Chemistry 141 Name key

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Exam 3A April 24, 2012

Multiple Choice (30 points)

Page 1 (18 points)

Page 2 (20 points)

Page 3 (16 points)

Page 4 (12 points)

Page 5 (10 points)

Total (106 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 transitions (in a hydrogen atom) represent **absorption** of the smallest frequency photon?
   1. n = 5 to n = 6
   2. n = 5 to n = 4
   3. n = 4 to n = 1
   4. n = 1 to n = 3
   5. n = 1 to n = 2
2. Each of the following sets of quantum numbers is supposed to specify an orbital. Which of the following sets of quantum numbers contains an error?
   1. *n* = 1, *l* = 0, *ml* =0
   2. *n* = 3, *l* = 0, *ml* =0
   3. *n* = 2, *l* = 1 , *ml* = -1
   4. *n* = 4, *l* = 2, *ml* =0
   5. *n* = 3, *l* =3 , *ml* = -2
3. What is the maximum number of f orbitals that are possible?
   1. 1
   2. 3
   3. 5
   4. 7
   5. 14
4. Place the following elements in order of increasing atomic radius.

P Ba Cl

* 1. Ba < P < Cl
  2. P < Cl < Ba
  3. Cl < P < Ba
  4. Cl < Ba < P
  5. Ba < Cl < P

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. Which ionization process requires the most energy?
   1. W(*g*) → W+(*g*) + e-
   2. W+(*g*) → W2+(*g*) + e-
   3. W2+(*g*) → W3+(*g*) + e-
   4. W3+(*g*) → W4+(*g*) + e-
3. Choose the compound below that should have the **lowest** melting point according to the ionic bonding model.
   1. LiF
   2. NaCl
   3. CsI
   4. KBr
   5. RbI
4. Place the following elements in order of **increasing** electronegativity.

K Cs P

* 1. P < K < Cs
  2. K < P < Cs
  3. Cs < P < K
  4. Cs < K < P
  5. P < Cs < K

1. Using periodic trends, place the following bonds in order of **increasing** ionic character.

S-F Se-F O-F

* 1. Se-F < S-F < O-F
  2. S-F < Se-F < O-F
  3. O-F < Se-F < S-F
  4. Se-F < O-F < S-F
  5. O-F < S-F < Se-F

1. Which molecule or compound below contains a pure covalent bond?
   1. Li2CO3
   2. Cl2
   3. SCl6
   4. PF3
   5. NaCl
2. How many of the following elements can form compounds with an expanded octet?

I O Cl Xe

* 1. 2
  2. 0
  3. 3
  4. 1
  5. 4

1. Choose the bond below that is the **strongest**.
   1. C-F
   2. C=O
   3. C-I
   4. I-I
   5. C≡N
2. Give the approximate bond angle for a molecule with a tetrahedral shape.
   1. 109.5°
   2. 180°
   3. 120°
   4. 105°
   5. 90°
3. List the number of sigma bonds and pi bonds in a triple bond.
   1. 1 sigma, 1 pi
   2. 2 sigma, 1 pi
   3. 2 sigma, 2 pi
   4. 1 sigma, 2 pi
   5. 3 sigma, 0 pi
4. Which of the following statements is TRUE?
   1. The total number of molecular orbitals formed doesn't always equal the number of atomic orbitals in the set.
   2. 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.
   3. A bond order of 0 represents a stable chemical bond.
   4. Electrons placed in antibonding orbitals stabilize the ion/molecule.
   5. All of the above are true.

Problems (70 points)

1. (4 points) Describe the difference between a pure covalent bond and a polar covalent bond.

A pure covalent bond occurs when bonding electrons are shared equally (or very close to it) as in the N-N bond. A polar covalent bond is formed between 2 atoms of differing electronegativities. The bonding electrons are unequally shared between the two atoms as in the CO molecule.

1. (4 points) How does the concept of an orbit in the Bohr model of the hydrogen atom differ from the concept of an orbital in quantum theory?

In the Bohr model, the electrons circle the nucleus in a circular orbit whereas in quantum we recognize that the electron exists in an orbital or a volume in space and it does not have a particular path.

1. (6 points) The Na+ ion and the Ne atom are isoelectronic.
   1. Define isoelectronic.

Isoelectronic species are atoms and ions that have the same electron configuration.

* 1. Which of the two species is larger? Explain your reasoning.

TheNe atom is larger because both have the same number of electrons, (are isoelectronic), but the sodium has more protons in its nucleus to pull the electrons closer thus giving a smaller particle.

1. (4 points) Why do C, N, O, and F atoms in covalently bonded molecules and ions have no more than 8 valence electrons (4 bonds)?

These elements do not have any available d orbitals in their valence shell into which the extra electrons can be placed. For this reason they are unable to expand their valences.

1. (4 points) Draw the complete electron configuration for a cobalt (II) ion.

1s2 2s2 2p6 3s2 3p6 3d7

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

[Xe] 6s2 5d3 4f14

1. (4 points) Explain how sigma and pi bonds differ.

Sigma bonds have overlap between the atoms and pi bonds have overlap above and below the atoms.

1. (12 points) Complete the following table

|  |  |
| --- | --- |
| Molecule | Lewis Diagram |
| IF5  Orbital geometry  octahedral  Molecular geometry  Square pyramidal  Hybridization of iodine  sp3d2 |  |
| NO3-1  (show formal charges on atoms and any resonance structures)  Orbital geometry  Trigonal planar  Molecular geometry  Trigonal planar  Hybridization of iodine  sp3 |  |

1. (8 points) Two structures may be drawn for C4H5N2Br:

 

Structure a Structure b

* 1. Are these two resonance structures of the same molecule? Explain.

These are different molecules because they have different skeleton structures. Resonance structures must have the same skeleton structure!

* 1. How many sigma bonds are in structure a? \_\_\_\_\_\_\_\_How many pi bonds?\_\_\_\_\_\_\_\_
  2. Which bonds are longer, the CC bonds in structure a or b? Explain.

The CC bonds in b are longer because single bonds are longer than triple bonds.

* 1. Which bonds are stronger, the CN bonds in a or b? Explain.

The CN bonds in b are stronger because double bonds are stronger than single bonds.

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



Xe

Promotion

Xe

Hybridization

Xe

1. (12 points) Answer the following questions for the structure below
   1. What is the hybridization of N?

sp3

What is the formal charge on N?

+1

* 1. What is the orbital geometry of Xe?

Trigonal bipyramidal

What is the molecular geometry of Xe

See-saw

* 1. What is the charge on Br?

+1

What is the molecular geometry of Br?

Bent

* 1. What is the orbital geometry of C?

Linear

What is the hybridization of N?

sp

* 1. What is the hybridization of chlorine?

sp3d

What is the molecular geometry of Cl?

Linear

What is the formal charge on Cl?

-1

* 1. What is the molecular geometry of carbon?

Tetrahedral



1. (10 points) Draw lewis electron dot structures for OF and OF-1. Next determine the molecular orbital representation of these two species. Does valence bond theory and molecular orbital theory predict the same bond orders for these two species? Answer the questions regarding these structures in the table below

|  |  |  |
| --- | --- | --- |
|  | OF | OF-1 |
| Lewis Structure |  |  |
| Bond order predicted by VB theory | 1 | 1 |
| Molecular orbital diagram | 10_13-10UN | 10_13-10UN |
| Bond order predicted by MO theory | 1 ½ | 1 |
| Paramagnetic or diamagnetic? | paramagnetic | diamagnetic |

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

OF should have the shortest bond length.