

ap chemistry summer prep course

name:

[click here](#) the video playlist

this course is online at chemistryacademy.org.

To complete this course, [watch the videos](#) then complete the [problem set](#) at the end of this packet. This is the best way to take this course. However...if you are already familiar with these topics, or are pressed for time, you can go directly to the problem set using the link below and watch the suggested videos as you go.

This document is best completed digitally: save a copy, then fill in the blanks by typing or drawing. If that proves problematic, you may print the problem set, complete it, take pictures of each page with your [android](#) or [iphone](#), and hand in a single scanned document.

[click here to go directly to the problem set](#)





welcome to your ap chemistry summer prep course!

some inspirational
thoughts

a history of ap
chemistry

about the exam

useful resources

a little bit about each chapter and a quiz for each

1. some things to memorize

2. stoichiometry

3. solutions

4. rates

5. equilibrium

6. acids and bases

7. buffers

8. the atom

9. gases

10. bonding

11. intermolecular forces

12. energy

13. electrochemistry

14. putting it all together

problem set with
selected answers





ap chemistry:
some inspirational thoughts



congratulations!





if the wind will not serve...
take to the oars.

andy allan's (sciencegeek.net) favorite quote

chemists are scrappy



Shirley Urban's favorite quote



about the ap chemistry exam



AP chemistry FAQ

when is the test?

early in may each year

how long is the test?

3 hours

what are the course prerequisites?

Students should have successfully completed a general high school chemistry course and Algebra II.

what is the format of the test?

Section I: Multiple Choice: 60 Questions | 90 Minutes | 50% of Exam Score
Section II: Free Response: 7 Questions (3 long and 4 short) | 105 Minutes | 50% of Exam Score

primary source: [ap chemistry course overview](#) by the college board

what is on the test?

topics include atomic structure, intermolecular forces and bonding, chemical reactions, kinetics, thermodynamics, and equilibrium.
good question- they are very specific
update: in 2019 they now list what is not on the exam as "exclusion statements"
(Best searched in the course and exam description as "spaceXspace")

what is not on the test?

what scores get college credit?

- 5 - Extremely well qualified to receive college credit
- 4 - Well qualified to receive college credit
- 3 - Qualified to receive college credit
- 2 - Possibly qualified to receive college credit
- 1 - No recommendation to receive college credit

AP Test	Average Score
Chinese Language	4.36
Spanish Language	3.79
Calculus BC	3.72
Japanese Language	3.69
Physics C Mechanics	3.55
Spanish Language Standard	3.54
Physics C E&M	3.44
Studio Art 2D Design	3.37
French Language	3.30
Studio Art Drawing	3.28
Chinese Language (Standard)	3.25
Italian Language	3.21
Studio Art 3-D Design	3.17
Economics - Micro	3.15
French Language (Standard)	3.15
Spanish Literature	3.12
Psychology	3.12
Computer Science A	3.09
German Language (Standard)	3.05
German Language	3.05
Music Theory	3.03
Latin	2.98
Biology	2.91
Japanese Language (Standard)	2.91
Italian Language (Standard)	2.87
Gov and Politics - Comparative	2.86
Calculus AB	2.86
Statistics	2.80
Economics - Macro	2.79
English Language	2.79
English Literature	2.78
Physics 2	2.77
Art History	2.76
European History	2.75
Human Geography	2.69
Chemistry	2.66
United States History	2.64
World History	2.61
Environmental Science	2.59
Gov and Politics - US	2.54
Physics 1	2.32



Percent correct "composite score"	score
<35	1 or 2
35-51	3
52-67	4
>67	5



ap chemistry: advice from students





student post-exam comments 2018-2019

Was it harder
or easier than
expected?

"Harder than expected" 2
Easier than expected 10
About what I expected 1

Did you feel prepared for
conceptual questions?

Yes: 0%
No: 100%

Did you have
enough time?

Yes: 87%
No: 13%

Did you feel
prepared for
math-based
questions?

Yes: 100%
No: 0%

What is your advice for next
years students?

- Do more practice FRQ's
- Redo previous tests to study
- Spend less time solving math questions
- Spend more time on theoretical questions (4)
- More time on buffers/titrations (6)
- More time on acids/bases (3)
- More time on real life scenarios

ap chemistry: a typical schedule



ap chemistry general schedule 2018-2019

August/September 2018 (19/19)

Su	M	T	W	Th	F	Sa
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

October 2018 (22/41)

Su	M	T	W	Th	F	Sa
30	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

November 2018 (18/59)

Su	M	T	W	Th	F	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

December 2018 (15/74)

Su	M	T	W	Th	F	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

January 2019 (21/95)

Su	M	T	W	Th	F	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

1,2. welcome and stoichiometry test mid september

3. solutions test end september

4. rates test end october

5. equilibrium test mid november

6. acids and bases test early december

7. buffers test end december

8. atom test mid january

9. midterm exam January __

10. gases test end january

February 2019 (18/113)

Su	M	T	W	Th	F	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28		

March 2019 (20/133)

Su	M	T	W	Th	F	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

April 2019 (17/150)

Su	M	T	W	Th	F	Sa
31	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

May 2019 (22/172)

Su	M	T	W	Th	F	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

June 2019 (8/180)

Su	M	T	W	Th	F	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

11. bonding test mid february

12. IM forces test end feb

13. energy test mid march

14. electrochemistry test end march

15. review april

16. exam May 9

17. post-exam May 8- graduation



ap chemistry: history and growth



1961 – The first AP Chemistry Exam. 2 hours, 18 free-response questions.

1970 – 20 free-response questions.

1971 – 18 free-response questions.

1976 – 9 free-response questions.

1980 90 minutes, calculators allowed

2008 a full practice exam was released by the College Board.

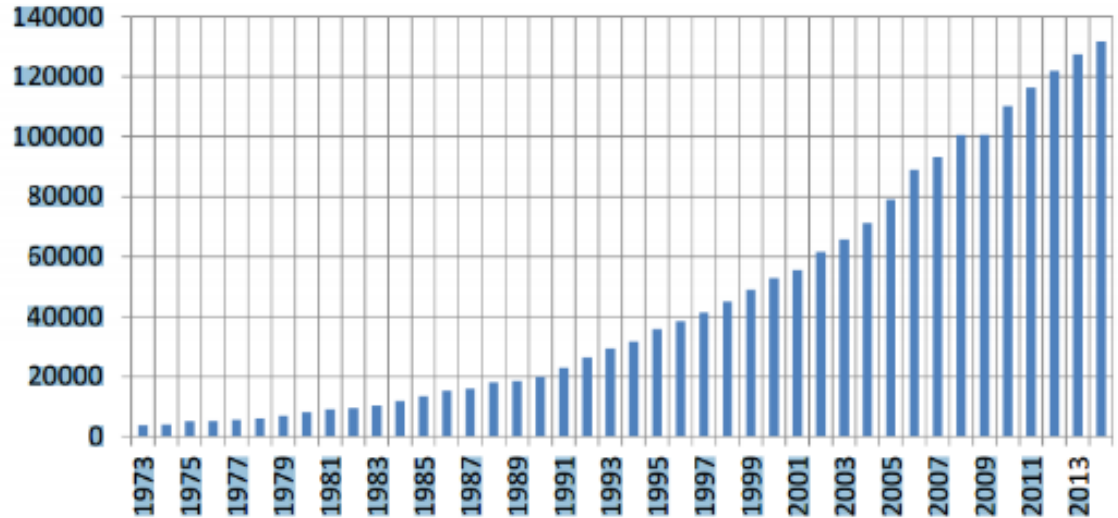
2014 – 7 free-response questions. The first examination of the new AP Chemistry Curriculum.

2015 As 2014, but with an extended period of 105 minutes for the free-response section (in response to not enough time being allocated for the 2014 exam).

AP Chemistry growth curve



AP Chem Operational Exam Volume



2019 9 chapter system replaces six big ideas
sources: Adrian Dingle, J. Chem. Ed. article



ap chemistry: about the exam

QUIZ



about the ap chemistry exam

QUIZ

when is the test? early in may each year

how long is the test? 3 hours 15 minutes

what is the format of
the test? Section I: Multiple Choice: 60 Questions | 90 Minutes | 50% of Exam Score
Section II: Free Response: 7 Questions (3 long and 4 short)
| 105 Minutes | 50% of Exam Score

what do the scores
mean? 5 - Extremely well qualified to receive college credit
4 - Well qualified to receive college credit
3 - Qualified to receive college credit
2 - Possibly qualified to receive college credit
1 - No recommendation to receive college credit

what is the average
score? about 2.6

what is my score if I get
half the questions
wrong? about a 3





some useful ap chemistry resources



1. Welcome to chemistry

$$d = \frac{m}{V} \quad d = \text{density; } m = \text{mass in g; } v = \text{volume in mL (} = \text{cm}^3\text{)}$$

$$\text{temperature: } K = ^\circ\text{C} + 273.15$$

$$^\circ\text{C} = (^\circ\text{F} - 32) \times \frac{5}{9} \quad ^\circ\text{F} = \frac{9}{5}^\circ\text{C} + 32$$

2. Stoichiometry 1 mole = 6.02 x 10²³

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$\% \text{ error} = \frac{\text{error}}{\text{accepted value}} \times 100$$

% composition

$$= \frac{\text{molar mass of each element}}{\text{molar mass of compound}} \times 100\%$$

3. Solutions

$$\text{Molarity (M)} = \frac{\text{moles of solute}}{\text{liters of solution}}$$

$$C_1V_1 = C_2V_2$$

c = concentration, v = volume

4. Rates (kinetics)

rate law for A → B

$$\text{rate} = \frac{\Delta[A]}{\Delta t} = -\frac{\Delta[B]}{\Delta t}$$

order	0 th	1 st	2 nd
rate law	rate = k	rate = k[A]	rate = k[A] ²
integrated form	A _t = -kt + A ₀	ln A _t = -kt + ln A ₀	$\frac{1}{ A _t} = kt + \frac{1}{ A _0}$
straight line	A versus t	ln A versus t	1/ A versus t
half life	$t_{1/2} = \frac{\ln 2}{k}$	$t_{1/2} = \frac{\ln 2}{k}$	$t_{1/2} = \frac{1}{k[A]_0}$
units for k	M/s	1/s	1/Ms

Arrhenius equation: relates rate to activation energy and temperature

$$k = Ae^{E_a/RT}$$

k = rate constant T = Kelvin temperature

E_a = activation energy in J/mol

better form:

$$E_a = \frac{(\ln \frac{k_2}{k_1})R}{\frac{1}{T_2} - \frac{1}{T_1}}$$

A = frequency factor (a constant, no units)

$$R = \text{gas constant} = \frac{8.314 \text{ J}}{\text{K mol}}$$

5. Equilibrium for aA + bB ⇌ cC + dD

$$K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

omit liquids and solids

K_{eq} = equilibrium constant

[A] = molar concentration of A

$$K_p = K_c(RT)^{\Delta n}$$

K_p = equilibrium constant (pressure)

K_c = equilibrium constant (concentration)

R = 0.08206 L.atm/mol.K

T = temperature (in Kelvin)

Δn = sum of the coefficients of the gaseous products minus the sum of the coefficients of the gaseous reactants

6. Acids and Bases H₂O (l) ⇌ H⁺(aq) + OH⁻(aq); K_w = [H⁺][OH⁻] = 10⁻¹⁴

$$pH = -\log[H^+] \quad HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq) \quad K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

$$10^{-pH} = [H^+] \quad B(aq) + H_2O(l) \rightleftharpoons BH^+(aq) + OH^-(aq) \quad K_b = \frac{[BH^+][OH^-]}{[B]}$$

$$pOH = -\log[OH^-]$$

$$K_a \times K_b = K_w = 10^{-14}$$

$$10^{-pOH} = [OH^-]$$

$$pH + pOH = 14$$

pH sig figs = # of decimal places. Ex: 7.2 = 1, 7.22 = 2, 7.222 = 3

ap chemistry equations

black: included on formula sheet

red: not on formula sheet (memorize)

