

LAST NAME: _____

FIRST NAME: _____

Student Number: _____

CHM 1311 A Midterm #1 Fall 2017

STAGE 1 – 60 min

Please keep your work covered at all times and keep your eyes on your own paper! Cheating or any appearance of cheating will result in an F in the course and possible expulsion from the university.

There are 6 pages in this test. A periodic table, data tables, and a formula sheet are provided separately. Please show your work to receive partial credit.

Cellular phones, unauthorized electronic devices or course notes (unless an open-book exam) are not allowed during this exam. Phones and devices must be turned off and put away in your bag. Do not keep them in your possession, such as in your pockets. If caught with such a device or document, the following may occur: academic fraud allegations will be filed which may result in you obtaining a 0 (zero) for the exam.

By signing below, you acknowledge that you have ensured that you are complying with the above statement.

Signature: _____

1. Short Answer Questions

a) (0.5 pts) Which compound has the highest oxidation state of nitrogen?

NO⁺ N₂ **NO₃⁻** NO₂ N₂O NH₃

b) (1.5 pts) The standard heat of formation of solid potassium perchlorate is -432.8 kJ. Write the chemical equation for the reaction to which this value applies.



c) (0.5 pt) Which of the following is/are a state function? ΔU ΔH q W

d) (0.5 pt) 1.0 mol of an ideal gas is placed in a 1.0 L flask at 22°C. Which of the following would result in the greatest increase in the pressure of the gas?

- reducing the volume of the container to 0.50 L**
- increasing the amount of gas to 1.5 mol
- increasing the temperature to 300°C

e) (1 pt) An aqueous solution of sulphuric acid has a concentration of 0.650 mol/kg. The mole fraction of H₂SO₄ in this mixture is : 0.0116.

f) (1 pt) Two objects of identical mass and size, A and B, absorb the same amount of heat when placed in an oven. However, the temperature of A increases more than B. This is because A has a lower specific heat capacity than B (q = mcΔT).

(1 pt) BONUS:

Which answer(s) is/are true when comparing 1.0 mol of H₂ (g) and 1.0 mol of He (g), both at STP? The two gases have equal:

- | | | |
|----------------------------|-------------|--------------|
| • volumes | TRUE | FALSE |
| • root-mean-squared speeds | TRUE | FALSE |
| • masses | TRUE | FALSE |
| • densities | TRUE | FALSE |

2. Complete combustion of a 1.119 g sample of an unknown gaseous compound (consisting of C, H, and S) yields 2.020 g of CO₂, 0.689 g of H₂O, and some SO₂.

THIS QUESTION IS FROM MIDTERM 1 2016

a) (6 pts) Find the number of moles of each element in the sample.

$$? \text{ mol C} = 2.020 \text{ g CO}_2 \times \frac{\text{mol CO}_2}{44.01 \text{ g CO}_2} \times \frac{1 \text{ mol C}}{1 \text{ mol CO}_2} = 0.0460 \text{ mol C}$$

$$? \text{ mol H} = 0.689 \text{ g H}_2\text{O} \times \frac{\text{mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{2 \text{ mol H}}{1 \text{ mol H}_2\text{O}} = 0.0765 \text{ mol H}$$

$$? \text{ g C} = 0.0460 \text{ mol C} \times \frac{12.011 \text{ g C}}{1 \text{ mol C}} = 0.552 \text{ g C}$$

$$? \text{ g H} = 0.0765 \text{ mol H} \times \frac{1.008 \text{ g H}}{1 \text{ mol H}} = 0.0771 \text{ g H}$$

$$\therefore ? \text{ g S} = 1.119 \text{ g sample} - 0.552 \text{ g C} - 0.0771 \text{ g H} = 0.0490 \text{ g S}$$

$$? \text{ mol S} = 0.0490 \text{ g S} \times \frac{1 \text{ mol S}}{32.066 \text{ g S}} = 0.0153 \text{ mol S}$$

$$\text{C} = \underline{0.0460 \text{ mol}} \quad \text{H} = \underline{0.0765 \text{ mol}} \quad \text{S} = \underline{0.0153 \text{ mol}}$$

b) (1 pt) What is the empirical formula of the compound?

