

Chem 1B Midterm 3

Version A

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)	$1.13 \times 10^{-23} \frac{J}{K}$		
2 (6 pts)	1.95 g		
3 (6 pts)	4.83%		
4 (6 pts)	Solution at Anode: ☒ 1.0 M ☐ 10. M		Potential: 0.029 V
5 (6 pts)	ΔG°	K	E°
	$255. \frac{kJ}{mol}$ ☐	4.72×10^{44} ☒	-1.32 V ☐
	$60. \frac{kJ}{mol}$ ☐	3.08×10^{-11} ☐	0.31 V ☒
	$264 \frac{kJ}{mol}$ ☒	5.31×10^{45} ☐	1.35 V ☐
6 (7 pts)	$-50. \frac{kJ}{mol}$		

Multiple Choice	
Question (Points)	Answer
7 (6 pts) 2 each section	☐ A ☒ B ☐ C
	☒ A ☐ B ☐ C
	☐ A ☒ B ☐ C
	☐ A ☒ B ☐ C
	☐ A ☐ B ☒ C
	☐ A ☐ B ☒ C
8 (5 pts)	☒ A ☐ B ☐ C ☐ D ☐ E
9 (5 pts)	☒ A ☐ B ☐ C ☐ D ☐ E
10 (5 pts)	☒ A ☐ B ☐ C ☐ D
	☐ A ☐ B ☐ C ☒ D
	☐ A ☐ B ☒ C ☐ D
	☐ A ☒ B ☐ C ☐ D
11 (8 pts)	☐ A ☒ B ☐ C ☐ D ☐ E
12 (6 pts)	☐ A ☐ B ☐ C ☐ D ☒ E

Challenge Problems		
Question (Points)	Answer	
13 (8 pts) 4 each	E = 0.151 V	$\Delta G = -29.1 \frac{\text{kJ}}{\text{mol}}$
14 (20 pts) 4 each	q = 49.7 kJ	w = -3.43 kJ
	$\Delta E = 46.3 \text{ kJ}$	$\Delta H = 49.7 \text{ kJ}$
	$\Delta S = 136 \frac{\text{J}}{\text{K}}$	

Fundamental Questions

- 1) 6 pts An oxygen molecule (O_2) is adsorbed on a patch of surface (see sketch at right). This patch is known to contain 64 adsorption sites. The (O_2) molecule has enough energy to move from site to site, so it could be on any one of them.



One way of O_2 molecule could be adsorbed on a patch of surface with 16 sites.

Suppose additional surface becomes exposed, so that 144 adsorption sites are now available for the molecule. Calculate the change in entropy.

Round your answer to 3 significant digits, and be sure it has the correct unit symbol.

- 2) 6 pts When a lead-acid car battery is recharged by the alternator, it acts essentially as an electrolytic cell in which solid lead (II) sulfate ($PbSO_4$) is reduced to lead at the cathode and oxidized to solid lead (II) oxide (PbO) at the anode. Suppose a current of 79.0 A is fed into a car battery for 23.0 seconds. Calculate the mass of lead deposited on the cathode of the battery. Round your answer to 3 significant digits. Also, be sure your answer contains a unit symbol.

- 3) 6 pts A machine employs the isothermal expansion of 4.5 moles of ideal gas from 2.6 L to 9.05 L. At 24°C, the machine performs 0.67 kJ of work. What percent of the maximum possible work is the machine producing?

- 4) 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?

- 5) 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.

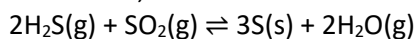
Note: If there is a mistake in a row, only one of the three quantities listed is wrong.

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	ΔG°		K		E°	
A	2	$255. \frac{\text{kJ}}{\text{mol}}$	☐	4.72×10^{44}	☐	-1.32 V	☐
B	2	$60. \frac{\text{kJ}}{\text{mol}}$	☐	3.08×10^{-11}	☐	0.31 V	☐
C	2	$264 \frac{\text{kJ}}{\text{mol}}$	☐	5.31×10^{45}	☐	1.35 V	☐

- 6) 7 pts Using data from the constant sheet, calculate ΔG for the reaction



for the following conditions at 25°C:

$$P_{\text{H}_2\text{S}} = 1.0 \times 10^{-4} \text{ atm}$$

$$P_{\text{SO}_2} = 1.0 \times 10^{-2} \text{ atm}$$

$$P_{\text{H}_2\text{O}} = 3.0 \times 10^{-2} \text{ atm}$$

Multiple Choice

- 7) 6 pts Use the observations about each chemical reaction in the table below to decide the sign (positive or negative) of the reaction enthalpy ΔH and reaction entropy ΔS .
Note: if you have not been given enough information to decide a sign, select the "unknown" option.