7. Buffers

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

$$K_b = \frac{[OH^-][HA]}{[A^-]}$$

Henderson-Hasselbalch equation:

$$pH = pK_a + \log[A^-]/[HA]$$

$$pOH = pK_b + \log[BH^+]/[B]$$

10. Gases

units

P pressure 1 atm = 14.7 psi = 760 mm Hg or Torr = 101.3 kPa

V = volume (L)

T = Kelvin Temp (K)

STP = standard temp and pressure = 1 atm, 273.15 K

M = molar masses (g/mol)

d = density

n = # of moles (mol)

R = 0.0821 L.atm/mol K

formulas

boyles: charles: gay-lussac: combined:

$$\frac{T_1}{V_1} = \frac{T_2}{V_2} \quad \frac{T_1}{P_1} = \frac{T_2}{P_2} \quad \frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

ideal gas law:

$$PV = nRT \quad \text{must use L.atm mol K}$$

law:

22.4 L

= 1 mole gas at STP

$$\text{density formula } d = \frac{PM}{RT}$$

$$\text{graham's law: } \frac{\text{rate}_1}{\text{rate}_2} = \sqrt{\frac{M_2}{M_1}}$$

partial pressure

$$\text{partial pressure of gas a} = \frac{\text{moles of gas a}}{\text{total moles of gas}} \times \text{total pressure}$$

11, 12: Bonds and intermolecular forces:
no equations

12. Intermolecular forces

no equations

9. Midterm examination

13. Energy (thermochemistry and thermodynamics)

$$q = mc\Delta T$$

q = heat, m = mass

c = specific heat (J/g°C)

= 4.184 J/g °C for H₂O (l)

ΔT = temp change in °C

1 Nutritional Calorie

= 4184 Joules

= 4 British Thermal Units (BTU)

= 1000 calories

= 0.0016 kilowatt hours

$$\Delta G = \Delta H - T\Delta S$$

ΔG = change in free energy

ΔH = change in enthalpy

T = temperature

ΔS = change in entropy

14. Electrochemistry

$$\Delta G = -nFE$$

ΔG = free energy in joules

n = number of electrons

F = 96,500 coulombs (J/V mol)

E = cell potential (volts)

$$K = e^{En/0.0257}$$

K = equilibrium constant (no units)

E = cell potential

n = number of electrons

$$\Delta G = -RT \ln K$$

R = 8.314 J/k mol

T = kelvin temp

K = equilibrium constant (no units)

Ampere = 1 C/s

1 valence electron
+1
alkali metals
group 1

2 valence electrons
+2
alkaline earth metals
group 2

1s	1 H hydrogen 1.008	2 He helium 4.00
2s	3 Li lithium 6.94	4 Be beryllium 9.012
3s	11 Na sodium 22.99	12 Mg magnesium 24.31
4s	19 K potassium 39.10	20 Ca calcium 40.08
5s	37 Rb rubidium 85.47	38 Sr strontium 87.62
6s	55 Cs cesium 132.91	56 Ba barium 137.33
7s	87 Fr francium 223.02	88 Ra radium 226.05



periodic table of the elements

AP chemistry edition

this side is full of details... the other side is the version you're allowed to use on tests

valence electrons: 3, 4, 5, 6, 7, 8

common charges: +3, -3, -2, -1

metals, nonmetals, noble gases

5 B boron 10.81	6 C carbon 12.01	7 N nitrogen 14.01	8 O oxygen 16.00	9 F fluorine 19.00	10 Ne neon 20.18
13 Al aluminum 26.98	14 Si silicon 28.09	15 P phosphorus 30.97	16 S sulfur 32.07	17 Cl chlorine 35.45	18 Ar argon 39.95
31 Ga gallium 69.72	32 Ge germanium 72.59	33 As arsenic 74.92	34 Se selenium 78.96	35 Br bromine 79.91	36 Kr krypton 83.80
49 In indium 114.82	50 Sn tin 118.69	51 Sb antimony 121.75	52 Te tellurium 127.60	53 I iodine 126.90	54 Xe xenon 131.30
81 Tl thallium 204.37	82 Pb lead 207.19	83 Bi bismuth 208.980	84 Po polonium 208.982	85 At astatine 209.99	86 Rn radon 222.02
113 Nh nihonium 286.19	114 Fl flerovium 289.19	115 Mc moscovium 289.19	116 Lv livermorium 293.20	117 Ts tennessine 294	118 Og oganesson 294

transition metals

21 Sc scandium 44.96	22 Ti titanium 47.90	23 V vanadium 50.94	24 Cr chromium 52.00	25 Mn manganese 54.94	26 Fe iron 55.85	27 Co cobalt 58.93	28 Ni nickel 58.71	29 Cu copper 63.55	30 Zn zinc 65.37
39 Y yttrium 88.91	40 Zr zirconium 91.22	41 Nb niobium 92.91	42 Mo molybdenum 95.94	43 Tc technetium 96.91	44 Ru ruthenium 101.07	45 Rh rhodium 102.91	46 Pd palladium 106.40	47 Ag silver 107.87	48 Cd cadmium 112.40
71 Lu lutetium 174.97	72 Hf hafnium 178.49	73 Ta tantalum 180.95	74 W tungsten 183.85	75 Re rhenium 186.21	76 Os osmium 190.20	77 Ir iridium 192.22	78 Pt platinum 195.09	79 Au gold 196.97	80 Hg mercury 200.59
105 Lr lawrencium 262.11	104 Rf rutherfordium 267.12	105 Db dubnium 268.13	106 Sg seaborgium 271.15	107 Bh bohrium 270.13	108 Hs hassium 277.15	109 Mt meitnerium 278.16	110 Ds darmstadtium 281.17	111 Rg roentgenium 281.16	112 Cn copernicium 285.18

atomic number

symbol

solid

liquid

gas

metalloid

name

average atomic mass (amu)

metal

metalloid

nonmetal

common ions

57 La lanthanum 138.91	58 Ce cerium 140.12	59 Pr praseodymium 140.91	60 Nd neodymium 144.24	61 Pm promethium (144.91)	62 Sm samarium 150.41	63 Eu europium 151.96	64 Gd gadolinium 157.25	65 Tb terbium 158.92	66 Dy dysprosium 162.50	67 Ho holmium 164.93	68 Er erbium 167.26	69 Tm thulium 168.93	70 Yb ytterbium 173.04
89 Ac actinium 227.05	90 Th thorium 232.04	91 Pa protactinium 231.04	92 U uranium 238.05	93 Np neptunium 237.05	94 Pu plutonium 244.06	95 Am americium 243.06	96 Cm curium 247.07	97 Bk berkelium 247.07	98 Cf californium 251.08	99 Es einsteinium 252.08	100 Fm fermium 257.10	101 Md mendelevium 258.10	102 No nobelium 259.10

common ions

acetate CH ₃ CO ₂ ⁻	bisulfite HSO ₃ ⁻	chlorite ClO ₂ ⁻	hydroxide OH ⁻	nitrite NO ₂ ⁻	phosphide P ³⁻
ammonium NH ₄ ⁺	bromide Br ⁻	chromate CrO ₄ ²⁻	hypochlorite ClO ⁻	oxide O ²⁻	sulfate SO ₄ ²⁻
bromide Br ⁻	carbonate CO ₃ ²⁻	cyanide CN ⁻	iodide I ⁻	perchlorate ClO ₄ ⁻	sulfide S ²⁻
bicarbonate HCO ₃ ⁻	chlorate ClO ₃ ⁻	dichromate Cr ₂ O ₇ ²⁻	nitrate NO ₃ ⁻	permanganate MnO ₄ ⁻	sulfite SO ₃ ²⁻
bisulfate HSO ₄ ⁻	chloride Cl ⁻	fluoride F ⁻	nitride N ³⁻	phosphate PO ₄ ³⁻	thiosulfate S ₂ O ₃ ²⁻

PERIODIC TABLE OF THE ELEMENTS

1 H 1.008																	2 He 4.00
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
6.94	9.01											10.81	12.01	14.01	16.00	19.00	20.18
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
22.99	24.30											26.98	28.09	30.97	32.06	35.45	39.95
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
39.10	40.08	44.96	47.90	50.94	52.00	54.94	55.85	58.93	58.69	63.55	65.39	69.72	72.59	74.92	78.96	79.90	83.80
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
85.47	87.62	88.91	91.22	92.91	95.94	(98)	101.1	102.91	106.42	107.87	112.41	114.82	118.71	121.75	127.60	126.91	131.29
55 Cs	56 Ba	*La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
132.91	137.33	138.91	178.49	180.95	183.85	186.21	190.2	192.2	195.08	196.97	200.59	204.38	207.2	208.98	(209)	(210)	(222)
87 Fr	88 Ra	*Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg							
(223)	226.02	227.03	(261)	(262)	(266)	(264)	(277)	(268)	(271)	(272)							

*Lanthanide Series

38 Ce	39 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
140.12	140.91	144.24	(145)	150.4	151.97	157.25	158.93	162.50	164.93	167.26	168.93	173.04	174.97

†Actinide Series

90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
232.04	231.04	238.03	(237)	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(262)

ADVANCED PLACEMENT CHEMISTRY EQUATIONS AND CONSTANTS

Throughout the rest 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

$$E = h\nu$$

$$c = \lambda\nu$$

$$E = \text{energy}$$

$$\nu = \text{frequency}$$

$$\lambda = \text{wavelength}$$

$$\text{Planck's constant, } h = 6.626 \times 10^{-34} \text{ J s}$$

$$\text{Speed of light, } c = 2.998 \times 10^8 \text{ m s}^{-1}$$

$$\text{Avogadro's number} = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$\text{Electron charge, } e = -1.602 \times 10^{-19} \text{ coulomb}$$

EQUILIBRIUM

$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}, \text{ where } aA + bB \rightleftharpoons cC + dD$$

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

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

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

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

$$= K_a \times K_b$$

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

$$14 = pH + pOH$$

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

$$pK_w = -\log K_w, \text{ p}K_b = -\log K_b$$

Equilibrium Constants

$$K_c \text{ (molar concentrations)}$$

$$K_p \text{ (gas pressures)}$$

$$K_a \text{ (weak acid)}$$

$$K_b \text{ (weak base)}$$

$$K_w \text{ (water)}$$

GASES, LIQUIDS, AND SOLUTIONS

$$PV = nRT$$

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

$$P_{\text{total}} = P_A + P_B + P_C + \dots$$

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

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

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

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

$$\text{Molarity, } M = \text{moles of solute per liter of solution}$$

$$A = abc$$

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

Gas constant, $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
 $= 0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$
 $= 62.36 \text{ L torr mol}^{-1} \text{ K}^{-1}$
 $1 \text{ atm} = 760 \text{ mm Hg}$
 $= 760 \text{ torr}$
 $STP = 0.0^\circ\text{C}$ and 1.000 atm

THERMOCHEMISTRY/ELECTROCHEMISTRY

$$q = mc\Delta T$$

$$m = \text{mass}$$

$$c = \text{specific heat capacity}$$

$$T = \text{temperature}$$

$$S^\circ = \text{standard entropy}$$

$$H^\circ = \text{standard enthalpy}$$

$$G^\circ = \text{standard free energy}$$

$$n = \text{number of moles}$$

$$E^\circ = \text{standard reduction potential}$$

$$i = \text{current (amperes)}$$

$$q = \text{charge (coulombs)}$$

$$t = \text{time (seconds)}$$

Faraday's constant, $F = 96,485 \text{ coulombs per mole of electrons}$
 $1 \text{ volt} = \frac{1 \text{ joule}}{1 \text{ coulomb}}$

