

3. Why do systematic (determinate) errors typically have a larger impact on the accuracy of a measurement than indeterminate errors?

Do four of problems 4-8. Clearly mark the problem you do not want graded. (15 pts each)

4. The data below is for the determination of sodium in potato-chip samples using atomic spectroscopy. Least-squares analysis resulted in a line with slope of 0.016394 V/ppm and an intercept of 0.041373 V. Measurement of a single unknown sample resulted in a signal of 0.576 V. Calculate the concentration of sodium in the unknown, and its 95% confidence interval. The value for the D determinate is 9850.

	Na Conc. x (ppm)	Signal y (V)	x^2	y^2	xy	y_{line}	residuals d	d^2	$(x_i - \bar{x})^2$
	5	0.088	25	0.007744	0.440	0.1233	-0.03535	0.001249	676
	15	0.299	225	0.08940	4.485	0.2872	0.01171	0.000137	256
	30	0.560	900	0.3136	16.80	0.5332	0.02679	0.000718	1
	45	0.820	2025	0.6724	36.90	0.7791	0.04087	0.001671	196
	60	0.981	3600	0.9623	58.86	1.0250	-0.04404	0.001939	841
Sum (Σ)	155	2.748	6775	2.0455	117.48	2.748	2.2×10^{-16}	0.005715	1970
Average	31	0.5496	1355	0.4091	23.497	0.5496	4.4×10^{-17}	0.001143	394

5. A series of titrations have been run in order to determine the percent benzoic acid (molar mass 122.123 ± 0.002 g/mol) in a solid mixture that contains benzoic acid and an inert compound. If it requires 42.07 ± 0.02 mL of 0.0997 ± 0.0004 M NaOH to neutralize the benzoic acid present in 1.5835 ± 0.0002 grams of the sample, what is the percent benzoic acid in the unknown? Include calculation of the absolute uncertainty in your result. Benzoic acid is a monoprotic acid.
6. While preparing for this exam, one of your classmates asks you why a confidence interval is used to describe the “quality” of a result, as opposed to a standard deviation alone. Clearly explain why a confidence interval is used and what types of information we can infer from the confidence interval about the quality of a result.

7. The Au content (wt %) of a single ore sample was determined using two independent methods. The results for five replicate measurements of the same sample for each method are given the table below. Do the results indicate a significant difference at the 95% confidence level?

Measurement	1	2	3	4	5
Method A	0.0134	0.0144	0.0126	0.0125	0.0137
Method B	0.0135	0.0156	0.0137	0.0137	0.0146

8. You have been given the task of teaching a quantitative analysis student, Al Thumbs, the proper laboratory techniques to obtain high quality quantitative results. Chose **one** of the two lab procedures below and clearly describe your instructions to this student, include reminders of common pitfalls Al should avoid.
- Handling and accurately massing solid samples
 - The proper use of a Class A buret for titrations

Blank Space if You Need Extra Room

PERIODIC CHART OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VIIIB	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	INERT GASES		
1 H 1.00797														1 H 1.00797	2 He 4.0026		
3 Li 6.939	4 Be 9.0122										5 B 10.811	6 C 12.0112	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183	
11 Na 22.9898	12 Mg 24.312										13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948	
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
55 Cs 132.905	56 Ba 137.34	*57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	†89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 ? (271)	111 ? (272)	112 ? (277)						

Numbers in parenthesis are mass numbers of most stable or most common isotope.

Atomic weights corrected to conform to the 1963 values of the Commission on Atomic Weights.

The group designations used here are the former Chemical Abstract Service numbers.

