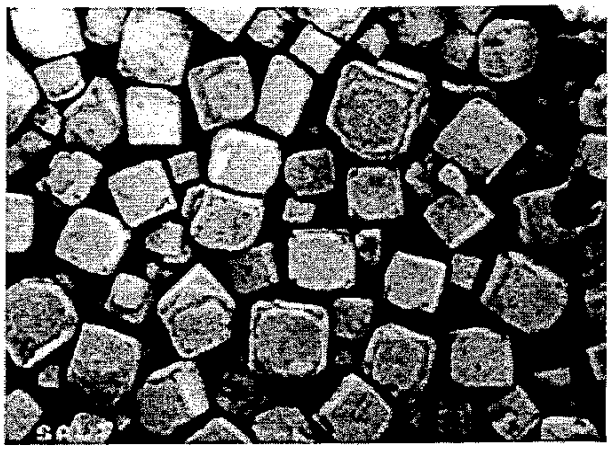
Chemistry 1A **Midterm III** **November 11, 1997**
Page 1 of 8. **(Closed Book, 90 Minutes, 135 Points)** **Professor Pines**

Name:_____ **TA:**_____

SID:_____ **Section:**_____

Identification Sticker



Scanning probe microscopy (SPM) refers to a variety of techniques which allow scientists to image the structures of extremely small objects. (0 Points) What are the objects in this SPM image?

Atoms Bacteria Crystals DNA Enzymes

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:	

 Name: _____

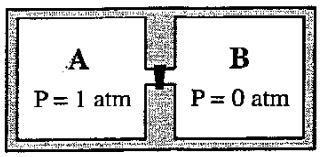
Section 1: Multiple Choice. 12 questions, 4 points each.

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.) Which of the following waves has the highest energy?

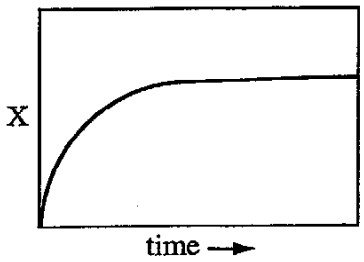
A)  B)  C)  D)  E) 

3.) 

An ideal gas is expanded adiabatically (q=0) from vessel A (intially at 1 atm) into vessel B (initially a vacuum). Which of the following is true for the system?

A) $\Delta T > 0$ B) $\Delta E > 0$ C) $\Delta S > 0$ D) $\Delta G > 0$ E) $\Delta P > 0$

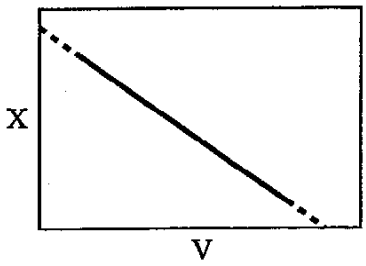
In the following 3 problems, choose the one answer that best describes "X" in the given figures.

4.) 

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

A) K B) ΔE_{univ} C) S_{univ}

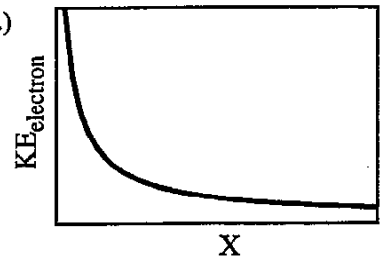
D) $\Delta G°$ E) Total mass

5.) 

For the adiabatic (q=0) expansion of an ideal gas against a constant external pressure of 1.0 atm, X=?

A) 1/P B) T C) S

D) ΔE_{univ} E) R

6.) 

For electrons ejected from the surfaces of metals by photons of light via the photoelectric effect, X=?

A) hν B) Φ, (work function) C) λ

D) T E) color

 Name: _____

7.) Gadolinium (Gd) melts at 1300 °C and has an enthalpy of fusion ($\Delta H°_{fus}$) of 10.0 kJ·mol^{-1}. What is the entropy of fusion ($\Delta S°_{fus}$) for gadolinium in J·K^{-1}·mol^{-1}?

A) 6.35 B) 7.69 C) 13.0 D) 130 E) 157

8.) Which of the following molecules ***must*** be chiral?

