Chemistry 141 Name key

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Exam 3A April 29. 2013

Multiple Choice (30 points)

Page 1 (16 points)

Page 1 (21 points)

Page 6 (12 points)

Page 7 (16 points)

Page 8 (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. The bonding in a molecule
   1. Must be either totally ionic or totally covalent
   2. May be more ionic-like or more covalent-like, depending on the atoms bonding
   3. Is the same mixture of ionic-like and covalent-like bonds, regardless of the atoms involved
   4. There is no difference between ionic and covalent bonding
2. The bond length between atoms involved in resonance
   1. Changes between bonds every microsecond or so within the molecule
   2. Has one preferred position so that one bond is shorter than the other, which is the same for each molecule; however, the shorter bond can only be detected experimentally
   3. Has one preferred position so that one bond is shorter than the other, but its position varies between molecules so that the average bond length over a mole is the same for all resonance positions
   4. Is exactly the same for all bond lengths
3. For an atom to expand its octet, it must
   1. Have an available d orbital in its valence shell
   2. Have a minimum of four valence electrons as an atom
   3. Have a maximum of four valence electrons as an atom
   4. Be a metalloid
4. The effect of lone pairs on bond angle is that the bonds
   1. Get farther apart
   2. Get closer together
   3. Remain at the same angle
   4. Depend on the identity of the central atom
5. According to the Heisenberg uncertainty principle,
   1. neither the position nor the momentum of a particle can be measured precisely.
   2. the position of a particle cannot be measured precisely.
   3. the momentum of a particle cannot be measured precisely.
   4. the position and momentum of a particle can be measured precisely, but not at the same time.
6. What are the possible values of *n* and *ml* for an electron in a 5*d* orbital?
   1. *n* = 5 and *ml* = 2
   2. *n* = 1, 2, 3, 4, or 5 and *ml* = 2
   3. *n* = 5 and *ml* = -2, -1, 0, +1, or +2
   4. *n* = 1, 2, 3, 4, or 5 and *ml* = -2, -1, 0, +1, or +2
7. Which of the following is *not* a valid set of quantum numbers?
   1. *n* = 3, *l* = 0, *ml* = 0, and *ms* = 1/2
   2. *n* = 3, *l* = 2, *ml* = 3, and *ms* = 1/2
   3. *n* = 2, *l* = 1, *ml* = -1, and *ms* = -1/2
   4. *n* = 2, *l* = 1, *ml* = 0, and *ms* = -1/2
8. Of the following, which atom has the smallest atomic radius?
   1. Sr
   2. Te
   3. S
   4. Mg
9. Arrange the ions N3-, O2-, Mg2+, Na+, and F- in order of increasing ionic radius, starting with the smallest first.
   1. N3-, Mg2+, O2-, Na+, F-
   2. N3-, O2-, Mg2+, F-, Na+
   3. N3-, O2-, F-, Na+, Mg2+
   4. Mg2+, Na+, F-, O2-, N3-
10. List the elements Cs, Ca, Ne, K, Ar in order of decreasing first ionization energy.
    1. Ne > K > Cs > Ca > Ar
    2. Ne > Ar > K > Cs > Ca
    3. Ar > Ca > Cs > K > Ne
    4. Ne > Ar > Ca >K > Cs
11. In the reaction of sodium metal with chlorine gas which of the following processes releases energy?
    1. Cl2(*g*) 🡪 2 Cl(*g*)
    2. Na(*g*) 🡪 Na+(*g*) + e-
    3. Na(*s*) 🡪 Na(*g*)
    4. Cl(*g*) + e- 🡪 Cl-(*g*)
12. The greater the electronegativity difference between two bonded atoms, the
    1. greater the bond order.
    2. greater the ionic character of the bond.
    3. more unstable the bond.
    4. greater the covalent character of the bond.
13. Which of the following occur as the wavelength of a photon increases?
    1. the frequency decreases
    2. the energy increases
    3. the speed decreases
    4. Planck's constant decreases
14. Choose the statement that is TRUE.
    1. Outer electrons efficiently shield one another from nuclear charge.
    2. Core electrons efficiently shield outer electrons from nuclear charge.
    3. Valence electrons are most difficult of all electrons to remove.
    4. Core electrons are the easiest of all electrons to remove.
15. Which of the following elements can form compounds with an expanded octet?
    1. Se
    2. C
    3. Li
    4. F