$$\frac{\text{C}_{0.0460}}{0.0153} \frac{\text{H}_{0.0765}}{0.0153} \frac{\text{O}_{0.0153}}{0.0153} = \text{C}_3\text{H}_5\text{S}$$

c) (3 pts) A 0.234 g sample of the gas in a 40.0 mL container has a pressure of 0.9986 bar at 300.0 K. What is the molar mass of the unknown compound?

$$n = \frac{PV}{RT} = \frac{0.9986 \text{ bar} \times 0.0400 \text{ L}}{0.083145 \text{ L} \cdot \text{atm} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \times 300.0 \text{ K}} = 0.00160 \text{ mol}$$

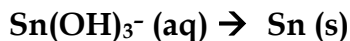
$$\therefore \text{MM} = \frac{0.231 \text{ g}}{0.00160 \text{ mol}} = 146 \text{ g/mol}$$

$$\text{Answer: } \underline{146 \text{ g/mol}}$$

d) (1 pt) What is the molecular formula of the compound?

$$n = \frac{\text{MF mass}}{\text{EF mass}} = \frac{146}{73} = 2 \quad \therefore \text{C}_3\text{H}_5\text{S} \times 2 = \text{C}_6\text{H}_{10}\text{S}_2$$

3. Elemental tin can be isolated from basic solutions using the following half reactions:



THIS IS SILBERBERG PROBLEM 19.16c AND WAS ON THE 2015 MIDTERM #1

a) (4 pts) Determine the balanced chemical equation for the overall redox reaction.



reducing agent

oxidizing agent

b) (1 pt) Identify the oxidizing agent and the reducing agent in your reaction above.

c) (4 pts) 1.093 g of Fe(OH)_2 is added to 120.0 mL of a 0.0894 M aqueous basic solution of Sn(OH)_3^- and 0.633 g of solid tin is obtained. What was the yield of the redox reaction?

THIS IS VERY SIMILAR TO AN ECHO360 QUESTION DONE IN CLASS

$$\begin{aligned} ? \text{ g Sn from Fe(OH)}_2 &= 1.093 \text{ g Fe(OH)}_2 \times \frac{\text{mol Fe(OH)}_2}{89.86 \text{ g Fe(OH)}_2} \times \frac{1 \text{ mol Sn}}{2 \text{ mol Fe(OH)}_2} \times \frac{118.7 \text{ g Sn}}{\text{mol Sn}} \\ &= 0.722 \text{ g} \end{aligned}$$

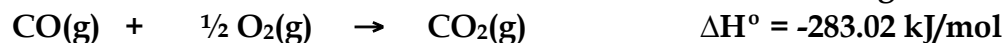
$$\begin{aligned} ? \text{ g Sn from Sn(OH)}_3^- &= 0.1200 \text{ L solution} \times \frac{0.0894 \text{ mol Sn(OH)}_3^-}{\text{L solution}} \times \frac{1 \text{ mol Sn}}{1 \text{ mol Sn(OH)}_3^-} \times \frac{118.7 \text{ g Sn}}{\text{mol Sn}} \\ &= 1.27 \text{ g} \end{aligned}$$

Therefore, Fe(OH)_2 is the limiting reagent.

$$\% \text{ yield} = \frac{0.633 \text{ g}}{0.722 \text{ g}} \times 100\% = 87.7\%$$

