Chem 1B Midterm 3
Version B

Credit will only be given for answers on this sheet. Units must be included in your answers and points will be taken off for incorrect or missing units. No partial credit will be awarded. Calculators are allowed. Cell phones may not be used as calculators.

Name:	**Perm Number**

Make sure your writing is dark and large enough to be picked up by a scanner. Failure to do this results in the loss of 5 points on the exam.

If you are sitting next to someone with the same version of the test, you both will lose 5 points on the exam.

If you are still writing after time is called, you will lose 5 points on the exam.

Fundamentals	
Question (Points)	**Answer**
1 (6 pts) 2, 4	Anode solution: ● 1.0 M ○ 10. M
	0.029 V
2 (6 pts)	3+
3 (6 pts)	-371 kJ
4 (7 pts)	-31.0 $\frac{kJ}{mol}$
5 (6 pts) 2 each	● Rise ○ Fall
	● Yes ○ No
	0.36 atm
6 (6 pts)	59%

Multiple Choice	
Question (Points)	**Answer**
7 (8 pts) 2 each	○ A ○ B ● C ○ D ○ E ○ F ○ G
	○ A ○ B ○ C ○ D ○ E ● F ○ G
	○ A ○ B ○ C ○ D ○ E ● F ● G
	○ A ○ B ● C ○ D ● E ○ F ○ G
8 (4 pts) 1 each	● A ○ B
	○ A ● B
	● A ○ B
	○ A ● B
9 (4 pts)	● A ○ B ○ C ○ D ○ E
10 (6 pts) 2 each	ΔG° K E°
	○ 255. $\frac{kJ}{mol}$ ● 4.72x10^{44} ○ -1.32 V
	○ 60. $\frac{kJ}{mol}$ ○ 3.08x10^{-11} ● 0.31 V
	● 264. $\frac{kJ}{mol}$ ○ 5.31x10^{45} ○ 1.35 V
11 (7 pts)	○ A ● B ○ C ○ D ○ E
12 (6 pts)	● A ○ B ○ C ○ D ○ E

Challenge Problems		
Question (Points)	**Answer**	
13 (8 pts)	1.50 V	
14 (20 pts) 4 each	q = 49.7 kJ	w = -3.43 kJ
	ΔE = 46.3 kJ	ΔH = 49.7 kJ
	ΔS = 136 $\frac{J}{K}$	

Fundamental Questions

1) *6 pts* A concentration cell is made from two Cu electrodes and a 1.0 M Cu^{2+} solution and a 10. M Cu^{2+} solution. Which solution is at the anode to make a galvanic cell (25˚C)? What is the cell potential?

2) *6 pts* An aqueous solution of an unknown salt of ruthenium is electrolyzed by a current of 2.50 A passing for 50.0 min. If 2.618 g Ru is produced at the cathode, what is the charge on the ruthenium ion in solution?

3) *6 pts* Using standard reduction potentials from the constant sheet, calculate the standard reaction free energy ΔG° (in kJ) for the following redox reaction.

$$H_2(g) + 2OH^-(aq) + Br_2(l) \rightarrow 2H_2O(l) + 2Br^-(aq)$$

Be sure your answer has the correct number of significant digits.

4) *7 pts* What is ΔG° (in $\frac{kJ}{mol}$) for the reaction $2NO_2(g) \rightarrow 2NO(g) + O_2(g)$ at 700°C?

5) *6 pts* Consider the following equilibrium:

$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$ $\Delta G^\circ = 41.kJ$ (at 986°C)

Now suppose a reaction vessel is filled with 2.47 atm of nitrosyl chloride (NOCl) and 0.960 atm of chlorine (Cl_2) at 986.˚C. Answer the following questions about this system:

Under these conditions, will the pressure of Cl_2 tend to rise or fall?	☐Rise ☐Fall
Is it possible to revese this tendency by adding NO? In other words, if you said the pressure of Cl_2 will tend to rise, can that be changed to a tendency to fall by adding NO? Similarly, if you said the pressure of Cl_2 will tend to fall, can that be changed to a tendency to rise by adding NO?	☐Yes ☐No
If you said the tendency can be reversed in the second question, calculate the minimum presure of NO needed to reverse it. Round your answer to 2 significant digits	_____atm

6) *6 pts* A machine employs the isothermal expansion of 1.4 moles of ideal gas from 1.98 L to 18.34 L. At 25.6°C, the machine performs 4.58 kJ of work. What percent of the maximum possible work is the machine producing?

