Chemistry 141 Name key

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Exam 3A November 13. 2013

Multiple Choice (30 points)

Page 5 (12 points)

Page 6 (17 points)

Page 7 (20 points)

Page 8 (16 points)

Page 9 (12 points)

Total (107 points)

Chemistry Formulas and Constants

Kinetic energy = ½ mv2

w = -PΔV

Ptotal = P1+P2+P3+…

u = (3RT/MW)½

ΔG = ΔH - TΔS

PV = nRT

Rate ∝ (MW)-½

P1=X1\*Ptotal

C = q/ΔT

Ptotal = P1 + P2 + P3 + …

M = mol/L

K = oC + 273.16

m = mol/kg solvent

Xi = moli/ moltotal





1 kcal = 4.184 kJ

NA = 6.02 x 1023 /mol

R = 0.0821 L atm/mol K = 62.4 L torr/mol K = 8.31 kJ/mol K

Standard Temperature and Pressure = 0oC and 1 atm

760 torr = 760 mm Hg = 1.00 atm = 101 kPa = 14.6 psi = 30 in Hg

Grossmont College

Periodic Table

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| IA |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  | VIIA | NOBLE GASES |
| 1  **H**  1.008 | IIA |  |  |  |  |  |  |  |  |  | |  | IIIA | IVA | VA | VIA | 1  **H**  1.008 | 2  **He**  4.002 |
| 3  **Li**  6.941 | 4  **Be**  9.012 |  |  |  |  |  |  |  |  |  | |  | 5  **B**  10.81 | 6  **C**  12.01 | 7  **N**  14.01 | 8  **O**  16.00 | 9  **F**  19.00 | 10  **Ne**  20.18 |
| 11  **Na**  23.00 | 12  **Mg**  24.30 | IIIB | IVB | VB | VIB | VIIB | VIII VIII VIII | | | | IB | IIB | 13  **Al**  27.00 | 14  **Si**  28.09 | 15  **P**  30.97 | 16  **S**  32.06 | 17  **Cl**  35.45 | 18  **Ar**  39.95 |
| 19  **K**  39.10 | 20  **Ca**  40.08 | 21  **Sc**  44.96 | 22  **Ti**  47.90 | 23  **V**  50.94 | 24  **Cr**  52.00 | 25  **Mn**  54.94 | 26  **Fe**  55.85 | 27  **Co**  58.93 | 28  **Ni**  58.70 | | 29  **Cu**  63.55 | 30  **Zn**  65.38 | 31  **Ga**  69.72 | 32  **Ge**  72.59 | 33  **As**  74.92 | 34  **Se**  78.96 | 35  **Br**  79.90 | 36  **Kr**  83.80 |
| 37  **Rb**  85.47 | 38  **Sr**  87.62 | 39  **Y**  88.91 | 40  **Zr**  91.22 | 41  **Nb**  92.91 | 42  **Mo**  95.94 | 43  **Tc**  (99) | 44  **Ru**  101.1 | 45  **Rh**  102.9 | 46  **Pd**  106.4 | 47  **Ag**  107.9 | | 48  **Cd**  112.4 | 49  **In**  114.8 | 50  **Sn**  118.7 | 51  **Sb**  121.8 | 52  **Te**  127.6 | 53  **I**  126.9 | 54  **Xe**  131.3 |
| 55  **Cs**  132.9 | 56  **Ba**  137.3 | 57  **La**  138.9 | 72  **Hf**  178.5 | 73  **Ta**  180.9 | 74  **W**  183.9 | 75  **Re**  186.2 | 76  **Os**  190.2 | 77  **Ir**  192.2 | 78  **Pt**  195.1 | 79  **Au**  197.0 | | 80  **Hg**  200.6 | 81  **Tl**  204.4 | 82  **Pb**  207.2 | 83  **Bi**  209.0 | 84  **Po**  (209) | 85  **At**  (210) | 86  **Rn**  (222) |
| 87  **Fr**  (223) | 88  **Ra**  226.0 | 89  **Ac**  227.0 | 104  **Rf**  (261) | 105  **Db**  (262) | 106  **Sg**  (263) | 107  **Bh**  (262) | 108  **Hs**  (265) | 109  **Mt**  (266) | 110  **??**  (269) |  | |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 58  **Ce**  140.1 | 59  **Pr**  140.9 | 60  **Nd**  144.2 | 61  **Pm**  (147) | 62  **Sm**  150.4 | 63  **Eu**  152.0 | 64  **Gd**  157.3 | 65  **Tb**  158.9 | 66  **Dy**  162.5 | 67  **Ho**  164.9 | 68  **Er**  167.3 | 69  **Tm**  168.9 | 70  **Yb**  173.0 | 71  **Lu**  175.0 |
| 90  **Th**  232.0 | 91  **Pa**  231.0 | 92  **U**  238.0 | 93  **Np**  (237) | 94  **Pu**  (244) | 95  **Am**  (243) | 96  **Cm**  (247) | 97  **Bk**  (247) | 98  **Cf**  (251) | 99  **Es**  (252) | 100  **Fm**  (257) | 101  **Md**  (258) | 102  **No**  (259) | 103  **Lr**  (260) |

