Student Name: ____________________ Recitation T.A Name: ____________________

THE OHIO STATE UNIVERSITY

CHEMISTRY 1210 – SPRING 2014

DR. FUS: MIDTERM EXAM 3 - TEST FORM A

Please fill in your name and Recitation T.A Name above.
Your scan sheet must be completed using a PENCIL only.
Fill your Scan Sheet in with the following items. Use the picture below as a guide:

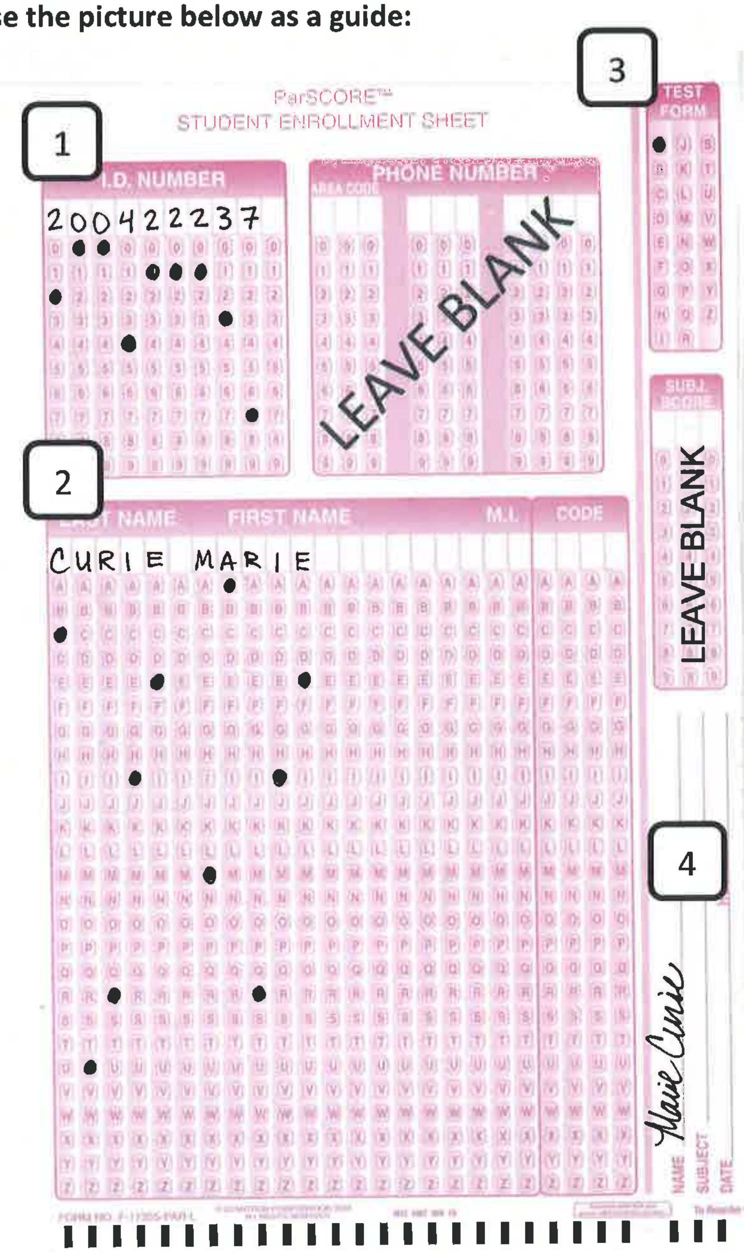
1. **I.D. NUMBER:** Write AND bubble in your **9 digit** SIS ID # (which is the same number as your Carmen ID #). ***Only*** *add a preceding 0 if you have an 8 digit ID #.*
   No ID # should be more than 9 digits!

2. **NAME:** Write AND bubble in your last name, first name, and middle initial; each separated with one blank space.

3. **TEST FORM:** You have **Test Form A.** Bubble in "A" in the Test Form category. This is extremely important! If you leave this column blank, your exam cannot be scored.

