1.1. A transducer is a device that converts information contained in chemical or physical domain into an electrical signal or the reverse. The most common input transducers convert chemical or physical information to current, voltage, or charge and the most common output transducers convert electrical signals into some numerical form.

1.7. (a) LCD readout, indicates alphanumeric information.
(b) Computer monitor, indicates alphanumeric information.
(c) Second hand on an analog clock, indicates time by position of the second hand.
(d) Laser printer, produces plots of experimental data for interpretation

1.8. A figure of merit is a criterion that demonstrates the quantitative performance of a certain method.

1.9. Using Beer's Law, A=εbc, and since signal is proportional to concentration:
$A_1 = 23.6$ $A_2 = 37.9$

$c_1 = ?$ $c_2 = \dfrac{(0.025\text{ L})(c_1) + (0.0287\text{ M})(.0005\text{ L})}{.0255L}$

$$\frac{A_1 = \varepsilon bc_1}{A_2 = \varepsilon bc_2} \rightarrow \frac{A_1}{A_2} = \frac{c_1}{c_2} \rightarrow c_1 = \left(\frac{A_1}{A_2}\right)c_2 = \left(\frac{23.6}{37.9}\right)\frac{(0.0287M)(.0005L) + (0.025L)(c_1)}{0.0255L} \rightarrow c_1 = 0.0009M$$

1.10.

A	B	C	D	E
1	**Conc. (mM)**	**A**	Σx_i^2	220
2	0	.002	$(\Sigma x_i)^2$	900
3	2	.150	$\Sigma x_i y_i$	15.68
4	4	.294	Σx_i	32.154
5	6	.434	Σy_i	2.154
6	8	.570	$\bar{x}$	5
7	10	.704	$\bar{y}$	0.359

a.) From appendix a1D-2, the slope of the curve can be found using $m = \dfrac{S_{xy}}{S_{xx}}$ where S_{xx} and S_{xy} are the sum of the squares of the deviations from the mean. To Caclulate S_{xx} and S_{xy}, use the following equations

$$S_{xx} = \sum x_i^2 - \frac{(\sum x_i)^2}{N} = 220 - \frac{900}{6} = 70$$

$$S_{xy} = \sum x_i y_i - \frac{\sum x_i \sum y_i}{N} = 15.68 - \frac{(30)(2.154)}{6} = 4.91$$

$$m = \frac{S_{xy}}{S_{xx}} = \frac{4.91}{70} = 0.0701$$

The intercept can be found using the formula for a line $\bar{y} = m\bar{x} + b$, where $\bar{y}$ and $\bar{x}$ are the averages of the y data and x data, respectively. This can be rearranged to solve for b, to get the following:

$$b = \bar{y} - m\bar{x} = 0.359 - (0.0701)(5) = 0.0085$$

b.) The equation must be entered as an array in Excel. To do this, first select the number of cells that the data is going into, and press Ctrl+Shift+Enter to enter the data. The formula line should look like so, using the table above:
=LINEST(C2:C7,B2:B7,true,true)
And the equation should output the following cells:

Slope	0.070143	0.008286	**Intercept**
S_m	**0.000667**	**0.004039**	**S_b**
R^2	0.999638	**0.005581**	**S_y**
	11058.76	**4**	**df**
SS_{reg}	0.344401	0.000125	

The numbers in bold are the useful values for this problem. S_m is the error in the slope, s_b is the error in the intercept, and S_y is the error in the measurement.

c.) One of the values output by the LINEST function is the degrees of freedom (df) of the measurement, which is useful in selecting a value of t in order to get our confidence intervals. Using Table a1-5, and the fact that degrees of freedom = 4 and a 95% confidence interval, we get a t-value of 2.78

$x \pm t\sigma$

where x is either the slope or intercept, and σ is the error in the slope or intercept.

Slope: $0.070143 \pm (2.78)(.000667) = 0.070 \pm .002$
Intercept: $0.008286 \pm (2.78)(0.004039) = 0.008 \pm .01$

Another way of going about this problem is to assume that we only have one measurement of the slope or intercept, so we must use the table of z values on page 978, and for our 95% confidence level, the z value is 1.96, and plugging into the equation above we obtain

Slope: $0.070143 \pm (1.96)(.000667) = 0.070 \pm .001$
Intercept: $0.008286 \pm (1.96)(0.004039) = 0.008 \pm .01$

d.) The concentration value can be calculated by rearranging our y = mx +b function to solve for x, and plugging in our values of y, m, and b.

$$x = \frac{y - b}{m} = \frac{0.350 - 0.0085}{0.0701} = 4.872M$$

The standard deviation for the concentration measurement can be found using the following equation:

$$s_c = \frac{s_y}{m}\sqrt{\frac{1}{M}+\frac{1}{N}+\frac{(\bar{y}_c-\bar{y})^2}{m^2 S_{xx}}}$$

Where s_y is the error in the estimate, which was calculated using the LINEST function, M is the number of replicates in our measurement (1 in this case), N is the number of points in the calibration (6), $\bar{y}_c$ is the average of the calibration y values, and $\bar{y}$ is the average y value in our measurement (0.350 since we only have one measurement). S_{xx} was calculated in part a as part of the slope calculation. Plugging these numbers into the equation gives

$$s_c = \frac{0.005581}{0.0701}\sqrt{\frac{1}{1}+\frac{1}{6}+\frac{(0.359-0.350)^2}{(0.0701)^2 70}} = 0.086 = 0.09$$

Giving a value of 4.87 ± .09 M