A) DLDLDL B) LDLDLD C) DDDLLL D) DDLLDD E) DLLDDL

9.) Which of the following statements about the **rapid** stretching of a rubber band is true?

A) $w < 0$ B) $w > 0$ C) $q < 0$ D) $q > 0$ E) $\Delta E = q$

10.) Given the following two enzyme/substrate reactions for which $K_1 << K_2$:

$$E + S_1 \underset{}{\overset{K_1}{\rightleftharpoons}} ES_1 \quad \text{and} \quad E + S_2 \overset{K_2}{\rightleftharpoons} ES_2$$

Which of the following must be true for $[ES_1] = [ES_2]$ assuming the initial [E] is the same.

A) $[S_1]=[S_2]$ B) $[S_1]<<[S_2]$ C) $[S_1]>>[S_2]$ D) $[E]=[S_1]+[S_2]$ E) $\frac{[ES_1]}{[ES_2]} = \frac{K_1}{K_2}$

11.) A mass of 16.8 mg of of calcium fluoride (CaF_2) will dissolve in 1.0 L of water at 25 °C. What is the K_{sp} for CaF_2 at 25 °C? The molar mass of CaF_2 is 78 g·mol^{-1}.

A) 4.6×10^{-8} B) 9.2×10^{-8} C) 2.0×10^{-11} D) 4.0×10^{-11} E) 9.9×10^{-12}

12.) Light with a wavelength λ=580 nm can eject electrons from a cesium surface with near zero kinetic energy. For which of the following wavelengths of light will ejected electrons have the least kinetic energy?

A) 440 nm B) 530 nm C) 600 nm D) 680 nm E) 720 nm

13.) A student is titrating a sample of Borax using 0.500 M HCl and finds that the first trial requires less HCl than her other two trials. Which of the following could have resulted in the discrepancy?

A) Not rinsing the buret with HCl before use.
B) Incorrectly reading the volume of the buret in trial #1.
C) Leaving the funnel in the buret during trial #1.
D) Large air bubbles in the buret tip.
E) Any of the above.

14.) Two photons of wavelengths λ_1=300 nm and λ_2=600 nm combine to form a third photon. What is the wavelength of the third photon?

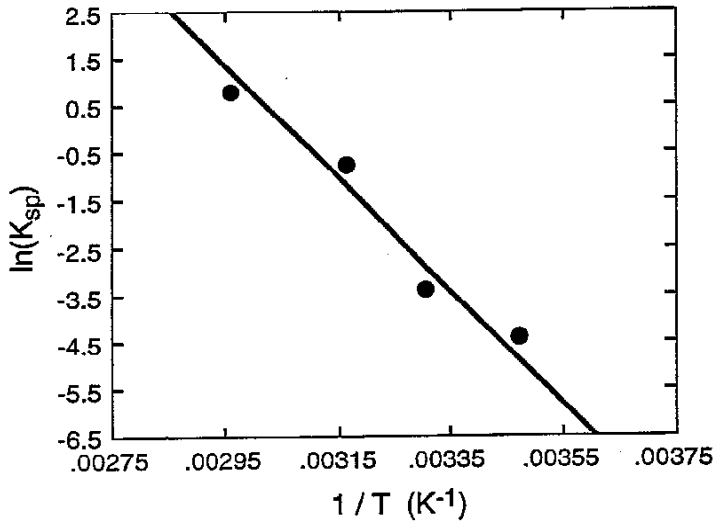
A) 100 nm B) 200 nm C) 300 nm D) 500 nm E) 900 nm

 Name: _____

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.) A student working on the Borax lab creates the following van't Hoff plot:



The student determines that the formula for the best fit regression line is:

$$\ln(K_{sp}) = -11929 \times (1/T) + 35.55$$

a.) (3 Points) Given these data, determine the value of $\Delta H°$ for the dissolution of Borax in water at 25 °C.

$\Delta H° =$

b.) (3 Points) Determine the value of $\Delta S°$ for the dissolution of Borax in water at 25 °C.

$\Delta S° =$

c.) (4 Points) Determine the value of $\Delta G°$ for the dissolution of Borax in water at 25 °C.

