Name:________________________________ Lab TA______________________________

SID: ________________________________ Discussion TA ________________________

Exam Version: A1

Identification Sticker

Write your name on all 13 pages. This test consists of **two parts**: Multiple choice and problems requiring a longer answer. **For the multiple choice section, mark one correct answer for each question AND use a #2 pencil to bubble in one correct answer on your Scantron™ form for each question.**

- Budget your time. Anticipate spending about 90 minutes on the first part and 60 minutes on the second.
- Be sure to leave sufficient time to transfer your multiple choice answers to the Scantron™ form.
- **The last three pages of the exam contain potentially useful formulae, tables and a blank piece of scratch paper which can be detached for your convenience.**
- Good luck and have a nice break!

Anticipate writing 10-15 words for each written answer.
Only the first 25 words will be graded.

(For Administrative Use Only)

Multiple Choice		Question 2	
Question 1		Total	

Part I: Multiple Choice, 5 points each, 150 points total
MARK THE CORRECT ANSWER ON YOUR EXAM <u>AND</u> SHADE IN THE BUBBLE OF THE CORRECT ANSWER FOR EACH QUESTION WITH A #2 PENCIL ON YOUR SCANTRON™ FORM.

1.) The answer to 1 is A. Bubble in A for #1.

2.) The answer to 2 is A. Bubble in A for #2.

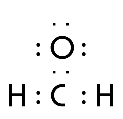
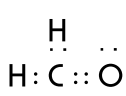
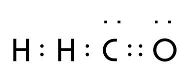
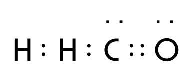
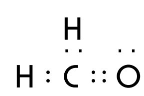
3.) How many atoms are there in 12.00 grams of ^{13}C?

A) 12 B) 13 C) 5.559×10^{23} D) 6.022×10^{23} E) 6.524×10^{23}

4.) If the root-mean-square velocity of H_2 molecules is 1,000 meters·sec^{-1} then the velocity of He atoms at the same temperature is (in meters·sec^{-1}) :

A) 250 B) 500 C) 707 D) 1,000 E) 1,414

5.) What is the Lewis electron-dot structure of formaldehyde (CH_2O)?

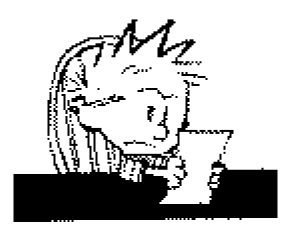
A) 
B) 
C) 
D) 
E) 

6.) The empirical formula of a gaseous fluorocarbon is CF_2. If 1.17 g of this compound occupies 0.174 L at STP, what is the molecular formula?

A) CF_2B) CF_4 C) C_2F_4 D) C_2F_6 E) C_3F_6

7.) Which of the following has a non-zero dipole moment?

A) BF_3B) CCl_4 C) SF_6 D) CH_2Cl_2 E) CO_2



8.) A formic acid (HCOOH, $K_a = 1.77 \times 10^{-4}$) solution of unknown concentration required 50.0 mL 0.10 M NaOH to reach the equivalence point . What volume (mL) of 0.10 M HCl must be added to give pH = 3.75?

A) 12.5 B) 25 C) 50 D) 75 E) 100

9.) Consider the reaction $2OF_2\ (g) \rightleftharpoons O_2\ (g) + 2F_2\ (g)$. 1.00 atm OF_2 is placed in a sealed vessel. At equilibrium, the partial pressure of OF_2, $P_{OF_2} = 0.90$ atm. What is P_{O_2} (atm)?

