Disclaimer: This exam is multiple years old and is likely to be obsolete.

MSE 120 - Fall, 2006 – Second mid-term

Monday, November 6th, 1.10-2pm

There are three questions – each carries the same maximum credit

CLOSED BOOKS – CLOSED NOTES – NO CALCULATORS

Put your answers on the sheets provided and keep the questions.

The predominance diagram for the Cu-S-O system at 1000K appears on the first page of the answer sheets. Use it to do the following:
Show on the diagram where CuO is in equilibrium with two other solid phases (copper and all the copper compounds in this diagram are solid at 1000K)
What is the stable species in the Cu-S-O system when the gas phase has a sulfur dioxide partial pressure of one atmosphere and an oxygen partial pressure of 10^{-8}atm.?
By considering the line separating the Cu_2S region from the $CuSO_4$ region, show what determines the slope of that line.
Why is the line separating the Cu region from the Cu_2O region vertical?

Many years ago your instructor and a graduate student studied the deposition of aluminum by thermal decomposition of aluminum alkyls. These alkyls are organometallic compounds that are liquid at room temperature but can be vaporized by passing a "carrier" gas, such as argon, through the liquid. The vaporized alkyl and argon were passed over an electrically heated filament onto which the aluminum deposited, e.g. for tri-isobutyl aluminum (TiBA)

$$(C_4H_9)_3Al = Al(solid) + 3/2H_2 + 3C_4H_8$$

Apart from the aluminum, the products of the reaction (which can be considered irreversible) are gasses.

Two plots of experimental results (one with calculated curves in addition) appear on the next page. Recall that

$$\text{Reynolds number} = \frac{\text{velocity x diameter (of the filament) x density}}{\text{viscosity}}$$

Is the reaction homogeneous or heterogeneous?
From what you have learned in the course, explain why the deposition rate depends on gas velocity at 664K but not at 540K (Fig. 10)
Explain why the experimental data do not fit a straight line in the Arrhenius plot (Fig. 13)
There are curves in Fig. 13 labeled “calculated”. How could you calculate deposition rates for such a reaction; what information would you need to do the calculation?

3.

The sketch below shows a piece of nickel immersed in a solution containing nickel ions at a concentration of 0.18molal. The solution temperature is 25^0C. The activity coefficient for nickel ions in this solution is 0.1. The standard electrode potential for nickel is -0.236V. Also immersed in the solution is a hydrogen electrode and the pH of the solution is -0.1.

(a) Write down equations for the half-cell potential of the nickel and for the half-cell potential of the hydrogen electrode. As you do not have a calculator you cannot obtain numerical values for these potentials but the right hand sides of your equations should contain numbers, rather than symbols, except for the gas constant and Faraday's constant.

[Hints: pH = log(1/activity of hydrogen ion). Natural and base 10 logs are related by

ln(x) = 2.303log(x)]

(b) What is the open circuit potential that shows on the voltmeter when the switch is open (again using the gas constant as a symbol but no others)?

(c) Which way will the current flow in the resistor when the switch is closed? Which way will electrons flow?

(d) Write down the reactions that occur at the hydrogen electrode and at the nickel when the switch is closed.

SHAPE * MERGEFORMAT

NAME……

1.

Switch

Ni

Resistor

Solution

Voltmeter

H_2 electrode