Problems (70 points)

1. (12 points)One of the photoreceptors in the human eye detects light with a wavelength of 534 nm.
   1. What is the frequency of this light?
   2. What is the energy of one photon of this light?
   3. If the minimum energy that can be detected by the eye is 1.0 x 10-10J, how many photons of light must reach the eye to be detected?
2. (4 points) The ionization energy of sodium is 495 kJ/mol. What is the minimum wavelength of light required to remove an electron from a sodium atom?
3. (4 points) What is the main difference in the way valence bond theory and molecular orbital theories view the bonds in a molecule.

Valence bond theory says that bonds form when half filled atomic orbitals overlap. Molecular orbital theory says that new molecular orbitals are created when bonds form and the atom’s electrons will inhabit these new orbitals.

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

1s2 2s2 2p6 3s2 3p2

* 1. Platinum (shorthand configuration)

[Xe] 6s2 5d8 4f14

* 1. Cobalt(II) ion (shorthand configuration)

[Ar]3d7

1. (4 points) Which ion has a larger radius, Sr2+ or Rb+? Explain your choice.

Rubidium would have the larger radius. Although both ions are isoelectronic (have the same electron configuration), the strontium has more protons and the higher nuclear charge will pull the electrons closer resulting in a smaller ion.

1. (4 points) The ionization energies for aluminum are IE1 = 580 kJ/mol, IE2 = 1815 kJ/mol, IE3 = 2740 kJ/mol, and IE4 = 11,600 kJ/mol. Why does the ionization energy increase as we remove successive electrons and why is there such a big increase in ionization energy to remove the 4th electron?

As we remove successive electrons, the ionization energy increases because the charge on the ion is increasing. As the positive charge increases it becomes more difficult to remove an electron. There is a large increase in ionization energy for the 4th electron because this electron is located in an inner shell. It is much more difficult to remove this electron which is a much lower energy orbital.

1. (12 points) Complete the following table

|  |  |
| --- | --- |
| Molecule | Lewis Diagram |
| AsBr3  Orbital geometry  tetrahedral  Molecular geometry  trigonal pyramidal  Hybridization of arsenic  sp3 |  |
| SF4  Orbital geometry  Trigonal bipyramidal  Molecular geometry  See Saw  Hybridization of sulfur  sp3d |  |

1. (8 points) Draw Lewis electron dot structures for all resonance forms of SO2. Evaluate each of the structures and tell why each is favored or disfavored.

|  |  |
| --- | --- |
|  | Advantage no charge  Disadvantage – requires expanded octet |
|  | Advantage – all atoms have an octet  Disadvantage – S and O atoms have a formal charge. |
|  |

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 Br 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 Br. You do not need to draw a 3D representation of the orbitals.



Br

Promotion

Br

Hybridization

Br

(12 points) Some species with two oxygen atoms only are the oxygen molecule, O2, the peroxide ion, O2-2, the superoxide ion, O2-1, and the dioxgenyl ion, O2+1. Draw an MO diagram for each, on the following page and answer the questions. Note that each box is labeled with a particular species.

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

\_\_\_ O2-2\_\_\_>\_\_\_ O2-1\_\_\_>\_\_ O2\_\_\_\_>\_\_\_ O2+1\_\_\_

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

\_\_\_O2+1\_\_\_>\_\_\_O2\_\_\_>\_\_O2-1\_\_\_\_>\_\_\_O2-2\_\_\_

* 1. Give the bond order in all species

O2 2 O2-2 1

O2-1 1.5 O2+1 2.5

* 1. Identify each species as diamagnetic or paramagnetic

O2 paramagnetic O2-2 diamagnetic

O2-1 paramagnetic O2+1 paramagnetic

|  |  |
| --- | --- |
| f1q52g1  Oxygen gas, O2 | Peroxide ion, O2-2  f1q52g1  Dioxygenyl ion, O2+1 |
|  |  |
| f1q52g1  Superoxide ion, O2-1 | f1q52g1 |