarrow$
19. $C_3H_8 + O_2 \rightarrow$
20. $Li + S \rightarrow$
21. Solid sodium bicarbonate is mixed with copper (II) nitrate.
22. Magnesium oxide is heated.
23. Acetic acid is added to a solution of ammonia.
24. Iron (III) chloride is mixed with silver sulfite.
25. A solid piece of aluminum is put into a solution of nickel (II) chloride.
26. A solution of lithium chloride is added to a solution of lead (IV) nitrite.
27. Sulfuric acid is added to a solution of aluminum hydroxide.
28. Cadmium nitrate is added to sodium sulfide.
29. Chromium (III) sulfate is added to ammonium carbonate.
30. Methane combusts with oxygen in air.

VII. Mole Concept Sample Problems] [due no later than Aug 24st , recommend early submission]

1. Convert each of the following to moles.
   a. 12.64 g $NaOH$
   b. 800. g $CaBr_2$
   c. 3.00 x 10^{24} atoms Au
   d. 3.011 x 10^{22} molecules H_2O
   e. 40.0 L of Ne gas
   f. 6.78 L of Ar gas
2. Given 0.250 moles of Sulfur trioxide determine
   a. the mass
   b. the number of atoms
   c. the volume at STP
3. How many molecules are in 100.0 L of Carbon dioxide at STP?
4. If you have 3.45 mole of a gas at STP how many liters do you have?
5. How many moles are in 3.02 x 10^{26} molecules of water?
6. If you have 0.00982 mole of water how many molecules of water?

   Molecular and Empirical Formula reference:
   http://www.cabrillo.edu/~aromero/CHEM_1A/1A_Handouts/Empirical%20Formulas.pdf
7. A pure sample of an oxide of sulfur contains 40.0 % sulfur and 60.0 % oxygen by mass. What is the empirical formula of the oxide?
8. A compound contains 18.8% sodium, 29.0% chlorine, and 52.2% oxygen, by mass. If the molar mass of the compound is 122.44 g/mol, determine the empirical and molecular formulas.
9. 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.
10. 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.

VIII. Stoichiometry] [due no later than Aug 28th , recommend early submission]

1. 30.5 g of sodium metal reacts with a solution of excess lithium bromide. How many grams of lithium metal are produced? $Na + LiBr \rightarrow NaBr + Li$
2. Propane, C_3H_8, undergoes combustion. How many grams of propane are needed to produce 45.9 g of water?
   $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$
3. Using the equation in number 2 if 13.5 L of oxygen is combusted at 150°C how many grams of water is produced. (density of O_2 @ 150°C = 0.922 g/L).
4. 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? $2\ Na_3PO_4 + 3\ Ba(NO_3)_2 \rightarrow Ba_3(PO_4)_2 + 6\ NaNO_3$
5. Octane, C_8H_{18}, undergoes combustion. How many grams of oxygen are needed to burn 10.0 g of octane?
   $2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$
9. Sodium azide, NaN_3, decomposes into its elements. How many grams of sodium azide are required to form 34.8 g of nitrogen gas? $2\ NaN_3 \rightarrow 2\ Na + 3\ N_2$
10. If you produce 26.04 g of barium phosphate how many grams of sodium phosphate was consumed.
    $2\ Na_3PO_4 + 3\ Ba(NO_3)_2 \rightarrow Ba_3(PO_4)_2 + 6\ NaNO_3$
11. 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? $4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$

IX. Molarity [Molarity(M) = mole/liter] [due no later than Aug 28th, recommend early submission]

Reference Video: https://www.youtube.com/watch?v=SXf9rDnVFao [calculating molarity]
Reference video: https://www.youtube.com/watch?v=KLjWa9cE2uk [using molarity]
Reference video: https://www.youtube.com/watch?v=sWfn8hbXRp8 [using molarity]

1. What is the molarity of a 0.550 L solution containing 25 g sodium chloride [NaCl]?
2. What is the mass of HI used to create 2.50L of a 0.48 M solution of hydroiodic acid [HI]?
3. How many moles of aluminum hydroxide [$Al(OH)_3$] are needed to make 755 mL of 0.250 M solution?
4. If you have 2.50 moles of sulfuric acid [H_2SO_4] and want to make a 0.50 M solution how many liters of water do you need?
5. How many grams of $Mg_3(PO_4)_2$ do you need to make 2750 mL of a 4.50 M solution?
6. How many milliliters is needed to make use 48.0 g calcium sulfide [CaS] to make a 0.250 M solution?

