Chemistry 1A **Final Exam** **December 11, 1996**
Page 1 of 14. **(Closed Book, 180 minutes, 400 points)** **Professor Pines**
Version Bio-1

Name:_____ **TA:**_____

SID:_____ **Section:**_____

Identification Sticker

Whose picture is this (circle one), and what is his connection to Chemistry 1A?

Einstein Pines Capone Elvis Gibbs

Test-taking strategy: PLEASE READ THIS FIRST!
Write your name on all 14 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-out back page has some data and useful equations.**

Page	Points	Page	Points
Multiple Choice		10	
5		11	
6		12	
7		13	
8		Total:	
9			

 Name: _____

Section 1: Multiple Choice. 20 questions, 6 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. No credit will be awarded for partially-correct answers.**

1.) You are taking test version **Bio-1**. Please fill in bubble "**A**" on your Scantron sheet.

2.) Which of the following compounds exhibit a dipole moment? **Mark all that apply.**

A) CO_2 **B)** CO **C)** SF_6 **D)** CH_4 **E)** N_2

3.) At 300 K, argon atoms travel with an rms speed of 433 $m \cdot s^{-1}$. Which of the following gases has one-half the rms speed of argon at 300 K?

A) O_2 **B)** C_6H_8 **C)** N_2 **D)** Br_2 **E)** Ne

4.) 1.0 mole of sodium hydrosulfide, NaHS, (HS^- is the conjugate base of the weak acid H_2S, whose pK_a is 6.9) is dissolved in 1.0 L of water. HCl is then added until the pH is 6.4. Which of the following has the highest concentration?

A) H_3O^+ **B)** OH^- **C)** H_2S **D)** H_2 **E)** HS^-

5.) Which of the following species will oxidize Co, but not Br^- under standard conditions?

A) $Cl_2(g)$ **B)** Ag(s) **C)** Pb^{2+} **D)** Li^+ **E)** None of these.

6.) How many moles of Na_2SO_4 can be added to 1.0 L of an aqueous 0.10 M $Ca(NO_3)_2$ solution before a precipitate forms? Assume that Na_2SO_4 and $Ca(NO_3)_2$ dissociate completely in water. The K_{sp} for $CaSO_4$ is 2.4×10^{-5}.

A) 2.4×10^{-6} **B)** 2.4×10^{-5} **C)** 2.4×10^{-4} **D)** 4.8×10^{-4} **E)** 4.9×10^{-3}

7.) Which of the following can have the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^4$?

A) Ga^{3+} **B)** Te **C)** As^- **D)** Br **E)** None of these.

8.) Which of the following has the highest ionization energy?

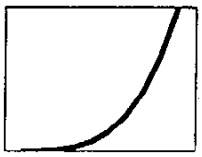
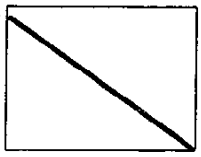
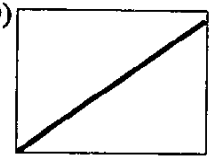
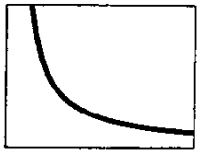
A) F **B)** F^- **C)** Ne **D)** Na **E)** Na^+

9.) How many ***atoms*** are there in 36 g of pure water?

A) 3.0×10^{25} **B)** 3.6×10^{24} **C)** 1.8×10^{24} **D)** 1.2×10^{24} **E)** 6.0×10^{23}

 Name: _____

10-13. In the next four problems, choose which of the following five graphs best describes the behaviors listed below.

A)  B)  C)  D)  E) 

10.) $[H_3O^+]$ as a function of NaOH(s) added to water.

11.) PV as a function of P for an ideal gas at 25 °C.

12.) The de Broglie wavelength, λ, as a function of speed for a sodium atom.

13.) lnK as a function of 1/T for an endothermic reaction.

14.) The work function, Φ, for chromium is 7.2×10^{-19} J. A photon of which energy ($h\nu$) will eject an electron with the lowest electron kinetic energy?

A) 2.0×10^{-19} J **B)** 5.3×10^{-19} J **C)** 1.3×10^{-18} J

D) 2.7×10^{-18} J **E)** 6.6×10^{-18} J

15.) A compound comprised of only oxygen and carbon is found to contain 27.29% carbon by mass. What is the empirical formula for the compound?

