SL & HL Answers to Uncertainties & errors in measurement and results questions

1. Repeating the measurements and taking an average will decrease the random error as the + or – uncertainties for each reading will tend to cancel each other out. If a systematic error is present repeating the measurements will have no effect on the systematic error as the same error will be present in each reading.

2. (a) Placing the magnesium directly on the balance will always give a reading that is 1.00 g too high. Repeating this measurement carefully several times will give precise results but they will always be 1.00 g too high.

(b) Weigh an empty container and record the mass then reweigh the container with the magnesium inside it. Both readings will be 1.00 g too high but the difference in mass between the two readings will be the accurate mass of the magnesium. Carefully repeat this process several times, possibly even with different containers, to obtain precise results.

3. The 25.0 cm^3 of water from the measuring cylinder can have a volume of between 24.0 and 26.0 cm^3. When placed in the burette this will be accurate between 23.95 and 26.05 cm^3

4. The student is being realistic about her reaction times in using the stop-watch. She will not be able to stop the watch and record the volume of gas within a time span of just 0.01 s.

5. (a) (i) (0.001/1.541) x 100 = 0.065 = 0.07%

(ii) (0.5/250.0) x 100 = 0.200 = 0.2 %

(iii) (0.04/25.00) x 100 = 0.160 = 0.2%

(iv) (0.001/0.100) x 100 = 1.00 = 1%

(v) (0.08/24.90) x 100 = 0.321 = 0.3%

(b) Total percentage uncertainty = 0.065 + 0.200 + 0.160 + 1.00 + 0.321 = 1.75%
(or using the 1 significant figure answers to (a) = 0.07 + 0.2 + 0.2 + 1 + 0.3 = 2%)

(c) Amount of NaOH in 24.90 cm^3 = 24.90 x 0.100/1000 = 2.49 x 10^{-3} mol
Since two mol of NaOH reacts with one mol of $(COOH)_2$

Amount of acid in 25.00 cm^3 = ½ x 2.49 x 10^{-3} = 1.245 x 10^{-3} mol
Amount of acid in 250.0 cm^3 = 1.245 x 10^{-2} mol
1.541 g gives 1.245 x 10^{-2} mol hence molar mass = 1.541/(1.245 x 10^{-2})
= 124 g mol^{-1}

Since the total uncertainty is 1.75% and 1.75% of 124 is 2.17 (or 2% to give 2.48)
Molar mass = 124 ± 2 g mol^{-1}. (Three significant figures are given as the molarity of the NaOH was given to three significant figures)

(d) Percentage error = [(126-124) / 126] x 100 = 1.6%

(e) The oxalic acid used was pure.
No other reactions were taking place.

(f) (It is worth noting that the greatest known uncertainty was due to the molarity of the standardized solution of sodium hydroxide and yet when doing practicals this is often ignored if the solution is provided by the teacher or technician.)