KINETICS

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

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

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

$$k = \text{rate constant}$$

$$t = \text{time}$$

$$t_{1/2} = \text{half-life}$$



QUIZ

some useful ap chemistry resources



ap chemistry resources

QUIZ

do they supply a periodic table
on the exam

yes but it is bare bones

do I have to memorize any formulas

yes, some

should I focus more on
math aspects or
qualitative aspects of
the exam

post test surveys overwhelmingly
indicate students should focus
more on nonmathematical aspects
of the course

can you use a
calculator?

only for the frq section





ap chemistry

memorization 1 of 4



AP chemistry memorization part 1

common polyatomic ions (radicals)

acetate	$\text{CH}_3\text{CO}_2^{-1}$ or $\text{C}_2\text{H}_3\text{O}_2^{-1}$ or OAc^{-1}
ammonium	NH_4^+
carbonate	CO_3^{2-}
chromate	CrO_4^{2-}
cyanide	CN^{-1}
dichromate	$\text{Cr}_2\text{O}_7^{2-}$
bicarbonate or hydrogen carbonate	HCO_3^{-1}
hydroxide	OH^{-1}
nitrate	NO_3^{-1}
phosphate	PO_4^{-3}
sulfate	SO_4^{-2}
sulfite	SO_3^{-2}

charges by group number

IA (1)	+1
IIA (2)	+2
IIIA (3)	+3,
IVA (14)	+4
VA (15)	-3,
VIA (16)	-2
VIIA (17)	-1
VIIIA (18)	0

diatomics, allotropes, more ions

diatomic elements	HBrONClIF: H_2 , Br_2 , O_2 , N_2 , Cl_2 , I_2 , F_2
most common P, S allotropes	P_4 S_8
hypo fluoride, hypochlorite, hypobromite, hypoiodite	FO^{-1} , ClO^{-1} , BrO^{-1} , IO^{-1}
fluorite, chlorite, bromite, iodite	FO_2^{-1} , ClO_2^{-1} , BrO_2^{-1} , IO_2^{-1}
fluorate, chlorate, bromate, iodate	FO_3^{-1} , ClO_3^{-1} , BrO_3^{-1} , IO_3^{-1}
perfluorate, perchlorate, perbromate, periodate	FO_4^{-1} , ClO_4^{-1} , BrO_4^{-1} , IO_4^{-1}



ap chemistry

memorization 2 of 4



acids and bases

Six strong acids	Hydrochloric acid (HCl), Hydrobromic acid (HBr), Hydroiodic acid (HI), nitric acid (HNO ₃), perchloric acid (HClO ₄), and sulfuric acid (H ₂ SO ₄)
Strong bases	group 1 hydroxides, barium hydroxide and its hydrates, strontium hydroxide
Are group 2 hydroxides strong or weak bases?	Weak until strontium

AP chemistry: memorization part 2

solubility guidelines (don't have to know exceptions)

soluble cations	sodium potassium, ammonium,
soluble anions	nitrate
are sulfates soluble?	usually (all except calcium, strontium, barium, and lead)
are chlorides, bromides and iodides soluble?	usually (except Ag ⁺¹ , Pb ⁺² , and Hg ₂ ⁺²)
are carbonates, sulfides, or phosphates soluble	no (except if with group 1 or ammonium cation as shown above)
are metal hydroxides and oxides soluble?	no (except if with group 1 or ammonium cation as shown above)

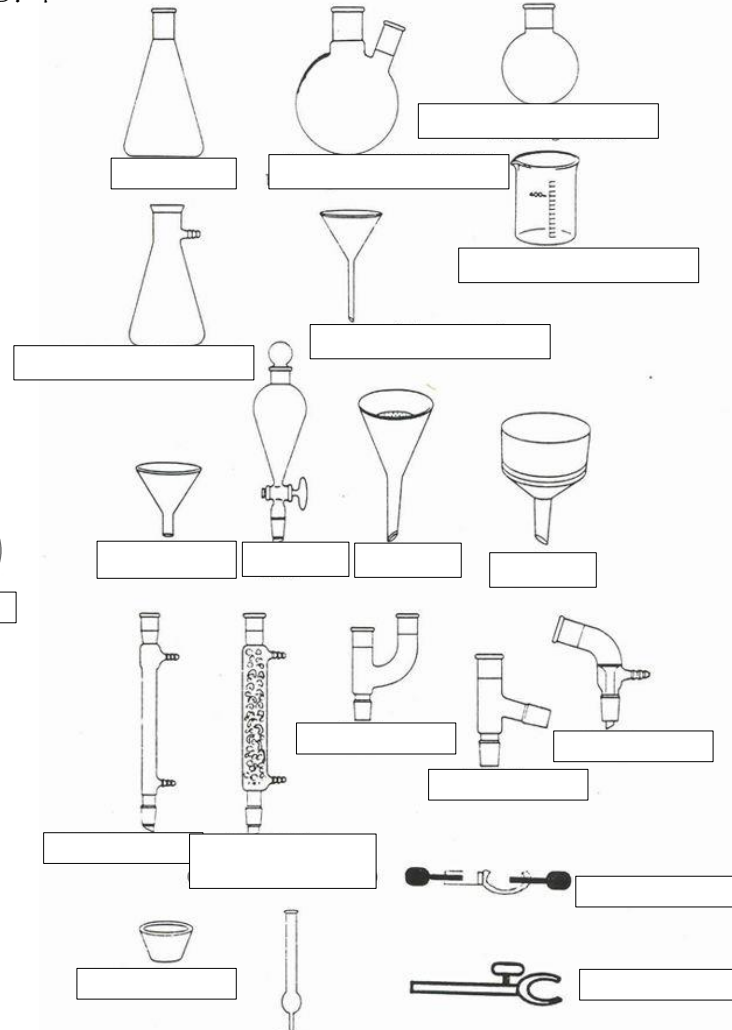
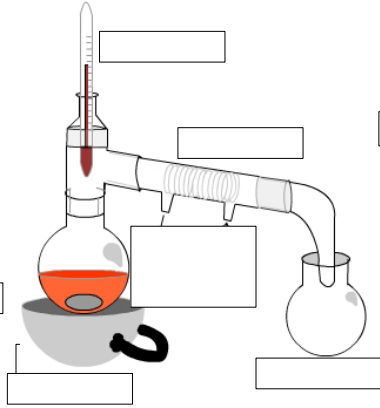
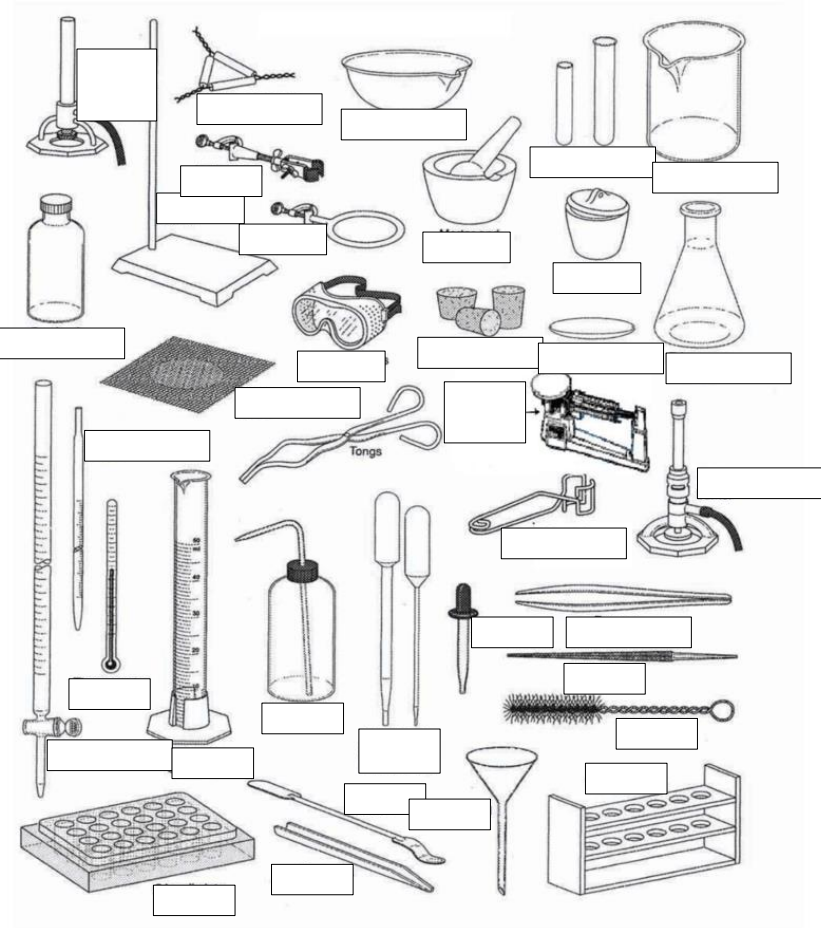


ap chemistry

memorization 3 of 4



chemistry lab equipment





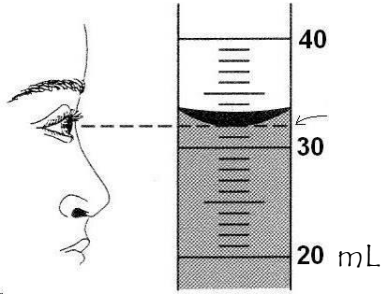
ap chemistry

memorization 4 of 4



ap chemistry memorization part 4: significant figures

volume?



32.0 mL

when measuring:

include the known digits plus one estimated digit.

why is it important to line up level to the meniscus?

to minimize parallax

how does this device minimize parallax??

no reflection when aligned



number

sig. figs (sf). why

32

2 "non-zero numbers are always significant"

0.0323

3 "leading zeroes are never significant"

3.004

4 "sandwiched zeroes are always significant"

300

1 "trailing zeroes are only significant if there is a decimal place"

300.

3

300.20

5

how many significant figures??



dump

keep

keep if decimal present
5 sf

rounding: ex: 2.25 to 2 sf: 2.3 5 or >: go up

+,- ex: 4.16+ 3.3 = 7.5 s.f. based on decimal places
x, / ex: 666 / 333 = 2.00 keep fewest sig figs

infinite sig. figs. for counted or defined numbers
ex: 3 oranges... 12 in = 1 foot

round as you go? nope only at end

how many extra digits should I carry along?

at least 1 guard digit, more is ok

combinations?

apply the more stringent rule at end.

ex: (3.111 + 5.03) x 33 =

raw number is 268.653
needs 2 decimal places and 2 sf...
2 sf is more stringent...
answer is 270 or 2.7 x 10²



QUIZ

ap chemistry

memorization



ap chemistry memorization

QUIZ

name these: SO_4^{2-} , SO_3^{2-} , S^{2-}

sulfate, sulfite, sulfide

provide formulas for nitrate, nitrite, nitride

NO_3^- , NO_2^- , N^{3-}

list the diatomic
elements

HBrONClIF: hydrogen (H_2), bromine (Br_2), oxygen (O_2),
nitrogen (N_2), chlorine (Cl_2), iodine (I_2) and fluorine (F_2)

list six strong acids

HCl , HBr , HI , HNO_3 , H_2SO_4 , HClO_4

list four ions that render any
ionic compound water soluble

Na^+ , K^+ , NH_4^+ , NO_3^-

what are these and what are
they good for?



how many significant figures
are in 1.0, 0.010, and 10.?