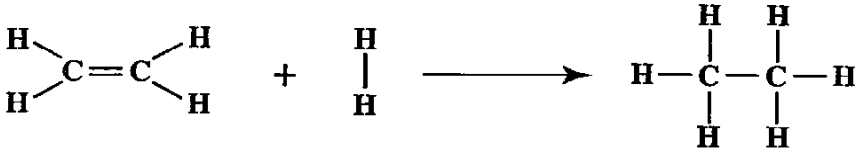
A) CO **B)** CO_2 **C)** C_2O_3 **D)** C_2O_2 **E)** $C_{27}O_{73}$

16.)  Which of the following energy level diagrams could give rise to the emission spectrum pictured to the left?

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

 Name: _____

17.) Using bond enthalpies, estimate $\Delta H°$ for the following reaction (in $kJ \cdot mol^{-1}$).



A) -550 **B)** -350 **C)** -100 **D)** 350 **E)** 550

18.) A gaseous mixture of $NO_2(g)$ and $N_2O_4(g)$ is in equilibrium:

$$2\,NO_2(g) \rightleftharpoons N_2O_4(g)$$

If the volume is suddenly doubled without changing the temperature, which of the following will be true once the system regains equilibrium (compared to the original system before the volume was changed)?

A) The total pressure will be higher.
B) The partial pressure of $N_2O_4(g)$ will be higher.
C) The mole fraction of $NO_2(g)$ will be higher.
D) The equilibrium constant, K, will be lower.
E) The equilibrium constant, K, will be higher.

19.) Which of the following reactions/processes has a negative $\Delta S°$?

A) $LiCl(s) \text{ -----> } Li^+(aq) + Cl^-(aq)$
B) $H_2O(\ell) \text{ -----> } H_2O(g)$
C) $2\,MgO(s) + C(s) \text{ -----> } CO_2(g) + 2\,Mg(s)$
D) $BF_2Cl(g) + BCl_2F(g) \text{ -----> } BCl_3(g) + BF_3(g)$
E) $PCl_5(g) \text{ -----> } PCl_3(g) + Cl_2(g)$

20.) The theoretical acid neutralizing capacity (ANC) for one Tums tablet (containing 500 mg $CaCO_3$) is 10.0. A group of devoted Chem 1A students used the FDA procedure to determine the experimental ANC of a Tums tablet; their experimental value was 8.2.

Which of the following could explain the discrepancy between the theoretical and experimental values?

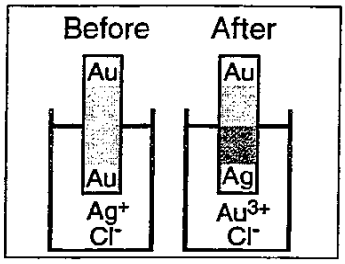
A) Titrating to an endpoint of pH 3.5 rather than pH 7.0.
B) Incomplete reaction of the antacid tablet with the hydrochloric acid.
C) Error in pipetting the hydrochloric acid such that less than the recorded amount was added to the Tums sample.
D) Both B and C could explain it.
E) A, B, and C could all explain it.

 Name: _____

Section 2: *What's Wrong*. 8 questions, 10 points each.

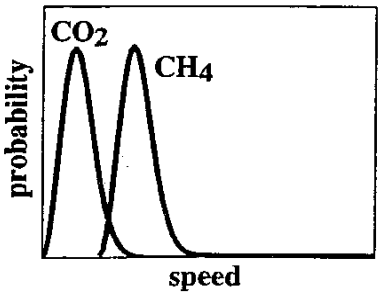
For this section, in no more than twenty words per response, **explain** what is wrong with the following pictures. **Note: only the first 20 words of each answer will be read!**

1.) For the plating of silver onto a gold plate:



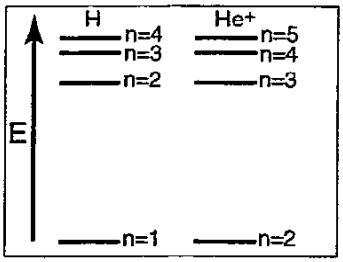
Answer:

2.) For two ideal gases at 25 °C:



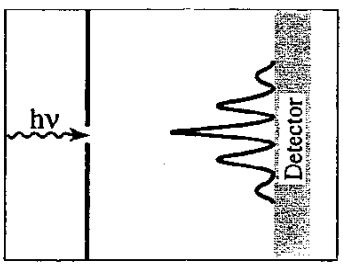
Answer:

3.) Energy level diagrams for the one electron species H and He^+, where $E_n = -\frac{Z^2}{n^2}R_y$:



Answer:

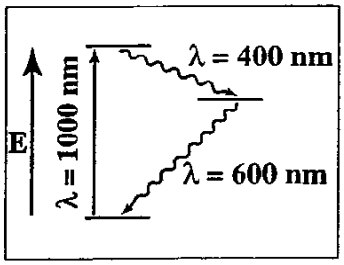
4.) For the diffraction of light through a slit:



Answer:

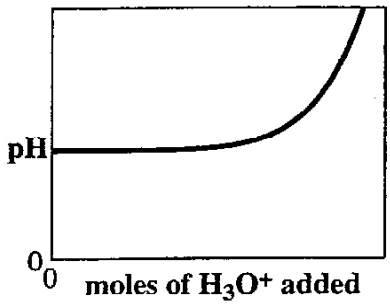
 Name: _____

5.) An energy level diagram for absorption and emission:



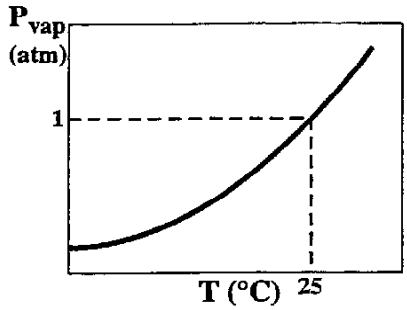
Answer:

6.) For the addition of 0.1 M HCl to a solution in which initially [HA] = [A⁻]:



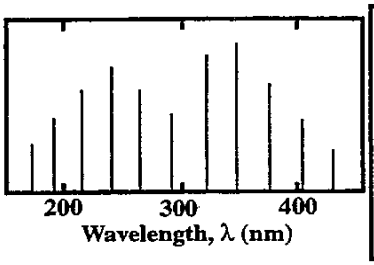
Answer:

7.) For the vapor pressure of water:



Answer:

8.) Absorption spectrum for a Coppertone sunscreen product:



Answer:

 Name: _____

Section 3: Short Answer. 10 questions, 20 points each.

Answer the following ten short answer questions. Partial credit will be given, so show your work whenever possible. Your final answers **must** be written in the boxes provided.

1.) Consider an ideal gas at a volume of 1 L and a pressure of 1 atm. The gas is expanded **adiabatically** and **irreversibly** against a constant external pressure of 0.1 atm until it reaches a volume of 2 L.

For each quantity below, indicate (by checking the box) whether it is =0, >0, or <0 for the overall adiabatic and irreversible expansion.

Quantity	= 0	> 0	< 0
ΔP_{sys}			
ΔV_{sys}			
ΔT_{sys}			
w			
q			
ΔE_{sys}			
ΔE_{surr}			
ΔS_{sys}			
ΔS_{surr}			
ΔS_{tot}			

2a.) Using the table on page 14, calculate $\Delta H°$ and $\Delta S°$ for the following reaction:

$$CO(g) + 2\,H_2(g) \rightleftharpoons CH_3OH(g)$$

$\Delta H°$=
$\Delta S°$=

b.) Is this reaction spontaneous under standard conditions at 25 °C? Circle your answer.

Yes **No**

c.) Assuming $\Delta H°$ and $\Delta S°$ are independent of temperature, at which temperature will this reaction be at equilibrium? Assume all the pressures are 1.0 atm.

Answer:

 Name: _____

3a.) Formic acid (HCOOH) has a $K_a=1.8x10^{-4}$, $pK_a=3.74$. If 0.050 moles of formic acid are dissolved in 1.0 L of water, what will the pH be?

pH=

b.) How many mL of 0.10 M NaOH should be added to the solution in **a)** in order to raise the pH to 3.74?

Answer:

c.) The solution in **a)** is titrated to the equivalence point with 500 mL of 0.10 M NaOH. This solution now has the same pH as which of the following. Circle your answer.

0.10 moles of $HCOO^-Na^+$ (sodium formate) in 3.0 L of water.

$1.0x10^{-5}$ moles of NaOH in 1.0 L of water.

0.050 moles of formic acid and 0.10 moles of NaOH in 1.5 L of water.

 Name: _____

4a.) Draw the Lewis electron dot structure for XeF_4. Include all the lone pairs.

Lewis Dot Structure:

b.) Which of the following best describes the geometry of the electron pairs (including bonds) around the central atom? Circle your answer.

Linear

Trigonal Planar

Tetrahedral

Trigonal Bipyramidal

Octahedral

c.) Name, describe, or draw the ***molecular*** geometry of the molecule.