*** Lanthanide Series**

58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (147)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97
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† Actinide Series

90 Th 232.038	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (256)	103 Lr (257)
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Possibly Useful Information

$m = \frac{m' \left(1 - \frac{d_a}{d_w}\right)}{\left(1 - \frac{d_a}{d}\right)}$	<p>Density of air = 0.012 g/ml Density of balance weights = 8.0 g/ml</p>
$\mu = \bar{x} \pm \frac{ts}{\sqrt{n}}$	$y = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2/2\sigma^2}$
$t_{\text{calculated}} = \frac{ \text{known value} - \bar{x} }{s} \sqrt{n}$	$s = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{n-1}}$
$t_{\text{calculated}} = \frac{ \bar{x}_1 - \bar{x}_2 }{s_{\text{pooled}}} \sqrt{\frac{n_1 n_2}{n_1 + n_2}}$	$s_{\text{pooled}} = \sqrt{\frac{s_1^2(n_1 - 1) + s_2^2(n_2 - 1)}{n_1 + n_2 - 2}}$
$t_{\text{calculated}} = \frac{\bar{d}}{s_d} \sqrt{n}$	$s_d = \sqrt{\frac{\sum_i (d_i - \bar{d})^2}{n-1}}$
$m = \left \begin{array}{cc} \sum (x_i y_i) & \sum x_i \\ \sum y_i & n \end{array} \right \div D$	$b = \left \begin{array}{cc} \sum x_i^2 & \sum (x_i y_i) \\ \sum x_i & \sum y_i \end{array} \right \div D$
$D = \left \begin{array}{cc} \sum x_i^2 & \sum x_i \\ \sum x_i & n \end{array} \right $	$s_y = \sqrt{\frac{\sum (d_i - \bar{d})^2}{n-2}} = \sqrt{\frac{\sum d_i^2}{n-2}}$
$s_m^2 = \frac{s_y^2 \times n}{D}$	$s_b^2 = \frac{s_y^2 \sum x_i^2}{D}$
$s_x = \frac{s_y}{ m } \sqrt{\frac{1}{k} + \frac{x^2 n}{D} + \frac{\sum x_i^2}{D} - \frac{2x \sum x_i}{D}}$	$s_x = \frac{s_y}{ m } \sqrt{\frac{1}{k} + \frac{1}{n} + \frac{(y - \bar{y})^2}{m^2 \sum (x_i - \bar{x})^2}}$
$Q_{\text{calculated}} = \frac{\text{gap}}{\text{range}}$	$G_{\text{calculated}} = \frac{ \text{suspect value} - \bar{x} }{s}$
$F_{\text{calculated}} = \frac{(s_1)^2}{(s_2)^2}$	<p>Look both ways before crossing the street</p>

Values of Student's t

Degrees of Freedom	Confidence Level (%)			
	90	95	99.5	99.9
1	6.314	12.706	127.32	636.619
2	2.920	4.303	14.089	31.598
3	2.353	3.182	7.453	12.924
4	2.132	2.776	5.598	8.610
5	2.015	2.571	4.773	6.869
6	1.943	2.447	4.317	5.959
7	1.895	2.365	4.029	5.408
8	1.860	2.306	3.832	5.041
9	1.833	2.262	3.690	4.781
10	1.812	2.228	3.581	4.587
20	1.752	2.086	3.153	3.850
30	1.697	2.042	3.030	3.646
40	1.684	2.021	2.971	3.551
60	1.671	2.000	2.915	3.460
120	1.658	1.980	2.860	3.373
∞	1.645	1.960	2.807	3.291

Values of Q for rejection of data

# of Observations	Q (90% Confidence)
4	0.76
5	0.64
6	0.56
7	0.51
8	0.47
9	0.44
10	0.41

Grubbs Test for Outliers

# of Observations	$G_{critical}$ At 95% confidence
4	1.463
5	1.672
6	1.822
7	1.938
8	2.032
9	2.110
10	2.176

Critical Values of F at the 95% Confidence Level

Degrees of freedom for s_2	Degrees of freedom for s_1								
	2	3	4	5	6	7	8	9	10
2	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4
3	9.55	9.28	9.12	9.01	8.94	8.89	8.84	8.81	8.79
4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96
5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74
6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06
7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64
8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35
9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14
10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98