2 for each number.

beaker, graduated cylinder, flask

$5.000(3.20 + 4.800) = ?$

40.0 (the least precise calculation is multiplying,
calling for 3 significant figures)





ap chemistry

introduction to stoichiometry



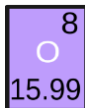
the mole

is just a number
and easy to measure

= Avogadro's number
= 6.02×10^{23} (that's 6E23)



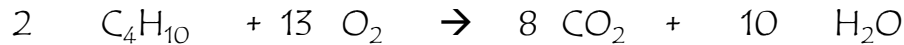
6.02×10^{23} H atoms
= 1.0 g H atoms
= 1 mole H atoms



6.02×10^{23} O atoms
= 16.0 g O atoms
= 1 mole O atoms



1. mole-mole conversions



2 moles butane: = 13 moles oxygen = 8 moles CO₂ = 10 moles water

How many **moles** of CO₂ will be produced from 1 **mole** of butane and excess oxygen?

4 (2 makes 8, so 1 makes 4)

How many **moles** of oxygen are needed to react with 17.26 **moles** of butane?

$$17.26 \text{ moles C}_4\text{H}_{10} \times \frac{13 \text{ moles O}_2}{2 \text{ moles C}_4\text{H}_{10}} = 112.2 \text{ moles O}_2$$

How many **moles** of butane react with 0.42 **moles** of oxygen?

$$0.42 \text{ moles O}_2 \times \frac{2 \text{ moles C}_4\text{H}_{10}}{13 \text{ moles O}_2} = 0.065 \text{ moles C}_4\text{H}_{10}$$

2. mole-gram conversions



The combustion of 3 **moles** of butane (C₄H₁₀) with excess oxygen will produce ___ **grams** of CO₂.

$$3 \text{ moles C}_4\text{H}_{10} \times \frac{8 \text{ moles CO}_2}{2 \text{ moles C}_4\text{H}_{10}} \times \frac{44 \text{ grams CO}_2}{1 \text{ moles CO}_2} = 528 \text{ grams CO}_2$$

For you: The combustion of 4 moles of butane (C₄H₁₀) will require ___ grams of O₂.

$$4 \text{ moles C}_4\text{H}_{10} \times \frac{13 \text{ moles O}_2}{2 \text{ moles C}_4\text{H}_{10}} \times \frac{32 \text{ grams O}_2}{1 \text{ moles O}_2} = 832 \text{ grams O}_2$$



ap chemistry

mole conversions





3. gram-gram conversions



example: The combustion of 100 grams of butane (C_4H_{10}) with excess oxygen will produce ___ grams of CO_2 .

$$100 \text{ g C}_4\text{H}_{10} \times \frac{1 \text{ mole C}_4\text{H}_{10}}{58 \text{ g C}_4\text{H}_{10}} \times \frac{8 \text{ moles CO}_2}{2 \text{ moles C}_4\text{H}_{10}} \times \frac{44 \text{ grams CO}_2}{1 \text{ mole CO}_2} = 303 \text{ grams CO}_2$$

for you: The combustion of 453 grams of butane (C_4H_{10}) with excess oxygen will produce ___ grams of H_2O .

$$453 \text{ g C}_4\text{H}_{10} \times \frac{1 \text{ mole C}_4\text{H}_{10}}{58 \text{ g C}_4\text{H}_{10}} \times \frac{10 \text{ moles H}_2\text{O}}{2 \text{ moles C}_4\text{H}_{10}} \times \frac{18 \text{ grams H}_2\text{O}}{1 \text{ mole H}_2\text{O}} = 703 \text{ grams H}_2\text{O}$$

4. molecular and other conversions

a microgram is barely visible. If one microgram of butane is set on fire, how many molecules of carbon dioxide will be produced?



solution: micrograms \rightarrow grams \rightarrow moles butane \rightarrow moles CO_2 \rightarrow molecules CO_2
note plenty of oxygen.

$$1 \text{ microgram } \frac{\text{C}_4\text{H}_{10}}{\text{C}_4\text{H}_{10}} \times \frac{1 \text{ gram C}_4\text{H}_{10}}{1 \times 10^6 \text{ micrograms C}_4\text{H}_{10}} \times \frac{1 \text{ mole C}_4\text{H}_{10}}{58 \text{ g C}_4\text{H}_{10}} \times \frac{8 \text{ moles CO}_2}{2 \text{ mole C}_4\text{H}_{10}} \times \frac{6 \times 10^{23} \text{ molecules CO}_2}{1 \text{ mole CO}_2} = 4.1 \times 10^{16} \text{ grams CO}_2$$

ap chemistry

QUIZ

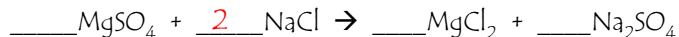
introduction to stoichiometry



ap chemistry stoichiometry

QUIZ

1. The reaction of magnesium sulfate with table salt produces magnesium chloride and sodium sulfate. Balance the reaction below:



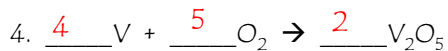
2. How many moles of NaCl must be used in order to produce 42.1 moles of Na₂SO₄?

$$84.2 \text{ moles since mol ratio is } 2:1 \dots 42.1 \text{ mol Na}_2\text{SO}_4 \times \frac{2 \text{ mol NaCl}}{\text{mol Na}_2\text{SO}_4} = 84.2 \text{ mol NaCl}$$

3. How many moles of MgSO₄ must be used in order to produce 100 moles of MgCl₂?

100 mole MgSO₄ will be needed (assuming 100% yield) since mol ratio is 1:1

$$100 \text{ mol MgCl}_2 \times \frac{\text{mol MgSO}_4}{\text{mol MgCl}_2} = 100 \text{ mol MgSO}_4$$



Use the equation in question 4 to solve, questions 5 and 6.

5. How many moles of Vanadium are required to produce 47 grams of V₂O₅?

$$47 \text{ g V}_2\text{O}_5 \times \frac{\text{mol V}_2\text{O}_5}{182 \text{ g V}_2\text{O}_5} \times \frac{4 \text{ mol V}}{2 \text{ mol V}_2\text{O}_5} = 0.52 \text{ mol V}$$

6. How many grams of Oxygen gas are required to produce 31.4 grams of V₂O₅?

$$31.4 \text{ g V}_2\text{O}_5 \times \frac{\text{mol V}_2\text{O}_5}{182 \text{ g V}_2\text{O}_5} \times \frac{5 \text{ mol O}_2}{2 \text{ mol V}_2\text{O}_5} \times \frac{32 \text{ g O}_2}{\text{mol O}_2} = 13.8 \text{ g O}_2$$





ap chemistry

introduction to solutions



solutions!



what are they?

homogeneous mixtures:

only one thing visible

where are they?

everywhere!

what is in a solution?

solvent: solute(s):

major component
(dissolver)

minor component (s)
dissolved

list one
detergents

is it a solution?



water



water

CO₂



no



major oil

minor oils



yes



Cu

Zn



no



water

salts



no



water

ethanol



yes



N₂

O₂

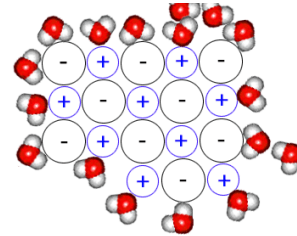


no

solubility

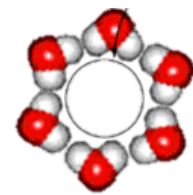
why don't oil and water mix?

a molecular view of dissolving:



Na⁺ Cl⁻

a salt:
not
dissolved



it is
solvated
= solvent
surrounds
the solute

partly dissolved fully dissolved (aq) **electrolyte:** it is an (salt solution)

what makes things dissolve?

consider this data:

name	formula	soluble in water?
methanol	CH ₃ OH	yes
ethanol	CH ₃ CH ₂ OH	yes
propanol	CH ₃ CH ₂ CH ₂ OH	yes
butanol	CH ₃ CH ₂ CH ₂ CH ₂ OH	no!
	greasy	watery



solubility
rule of
thumb:
"like
dissolves
like"



QUIZ

ap chemistry

introduction to solutions



ap chemistry solutions

QUIZ

describe each as a substance,
solution, or heterogeneous
mixture: water, gasoline, granite

substance, solution,
heterogeneous mixture

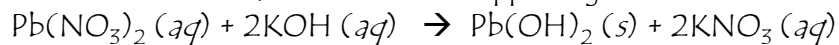
identify the solvent in club soda,
air, and 14 carat gold

water, nitrogen, and gold

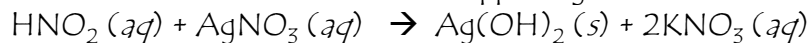
soluble in water?: $\text{CH}_3\text{CH}_2\text{OH}$,
Fe, $\text{CH}_3\text{CH}_2\text{CH}_3$

yes, no, no

describe what is happening



describe what is happening



each mole of aqueous lead(II)nitrate reacts with 2
moles of aqueous potassium hydroxide to form one
mole of precipitated solid lead(II)hydroxide as well as
2 moles of aqueous potassium nitrate

each mole of aqueous nitrous acid reacts with 1
moles of aqueous silver nitrate to form one mole of
precipitated solid silver hydroxide as well as 2 moles
of aqueous potassium nitrate





ap chemistry

introduction to reaction rates



how can we measure the rate of a reaction?

reaction rates

consider:



reactant concentration decreases product concentration increases

the speed (rate) of a reaction is like the speed of anything else (a car, for example):

$$\text{rate} = \frac{\text{change}}{\text{time}}$$



example: miles/hour

For a chemical reaction:

$$\text{rate} = \frac{\Delta \text{concentration}}{\Delta \text{time}} = \frac{M}{s}$$

[] = concentration in moles/liter



[Ca(OH)₂] at time = 0: 0.22 M

[Ca(OH)₂] after four seconds 0: 0.100 M

what is the reaction rate for Ca(OH)₂?

$$\frac{-0.12 \text{ M}}{4 \text{ s}} = \frac{-0.030 \text{ M}}{\text{s}}$$

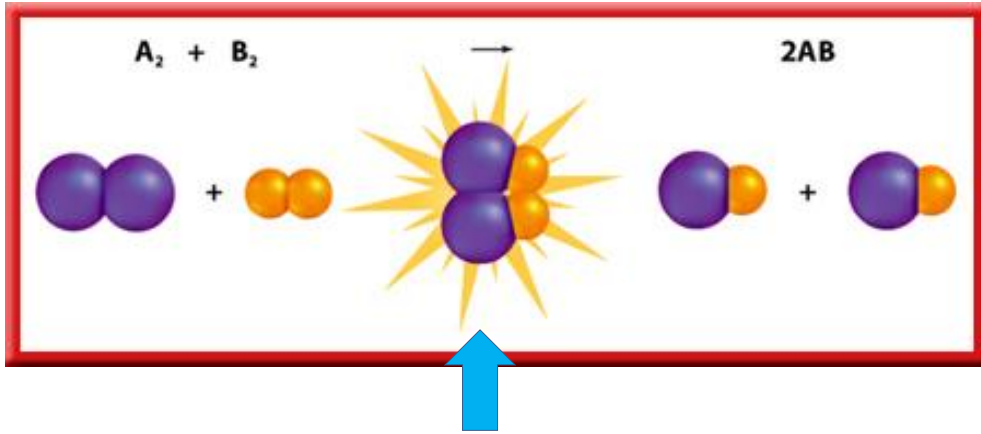
what is the reaction rate for HCl?

$$\frac{0.060 \text{ M}}{\text{s}}$$

(since two HCl molecules must react for each CaCl₂ molecule)

how do molecules react?

kinetic molecular theory (kmt)



transition state
or
activated complex

suggests a reaction
mechanism (process)

collision
theory:

they collide
with enough force to react
and at the right location

applying KMT
5 ways to change the rate of
reaction

hit it with a **STICC!**

change the

Surface area
Temperature

rule of thumb: rate doubles every 10°C

Identity (of reactants)

