Chemistry 1A, Spring 2006

Midterm Exam II, Version 1

March 6, 2006

(90 min, closed book)

Name:____________________

SID:______________________

TA Name:_________________

Identification Sticker

- Write your name on every page of this exam.
- This exam has 38 multiple choice questions. Fill in the Scantron form AND circle your answer on the exam.
- There is no penalty for guessing, so answer every question.
- Some questions may require bubbling in more than one choice to receive credit.

Name__________________________

$E = h\nu$

$\lambda\nu = c$

$\lambda_{deBroglie} = h / p = h / mv$

E_{kin} (e-) $= h\nu - \Phi = h\nu - h\nu_0$

$$E_n = -\frac{Z^2}{n^2} R_\infty$$

$\Delta x \, \Delta p \sim h$

$p = mv$

Particle in a box (1-D Quantum):

$E_n = h^2n^2/8mL^2$; $n = 1, 2, 3...$

$PV = nRT$

$$E_{kin} = \frac{3}{2} RT$$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$\Delta E = q + w$

$w = - P_{ext}\Delta V$

$$\Delta E = \frac{3}{2} nR\Delta T$$

$N_0 = 6.02214 \times 10^{23}$ mol^{-1}

$R_\infty = 2.179874 \times 10^{-18}$ J

$R_\infty = 3.28984 \times 10^{15}$ Hz

$k = 1.38066 \times 10^{-23}$ J K^{-1}

$h = 6.62608 \times 10^{-34}$ J s

$m_e = 9.101939 \times 10^{-31}$ kg

$c = 2.99792 \times 10^{8}$ m s^{-1}

Gas Constant:

$R = 8.31451$ J K^{-1} mol^{-1}

$R = 8.20578 \times 10^{-2}$ L atm K^{-1} mol^{-1}

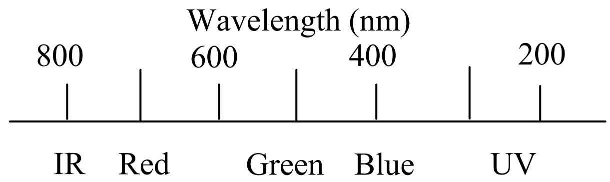
T (K) = T (C) + 273.15

F = 96,485 C / mol

1 V = 1 J / C 1 nm = 10^{-9} m

1 kJ = 1000 J

Color and Wavelength of Light



$\Delta G° = \Delta H° - T\Delta S°$

$\Delta H° = \Sigma \, \Delta H°_f$ (products) $- \Sigma \, \Delta H°_f$ (reactants)

$\Delta S° = \Sigma \, S°$ (products) $- \Sigma \, S°$ (reactants)

$\Delta G° = \Sigma \, \Delta G°_f$ (products) $- \Sigma \, \Delta G°_f$ (reactants)

$S = k_B \ln W$

for $aA + bB \rightleftarrows cC + dD$

$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$ At equilibrium, Q = K

$\Delta G° = - RT\ln K$

$$\ln K = -\frac{\Delta H°}{R}\frac{1}{T} + \frac{\Delta S°}{R}$$

$\Delta G° = - nF\Delta \mathcal{E}°$

$pX = - \log X$

$$pH = pK_a + \log\frac{[A^-]}{[HA]}$$

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SECTION 1: PERIODIC TABLE

1.) Why does the ionization energy increase when electrons are consecutively removed from an atom (mark all that apply)?

A) The outermost electron experiences a higher *effective* nuclear charge.
B) The remaining electrons are held more strongly.
C) The atomic radius is increasing.
D) The charge on the nucleus is increasing.
E) The atomic radius is decreasing

For the questions 2-6 consider the ionization energy of sodium is 496 kJ/mol and the electron affinity of Cl is -349 kJ/mol (all reactions are for the gas phase).

2.) Which equation proceeds with an absorption of 496 kJ per mole of sodium?

A) $Na + e^- \rightarrow Na^-$
B) $Na^+ + e^- \rightarrow Na$
C) $Na \rightarrow Na^+ + e^-$
D) $Na^- \rightarrow Na + e^-$
E) $Na^+ \rightarrow Na + e^-$

3.) Which equation proceeds with a release of 349 kJ per mole of chlorine?

