Chemistry 448
Fall 2000 Exam #2

This is a 90 minute exam.
It is open notes, but not open book.
You may use any handwritten or typed (by you) notes prepared prior to starting the exam.

Do *NOT* proceed to page 2 until you are ready to start (and continue for 90 consecutive minutes!

Prepare your handwritten or typed notes for the exam before proceeding to the next page.
You may not use handouts or books.

Name _____

Date _____

Start Time _____

End Time _____

If you have taken longer than allowed, please explain why, unless it is by prior arrangement.

The exam is in class on Monday 4 December, or to one of our offices before that time.

Prof. Weiss **407 Davey**
Prof. Allara **185 Materials Research Institute**

1) (30 points)

As discussed in Somorjai's book, when atoms are first adsorbed on a metal surface (for the first small fraction of a monolayer), there is typically a rapid linear change in the work function as a function of coverage. This is followed by a region of slower change up to monolayer coverage.

a) Describe work function with an annotated, labeled energy level diagram. (10 points)
b) Describe an experiment to determine the origin of these work function changes in which you also track the work function.
   What do you expect to see in each aspect of your experiment if the work function behaves as described above? (20 points)

2) (20 points)

The toy company for which you now work (!) has had a major catastrophe in their widget production line. The final assembly step in which part A is connected to part B appears to be failing, so that metal part A does not remain attached to plastic part B, despite the use of a series of 50 nm thick adhesive strips that are meant to couple the two.

Describe the experiments you will use to determine the point(s) of failure. (Note that you still have a small supply of good, intact widgets left over from last Christmas in your office.)

3) (50 points)

Consider the transition metal surface catalyzed reaction of N_2 (N≡N) and H_2:

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

A. Before you start to do experiments you want to make a guess at which metal might be the best catalyst to try.
   How might you do this? Give your reasoning in detail. (20 points)

B. You find the best metal catalyst by trial and error in the lab and begin producing NH_3 over a high surface area aluminum oxide powder containing metal clusters on the particle surfaces. (30 points)
   i. It is of interest to measure the equilibrium adsorption isotherm of NH_3 on the catalyst surface. Design an experiment to do this.
      Sketch the shape of the adsorption isotherm in terms of a plot of θ vs P.
      Show the plot between $\theta = 0$ to $\theta = 1$. How could these data be useful in understanding the catalytic process?
   ii. You switch to a single crystal surface to do fundamental studies of the mechanism. You think that the N_2 molecules dissociatively chemisorb on the surface.
      Design an experiment (or experiments) to test this hypothesis. Include the capability to be able to count the actual number, *N*, of atoms produced on the surface as a function of the N_2 dose (in *Langmuirs*).