4. **SIGNATURE:** Sign the scan sheet in the vertical space provided below "SUBJ SCORE".

5. There are 17 numbered exam pages in this exam booklet, including a periodic table and useful information.



Failing to properly bubble in your SIS/Carmen ID #, or your Test Form, will delay the grading of your test.

1. Do the indicated arithmetic and give the answer to the correct number of significant figures.

   (3.53 ÷ 0.0840) - (14.8 x 0.046) + 39.011

   A. 80.291
   B. 80.29
   C. 80
   D. 80.3
   E. 8.0×10^1

2. Zinc and phosphorus react to form Zn_3P_2. A 4.0 g sample of zinc is reacted with 2.0 g of phosphorus. What weight of what substance remains unreacted?

   A. 0.74 g P
   B. 0.16 g P
   C. 0.10 g P
   D. 0.22 g Zn
   E. 1.2 g Zn

3. The titration of 25.0 mL of an unknown concentration H_2SO_4 solution requires 83.6 mL of 0.12 M LiOH solution. What is the concentration of the H_2SO_4 solution (in M)?

   A. 0.10 M
   B. 0.20 M
   C. 0.25 M
   D. 0.36 M
   E. 0.40 M

4. What amount of heat energy (kJ) is released in forming 31.4 g of Ga_2O_3 by the following reaction?

   $$4\ Ga(s) + 3\ O_2(g) \rightarrow 2\ Ga_2O_3(s) \qquad \Delta H° = -2158\ kJ$$

   A. 362
   B. 90.5
   C. 143
   D. 181
   E. 212

5. Choose the ground state electron configuration for Ti^{2+}.

A. $[Ar]3d^4$

B. $[Ar]3d^2$

C. $[Ar]4s^23d^4$

D. $[Ar]4s^23d^2$

E. $[Ar]4s^2$

6. What period 3 element has the following ionization energies (all in kJ/mol)?

$IE_1 = 1012$

$IE_2 = 1900$
$IE_3 = 2910$
$IE_4 = 4960$
$IE_5 = 6270$
$IE_6 = 22{,}200$

A. Mg
B. P
C. Si
D. S
E. Cl

7. Which of the following is not a correct representation of an electron dot symbol?

A. 

B. 

C. 

D. 

E. 

8. The octet rule relates the number 8

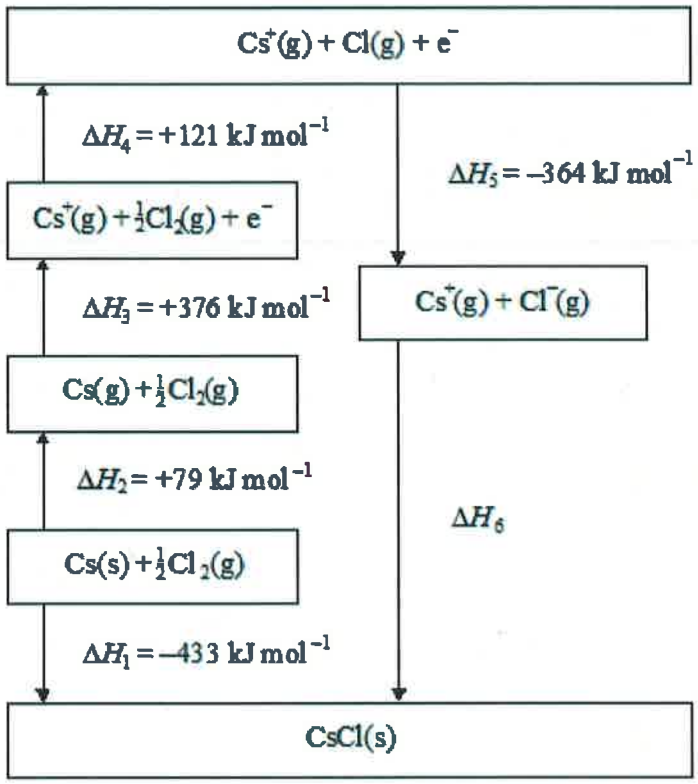
A. to atoms having 8 valence electrons.
B. orbitals having 8 electrons.
C. to atoms having only s and p subshells.
D. to the number of electrons in the subshell which atoms tend to gain.
E. to the number of orbitals.