A) $Cl + e^- \rightarrow Cl^-$
B) $Cl^+ + e^- \rightarrow Cl$
C) $Cl \rightarrow Cl^+ + e^-$
D) $Cl^- \rightarrow Cl + e^-$
E) $Cl^+ \rightarrow Cl + e^-$

4.) What is the approximate net energy change in producing Na^+ and Cl^- from Na and Cl atoms (kJ/mol)?

A) 150 B) 0 C) -323 D) -642 E) -1776

5.) What is the net energy change in making the NaCl molecule (kJ/mol)?

A) -642 B) 0 C) 150 D) 510 E) 1776

6.) What explains any energy difference between transferring an electron from sodium to chlorine and the net energy change in forming NaCl?

A) Nothing, the energy for each process is the same.
B) Coulombic (positive to negative) attraction in the NaCl pair bond.
C) Na^+ is more stable than Na.
D) Cl^- is more stable than Cl.
E) A free electron is captured to form the bond.

Continue with the next question:

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7.) Which of the following is the arrangement from lowest to highest electronegativity?

A) F, Cl, I, Br
B) I, Br, F, Cl
C) F, I, Cl, Br
D) F, Cl, Br, I
E) I, Br, Cl, F

8.) Which bond is most ionic?

A) HF B) HCl C) HBr D) HI E) all are equal

9.) Which bond is strongest?

A) HF B) HCl C) HBr D) HI E) all are equal

10.) For which X does the formation of HX release the most energy?

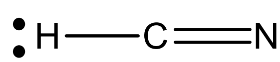
A) Cl B) Br C) F D) I E) all are equal.

11.) For the element aluminum, which ionization will require the greatest amount of energy?

A) $Al \rightarrow Al^{+} + 1e^-$
B) $Al^{+} \rightarrow Al^{2+} + 1e^-$
C) $Al^{2+} \rightarrow Al^{3+} + 1e^-$
D) $Al^{3+} \rightarrow Al^{4+} + 1e^-$

SECTION 2: MOLECULAR STRUCTURE AND BONDING

12.) According to Lewis theory, what is wrong with this structure for hydrogen cyanide, HCN (mark all that apply)?



A) Hydrogen cannot accommodate more than 2 electrons.
B) Nitrogen does not have an octet.
C) Carbon does not have an octet.
D) There are not enough electrons in the structure.
E) There are too many electrons in the structure.

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For the following ten questions, consider the lowest energy Lewis structure (minimized formal charge etc.) for the following molecules/ions: **Xe**F_4, **Xe**O_4, O**C**N^{-1} (you may want to draw the Lewis structures in the space provided, the central atom is highlighted).

13.) Which will absorb microwaves?

A) XeF_4 $\boxed{\text{B)}}$ OCN^{-1} C) XeO_4 D) all three E) none

14.) What is the O-Xe-O bond angle in XeO_4?

A) 60 B) 90 $\boxed{\text{C)}}$ 110 D) 120 E) 180

15.) What is the F-Xe-F bond angle in XeF_4?

A) 60 $\boxed{\text{B)}}$ 90 C) 110 D) 120 E) 180

16.) What is the bond angle in OCN^{-1}?

A) 60 B) 90 C) 110 D) 120 $\boxed{\text{E)}}$ 180

17.) What is the oxidation number of C in OCN^{-1}?

A) -4 B) -2 C) 0 D) 2 $\boxed{\text{E)}}$ 4

18.) What is the Xe-F bond order in XeF_4?

A) 0 $\boxed{\text{B)}}$ 1 C) 1.5 D) 2 E) 2.5

19.) What is the Xe-O bond order in XeO_4?

A) 0 B) 1 C) 1.5 $\boxed{\text{D)}}$ 2 E) 2.5

20.) What is the shape of XeF_4?

A) tetrahedral
$\boxed{\text{B)}}$ square planar
C) square pyramidal
D) see saw
E) bent

21.) What is the hybridization of the Xe in XeF_4?

