Chapter 3

10. - systematic errors are repeatable and their source can be determined and avoided
- random errors can cause experimental values to either increase or decrease and cannot be avoided.

12. a. - the 0.031 mL above 25mL is systematic error
- the ±0.009mL is random error.

b. - the difference between the actual volume delivered (1.98mL and 2.03mL) and the volume delivered according to the buret is systematic error
- the variation in the volume delivered (0.01mL and (0.02mL) is random.

c. The average amount that the volume delivered is low: in this case $25 - \left(\frac{1.9839+1.9900}{2}\right) = 0.0130$ mL is systematic.
- The variation in the amount delivered (0.0061 mL) is random

d. The variation in peak areas is random. With the information given, there is no way to tell if systematic error is present.

15. a. $6.2 - 4.1 = 2.1$

$e = \sqrt{0.2^2 + 0.1^2}$

$= 0.2_2$

$\boxed{2.1(\pm 0.2)}$ and $\boxed{2.1(\pm 10\%)}$

b. $9.43 \times 0.016 = 0.15_1$

$e_{rel} = \sqrt{\left(\frac{0.05}{9.43}\right)^2 + \left(\frac{0.001}{0.016}\right)^2}$

$= \sqrt{2.8 \times 10^{-5} + 3.9 \times 10^{-3}}$

$e_{rel} = 0.06_3$ $\quad 9.5 \times 10^{-3}$

$e = 0.06_3 \times 0.15_1 = 9.47 \times 10^{-3}$

$= \boxed{0.151 \pm 0.009}$ or $0.15(\pm 0.01)$

$= \boxed{0.151(\pm 6\%)}$

c. $(6.2 - 4.1) \div 9.43 = 0.22_3$

$e = \sqrt{0.2^2 + 0.1^2} = 0.2_2$

$e_r = \sqrt{\left(\frac{0.2_2}{2.1}\right)^2 + \left(\frac{0.05}{9.43}\right)^2}$

$= \sqrt{1.1_0 \times 10^{-2} + 2.8 \times 10^{-5}}$

$= ~~0.01_2~~ \quad 0.1_0$

$e = 0.1_0 \times 0.22_3 = 0.02_3$

$= \boxed{0.22(\pm 0.02)}$

$\boxed{0.22(\pm 10\%)}$

d. $9.43 \times \frac{(6.2\times10^{-3} + 4.1\times10^{-3})}{1.03\times10^{-2}} = 0.097_1$

$$e = \sqrt{(0.2\times10^{-3})^2 + (0.1\times10^{-3})^2}$$

$$= 2.2\times10^{-4}$$

$$e_{rel} = \sqrt{\left(\frac{2.2\times10^{-4}}{1.03\times10^{-2}}\right)^2 + \left(\frac{0.05}{9.43}\right)^2}$$

$$e_{rel} = \sqrt{\frac{0.047}{4.6\times10^{-4}} + 2.8\times10^{-5}}$$

$$= 0.021 \quad 0.022$$

$$e = 0.022(0.097_1) = 0.002$$

$$= \boxed{0.097(\pm 0.002)}$$

$$\boxed{0.097(\pm 2.2\%)}$$

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$$\frac{0.9674\ g\ Na_2CO_3}{27.35\ mL\ HCl} \left| \frac{1\ mol\ Na_2CO_3}{105.988\ g\ Na_2CO_3} \right| \frac{2\ mol\ HCl}{1\ mol\ Na_2CO_3} \left| \frac{1000\ mL}{1\ L} \right| = 0.667\ M$$

$$e_{rel} = \sqrt{\left(\frac{0.0009}{0.9674}\right)^2 + \left(\frac{0.04}{27.35}\right)^2 + \left(\frac{0.001}{105.988}\right)^2}$$

$$= \sqrt{8.66\times10^{-7} + 2.14\times10^{-6} + 8.90\times10^{-11}}$$

$$= 0.0017$$

$$e = 0.0017(0.667) = 0.001$$

$$\boxed{0.667(\pm 0.001)\ M}$$