9. How many electrons are in a single covalent bond?
A. 1
B. 2
C. 3
D. 4
E. 8

10. Two atoms are held together by a chemical bond because:
A. their nuclei attract each other.
B. the electrons forming the bond attract each other.
C. their nuclei are attracted to the bonding electrons.
D. the bonding electrons form an electrostatic cloud that wraps and contains both nuclei.

11. Given the figure below, calculate the lattice energy for caesium chloride.

The energy level diagram (Born-Haber cycle) for caesium chloride is shown below.



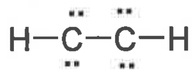
A. -645 kJ/mol
B. -221 kJ/mol
C. -1009 kJ/mol
D. -1373 kJ/mol
E. -212 kJ/mol

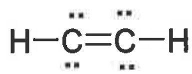
12. Consider the following ionic substances and arrange them in order of decreasing lattice energy.

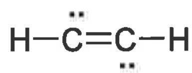
NaI KI LiCl

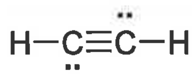
A. LiCl > KI > NaI
B. NaI > KI > LiCl
C. KI > NaI > LiCl
D. NaI > LiCl > KI
E. LiCl > NaI > KI

13. Which of the following is an acceptable Lewis structure for C_2H_2?

A. 

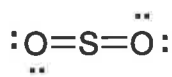
B. 

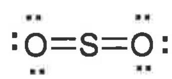
C. 

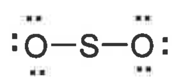
D. 

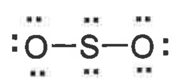
E. 

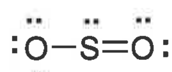
14. Which of the following is the correct Lewis structure for SO_2?

A. 

B. 

C. 

D. 

E. 

15. Which of the following species has a triple covalent bond?

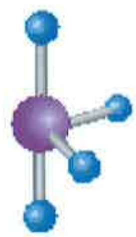
A. NO_3^-
B. CN^-
C. CO_2
D. $AlCl_3$
E. NH_3

16. The shape of the reactant containing sulfur in the following reaction is __ and that of the product is ___.

$$SF_2 + F_2 \longrightarrow SF_4$$

A. linear, see-saw
B. linear, tetrahedral
C. bent, square planar
D. bent, tetrahedral
E. bent, see-saw

17. Determine the most likely the central atom in the molecular geometry shown in the figure.



A. Be
B. N
C. Si
D. S
E. Br

18. Consider the following molecules and select those that are polar.

1) ClF 2) ClF_3 3) ClF_5

A. 1 and 2
B. 2 and 3
C. 1 and 3
D. 1, 2 and 3
E. only 3

19. Which of the following has bond angles of approximately 109.5°?

1) ClF_3 2) BF_3 3) ClO_4^- 4) SF_4 5) $GeCl_4$

A. 1 and 4
B. 2 and 3
C. 3 and 5
D. 4 only
E. 5 only

20. Which of the following compounds is not possible?

A. SF_6, because fluoride does not have empty d-orbitals available to form an expanded octet.
B. OCl_6, because oxygen does not have empty d-orbitals available to form an expanded octet.
C. H^-, because hydrogen only forms positive ions.
D. PbO_2, because the only charge on the lead ion is +2
E. XeF_4, becuase noble gases do not react.

21. What types of hybrid orbitals are involved in bonding of BrF_5?

A. sp^3
B. sp^2
C. sp
D. dsp^3
E. d^2sp^3

22. As bond length between a given pair of atoms increases:
A. bond strength and bond energy decrease.
B. bond strength and bond energy increase.
C. bond strength increases and bond energy decreases.
D. bond strength decreases and bond energy increases.