Polyatomic ions and transition metal exceptions

Frequently given the chemical formula and chemical name will be given to you in the prompt. But will need to know the charge of polyatomic ions in addition to the charge (oxidation state) of the representative groups.. Check out video for trick in remembering polyatomics. [T43 trick https://www.youtube.com/watch?v=BxJXe0_dBOQ]

Name	Formula	Name	Formula	Name	Formula
silver	Ag^{+}	nitrate	NO_3^{-1}	**Strong Acids**	
Zinc	Zn^{2+}	nitrite	NO_2^{-1}	Hydrochloric acid	HCl
ammonium	NH_4^{+1}	hydronium	H_3O^{+1}	Hydrobromic acid	HBr
bicarbonate	HCO_3^{-1}	hydroxide	OH^{-1}	Hydroiodic acid	HI
bisulfate	HSO_4^{-1}	hypobromite	BrO^{-1}	Sulfuric acid	H_2SO_4
bisulfide	HS^{-1}	hypochlorite	ClO^{-1}	Nitric acid	HNO_3
bisulfite	HSO_3^{-1}	hypoiodite	IO^{-1}	Chloric acid	$HClO_3$
bromate	BrO_3^{-1}	iodate	IO_3^{-1}	Perchloric acid	$HClO_4$
bromite	BrO_2^{-1}	iodite	IO_2^{-1}	**Strong Bases**	
carbonate	CO_3^{-2}	cyanide	CN^{-}	Lithium hydroxide	LiOH
chlorate	ClO_3^{-1}	dichromate	$Cr_2O_7^{2-}$	Sodium hydroxide	NaOH
chlorite	ClO_2^{-} 1	sulfate	SO_4^{2-}	Potassium hydroxide	KOH
chromate	CrO_4^{-2}	sulfite	SO_3^{2-}	Rubidium hydroxide	RbOH
oxalate	$C_2O_4^{2-}$	periodate	IO_4^{-}	Cesium hydroxide	CsOH
perbromate	BrO_4^{-}	permanganate	MnO_4^{-}	Calcium hydroxide	$Ca(OH)_2$
perchlorate	ClO_4^{-}	peroxide	O_2^{2-}	Strontium hydroxide	$Sr(OH)_2$
acetate	$C_2H_3O_2^{-1}$	phosphite	PO_3^{3-}	Barium hydroxide	$Ba(OH)_2$
phosphate	PO_4^{3-}	thiocyanate	SCN^{-}		

AP Periodic Table and Formula Sheets on Next few pages

PERIODIC TABLE OF THE ELEMENTS

1																	18
1 **H** 1.008	2											13	14	15	16	17	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.30	3	4	5	6	7	8	9	10	11	12	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.97	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.95	43 **Tc**	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57–71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po**	85 **At**	86 **Rn**
87 **Fr**	88 **Ra**	89–103 †	104 **Rf**	105 **Db**	106 **Sg**	107 **Bh**	108 **Hs**	109 **Mt**	110 **Ds**	111 **Rg**	112 **Cn**	113 **Nh**	114 **Fl**	115 **Mc**	116 **Lv**	117 **Ts**	118 **Og**

*Lanthanoids	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm**	62 **Sm** 150.36	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
†Actinoids	89 **Ac**	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lr**

AP® CHEMISTRY EQUATIONS AND CONSTANTS

Throughout the exam the following symbols have the definitions specified unless otherwise noted.

