Name:_______________________________ Lab TA_______________________________

SID:_______________________________ Discussion TA _______________________

The following formulae and data may be useful:

For $aA + bB \Leftrightarrow cC + dD$: $\Delta E = q + w$

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

At equilibrium, $Q = K$

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

$R = 8.314 JK^{-1}mole^{-1}$

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

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

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

$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ = -RT \ln K = -nF\Delta\varepsilon^\circ$

Photon: $E = h\upsilon$, $\lambda\upsilon = c$

Wave-Particle Duality:

$\lambda p = h$

$h = 6.626 \times 10^{-34}$ J s

$c = 3.0 \times 10^8$ $m \cdot s^{-1}$

Thermodynamic Properties

Substance	ΔH_f° (kJ mol^{-1})	S° (J K^{-1}mol^{-1})	Substance	ΔH_f° (kJ mol^{-1})	S° (J K^{-1}mol^{-1})
O_2	0	205.03	H_2SO_4	-814.0	156.9
FeS_2	-178.2	52.93	$H_2O(l)$	-285.8	69.91
Fe_2O_3	-824.2	87.4	NaCl	- 411.15	72.13

Standard Reduction Potentials

Half-Reaction	ε°(V)	Half-Reaction	ε°(V)
$MnO_4^- + 8 H^+ + 5 e^- \varnothing Mn^{2+} + 4 H_2O$	+1.49	$Sn^{2+} + 2 e^- \varnothing Sn (s)$	-0.14
$Cl_2 (g) + 2 e^- \varnothing 2 Cl^-$	+1.36	$Fe^{2+} + 2 e^- \varnothing Fe (s)$	-0.41
$O_2 (g) + 4 H^+ + 4 e^- \varnothing 2 H_2O$	+1.23	$Zn^{2+} + 2 e^- \varnothing Zn (s)$	-0.76
$Cu^{2+} + 2 e^- \varnothing Cu (s)$	+0.34	$2 H_2O + 2 e^- \varnothing H_2 (g) + 2 OH^-$	-0.83
$2H^+ + 2 e^- \varnothing H_2(g)$	0	$Na^+ + e^- \varnothing Na (s)$	-2.711

Write your name on all 7 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 <u>AND</u> use a #2 pencil to bubble in one correct answer on your Scantron™ form for each question.**

- Budget your time. Anticipate spending about 50 minutes on each part.
- Be sure to leave sufficient time to transfer your multiple choice answers to the Scantron™ form.

(for Administrative use only)

MC3		2		Total E3	
MC2		3		Total E2	
1		4			

Name_____________________

Part I: Multiple Choice, 3 points each, 54 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 question 1 is **A**. Bubble in **A** on your Scantron™ form.

2.) Consider the endothermic reaction $N_2O_4\ (g) \rightleftharpoons 2NO_2\ (g)$ in a sealed vessel. If K_1 is the equilibrium constant at 300 K, and K_2 is the equilibrium constant at 400 K, which of the following must be true?

A) $K_1 = K_2$ B) $K_1 = K_2^{-1}$ C) $K_1K_2 = K_w$ D) $K_1 < K_2$ E) $K_2 < K_1$

3.) What conditions favor the yield of ammonia (NH_3) at equilibrium, given the following exothermic reaction:

$$N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g)$$

A) High Temperature B) Low Pressure C) High Pressure D) Open Container E) Thermal Insulation

4.) An HCl (strong acid) solution with pH=3 is diluted by a factor of 10 with water. The new pH is:

A) <3 B) =3 C) Between 3 and 4 D) = 4 E) > 4

5.) An HAc (weak acid) solution with pH = 3 is diluted by a factor of 10 with water. The new pH is:

A) <3 B) =3 C) Between 3 and 4 D) = 4 E) > 4

6.) A sealed can half full of soda expands on a warm day. The reaction below is:

$$CO_2\ (aq) \longrightarrow CO_2\ (g)$$

A) isothermal B) exothermic C) endothermic D) basic E) acidic

7.) An electrically conducting solution of $Ba(OH)_2$ (a soluble salt) is titrated with H_2SO_4 until the conductance is at a minimum. (K_{sp} for $BaSO_4 = 1.1\times10^{-10}$) At this point:

A) $[Ba^{2+}]=[SO_4^{2-}]$ B) $[Ba^{2+}]<[SO_4^{2-}]$ C) $[SO_4^{2-}]<[Ba^{2+}]$ D) $[H_3O^+]<[OH^-]$ E) $[OH^-]<[H_3O^+]$

8.) A 1.0 x 10^{-8} mole speck of AgCl (K_{sp} = 1.6 x 10^{-10}) is added to 1.0 L of H_2O. What is [Ag^+] in the resulting solution?

A) 1.0 x 10^{-16} M B) 1.6 x 10^{-10} M C) 1.0 x 10^{-8} M D) 1.3 x 10^{-5} M E) 1.0 x 10^{-4} M

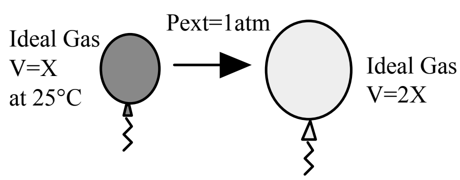
9.) Under what conditions will a reaction with $\Delta H° > 0$ and $\Delta S° < 0$ be spontaneous?