Concentration (of reactants)

add a Catalyst



QUIZ

ap chemistry

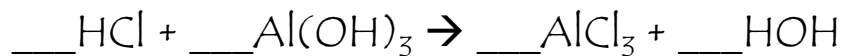
introduction to reaction rates



ap chemistry kinetics

QUIZ

balance:



$[\text{Al(OH)}_3]$ at time = 0: 0.50 M

$[\text{Al(OH)}_3]$ after four minutes: 0.100 M

$$\text{rate} = \frac{\Delta_{\text{concentration}}}{\Delta_{\text{time}}} = \frac{-0.40 \text{ M}}{4 \text{ min}} = \frac{-0.10 \text{ M}}{\text{min}}$$

what is the reaction rate for the loss of Al(OH)_3 ?

what is the reaction rate for production of H_2O ?

$$\frac{0.30 \text{ M}}{\text{s}}$$

(for every molecule of Al(OH)_3 that reacts three molecules of water are formed during that time)





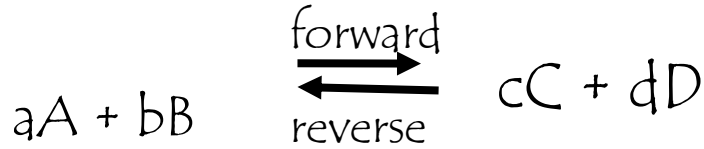
Watch the video

ap chemistry

introduction to equilibrium



chemical reactions are often reversible:



chemical equilibrium: forward rate = reverse rate

$$\text{rate} = k[A]^m[B]^n$$

$$K_{eq} = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

the "equilibrium constant"

<1: mostly reactants (bad) >1: mostly products (good)

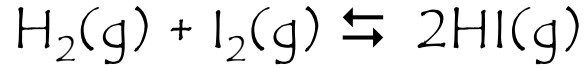
generally: omit liquids and solids

if the actual ratio of products to reactants (Q) is <K the reaction will proceed forward; if the measured concentrations are >K the reaction will shift to the left until it matches the equilibrium concentrations

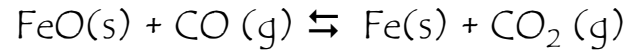
Equilibrium

= reversibility

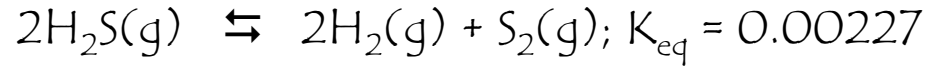
write the equilibrium expression



$$K_{eq} = \frac{[HI]^2}{[H_2][I_2]}$$



$$K_{eq} = \frac{[CO_2]}{[CO]}$$



if $[S_2] = 0.0540$ mol/L and $[H_2S] = 0.184$ mol/L, what is $[H_2]$?

$$K_{eq} = 0.00227 = \frac{[H_2]^2 [S_2]}{[H_2S]^2} = \frac{[H_2]^2 [0.054]}{[0.184]^2}$$

$$[H_2] = 0.0377 \text{ moles/liter}$$



ap chemistry

introduction to acids and bases



acids and bases: they change the pH of water



lower pH

sour, bitter aqueous soft, slippery

raise pH

what is an acid? a substance that releases H⁺, or creates it when added to water
 what is a base? a substance that releases OH⁻, or creates it when added to water



what is water?

H₂O

Both!

Is it H-O-H, or is it H⁺OH⁻?

covalent ionic (salt)



56 M 10⁻⁷M 10⁻⁷M

99.9999998% 0.0000001% 0.0000001%

pH = 7 pOH = 7

pH < 7 = acidic pH > 7 = basic

12. oil
 none!
 must be
 aqueous

exponent math and water

$[10^{-7}][10^{-7}]$	$[10^{-14}]$	[H ⁺]	[OH ⁻]	pH:	pOH:
$[10^3][10^{-7}]$	$[10^{-4}]$	$[10^{-7}]$	$[10^{-7}]$	7 (n)	7
$[10^3][10^7]$	$[10^{10}]$	$[10^{-3}]$	$[10^{-11}]$	3 (a)	11
$[10^{-3}][10^{-11}]$	$[10^{-14}]$	$[10^{-5}]$	$[10^{-9}]$	5 (a)	9
$\frac{10^5}{10^3}$	10^2	$[10^{-13}]$	10^{-1}	13 (b)	1

$$K_{eq} = [\text{H}^+][\text{OH}^-] = 10^{-14} \text{ M} = K_w$$

find the hydroxide ion concentration of a 3.0 × 10⁻² M H⁺ solution.

$$[\text{H}^+][\text{OH}^-] = 1.0 \times 10^{-14}$$

estimate: 1.0 × 10⁻¹² M

$$[3.0 \times 10^{-2}][\text{OH}^-] = 1.0 \times 10^{-14}$$

$$[\text{OH}^-] = \frac{1.0 \times 10^{-14}}{3.0 \times 10^{-2}} = 3.3 \times 10^{-13} \text{ M}$$





ap chemistry

introduction to buffers



buffers

systems that contain both acid and base

A **buffer solution** resists a change in pH. It is composed of

1: a weak acid or a weak base example: acetic acid ($\text{HC}_2\text{H}_3\text{O}_2$)
and

2: it's conjugate acid or base example: sodium acetate

this could be prepared a few different ways..... CH_3COONa

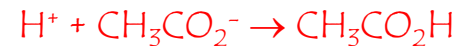
why it works: both acid and base are in the solution.

	[acid]	[base]	change in pH	
Add acid (H^+)	increases (in the form of $\text{HC}_2\text{H}_3\text{O}_2$)	decreases (reacts with acetate)	not much	HCl/KCl strong acid conjugate base no
Add base (OH^-)	decreases (and makes acetate)	increases	not much	$\text{HCl}/\text{sodium acetate}$ strong acid weak base yes if excess acetate

(a) H_3PO_4 / KH_2PO_4
weak acid conjugate base yes

(b) $\text{NaClO}_4/\text{HClO}_4$
conjugate base strong acid no

(c) $\text{C}_5\text{H}_5\text{N}/\text{C}_5\text{H}_5\text{NHCl}$
weak base conjugate acid yes



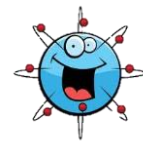


ap chemistry

introduction to the atom

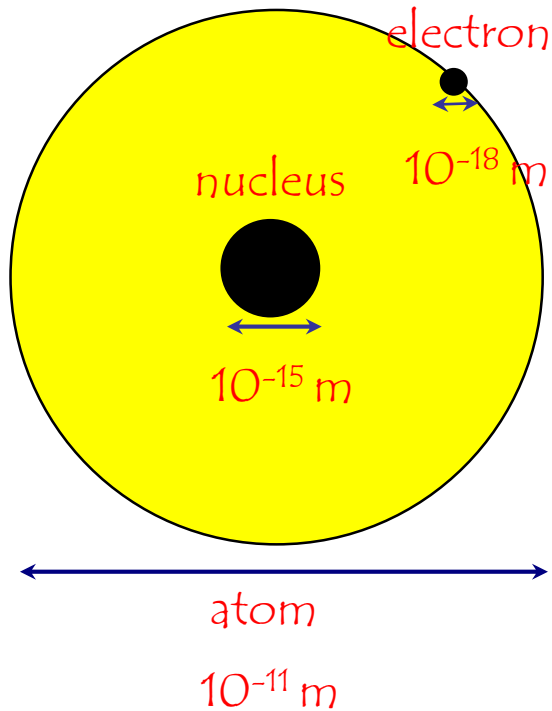


the atom



hydrogen atom model ground state

fact sheet some basic fact about atoms in general



size: $0.01 - 1 \text{ nm}$

composition: protons, neutrons, electrons

average mass of H: 10^{-24} g or 1.008 amu

average mass of C: 10^{-23} g or 12.011 amu

mass and charge of electron: 10^{-28} g or 0.0005 amu , negative

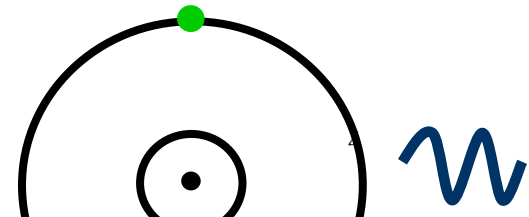
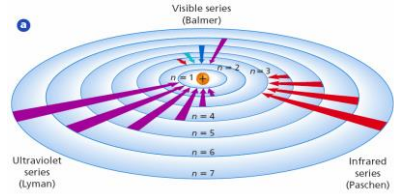
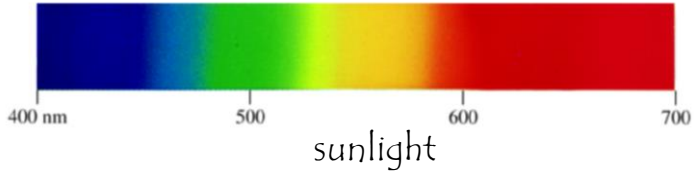
mass and charge of proton: 10^{-24} g or 1.007 amu

mass and charge of neutron: 10^{-24} g or 1.008 amu

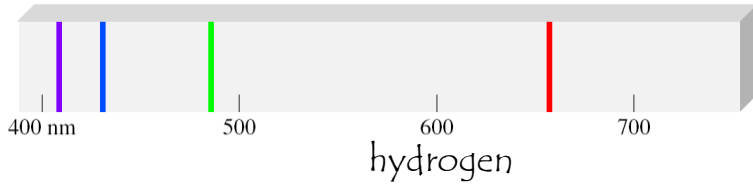


The Story of Bohr's Epiphany if energy is quantized, what else might be?

emission spectrum of sunlight and hydrogen spectrum



electron emission creates light



$w_{nm} = 656, 486, 434, 410 \dots$ what number is next??
what is happening??

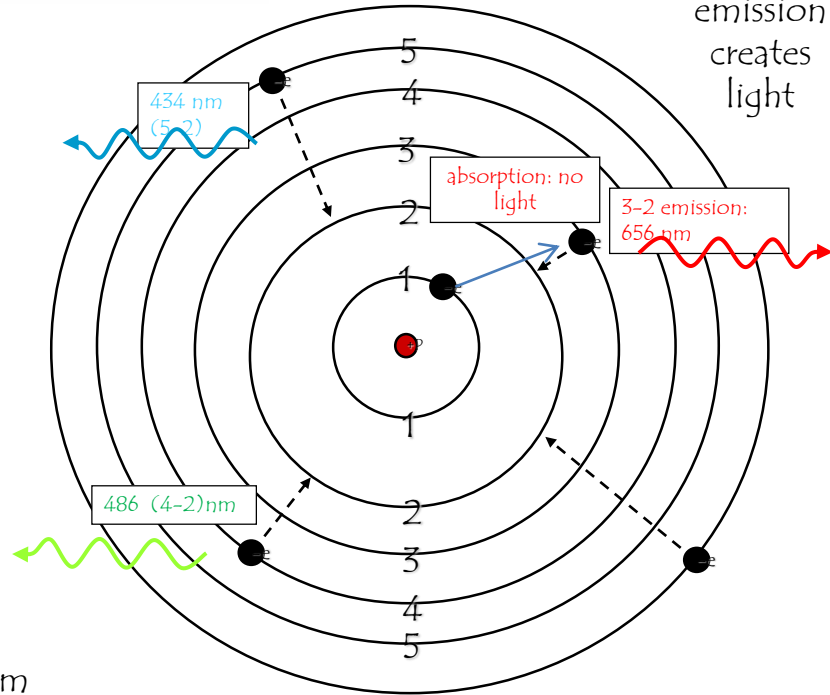
solved: the Balmer formula
requires 2 integers
("inner" and "outer")

$$w_{nm} = \frac{1}{0.01097 \left(\frac{1}{\text{inner}^2} - \frac{1}{\text{outer}^2} \right)}$$

w = wavelength in nm
= visible light (400-700 nm)
when inner = 2

try it for 3 → 2

$$w = 656 \text{ nm}$$



Bohr used this data to construct a model of the atom



ap chemistry

introduction to gases



gases: substances that lack intermolecular forces

what are they like?

typical density:

about 1 g/L
highly
compressible

distribution:

fill up containers
regardless of amount

appearance:

often invisible...
No reflection
plane

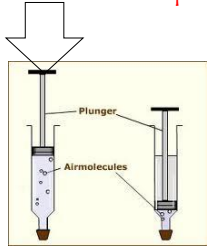
reaction rate compared to other phases

interwoven:
gases react much
faster

pressure units

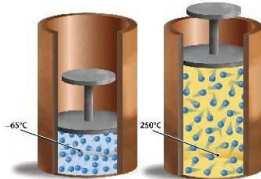
1 atm = 14.7 psi = 101.3 kPa = 760 mm Hg or Torr

consider the physical behavior of gases. What will happen physically when you....



push in a closed
syringe barrel

As V goes down,
P goes up.
T is constant



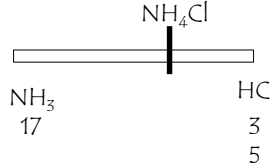
heat a piston

As T goes up,
V goes up
P is constant



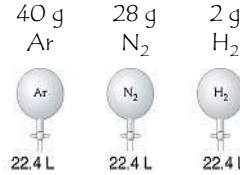
heat a closed
container

As T goes up,
P goes up
V is constant



which gases
move fastest?

light gases
move faster



does the identify of
the gas matter?