Lanthanide series

Actinide series

Multiple choice (30 points)

1. Which of the following occur as the wavelength of a photon increases?
   1. the energy increases
   2. the speed decreases
   3. the frequency decreases
   4. Planck's constant decreases
   5. None of the above occur as the wavelength of a photon increases.
2. Which of the following transitions (in a hydrogen atom) represent **absorption** of the smallest frequency photon?
   1. *n* = 5 to *n* = 3
   2. *n* = 2 to *n* = 1
   3. *n* = 1 to *n* = 3
   4. *n* = 1 to *n* = 2
   5. *n* = 5 to *n* = 6
3. Identify the correct values for a 3p sublevel.
   1. *n* = 3, *l* = 1, *ml* = 0
   2. *n* = 2, *l* = 1, *ml* = +2
   3. *n* = 1, *l* = 0, *ml* = 0
   4. *n* = 2, *l* = 0, *ml* = 0
   5. *n* = 4, *l* = -1, *ml* = -2
4. Which of the following statements is TRUE?
   1. An orbital that penetrates into the region occupied by core electrons is less shielded from nuclear charge than an orbital that does not penetrate and therefore has a lower energy.
   2. An orbital that penetrates into the region occupied by core electrons is more shielded from nuclear charge than an orbital that does not penetrate and therefore has a lower energy.
   3. It is possible for two electrons in the same atom to have identical values for all four quantum numbers.
   4. Two electrons in the same orbital can have the same spin.
   5. None of the above are true.
5. Place the following in order of increasing radius.

Br⁻ Na⁺ Rb⁺

* 1. Br⁻ < Rb⁺ < Na⁺
  2. Na⁺ < Rb⁺ < Br⁻
  3. Rb⁺ < Br⁻ < Na⁺
  4. Br⁻ < Na⁺ < Rb⁺
  5. Rb⁺ < Na⁺ < Br⁻

1. Place the following in order of increasing *IE1*.

K Ca Rb

* 1. Ca < K < Rb
  2. Rb < Ca < K
  3. Ca < Rb < K
  4. Rb < K < Ca
  5. K < Ca < Rb

1. Which reaction below represents the **electron affinity** of Li?
   1. Li(g) + e⁻ → Li⁻(g)
   2. Li(g) → Li⁺(g) + e⁻
   3. Li(g) + e⁻ → Li⁺(g)
   4. Li⁺(g) → Li(g) + e⁻
   5. Li⁺(g) + e⁻ → Li(g)
2. A double covalent bond contains \_\_\_\_\_\_\_\_ of electrons.
   1. 0 pairs
   2. 1 pair
   3. 2 pairs
   4. 3 pairs
   5. 4 pairs
3. Identify the weakest bond.
   1. single covalent bond
   2. double covalent bond
   3. triple covalent bond
   4. all of the above bonds are the same strength
4. Using periodic trends, place the following bonds in order of **increasing** ionic character.

Si-P Si-Cl Si-S

* 1. Si-S < Si-Cl < Si-P
  2. Si-Cl < Si-P < Si-S
  3. Si-Cl < Si-S < Si-P
  4. Si-P < Si-Cl < Si-S
  5. Si-P < Si-S < Si-Cl

1. Which of the following processes are endothermic?
   1. the reaction associated with the lattice energy of LiCl.
   2. the reaction associated with the heat of formation of CaS.
   3. the formation of F2 from its elements in their standard states.
   4. the reaction associated with the ionization energy of potassium.
   5. None of the above are endothermic.
2. The compound ClF contains
   1. ionic bonds.
   2. nonpolar covalent bonds.
   3. polar covalent bonds with partial negative charges on the F atoms.
   4. polar covalent bonds with partial negative charges on the Cl atoms.
3. Which of the following elements can form compounds with an expanded octet?
   1. Se
   2. C
   3. Li
   4. F
   5. All of the above elements can form compounds with an expanded octet.
4. A molecule containing a central atom with sp3d hybridization has a(n) \_\_\_\_\_\_\_\_ electron geometry.
   1. tetrahedral
   2. bent
   3. octahedral
   4. square planar
   5. trigonal bipyramidal
5. List the number of sigma bonds and pi bonds in a single bond.
   1. 1 sigma, 0 pi
   2. 0 sigma, 0 pi
   3. 1 sigma, 1 pi
   4. 3 sigma, 2 pi