Answer: _____

4. Carbon monoxide can be further oxidized to carbon dioxide according to the reaction:



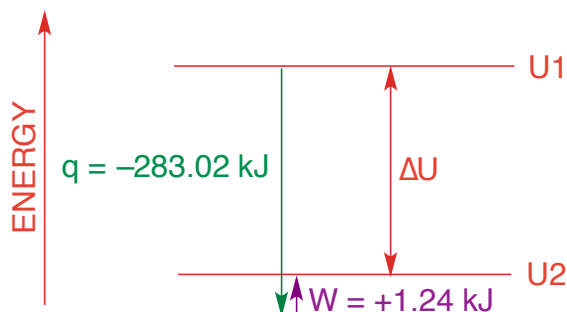
a) (3 pts) What is the change in internal energy for the oxidation of one mole of CO at 298 K under constant pressure conditions?

THIS IS SIMILAR TO A QUESTION SOLVED IN CLASS, AND I COVERED A SIMILAR PROBLEM IN THE OCT 9 DGD, AND IT APPEARED ON THE 2010 MIDTERM #1

$$\begin{aligned}
 q &= 1 \text{ mol CO} \times \frac{-283.02 \text{ kJ}}{\text{mol}} = -283.02 \text{ kJ} \\
 W &= -P\Delta V \\
 &= -\Delta nRT \\
 &= -(1 - 1.5 \text{ mol})(8.3145 \text{ J/mol K})(298 \text{ K}) \\
 &= +1239 \text{ J} \\
 &= 1.24 \text{ kJ} \\
 \Delta U &= q + W \\
 &= -283.02 \text{ kJ} + 1.24 \text{ kJ} \\
 &= -281.78 \text{ kJ}
 \end{aligned}$$

Answer: -281.78 kJ

b) (2 pts) Draw a representative energy diagram for this reaction. Fully label your diagram, including: ΔU , U_1 , U_2 , q , and W .



Note that this reaction is an exothermic contraction, but because q is so much larger than W , overall, ΔU is NEGATIVE.

5. In a constant-pressure calorimeter, 65.0 mL of 0.900 M H_2SO_4 was added to 65.0 mL of 0.250 M NaOH. The reaction caused the temperature of the solution to rise from 23.60 °C to 25.30 °C.

THIS QUESTION IS TAKEN FROM SAPLING ASSIGNMENT #5, AND IS ALSO VERY SIMILAR TO A QUESTION SOLVED IN THE OCT 9 DGD

a) (1 pt) Write a balanced molecular equation (including phases) for the neutralization.



b) (4 pts) If the solution has the same density and specific heat as water, what is ΔH for this reaction (per mole of H_2O produced)? You may assume that the total volume is the sum of the individual volumes.

$$? \text{ mol H}_2\text{O from H}_2\text{SO}_4 = 0.065 \text{ L soln} \times \frac{0.900 \text{ mol H}_2\text{SO}_4}{\text{L soln}} \times \frac{2 \text{ mol H}_2\text{O}}{1 \text{ mol H}_2\text{SO}_4} = 0.117 \text{ mol}$$

$$? \text{ mol H}_2\text{O from NaOH} = 0.065 \text{ L soln} \times \frac{0.250 \text{ mol NaOH}}{\text{L soln}} \times \frac{2 \text{ mol H}_2\text{O}}{2 \text{ mol NaOH}} = 0.01625 \text{ mol}$$

Therefore, the NaOH is the limiting reagent.

$$\begin{aligned} q_{\text{reaction}} &= -q_{\text{surr}} \\ &= -m_{\text{total}} \times c \times \Delta T \\ &= -(130 \text{ g} \times \frac{1 \text{ mL}}{1 \text{ g}})(4.184 \text{ J/g}^\circ\text{C})(25.30^\circ\text{C} - 23.60^\circ\text{C}) \\ &= -924.7 \text{ J} \\ \Delta H &= \frac{q}{n} = \frac{-924.7 \text{ J}}{0.01625 \text{ mol}} = -56.9 \text{ kJ/mol} \end{aligned}$$

Answer: _____ **-56.9 kJ/mol** _____