CHEM121H Honors General Chemistry 1 Friday, December 4, 2009

HOUR EXAM #3

NAME:_____ SPIRE ID /__/__/__/__/__/__/__/__/__/

*****Not all information needed to complete exam correctly*****

Physical Constants and Conversion Factors

$e = 1.602 \times 10^{-19}$ C
1 eV = 96.48 kJ/mol
$N_A = 6.022 \times 10^{23}$
Electron mass = 0.0005485799 u
Proton mass = 1.007276 u
Neutron mass = 1.008665 u
R (Ideal gas constant) = 0.082057 L·atm/mol·K or 8.3145 J/ mol·K
Hydrogen atom, $^{1}_{1}H$, mass = 1.007825 u
$k = 1.38 \times 10^{-23}$ JK^{-1} (Boltzmann Constant)

$1\ u = 1.66 \times 10^{-24}$ g
R (Rydberg constant) = 1.097×10^{7} m^{-1}
$h = 6.63 \times 10^{-34}$ J·s
$c = 3.00 \times 10^{8}$ m/s
$Rhc = 2.18 \times 10^{-18}$ J
$1.0\ g/mol = 9.00 \times 10^{10}$ kJ/mol

Other information:

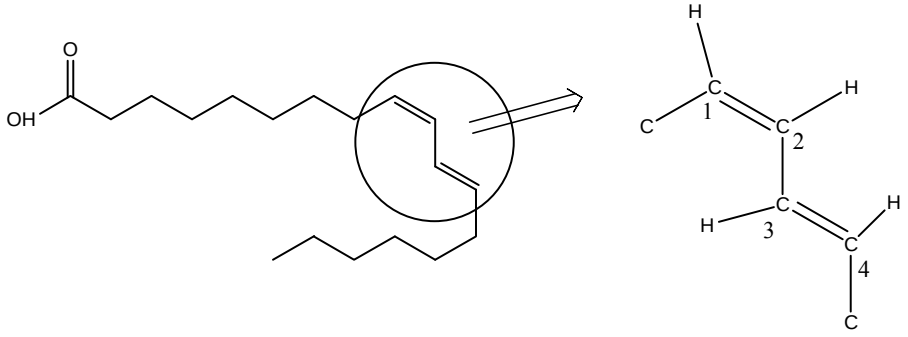
(1) Periodic Table (attached)
2) Electronegativities.

H – 2.2	B – 2.0	C – 2.6	N – 3.0	O – 3.4	F – 4.0
		Si – 1.9	P – 2.2	S – 2.6	Cl – 3.2
			As – 2.2	Se – 2.6	Br – 3.0

NOTE: FOR FULL CREDIT, ALL WORK MUST BE SHOWN FOR ANY QUESTION REQUIRING CALCULATIONS OR COMPUTATIONS.

Problems (55 points – valued as indicated)

(1) Conjugated linoleic acid (CLA) is a fatty acid found especially in meat and dairy derived from ruminents. As the name implies, CLA has a 4 atom conjugated bond pattern (C_1-C_4) as shown in the expanded structure to the right.



For **only** the conjugated system C_1 through C_4 shown to the right: (20 pts)

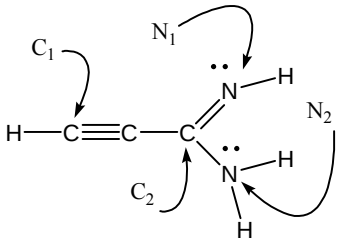
(a) Draw an orbital diagram showing bond overlaps for both the σ framework and π system for the four atoms (C_1 thru C_4) involved in the conjugated system in this molecule.
(b) Draw an energy diagram for the π MOs in the conjugated system.
(c) Show where the pi electrons are in these molecular orbitals and what the overall π bond order is for this conjugated system.
(d) Draw the wave function signs for π_2, the next to lowest energy π MO
(e) Indicate the number of nodes in the lowest energy unoccupied molecular orbital in this π system.

