Chemistry 1A, Fall 2003

Final Exam, Version A
Dec 10, 2003
(180 min, closed book)

KEY

Name:_____

SID:_____

TA Name:_____

- Write your name on every page of this exam.
- This exam is multiple choice. Some questions have more than one correct answer. Mark all that apply. Fill in the Scantron form AND circle your answer on the exam.
- Each question is worth 3.89 points.

Potentially useful relations:

$E = h\nu$

$\lambda\nu = c$

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

$p = mv$

$E_{kin} = ½\ mv^2$

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

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

$PV = nRT$

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

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

$\Delta E = q + w$

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

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

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

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

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

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

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

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

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

Gas Constant:

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

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

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

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

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

$1\ kJ = 1000\ J$

$Cp(H_2O) = 4.184 J/g\ K$

$\Delta G° = \Delta H° - T\Delta S°$

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

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

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

$S = k_B \ln W$

for $aA + bB \rightleftarrows cC + dD$

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

$\Delta G° = - RT \ln K$

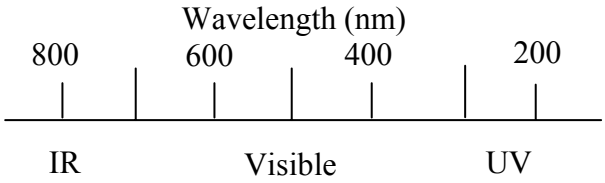
$$\ln K = -\frac{\Delta H°}{R}\frac{1}{T} + \frac{\Delta S°}{R}$$

$\Delta G° = - nF\Delta Є°$

$pX = - \log X$

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

Color and Wavelength of Light

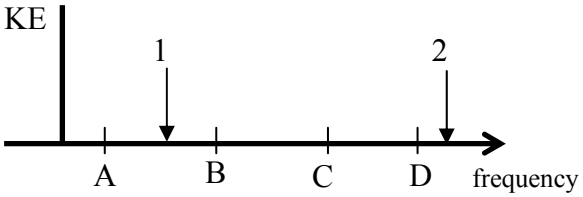


ΔG° of Formation

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

Name_____

Points 1 and 2 represent the work functions in frequency units of two different metals on the plot of photo-electron kinetic energy vs. photon frequency for a photoelectric effect experiment. Use the photon frequencies labeled A, B, C and D to answer the following four questions.



1.) Which photon ejects an electron with the greatest kinetic energy from metal 1?

A) A B) B C) C D) D E) none

2.) Which photon will not eject an electron from either metal?

A) A B) B C) C D) D E) none

3.) Which photon ejects an electron from metal 2?

A) A B) B C) C D) D E) none

4.) What is the wavelength (nm) of photon A if the frequency at point 'A' is 3.0×10^{14} Hz (in the infrared region of the electromagnetic spectrum)?

A) 1000 B) 1500 C) 2200 D) 3300 E) 4200

Continue with the next question:

Consider the electronic energy levels of the He^{+} ion for the following three questions.

5.) What is the ground state energy in units of R_{∞} (Rydbergs)?

A) -9 B) -4 C) 0 D) 4 E) 16

6.) What wavelength photon is required to excite this ion from its ground state to first excited state (nm)?

A) 1.00 B) 3.14 C) 13.5 D) 18.8 E) 30.4

7.) What is the ionization energy of the ion in units of R_{∞}?

A) -9 B) -4 C) 0 D) 4 E) 16

Continue with the next question:

Name_____

8.) Which atomic orbital has the greatest number of radial nodes?

A) 1s B) 2s C) 3s D) 3p E) 4d

9.) The process of removing an electron from a neutral element in the gas phase...

A) requires energy for all elements, because the initial state is less stable than the final state.

B) requires energy for all elements, because the initial state is more stable than the final state.

C) does not require energy for any element, because the initial state is the same energy as the final state.

D) requires energy for some elements, because sometimes the initial state is more stable than the final state.

10.) Which of the following is a reasonable electronic configuration for neutral Tin (Sn)?

A) $[Kr]4s^2 3d^{10} 4p^2$

B) $[Kr]5s^2 5d^{10} 5p^2$

C) $[Kr]5s^2 4d^{10} 5p^3$

D) $[Kr]5s^2 4d^{12} 5p^0$

E) $[Kr]5s^2 4d^{10} 5p^2$

11.) In an atom of any element, the 2s orbital is:

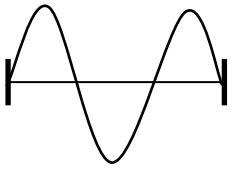
A) always at the same energy as the 2p orbital.

