Chemistry 141 Name

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Exam 3 April 30, 2009

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| --- | --- | --- |
|  | Points Earned | Points Possible |
| Page 3 multiple choice |  | 30 |
| Page 5 |  | 21 |
| Page 6 |  | 19 |
| Page 7 |  | 16 |
| Page 8 |  | 11 |
| Page 9 |  | 8 |
| Total |  | 105 |

Note: All work must be shown to receive credit. On calculation problems show answer with the correct number of significant figures using scientific notation if necessary.

PERIODIC CHART

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 | Transition Metals | | | | | | | | | | 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 | VIIIB | | | 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**  (268) | 110  **??**  (???) |  |  |  |  |  |  |  |  |

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| 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

Chemistry Formulas and Constants

Formulas

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

w=dxF

E = IR

ΔGo = -nFEo

ΔG = - RTlnK

E = mc2

Ba(Na)2 = fruit

HΨ=EΨ

Amp = C/sec

Π= iMRT

E = hν = hc/λ

M1V1 = M2V2

Ptotal = P1 + P2 + P3 + …

M = mol/L

m = mol/kg solvent

Xi = moli/ moltotal

ΔTb = i(kb)(m)

ΔTf = i(kf)(m)

Psoln = (Psolv)(Xsolv)



Constants

= 10-8 cm

F = 9.65 x 104 C

h = 6.626 x 10-34 J sec

c= 2.9979 x 108 m/sec

e = 1.602 x 10-19 C

NA = 6.022 x 1023/mol

k = 1.381 x 10-23 J/K

K = oC + 273.16

Kw = 1.0 x 10-14M2

mass electron = 9.109 x 10-31 kg

R = 0.0821 L atm/mol K= 8.314 J/K mol= 1.987 cal.mol K= 62.4 L torr/mol K

Standard Temperature and Pressure = 0oC and 1 atm

Multiple Choice (30 points)

1. For an orbital, a node is
   1. a surface where there is a maximum probability of finding the electron.
   2. a surface where there is no chance of finding the electron.
   3. a surface inside which there is a 90% chance of finding the electron.
   4. the midpoint of the orbital.
2. Arrange the ions P3-, S2-, Ca2+, K+, and Cl- in order of increasing ionic radius, starting with the smallest first.
   1. P3-, Ca2+, S2-, K+, Cl-
   2. P3-, S2-, Ca2+, Cl-, K+
   3. P3-, S2-, Cl-, K+, Ca2+
   4. Ca2+, K+, Cl-, S2-, P3-
   5. K+, Ca2+, Cl-, S2-, P3-
3. 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
   5. all of the above are valid
4. Which element can expand its valence shell to accommodate more than eight electrons?
   1. S
   2. F
   3. He
   4. N
   5. All except He can expand their valences.
5. 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
6. Which of the following have their valence electrons in the same shell?
   1. B, Si, As
   2. N, As, Bi
   3. K, As, Br
   4. He, Ne, F
   5. none of the above
7. Of the following, which element has the highest first ionization energy?
   1. Al
   2. P
   3. Na
   4. Cl
8. Which ionic compound would be expected to have the highest lattice energy?
   1. Al2O3
   2. MgO
   3. NaCl
   4. AlF3
9. 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*)
   5. none of the above release energy
10. Which of the following should be nonplanar?

|  |  |  |
| --- | --- | --- |
|  |  |  |
| I | II | III |

* 1. only I
  2. only II
  3. only III
  4. I and III
  5. II and III

1. Two resonance forms for SOCl2 are given below.

|  |  |
| --- | --- |
|  |  |
| I | II |

Which is favored by the octet rule and which by formal charge considerations?

* 1. II is favored by the octet rule and by formal charge considerations.
  2. I is favored by the octet rule and II by formal charge considerations.
  3. I is favored by the octet rule and by formal charge considerations.
  4. II is favored by the octet rule and I by formal charge considerations.
  5. I is favored by the octet rule and neither if favored by formal charge considerations.

1. 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
2. Which of the following is **not** a valence bond concept?
   1. Lone pair electrons are in atomic orbitals or in hybrid atomic orbitals.
   2. Atomic orbitals on two atoms may overlap to form antibonding orbitals.
   3. A pair of electrons in a bond is shared by both atoms.
   4. The greater the overlap between the orbitals on two atoms, the stronger the bond.
   5. Unhybridized orbitals participate in pi bonding.
3. 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
4. Which orbital hybridization is associated with an octahedral charge cloud arrangement?
   1. *sp*
   2. *sp2*
   3. *sp3*
   4. *sp3d2*
   5. none of the above

Problems (75 points)

1. (4 points) Write the complete electron configuration for an atom of silicon.

