SL & HL Questions on Uncertainties & errors in measurement and results

1. Explain why repeating a measurement and taking the average of five separate readings of data will decrease the random error but have no effect on the systematic error.

2. A balance has been wrongly calibrated so that it always records a reading that is 1.00 g too high. Explain how, without recalibrating it, the balance could be used to obtain:
(a) an inaccurate and precise result for the mass of a piece of magnesium metal.
(b) an accurate and precise result for the mass of a piece of magnesium metal.

3. A 100 cm^3 measuring cylinder has an uncertainty of ± 1.00 cm^3. A student used the measuring cylinder to measure 25.00 cm^3 of a solution into a burette. The burette has an uncertainty of 0.05 cm^3. Assuming no other errors what range of readings could the burette give for the accurate transfer of the 25.00 cm^3 of solution.

4. A stop-watch states that it can record to ± 0.01 s. A student used this stop-watch to record measurements every 30 seconds for the volume of gas evolved in a particular reaction. She recorded her values of time with an uncertainty of ± 1 s. Explain why she gave the uncertainty as ± 1 s rather than ± 0.01 s.

5. 1.541 ± 0.001 g of hydrated oxalic acid crystals were dissolved in distilled water. The solution was placed in a 250.0 ± 0.5 cm^3 volumetric flask and the total volume made up to the mark with distilled water. After thoroughly mixing the contents, 25.00 ± 0.04 cm^3 of this solution was pipetted into a conical flask. This required 24.90 ± 0.08 cm^3 of 0.100 ± 0.001 mol dm^3 sodium hydroxide solution to be neutralised completely.
The equation for the reaction is: $(COOH)_2(aq) + 2NaOH(aq) \rightarrow (COONa)_2(aq) + 2H_2O(l)$
(a) Calculate the percentage uncertainty associated with:
(i) the mass of the oxalic acid.
(ii) the volume of the solution in the volumetric flask.
(iii) the volume in the pipette.
(iv) the molarity of the sodium hydroxide solution.
(v) the volume of sodium hydroxide solution used.
(b) Calculate the total percentage uncertainty for this experiment.
(c) Calculate the molar mass of the oxalic acid obtained from these experimental results to the correct number of significant figures and state the uncertainty.
(d) The correct literature value for the molar mass of the acid is 126.06 g mol^{-1}. Calculate the percentage error.
(e) State any other assumptions which may have affected the accuracy of the result.