00149

Student Name: KEY Recitation T.A Name: ____________

THE OHIO STATE UNIVERSITY

CHEMISTRY 1210 – AUTUMN 2013

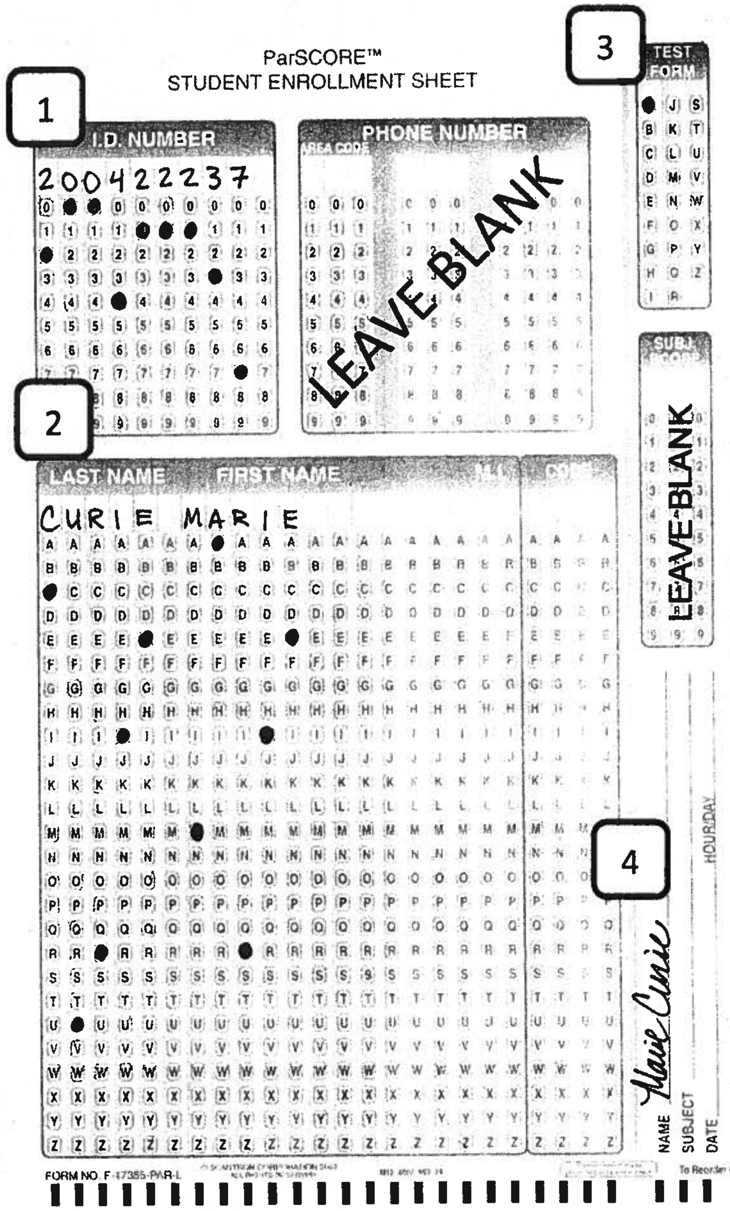
DR. FUS: MIDTERM EXAM 3 - TEST FORM A

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 8 numbered pages in this exam booklet, as well as 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. In the past two decades, a new method termed solid-state metathesis (SSM) has been developed to synthesize compounds that are often difficult to produce conventionally. The driving force behind SSM reactions is the formation of stable byproducts. For example, combining gallium iodide with lithium nitride to produce gallium nitride, as given below in the unbalanced reaction:

$$GaI_3(s) + Li_3N(s) \rightarrow GaN(s) + 3LiI(s)$$

When the reaction above is balanced what is the sum of the whole number coefficients for all the reactants and products?

$1+1+1+3 = 6$

A. 4
B. ~~5~~
96.48% C. 6
D. ~~10~~
E. 12

2. If 3.0 grams of GaI_3 reacted fully with 3.0 grams of Li_3N, what is the mass of the excess reactant that remains after the reaction is complete?

