Chem 1A Second Midterm Examination
March 7, 2005
Professor David Chandler

Page	**Possible**	**Earned**
3	45	
4	20	
5	15	
6	20	
7	20	
8	15	
Total	**135**	

Name: ______**KEY**______

Signature: ______________________

Section: ______________________

GSI: ______________________

Instructions

As indicated, either fill in blank space with appropriate symbol or number or circle the correct answer(s). Some multiple choice questions may have more than one correct answer, in which case all correct answers are required for full credit.

Use back of pages for your scratch work.

Formulas and Physical Constants you may need:

$R = 8.3\ J{\cdot}K^{-1}{\cdot}mol^{-1} = 0.082\ L{\cdot}atm{\cdot}K^{-1}{\cdot}mol^{-1}$

$k_B = 1.4 \times 10^{-23}\ J \cdot K^{-1}$

0 K = -273°C

Avogadro's number, $N_0 \approx 6.0 \times 10^{23}\ mol^{-1}$

Planck's constant, $h \approx 6.6 \times 10^{-34}\ J{\cdot}s$

Speed of light, $c \approx 3.0 \times 10^{8}\ m \cdot s^{-1}$

Lowest (ground state) electronic energy of a hydrogenic atom with nuclear charge Ze,

$E = -R_H Z^2, \quad R_H \approx 2.2 \times 10^{-18}\ J$

Average distance of the electron from the nucleus of a hydrogenic atom of nuclear charge Ze,

$a_0/Z, \quad a_0 \approx 0.5Å = 50\ pm$:

Coulomb potential of the hydrogenic atom,

$$-\frac{Ze^2}{4\pi\varepsilon_o r} - -\frac{(2.3 \times 10^{-16}\ J{\cdot}pm)\ Z}{r}$$

A particle of mass M and momentum p has kinetic energy

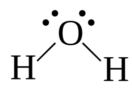
$KE = p^2/2m$

And DeBroglie wavelength

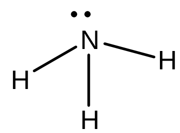
$\lambda = h/p$

The energy of a photon with frequency ν is $E = h\nu$

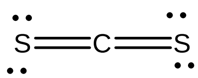
1. A Lewis (electron dot and bond) structure of water is



15 pts (a) With similar drawing conventions, give a likely Lewis structures for the following compounds (placing each drawing adjacent to the formula):

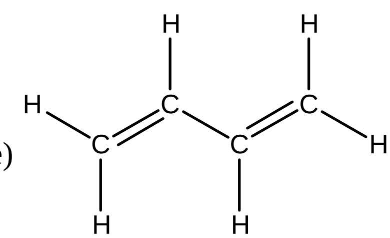


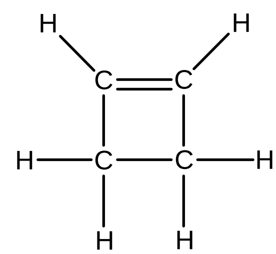
i) NH_3



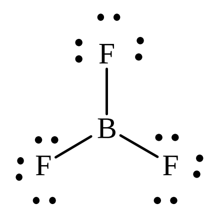
ii) CS_2

iii) $CH_2CHCHCH_2$ (either is fine)





15 pts (b) Consider the molecule BF_3 (shown right) and circle the answer that best completes each statement.



i) BF_3 is _______. polar $\boxed{\text{nonpolar}}$

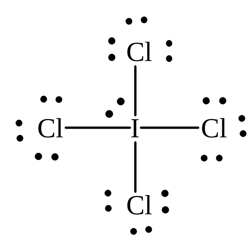
ii) the electronic shape of BF_3 is ______.

$\boxed{\text{trigonal planar}}$ tetrahedral trigonal bipyramidal square planar

iii) the molecular shape of BF_3 is______.

$\boxed{\text{trigonal planar}}$ bent see saw square planar

15 pts (c) Consider the molecule ICl_4^+ (shown right) and circle the answer that best completes each statement.



i) ICl_4 is ______. $\boxed{\text{polar}}$ nonpolar

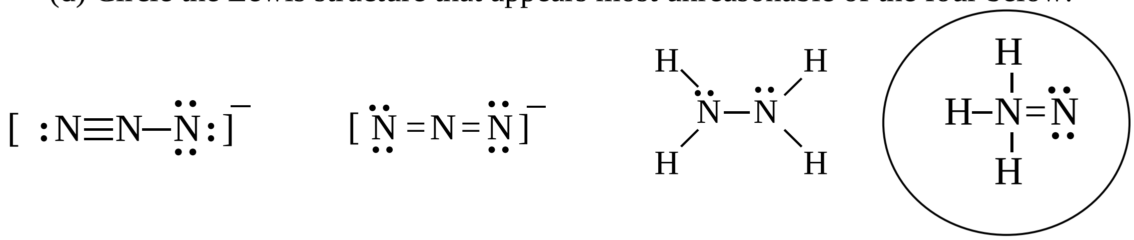
ii) the electronic shape of ICl_4^+ is ______.

trigonal planar tetrahedral $\boxed{\text{trigonal bipyramidal}}$ square planar

iii) the molecular shape of ICl_4^+ is______.

trigonal planar bent $\boxed{\text{see saw}}$ square planar

5 pts (d) Circle the Lewis structure that appears most unreasonable of the four below:



5 pts (e) Which of the two molecules, H_2S and H_2O, has the <u>larger</u> dipole moment?