A) 0.050 B) 0.10 C) 0.71 D) 0.80 E) 1.8

10.) For the reaction $N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g)$, at equilibrium P_{NH_3}=20.0 atm. Gaseous He is injected into the reaction vessel at constant volume and temperature. P_{NH_3} (atm) at equilibrium is:

A) < 20 B) = 20 C) > 20 D) = K_p E) Can't determine

11.) A solution made by mixing equimolar quantities of ammonia (NH_3 , $K_b = 1.78 \times 10^{-5}$) and acetic acid ($CH_3COOH$, $K_a = 1.76 \times 10^{-5}$) conducts electricity by means of the ions:

A) Na^+ & Cl^- B) H_3O^+ & OH^- C) NH_4^+ & OH^-

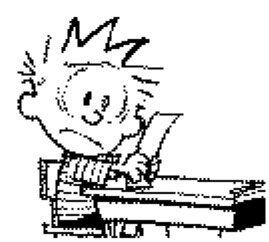
D) H_3O^+ & CH_3COO^- E) NH_4^+ & CH_3COO^-

12.) 0.10 M HCl is added drop by drop (0.1 ml/drop) to 1.0 L of 10^{-5} M $AgNO_3$. After how many drops will AgCl begin to precipitate (K_{sp} for AgCl = 1.6×10^{-10}).

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

13.) The solubility of NH_4Cl increases with increasing temperature. This shows that:

A) the pH of H_2O increases with increasing temperature
B) silver is removed from H_2O with increasing temperature
C) the entropy decreases with increasing temperature
D) the dissolution of NH_4Cl is exothermic
E) the dissolution of NH_4Cl is endothermic



14.) 2.0 moles of NaCl are dissolved in 1.0 L water at 25 °C. The final temperature (°C) of the water (cp_W=4.186 J $°C^{-1}$ g^{-1}) is:

A) < 25 B) = 25 C) > 25 D) = PV/nR E) Can't determine

15.) For an ideal gas expanding isothermally (Constant T), Which of the following must be true?

A) $q = 0$ B) $w = 0$ C) $q + w = 0$ D) $q - w = 0$ E) Can't determine

16.) A photon of blue light (400 nm) breaks into two photons. If one of those photons is infrared (1000 nm) then, because energy is conserved, the other photon will have a wavelength of:

A) 400 nm B) 600 nm C) 667 nm D) 1000 nm E) 1400 nm

17.) Which transition in He^+ has the same λ as 3 --> 2 for H ?

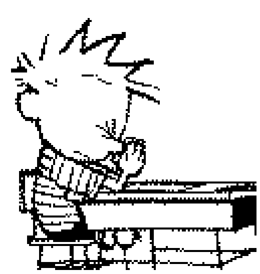
A) 2 --> 1 B) 6 --> 4 C) 9 --> 4 D) 12 --> 8 E) No transitions

18.) As a "white-hot" piece of iron cools down, the photons emitted tend to be, on average:

A) Faster B) Slower C) Longer wavelengths D) Shorter wavelengths E) Adiabatic

19.) The $1s^2 2s^2 2p^5$ electron configuration corresponds to

A) F (ground state) B) F (excited state) C) F^- (ground state) D) O^- (excited state) E) Ne (ground state)



Name________________________________

20.) Which is most paramagnetic (has the most unpaired electrons)?

A) B B) C C) N D) O E) F

21.) What can you say about the H-N-H angle in NH_3?

A) = 90° B) < 109.5° C) =109.5° D) >109.5° E) =120°

22.) Which of the following statements about atomic radius is correct?

A) $K<Na<K^+<Na^+$ B) $Na^+<K^+<Na<K$ C) $Na < K<K^+<Na^+$

D) $Na<K<Na^+<K^+$ E) none

23.) Which is the correct ordering of Ionization Energies (IE's) for B, C, N?

A) B<C<N B) C<B<N C) B<N<C D) N<B<C E) N<C<B

24.) A standard cell **Zn | Zn^{2+} || Cu^{2+} | Cu** has 1.0 L of 1.0 M Zn^{2+} solution in the left half cell. The cell is allowed to run until 0.50 moles Cu plate out. What is now [Zn^{2+}] in the left half cell?

A) 2.0 M B) 1.5 M C) 1.0 M D) 0.50 M E) 0.0 M

25.) The metal Al produces H_2 bubbles when immersed in HCl, but Hg does not. Which is the strongest reducer?

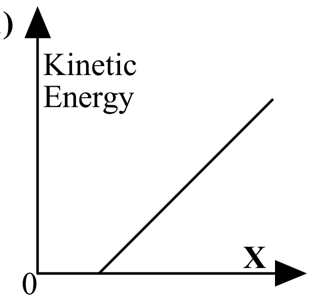
A) Al^{3+} B) Al C) Hg D) Hg^+ E) H_2

26.) Who is the composer of the Chemistry 1A theme music?