A. 0.23 grams
B. 0.56 grams
C. ~~2.44 grams~~
72.71% D. 2.77 grams
E. ~~7.21 grams~~

$3.0\,g\ GaI_3 \times \frac{1\,mol\ GaI_3}{69.723+3(126.90)} \times \frac{1\,mol\ GaN}{1\,mol\ GaI_3} = 0.00666\,mol\ GaN$

$3.0\,g\ Li_3N \times \frac{1\,mol\ Li_3N}{3(6.94)+14} \times \frac{1\,mol\ GaN}{1\,mol\ Li_3N} = 0.08614\,mol\ GaN$

$0.00666\,mol\ GaN \times \frac{1\,mol\ Li_3N}{1\,mol\ GaN} \frac{34.823\,g}{1\,mol\ Li_3N} = 0.2319\,g\ Li_3N$ $3.0\,g - 0.2319\,g = 2.77\,g$

3. Which species in this reaction has the greatest lattice energy?

A. GaI_3 $(+3)(-1)$
B. ~~Li_3N~~ $(+1)(-3)$
63.73% C. GaN $(+3)(-3)$ ✓
D. LiI $(+1)(-1)$
E. since all species are solids, they will have the same lattice energy

4. In this reaction gallium has a +3 oxidation state. What is the electron configuration for the Ga^{3+} cation?

A. [Ar] $4s^2 3d^{10} 4p^1$

B. [Ar] $4s^2 3d^8$

83.45% C. [Ar] $3d^{10}$

D. [Ar] $4s^2 4f^{14} 4d^{10} 4p^1$

E. [Ne] $3s^2 3p^6$

Ga: [Ar] $4s^2 3d^{10} 4p^1$

Ga^{3+}: [Ar] $3d^{10}$

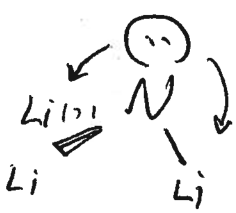
5. In the vapor phase, Li_3N exists as a discrete molecule. What is its molecular geometry?

A. trigonal planar
B. bent
83.45% ~~C. tetrahedral~~
D. trigonal pyramid
~~E. t-shaped~~

N: 5 val e⁻
Li: 3(1e⁻)
8e⁻ → 4 pairs → 3 bp, 1 lp
Trigonal Pyramid

6. In the vapor phase, Li_3N exists as a discrete molecule. What would you predict the Li - N bond angles to be?

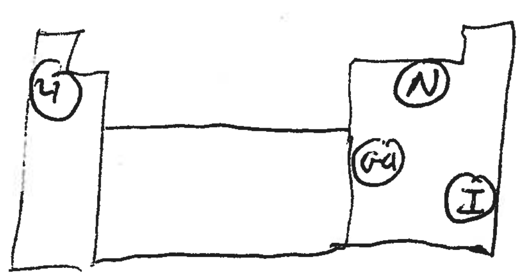
A. Slightly less than 90 °
~~B. Exactly 90 °~~
78.70% C. Slightly less than 109.5 °
D. Exactly 109.5 °
E. Exactly 120 °



less than 109.5°

7. The list below includes all the possible bonds from the products/reactants in this reaction. Which bond is the most polar?

~~A. Ga - I~~
41% B. Li - N
~~C. Ga - N~~
D. Li - I
E. All four bonds are non-polar



most polar: largest electronegativity difference

Li-N

8. This reaction is highly exothermic with a ΔH_{rxn} of -515 kJ. If 5.3 grams of LiI(s) is produced, how much energy is released in the reaction?

43.84%
A. 6.80 kJ
B. 20.4 kJ
C. 97.2 kJ
D. 515 kJ
E. 2729 kJ

$5.3 g\ LiI \times \frac{1 mol\ LiI}{133.8447 g} \times \frac{-515 kJ}{3 mol\ LiI} = 6.80 kJ$

9. Based on the atomic radii given below (in Angstroms), what would you predict for the trend in ionic radii?

Li: 1.34 Å — Li^+ smaller than 1.34 Å
N: 0.75 Å — N^{3-} larger than 0.75 Å
Ga: 1.26 Å — Ga^{3+} smaller than 1.26 Å
I: 1.33 Å — I^- larger than 1.33 Å

A. largest $Li^+ > N^{3-} > Ga^{3+} > I^-$ smallest
B. largest $I^- > Ga^{3+} > N^{3-} > Li^+$ smallest
C. largest $I^- > Ga^{3+} > Li^+ > N^{3-}$ smallest
D. largest $Ga^{3+} > Li^+ > I^- > N^{3-}$ smallest
40.49% E. largest $I^- > N^{3-} > Li^+ > Ga^{3+}$ smallest

