MTS723 F97 Homework 2 Solution J. J. Weimer 1.Oct.97

Problem 1

See the separate plot of Deviation versus Measured BE for the values.

offset = -0.13 ± 0.01 eV

scaling = - 2.4 x 10e-4 eV/eV   random = - 0.3 x 10e-4 eV/eV

A peak measured to be at 287.50 eV will have a deviation of - 0.209 ± 0.007 eV. This is determined using the equation of the straight line fit as well as the maximum and minimum slope lines.

Not accounting for measurement errors, its actual BE will be 287.71 ± 0.01 eV.

Problem 2

The relationship between KE, BE, and phi is   KE = hv - BE - phi

The uncertainity in setting phi will propagate as an absolute error in KE. Therefore, the total uncertainity in a BE for a peak measured in a spectrum with a 0.05 eV step size is

```
> totalerror =sqrt((0.05/2)^2 + (0.05/2)^2);
```

$$totalerror = .03535533906$$

The error is ± 0.04 eV.

Problem 3

The values of peak-to-peak intensity were measured using a millimeter ruler. The values are

```
> IA := array([47.5,43,49.5,54,56]); IB := array([21.5,20,15.5,21,20]);
```

$$IA := [\,47.5,\ 43,\ 49.5,\ 54,\ 56\,]$$

$$IB := [\,21.5,\ 20,\ 15.5,\ 21,\ 20\,]$$

Determine the intensity ratios, average, and standard deviation

> $IR_i := \frac{IB_i}{IA_i}$

> $average := \frac{\sum_{i=1}^{5} IR_i}{5}$

$$average := .3953821834$$

> $standdev := \sqrt{\frac{\sum_{i=1}^{5} (IR_i - average)^2}{4}}$

$$standdev := .06405066743$$

The ruler had a precision of ± 0.5 mm. The relative measurement error on each intensity is determined from

> $REIR_i := \sqrt{\left(\frac{.5}{IA_i}\right)^2 + \left(\frac{.5}{IB_i}\right)^2}$

The absolute error on each point is

```
> AEIR[i] := REIR[i]*IR[i];
```

$$AEIR_i := \frac{\sqrt{\frac{.25}{IA_i^2} + \frac{.25}{IB_i^2}}\ IB_i}{IA_i}$$

The total measurement error on the average value is

> $TMEIR := \sqrt{\frac{\sum_{i=1}^{5} AEIR_i^2}{5}}$

$$TMEIR := .01094152212$$

The total error incorporates the standard deviation and measurement errors

> $TEIR := \sqrt{TMEIR^2 + standdev^2}$

$$TEIR := .06497849570$$

The estimated ratio of IA/IB is 0.40 ± 0.06.

Since the standard deviation of the values dominates, the reported value and error will be essentially unchanged even if the measurement error were to be reduced to zero.

Just for fun, here are the values determined from by subtracting max-min at each peak in the raw data.

```
> IA := array([0.343804,0.332213,0.302863,0.259989,0.288143]):
  IB := array([0.123323,0.129097,0.0978825,0.120143,0.132713]):
> average;
```

.3953821834

```
> standdev;
```

.06405066743

This gives a value of IA/IB of 0.40 ± 0.06.

Based on the above results, the extra effort that was required to reduce the measurement errors to zero did not pay off. Measurements by hand using a ruler were just as accurate.

The following is generally true:

To reduce the error in a reported result, DO MORE EXPERIMENTS --- TAKE MORE DATA!