23. Draw the Lewis structure for the molecule CH_2CHCH_3. How many sigma and pi bonds does it contain?

A. 9 sigma, 0 pi
B. 9 sigma, 1 pi
C. 7 sigma, 1 pi
D. 8 sigma, 1 pi
E. 8 sigma, 2 pi

24. Write resonance structures for CO_3^{2-}. Based on these structures one can conclude that the bond order of the C - O bond is

A. ½
B. ⅔
C. 1
D. 1 ⅓
E. 1 ⅔

25. Removal of an electron from O_2 ___ the bond, removal of an electron from N_2 ___ the bond.

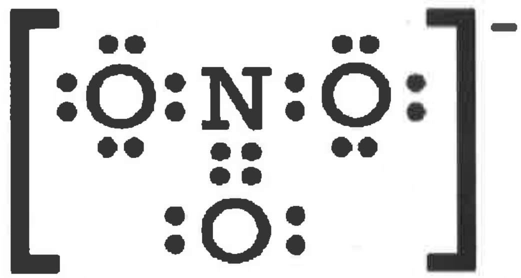
A. weakens, weakens
B. strengthens, strengthens
C. weakens, strengthens
D. strengthens, weakens

26. Which concept describes the formation of four equivalent, single, covalent bonds by carbon in its compounds that resemble methane, CH_4?
A. hydrogen bonding
B. sigma bonding
C. hybridization
D. molecular orbital theory
E. π delocalization

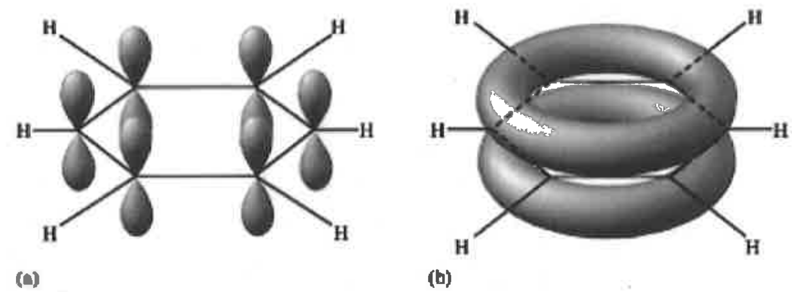
27. Knowing that F is more electronegative than either B or P, what conclusion can be drawn from the fact that BF_3 has no dipole moment, but PF_3 does?
    A. The atomic radius of P is larger than the atomic radius of B.
    B. BF_3 violates the octet rule.
    C. P is more electronegative than B.
    D. The BF_3 molecule must be trigonal planar.
    E. The PF_3 molecule must be trigonal planar.

28. A google search of the nitrate anion resulted in the following structures.

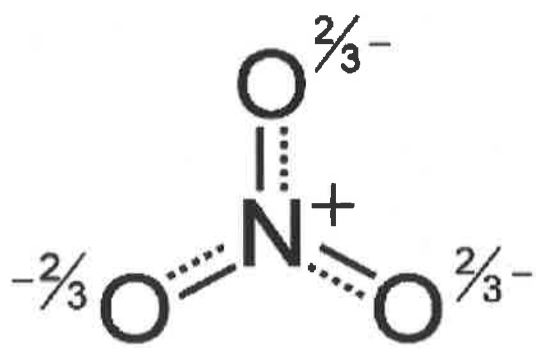
A



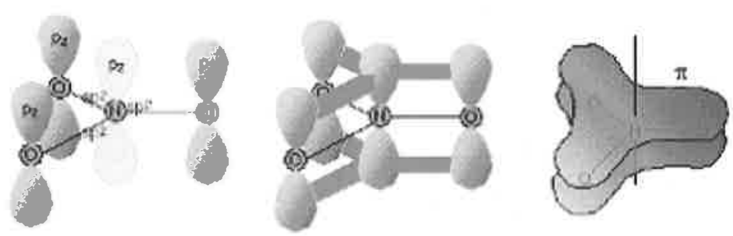
B



C



D



Which of these structures represent an accurate depiction of the nitrate anion?