$\Delta G° =$

 Name: _____

2a.) (6 Points) An ideal monotonic gas is expanded isothermally (i.e. $\Delta T=0$) against a constant external pressure of 0.5 atm from an initial volume of 4.0 L to a final volume of 10.0 L. What are the heat (q), the work (w), and ΔE_{sys} for this process in L·atm?

q =	w =	ΔE_{sys} =

b.) (6 Points) Now the external pressure is suddenly increased from 0.5 atm to 4.0 atm and the gas is isothermally ($\Delta T=0$) compressed from 10.0 L down to 7.0 L. What are q, w, and ΔE_{sys} for this process? Choose whether the value is >, < or = 0 by checking the appropriate box.

	> 0	< 0	= 0
q			
w			
ΔE_{sys}			

c.) (3 Points) Compared to the entropy of the gas before it was expanded and compressed, is the entropy of the gas in the end higher, lower, or the same? (Circle one)

Higher Lower Same

3.) Under standard conditions, manganese dioxide (MnO_2) reacts spontaneously with carbon monoxide (CO) to form manganese oxide (MnO) and carbon dioxide (CO_2).

$$MnO_2(s) + CO(g) \rightleftharpoons MnO(s) + CO_2(g)$$

a.) (4 Points) What is $\Delta G°$ for this reaction at 298 K?

$\Delta G°$ =

b.) (6 Points) What is the ratio of P_{CO_2} to P_{CO} when the reaction comes to equilibrium at 298 K?

P_{CO_2} / P_{CO} =

c.) (5 Points) In what range of temperatures are the products of this reaction more thermodynamically stable than the reactants? (Circle one)

All T No T High T Low T

 Name: _____

4.) On page 8 is a table of solubility product constants (K_{sp}'s) for Ag^+ and Cu^+ with a variety of different anions. Neglect any possible reactions between the Cu^+ and the Ag^+.

a.) (4 Points) Which of the anions Br^-, I^-, Cl^-, and SCN^- would be best suited to separating out Ag^+ and Cu^+ in solution by selective precipitation?

Anion =

b.) (6 Points) If one started out with 0.1 M Ag^+ and 0.1 M Cu^+ and began to add NaCl(s), at what concentration of Cl^- would the Ag^+ begin to precipitate?

$[Cl^-]$ =

c.) (5 Points) At the point when Ag^+ first begins to precipitate, what is the Cu^+ concentration?

$[Cu^+]$ =

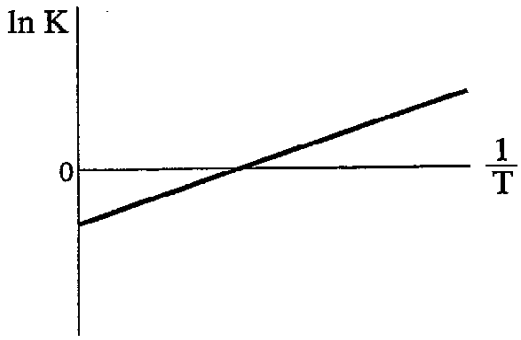
Section 3: Finish the Picture. 4 questions, 7 points each.

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, but may also cost you points if it contradicts the picture you draw.

1.) Shown below is a van't Hoff plot for the reaction:

$$2\ Al(s) + 3\ Br_2(g) \rightleftharpoons 2\ AlBr_3(s)$$

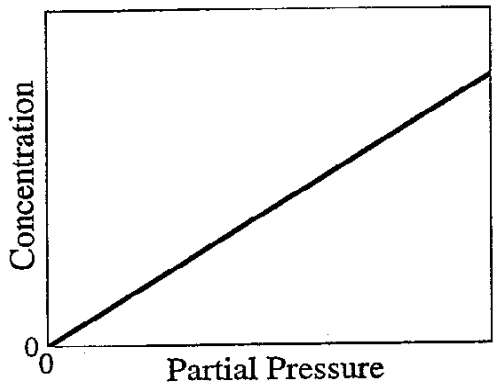
Sketch a van't Hoff plot for the reverse of this reaction.



