

Chemistry 1A
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Midterm II
(Closed Book, 90 Minutes, 135 Points)

October 14, 1997
Professor Pines

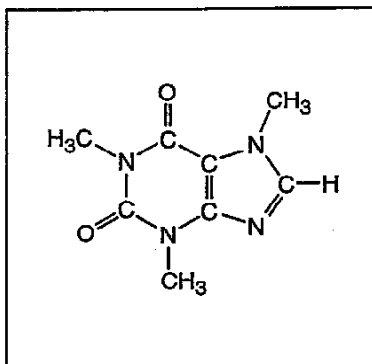
Name: _____

TA: _____

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Section: _____

Identification Sticker



Which compound is this? (0 Points)

Aspirin

Buckminsterfullerene

Caffeine

Dopamine

Endorphin

Test-taking strategy: PLEASE READ THIS FIRST!

Write your name on all 8 pages. This test consists of two parts: multiple choice (answers to be circled *and* entered on the Scantron sheet) and short answer. In order to maximize your score on the exam:

- Do the questions you know how to do first, then, go back and answer the questions you skipped.
- Budget your time carefully -- don't spend too much time on any one problem.
- Show all work for which you want credit and don't forget to include units.
- The "tear off" back page has some useful data and equations.

Page	Points	Page	Points
Multiple Choice		6	
4		7	
5		Total:	

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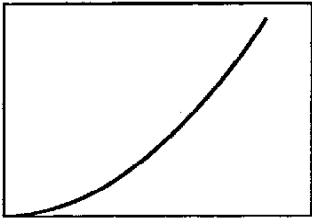
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Section 1: Multiple Choice. 13 questions, 4 points each.

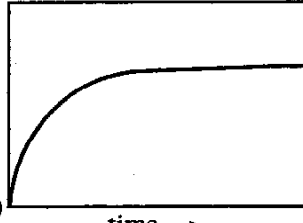
Instructions: For the following questions, circle the answer on the exam sheet **and bubble in the correct answer on your Scantron sheet.** Unless you are specifically told that there might be more than one answer to a problem, assume that only one answer is correct.

- 1.) You are taking test version C. Please fill in bubble "C" on the Scantron sheet.
- 2.) Assuming that studying for a Chem 1A midterm consumes 100 W, how long could you study for this midterm on two 10 Calorie sticks of gum?
- A) seconds B) minutes C) hours D) days E) weeks
- 3.) Suppose 0.10 M solutions of each of the following substances are prepared. Which solution would have the *second highest* pH?
- A) NH_4Cl B) NaOH C) KCl D) NH_3 E) HCl
- 4.) Which of the following species has a dipole moment?
- A) PCl_4^+ B) SO_4^{2-} C) NH_3 D) CS_2 E) F_2

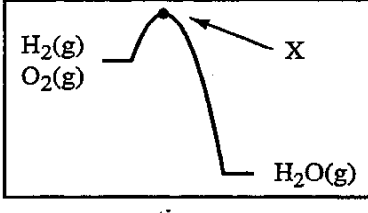
In the following 3 problems, choose the one answer that best describes "X" in the given figures.

5.)  For the reaction $2 \text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$ at equilibrium and constant temperature, X=?

A) P_{NO_2} B) $P_{\text{NO}_2}^2$ C) K_P
D) $P_{\text{N}_2\text{O}_4}$ E) $P_{\text{N}_2\text{O}_4}^2$

6.)  For a reaction in a sealed vessel, beginning only with reactants, that proceeds monotonically towards equilibrium, X=?

A) K B) [Reactants] C) Q
D) $1/K$ E) Total mass

7.)  Which of the following species could be X? Note: See page 8 for a table of enthalpies.