A. A and C
B. B and D
C. C and D
D. A, C, and D
E. A, B, C, and D

29. Which of the following statements is TRUE?

A. A bond order of 0 represents a stable chemical bond.

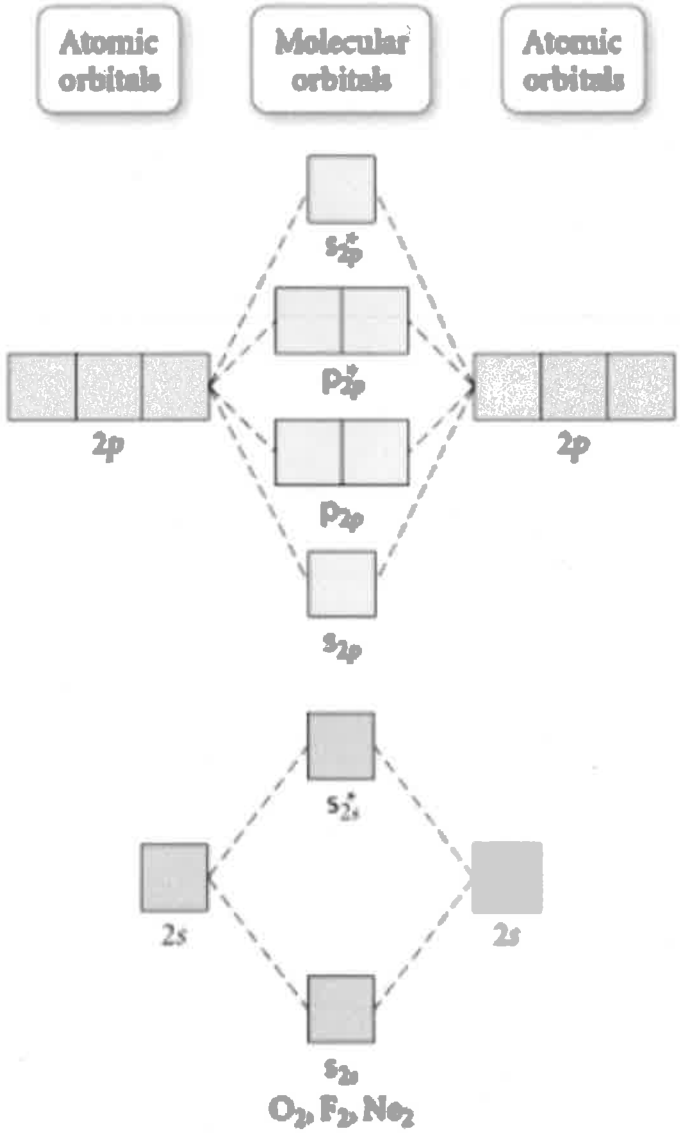
B. Electrons placed in antibonding orbitals stabilize the ion/molecule.

C. When two atomic orbitals come together to form two molecular orbitals, one molecular orbital will be lower in energy than the two separate atomic orbitals and one molecular orbital will be higher in energy than the separate atomic orbitals.

D. The total number of molecular orbitals formed doesn't always equal the number of atomic orbitals in the set.

E. All statements in this question are true.

30. Use the molecular orbital diagram shown to determine which of the following is **most** stable.



A. Ne_2^{2+}

B. F_2^{2+}

C. O_2^{2+}

D. F_2^{2-}

E. F_2

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CHEMISTRY 1210 SUPPLEMENTAL INFORMATION

Useful Conversion Factors and Relationships

Length

SI unit: meter (m)

1 km = 0.62137 mi
1 mi = 5280 ft
= 1.6093 km
1 m = 1.0936 yd
1 in. = 2.54 cm (exactly)
1 cm = 0.39370 in.
$1\ \text{Å} = 10^{-10}$ m

Mass

SI unit: kilogram (kg)