(2) In a mixture of CO (g) and CO_2 (g) the partial pressure of CO (g) is 0.20 atm and the partial pressure of CO_2 (g) is 0.60 atm. If this mixture occupies a volume of 11.6 L at 50°C, what is the mass in grams of each gas in the mixture? (20 pts)

(3) Chloroform, $CHCl_3$. once used as an anesthetic, has a normal boiling point of 61.0°C. Its enthalpy of vaporization, ΔH_{vap}, is 29.4 kJ/mol. Calculate the temperature in °C when the equilibrium vapor pressure of chloroform is 50.0 torr. (15 pts)

Multiple-Choice (45 points, 3 points each –15 of 16 counted toward grade)

(1) In the structure to the right indicate the **hybrid orbital set** is used by atoms C_1, C_2, N_1, and N_2 ?



(a) sp, sp^3, sp^2,sp^2 (b) sp, sp^2, sp^3,sp^2

(c) sp, sp^2, sp^2,sp^3 (d) sp^2, sp^3, sp^2,sp^3

(2) In CO the C-O sigma (σ) bond results from overlap of a _____orbital on C with a _____orbital on O.

(a) p, sp^2 (b) sp, sp^3 (c) sp^2, sp^3 (d) sp, sp

(3) The delocalized electrons from VB bonding theory are:

(a) the sigma electrons of MO theory
(b) localized in the MO theory
(c) the π system electrons in MO theory
(d) not allowed to move in the MO theory

(4) For the carbonate anion, CO_3^{2-}, as discussed in the practice exam, the π-molecular orbital where the signs of the atomic orbital wave functions are all the same is the:

(a) highest occupied bonding orbital (b) lowest energy antibonding orbital
(c) MO with the maximum number of nodes (d) MO with no nodes

(5) What is the final temperature in K of a gas sample originally at 500 K whose volume is decreased from 500.0 mL to 100.0 mL at constant pressure?

(a) 50 (b) 100 (c) 250 (d) 2500

(6) If the pressure is held constant at 1.00 atm, at what temperature in K will nitrogen gas, N_2 (g), have a density of 0.500 g/L?

(a) 297 (b) 352 (c) 682 (d) 1732

(7) 10.g of He and 10.0 g of Ar are in the same vessel at 298K. Which parameter(s) are the same for the two gases in this mixture?

I. molecular speed II. average kinetic energy III. pressure IV. number of moles

(a) I only (b) II only (c) I & III (d) II & IV

(8) As intermolecular forces increase in a real gas, deviations from ideal gas behavior become more significant at _____ temperature.

(a) high (b) low (c) any (d) doesn't matter for a real gas

(9) To what temperature in K would nitrogen gas, N_2 (g), have to be heated to have the same average speed as hydrogen gas, H_2 (g), at 25°C?

(a) 1927 (b) 2783 (c) 3896 (d) 4173

(10) Regarding real gases and the van der Waals equation of state for a real gas which statement is false?

(a) the pressure factor has units of $(atm \cdot L^2)/mol^2$
(b) the pressure factor is directly related to the intermolecular forces between the gas particles
(c) at high pressure for large molecules, the compressibility factor, Z, is >> 1.
(d) the volume of a real gas < volume of an ideal gas because the IMFs pull the gas particles together.

(11) Arrange the following compounds in order of increasing strength (lesser<greater) of their intermolecular forces.

I. NaCl II. H_2 III. H_2S IV. H_2Te

(a) II<III<IV<I (b) IV<I<III<II (c) II<IV<III<I (d) IV<III<II<I

(12) Which is not directly proportional to all the others?

(a) T_b (b) ΔH_{vap} (c) vapor pressure (d) IMF

(13) For a certain liquid with $\Delta H_{vap} = 29.4$ kJ/mol, a plot is made of the ln of its vapor pressure vs 1/T. In this plot, what is the slope in K.

(a) -2940 (b) 2414 (c) -3536 (d) 4745

(14) Which is likely to have the **lowest** vapor pressure at any given temperature?

(a) CH_4 (b) CF_4 (c) CCl_4 (d) CI_4

(15) An unknown compound has a normal melting point (T_b) of 100K and a normal boiling point (T_m) of 300K. Its liquid density is less than its solid density. The triple point temperature is 90K and the triple point pressure is .01 atm. Based on these data, if a sample of this substance at 100K and 0.5 atm has its pressure increased to 5 atm at constant temperature which phase change, if any, occurs?