10. Which of the following statements is/are true?

I. The 4[th] ionization energy for Ga is greater than the 4[th] ionization energy of N. True
II. Iodine has a larger (more negative) electron affinity than Li. True
III. We would expect gallium to react vigorously with water, while lithium will not react with water. False
IV. The electronegativity for nitrogen is greater than iodine. True

A. II only
B. II and IV only
44.72% C. I and IV only
D. I, II, and IV
E. I, II, III, and IV

I. 4th IE: $Ga^{3+} \rightarrow Ga^{4+} + e^-$ ← removes e^- from filled d block
$N^{3+} \rightarrow N^{4+} + e^-$

II. Halogens have large (highly (-)) EA. Noble Gas core

[1l] [1l|1l|1l] ← adding e^- gives NG core.

III. From lecture video, Li reacts vigorously w/ water

IV. N is highly electronegative
EN decreases ↓ N > I

11. 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?

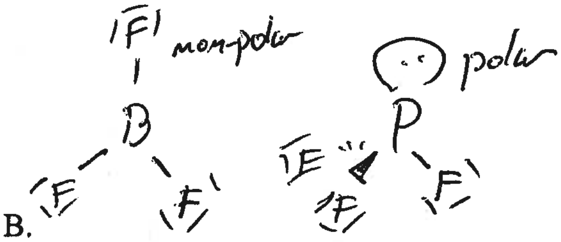
different structures

A. BF_3 is not spherically symmetrical, but PF_3 is.

84.57% B. The BF_3 molecule must be trigonal planar

C. The BF_3 molecule must be linear

D. The atomic radius of P is larger than the atomic radius of B.



12. Fe^{2+} has a higher ionization energy than Fe. Which of the following is a reasonable explanation of this fact?

A. Fe^{2+} is larger than Fe ✗ cations are smaller

B. Fe^{2+} is isoelectronic with chromium, which has a higher ionization energy than Fe — This does not explain why

71.83% C. The outer electrons on Fe^{2+} experience a greater effective nuclear charge than those of Fe ✓

D. Energy had to be put into Fe to ionize it to Fe^{2+}

does not explain IE

13.

Ionization Energies for element X (kJ/mol)				
First	Second	Third	Fourth	Fifth
580	1,815	2,740	11,600	14,800

The ionization energies for an element X are listed in the table above. On the basis of this data, element X is most likely to be

A. Na

B. Mg

63.56% C. Al

D. Si

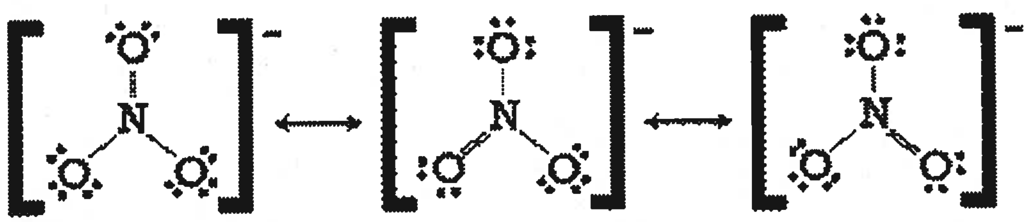
E. P

large jump from 3rd → 4th

↳ 3 val e⁻

↳ Al

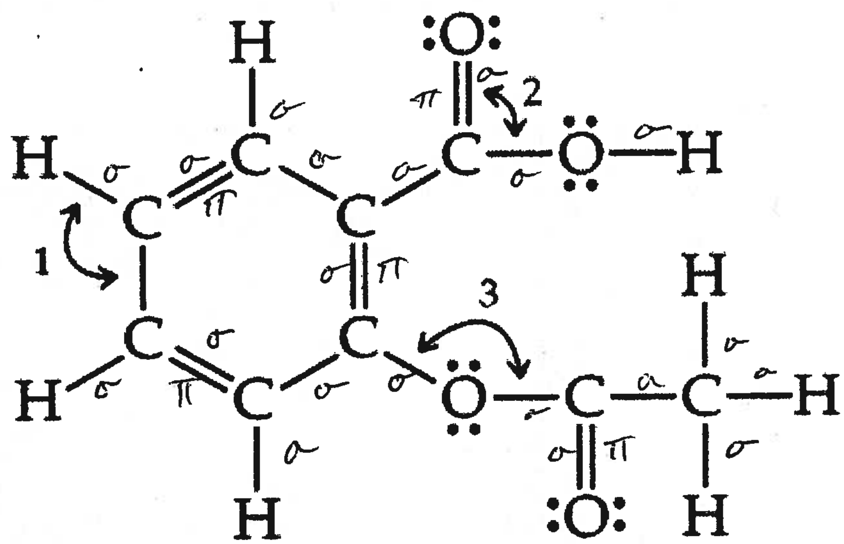
14. The structure of NO_3^- can be described in the Lewis formulation by these three structures.