1 kg = 2.2046 lb
1 lb = 453.59 g
= 16 oz
$1\ \text{amu} = 1.660538782 \times 10^{-24}$ g

Temperature

SI unit: Kelvin (K)

0 K = −273.15 °C
= −459.67 °F
K = °C + 273.15
$°C = \frac{5}{9}(°F - 32°)$
$°F = \frac{9}{5}°C + 32°$

Energy (derived)

SI unit: Joule (J)

$1\ \text{J} = 1\ \text{kg-m}^2/\text{s}^2$
= 0.2390 cal
= 1 C-V
1 cal = 4.184 J
$1\ \text{eV} = 1.602 \times 10^{-19}$ J

Pressure (derived)

SI unit: Pascal (Pa)

$1\ \text{Pa} = 1\ \text{N/m}^2$
$= 1\ \text{kg/m-s}^2$
$1\ \text{atm} = 1.01325 \times 10^5$ Pa
= 760 torr
$= 14.70\ \text{lb/in}^2$
$1\ \text{bar} = 10^5$ Pa
1 torr = 1 mm Hg

Volume (derived)

SI unit: cubic meter (m^3)

$1\ \text{L} = 10^{-3}\ \text{m}^3$
$= 1\ \text{dm}^3$
$= 10^3\ \text{cm}^3$
= 1.0567 qt
1 gal = 4 qt
= 3.7854 L
$1\ \text{cm}^3 = 1$ mL
$1\ \text{in}^3 = 16.4\ \text{cm}^3$

TABLE 4.1 • Solubility Guidelines for Common Ionic Compounds in Water

Soluble Ionic Compounds		Important Exceptions
Compounds containing	NO_3^-	None
	CH_3COO^-	None
	Cl^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	Br^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	I^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	SO_4^{2-}	Compounds of Sr^{2+}, Ba^{2+}, Hg_2^{2+}, and Pb^{2+}
Insoluble Ionic Compounds		**Important Exceptions**
Compounds containing	S^{2-}	Compounds of NH_4^+, the alkali metal cations, Ca^{2+}, Sr^{2+}, and Ba^{2+}
	CO_3^{2-}	Compounds of NH_4^+ and the alkali metal cations
	PO_4^{3-}	Compounds of NH_4^+ and the alkali metal cations
	OH^-	Compounds of NH_4^+, the alkali metal cations, Ca^{2+}, Sr^{2+}, and Ba^{2+}

TABLE 4.5 • Activity Series of Metals in Aqueous Solution

Metal	Oxidation Reaction
Lithium	$Li(s) \longrightarrow Li^+(aq) + e^-$
Potassium	$K(s) \longrightarrow K^+(aq) + e^-$
Barium	$Ba(s) \longrightarrow Ba^{2+}(aq) + 2e^-$
Calcium	$Ca(s) \longrightarrow Ca^{2+}(aq) + 2e^-$
Sodium	$Na(s) \longrightarrow Na^+(aq) + e^-$
Magnesium	$Mg(s) \longrightarrow Mg^{2+}(aq) + 2e^-$
Aluminum	$Al(s) \longrightarrow Al^{3+}(aq) + 3e^-$
Manganese	$Mn(s) \longrightarrow Mn^{2+}(aq) + 2e^-$
Zinc	$Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$
Chromium	$Cr(s) \longrightarrow Cr^{3+}(aq) + 3e^-$
Iron	$Fe(s) \longrightarrow Fe^{2+}(aq) + 2e^-$
Cobalt	$Co(s) \longrightarrow Co^{2+}(aq) + 2e^-$
Nickel	$Ni(s) \longrightarrow Ni^{2+}(aq) + 2e^-$
Tin	$Sn(s) \longrightarrow Sn^{2+}(aq) + 2e^-$
Lead	$Pb(s) \longrightarrow Pb^{2+}(aq) + 2e^-$
Hydrogen	$H_2(g) \longrightarrow 2\,H^+(aq) + 2e^-$
Copper	$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$
Silver	$Ag(s) \longrightarrow Ag^+(aq) + e^-$
Mercury	$Hg(l) \longrightarrow Hg^{2+}(aq) + 2e^-$
Platinum	$Pt(s) \longrightarrow Pt^{2+}(aq) + 2e^-$
Gold	$Au(s) \longrightarrow Au^{3+}(aq) + 3e^-$