Molecular Structure:

 Name: _____

5a.) Balance the following combustion equation:

_____ $C_3H_8(g)$ + _____ $O_2(g)$ --------> _____ $CO_2(g)$ + _____ $H_2O(g)$

b.) 1.0 atm of $C_3H_8(g)$ and 4.0 atm of $O_2(g)$ are sealed in a flask and ignited. How many **moles** of $O_2(g)$ remain once the reaction has gone to completion? Assume all the gases are ideal.

Answer:

c.) After the above reaction has run to completion, what is the total pressure in the flask?

Answer:

6.) An excited state of helium is created such that one electron is in the 1s orbital and one electron is in a 3p orbital.

a.) What is the ionization energy of the 3p electron in He(1s3p)?

IE=

b.) The first ionization energy for $He(1s^2)$ is found to be 2372 $kJ \cdot mol^{-1}$ (which is $1.8R_y$). What is the effective charge, Z_{eff}, for the ionization of a 1s electron?

Z_{eff}=

c.) Which one of the following is a possible ***excited state*** electronic configuration for lithium? Circle your answer.

$1s^2$ $1s^21p^1$ $1s^3$ $1s^22s^1$ $1s^23p^1$

 Name: _____

7a.) Write a balanced spontaneous ***net*** reaction in acidic solution based on the **unbalanced** and **incomplete** half-reactions below.

$$MnO_4^- + 5e^- \text{ --------> } Mn^{2+}$$

$$O_2(g) + 4e^- \text{ --------> } 2\,H_2O$$

Answer:

b.) Under standard conditions, what is $\Delta\varepsilon^\circ$ for this reaction?

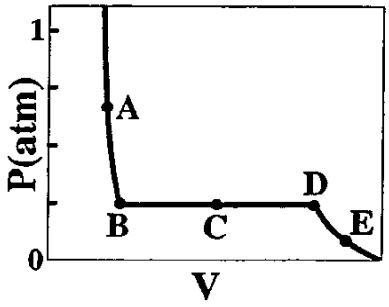
$\Delta\varepsilon^\circ =$

c.) What would happen to $\Delta\varepsilon$ if you lowered the pH of the solution? Limit yourself to 20 words or less.

Answer:

 Name: _____

8.) The graph pictured below is an isotherm for Br_2 at 25 °C.



For the following four questions, circle the point (or points) on the isotherm (A-E) which describes the statement given. **Circle all that apply.**

a.) **Only** gas is present.	**A**	**B**	**C**	**D**	**E**
b.) **Only** liquid is present.	**A**	**B**	**C**	**D**	**E**
c.) Gas and liquid are in equilibrium.	**A**	**B**	**C**	**D**	**E**
d.) Point with the lowest compressibility.	**A**	**B**	**C**	**D**	**E**

e.) What is the vapor pressure of $Br_2(\ell)$ at 25 °C?

P_{vap}=

9.) At 25 °C, the equilibrium constant for the following reaction is 4.2×10^{-31}.

$$N_2(g) + O_2(g) \rightleftharpoons 2\,NO(g)$$

a.) Write the equilibrium expression for this reaction.

K_p =

b.) NO(g) is placed in a vacuum at 25 °C and dissociates until it reaches its equilibrium partial pressure of 1.0×10^{-16} atm. What is the partial pressure of $N_2(g)$ at equilibrium?

P_{N_2}=

c.) If 1.0 atm of $N_2(g)$ is mixed with 1.0 atm of $O_2(g)$ at 25 °C, what will be the equilibrium partial pressure of NO(g) in equilibrium?

P_{NO}=

 Name: _____

10.) Drugs called histamine H2-receptor antagonists (H2RAs) are now being sold over the counter, and are providing competition for antacid products. H2RA's such as famotidine (Pepcid AC®), ranitidine (Zantac 75®), cimetidine (Tagamet HB®), and nizatidine (Axid AR®) inhibit gastric acid secretion in the stomach by blocking the histamine receptors on the parietal cells.

