CHEM 221

Instrumental Analysis

Problem Set #1 – Solutions

Spring 2005

Appendix 1

#1 a & b, #2 a & b.

Mean = $\Sigma X_i/N = X_{avg}$
Standard Deviation = <use Std Dev calculator function> = s
Relative Std Dev (RSD), ppt = $(s/X_{avg}) \times 1000$
Error = $X_{avg} - \mu$
%-relative error = $(\text{error}/\mu) \times 100$

	A	B	C	D
X_{avg}	61.43	3.25	12.10	2.6
s	0.11	0.02	0.06	0.2
RSD	1.7 ppt	6.0 ppt	4.7 ppt	79. ppt
μ	61.71	3.28	12.23	2.75
error	-0.28	-0.03	-0.13	-0.10
%-rel error	-0.45 %	-0.91 %	-1.1 %	-3.6 %

#3.

a. (–0.5 mg/25 mg) × 100 = ***-2.0 %***
b. (-0.5 mg/100 mg) × 100 = ***-0.5 %***
c. (-0.5 mg/250 mg) × 100 = ***-0.2 %***
d. (-0.5 mg/500 mg) × 100 = ***-0.1 %***

#4.

a. 0.5 mg/x = 0.001 → x = 500 mg Cu

(sample mass) × 0.048 = 0.500 g
sample mass = ***10. grams***

b. x = 100 mg Cu
sample mass = ***2.1 grams***

c. x = 62.5 mg Cu
sample mass = ***1.3 grams***

d. x = 41.67 mg Cu
sample mass = ***0.87 gramsf***

#7.

(0.18)(0.400 g sample) = 72.0 mg Cr

error = -1.8 mg Cr $\rightarrow$ (-1.8 mg/72.0 mg) $\times$ 1000 = ***-25. ppt***

Chapter 1

#9. A plot of the data gives a straight line with a linear least squares determined equation: $S = 0.0670\ c_x + 0.031$

a). The calibration sensitivity is simply the slope of the analytical curve: ***0.0670***

b). The analytical sensitivity (γ) is: m/s_s (where: m = slope of analytical curve and s_s = standard deviation of the signal). So, since s_s varies with the concentration, the analytical sensitivity will also vary with concentration giving:

Conc (ppm)	γ
2.00	7.1 (= 0.0670/0.0094)
6.00	8.0
10.00	8.0
14.00	7.9
18.0	6.1

c). The coefficient of variation (CV) = (s_s/S) x 100% (this is also commonly referred to as the % relative standard deviation (%RSD). Since this varies with concentration also:

Conc (ppm)	CV
2.00	5.4% (= (0.0094/0.173) x 100%)
6.00	2.0%
10.00	1.2%
14.00	0.89%
18.00	0.88%

d). Recall equation 1-4 on page 13: $S_m = S_{avgbl} + 3s_{bl}$

Substituting in the values for this set of data gives:

$$S_m = 0.031 + 3(0.0079) = 0.0547$$

This is the *measured* signal at the detection limit.

We use the linear least squares equation to find the corresponding concentration at the detection limit:

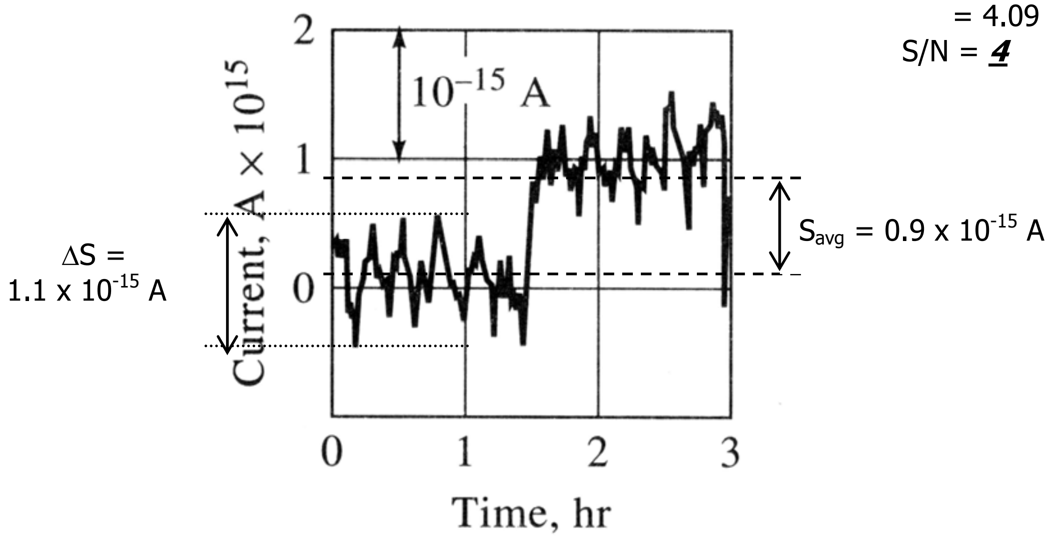
$$S_m = 0.0670\ c_m + 0.031$$

Solving for c_m gives: $c_m = (S_m - 0.031)/0.0670 = (0.0547 - 0.031)/0.0670$

c_m = ***0.35 ppm X***

Chapter 5

#6.



So: $S/N = 5\,S_{avg}/\Delta S$

$$= \frac{5(0.9 \times 10^{-15}\ \text{A})}{1.1 \times 10^{-15}\ \text{A}}$$

$= 4.09$

S/N = ***4***

#7.

a. From data set (n=9), we calculate: avg = 1.002889 g = Signal
s = 0.002804 g = Noise

So, S/N = 1.002889/0.002804 = 357.7 ≈ ***360***

b. We know that: $(S/N)_n = (n)^{1/2}(S/N)_{n=1}$
So, for n=9: $357.7 = (9)^{1/2}(S/N)_{n=1}$
$(S/N)_{n=1} = 119.23$

For S/N = 500: $500 = (n)^{1/2}(119.23)$
$(n)^{1/2} = 4.1935$
n = 17.59 ≈ ***18***

#8.

a. From data set (n = 8): avg = Signal = 1.435
S = Noise = 0.2707 so: S/N= ***5.3***

b. Using same method as in #7b, $(S/N)_{n=1} = 1.874$,
so to get S/N = 10, need n = 28.5 ≈ ***29***