Chemistry 201
Final Exam
June 16,1999
120 minutes

Name: _____

ID#: _____

Section (circle one):

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Read carefully before you start:

- **Calculators are allowed.**
- **Periodic tables are provided.**
- **No pencils or red pen.**
- **No penalty.**
- **You can also use any white space as scratch.**
- **Do not detach any page.**

Useful information

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

$c = 2.998 \times 10^{8}$ m/s

$R = 8.3145\ JK^{-1}mol^{-1} = 0.08206\ atm.L.\ K^{-1}mol^{-1}$

$1\ m = 10^{9}$ nm

$E_n = -2.180 \times 10^{-18}\ (J) / n^2$

K_b (water) = 0.52 °C/m

K_f (water) = 1.86 °C/m

- Which of the following should have the most resonance structures?

a. O_3
b. SO_2
c. NO_2^-
d. CH_4
e. I_3^-

- What is the shape of $AsCl_3$?

a. T-shaped
b. Tetrahedral
c. Trigonal planar
d. Trigonal pyramidal
e. Octahedral

- Which best describes ICl_2^-?

a. Linear with no lone pairs on I
b. Linear with 3 lone pairs on I
c. Nonlinear with no lone pairs on I
d. Nonlinear with 2 lone pairs on I
e. Nonlinear with 3 lone pairs on I

- Which of the following is <u>not true</u>?

a. The intensity of a beam of light is related to the number of photons.
b. For objects moving at a given speed, the larger the mass, the shorter the wavelength.
c. According to the Heisenberg principle the momentum of a particle cannot be measured precisely.
d. The maximum number of electrons a single orbital in the n^{th} energy level can hold is $2n - 1$.
e. The electron probability density is independent of distance from the nucleus for a 1s orbital.
f. c ,d, and e
g. c and e

- What is the wavelength of the photon emitted when an electron drops from a 4d orbital to a 2p orbital in a hydrogen atom?

a. 1094 nm
b. 486.1 nm
c. 364.6 nm
d. 298.0 nm
e. 100.5 nm

- Which of the following represent electron configuration(s) that violate the Pauli exclusion principle?
(I) [Ne] $3s^1\ 3p^2$ (II) [Kr] $4d^{12}\ 5s^2\ 5p^3$ (III) [Ar] $3d^{10}\ 4s^1\ 4p^2$

a. Only (I)
b. Only (II)
c. Only (III)
d. (I) and (II)
e. (I) and (III)
f. (I) and (III)

- Which one of the following would have a density of 1.21 g/L at 7.0 °C and 0.987 atm?

a. Ar
b. N_2
c. Ne
d. O_2
e. Xe

- Which is expected to have the largest dispersion forces?

a. C_2H_6
b. C_8H_{18}
c. N_2
d. O_2
e. CO_2

- Commercial cold packs often contain solid NH_4NO_3 and a pouch of water. The temperature of the pack drops as the NH_4NO_3 dissolves in water. Therefore, for dissolving of NH_4NO_3 in water.

a. ΔH_{sol} is negative and ΔS_{sol} may be negative or positive.
b. ΔH_{sol} is negative and ΔS_{sol} is positive.
c. ΔH_{sol} is positive and ΔS_{sol} may be negative or positive.
d. ΔH_{sol} is positive and ΔS_{sol} is positive.
e. ΔH_{sol} is positive and ΔS_{sol} is negative.

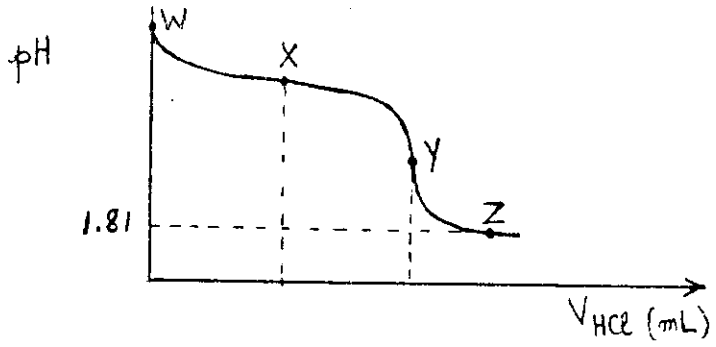
- Most gases become less soluble in water as the temperature increases. What can be concluded about the signs of ΔH_{sol} and ΔS_{sol} in this case?

a. ΔH_{sol} is positive and ΔS_{sol} is negative.
b. ΔH_{sol} is negative and ΔS_{sol} is positive.
c. ΔH_{sol} is positive and ΔS_{sol} is positive.
d. ΔH_{sol} is negative and ΔS_{sol} may be negative or positive.
e. ΔH_{sol} is negative and ΔS_{sol} is negative.