Gas atoms occupy the
same volumes

This leads to the formulas



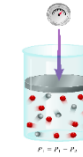
$$PV = nRT$$

P: atm
V: liters
n: moles
R: 0.0821 L atm/mol K
T: K

and

$$d = \frac{PM}{RT}$$

d = (g/L)
P = (atm)
M = (g/mol)
R = 0.0821 L atm/mol K
T = (K)



and

$$P_a = X_a P_T$$

The partial pressure of a
gas (P_a) proportional to
its mole fraction (X_a).

1662



Boyle

$$P_1 V_1 = P_2 V_2$$

1787



Charle

$$T_1/V_1^2 = T_2/V_2$$

1808



Gay-Lussac

$$T_1/P_1 = T_2/P_2$$

1848



Graham

$$\frac{\text{Rate}_1}{\text{Rate}_2} = \sqrt{\frac{M_2}{M_1}}$$



Avogadro

1 mol = 22.4 L
At STP (0 °C, 1 atm)

1811



ap chemistry

introduction to bonding






what is a chemical bond? the force that holds 2 atoms or ions together

which elements do not form chemical bonds? the noble gases

why do elements form bonds? to obtain noble gas configurations

bond types:

if the bond is between	it is a ___ bond	example
metals 	metallic	Fe-Fe
metals-nonmetals 	ionic	Na-Cl
nonmetals 	covalent or covalent network solid	C-Cl diamond, graphite, glass (SiO ₂)...

polarity of bonds, molecules

bond	type
C-C (same nonmetals)	nonpolar covalent
C-O (different nonmetals)	polar covalent
C-H (an exception)	nonpolar covalent

ionic, covalent, or metallic?



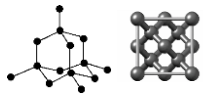
NaCl	Ionic
F ₂	Covalent
I ₂	Covalent
Cl-Mg-Cl ₂	Ionic
CO ₂	Covalent
Na-OH	Ionic
Fe	metallic

metal present: ionic or metallic (metallic if alone)

ap chemistry

introduction to intermolecular forces





chemical bonds and forces

bond or force

example

strength
(kJ/mol)

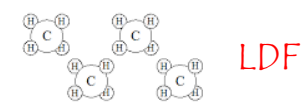
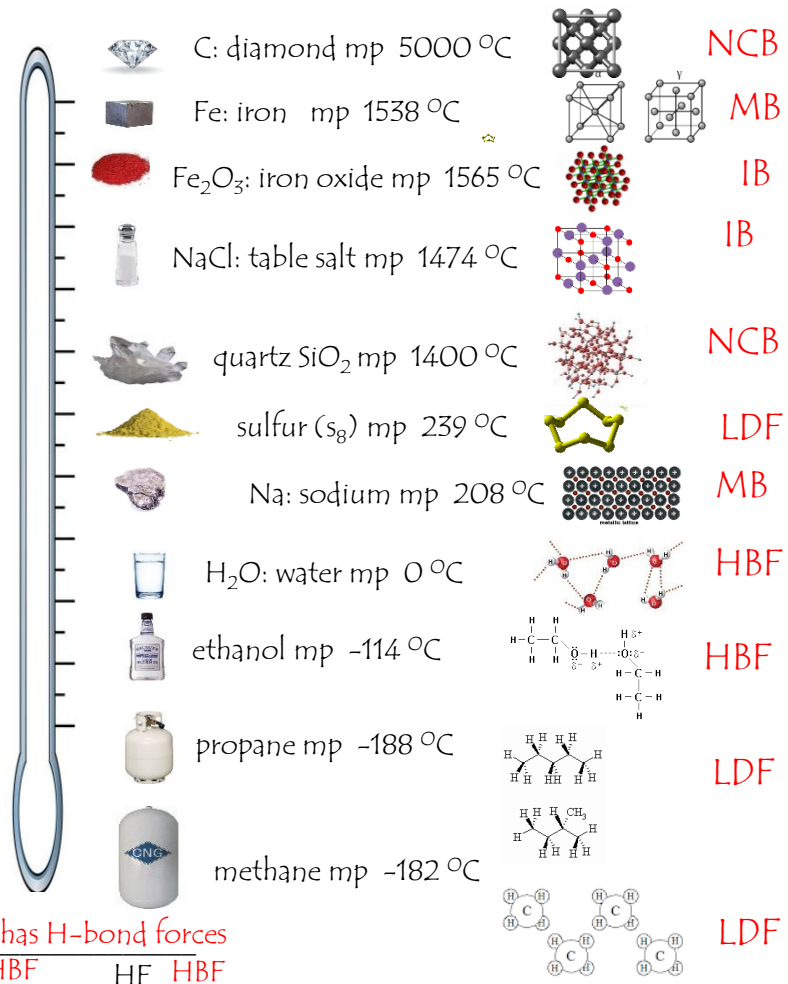
networked bonds (no individual molecules)	network covalent bond	NCB	C-C (diamond)	300 - 5000
	ionic bond	IB	Na ⁺ -Cl ⁻	400-4000
	metallic bond	MB	Fe-Fe	100-500

intramolecular bonds	covalent bond	C	C-C	150-1100
----------------------	---------------	----------	-----	----------

Intermolecular forces	ion-dipole force	IDF	Na ⁺ --OH ₂	40-600
	hydrogen bond force	HBF	HO-H--OH ₂	10-200
	dipole-dipole force	DDF	CO--CO	5-25
london dispersion force (induced dipole)	LDF	N ₂ --N ₂ between nonpolar molecules	CCl ₄ , CO ₂ , BF ₃ ...	0.05-40

If the ionic bonds breaks but do not form new bonds the substance is dissolved
 If the ions are in solution and the ionic bond forms the substance has precipitated
 If the substance has no intermolecular forces or bonds it must be a gas
 If the substance has intermolecular forces that are fixed it must be a solid
 If the substance has fluid intermolecular forces it is a liquid
 Why is HF nearly a liquid at room temperature but HCl is a gas at room temp? Only HF has H-bond forces
 What is the strongest intermolecular force in N₂ LDF CO₂ LDF H₂O HBF HF HBF
 CH₃OH HBF CHCl₃ DDF

what strongest bonds or forces must be broken to melt it?





ap chemistry

introduction to energy



how can we measure energy?

energy:

by temperature change. For 1 L of water
each °C

- = 4184 joule (j)
- = 1000 calories (c)
- = 4 British Thermal Units (btu)
- = 1 Nutritional Calories (C)
- = .00116 kilowatt hours (kwh)

the
ability to
do work
or
produce
heat:





ap chemistry

introduction to electrochemistry

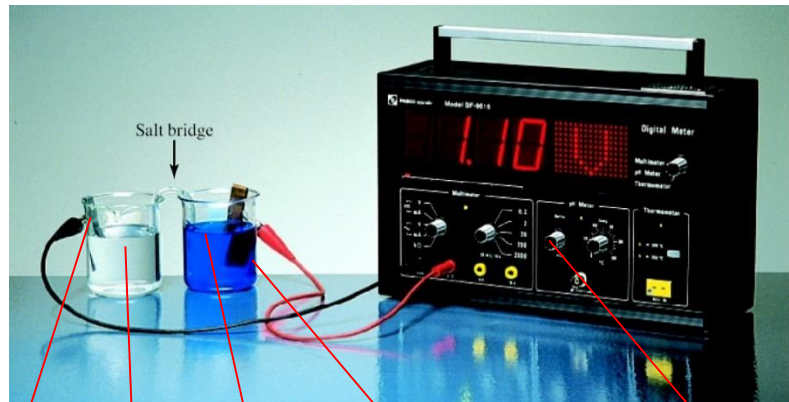
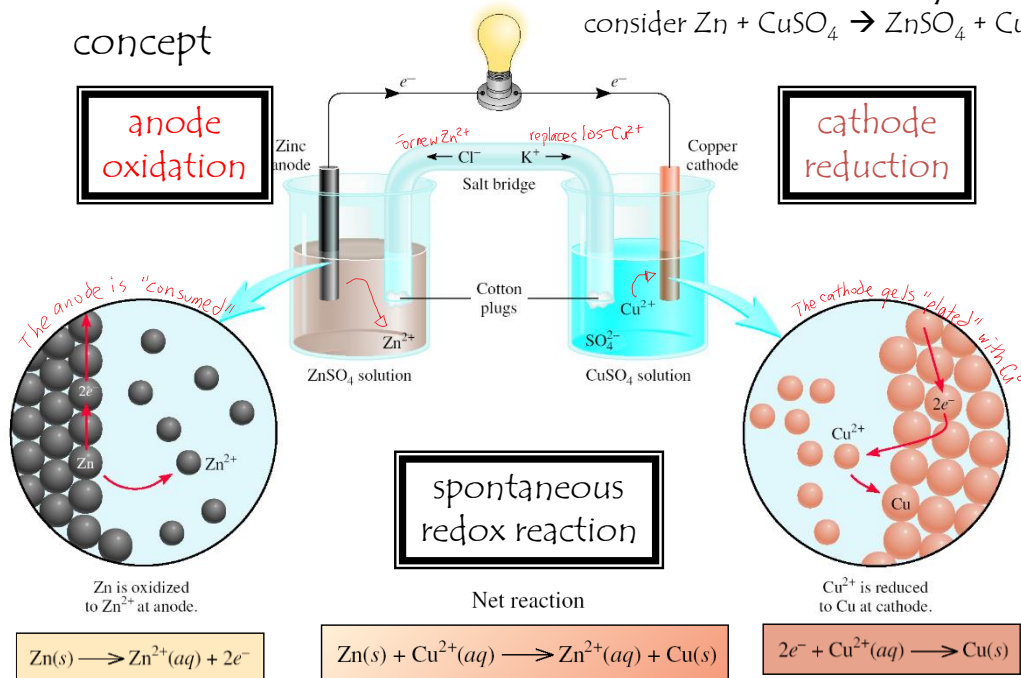


electrochemistry



practice

concept

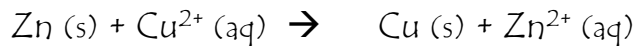


ZnSO₄ CuSO₄ cathode (Cu)

