

Q1

precision is a measure of reproducibility of individual results. It can be assessed by conducting replicate measurements and calculating the standard deviation or variance.

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} \quad v = s^2$$

accuracy is a measure of how close a result is to an actual or true value. It can be assessed by measuring a standard or certified reference material and calculating the difference expressed by % bias = $\frac{\text{expt} - \text{actual}}{\text{actual}} \times 100$

Q2 12 tablets yields 0.2774 g of Fe_2O_3

mass of Fe in tablet = ?

$$\text{mass of Fe in 12 tablets} = 0.2774 \text{ g} \times \frac{55.85 \text{ g/mol}}{159.69 \text{ g/mol}}$$

$$\times \frac{2 \text{ Fe mol}}{1 \text{ Fe}_2\text{O}_3 \text{ mol}}$$

$$= 0.1940 \text{ g Fe}$$

\therefore each tablet contains 0.01617 g

or 16.17 mg

Q3 comparison of two mean values

$$|\bar{x}_1 - \bar{x}_2| = \frac{t_{\text{pooled}}}{\sqrt{\frac{N_1 N_2}{N_1 + N_2}}}$$

$$\therefore t_{\text{calc}} = \frac{|\bar{x}_1 - \bar{x}_2|}{S_{\text{pooled}}} \cdot \sqrt{\frac{N_1 N_2}{N_1 + N_2}}$$

where $S_{\text{pooled}} = 8 \mu\text{g/L}$ since both means $n=5$

$$\begin{aligned} t_{\text{calc}} &= \left(\frac{87 - 63 \mu\text{g/L}}{8 \mu\text{g/L}} \right) \cdot \sqrt{\frac{25}{10}} \\ &= (3.00) \times (1.581) = 4.74 \end{aligned}$$

$$t_{\text{table}} (\text{at } df = 5 + 5 - 2 = 8) = 2.31 @ 95\%$$

Since $t_{\text{table}} < t_{\text{calc}}$, there is a statistically significant difference between the nitrite conc. in drinking water and rainwater.

Q4

$$N_{O_2} \cdot V_{O_2} = N_{S_2O_3^{2-}} \cdot V_{S_2O_3^{2-}}$$

$$N_{O_2} = \frac{(8.74 \text{ mL})(2.00 \times 10^{-3} \text{ eq/L})}{(20.0 \text{ mL})}$$

$$= 8.74 \times 10^{-4} \text{ eq/L of } O_2$$

$$K(O_2 \rightarrow H_2O) = \frac{4 \text{ mol } e^-}{1 \text{ mol } O_2 \rightarrow H_2O} = 4 \text{ eq/mol}$$

$$\text{Hence, } EW(O_2) = \frac{MW(O_2)}{K(O_2)} = \frac{32.0 \text{ g/mol}}{4 \text{ eq/mol}}$$

$$= 8.00 \text{ g/eq}$$

$$\text{or } 8,000 \text{ mg/eq}$$

$$\begin{aligned} \therefore \text{Conc of } O_2 &= 8.74 \times 10^{-4} \frac{\text{eq}}{\text{L}} \times 8,000 \frac{\text{mg}}{\text{eq}} \\ &= 6.992 \text{ mg/L } O_2 \end{aligned}$$

Q5

$$y = 500(\pm 5) + 10.0(\pm 0.1)$$

where $y = \text{signal} = 260 \pm 30$

$x = \text{conc of Ca in mM}$

$$m = 500. \pm 5$$

$$b = 10.0 \pm 0.1$$

$$\therefore x = \frac{y-b}{m} = \frac{260(\pm 30) - 10.0(\pm 0.1)}{500. \pm 5}$$