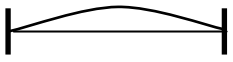
B) always at lower energy than the 2p orbital.

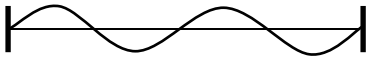
C) only at the same energy as the 2p orbital for atoms with more than one electron.

D) only at lower energy than the 2p orbital for atoms with more than one electron.

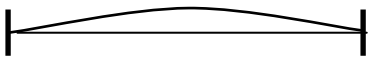
12.) Which wave form for a particle trapped in a 1-dimensional box has the lowest energy?

A) 

B) 

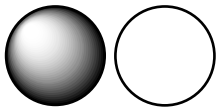
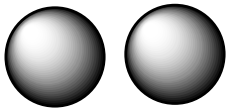
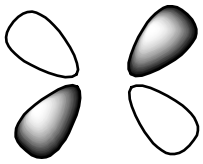
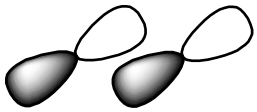
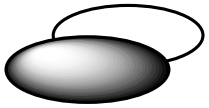
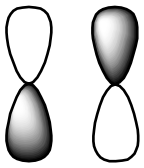
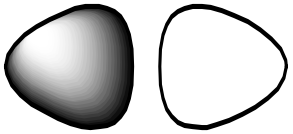
C) 

D) 

E) 

Name_____

For the following five questions match the atomic orbitals with the molecular orbital formed by their sum:

Question	Atomic Orbitals			Molecular Orbitals
13.) **E**			A	
14.) **A**			B	
15.) **B**			C	
16.) **D**			D	
17.) **C**			E	

18.) Which of the molecular orbitals in the preceding table would have the lowest energy?

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

Continue with the next question:

19.) Which of the following mixtures of atomic orbitals best describes a π bonding orbital in O_2 (the internuclear axis is 'z')?

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

20.) 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) $p_x + p_y$

21.) What is the bond order of Li_2^+.

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

Name_____

Consider the combustion of formaldehyde CH_2O and the data below for the following five questions.

I. $CH_2O\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (l)$

II. $4\ H^+ + 4\ e^- + O_2\ (g) \rightarrow 2\ H_2O\ (l) \quad \Delta\epsilon^\circ = 1.23\ V$

Compound	**ΔG°_f (kJ/mol)**
$CH_2O\ (g)$	-109
$CO_2\ (g)$	-393
$H_2O\ (l)$	-237

22.) Which compound is reduced in reaction **I**?

A) CH_2O B) H_2O C) O_2 D) CO_2 E) none of these

23.) What is the change in oxidation number of the carbon in reaction **I**?

A) -4 B) -1 C) 0 D) 1 E) 4

24.) What is ΔG° for the combustion of formaldehyde (kJ/mol)?

A) 224
B) -521
C) 96
D) -150
E) More data are required.

25.) How many electrons are required to balance the half reaction $CH_2O \rightarrow CO_2$ in acidic solution?

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

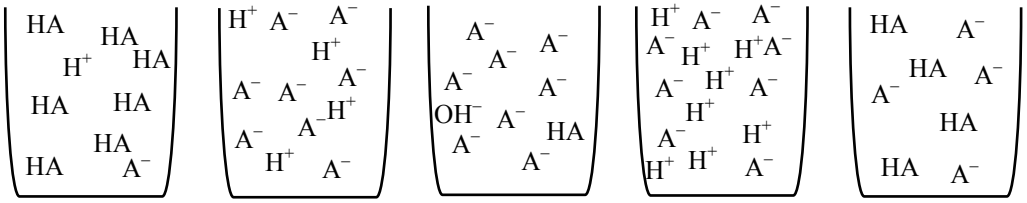
26.) What is the standard half cell potential (in volts) for the CH_2O oxidation?

A) 1.7
B) 0.76
C) 0.12
D) 3.33
E) 1.69

Continue with the next question:

Name_____

Consider the schematic reaction flasks for the titration of the acid HA with strong base in answering the following five questions.



A B C D E

27.) Which schematic best depicts the beginning of the titration if HA is a strong acid?

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

28.) Which schematic best depicts the beginning of the titration if HA is a weak acid?

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

29.) Which schematic best depicts the equivalence point of the titration if HA is a strong acid?

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

30.) Which schematic best depicts the half-equivalence point of the titration if HA is a weak acid?

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

31.) Which schematic best depicts the equivalence point of the titration if HA is a weak acid?