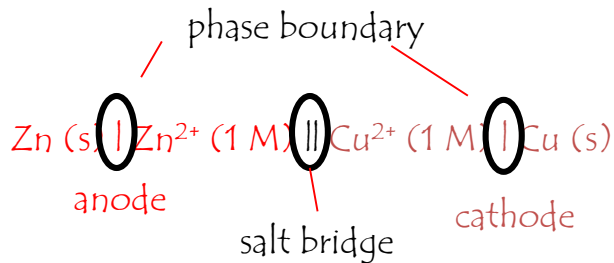
anode (Zn)

cell voltage = electromotive force (emf) = cell potential

cell notation



cell Diagram:



ap chemistry

putting it all together



chemistryacademy
ap chemistry summer prep course

name:

problem set

includes hints and selected solved problems

may be answered by hand or digitally using
the fillable forms



common polyatomic ions (radicals)

charges by group number

diatomics, allotropes, more ions

1. acetate	$\text{CH}_3\text{CO}_2^{-1}$ or $\text{C}_2\text{H}_3\text{O}_2^{-1}$ or OAc^{-1}
2 ammonium	
3 carbonate	
4 chromate	
5 cyanide	
6 dichromate	
7 bicarbonate or hydrogen carbonate	
8 hydroxide	
9 nitrate	
10 phosphate	
11 sulfate	
12 sulfite	

13) IA (1)	+1
14) IIA (2)	
15) IIIA (3)	
16) IVA (14)	
17) VA (15)	
18) VIA (16)	
19) VIIA (17)	
20) VIIIA (18)	

need assistance? [watch this video](#)

these links can be found on the online
pdf's at chemistryacademy.org

hint: most of these ions can be found on the [ap chemistry periodic table](#); note also that the [suggested video](#) is very helpful

21 diatomic elements	
22 most common P, S allotropes	
23 hypo fluorite, hypochlorite, hypobromite, hypoiodite	
24 fluorite, chlorite, bromite, iodite	
25 fluorate, chlorate, bromate, iodate	
26 perfluorate, perchlorate, perbromate, periodate	

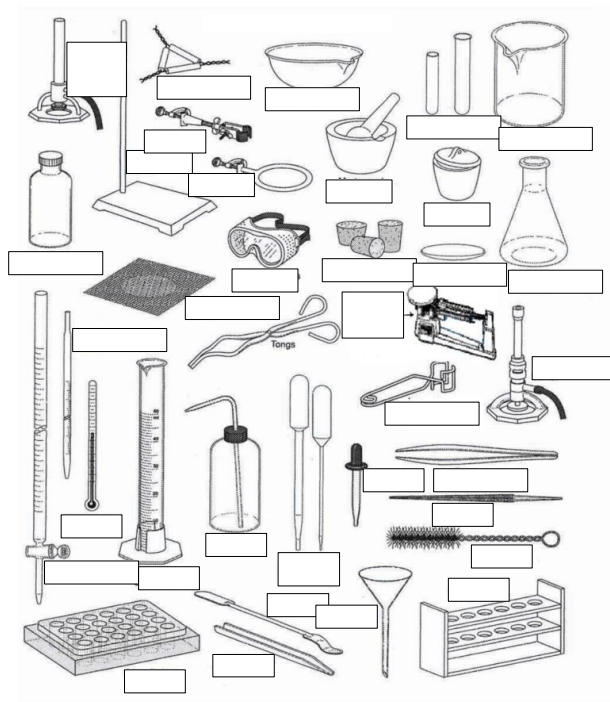
solubility guidelines (don't have to know exceptions)

35 Six strong acids	
36 Strong bases	
37 Are group 2 hydroxides strong or weak bases?	

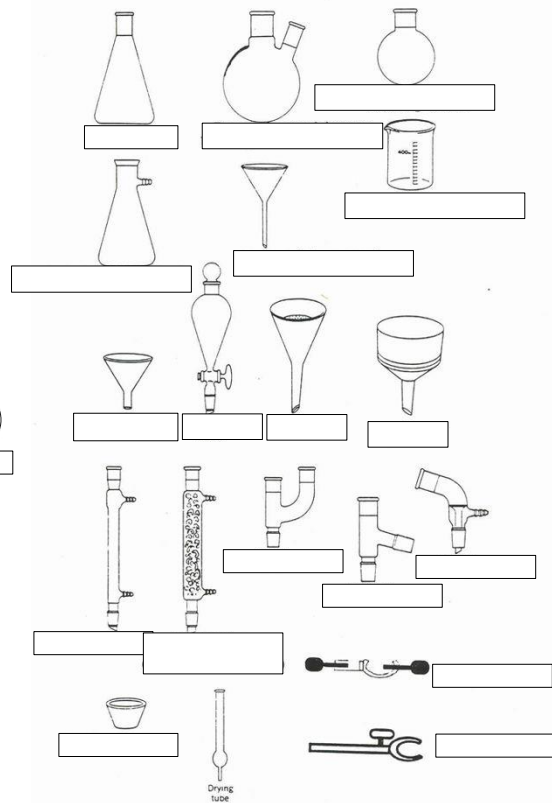
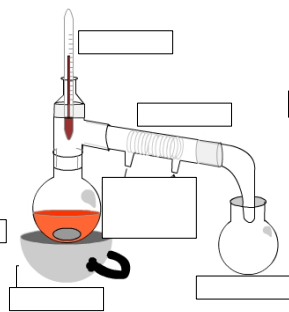
soluble cations	
soluble anions	
are sulfates soluble?	
are chlorides, bromides and iodides soluble?	
are carbonates, sulfides, or phosphates soluble	
are metal hydroxides and oxides soluble?	

need assistance? watch this [very helpful video](#)

AP chemistry: memorization part 3



chemistry lab equipment



not enough room to enter your answers? Point to the piece of gear and place your answers around the edges

need assistance? watch this [very helpful video](#)

For all remaining please use the correct number of significant figures in your answers. Show work when indicated. Suggestion: Make a list of problems you cannot answer by topic and move on. Review the topics (the first year screencasts on chemistryacademy.org may help) and have another go at them. Copies available through the website.

Topics: significant figures, unit conversion

Write your answers in pencil or with a frixion pen so you can erase errors. Sloppy work: 20% deduction.

55 Solve the problem $0.089 \text{ meters/second} \times 3.0343 \text{ second}^{-1}$

$$\frac{0.089 \text{ meters}}{\text{second}} \times \frac{1}{3.043 \text{ second}} = 0.029 \text{ m/s}^2 \quad (\text{an acceleration unit; note 2 significant figures in answer})$$

56. As for all problems, show your work for each problem neatly. Include intermediate units, cancel as needed, and circle your answer

a. 200.0 meters = _____ miles (1609 meters = 1.000 mile)

(0.1243 miles)

b. 650. in = _____ meters (2.54 centimeters = 1.00 inch)

(16.5 meters)

c. 4.0 years = _____ seconds. d. 200 liters = _____ ml (1000 mL = 1 L)

1.3 X 10⁸ seconds)

(200,000 mL)

57 Classify each of the following as units of mass (M) volume (V), length (L), density (D), energy (E), or pressure (P).

a. Kg

b. Liter

c. m³

d. mm

e. kg/m³

f. Joule

g. atm

h. cal

i. Torr

j. g/ml

58. A laboratory experiment is performed at room temperature, which in this case is at 65.0 °C. Express this temperature in:

A. °F: _____ (F = 1.8C + 32)

B. K (°C + 273.15 = K)

need assistance with this page? watch [this video](#) (unit conversion)

59 How many significant figures are in each of the following?

- 1.9200 mm 5
- 0.0301001 kJ _____
- 6.022×10^{23} atoms _____
- 460.000 L _____
- 0.000036 cm³ _____
- 10000 frogs _____
- 1001 dalmations _____
- 0.001345 micrometers 4
- 0.0101 lumens _____
- 3.02×10^4 candelas _____
- 3.21×10^{-2} deciliters _____

60 Record the following in proper scientific notation:

- 4050,000,000 cal _____
- b. 0.000123 mol _____
- c. 0.00345 Å _____
- d. 700,000,000 atoms _____

61 Calculate the following to the correct number of significant figures. Don't forget to include the units in your answers

- $1.270 \text{ g} / 5.296 \text{ cm}^3$ _____
- $12.235 \text{ g} / 1.010 \text{ g L}$ _____
- $12 \text{ g} + 0.38 \text{ g}$ _____
- $170 \text{ mg} + 2.785 \text{ g}$ _____
- $2.1 \text{ miles per hour} \times 3.2102 \text{ hours}$ 6.7 miles _____
- $200.1 \text{ liters atmospheres/mole K} \times 120 \text{ liters}$ _____
- $17.6 \text{ g} + 2.838 \text{ mg} + 2.3 \text{ kg} + 200 \text{ nanograms}$ _____ please show your work for this one.

62 A solid white substance A is heated strongly in the absence of air. It decomposes to form a white substance B and a gas C. The gas C has exactly the same properties as the product obtained when carbon is burned in an excess of oxygen. Based on these observations, can we determine whether solids A and B and the gas C are elements or compounds? Explain your conclusions for each substance.

63 Label each of the following as either a physical process (P) or a chemical process (C)

- a. Corrosion of aluminum metal: _____
- b. Melting of ice: _____
- c. Pulverizing an aspirin: _____
- d. Digesting a candy bar: _____
- e. Explosion of nitroglycerin: _____
- f. Milk turning sour: _____
- g. Burning of paper: _____
- h. Forming of frost on a cold night: _____
- i. Bleaching of hair with hydrogen peroxide: _____
- j. A copper wire is hammered flat: _____

need assistance?
watch [this video on chemical and physical processes](#).
Note that chemical processes produce new substances.

64 You may notice when pure water boils, you can see bubbles that rise to the surface of the water.

- a. What is inside these bubbles? _____
- b. Is the boiling of water a chemical or physical change?
_____ Why? _____

65 Why do we call $\text{Ba}(\text{NO}_3)_2$ barium nitrate, but we call $\text{Fe}(\text{NO}_3)_2$ iron(II) nitrate?

need assistance? watch [this video on naming binary substances](#). Consider the use of terms *monovalent* and *polyvalent* in your answer

Topics: physical and chemical properties

Binary compound naming, unit conversion, vocabulary

66 Write the formulas of the following compounds:

- a. Calcium sulfate: _____
- b. Ammonium Phosphate: _____
- c. Lithium Nitrite: _____
- d. potassium perchlorate: _____
- e. Barium Oxide: _____
- f. Zinc sulfide: _____
- g. Sodium Perbromate: _____
- h. Calcium Iodide: CaI_2
- J. Aluminum _____

18 Convert 6.75 atm to:

- a. mmHg: _____

760 mm Hg = 1 atm;

101.3 kPa = 1 atm

- b. kilopascals: _____

don't forget to show your work for all conversions

67. Define the words by example. The first one is done for you.

atomic number:

Magnesium is atomic number 12

atomic mass:

mass number:

molecular formula:

structural formula:

empirical formula:

H_2O_2 has an empirical formula of HO

isotopes:

68. White gold is an alloy that typically contains 45.0% by mass gold and the remainder is platinum. If 154 g of gold are available, how many grams of platinum are required to combine with the gold to form this alloy? Please show your work with cancelled units and circle your answer.

69. What is the empirical formula of a compound that contains 53.73% Fe and 46.27% of S? Please show your work with cancelled units and circle your answer.

Hint: convert to moles then whole numbers

70. Determine the number of molecules present in 4.56 mol of nitrogen (N_2). Please show your work with cancelled units and circle your answer.

71. List the following as a diatomic molecule (DM), molecular compound (MC), ionic compound (IC), or Atomic element (AE).

- a. F_2 b. Cl_2 c. C d. NaCl e. KF f. CO_2 g. H_2 h. Ag
i. Rust (Fe_2O_3) j. MgO k. O_2 l. I_2 m. CO n. K_2CO_3
MC IC

Topics: empirical formulas, percent composition, mole conversions, hydrates.