This means that

A. two nitrogen-to-oxygen bonds are single bonds, the third is a double bond ✗ resonance ⇒ equal bonds
B. three independent forms of the NO_3^- ion coexist in equilibrium ✗
C. the electrons must be rapidly exchanging among the three forms resonance ⇒ one form
40.85% D. the NO_3^- ion exists in only one form: an average of the three principle structures shown.

15. For questions 15-16, use the following Lewis Structure for acetylsalicylic acid, or aspirin:

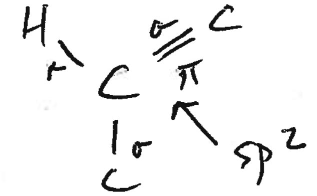


How many sigma bonds are in the molecule?

A. 5
B. 8
C. 16
32% D. 21
E. 26

16. How would you describe the bonding interaction between the hydrogen atom directly above the number 1 with the carbon atom to its immediate right?

A. H 1s - C 2s
B. H 1 s - C 2p
C. H 1s - C sp
D. H 1s - C sp^2
E. H 1s - C sp^3



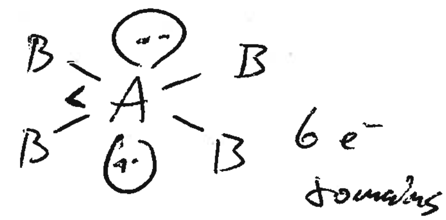
$Csp^2 - H_{1s}$

17. A certain AB_4 molecule has a square-planar molecular geometry. Which of the following statements about the molecule is or are true?

I. The molecule has four electron domains about the central atom A.

II. The B—A—B angles between neighboring B atoms is 90°.

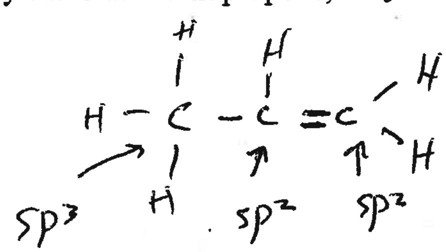
III. The molecule has two nonbonding pairs of electrons on atom A.



A. Only one of the statements is true
B. Statements I and II are true
C. Statements I and III are true
D. Statements II and III are true
E. All three statements are true

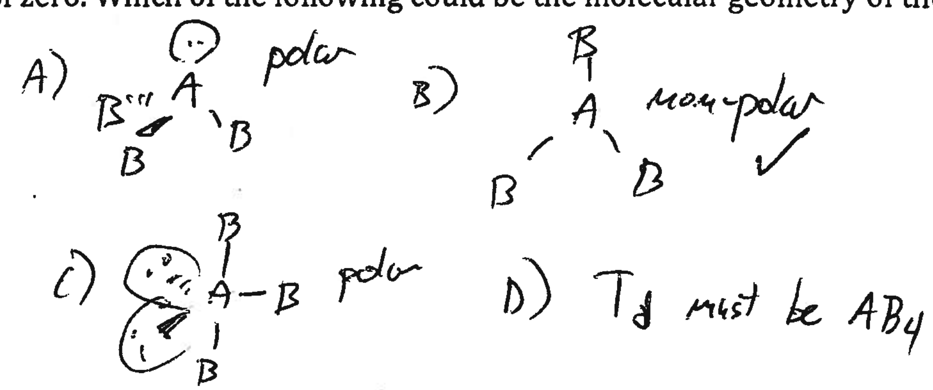
18. Types of hybridization exhibited by the C atoms in propene, CH_3CHCH_2, include which of the following?