A) $\text{H}_2\text{O}(\text{s})$ B) $\text{H}_2\text{O}(\ell)$ C) $\text{H}_2\text{O}_2(\text{g})$
D) $\text{H}(\text{g})$ and $\text{O}(\text{g})$ E) $\text{H}_2(\text{g})$ and $\text{O}_2(\text{g})$

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8.) Which of the following is the correct equilibrium expression for the reaction:



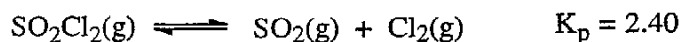
- A) $\frac{[\text{Cu}^{2+}]^2 [\text{I}^{-}]^4}{[\text{CuI}]^2 [\text{I}_2]}$ B) $\frac{[\text{I}_2]}{[\text{Cu}^{2+}]^2 [\text{I}^{-}]^4}$ C) $\frac{[\text{I}_2]}{[\text{Cu}^{2+}] [\text{I}^{-}]}$ D) $\frac{[\text{Cu}^{2+}]^2 [\text{I}^{-}]^4}{[\text{I}_2]}$ E) $\frac{[\text{CuI}]^2 [\text{I}_2]}{[\text{Cu}^{2+}]^2 [\text{I}^{-}]^4}$

9.) For a reaction in which $\text{A} \xrightleftharpoons{K_1} \text{B} \xrightleftharpoons{K_2} \text{C}$, what is the equilibrium constant for $\text{C} \xrightleftharpoons{??} \text{A}$?

- A) $K_1 K_2$ B) $\frac{K_1}{K_2}$ C) $\frac{K_2}{K_1}$ D) $\frac{1}{K_1 K_2}$ E) $K_1 + K_2$

10.) Which of the following is **not** a valid means of creating a solution whose pH=1.0?

- A) Diluting 100 mL of 1.0 M HCl to 1.0 L with water.
 B) Adding 90 mL of 0.1 M NaOH to 100 mL of 1.0 M HCl.
 C) Dissolving 0.1 moles of HCl in 1.0 L of water.
 D) Adding 0.6 moles of HCl to 1.0 L of 0.5 M NaOH.
 E) Dissolving 0.1 moles of HCl in 1.0 L of 1.0 M NaNO_3 .

11.) A quantity of $\text{SO}_2\text{Cl}_2(\text{g})$ decomposes to form $\text{SO}_2(\text{g})$ and $\text{Cl}_2(\text{g})$:If the equilibrium partial pressure of SO_2Cl_2 is 0.70 atm, what is the partial pressure of SO_2 ?

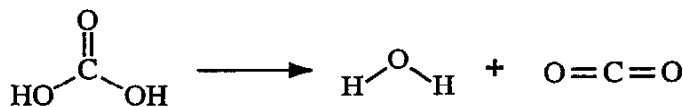
- A) 0.7 atm B) 1.3 atm C) 1.5 atm D) 1.7 atm E) 2.4 atm

12.) For the reaction: $3 \text{BFCl}_2(\text{g}) \rightleftharpoons 2 \text{BCl}_3(\text{g}) + \text{BF}_3(\text{g})$ at equilibrium, what happens to the reaction quotient, Q , relative to K if the volume is suddenly doubled at constant T ?

- A) $Q < K$ B) $Q = K$ C) $Q > K$ D) $Q = K^{-1}$ E) Can't determine.

13.) Suppose that for three acids (HA, HB, and HC), the acidic strength of $\text{HA} > \text{HB} = \text{HC}$. What can be said about the strength of their conjugate bases?

- A) $\text{A}^{-} > \text{B}^{-} = \text{C}^{-}$ B) $\text{A}^{-} = \text{B}^{-} > \text{C}^{-}$ C) $\text{C}^{-} = \text{B}^{-} > \text{A}^{-}$ D) $\text{C}^{-} > \text{B}^{-} = \text{A}^{-}$ E) $\text{C}^{-} > \text{B}^{-} > \text{A}^{-}$

14.) Using bond enthalpies (see page 8), estimate ΔH° for the decomposition of 1 mole of carbonic acid, H_2CO_3 :

- A) -430 kJ B) -30 kJ C) 30 kJ D) 490 kJ E) 730 kJ

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Section 2: Short Answer. 4 questions, 55 points total.

Answer the following four short answer questions. Partial credit will be given, so show your work whenever possible. Your final answers (including units where applicable) **must** be written in the boxes when provided.

