Chemistry 141 Name key

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Exam 3A November 14, 2012

Multiple Choice (30 points)

Page 1 (24 points)

Page 6 (18 points)

Page 7 (18 points)

Page 8 (10 points)

Total (100 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 number of orbitals in a given subshell, such as the 5*d* subshell, is determined by the number of possible values of
   1. *l*
   2. *ml*
   3. *n*
   4. *ms*
   5. none of the above
2. 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
   5. none of the above
3. How many electrons can a single orbital hold?
   1. 2
   2. 8
   3. 2*l* + 1
   4. 2*n*
   5. none of the above
4. For an electron in a given atom, the larger *n*, the
   1. larger the average distance from the nucleus and the lower the orbital energy.
   2. smaller the average distance from the nucleus and the higher the orbital energy.
   3. larger the average distance from the nucleus and the higher the orbital energy.
   4. smaller the average distance from the nucleus and the lower the orbital energy.
   5. none of the above
5. 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* = -2, 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
   5. all of the above are valid sets of quantum numbers
6. Which of the following have the same number of valence electrons?
   1. N, As, Bi
   2. K, As, Br
   3. He, Ne, F
   4. B, Si, As
   5. none of the above
7. Of the following, which atom has the smallest atomic radius?
   1. Sr
   2. Te
   3. S
   4. Mg
   5. none of the above
8. 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-
   5. none of the above
9. Which ionization process requires the most energy?
   1. P2+(*g*) 🡪 P3+(*g*) + e-
   2. P+(*g*) 🡪 P2+(*g*) + e-
   3. P(*g*) + e-🡪 P−(*g*)
   4. P(*g*) 🡪 P+(*g*) + e-
   5. P3+(*g*) 🡪 P4+(*g*) + e-
10. Which chemical process is associated with the lattice energy for sodium chloride?
    1. NaCl(*g*) 🡪 Na+(*g*) + Cl-(*g*)
    2. NaCl(*s*) +H2O(*l*)🡪Na+(*aq*) +Cl-(*aq*)
    3. Na(*s*) + 1/2 Cl2(*g*) 🡪 NaCl(*s*)
    4. NaCl(*s*) 🡪 Na+(*g*) + Cl-(*g*)
    5. none of the above
11. Which bond should have the longest length?
    1. N-N
    2. N=N
    3. N≡N
    4. All three bond lengths should be about the same.
    5. Impossible to determine from the data given
12. The Cl-Cl bond energy is 243 kJ/mol. Therefore the formation of a single bond between chlorine atoms
    1. should require the absorption of 486 kJ per mole of Cl2 formed.
    2. should result in the release of 243 kJ per mole of Cl2 formed.
    3. should require the absorption of 243 kJ per mole of Cl2 formed.
    4. should result in the release of 486 kJ per mole of Cl2 formed.
    5. none of the above
13. 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.
    5. none of the above
14. Compare the energies of molecular orbitals of homonuclear diatomic molecules with the energies of the atomic orbitals with which they correlate.
    1. Both bonding and antibonding molecular orbitals lie lower in energy than the atomic orbitals.
    2. Bonding orbitals are higher and antibonding orbitals are lower in energy than the atomic orbitals.
    3. Bonding orbitals are lower and antibonding orbitals are higher in energy than the atomic orbitals.
    4. Both bonding and antibonding molecular orbitals are higher in energy than the atomic orbitals.
    5. none of the above
15. Which orbital hybridization is associated with an octagedral charge cloud arrangement?
    1. *sp*
    2. *sp3d*
    3. *sp2*
    4. *sp3*
    5. *sp3d2*

Problems (70 points)

1. (4 points) How can we use electronegativity to predict whether a bond between two atoms is likely to be covalent or ionic? Explain your reasoning.

The higher the difference in electronegativity the less evenly the bonding electrons are shared between the two bonded atoms. As the sharing becomes less even and one atom is holding most of the electron density the bond begins to look more like an ionic bond where one atom takes all of the electrons.

1. (4 points) Why do we use probabilities when we discuss the position of an electron in the space surrounding the nucleus of an atom?

According to Heisenberg, we can not know where an electron is at any given time so we use probability diagrams to show the region in space where the electron is likely to exist.

1. (4 points) Draw a sketch of a 1s orbital and a 2s orbital. (If there are any differences between these two orbitals be sure to note them.)

1s orbital 2s orbital

Note that the 2 s orbital is larger than the 1 s orbital. The 2s orbital will also have a node in it.

1. (4 points) Why do so many of the transition elements in period 4 form ions with a 2+ charge?

Most of the transition elements in period 4 have 2 ns valence electrons which will be lost when they ionize.

1. (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. (4 points) Write the shorthand electron configuration for an atom of tantalum.

[Xe] 6s2 5d3 4f14

1. (10 points) Complete the following table

|  |  |
| --- | --- |
| Molecule | Lewis Diagram |
| SeF2  Orbital geometry  tetrahedral  Molecular geometry  bent  Hybridization of selenium  sp3 |  |
| XeCl2  (show formal charges on atoms and any resonance structures)  Orbital geometry  Trigonal bipyramidal  Molecular geometry  Linear  Hybridization of iodine  sp3d |  |

1. (8 points) Draw Lewis electron dot structures for NO2− and NO3−. Which has greater bond lengths? Explain your reasoning.



In nitrate the double bond is delocalized over 3 positions giving a net bond order of about 1⅓, In nitrite the double bond is delocalized over 2 positions giving a net bond order of about 1½. The nitrite has a higher bond order and thus a shorter bond length.

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



Xe

Promotion

Xe

Hybridization

Xe

1. (10 points) Given the structure below, what are the formal charges on N, I, and O? What is the molecular and orbital geometries around the iodine atom?



Formal charges

N +1 , I -1 , O -1

Iodine:

Orbital geometry octahedral

Molecular geometry square planar

1. (10 points) Describe the bonding in NO, and NO+ using localized electron (Lewis structures) and molecular orbitals. Answer the questions below regarding these models.

|  |  |  |
| --- | --- | --- |
|  | NO | NO+1 |
| Lewis Structure |  |  |
| Bond order predicted by VB theory | 2 | 3 |
| Molecular orbital diagram | 10_13-10UN | 10_13-10UN |
| Bond order predicted by MO theory | 2 ½ | 3 |
| Paramagnetic or diamagnetic? | paramagnetic | diamagnetic |

Which species has the shorter bond length based on molecular orbital theory?

NO+  should have the shortest bond length.