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APPENDIX

5.8 Limits of Detection and Determination

Important characteristics of a method are the limits of detection and determination. The limit of detection is the smallest concentration giving a significant response of the instrument that can be distinguished as being present to above the blank or background response. The limit of determination is the smallest amount of measurand that can be measured with a stated precision.

If a blank material, that is, the matrix of the test material without the analyte, can be analyzed a number of times, the limit of detection is often defined as three times the standard deviation of this blank determination. The limit of detection of the instrumental response is therefore $y_B + 3s_B$, where the subscript B refers to a blank determination. The corresponding concentration is then calculated from the calibration equation (equation 5.4), if it may be assumed that the equation is valid down to that concentration:

$$\hat{x}_{DL} = \frac{y_B + 3s_B - a}{b} \tag{5.27}$$

It may be not possible to make a measurement in the absence of the analyte. In this case it is reasonable to substitute the intercept of the calibration equation for the blank response (after all, it is supposed to be the response when the concentration is zero) and the standard error of the regression, $s_{y/x}$ for the standard deviation of the blank. In equation 5.27, therefore, $y_B = a$ and $s_B = s_{y/x}$, which gives

$$\hat{x}_{DL} = \frac{3s_{y/x}}{b} \tag{5.28}$$

Equation 5.28 has the advantage that it is calculated entirely from the calibration equation. A more statistically defensible equation from calibration data has been published by ISO (ISO 11843-2:2000, ISO, Geneva):

$$\hat{x}_{DL} = \frac{2t_{0.05,n-2}s_{y/x}}{b}\sqrt{\frac{1}{K} + \frac{1}{I \times J} + \frac{\bar{x}^2}{J\sum_i (x_i - \bar{x})^2}} \tag{5.29}$$

Here, a calibration is performed with I independent calibration materials (including a blank if possible and a calibrator having a value near the expected detection limit) each measured J times. K is the number of replicate measurements that will be done on each test solution to give an average response. (If you are willing to do more repeats you are more likely to pick up the presence of the analyte at small concentrations.) Note that as the t-statistic limits to the value 1.64 for large n, this equation multiplies $s_{y/x}/b$ by at least 3.3 (for $K = 1$), and so gives somewhat greater detection limits than equation 5.28.

Precision and Reproducibility

Table A1 Analyte concentration versus precision within or between days (88)

Analyte %	Analyte ratio	Unit	RSD [%]
100	1	100%	1.3
10	10-1	10%	2.8
1	10-2	1%	2.7
0.1	10-3	0.1 %	3.7
0.01	10-4	100 ppm	5.3
0.001	10-5	10 ppm	7.3
0.0001	10-6	1 ppm	11
0.00001	10-7	100 ppb	15
0.000001	10-8	10 ppb	21
0.0000001	10-9	1 ppb	30

Accuracy and recovery

Table A2 Analyte recovery at different concentrations (88)

Active Ingred. [%]	Analyte ratio	Unit	Mean recovery [%]
100	1	100%	98-102
>=10	10-1	10%	98-102
>=1	10-2	1%	97-103
>=0.1	10-3	0.1 %	95-105
0.01	10-4	100 ppm	90-107
0.001	10-5	10 ppm	80-110
0.0001	10-6	1 ppm	80-110
0.00001	10-7	100 ppb	80-110
0.000001	10-8	10 ppb	60-115
0.0000001	10-9	1 ppb	40-120

VITAE

Name:		Sarawadee Korsrisakul
Date and place of birth:		6 January 1982, Bangkok, THAILAND
Home:		234/35 Teparuk Rd. Tararuk, Maung, Samutprakarn, 10270, Thailand
Education:	2006-2004	Chulalongkorn University, postgraduate study leading to a Master of Science degree in Analytical chemistry
	2003-2001	Burapha University, Bachelor of Science (Chemistry)