- 1.) To measure the energy content of a peanut, a calorimeter is constructed in which the burning peanut is used to heat 100 mL of water. The following data were collected:

Mass of the peanut: 0.84 grams

Mass of peanut + clip + stand before burning: 4.15 grams

Mass of peanut + clip + stand after burning: 3.48 grams

Initial water temperature: 22.5°C

Final water temperature: 37.9°C

- a.) (3 Points) What percent of the nut was consumed?

Percent consumed=

- b.) (7 Points) What is the total energy in kJ available in 1.0 gram of peanuts? Assume that no energy can be extracted from the unburnt part of the peanuts.

Energy =

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2a.) (4 Points) What is the steric number for the xenon atom in xenon pentafluoride, XeF_5^+ ?

Stereic Number =

b.) (7 points) Sketch the structure of xenon pentafluoride, XeF_5^+ , and enter the approximate value of the bond angle using $>$, $<$ or $=$.

Structure:	F-Xe-F angle
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c.) (4 Points) Circle the correct molecular geometry for tellurium pentafluoride, TeF_5^+ .

Square Planar Tetrahedral Trigonal Planar Bent
 Trigonal Bipyramid Octahedral Linear Square Pyramid

3.) Hydrofluoric acid, HF, is a weak acid with a $K_a=6.6 \times 10^{-4}$ and a $\text{p}K_a=3.18$.

a.) (5 points) What is the pH of a 1.0 M HF solution to within 5% accuracy?

pH=

b.) (6 points) 0.5 moles of NaOH is added to 1.0 L of 1.0 M HF. What is the pH?

pH=

c.) (4 points) If NaF is added to the solution in b.), what will happen to the pH? Circle your answer.

The pH will increase.

The pH will decrease.

The pH will stay exactly the same.

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4.) A student places 2.0 atm of formaldehyde, $\text{CH}_2\text{O}(\text{g})$, and 1.0 atm of oxygen, $\text{O}_2(\text{g})$, in a rigid 1.0 L flask at 100°C . She then combusts the mixture to form $\text{H}_2\text{O}(\text{g})$ and $\text{CO}_2(\text{g})$.

a.) (5 points) Assuming no change in temperature, what is the final pressure after the reaction has run to completion?

Pressure =

b.) (5 points) What is ΔH° for the combustion of 1.0 mole of formaldehyde?

$\Delta H^\circ =$

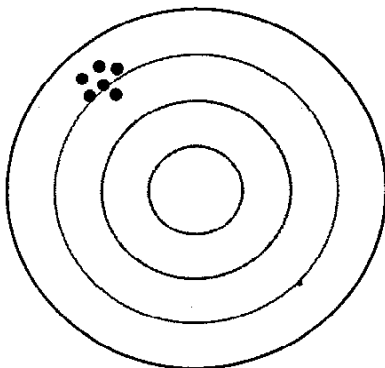
c.) (5 points) Given your answer in part b), determine the total heat evolved from the student's combustion reaction.

Heat evolved =

Section 2: Finish the Picture. 4 questions, 7 points each.

For each question in this section, provide the sketch required on the same graph and, if you wish, explain your answer in 20 words or less in the box provided. Your explanation might allow partial credit to be assigned.

1.) Below is a diagram that depicts a high degree of precision, but low accuracy for a sampling in which the center of the target is considered the correct answer. Draw a diagram (using X's) that shows high accuracy but low precision.

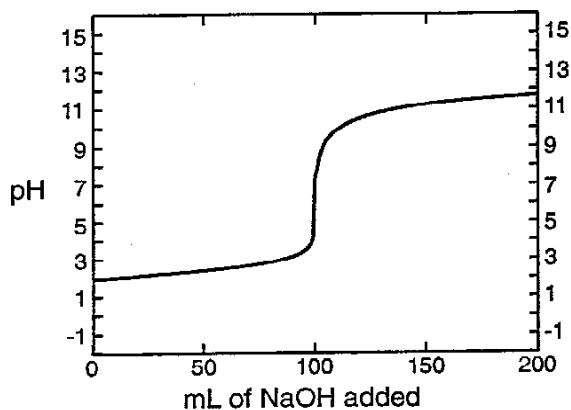


Explanation:

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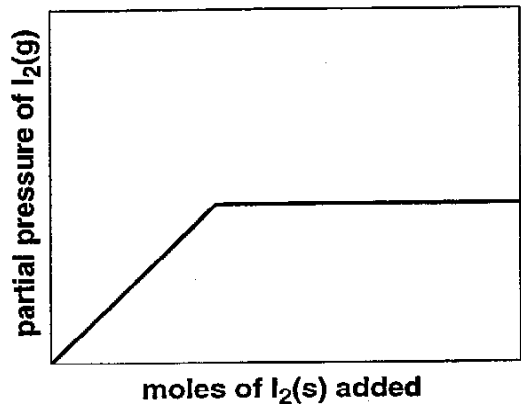
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- 2.) Below is a graph for the titration of 100 mL of 0.01 M HCl with 0.01 M NaOH. Draw a graph which shows the titration of 100 mL of 0.001 M HCl with 0.001 M NaOH.



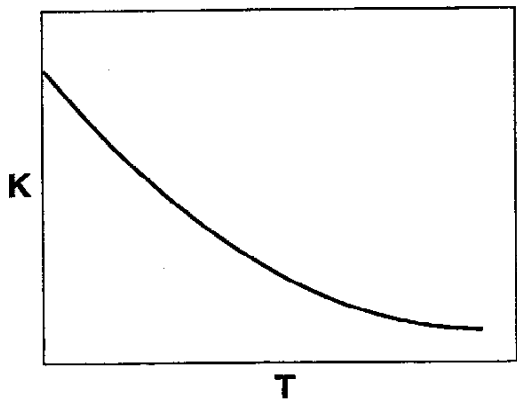
Explanation:

- 3.) Below is a graph of the partial pressure of $I_2(g)$ as a function of $I_2(s)$ added at $25^\circ C$. Draw a graph which shows the partial pressure of $I_2(g)$ as a function of $I_2(s)$ at a higher temperature.



Explanation:

- 4.) Below is a graph of the equilibrium constant, K , as a function of temperature for an exothermic reaction. Draw a graph which shows K as a function of T for a reaction in which $\Delta H^\circ = 0$.



Explanation:

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Possibly Useful Information**Thermochemistry:**

$$\text{Absolute } T(\text{K}) = T(^{\circ}\text{C}) + 273.15$$

$$\Delta H^{\circ} = \sum \Delta H_f^{\circ}(\text{products}) - \sum \Delta H_f^{\circ}(\text{reactants})$$

$$q = m \cdot c_p \cdot \Delta T$$

$$\text{Heat capacity of } \text{H}_2\text{O}(\ell), c_p = 4.184 \text{ J}\cdot\text{K}^{-1}\cdot\text{g}^{-1}$$

$$1 \text{ Calorie} = 1000 \text{ calories} = 4.184 \text{ kJ}$$

$$1 \text{ W} = 1 \text{ J}\cdot\text{s}^{-1}$$

Ideal Gas:

$$PV = nRT$$

$$V = 22.414 \text{ L}\cdot\text{mol}^{-1} \text{ at STP}$$

$$R = 0.08206 \text{ L}\cdot\text{atm}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$$

$$R = 8.3145 \text{ J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$$

Acid/Base:

$$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1.0 \times 10^{-14} \text{ @ } 25^{\circ}\text{C}$$

$$\text{pH} = \text{p}K_a - \log\left(\frac{[\text{HA}]}{[\text{A}^-]}\right)$$

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]}$$

$$K_b = \frac{[\text{OH}^-][\text{HA}]}{[\text{A}^-]}$$

Standard Enthalpies of Formation (in kJ·mol⁻¹)

O ₂ (g), H ₂ (g)	0	H ₂ O(g)	-242
O(g)	250	H ₂ O ₂ (g)	-145
H(g)	220	CH ₂ O(g)	-109
H ₂ O(ℓ)	-286	CO ₂ (g)	-394

Average Bond Enthalpies (in kJ·mol⁻¹)

O = O	500	C = O	730
H - O	460	C = C	620
C - O	350	H - H	440