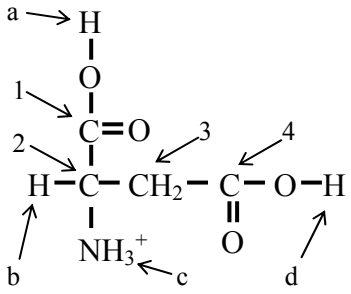
A) A B) B C) C D) D E) E

Continue with the next question:

Name_____

Consider the Lewis Structure for aspartic acid (an amino acid found in proteins) for the next nine questions (lone pairs are not shown).

Proton	pKa
a	1.99
b	34
c	9.80
d	3.97



32.) What is the hybridization on carbon atom one (1) in aspartic acid?

A) s B) sp C) sp^2 D) sp^3 E) sp^4

33.) What is the O-C-O bond angle at carbon one (1) in aspartic acid?

A) 60 B) 90 C) 120 D) 180 E) 270

34.) Which is the best description of the molecular orientation about carbon two (2)?

A) trigonal planar
B) square planar
C) T-shaped
D) See-Saw
E) Tetrahedral

35.) Which carbon is a chiral?

A) 1 B) 2 C) 3 D) 4 E) none

36.) In which of the following pH regions will aspartic acid have the greatest pH buffering capacity?

A) ~0 B) ~4 C) ~6 D) ~7 E) ~11

37.) What is the charge on the aspartic acid molecule at pH 7.0?

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

38.) Which acidic sites are more that 50% protonated at ph 5.0 (mark all that apply)?

A) a B) b C) c D) d E) can't tell

Name_____

39.) Which is the most acidic proton on the aspartic acid molecule?

A) a B) b C) c D) d E) can't tell

40.) Which best describes the pH titration curve of aspartic acid solution with a strong base from pH 1.0 to pH 13?

A) A single flat region around pH 6 and an equivalence point at pH 7
B) Three distinct flat regions and equivalence points.
C) A single flat region at pH 7 and a basic equivalence point
D) A single flat region around pH 3 and a basic equivalence point
E) not enough information is provided

Continue with the next question:

The K_a for formic acid, HCOOH, is 1.77×10^{-4}. Use this information to answer the following four questions.

41.) What is [HCOOH] when 0.1 moles of formic acid are added to 1.0 L of water?

A) 0.02 B) 0.05 C) 0.1 D) 1 E) 2

42.) What is the conjugate base of formic acid?

A) HCl B) OH^- C) $HCOO^-$ D) HCOOH E) NaCl

43.) What is K_b for the conjugate base of formic acid?

A) 2.80E-8 B) 4.75E-10 C) 3.70E-9 D) 5.65E-11 E) 6.90E-7

44.) What is the pH of a 0.1 M formic acid solution when it is titrated to equivalence point with strong base (assume no volume change)?

A) 7.0 B) 7.4 C) 8.0 D) 8.4 E) 9.0

Continue with the next question:

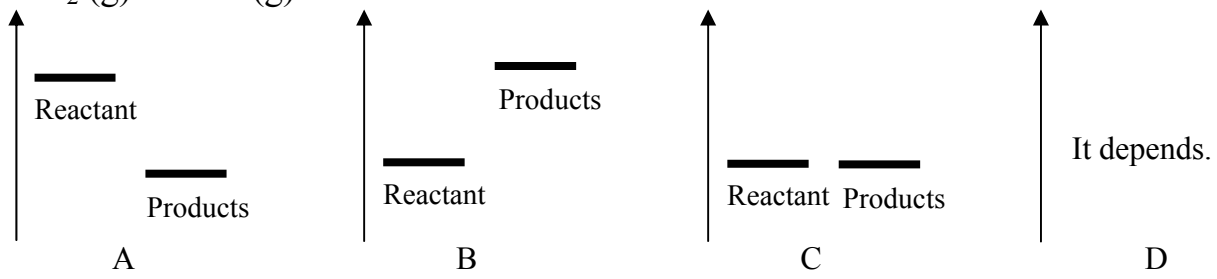
45.) A buffer

A) can be made by a combination of a strong acid and strong base.
B) can be a combination of a weak acid and its conjugate base.
C) resists changes in pH.
D) both A and C.
E) both B and C.

Name_____

For the next thirteen questions, consider the plots below and the generic atomization of a stable diatomic molecule 'A_2' at 298 K in a 1.0 L flask.

A_2 (g) → 2 A (g)



46.) Which plot represents the standard enthalpy change for the reaction?