A) Le Chatelier B) Pines C) Bach D) Schwarzenegger E) Hootie

Identify **X** in figures **1** through **6** for questions **27** through **32**

(1)



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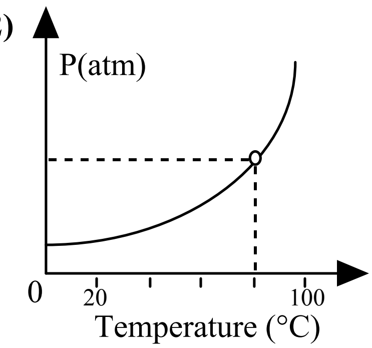

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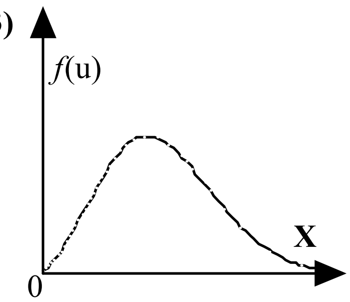

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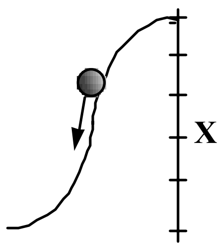
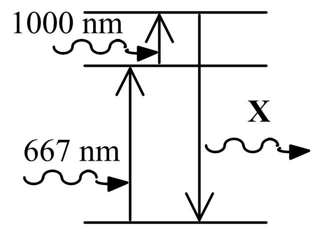


(5)



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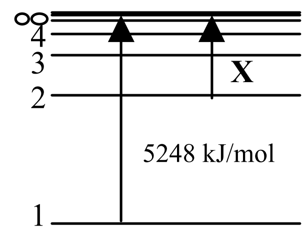


27.) (Figure **1**) The kinetic energy of an electron ejected by light from a metal depends on **X**. **X** is:

A) λ B) υ C) $\lambda\upsilon$ D) T E) Time

28.) (Figure **2**) The normal boiling point of benzene is 80 °C. **X** is (in atm):

A) 0 B) 0.032 C) 1.0 D) 5.0 E) Can't determine

29.) (Figure **3**) For the probability distribution of molecular speeds (u) in a gas **X** is:

A) T B)1/T C) m D) V E) u

30.) (Figure **4**) For any spontaneous reaction, at constant pressure and temperature, **X** is:

A) q B) P C) S D) H E) G

31.) (Figure **5**) The wavelengths of light for absorption and emission, **X**, is (in nm):

A) 333 B) 400 C) 733 D) 1000 E) 1667

32.) (Figure **6**) The ionization energy of He^+, **X**, is (in kJ/mol^{-1}):

A) 328 B) 656 C) 1312 D) 2624 E) 5248

Part II: 2 Problems, 110 points total
SHOW ALL OF YOUR WORK AND USE UNITS IN YOUR CALCULATIONS. PARTIAL CREDIT IS AVAILABLE, SO ATTEMPT EACH PART OF EACH QUESTION EVEN IF YOU WERE UNABLE TO DO THE PREVIOUS PART(S).

(Two pages, 50 pts.)
Explanations should take between 10-15 words. ONLY the first 25 words will be graded.
1.) A student decided to make airbags from chalk (calcium carbonate, $CaCO_3$) and hydrochloric acid (HCl, strong acid). Her goal was to inflate a 6.0 L Ziploc™ baggie while minimizing the amount of reagent used.

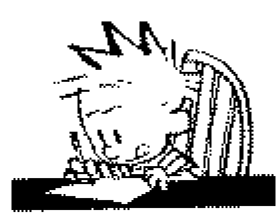
Her first experimental procedure was:

- She added 500 mL of 1.00 M hydrochloric acid, 20.0 g of chalk, and 500 mL of water to a baggie
- She excluded all air from the baggie
- She zipped her baggie closed
- She noted that room temperature was 25 °C and that her barometer (a device used to measure atmospheric pressure) read 1.00 atm.

a.) Write a balanced chemical equation for the reaction between hydrochloric acid and chalk to produce carbon dioxide gas, water, and calcium chloride.

b.) What is the limiting reagent in this reaction? Explain.

c.) What will be the volume of the baggie? Assume that the baggie does not burst and that the hydrochloric acid and chalk react completely. Show your work.