1s2 2s2 2p6 3s2 3p2

1. (4 points) Write the shorthand electronic configuration for an atom of Tantalum (element number 73) as predicted by the periodic table.

Ta [Xe] 6s2 5d3 4f14

1. (4 points) Write the shorthand electronic configuration for a manganese (II) ion, Mn+2.

Mn+2 [Ar] 3d5

1. (4 points) A general chemistry student tells a chemistry classmate that when an electron goes from a 2d orbital to a 1s orbital, it emits more energy than that for a 2p to a 1s transition. The other student is skeptical and says that such an energy change is not possible and explains why. What explanation was given?

There are no 2d orbitals and therefore there can be no such transition.

1. (5 points) Many early chemists noted a diagonal relationship among elements in the periodic table, whereby a given element is sometimes more similar to the element below and to the right that it is to the element directly below. For example, lithium is more similar to magnesium than sodium and boron is more similar to silicon than to aluminum. Use your knowledge about periodic trends of such properties as atomic radii and ionization energy to explain the existence of diagonal relationships.

Atomic radius increases as you go down the table and decreases as you go across the table. An element down and to the right would be bigger by being below and smaller by being to the right. Thus it would be more similar to the element on the diagonal than either the element directly underneath or directly to the right.

Similarly ionization energy increases as you go across and decreases down so the element diagonally down would be more similar than either the element directly below or directly to the right.

1. (10 points) Draw a Lewis electron dot structure for each of the following. Show resonance structures where appropriate and show any formal charges. Give the molecular geometry and hybridization of the central atom.

|  |  |
| --- | --- |
| Species | Lewis Structure |
| **IF5**  Orbital geometry  octahedral  Molecular geometry  Square pyramidal  Hybridization of iodine  sp3d2 |  |
| **SO2**  Orbital geometry  Trigonal planar  Molecular geometry  bent  Hybridization of sulfur  sp2 |  |

1. (9 points) In the cyanate ion, OCN-1, carbon is the central atom.
   1. Draw as many resonance structures as you can for OCN-1, and assign formal charges to the atoms in each structure.



* 1. Which resonance structure makes the greatest contribution to the resonance hybrid? Which makes the least contribution? Justify your choices.

The first resonance structure is the best because it puts the charge on the most electronegative atom – the oxygen

The third structure is the worst because it has the most separation of charge

1. (8 points) Two structures can be drawn for cyanuric acid:
   1. Are these two resonance structures of the same molecule? Explain.



No, these are not resonance structures. They are different isomers with the same molecular formula

* 1. How many sigma bonds are in structure a?

There are 12 sigma bonds in structure a

* 1. How many pi bonds are in structure a?

There are 3 pi bonds in structure a

* 1. Which bonds are longer, the CO bonds in structure a or b? Explain.

The CO bonds are longer in structure b because they are single rather than double 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 N atom, describe any electron promotion and hybridization necessary, and show the orbitals involved in both sigma and pi bonding as well as the orbital holding the lone pair of electrons.

N



N



1. (6 points) Answer the following questions for the structure above
   1. What is the charge on N?

+1

* 1. What is the hybridization of Xe?

sp3d2

* 1. What is the charge on Br?

+1

* 1. What is the molecular geometry of C?

linear

* 1. What is the molecular geometry of chlorine?

linear

* 1. What is the hybridization of carbon?

sp3

1. (5 points) Explain why there is an ionization energy increase from aluminum to argon.

There is an increase in ionization energy from aluminum to argon because as more protons are added to the nucleus of the atom, the effective nuclear charge experienced by the electrons increases resulting in a stronger attraction.

1. (8 points) At high temperatures, sulfur vapor is predominantly in the S2(g) molecules.
   1. Assuming that the molecular orbitals for 3rd row diatomic molecules are analogous to those for 2nd row molecules, construct an MO diagram for the valence orbitals of S2(g)

|  |  |
| --- | --- |
| 10_13-10UN | 10_13-10UN |
| S2 | S2-2 |

* 1. Is S2 likely to be paramagnetic or diamagnetic?

S2 is likely to be paramagnetic because it has 2 unpaired electrons

* 1. What is the bond order of the disulfide molecule?

The bond order is 2

* 1. When two electrons are added to the disulfide molecule, the S22- ion is formed. Is the bond length likely to be shorter or longer than the bond length in S2? Explain.

The bond length will be longer because the bond order will be decreased to 1.