A) High T B) Low T C) All T D) No T E) Can't determine

10.) It snows in the winter (low temperature) but it rains in the summer (high temperature). This implies that for the formation of snow (H_2O (l) $\longrightarrow$ H_2O (s)):

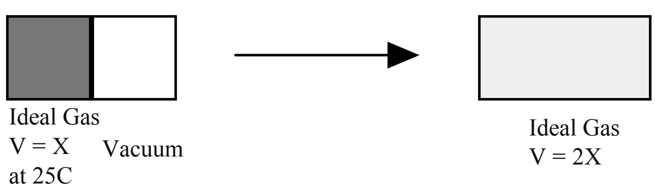
A) $\Delta H°>0, \Delta S°>0$ B) $\Delta H°<0, \Delta S°>0$ C) $\Delta H°>0, \Delta S°<0$ D) $\Delta H°<0, \Delta S°<0$ E) Can't determine

11.) A balloon, containing an ideal gas at 25 °C and 2 atm, adiabatically (q=0) expands to twice its original volume against an external pressure of 1 atm; the final temperature is:



A) < 25 °C B) = 25 °C C) > 25 ° D) = -RlnK$_p$ E) Can't determine

12.) An ideal gas at 25 °C and 2 atm adiabatically (q=0) expands into a vacuum to twice its original volume, the final temperature is:



A) < 25 °C B) = 25 °C C) > 25 ° D) = -RlnK$_p$ E) Can't determine

13.) A beam of blue light (400 nm) will eject electrons from an unknown metal surface while a beam of red light (700 nm) will not eject electrons. Will a beam of green light (475 nm) eject electrons from the same surface?

A) No B) Sometimes C) Yes D) Only at high intensity E) Can't determine

14.) A photon of blue light with a wavelength of 400 nm splits into two identical infrared photons. Knowing that energy is conserved, what is the wavelength of each of these two photons?

A) 200 nm B) 283 nm C) 400 nm D) 566 nm E) 800 nm

15.) Which one of the following species is the strongest oxidizer under standard conditions?

A) Mn^{2+} B) Cl^- C) Cu^{+2} D) O_2 (g) E) Cl_2 (g)

16.) Which of the following will be oxidized by Fe^{2+} but not by Na^+ under standard conditions?

A) Cl_2 B) Zn C) Na^+ D) Sn E) Cl^-

17.) Which of the following is a product of the reaction when NaCl is added to an acidic MnO_4^- solution?

A) Cl_2 B) Cl^- C) Na D) H^+ E) H_2

18.) Aluminum (Al) produces H_2 bubbles when immersed in HCl, mercury (Hg) does not. Which is the strongest reducer?

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

19.) Buried copper (Cu) pipes are often fitted with zinc (Zn) strips; why?

A) To prevent oxidation of Cu B) To prevent reduction of Cu C) Zn is shinier D) Zn is acid resistant E) Zn is base resistant

Name____________________

Part II: 4 Problems, 46 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).

(10 pts)

1.) Phosgene ($COCl_2$) is a poisonous gas. At 425 K it will dissociate to establish the following equilibrium:

$$COCl_2\ (g) \rightleftharpoons CO\ (g) + Cl_2\ (g) \qquad K = 1.00 \times 10^{-4}$$

a.) Starting with pure $COCl_2$ gas at $P_{COCl_2} = 2.00$ atm, when the system reaches equilibrium the total pressure (in atm) will be: (circle the correct answer)

A) = 1.00 B) Between 1.00 and 2.00 C) = 2.00 D) Between 2.00 and 4.00 E) = 4.00

b.) Calculate the partial pressure of CO for the equilibrium system of part **a.)**. Justify any assumptions made.

P_{CO} = ____________

c.) The container for the equilibrium system of part **a.)** is doubled in volume. When the system reaches the new equilibrium state the total pressure (in atm) will be: (circle the correct answer)

A) = 1.00 B) Between 1.00 and 2.00 C) = 2.00 D) Between 2.00 and 4.00 E) = 4.00

d.) Calculate the partial pressure of CO for the new equilibrium system of part **c.)**. Justify any assumptions made.

P_{CO} = ____________

(9pts)
2a.) Starting with a 1.0 liter solution of 1.0 M sodium acetate (Ac^-), how many moles of HCl do you need to add to make a buffer with pH= 4.75? (For HAc $pK_a = 4.75$). Show your work.

Moles HCl = ______________

b.) To 1.0 L of buffer solution ($pH=pK_a$) produced in part **a.)** 9.0 L of H_2O are added, what is the new pH? Show your work.

pH = ______________

c.) How many moles of acetic acid (HAc) must be added to H_2O to make 1.0 L of a solution with pH = 4.75? Show your work.

Moles HAc = ______________

(12pts)

3.) You make the following observation:

- Addition of tin metal (Sn) to a solution of silver ions (Ag^+) results in the formation of Ag and Sn^{2+}.

a.) Write a balanced equation for the net spontaneous reaction that describes this observation.

b.) Will Ag reduce Sn^{2+}? Explain.

c.) For the standard cell **Sn (s) | Sn^{2+} (1.0 M) || Ag^+ (1.0 M) | Ag (s)** when current flows, at which electrode, Sn or Ag, does oxidation occur? Explain in terms of electron flow for the operating cell.

d.) In the operating cell in part **c.)**, for each mole of anode (- electrode) that dissolves, how many moles of metal plate out onto the cathode (+ electrode)? Explain.

Moles = ____________

(15 pts)
4.) A study of the ancient geology of the earth shows that rocks greater than 2 billion years old contain iron in the form of FeS_2. In rocks less than 2 billion years old, iron appears mostly in the oxidized form Fe_2O_3 (hematite).

$$4FeS_2\,(s) + 8H_2O\,(l) + 15O_2\,(g) \longrightarrow 2Fe_2O_3\,(s) + 8H_2SO_4\,(l)$$

a.) Calculate ΔH° for the above reaction.

ΔH° = ____________

b.) Calculate ΔS° for the above reaction.

ΔS° = ____________

c.) Over what temperature range is the reaction spontaneous? Show your calculations.

From T = __________ to __________