A) A [B) B] C) C D) D

47.) Which plot represents the standard entropy change for the reaction?

A) A [B) B] C) C D) D

48.) Which plot represents the standard free energy change for the reaction?

A) A B) B C) C [D) D]

49.) In which temperature range will this reaction be spontaneous in the standard state?

[A) high T] B) low T C) all T D) no T E) can't tell

50.) Which is the best expression for the reaction quotient, Q?

A) P_A/P_{A2} B) P_{A2}/P_A C) $P_{A2}\,P_A$ [D) P_A^2 / P_{A2}] E) P_{A2}^2 / P_A

51.) Which will cause the equilibrium reaction to shift towards the products without changing the equilibrium constant (mark all that apply)?

A) Increasing the temperature.
[B) Increasing the volume.]
C) Adding A atoms.
[D) Adding A_2 molecules.]
E) Adding and inert gas (e.g. Neon).

52.) If the volume of the equilibrium reaction is halved, what is the relationship between Q and K?

A) Q = 1/2 K B) Q = K [C) Q = 2 K] D) $Q = K^2$ E) Q = 4 K

Name_____

53.) What is the total number of A atoms in the sample if only 1.0 atm of A_2 gas is initially present?

A) 4.9×10^{22}
B) 1.0×10^{15}
C) 9.3×10^{30}
D) 2.2×10^{-12}
E) 44,000

54.) What is the equilibrium pressure (in atm) in the flask if only 1.0 atm of A_2 gas is initially present and one half of the molecules are subsequently atomized?

A) 0.5 B) 1.0 C) 1.5 D) 2.0 E) 2.5

55.) What is the equilibrium partial pressure (in atm) of A atoms if only 1.0 atm of A_2 gas is initially present and one half of the molecules are subsequently atomized?

A) 0.5 B) 1.0 C) 1.5 D) 2.0 E) 2.5

56.) What is the equilibrium partial pressure (in atm) of A atoms if only 1.0 atm of A_2 gas is initially present, one half of the molecules are subsequently atomized and 1 mole of Neon gas is injected.

A) 0.5 B) 1.0 C) 1.5 D) 2.0 E) 2.5

57.) Which has the highest root mean squared velocity when there is a mixture of A, A_2 and Neon?

A) A B) A_2 C) Ne D) all are the same E) can't tell

58.) Which has the highest molar kinetic energy when there is a mixture of A, A_2 and Neon?

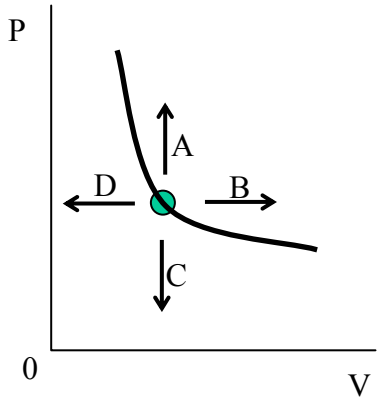
A) A B) A_2 C) Ne D) all are the same E) can't tell

Continue with the next question:

Name_____

For the next five questions, the points shown lie on the curve describing the relationship between the variables shown. Answer the questions about how the point will move along the curve when the conditions are changed as noted (for some cases, the point may leave the curve). If the point would move into a region between two lettered arrows, mark both letters on your scantron sheet. For example, if the point should move up and to the right, mark A and B on your answer sheet. For cases where the curve is not provided, it may help to sketch the curve passing through the point for the variables listed. Use answer E if the point does not move.

EXAMPLE: P vs. V for an ideal gas. How does the point move for an increase in P?



ANSWER: AD.

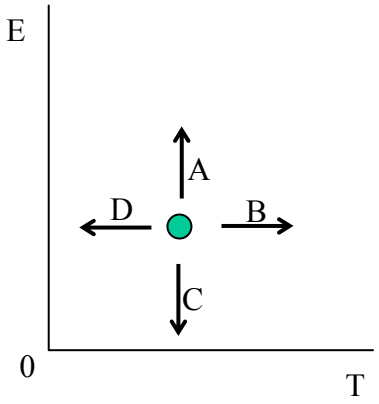
59.) P vs. V for an ideal gas. How does the point move for a increase in V?

A) A B) B C) C D) D E) doesn't move

60.) P vs. V for an ideal gas. How does the point move for a decrease in T, if the volume is held constant?