72. What is the difference between
a. Chlorine and Chloride?

b. a sodium atom and a sodium ion?

73. How many grams of methane (CH_4) are present in 5.6 moles of methane gas? Please show your work with cancelled units and circle your answer.

74. Calculate the mass in grams of each of the following:

a. 6.02×10^{23} atoms of Mg:

b. 12.4×10^{15} atoms of neon:

$$12.4 \times 10^{15} \text{ Ne atoms} \times \frac{20.18 \text{ g Ne}}{6.02 \times 10^{23} \text{ Ne atoms}} = 4.16 \times 10^{-7} \text{ g Ne.}$$

75. In an experiment, a student gently heated a hydrated copper compound to remove the water of hydration. The following data was recorded:

Mass of crucible, cover, and contents before heating 23.4 g.

mass of empty crucible and cover 18.82 g.

mass of crucible, cover, and contents after heating to constant mass

20.94 g.

Calculate the experimental percent of water in the compound. Please show your work with cancelled units and circle your answer.

need assistance? watch [this video on empirical and molecular formulas](#)

not enough room? Add a page for your answers.
(please do not hand in answers only)

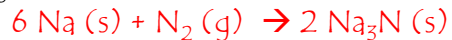
76. Determine the empirical and molecular formula of each of the following substances:

a. Ibuprofen, a headache remedy contains 75.6 % C, 8.80 % H , and 15.5 % O by mass and has a molar mass about 206 g/mol. Please show your work with cancelled units and circle your answer

b. Epinephrine (adrenaline), a hormone secreted into the bloodstream in times of danger or stress contains 59% C, 7.1% H, 26.2% O, and 7.7% N by mass, its molecular weight is about 180 amu. . Please show your work with cancelled units and circle your answer

77. Write balanced chemical equations for the reactions of sodium with the following nonmetals to form ionic solids.

a. Nitrogen



b. Oxygen

c. Sulfur

d. Bromine

Topics: empirical and molecular formulas, percent composition, mole conversions, hydrates, balanced chemical equations

78. Write a balanced equation for the following:

a. Reaction of boron trifluoride gas with water to give liquid hydrogen fluoride and solid boric acid, (H_3BO_3).

B. Reaction of magnesium Oxide with Iron to form Iron (III) Oxide and Magnesium. $3 \text{MgO (s)} + 2 \text{Fe (s)} \rightarrow \text{Fe}_2\text{O}_3 \text{(s)} + 3 \text{Mg (s)}$

c. The decomposition of dinitrogen Oxide gas to its elements.

d. The reaction of Calcium Carbide solid with water to form calcium hydroxide and acetylene (C_2H_2) gas.

e. The reaction of solid calcium cyanamide (CaCN_2) with water to form calcium carbonate and ammonia gas.

f. Ethane burns in air (oxygen).

g. Hydrogen reacts with oxygen to form water.

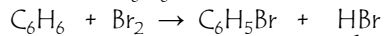
h. Nitrogen gas reacts with hydrogen to form ammonia.

i. Hydrogen reacts with Iodine gas to form hydrogen Iodide.

k. Sodium reacts with Iodine gas to form sodium Iodide.

l. Sodium Oxide reacts with water to form sodium hydroxide

79. When benzene (C_6H_6) reacts with bromine (Br_2), bromobenzene (C_6H_5Br) is obtained:



a. What is the theoretical yield of bromobenzene in this reaction when 30.0g of benzene reacts with 65.0 g of bromine? ? Please show your work with cancelled units and circle your answer.

need assistance? watch [this video on limiting reactants](#)

b. If the actual yield of bromobenzene was 56.7 g what was the percentage yield? ? Please show your work with cancelled units and circle your answer.

need assistance? watch [this video on theoretical and actual yield](#)

80. To prevent a condition called the "bends", deep sea divers breathe a mixture containing, in mole percent, 10.0% O_2 , 10.0% N_2 , and 80.0% He.

a. Calculate the molar mass of this mixture.

a "weighted average" problem

b. What is the ratio of the density of this gas to that of pure Oxygen at the same temperature and pressure?

hint: equal amounts of any two gases at the same temperature and pressure have the same volumes

81. A 2.0g sample of SX_6 (g) has a volume of 329.5 cm^3 at 1.00 atm and 20°C. Identify the element 'X'. Name the compound. ? Please show your work with cancelled units and circle your answer.

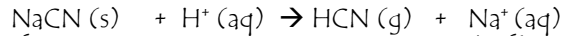
Topics: gas laws, naming substances, oxidation and reduction, oxidation number,

82. When Hydrogen sulfide gas, H_2S , reacts with oxygen, sulfur dioxide gas and steam are produced.

a. Write the balanced chemical equation for this reaction.

b. How many liters of sulfur dioxide would be produced from 4.0 l of Oxygen? Assume 100% yield and that all gases are measured at the same temperature and pressure. ? Please show your work with cancelled units and circle your answer.

83. Hydrogen cyanide, HCN, is a poisonous gas. It can be formed by the reaction:



What mass of sodium cyanide is required to make 8.5 l of hydrogen cyanide at 22°C and 751 mm Hg? ? Please show your work with cancelled units and circle your answer.

Hint: 1. use $PV = nRT$ to find moles HCN produced 2. Use stoichiometry to find moles NaCN needed 3. convert to grams

84. A gaseous mixture contains 5.78 g of methane, 2.15 g of neon, and 6.8 g of sulfur dioxide. What pressure is exerted by the mixture inside a 75.0 L cylinder at 85°C? Please show your work with cancelled units and circle your answer.

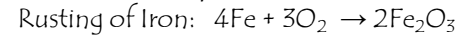
need assistance? watch this [video on partial pressure](#). Hint: use moles

85. Name the following:

- a. CO_2
- b. P_4S_{10}
- c. NI_3
- d. PCl_5
- e. CCl_4
- f. SF_6
- g. CH_4
- h. C_2H_6
- i. C_3H_8

need assistance?
watch this video on
[naming binary substances](#).

86. For the example below what is oxidized and what is reduced?.



need assistance?
watch this video on
[reduction and oxidation](#)

87. Find the Oxidation number of

- a. Carbon in CO_2 .
- b. Sulfur in H_2SO_4 .
- c. Phosphorus in PO_4^{3-}
- d. Manganese in MnO_4^{2-}

need assistance?
watch this video on
[oxidation number](#)

88. How much heat is required to raise the temperature of 100.0 grams of water from 25°C to 82°C? Please show your work with cancelled units and circle your answer.

need assistance? watch this [video on specific heat](#)

89. A piece of unknown metal with mass 14.9 g is heated to 100°C and dropped into 75.0 g of water at 20°C. The final temperature of the system is 28 degree Celsius. What is the specific heat of the metal? Please show your work with cancelled units and circle your answer.

90. What is a solute?:

...and solvent?

91. Calculate the molarity of a solution that contains 0.0345 mol NH₄Cl in exactly 400.0 ml of solution?

92. How many grams of solute are present in 50.0 ml of 0.360 M sodium chloride? Please show your work with cancelled units and circle your answer.

Topics: specific heat, solubility, molar conversions

93. DDT, an insecticide harmful to fish, birds, and humans, is produced by the following reaction:



If 114.2 g of chlorobenzene is reacted with 485 g of choral.

a. What mass of DDT is formed? Please show your work with cancelled units and circle your answer.

b. Which reactant is limiting? Which is in excess?

c. What mass of excess reactant is left over? Please show your work with cancelled units and circle your answer.

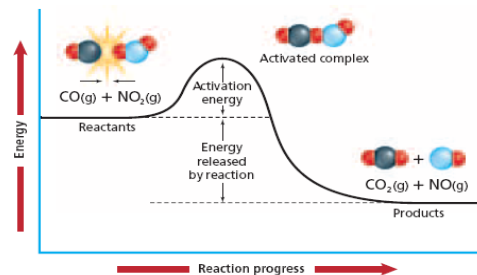
d. If the actual yield of DDT is 200.0 g, what is the percent yield?

need assistance? watch this [video about solutions](#)

94. In the reaction of 1.00 liter of hydrogen and 1.00 liter oxygen to create water, the concentration of hydrogen changes from 2.00 M to 0.200 M after 2.00 seconds., while the concentration of oxygen decreases from 1.00 M to 0.100 M over the same time interval.

- Write the balanced chemical equation.
- What is the reaction rate for the consumption of hydrogen in this reaction?
- What is the reaction rate for the consumption of oxygen in this reaction?
- Assuming the rates are steady, how long would this reaction take to go to completion?
- At standard temperature and pressure, how many grams of water would eventually form from this reaction?
- Would there be any remaining starting materials when this reaction is complete?

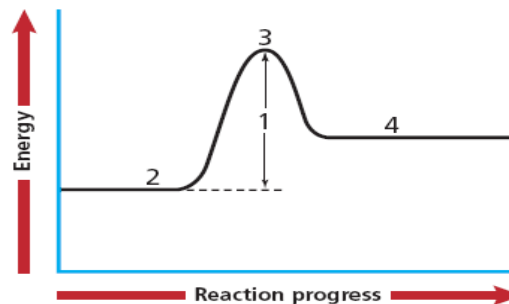
95. List six ways to increase the rate of a chemical reaction.



96. For the energy diagram above, **what single element** is being transferred in the chemical reaction of carbon monoxide with nitrogen dioxide to form carbon dioxide and nitrogen monoxide?

97. Is the reaction above endothermic or exothermic?

98. Label each number



need assistance? watch this [video on reaction rates](#)

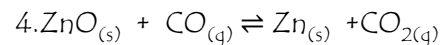
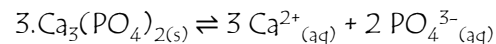
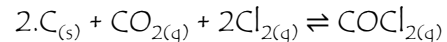
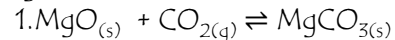
need assistance? watch this [video on energy diagrams](#)

99. Determine the rate law for the reaction shown below. Explain your reasoning.

experimental initial rates for $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$			
trial	initial $[\text{H}_2]$ in moles/liter	initial $[\text{O}_2]$ in moles/liter	Initial rate in moles per liter per second
1	0.6	0.3	0.04
2	1.2	0.3	0.08
3	0.6	0.6	0.16

Topics: kinetics, equilibrium

100. Write the equilibrium expression, K_{eq} , for each of the following reactions:



101. At the equilibrium point in the decomposition of phosphorus pentachloride to chlorine and phosphorus trichloride, the following concentrations are obtained: 0.010 mol/L PCl_5 , 0.15 mol/L PCl_3 and 0.37 mol/L Cl_2 . Determine the K_{eq} for the reaction.

need assistance? watch this [video on rate law](#)

need assistance? watch this [video on equilibrium](#)

Topic: acids and bases

102. How many molecules of NaOH are in 3.00 liters of a 2.00M NaOH solution?

hint: $\text{mol/L} \times \text{L} \times \text{molecules/mol} = \text{molecules}$

103. Example: How many molecules of NaOH are in 3.00 liters of a pH 13.2 solution?

104. Example: How many hydroxide ions are in 17.0 liters of a 0.42M $\text{Al}(\text{OH})_3$ solution?

105. If 323 mL of 2.1 M NaOH were required to neutralize 414 mL of an unknown acid. The $[\text{OH}^-]$ concentration of the acid must be _____ M.

hint: $C_1V_1 = C_2V_2$

need assistance? watch [this video on acids and bases](#) and [this one on titration](#)

chemistryacademy
ap chemistry summer prep course

final thoughts



chemistryacademy
ap chemistry summer prep course

certificate





congratulations!
for successful completion of the A Z chemistry
summer preparation course



• Dr. B. chemistryacademy.org