- At a given temperature the vapor pressures of benzene and toluene are 183 mm Hg and 59.2 mm Hg, respectively. Calculate the mole fraction of benzene in the vapor phase over a solution of benzene and toluene with mole fraction of benzene equal to 0.600.

a. 0.600
b. 0.678
c. 0.756
→ d. 0.823
e. 0.912

• Consider the following titration curve of 25.0 mL of a 0.200 M solution of a weak monoprotic base ($K_b = 6.50 \times 10^{-6}$), with 0.150 M HCl.



Which of the following statements is <u>incorrect</u>?

a. The pH at point W is 11.06
b. The pH at point X is 8.81
c. The pH at point Y is 4.94
d. The volume added at point Z is 45.0 mL
e. None of the above

• The indicator Bromothymol blue is a weak acid of $K_a = 1.6 \times 10^{-7}$.
The color of its acid form is yellow and that of its base form is blue.
Which of the following is <u>right</u> if two drops of indicator are added to a solution at the indicated pH?

a. pH = 4.5, the solution will be blue
b. pH = 8.1, the solution will be yellow
c. pH = 6.2, the solution will be greenish
d. pH = 0, the solution will be colorless
e. All of the above.

• The pH of a 1.00×10^{-3} M solution of the base pyrrolidine is 10.82. Calculate K_b for that base.

a. 1.3×10^{-3}
b. 4.8×10^{-10}
c. 6.6×10^{-1}
d. 2.4×10^{-6}
e. 4.4×10^{-5}

• Arrange the following 0.10 M solutions in order from most acidic to most basic.
Given: K_a (HNO_2) = 4.0×10^{-4}; K_b (NH_3) = 1.8×10^{-5}.

$CaBr_2$, KNO_2, $HClO_4$, HNO_2, NH_4ClO_4 and NH_4NO_2.

a. $HClO_4$/HNO_2/$CaBr_2$/ KNO_2/ NH_4ClO_4/ NH_4NO_2
b. $HClO_4$/HNO_2/KNO_2 /NH_4ClO_4/NH_4NO_2/$CaBr_2$
c. $HClO_4$/HNO_2/NH_4ClO_4/NH_4NO_2/$CaBr_2$/KNO_2
d. $HClO_4$/HNO_2/NH_4NO_2/ NH_4ClO_4/$CaBr_2$/KNO_2
e. $HClO_4$/NH_4NO_2/NH_4ClO_4/ HNO_2/$CaBr_2$/KNO_2

• Which of the following statements is <u>incorrect</u>?

a. The weaker the acid, the stronger is its conjugate base as a base.
b. A buffer solution with large initial concentrations of weak acid and its salt has a higher buffer capacity than a solution with small concentrations of the acid and the salt.
c. The equivalence pH in the titration of a weak acid solution (with $pK_a = 5$) of concentration *c*, is higher than that of a weak acid solution of the same concentration but with $pK_a = 8$.
d. The lower the pK_a of the titrated acid (of concentration *c*), the larger the pH range at the equivalence point.
e. At half-equivalence volume in the titration curve of a weak acid with a strong base, the buffering capacity of the solution is maximum.

• Which of the following processes has a positive $\Delta S°$?

a. $2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (l)$
b. $HCl\ (g) \rightarrow H^+\ (aq) + Cl^-\ (aq)$
c. $AgCl\ (s) \rightarrow Ag^+\ (aq) + Cl^-\ (aq)$

d. 

e. c and d

• Consider the reaction:

$$HCl\,(g) + NH_3\,(g) \rightarrow NH_4Cl\,(s)$$

Given the following data:	$\Delta H°_f$ (kJ/mol)	$S°$ (J/mol K)
$HCl\,(g)$	−92	187
$NH_3\,(g)$	−46	193.
$NH_4Cl\,(s)$	−314	96

Calculate $\Delta G°$ for the above reaction at 298 K:

a. −176 kJ
b. −284 kJ
c. −261 kJ
d. −91 kJ
e. −105 kJ

• Consider the reaction

$$N_2\,(g) + 3\,H_2\,(g) \rightarrow 2\,NH_3\,(g)$$

The equilibrium constant for the reaction at 298 K is 9.1×10^5. Calculate ΔG for the reaction at 298 K when $P_{N2} = 200$ atm. $P_{H2} = 600$ atm and $P_{NH3} = 200$ atm.

a. −34 kJ
b. −95 kJ
c. −51 kJ
d. −39 kJ
e. −68 kJ

• In each of the following, a set of quantum numbers is given with the maximum number of electrons in an atom that can have the shown set. Which number of electrons does <u>not</u> correspond to the given set?