Fundamental Constants*

Atomic mass unit	1 amu	$= 1.660538782 \times 10^{-27}$ kg
	1 g	$= 6.02214179 \times 10^{23}$ amu
Avogadro's number	N_A	$= 6.02214179 \times 10^{23}$/mol
Boltzmann's constant	k	$= 1.3806504 \times 10^{-23}$ J/K
Electron charge	e	$= 1.602176487 \times 10^{-19}$ C
Faraday's constant	F	$= 9.64853399 \times 10^{4}$ C/mol
Gas constant	R	= 0.082058205 L-atm/mol-K
		= 8.314472 J/mol-K
Mass of electron	m_e	$= 5.48579909 \times 10^{-4}$ amu
		$= 9.10938215 \times 10^{-31}$ kg
Mass of neutron	m_n	= 1.008664916 amu
		$= 1.674927211 \times 10^{-27}$ kg
Mass of proton	m_p	= 1.007276467 amu
		$= 1.672621637 \times 10^{-27}$ kg
Pi	π	= 3.1415927
Planck's constant	h	$= 6.62606896 \times 10^{-34}$ J-s
Speed of light in vacuum	c	$= 2.99792458 \times 10^{8}$ m/s

*Fundamental constants are listed at the National Institute of Standards and Technology Web site: http://www.nist.gov/physlab/data/physicalconst.cfm

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Energy states of the hydrogen atom: $E = (-2.18 \times 10^{-18}\ J)(1/n^2)$

$\lambda = h/mv$, $E = hc/\lambda$

$\Delta H^\circ_{rxn} = \Sigma\, \Delta H^\circ_{products} - \Sigma\, n\Delta H^\circ_{reactants}$, $\Delta H^\circ_{rxn} = \Sigma$ bonds broken $- \Sigma$ bonds formed

q = mass x specific heat x ΔT, PE of two interacting charges $E = k(Q_1Q_2)/d$

$F = ma$, $P = F/A$, $KE = ½\, mv^2$

$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$, and for an ideal gases: $PV = nRT$

$v = \sqrt{\frac{3RT}{M}}$ where v is rms speed

$z^2 = x^2 + y^2$ (diagonal of right angle triangle), $V_{box} = l \cdot w \cdot h$

$S_g = k_H P_g$, $P_A = X_A P^\circ_A$, $\Delta T_b = K_f m$, $\Delta Tf = K_f m$, $\Pi = (n/V)RT$

$\Delta P = X_{solute} P^\circ_{solvent}$ $\quad P_{solution} = X_{solvent} P^\circ_{solvent}$

$$ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_v}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) \quad \log\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_v}{2.303R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) \quad ln(P) = \frac{-\Delta H_v}{R}\left(\frac{1}{T}\right) + C$$

For the general equation: $aA + bB \leftrightarrows dD + eE$

$$\text{Rate} = -\frac{1}{a}\frac{\Delta[A]}{\Delta t} = -\frac{1}{b}\frac{\Delta[B]}{\Delta t} = \frac{1}{c}\frac{\Delta[C]}{\Delta t} = \frac{1}{d}\frac{\Delta[D]}{\Delta t} \qquad Q = \frac{[D]^d[E]^e}{[A]^a[B]^b}$$

$$K_c = \frac{[D^d][E]^e}{[A]^a[B]^b} \qquad K_p = \frac{(P_D)^d(P_E)^e}{(P_A)^a(P_B)^b} \qquad K_p = K_c(RT)^{\Delta n}$$