A. sp only
B. sp^3 only
C. sp and sp^2 only
D. sp^2 and sp^3 only
E. sp, sp^2, and sp^3

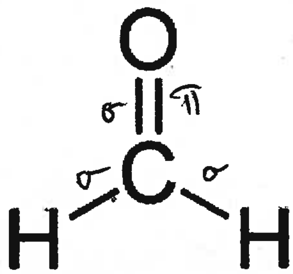


19. Consider an AB_3 molecule in which A and B differ in electronegativity. You are told that the molecule has an overall dipole moment of zero. Which of the following could be the molecular geometry of the molecule?

A. trigonal pyramidal
B. trigonal planar
C. T-Shaped
D. tetrahedral
E. More than one of the above



20. Formaldehyde has the Lewis Structure:

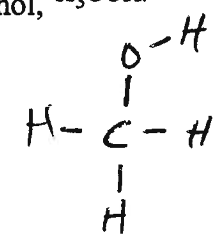


Considering how the bonds in the formaldehyde molecule are formed in terms of overlaps of hybrid and unhybridized orbitals, which of the following statements about the molecule is or are true?

True I. Two of the electrons in the molecule are used to make the π bond in the molecule. ✓

wording II. Six of the electrons in the molecule are used to make the σ bond in the molecule. ✓

True III. The C—O bond length in formaldehyde should be shorter than that in methanol, H_3COH. ✓

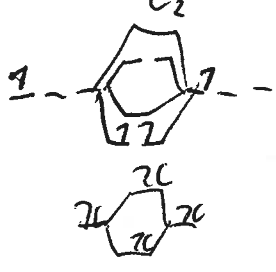


A. Only one of the statements are true
B. Statements I and II are true
C. Statements I and III are true also accept II and III
D. ~~Statements II and III are true~~
55.46% E. All three statements are true

21. Place the following molecular ions in order from smallest to largest bond order: C_2^{2+}, N_2^-, O_2^-, and F_2^-

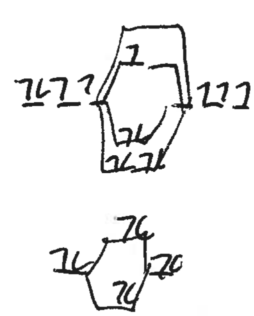
A. $C_2^{2+} < N_2^- < O_2^- < F_2^-$
B. $F_2^- < O_2^- < N_2^- < C_2^{2+}$
C. $O_2^- < C_2^{2+} < F_2^- < N_2^-$
D. $C_2^{2+} < F_2^- < O_2^- < N_2^-$
37.32% E. $F_2^- < C_2^{2+} < O_2^- < N_2^-$

C_2^{2+}



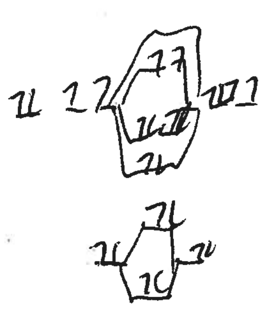
b.o. $= \frac{4-2}{2} = 1$

N_2^-



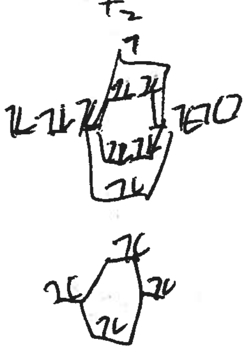
b.o. $= \frac{8-3}{2} = 5/2$

O_2^-



b.o. $= \frac{8-4}{2} = 2$

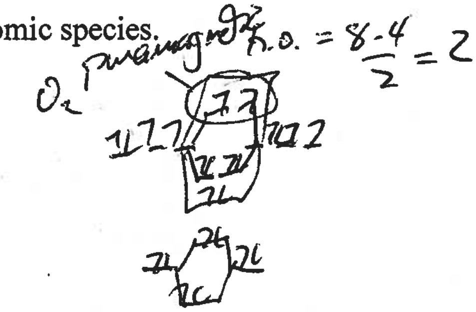
F_2^-

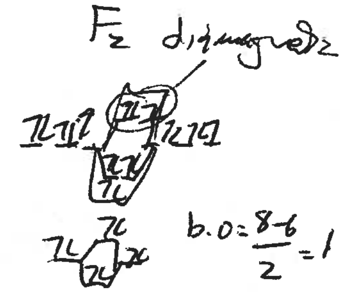


b.o. $= \frac{8-7}{2} = 1/2$

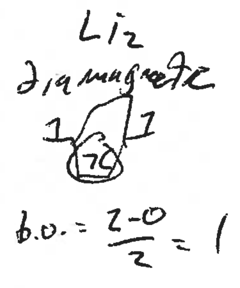
22. Questions 22 - 24 refer to the following diatomic species.