(a) none (b) liquid → solid (c) liquid → gas (d) solid → liquid

(16) Which statement is false?

(a) The pressure and temperature coordinates for a one component system with one degree of freedom lie on an equilibrium line in its phase diagram
(b) In π MO theory the greater the number of nodes the more antibonding (lass bonding) the orbital is
(c) As real gases become larger their deviation from ideality becomes more pronounced at higher temperature
(d) Although London dispersion forces exist between all molecules, they are the only IMF for non-polar molecules

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Problems (55 points – valued as indicated)

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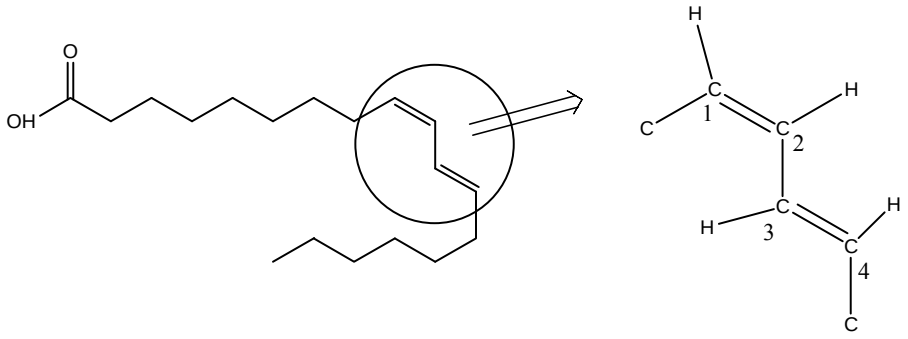


For **only** the conjugated system C_1 through C_4 shown to the right: (20 pts)

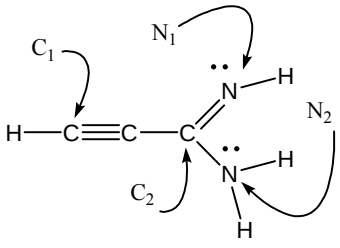
(a) Draw an orbital diagram showing bond overlaps for both the σ framework and π system for the four atoms (C_1 thru C_4) involved in the conjugated system in this molecule.
(b) Draw an energy diagram for the π MOs in the conjugated system.
(c) Show where the pi electrons are in these molecular orbitals and what the overall π bond order is for this conjugated system.
(d) Draw the wave function signs for π_3, the lowest energy antibonding π MO
(e) Indicate the number of nodes in the highest energy molecular orbital in this π system.

(2) In a mixture of CO (g) and CO_2 (g) the partial pressure of CO (g) is 0.20 atm and the partial pressure of CO_2 (g) is 0.60 atm. If this mixture occupies a volume of 23.5 L at 70°C, what is the mass in grams of each gas in the mixture? (20 pts)

(3) Chloroform, $CHCl_3$. once used as an anesthetic, has a normal boiling point of 61.0°C. Its enthalpy of vaporization, ΔH_{vap}, is 29.4 kJ/mol. Calculate the temperature in °C when the equilibrium vapor pressure of chloroform is 100.0 torr. (15 pts)

Multiple-Choice (45 points, 3 points each –15 of 16 counted toward grade)

(1) In the structure to the right indicate the **hybrid orbital set** is used by atoms C_1, C_2, N_1, and N_2 ?



(a) sp, sp^3, sp^2, sp^2 (b) sp, sp^2, sp^2, sp^3

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(2) In CO the C-O sigma (σ) bond results from overlap of a _____orbital on C with a _____orbital on O.

(a) p, sp^2 (b) sp, sp (c) sp^2, sp^3 (d) sp, sp^2

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(a) highest occupied bonding orbital (b) lowest energy antibonding orbital
(c) MO with no nodes (d) MO with the maximum number of nodes

(5) What is the final temperature in K of a gas sample originally at 500 K whose volume is decreased from 500.0 mL to 100.0 mL at constant pressure?