$\boxed{H_2O}$

(put answer in box)

5 pts (f) The bonding of methane, CH_4, involves:

A) sp hybridization B) sp^2 hybridization

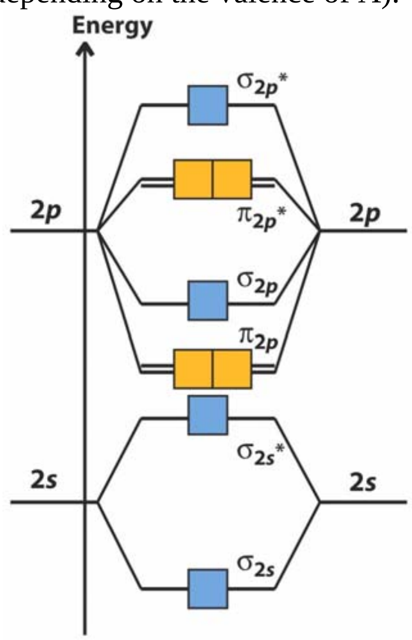
$\boxed{\text{C) } sp^3 \text{ hybridization}}$ D) no hybridization

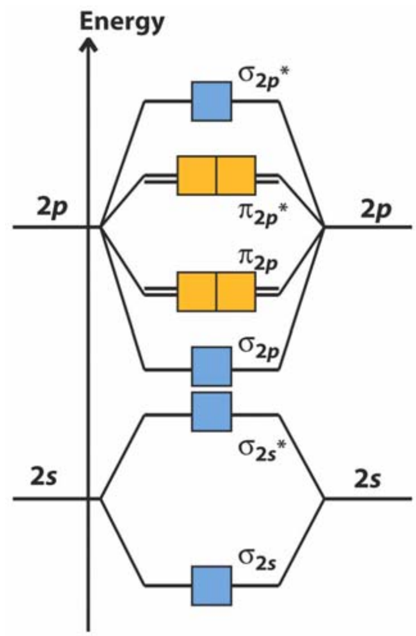
(circle correct answer(s))

5 pts (g) In the benzene molecule, C_6H_6, how many electrons probably reside in π orbitals?

$\boxed{6}$ (Put answer in box)

2. For atoms in the first two rows of the periodic table, the ordering of molecular orbitals in a diatomic molecule, A_2, is as indicated by one of the two diagrams (depending on the valence of A).





Refer to these diagrams and only the orbitals listed in answering the following questions.

10 pts (a) Which molecular orbitals (e.g., σ_{2p}*, π_{2p}, etc.) are formed from the overlap of

i. two atomic 2s orbitals

σ_{2s}, σ_{2s}*

(put answers in box)

ii. two atomic p orbitals that lie perpendicular to the internuclear axis

π_{2p}, π_{2p}*

(put answers in box)

5 pts (b) From the following list of molecules, which (if any) are paramagnetic: C_2, B_2, O_2, and N_2?

B_2, O_2

(put answer(s) in box)

5 pts (c) Which has a stronger chemical bond

i. O_2 or O_2^- (Circle answers)

ii. O_2 or O_2^+

5 pts (d) the O_2 molecule is hard primarily because of

A. the Pauli exclusion principle

B. the Aufbau principle

C. electrostatic repulsions between electrons

D. electrostatic repulsion between nuclei

(Circle most correct answer)

3. A 1L gas bulb is filled at 298K with Ar and He, each with partial pressures of 50 torr.

5 pts (a) Which of the following best describes the distribution of atoms in the bulb?

A. The gases tend to separate, with one half the bulb filled with Ar and the other half with He

B. The gases mix and fill the bulb uniformly

C. The gases mix with a much higher concentration of atoms in the lower half of the bulb than in the upper half.

(circle correct answer)

5 pts (b) A typical speed of a He atom in the bulb is:

A. 1 km/s

B. 1m/s

C. 1 cm/s

D. 10^6 Å/s

(circle correct answer)

5 pts (c) Typically, the speed of a He atom compared to that of an Ar atom is:

A. faster by a factor of 3 or 4

B. faster by a factor of 20

C. virtually the same

(circle correct answer)

5 pts (d) Approximately how many moles in total of Ar and He are in the bulb?

A. 0.02 B. 0.2

C. 2.0 D. 20

(circle correct answer)

Bad question, there's no right answer. Answer should be 0.005 moles. Since the partial pressure of Ar and He is each 50 torr, the total pressure is 100 torr.
Full credit for everyone.

4. The ground state (i.e. lowest energy state) configuration of He is $1s^2$, and its first excited state configuration is $1s^1\,2s^1$. Using similar notation specify:

5 pts (a) the configuration of an excited He atom with energy second closest to that of the ground state:

$1s^1\,2p^1$ (2 pts for $2s^2$ or $1s^1 3s^1$)

(put answer in box)

5 pts (b) The configuration of the ground state of Ti:

$[Ar]\,3d^2 4s^2$

(put answer in box)

5 pts (c) The configuration of the ground state of the ferrous ion, Fe^{+2}

$\boxed{[Ar]\ 3d^6}$

(put answer in box)

5. A cold solid material is found to be made of molecules containing C and O atoms. When warmed to 300K the solid sublimes. The gas formed from 1g of the material at this temperature fills a 1L container at 0.56 atm pressure.

5 pts (a) 1g of this material corresponds to how many moles of the gas?

A. 0.052	B. 0.012
$\boxed{\text{C. 0.023}}$	D. 0.004

(circle correct answer)

5 pts (b) The molecular formula for the molecule (e.g., CO, C_2O, ..) is:

moles = grams/ molar mass

molar mass = 1g/0.023moles = 43.48 g/mol

trying out different formulas and molar mass
CO = 28 g/mol
C_2O = 40 g/mol
CO_2 = 44 g/mol

$\boxed{CO_2}$

(show your work and put answer in box)