Problems (70 points)

1. (12 points)Enormous numbers of microwave photons are needed to warm macroscopic samples of matter. A portion of soup containing 252 g of water is heated in a microwave oven from 20.oC to 98oC, with radiation of wavelength 1.55 x 10−2 m.
   1. What is the frequency of this light?
   2. What is the energy of one photon of this light?
   3. How much energy is required to heat the water in the soup? (remember the specific heat of water is 4.184 J/g oC)
   4. How many photons are absorbed by the water in the soup?
2. (4 points)In order to remove the outermost electron from an atom of neon, light with a minimum frequency of 5.21 x 1015/sec must be shined on a sample of neon. What is the ionization energy (kJ/mol) for neon?
3. (4 points) What is the photoelectric effect?

Many metals emit electrons when light of high enough energy is shone on them. The photoelectric effect describes this phenomenom whereby a photon rather than a wave and is able to behave like a particle and knock an electron out of an atom. This observation brought the classical view of light into question.

1. (9 points) Write electron configurations for the following atoms and ions.
   1. Titanium (complete configuration)

1s2 2s2 2p6 3s2 3p6 4s3 3d2

* 1. Lead (shorthand configuration)

[Xe] 6s2 5d10 4f14 6p2

* 1. Ni(III) ion (shorthand configuration)

[Ar]3d7

1. (4 points) Why is the first ionization energy of sulfur smaller than the first ionization energy of phosphorus? (draw pictures if necessary)

When sulfur loses one electron, it take on a particularly stable, half-filled p subshell. The removal of this first electron therefore requires less energy than the removal of an electron from phosphorus initially half-filled p subshell.

1. (4 points) How are electron affinity and electronegativity different?

Electron affinity is the process of a single atom gaining an electron. Electronegativity is the strength of the attraction of a nucleus to a pair of shared (bonding) electrons within a covalent bond. Electronegativity is only important when looking at covalent bonds and electron affinity is only important when considering single atoms gaining electrons to form anions.

1. (12 points) Complete the following table

|  |  |
| --- | --- |
| Molecule | Lewis Diagram |
| COF2 (C is central)  Orbital geometry  trigonal planar  Molecular geometry  trigonal planar  Hybridization of carbon  sp2 |  |
| XeF4  Orbital geometry  octahedral  Molecular geometry  square planar  Hybridization of xenon  sp3d2 |  |

1. (8 points) Despite many attempts, the perbroamte ion (BrO4−) was not prepared in the laboratory until about 1970. (In fact, articles were published explaining theoretically why it could never be prepared!) Draw a Lewis structure for BrO4− with full octets around each atom and a structure in which all atoms have lowest formal charges. Identify each and show formal charge where appropriate.

|  |  |
| --- | --- |
|  |  |
| All atoms have an octet, but the separation of charge is very destabilizing | Octet expanded on bromine, but formal charge is significantly reduced. |

1. (8 points) Look at the compound pictured below. Explain the bonding in terms of valence bond theory. That is show the atomic orbitals on the I atom, describe any electron promotion and hybridization necessary, and label the orbitals involved in both sigma and pi bonding as well as the orbital holding the lone pair of electrons on I. You do not need to draw a 3D representation of the orbitals.



I

Promotion

I

Hybridization

I

(12 points) Draw molecular orbital diagramsfor C2−1, C2, and C2+1 and answer the questions below regarding these species.

* 1. Give the bond order in all species

C2−1 2 C2+1 1

C2  1.5

* 1. Rank these species in order of increasing bond length

\_\_\_ C2-1\_\_\_<\_\_ C2\_\_\_\_<\_\_\_ C2+1\_\_\_

* 1. Rank these species in order of increasing bond strength

\_\_\_ C2+1\_\_\_<\_\_ C2\_\_\_\_<\_\_\_ C2-1\_\_\_

* 1. Identify each species as diamagnetic or paramagnetic

C2− paramagnetic C2+ diamagnetic

C2  paramagnetic

 

C2

C2−

 

C2+