a. n=4: 32 electrons
b. n=5, m_l= −1: 10 electrons
c. n=5, m_s=+1/2: 25 electrons
d. n=2, l=1, m_l= −1, m_s= −1/2: 1 electron
e. n=3, l=0, m_l= 0: 2 electrons
f. n=3, l=3, m_l= −3, m_s=−1/2: 0 electron

• Which of the following statements is <u>false</u> about the Bohr theory of the H atom?

a. It takes more energy to ionize (remove) an electron from n=3 than from the ground state.
b. The electron is farther from the nucleus on average in the n=3 state than in the ground state.
c. The wavelength of light emitted if the electron drops from n=3 to n=2 is longer than the wavelength of light emitted if the electron falls from n=3 to n=1.
d. The wavelength of light emitted when the electron returns to the ground state from n=3 is the same as the wavelength of light absorbed to go from n=1 to n=3.
e. The first excited state corresponds to n=2

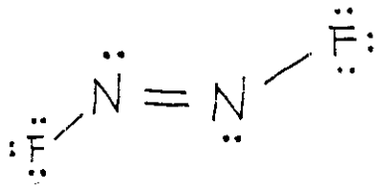
• Which element has the ground state electronic configuration $[Rn]7s^26d^1$?

a. Ce
b. Th
c. La
d. Ac
e. Hf

• The Lewis structure of XeO_4 which has zero formal charges on <u>all</u> the atoms has:

a. Four single bonds
b. One double bond and three single bonds
c. Two double bonds and two single bonds
d. Three double bonds and one single bond
e. Four double bonds

• Consider the molecule:

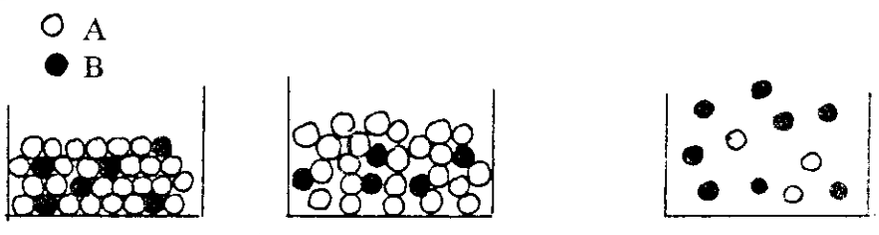


Which of the following is true about the N—F bond?

a. It is formed by the overlap of an sp^2 hybrid orbital on N and an sp^2 hybrid orbital on F.
b. It is formed by the overlap of an sp^3 hybrid orbital on N and an sp^3 hybrid orbital on F.
c. It is formed by the overlap of an sp^2 hybrid orbital on N and an sp^3 hybrid orbital on F.
d. It is formed by the overlap of an sp^3 hybrid orbital on N and an sp^2 hybrid orbital on F.
e. It is formed by the overlap of an sp hybrid orbital on N and an sp^3 hybrid orbital on F.

• Which of the following diagrams best illustrates the description below it?

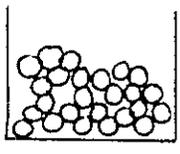
A



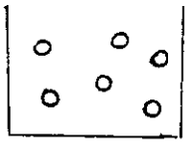
a. Solid solution (A solvent)

b. Liquid solution (B solvent)

c. Gas solution (A solvent)



d. Solid



e. Liquid

• Which statement correctly explains the deviation of the molecule from the octet rule?

a. NO_2 - electron pair deficient
b. BF_3 - odd electron molecule
c. $BeCl_2$ - electron deficient
d. PCl_5 - expanded octet
e. SO_2 - resonance forms
f. c) and d)

- Magnetic Resonance Imaging (MRI) is a powerful diagnostic tool in medicine. The imagers used in hospitals operate with a wavelength of 7.50×10^{8} nm. Calculate the energy in KJ/mol.

a. 1.60×10^{-4} KJ/mol.
b. 2.65×10^{-4} KJ/mol.
c. 2.65×10^{-3} KJ/mol.
d. 3.50×10^{-2} KJ/mol.
e. 2.65×10^{-28} KJ/mol.

- In the Pashen Series of the Hydrogen atom, $\mathbf{n}_{lower} = 3$. Calculate the longest wavelength possible for a transition in this series.