A) sp B) sp^2 C) sp^3 D) dsp^3 $\boxed{\text{E)}}$ d^2sp^3

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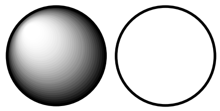
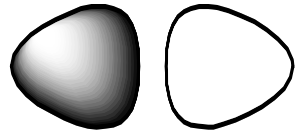
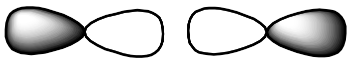
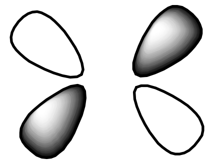
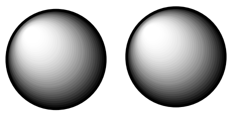
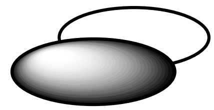
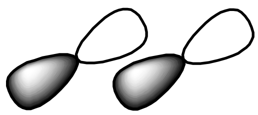
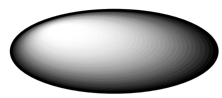
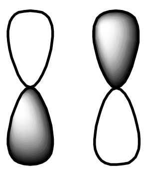
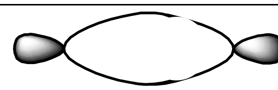
For the following five questions, match the atomic orbitals with the molecular orbital they would form.

Question	Atomic Orbitals			Molecular Orbitals
22.) A			A	
23.) E			B	
24.) D			C	
25.) C			D	
26.) B			E	

27.) Which of the molecular orbitals in the preceding table would have the highest energy?

A) A B) B C) C D) D E) E

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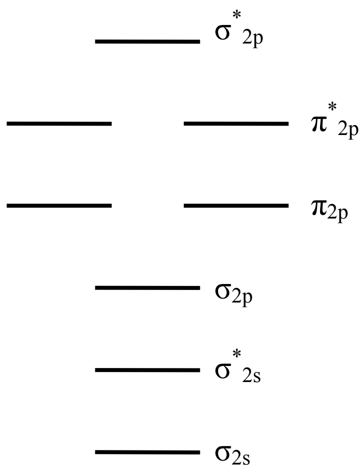
Electronic transitions in molecular orbitals are often between the highest (energy) occupied molecular orbital (or HOMO) and the lowest unoccupied molecular orbital (LUMO). Use the energy diagram below for O_2 with the z-axis as the internuclear axis to answer the following questions.

Consider the three species of oxygen: O_2, O_2^{+2} and O_2^-, for the following questions.



28.) Which of the following mixtures of atomic orbitals best describes the strongest contribution to σ bonding in O_2?

A) s + s B) s - s C) $p_z - p_z$ D) $p_x - p_x$ E) $p_y + p_y$

29.) Which of the following mixtures of atomic orbitals best describes the strongest contribution to σ bonding in O_2^{+2}?

A) s + s B) s - s C) $p_z - p_z$ D) $p_x - p_x$ E) $p_y + p_y$

30.) Which of the following mixtures of atomic orbitals best describes a HOMO in O^{+2}_2?

A) s + s B) s + p_z C) $p_z + p_z$ D) $p_x - p_x$ E) $p_y + p_y$

31.) Which of the following mixtures of atomic orbitals best describes the LUMO in O^{+2}_2?

A) s + s B) s + p_z C) $p_z + p_z$ D) $p_x - p_x$ E) $p_y + p_y$

32.) What is the bond order of O_2^-?

A) 0 B) 1/2 C) 1 D) 1 1/2 E) 2

33.) Which process would convert O_2 from paramagnetic to diamagnetic?

A) Electron capture
B) Ionization
C) Electron spin flip
D) None of these O_2 is diamagnetic

34.) Which process would convert O_2^{+2} from paramagnetic to diamagnetic?

A) Electron capture
B) Ionization
C) Electron spin flip
D) None of these O_2^{+2} is diamagnetic

35.) Which process would convert O_2^{-} from paramagnetic to diamagnetic?

A) Electron capture
B) Ionization
C) Electron spin flip
D) None of these O_2^{-} is diamagnetic

36.) Which is the correct order of the following processes from lowest (releases the most energy) to highest (absorbs the most energy) for O_2?

I) Electron capture II) Ionization III) Electron spin flip

A) I < II < III
B) III < II < I
C) III < I < II
D) II < III < I
E) I < III < II

37.) Consider electron capture and ionization reactions for O_2^{+2} which product has the stronger bond?

A) O_2^{+3} B) O_2^{+1} C) Both are about the same

38.) Which apparatus is (are) necessary to quantitatively determine the magnitude of paramagnetism in a molecule/material (mark all that apply)?

A) Magnet
B) Analytical balance
C) UV/Vis spectrometer
D) pH meter / voltmeter
E) Hot plate