A) A B) B C) C D) D E) doesn't move

Name_____

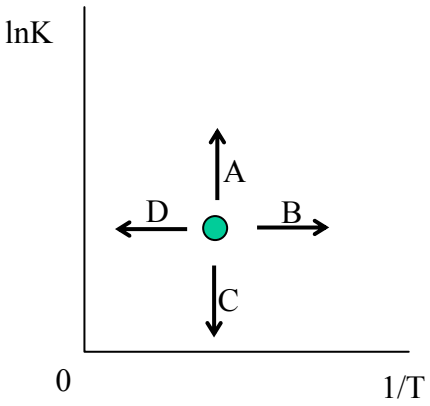


61.) Molar energy of an ideal gas vs. T. How does the point move for a doubling of T?

A) A B) B C) C D) D E) doesn't move

62.) Molar energy of an ideal gas vs. T. How does the point move for an isothermal decrease in the volume of the gas?

A) A B) B C) C D) D E) doesn't move



63.) lnK vs. 1/T for a reaction where $\Delta H > 0$ and $\Delta S > 0$. How does the point move for an increase in T?

A) A B) B C) C D) D E) doesn't move

Continue with the next question:

Name_____

64.) Electric current, or flow of electrons, is measured in Amperes (A). One Ampere is the delivery of one coulomb (C) of charge per second. What mass of Zinc (in g) is oxidized (to Zn^{2+}) by a dry cell battery that supplies 125 mA of current for two hours (recall that Faraday's constant is the charge in coulombs on a mole of electrons)?

A) 0.03 B) 0.1 C) 0.3 D) 1.0 E) 3.0

65.) Which is true of the chemical reaction $2\ H_2 + O_2 \rightarrow\ 2\ H_2O$, which can be carried out on a platinum catalyst in the gas phase or in a galvanic cell (shown below – mark all that apply)?

$Pt \mid H_2 \mid OH^- \parallel OH^- \mid O_2 \mid Pt.$

A) More energy is released with the catalyst.
B) The entropy change is greater with the catalyst.
C) The entropy of the universe increases for both processes.
D) An equal amount of energy is released in both processes.
E) None of these.

66.) Which is true when a gas expands isothermally against a constant pressure of two atmosphere (mark all that apply)?

A) The system does work.
B) The gas releases heat.
C) Heat is absorbed by the gas.
D) The temperature of the gas decreases.
E) No heat flows.

67.) .Which one of the following will change the value of an equilibrium constant?

A) changing temperature
B) adding other substances that do not react with any of the species involved in the equilibrium
C) varying the initial concentrations of reactants
D) varying the initial concentrations of products
E) all of these

68.) What is the amount of 'C' at equilibrium when 1 mole of A and 1 mole of B react according to chemical reaction: $2A + 2B \leftrightarrow C$?

A) between 0 and 0.5 mole
B) exactly 1 mole
C) between 0.5 and 2 moles
D) exactly 2 moles
E) greater than two moles

Name_____

69.) Henry's Law constants (K) are the equilibrium constants for the reaction of a gas dissolving in a liquid; X (g) → X (aq). Which of the following should have the largest Henry's Law constant for dissolving in water?

A) CO_2 B) He C) Ar D) N_2 E) NH_3

70.) Estimate the molar solubility of $CaCO_3$ in 0.1 M Na_2CO_3 solution (M).
K_{sp} ($CaCO_3$) = 1.0 x 10^{-8}, K_{sp} (Na_2CO_3) ~ 10^{8}.

A) ~10^{-5} B) ~10^{-7} C) ~10^{-9} D) ~10^{-10} E) can't tell

71.) In a calorimetry experiment a student determines the enthalpy for the reaction of magnesium with hydrochloric acid to be -430 kJ/mol. The true enthalpy for this reaction is -450 kJ/mol. Which of the following sources of error could account for this discrepency?

A) After recording the mass, some of the magnesium was dropped on the counter.
B) Some of the hot hydrogen gas escaped during the reaction.
C) The calorimeter was not tightly shut for the experiment.
D) The final temperature was recorded before the reaction was complete.
E) All of these errors would cause a falsely high value for the enthalpy.

72.) A sample of cold water was added to a sample of room temperature water in a calorimeter. Given the data below, determine the energy released by the calorimeter (joules).

mass of calorimeter (g)	*93.56*	
mass of cold water (g)	*63.92*	
mass of room temperature water (g)	*108.73*	
Δ T (final-initial) (°C)	*-7.5* *(Room Temp H_2O)*	*14.5* *(Cold H_2O)*

A) 4.98 B) 466 C) 7289 D) 77.9 E) can't tell