Chemistry 1A, Fall 2003

Midterm 2
Oct 14, 2003
(90 min, closed book)

Name:_____

SID:_____

TA Name:_____

- This exam has 45 multiple choice questions.
- Fill in the Scantron form AND circle your answer on the exam.
- Each question is worth 3.34 points.

Note:

- The questions on this exam do not depend on each other. They may be answered in any order.
- All the questions are equally weighted. Answer those you can quickly and go back to those that require more thought.
- Some questions may seem obvious or too simple. They are. There are no 'trick' questions.
- Questions that contain 'mark all that apply' may require you to mark more than one answer to get credit for that question.

- Potentially useful relations:

$E = h\nu$

$\lambda\nu = c$

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

$p = mv$

$E_{kin} = \frac{1}{2} mv^2$

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

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

$PV = nRT$

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

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

$\Delta E = q + w$

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

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

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

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

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

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

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

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

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

Gas Constant:

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

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

$T(K) = T(C) + 273.15$

$F = 96{,}485\ C / mol$

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

$1\ kJ = 1000\ J$

$\Delta G° = \Delta H° - T\Delta S°$

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

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

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

$S = k_B \ln W$

for $aA + bB \rightleftarrows cC + dD$

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

$\Delta G° = - RT \ln K$

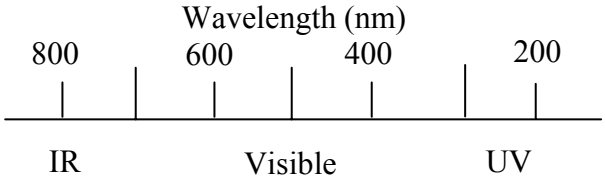
$$\ln K = -\frac{\Delta H°}{R}\frac{1}{T} + \frac{\Delta S°}{R}$$

$\Delta G° = - nF\Delta Є°$

$pX = - \log X$

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

Color and Wavelength of Light



ΔG° of Formation

compound	ΔG° (kJ / mol)
CO_2	-394.36
H_2O (g)	-228.57
$C_6H_{12}O_6$	-910
O_2	0

SECTION 1: PERIODIC TABLE

1.) Why does the ionization energy increase when electrons are consecutively removed from an atom?

A) the outermost electron experiences a higher effective nuclear charge
B) the remaining electrons are held more strongly
C) atomic radius is decreasing
D) all of the above
E) none of the above

For the next two questions consider the ionization energy of sodium is 496 kJ/mol and the electron affinity of Cl is -349 kJ/mol.

2.) 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) -510 E) -1776

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

A) -642 B) 0 C) 323 D) 510 E) 1776

Continue with the next question:

For the next four questions consider the following atoms Br, Sn, Sb, Te, I.

4.) Which has the largest atomic radius?

A) Br B) Sn C) Sb D) Te E) I

5.) Which is the most paramagnetic?

A) Br B) Sn C) Sb D) Te E) I

6.) Which has the largest ionization energy?

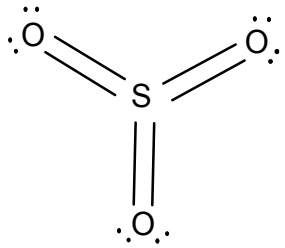
A) Br B) Sn C) Sb D) Te E) I

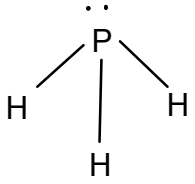
7.) Which has the largest electronegativity?

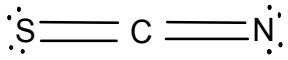
A) Br B) Sn C) Sb D) Te E) I

SECTION 1: CHEMICAL BONDING

For the following ten questions, consider the lowest energy Lewis structure for the following molecules/ions: **S**O_3, **P**H_3, S**C**N^{-1} (you may want to draw the Lewis structures in the space provided, the central atom is highlighted).







8.) Which is transparent to microwaves (mark all that apply)?

A) PH_3 B) SCN^{-1} C) SO_3 D) all three E) none

9.) What is the O-S-O bond angle in SO_3?

A) 90 B) 108 C) 110 D) 120 E) 180

10.) What is the H-P-H bond angle in PH_3?

A) 90 B) 108 C) 110 D) 120 E) 180

11.) What is the bond angle in SCN^{-1}?

A) 90 B) 108 C) 110 D) 120 E) 180

12.) What is the oxidation number of S in SO_3?

A) -6 B) -2 C) 0 D) +2 E) +6

13.) What is the SO bond order in SO_3?

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

14.) Which is the best description of the orbital overlap in the P-H bond in PH_3 (the 'z' axis is the internuclear axis)?

A) p_z on P with sp^2 on H
B) p_z on P with s on H
C) sp^2 on P with p_z on H
D) sp^2 on P with sp^2 on H
E) sp^3 on P with s on H

15.) Which molecule is chiral?

A) PH_3 B) SCN^{-1} C) SO_3 D) all three E) none

16.) If you could connect the atoms in any order, how many different structural isomers are possible for SCN^{-1}?

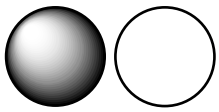
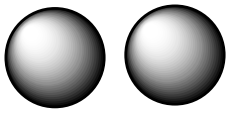
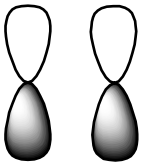
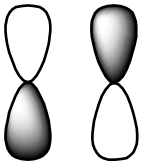
A) 1 B) 2 C) 3 D) 4 E)5

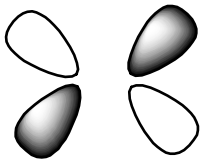
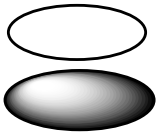
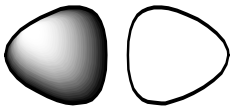
17.)What is the shape of PH_3?