Multiple Choice

7) *8 pts* Consider only the species (at standard conditions)

A. Na^+ B. Cl^- C. Ag^+ D Ag E. Zn^{2+} F. Zn G. Pb

Which is the strongest oxidizing agent?
Which is the strongest reducing agent?
Which species can be oxidized by SO_4^{2-}(aq) in acid?
Which species can be reduced by Al(s)?

8) *4 pts* For each of the following pairs of substances, which substance has the greater value of S° at 25°C and 1 atm?

A.	$C_{graphite}(s)$	B.	$C_{diamond}(s)$
A.	$CO_2(s)$	B.	$CO_2(g)$
A.	$N_2O(g)$	B.	He(g)
A.	HF(g)	B.	HCl(g)

9) *4 pts* What is ΔG° for $SO_2(g) + ½O_2(g) \rightarrow SO_3(g)$ given the following information?

$2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$ $\Delta G° = -742 \frac{kJ}{mol}$

$S(s) + O_2(g) \rightarrow SO_2(g)$ $\Delta G° = -300. \frac{kJ}{mol}$

A. $-71 \frac{kJ}{mol}$
B. $-442 \frac{kJ}{mol}$
C. $-671 \frac{kJ}{mol}$
D. $-1{,}042 \frac{kJ}{mol}$
E. None of the above

10) *6 pts* A student made measurements on some electrochemical cells and calculated three quantities:

- The standard reaction free energy ΔG°.
- The equilibrium constant K at 25.0°C.
- The cell potential under standard conditions E°.

His results are listed below.

Unfortunately, the student may have made some mistakes. Examine his results carefully and tick the box next to the incorrect quantity in each row, if any.

Note: If there is a mistake in a row, only one of the three quantities listed is wrong. Also, you may assume the number of significant digits in each quantity is correct.

Also note: for each cell, the number n of electrons transferred per redox reaction is 2.

		Calculated quantities (check box next to any that are wrong)		
Cell	n	△G°	K	E°
A	2	255. $\frac{kJ}{mol}$ ☐	4.72×10^{44} ☐	-1.32 V ☐
B	2	60. $\frac{kJ}{mol}$ ☐	3.08×10^{-11} ☐	0.31 V ☐
C	2	264 $\frac{kJ}{mol}$ ☐	5.31×10^{45} ☐	1.35 V ☐

11) *7 pts* Consider the reaction: $CH_4(g) + 2O_2(g) \rightleftharpoons CO_2(g) + 2H_2O(l)$

What is ΔG $\left(\frac{kJ}{mol}\right)$ at 300°C when the pressures are:

$P_{CH_4} = 7.0\ atm$, $P_{O_2} = 2.9\ atm$, and $P_{CO_2} = 13\ atm$?

A. -752 $\frac{kJ}{mol}$

B. -759 $\frac{kJ}{mol}$

C. -817 $\frac{kJ}{mol}$

D. -824 $\frac{kJ}{mol}$

E. None of the above

Thermodynamic Data at 298 K			
Substance	$\Delta H_f° \left(\frac{kJ}{mol}\right)$	$\Delta G_f° \left(\frac{kJ}{mol}\right)$	$S° \left(\frac{J}{mol \cdot K}\right)$
$CH_4(g)$	-75	-51	186
$O_2(g)$	0	0	205.
$CO_2(g)$	-393.5	-394	214
$H_2O(l)$	-286	-237	70.

12) *6 pts* Ammonium metavanadate reacts with sulfur dioxide in acidic solution as follows (hydrogen ions and H_2O omitted):

$xVO_3^- + ySO_2 \rightarrow xVO^{2+} + ySO_4^{2-}$

The ratio x : y is:

A. 2 : 1

B. 1 : 1

C. 1 : 3

D. 1 : 2

E. None of the above

Challenge Problems

13) 8 pts Consider the cell described below:

$$Al|Al^{3+}(1.00\ M)||Pb^{2+}(1.00\ M)|Pb$$

Calculate the cell potential after the reaction has operated long enough for the $[Al^{3+}]$ to have changed by 0.60 M. (Assume T=25˚C)

14) 20 pts A sample of water (l) weighing 18.02 g initially at 0.0˚C is heated to 140.0˚C at constant pressure of 1.00 atm. Calculate q, w, ΔE, ΔH, and ΔS for this process. The molar heat capacities (C_P) for solid, liquid, and gaseous water (37.5 $\frac{J}{K \cdot mol}$, 75.3 $\frac{J}{K \cdot mol}$, and 36.4 $\frac{J}{K \cdot mol}$, respectively) are assumed to be temperature independent. The enthalpies of fusion and vaporization are 6.01 $\frac{kJ}{mol}$ and 40.7 $\frac{kJ}{mol}$, respectively. Assume ideal gas behavior.