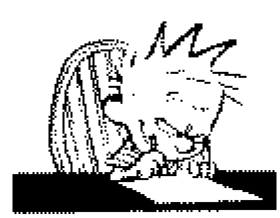


(1. continued)
Explanations should take between 10-15 words. ONLY the first 25 words will be graded.
d.) What will be the pH of the resulting solution? Assume that the maximum amount of carbon dioxide is produced and released as gas. Show your work.

e.) She realized that to get a 100% theoretical yield she would need to add 20.5 g chalk, 410 mL of 1.00 M hydrochloric acid, and 590 mL water. She ran a second experiment under these conditions and the experimental yield was only 95%. Circle the possibility from the list below that you believe is the predominant factor in causing the lower than expected percent yield. Explain how this factor might contribute to the lower yield.

Calcium carbonate is quite insoluble.
Some of the CO_2 gas produced in the reaction will always dissolve in the water.
Her barometer reads 5 % higher than the actual pressure.
The hydrochloric acid came straight from the refrigerator and hadn't yet come to room temperature.
She did not shake her baggie.

f.) Design an experiment that will allow you to test your hypothesis in **e.)**.



(Two pages, 60 pts)
Explanations should take between 10-15 words. ONLY the first 25 words will be graded.

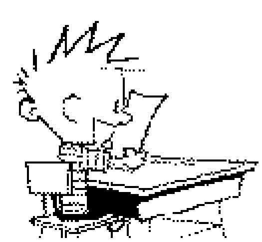
2.) In an acidic aqueous environment, copper statues tend to corrode because Cu (s) is oxidized to Cu^{2+} (aq) by gaseous oxygen (O_2)

a.) Write a balanced equation for the oxidation of Cu by oxygen in an acidic aqueous environment.

b.) Do you expect ΔS° for the reaction to be zero, positive or negative? Explain.

c.) ΔH° for the reaction -157.3 kJ per mole of Cu oxidized. How does temperature affect the tendency of Cu to be oxidized? Explain your reasoning.

d.) ΔG° for the reaction is -171.5 kJ per mole of Cu oxidized at 25 °C. Calculate the equilibrium constant for the reaction at 25 °C.



(2. continued)

Explanations should take between 10-15 words. ONLY the first 25 words will be graded.

e.) What is $\Delta\varepsilon°$ for the galvanic cell **Cu | Cu^{2+} || H^+ | O_2 | Pt** for which current flows spontaneously? Show your work.

f.) Which species is being reduced when the cell described in **e.)** operates? Explain.

g.) Calculate the equilibrium constant at 25 °C for the net reaction when the cell described in **e.)** operates.

h.) Gold (Au) strips are affixed to the statue in an effort to prevent oxidation. Will this work? Explain.

Potentially useful constants:

R = 0.08206 L atm mol^{-1} K^{-1}

= 8.3145 J $K^{-1}mol^{-1}$

h = 6.626 x 10^{-34} J s

N_0 = 6.0221 x 10^{23} mol^{-1}

V_m = 22.414 L·mol^{-1} (for an ideal gas)

c = 3.0 x 10^8 m·s^{-1}

Absolute T(K) = T(°C) + 273.15

STP is 273.15 K, 1.00 atm

tetrahedral angle =109.5°

Potentially useful formulae:

Ideal Gas:

PV = nRT

$$P = \frac{Nm\overline{u^2}}{3V}$$

$$u_{rms} = \sqrt{\overline{u^2}} = \sqrt{\frac{3RT}{M}}$$

$$E = \frac{nN_o m\overline{u^2}}{2} = \frac{3}{2}nRT$$

$$\overline{\varepsilon_k} = \frac{1}{2}m\overline{u^2} = \frac{E_k}{N_o}$$

Equilibrium:

For $aA + bB \Leftrightarrow cC + dD$

$$Q = [C]^c[D]^d/[A]^a[B]^b$$

At equilibrium, $Q = K$

Solubility:

$$MX_n(s) \Leftrightarrow M^{n+}(aq) + nX^-(aq)$$

$$K_{sp} = [M^{n+}][X^-]^n$$

Acids and Bases:

$$pH = -\log[H_3O^+]$$

$$pH + pOH = 14.0 \ (25\ °C)$$

pH =pK_a - log [HA]/[A^-]

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

$$K_w = 1.00\times10^{-14} (25°C)$$

Conjugate A/B $K_aK_b = K_w$

Thermodynamics:

First Law: $\Delta E = q + w$

Second Law: $\Delta S_{universe} \geq 0$

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

$$\Delta S^\circ = \sum S^\circ(products) - \sum S^\circ(reactants)$$

$$\Delta G^\circ = \sum \Delta G_f^\circ(products) - \sum \Delta G_f^\circ(reactants)$$

$$\Delta G° = \Delta H° - T\Delta S° = -RT\ln K$$

Electrochemistry:

Galvanic Cell: $\Delta\varepsilon° = \varepsilon°_{right} - \varepsilon°_{left}$

$\Delta\varepsilon°$ = (RT/n*F*)ln K

At 25 °C:

$\Delta\varepsilon°$ = (0.0592/n)$\log_{10}$ K

K = $10^{n\Delta\varepsilon°/0.0592}$

Quantum Mechanics:

Light: $\lambda\upsilon = c$

Photon: $E = h\upsilon$

One Electron Atom or Ion

$$E_n = -1312\frac{Z^2}{n^2}\ kJmol^{-1}$$

$$IE = 1312\frac{Z^2}{n^2}\ kJmol^{-1}$$

Emission:

$$\Delta E = -1312 \cdot Z^2\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)kJmol^{-1}$$

Wave/particle duality (photon):

$\lambda = h/p$, $p = h/\lambda$

Wave/particle duality (mass m, speed u)

$\lambda = h/p = h/mu$

$p = mu = h/\lambda$

Potentially useful information:

Thermodynamic Properties

Substance	ΔH_f° (kJ mol^{-1})	S° (J K^{-1}mol^{-1})	ΔG° (kJ mol^{-1})
Na	0	51.21	0
NaF	- 573.65	51.46	-543.51
NaCl	- 411.15	72.13	-384.15
Na^+(aq)	- 240.12	59.0	-261.90
Ca	0	41.42	0
H_2O (l)	-285.83	61.91	-237.18
CaF_2	- 1219.6	68.87	-1167.3
Cl^- (aq)	-167.16	56.5	-131.23
O_2	0	205.03	0
H_2SO_4	-814.0	156.9	-690.10
H_2	0	130.57	0
Cl_2	0	222.96	0
HCl (g)	-92.31	186.80	-95.30

Standard Reduction Potentials

Half-Reaction	ε° (V)	Half-Reaction	ε° (V)
$Au^+ + e^-$ ∅ Au (s)	+1.68	$Sn^{2+} + 2\ e^-$ ∅ Sn (s)	-0.14
$MnO_4^- + 8\ H^+ + 5\ e^-$ ∅ $Mn^{2+} + 4\ H_2O$	+1.491	$Fe^{2+} + 2\ e^-$ ∅ Fe (s)	-0.41
Cl_2 (g) + 2 e^- ∅ 2 Cl^-	+1.36	$Zn^{2+} + 2\ e^-$ ∅ Zn (s)	-0.76
O_2 (g) + 4 H^+ + 4 e^- ∅ 2 H_2O	+1.23	2 H_2O + 2 e^- ∅ H_2 (g) + 2 OH^-	-0.83
Br_2 (l) + 2e^- ∅ 2 Br	+1.06	Mn^{2+}+2e^-∅ Mn (s)	-1.029
$Cu^{2+} + 2\ e^-$ ∅ Cu (s)	+0.34	$Mg^{2+} + 2\ e^-$ ∅ Mg (s)	-2.38
2 H^+ + 2 e^- ∅ H_2 (g)	0.00	$Na^+ + e^-$ ∅ Na (s)	-2.71

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