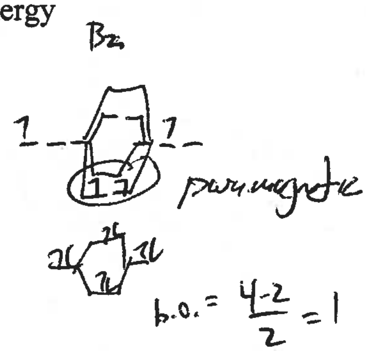
(A) Li_2
(B) B_2
(C) N_2
(D) O_2
(E) F_2

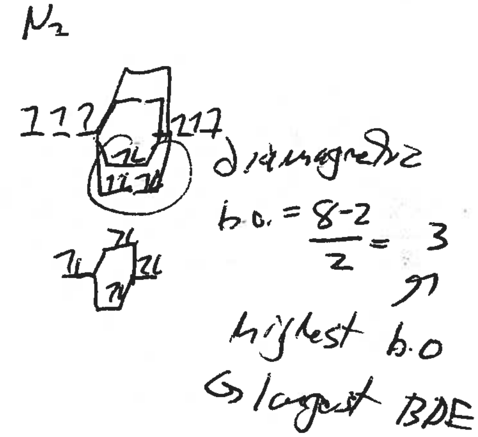




Which has the largest bond dissociation energy
A. Li_2
B. B_2
46.83% C. N_2
D. O_2
E. F_2

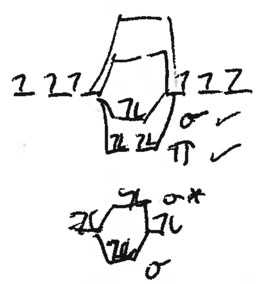






23. Which is paramagnetic?
~~A. Li_2~~ ×
B. B_2 para ✓
C. N_2 ×
40.72% D. O_2 para ✓
E. F_2 ×

24. Which has one sigma and two pi bonds?
A. Li_2
B. B_2
77.64% C. N_2
D. O_2
E. F_2



25. Commercial Vinegar was titrated with NaOH solution to determine the content of acetic acid, $HC_2H_3O_2$. For 20.0 mL of the vinegar, 26.7 mL of 0.600 M NaOH solution was required. What was the concentration of acetic acid in the vinegar if no other acid was present?
A. 1.60 M
76.76% B. 0.800 M
C. 0.600 M
D. 0.450 M
E. 0.343 M

$\frac{0.600 \text{ mol NaOH}}{L} \times 0.0267 L = \frac{0.01602 \text{ mol OH}^-}{0.200} = \text{mol } H^+$

$= 0.800 M$

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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 Å = 10^{-10} m

Mass

SI unit: kilogram (kg)

1 kg = 2.2046 lb
1 lb = 453.59 g
= 16 oz
1 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 J = 1 kg-m^2/s^2
= 0.2390 cal
= 1 C-V
1 cal = 4.184 J
1 eV = 1.602×10^{-19} J

Pressure (derived)

SI unit: Pascal (Pa)

1 Pa = 1 N/m^2
= 1 kg/m-s^2
1 atm = 1.01325×10^5 Pa
= 760 torr
= 14.70 lb/in^2
1 bar = 10^5 Pa
1 torr = 1 mm Hg

Volume (derived)

SI unit: cubic meter (m^3)

1 L = 10^{-3} m^3
= 1 dm^3
= 10^3 cm^3
= 1.0567 qt
1 gal = 4 qt
= 3.7854 L
1 cm^3 = 1 mL
1 in^3 = 16.4 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	= 9.64853399×10^{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	= 2.99792458×10^{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), $V_{box} = l \cdot w \cdot h$

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

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

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

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

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

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

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

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

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

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

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

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

$A = \varepsilon bc$

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

at 25°C, $K_w = 1.0\text{x}10^{-14}$

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

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

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

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

$$S = k_B \ln W$$

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

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

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

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

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

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

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

Periodic Table of the Elements

Main Group Representative Elements (groups 1A–2A); Transition metals (groups 3B–2B); Main Group Representative Elements (groups 3A–8A)

Metals | Metalloids | Nonmetals

Period	1A[a] 1	2A 2	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	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.