a. 1200 nm
b. 465 nm
c. 650 nm
d. 1875 nm
e. 2300 nm

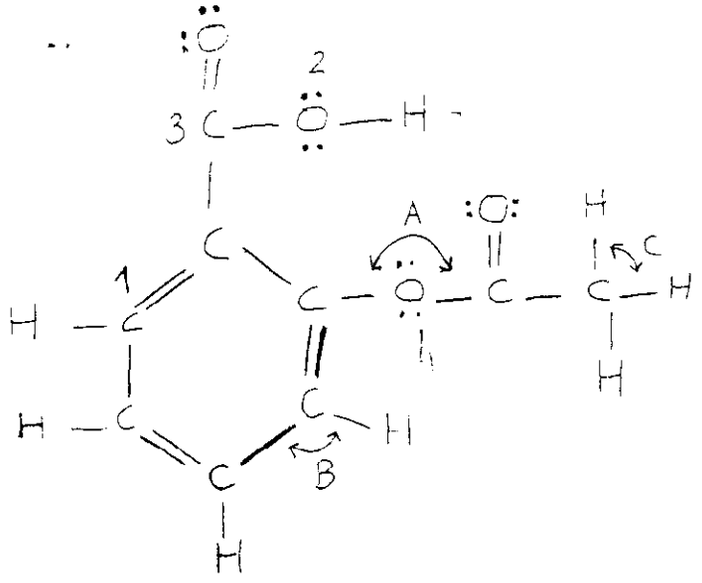
- Consider a molecule where the central atom forms 4 bonds. Two are *sigma* bonds, and two are *pi* bonds. The geometry and hybridization of the central atom are:

a. Linear, sp.
b. Tetrahedral, sp^3
c. Bent, sp^3
d. Angular, sp^2
e. Linear, dsp^3

- What type of orbital is designated by the following quantum numbers: **n** = 2, **l** =3, and **ml** = -1?

a. d (z^2)
b. d (x^2-y^2)
c. p (z)
d. d (xy)
e. does not exist

- Consider acetyl salicylic acid, known as aspirin:



What is the hybridization of the atoms designated 1, 2, and 3.

a. atom 1 is sp^2; atom 2 is sp^3; atom 3 is sp^2
b. atom 1 is sp; atom 2 is sp; atom 3 is sp^2
c. atom 1 is sp^2; atom 2 is sp; atom 3 is sp^3
d. atom 1 is sp^3; atom 2 is sp^3; atom 3 is sp^2
e. none of the above combinations is true

- Consider the formula shown for acetyl salicylic acid (aspirin), in the previous question, what are the closest approximate values of the angles marked A, B, and C.

a. Angle A is 109.5°, angle B is 120°, angle C is 107°.
b. Angle A is 109.5°, angle B is 120°, angle C is 109.5°.
c. Angle A is 107°, angle B is 120°, angle C is 109.5°.
(d.) Angle A is 105°, angle B is 120°, angle C is 109.5°.
e. Angle A is 105°, angle B is less than 120°, angle C is 109.5°.

- Which of the following statements correctly describes the behavior of a van der Waals gas: (Hint: positive deviation: $Z > 1$: negative deviation: $Z < 1$).

a. The van der Waals equation of state is independent of the nature of the gas.
b. The effect of intermolecular attractive forces causes a positive deviation from ideal gas behavior.
c. The effect of intermolecular attractive forces causes a negative deviation from ideal gas behavior.
d. The effect of the volume occupied by the particles causes the pressure of the gas to be larger than the pressure predicted by the ideal gas equation of state.
(e) c and d

- The freezing point of 0.10 m solution of $KHSO_3$ in water is -0.38 °C. Which of the following equations best represents what happens when $KHSO_3$ dissolves in water?

(I) $KHSO_3\ (s) \rightarrow KHSO_3\ (aq)$
(II) $KHSO_3\ (s) \rightarrow K^+\ (aq) + HSO_3^-\ (aq)$
(III) $KHSO_3\ (s) \rightarrow K^+\ (aq) + H^+\ (aq) + SO_3^{2-}\ (aq)$

a. (I)
b. (II)
c. (III)
d. none of the above

- What is the density of an aqueous solution of KNO_3 (electrolyte) that has a normal boiling point of 103.0 °C and an osmotic pressure of 122 atm at 25 °C.

a. 1.2 g/ml
b. 1.8 g/ml
c. 0.9 g/ml
d. 1.1 g/ml
e. 2.8 g/ml

- Calculate the pH of a solution prepared by mixing 100.0 ml of 1.20 M ethanolamine, $C_2H_5ONH_2$, with 50.0 ml of 1.0 M HCl. Ka for $C_2H_5ONH_3^+$ is 3.61×10^{-10}.

a. 9.59
b. 8.73
c. 10.51
d. 8.98
e. 7.85

- Which of the following statements is true regarding the titration of a weak acid (HA) with a strong base.

a. the volume of the titrant added to reach the equivalence point depends on the Ka of the acid (HA).
b. the pH at the equivalence point is independent of the Ka of the weak acid, it only depends on the amount of the weak acid originally present.
c. at the equivalence point, the pH is less than 7 because we are titrating a weak acid.
d. when half the equivalence volume is added, the pH is equal to the pKa of the weak acid (HA).
e. a and d
f. b and d