(a) 50 (b) 250 (c) 2500 (d) 100

(6) If the pressure is held constant at 1.00 atm, at what temperature in K will nitrogen gas, N_2 (g), have a density of 0.500 g/L?

(a) 297 (b) 682 (c) 572 (d) 1732

(7) 10.g of He and 10.0 g of Ar are in the same vessel at 298K. Which parameter(s) are the same for the two gases in this mixture?

I. molecular speed II. average kinetic energy III. pressure IV. number of moles

(a) I & III (b) II & IV (c) I only (d) II only

(8) As intermolecular forces increase in a real gas, deviations from ideal gas behavior become more significant at _____ temperature.

(a) low (b) high (c) any (d) doesn't matter for a real gas

(9) To what temperature in K would nitrogen gas, N_2 (g), have to be heated to have the same average speed as hydrogen gas, H_2 (g), at 25°C?

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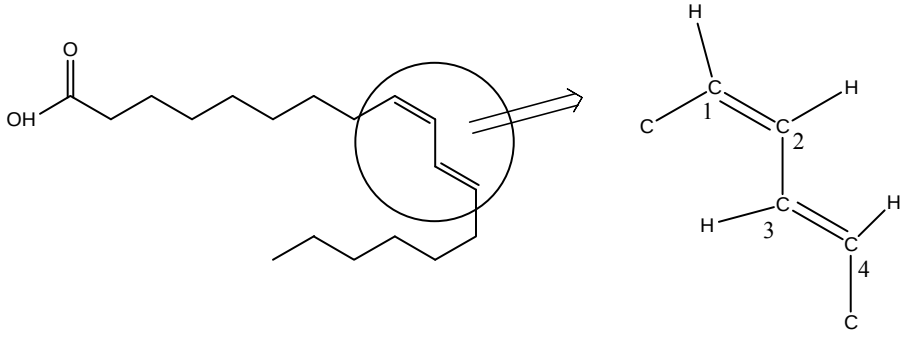

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(d) Draw the wave function signs for π_1, the lowest energy π MO
(e) Indicate the number of nodes in the highest occupied molecular orbital in this π system.

(2) In a mixture of CO (g) and CO_2 (g) the partial pressure of CO (g) is 0.20 atm and the partial pressure of CO_2 (g) is 0.60 atm. If this mixture occupies a volume of 15.6 L at 40°C, what is the mass in grams of each gas in the mixture? (20 pts)

(3) Chloroform, $CHCl_3$. once used as an anesthetic, has a normal boiling point of 61.0°C. Its enthalpy of vaporization, ΔH_{vap}, is 29.4 kJ/mol. Calculate the temperature in °C when the equilibrium vapor pressure of chloroform is 75.0 torr. (15 pts)

Multiple-Choice (45 points, 3 points each –15 of 16 counted toward grade)

(1) In CO the C-O sigma (σ) bond results from overlap of a _____orbital on C with a _____orbital on O.

(a) p, sp^2 (b) sp^2, sp^3 (c) sp, sp (d) sp, sp^2

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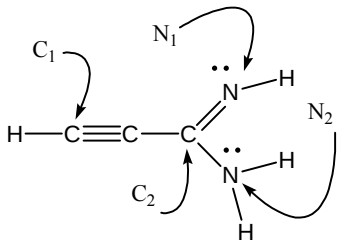

(a) sp, sp^2, sp^2, sp^3 (b) sp, sp^3, sp^2, sp^2

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(5) What is the final temperature in K of a gas sample originally at 500 K whose volume is decreased from 500.0 mL to 100.0 mL at constant pressure?

(a) 100 (b) 250 (c) 2500 (d) 50

(6) If the pressure is held constant at 1.00 atm, at what temperature in K will nitrogen gas, N_2 (g), have a density of 0.500 g/L?

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(7) 10.g of He and 10.0 g of Ar are in the same vessel at 298K. Which parameter(s) are the same for the two gases in this mixture?

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(a) vapor pressure (b) ΔH_{vap} (c) IMF (d) T_b

(13) For a certain liquid with $\Delta H_{vap} = 29.4$ kJ/mol, a plot is made of the ln of its vapor pressure vs 1/T. In this plot, what is the slope in K.

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