A) Linear.
B) Bent.
C) Trigonal pyramidal.
D) Square planar.
E) Tetrahedral.

Continue with the next question:

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

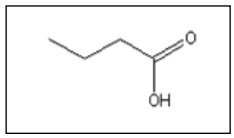
Question	Atomic Orbitals
18.) **E**	
19.) **A**	
20.) **B**	
21.) **D**	
22.) **C**	

	Molecular Orbitals
A	
B	
C	
D	
E	

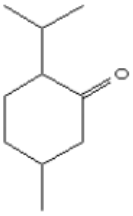
23.) Which of the molecular orbitals in the preceding table would have the highest energy?

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

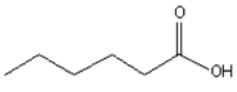
24.) If butyric acid (shown right) smells sour, which one of the following compounds is also likely to smell sour?



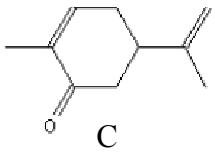
Butyric Acid



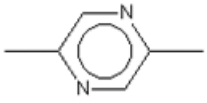
A



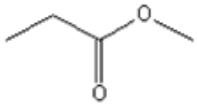
B



C



D



E

25.) In which of the following molecules is the carbon-carbon bond likely to be the strongest?

A) H_3CCH_3
B) H_2CCH_2
C) CH_3CH_2F
D) HCCH
E) H_2CO

26.) Which of the following mixtures of atomic orbitals best describes the σ bonding orbital in H_2?

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

27.) Which of the following mixtures of atomic orbitals best describes the σ bonding orbitals in HeH^+?

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

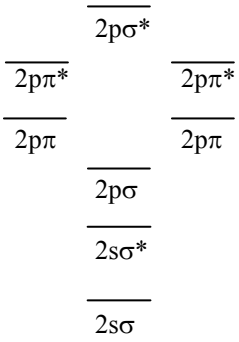
28.) Which of the following mixtures of atomic orbitals best describes the σ_{2p} bonding orbitals in C_2?

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

29.) What is the bond order of He_2^+.

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

Use the following molecular orbital energy diagram for the next three questions.



30.) How many unpaired electrons are in O_2^+?

A) 0 B) 1 C) 2 D) 3 E) 4

31.) What is the bond order of OF?

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

32.) Which of the following is not paramagnetic?

A) O_2^+ B) OF C) NO D) OF^- E) CO^+

SECTION 3: THE BEHAVIOR OF GASSES

Unless stated otherwise, the system for the next seven questions is a rigid 22.4 L flask containing an equal number of moles of gaseous N_2 molecules and Cl atoms at 1.00 atm and 25.0˚C.

33.) What is the total number of moles of gas in the flask?

A) 0.25 B) 0.50 C) 1.0 D) 1.50 E) 2.00

34.) What is the partial pressure of N_2 (atm)?

A) 0.25 B) 0.50 C) 0.75 D) 1.00 E) 2.00

35.) What is the pressure in the flask if the temperature were raised to 100˚C?

A) 0.26 B) 0.54 C) 1.25 D) 1.36 E) 2.11

36.) What is the total pressure in the flask if one mole of Ar gas were to be added at constant temperature (25˚C)?

A) 0.25 B) 0.50 C) 0.75 D) 1.00 E) 2.00

37.) If all the Cl atoms were to react and form Cl_2 molecules what would be the pressure in the flask containing only N_2 and Cl_2 (constant T and V) (25˚C)?

A) 0.25 B) 0.50 C) 0.75 D) 1.00 E) 2.00

38.) Which has the highest root mean squared velocity when there is a mixture of Cl, Cl_2 and N_2 (25˚C)?

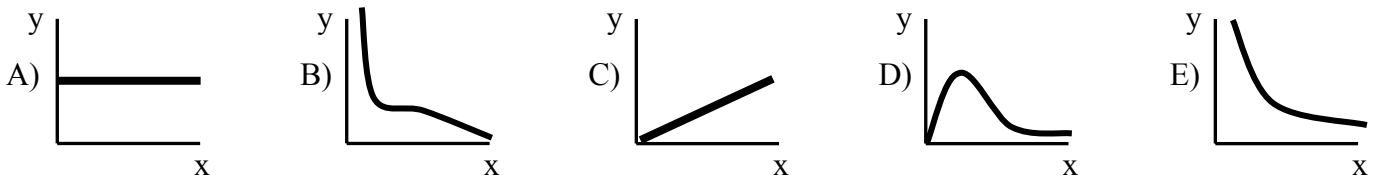
A) Cl B) N_2 C) Cl_2 D) all are the same

39.) Which has the highest molar kinetic energy when there is a mixture of Cl, Cl_2 and N_2 (25˚C)?

A) Cl B) N_2 C) Cl_2 D) all are the same

Continue with the next question:

For the next questions, choose the plot that best describes the relationship between the variables listed (y vs. x).



40.) Pressure vs. volume for a real gas below its critical temperature?

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

41.) Pressure vs. volume for a real gas above its critical temperature?

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

42.) Volume vs. temperature for an ideal gas?

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

43.) Particle count (at each velocity) vs. the velocity of a gas?

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

44.) Kinetic energy of a mole of gas particles vs. particle mass at constant temperature?

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

45.) Kinetic energy of a mole of particles vs. temperature.

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