A study published in the May 8, 1996 issue of the *Journal of the American Medical Association* compared the effect of a 10-mg dose of famotidine (an H2RA) with a 1000-mg dose of calcium carbonate given to subjects 1 hour after they had consumed identical test meals; two additional test meals were given at 2.5 and 6.0 hours after the medication was taken. The amount of acid present in the subjects' stomachs was monitored for a 10-hour period (1 hour before and 9 hours after the drug was taken). A summary of the results of the study follows:

"When evaluated in increments of 30 minutes, calcium carbonate had a rapid onset of action, neutralizing 6.7 mmol of acid in the first 30 minutes. However, its duration of effect was only 60 minutes. Famotidine had a delayed onset of action compared with antacid, beginning after 90 minutes. However, famotidine had a duration of effect of at least 9 hours. At its peak effect, 3.5 hours after administration, famotidine reduced acid secretion by 7.3 mmol per 30 minutes. The peak potencies of 10-mg of famotidine and 1000-mg of calcium carbonate are similar."

a.) For the subjects given <u>calcium carbonate</u>, which meal would you expect to be the <u>least</u> digested?

(Check one) _____Meal 1, given 1.0 hours before the medication
_____Meal 2, given 2.5 hours after the medication
_____Meal 3, given 6.0 hours after the medication

b.) For the subjects given <u>famotidine</u>, which meal would you expect to be the <u>least</u> digested?

(Check one) _____Meal 1, given 1.0 hours before the medication
_____Meal 2, given 2.5 hours after the medication
_____Meal 3, given 6.0 hours after the medication

c.) Several groups of students in the biologically-relevant lab sections designed experiments that simulated the effect of antacid preparations on digestion of proteins in the stomach. Assuming you have unlimited time in the Chemistry 1A lab, describe an experiment that you could conduct to determine the effect of famotidine on digestion of proteins in the stomach.

 Name: _____

Standard Reduction Potentials

Half Reaction	ε° (V)	Half Reaction	ε° (V)
$MnO_4^- + 8\ H_3O^+ + 5e^- \text{-----> } Mn^{2+} + 12\ H_2O$	1.49	$Ag^+ + e^- \text{-----> } Ag(s)$	0.80
$Au^{3+} + 3e^- \text{-----> } Au(s)$	1.42	$2\ H_3O^+ + 2e^- \text{-----> } H_2(g) + H_2O$	0.00
$Cl_2(g) + 2e^- \text{-----> } 2\ Cl^-$	1.36	$Pb^{2+} + 2e^- \text{-----> } Pb(s)$	-0.13
$O_2(g) + 4\ H_3O^+ + 4e^- \text{-----> } 6H_2O$	1.23	$Co^{2+} + 2e^- \text{-----> } Co(s)$	-0.28
$Br_2(\ell) + 2e^- \text{-----> } 2\ Br^-$	1.07	$Li^+ + e^- \text{-----> } Li(s)$	-3.05

Bond Enthalpies

Bond	ΔH° (kJ • mol^{-1})	Bond	ΔH° (kJ • mol^{-1})
C - H	400	C = C	600
C - C	350	H - H	450

Standard Thermodynamic Properties

Substance	ΔH° (kJ • mol^{-1})	S° (J • mol^{-1} • K^{-1})	ΔG° (kJ • mol^{-1})
$Br_2(g)$	31	245	3.14
$Br(\ell)$	0	152	0
CO(g)	-110	198	-137
$CH_3OH(g)$	-200	240	-162
$H_2(g)$	0	130	0
H(g)	225	115	203

Possibly Useful Information

Absolute T(K) = T(°C) + 273.15

$N_0 = 6.022 \times 10^{23}$

$PV = nRT$

$R = 0.0821\ L \cdot atm \cdot mol^{-1} \cdot K^{-1}$

$R = 8.31\ J \cdot mol^{-1} \cdot K^{-1}$

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

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

$K_w = [H_3O^+][OH^-]$

$\Delta E = q + w$

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

$\Delta E_{tot} = \Delta E_{sys} + \Delta E_{surr}$

$\Delta S_{tot} = \Delta S_{sys} + \Delta S_{surr}$

$\Delta G = \Delta H - T\Delta S$

$\Delta G° = -RT\ln K$

$\Delta S_{sys} = nR\ln\frac{V_2}{V_1}$

$\Delta S_{surr} = -\frac{q_{rev}}{T}$

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

$E = h\nu = \frac{hc}{\lambda}$

$mu = p = \frac{h}{\lambda}$

$E_n = -\frac{Z^2}{n^2}R_y$, $R_y = 1312\ kJ \cdot mol^{-1}$

$\Delta E = -Z^2\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)R_y$

$IE = \frac{Z_{eff}^2}{n^2}R_y$

$E_{kinetic} = \frac{mu^2}{2}$

$E_{electron} = E_{photon} - \Phi$