Chemistry 140 Name:

Exercise 2: Pennium

Objective:

a. Determine the mass and relative abundance of two "isotopes" of pennies.

b. Illustrate the principle of averages and standard deviations, and how they can be used to distinguish between random and systematic errors.

During the 1980s, copper prices on the spot market were so high that the US Mint spent more than one cent to make a copper penny. Starting sometime during that decade, the US Mint decided to change the composition of a penny from a 95% copper/5% zinc alloy to a 97.6% zinc/2.4% copper mixture, with the copper primarily in the cladding of the penny.

1. Write the **formula** for calculating the individual **percent abundances** of two isotopes of an element (let's call it "pennium"), given that you know the atomic masses (mass numbers) of the two pennium isotopes, as well as the overall (average) atomic mass of pennium. Hint: Let x = the percent abundance of isotope 1 of pennium. What must the percent abundance of isotope 2 be? Further hint: The math is remarkably similar to the analysis found towards the bottom of page 48 of the text.

Materials needed:

- A roll of pennies from before 1982
- A roll of pennies from after 1982
- A roll of pennies with mixed dates
- Electronic balance

(Note: a roll of pennies should contain 50 coins)

Remember: Use the **same balance** for the entire lab.

Procedure (work in pairs, but each person should turn in their own exercise)**:**

2. a. Weigh the roll of pennies from before 1982. Write this mass down, along with the proper units.

b. Weigh the roll of pennies from after 1982. Write this mass down.

c. Weigh the roll of pennies from the mixed bunch. Write this mass down.

The roll of pennies with mixed dates represents a sample of the element pennium.

3. Why did you measure the roll of pennies from before 1982? In other words, what do the "before 1982" pennies represent, in the element pennium analogy? Why did you measure the roll of pennies from after 1982? In other words, what do the "after 1982" pennies represent, in the element pennium analogy?

4. a. What is the **average** mass of a penny from before 1982? Show your work.

b. What is the **average** mass of a penny from after 1982? If you did part a correctly, you need not show your work.

c. What is the **average** mass of a penny with mixed dates? If you did part a correctly, you need not show your work.

5. Using your formula from question 1, calculate the **percent abundance** of the two isotopes of pennium. Please show your work.

6. Transfer the group data shown in the overhead transparency at the front of the class onto either your calculator or the Excel spreadsheet on the classroom laptops. Obtain a **class average** for each of the different decade pennies. Note: use the "Getting Started on Excel" instructions if you have not used this program before.

7. Calculate the **percent difference** between the pennies of your rolls and the class averages for the different decades.

8. a. Using Excel or your calculator, calculate the **standard deviation** of the roll of pennies from before 1982.

b. Using Excel or your calculator, calculate the **standard deviation** of the roll of pennies from after 1982.

c. Using Excel or your calculator, calculate the **standard deviation** of the roll of pennies with mixed dates.

9. Express the mass of a penny from before 1982 as "average mass ± standard deviation (units)". Express the mass of a penny from after 1982 using the same format.

10. a. To the **"two-sigma" significance level** (remember that "one sigma" is one standard deviation), are the masses of pennies of before 1982 **distinguishable** from the pennies of after 1982? Explain *thoroughly* how you arrived at your answer.

b. Are your penny mass averages within two sigma of the class averages for the appropriate decades? If not, then you have an **outlier** (I'm not marking you off for this, but realize that it means you have a piece of data that should be looked at more closely).

c. If your answer to question 10a had been "no", would you be as **confident** of your answers to question 3? Why not?

Extra credit — In a roll of mixed date pennies from the 1980s (in other words, pennies minted between 1980 and 1989), what should be the average number of pennies from 1980, 1981 or 1982? Then what should the *expected* mass of a mixed date penny roll be? (You can consider this the "published" value against which your value is compared) How does your roll compare (in other words, were the pennies randomly chosen to be put in the roll or were they probably selected?)?