L, mL	=	liter(s), milliliter(s)	mm Hg	=	millimeters of mercury
g	=	gram(s)	J, kJ	=	joule(s), kilojoule(s)
nm	=	nanometer(s)	V	=	volt(s)
atm	=	atmosphere(s)	mol	=	mole(s)

ATOMIC STRUCTURE

$E = h\nu$

$c = \lambda\nu$

E = energy
ν = frequency
λ = wavelength

Planck's constant, $h = 6.626 \times 10^{-34}$ J s
Speed of light, $c = 2.998 \times 10^{8}$ m s^{-1}
Avogadro's number = 6.022×10^{23} mol^{-1}
Electron charge, $e = -1.602 \times 10^{-19}$ coulomb

EQUILIBRIUM

$K_c = \dfrac{[C]^c[D]^d}{[A]^a[B]^b}$, where $a\,A + b\,B \rightleftarrows c\,C + d\,D$

$K_p = \dfrac{(P_C)^c(P_D)^d}{(P_A)^a(P_B)^b}$

$K_a = \dfrac{[H^+][A^-]}{[HA]}$

$K_b = \dfrac{[OH^-][HB^+]}{[B]}$

$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$ at 25°C

$= K_a \times K_b$

$pH = -\log[H^+]$, $pOH = -\log[OH^-]$

$14 = pH + pOH$

$pH = pK_a + \log\dfrac{[A^-]}{[HA]}$

$pK_a = -\log K_a$, $pK_b = -\log K_b$

Equilibrium Constants

K_c (molar concentrations)
K_p (gas pressures)
K_a (weak acid)
K_b (weak base)
K_w (water)

KINETICS

$[A]_t - [A]_0 = -kt$

$\ln[A]_t - \ln[A]_0 = -kt$

$\dfrac{1}{[A]_t} - \dfrac{1}{[A]_0} = kt$

$t_{1/2} = \dfrac{0.693}{k}$

k = rate constant
t = time
$t_{1/2}$ = half-life

GASES, LIQUIDS, AND SOLUTIONS

$$PV = nRT$$

$$P_A = P_{\text{total}} \times X_A, \text{ where } X_A = \frac{\text{moles A}}{\text{total moles}}$$

$$P_{total} = P_A + P_B + P_C + \ldots$$

$$n = \frac{m}{\boldsymbol{M}}$$

$$\text{K} = {}^\circ\text{C} + 273$$

$$D = \frac{m}{V}$$

$$KE_{\text{molecule}} = \frac{1}{2}mv^2$$

Molarity, M = moles of solute per liter of solution

$$A = \varepsilon bc$$

P = pressure
V = volume
T = temperature
n = number of moles
m = mass
$\boldsymbol{M}$ = molar mass
D = density
KE = kinetic energy
v = velocity
A = absorbance
ε = molar absorptivity
b = path length
c = concentration

Gas constant, R = 8.314 J $\text{mol}^{-1}\,\text{K}^{-1}$
= 0.08206 L atm $\text{mol}^{-1}\,\text{K}^{-1}$
= 62.36 L torr $\text{mol}^{-1}\,\text{K}^{-1}$

1 atm = 760 mm Hg = 760 torr

STP = 273.15 K and 1.0 atm

Ideal gas at STP = 22.4 L mol^{-1}

THERMODYNAMICS/ELECTROCHEMISTRY

$$q = mc\Delta T$$

$$\Delta S^\circ = \sum S^\circ \text{ products} - \sum S^\circ \text{ reactants}$$

$$\Delta H^\circ = \sum \Delta H_f^\circ \text{ products} - \sum \Delta H_f^\circ \text{ reactants}$$

$$\Delta G^\circ = \sum \Delta G_f^\circ \text{ products} - \sum \Delta G_f^\circ \text{ reactants}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$
$$= -RT \ln K$$
$$= -nFE^\circ$$

$$I = \frac{q}{t}$$

$$E_{cell} = E^\circ_{cell} - \frac{RT}{nF} \ln Q$$

q = heat
m = mass
c = specific heat capacity
T = temperature
S° = standard entropy
H° = standard enthalpy
G° = standard Gibbs free energy
n = number of moles
E° = standard reduction potential
I = current (amperes)
q = charge (coulombs)
t = time (seconds)
Q = reaction quotient

Faraday's constant, F = 96,485 coulombs per mole of electrons

$$1 \text{ volt} = \frac{1 \text{ joule}}{1 \text{ coulomb}}$$