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

$$t_{1/2} = -\frac{\ln 1/2}{k} = \frac{0.693}{k} \qquad t_{½} = \frac{1}{k[A]_0}$$

$$\ln k = -\frac{E_a}{RT} + \ln A$$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) \qquad \log\left(\frac{k_2}{k_1}\right) = \frac{E_a}{2.303R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$k = A\,e^{-E_a/RT} \qquad \ln(k) = -\left(\frac{E_a}{R}\right)\left(\frac{1}{T}\right) + \ln(A)$$

$$\text{Molarity}, M = \frac{\text{moles of solute}}{\text{liters of solution}} \qquad \text{Molality}, m = \frac{\text{moles of solute}}{\text{kilograms of solvent}}$$

$A = \varepsilon bc$

$$\pi = \left(\frac{n}{V}\right)RT = MRT$$

at 25°C, $K_w = 1.0\text{x}10^{-14}$

$$K_c = [H_3O^+][OH^-] = K_w$$

$$K_a = \frac{[H^+][A^-]}{[HA]} \qquad pH = -\log[H^+] = -\log[H_3O^+]. \qquad K_a \times K_b = K_w \qquad pOH = -\log[OH^-]$$

$$\%\ \text{ionization} = \frac{[H^+]_{\text{equilibrium}}}{[HA]_{\text{initial}}} \times 100\% \qquad pH = pK_a + \log\left(\frac{[base]}{[acid]}\right)$$

$$\text{for } ax^2 + bx + c = 0, \qquad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$S = k_B \ln W$$

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

$$\Delta G = \Delta G^\circ + RT \ln Q$$

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

$$E^\circ_{cell} = E^\circ_{red}\,(\text{cathode}) - E^\circ_{red}\,(\text{anode})$$

$$\Delta G = -nFE_{cell}$$

$$\mathrm{E_{cell}} = \mathrm{E^\circ_{cell}} - \frac{0.0592V}{n}\log Q$$

$$\ln K = -\Delta H^\circ/R(1/T) + C$$

Periodic Table of the Elements

Metals | Metalloids | Nonmetals

	Main Group Representative Elements 1A[a] 1	2A 2	Transition metals 3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	Main Group Representative Elements 3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1	1 H 1.00794																	2 He 4.002602
2	3 Li 6.941	4 Be 9.012182											5 B 10.811	6 C 12.0107	7 N 14.0067	8 O 15.9994	9 F 18.998403	10 Ne 20.1797
3	11 Na 22.989770	12 Mg 24.3050											13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.065	17 Cl 35.453	18 Ar 39.948
4	19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.64	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80
5	37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc [98]	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.293
6	55 Cs 132.90545	56 Ba 137.327	71 Lu 174.967	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po [208.98]	85 At [209.99]	86 Rn [222.02]
7	87 Fr [223.02]	88 Ra [226.03]	103 Lr [262.11]	104 Rf [261.11]	105 Db [262.11]	106 Sg [266.12]	107 Bh [264.12]	108 Hs [269.13]	109 Mt [268.14]	110 Ds [281.15]	111 Rg [272.15]	112 Cn [285]	113 [284]	114 [289]	115 [288]	116 [292]	117 ** [294]	118 [294]

Lanthanide series	57 La 138.9055	58 Ce 140.116	59 Pr 140.90765	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.259	69 Tm 168.93421	70 Yb 173.04
Actinide series	89 Ac [227.03]	90 Th 232.0381	91 Pa 231.03588	92 U 238.02891	93 Np [237.05]	94 Pu [244.06]	95 Am [243.06]	96 Cm [247.07]	97 Bk [247.07]	98 Cf [251.08]	99 Es [252.08]	100 Fm [257.10]	101 Md [258.10]	102 No [259.10]

[a]The labels on top (1A, 2A, etc.) are common American usage. The labels below these (1, 2, etc.) are those recommended by the International Union of Pure and Applied Chemistry (IUPAC).

The names and symbols for elements 113 and above have not yet been decided.

Atomic weights in brackets are the names of the longest-lived or most important isotope of radioactive elements.

Further information is available at http://www.webelements.com

** Discovered in 2010, element 117 is currently under review by IUPAC.