This reaction is always spontaneous, but proceeds slower at temperatures below 88°C

ΔH is

- A. Positive B. Negative C. Unknown

ΔS is

- A. Positive B. Negative C. Unknown

This reaction is spontaneous except above 64°C

ΔH is

- A. Positive B. Negative C. Unknown

ΔS is

- A. Positive B. Negative C. Unknown

This reaction is faster above -48°C than below

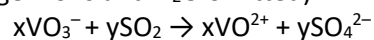
ΔH is

- A. Positive B. Negative C. Unknown

ΔS is

- A. Positive B. Negative C. Unknown

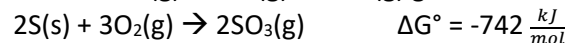
- 8) 5 pts Ammonium metavanadate reacts with sulfur dioxide in acidic solution as follows (hydrogen ions and H_2O omitted):



The ratio $x : y$ is

- A. 2:1
B. 1:1
C. 1:3
D. 1:2
E. None of the above

- 9) 5 pts What is ΔG° for $\text{SO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{SO}_3(\text{g})$ given the following information?



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

- 10) 5 pts Use the information on the constant sheet to sort the following chemical species by their reducing power
- Ca(s)
 A. 1 (highest) B. 2 C. 3 D. 4 (Lowest)
- Br⁻(aq)
 A. 1 (highest) B. 2 C. 3 D. 4 (Lowest)
- Ag(s)
 A. 1 (highest) B. 2 C. 3 D. 4 (Lowest)
- Zn(s)
 A. 1 (highest) B. 2 C. 3 D. 4 (Lowest)

- 11) 8 pts Consider the reaction: $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$
 What is $\Delta G \left(\frac{\text{kJ}}{\text{mol}} \right)$ at 300°C when the pressures are: $P_{\text{CH}_4} = 7.0 \text{ atm}$, $P_{\text{O}_2} = 2.9 \text{ atm}$, and $P_{\text{CO}_2} = 13 \text{ atm}$.

Thermodynamic Data at 298 K			
Substance	$\Delta H_f^\circ \left(\frac{\text{kJ}}{\text{mol}} \right)$	$\Delta G_f^\circ \left(\frac{\text{kJ}}{\text{mol}} \right)$	$S^\circ \left(\frac{\text{J}}{\text{mol}\cdot\text{K}} \right)$
CH ₄ (g)	-75	-51	186
O ₂ (g)	0	0	205.
CO ₂ (g)	-393.5	-394	214
H ₂ O(l)	-286	-237	70.

- A. $-752 \frac{\text{kJ}}{\text{mol}}$
 B. $-759 \frac{\text{kJ}}{\text{mol}}$
 C. $-817 \frac{\text{kJ}}{\text{mol}}$
 D. $-824 \frac{\text{kJ}}{\text{mol}}$
 E. None of the above
- 12) 6 pts What reaction occurs at the anode and at the cathode when electrolysis of aqueous MgI₂ occurs? Assume standard conditions.
- Helpful information: $\text{I}_2 + 2\text{e}^- \rightarrow 2\text{I}^-$ $E^\circ = 0.54 \text{ V}$
 $\text{Mg}^{2+} + 2\text{e}^- \rightarrow \text{Mg}$ $E^\circ = -2.37 \text{ V}$
- A. Iodine/Magnesium
 B. Water/Magnesium
 C. Water/Water
 D. Magnesium/Water
 E. None of the above

Challenge Problems

- 13) 8 pts Consider the following galvanic cell at 25°C:
$$\text{Pt} | \text{Cr}^{2+}(0.30 \text{ M}), \text{Cr}^{3+}(2.0 \text{ M}) || \text{Co}^{2+}(0.20 \text{ M}) | \text{Co}$$

The overall reaction and equilibrium constant values are
$$2\text{Cr}^{2+}(\text{aq}) + \text{Co}^{2+}(\text{aq}) \rightarrow 2\text{Cr}^{3+}(\text{aq}) + \text{Co}(\text{s}) \quad K=2.79 \times 10^7$$

Calculate the cell potential E for this galvanic cell and ΔG for the cell reaction at these conditions.

- 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.