Explanation:

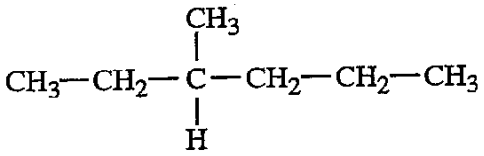
 Name: _____

2.) Shown below is a plot of the concentration of He(aq) in water at 25 °C as a function of the partial pressure of He(g) above the solution. Sketch a plot of the concentration of N_2(aq) in water at 25 °C as a function of the partial pressure of N_2(g) above the solution. See page 8 for the Henry's Law constants for N_2 and He.



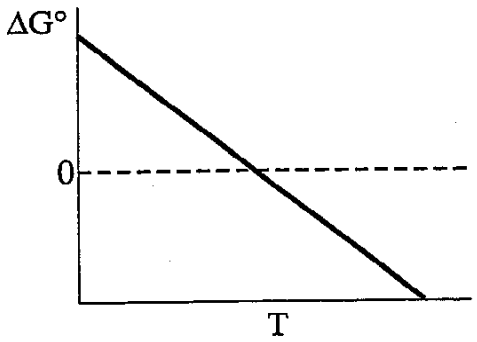
Explanation:

3.) Shown below is a chiral isomer of heptane (C_7H_{16}). Draw an ***achiral*** isomer of heptane.



Explanation:

4.) Shown below is a plot of ΔG° versus T for the vaporization of $H_2O(\ell)$. Draw a plot of ΔG° versus T for the vaporization of bromine, $Br_2(\ell)$, whose boiling point is 60 °C.



Explanation:

 Name: _____

Gas Constants: $R = 0.08206\ L\cdot atm\cdot mol^{-1}\cdot K^{-1}$ $R = 8.3145\ J\cdot mol^{-1}\cdot K^{-1}$

Ideal Monotonic Gas: $PV=nRT$ $V = 22.414\ L\cdot mol^{-1}$ at STP

$$\Delta S^\circ = \frac{3}{2} nR \ln\left(\frac{T_2}{T_1}\right), \text{ at const. V} \qquad \Delta E = \frac{3}{2} nR\Delta T$$

$$\Delta S^\circ = nR \ln\left(\frac{V_2}{V_1}\right), \text{ at const. T}$$

Thermodynamics: $\Delta S^\circ = \sum S_f^\circ(\text{products}) - \sum S_f^\circ(\text{reactants})$ $\Delta E_{sys} = q + w$

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

$\Delta G^\circ = \sum \Delta G_f^\circ(\text{products}) - \sum \Delta G_f^\circ(\text{reactants})$ $\Delta S_{univ} \geq 0$

$\Delta G^\circ = -RT \ln K$ $\Delta G = \Delta G^\circ + RT \ln Q$

$$\ln K = -\frac{\Delta H^\circ}{R}\left(\frac{1}{T}\right) + \frac{\Delta S^\circ}{R} \qquad \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

Light and Photoelectric Effect: $E_{photon} = h\nu = \frac{hc}{\lambda}$ $KE_{electron} = h\nu - \Phi$

$$A = \varepsilon bc = -\log T = -\log\left(\frac{I_t}{I_0}\right)$$

Solubility: For $A(g) \rightleftharpoons A(aq)$, $K_H = \frac{[A]}{P_A}$

For $M_aX_b(s) \rightleftharpoons aM^+(aq) + bX^-(aq)$, $K_{sp} = [M^+]^a[X^-]^b$

Standard Thermodynamic Parameters (25 °C)

Substance	ΔH_f° ($kJ\cdot mol^{-1}$)	S_f° ($J\cdot K^{-1}\cdot mol^{-1}$)	ΔG_f° ($kJ\cdot mol^{-1}$)
CO(g)	-110	198	-137
CO_2(g)	-394	214	-394
MnO(s)	-385	60	-363
MnO_2(s)	-521	53	-465

Solubility Product Constants (25 °C)

	Ag^+	Cu^+
Br^-	1×10^{-13}	1×10^{-8}
I^-	1×10^{-16}	1×10^{-12}
Cl^-	2×10^{-10}	2×10^{-7}
SCN^-	1×10^{-12}	2×10^{-13}

Henry's Constants (25 °C)

	k_H ($mM\cdot atm^{-1}$)
N_2	0.7
He	0.4