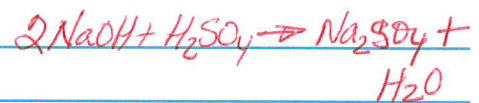
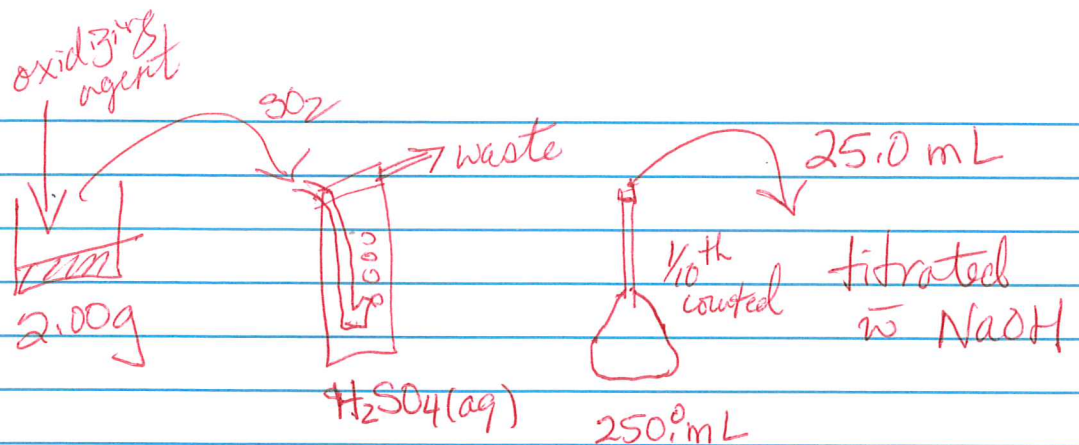
propagation of error depends on math +/- vs %

$$y-b \Rightarrow (260-10) \pm \left(\sqrt{(30)^2 + (0.1)^2} \right) \begin{array}{l} \text{absolute} \\ \text{errors} \\ \text{additive} \end{array}$$
$$= 250 \pm 30$$

$$\frac{(y-b)}{m} = \frac{250(\pm 30)}{500.(\pm 5)} \left(\pm \sqrt{\left(\frac{30}{250}\right)^2 + \left(\frac{5}{500}\right)^2} \right) \begin{array}{l} \text{relative} \\ \text{errors} \\ \text{are additive} \end{array}$$
$$= 0.500 \left(\pm \sqrt{0.0144 + 0.0001} \right)$$
$$= 0.500 \left(\pm 0.12 \text{ relative error} \right)$$

$$\therefore \text{Conc of Ca} = 0.500 \pm 0.060 \text{ mM}$$

Q6



$$\text{mass \% S} = \frac{\text{mass S}}{\text{mass sample}} \quad \leftarrow 2.00 \text{ g}$$

$$\text{mass S} = \# \text{ mol S} \times 32.0 \text{ g/mol}$$

$$\# \text{ mol S} = \# \text{ mol H}_2\text{SO}_4 \times \frac{1 \text{ mol S}}{1 \text{ mol H}_2\text{SO}_4}$$

$$\# \text{ mol H}_2\text{SO}_4 = \# \text{ mol NaOH} \times \frac{1 \text{ mol H}_2\text{SO}_4}{2 \text{ mol NaOH}}$$

$$\# \text{ mol NaOH} = M_{\text{NaOH}} \times V_{\text{NaOH}}$$

0.0100 N = 0.0100 M for NaOH

$$\text{mass S in 25 mL aliquot} = (1.00 \times 10^{-2} \frac{\text{mol}}{\text{L}}) (16.38 \times 10^{-3} \text{ L}) \times \frac{1 \text{ mol H}_2\text{SO}_4}{2 \text{ mol NaOH}} \times \frac{1 \text{ mol S}}{1 \text{ mol H}_2\text{SO}_4} \times$$

$$= 2.621 \times 10^{-3} \text{ g} \quad 32.0 \text{ g/mol}$$

$$\text{mass of S in sample} = 2.621 \times 10^{-2} \text{ g}$$

$$\text{mass \% in sample} = \frac{2.621 \times 10^{-2} \text{ g}}{2.00 \text{ g}} \times 100\% = 1.31\%$$

Q7

a) DOC vs POC

$\{CH_2O\}_{(aq)}$

vs

$\{CH_2O\}_{(s)}$

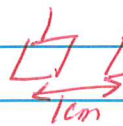
Both involve carbon containing compounds which are oxidizable and measured either by mass loss on ignition (550°C) or using CO_2 analyzer of exhaust combustion gases and reported as mg/L of C

Difference lies in whether or not they are initially dissolved (pass through $0.45\ \mu\text{m}$ filter) or suspended (do not pass $0.45\ \mu\text{m}$). Filtration with glass fibre membrane separates dissolved and suspended fraction of ~~known~~ sample with known volume.

b) Specific Conductivity vs Total Dissolved Solids

Both are a measure of the dissolved ion content of a water sample which is largely made up of inorganics (minerals).

Specific conductivity is measured with a conductivity meter ~~and~~ where the probe has been calibrated to yield a signal equivalent to that of two 1cm^2 inert metal electrodes at 1cm distance
units $\mu\text{S}/\text{cm}$
or mS/cm .



TDS is defined as the mass of all dissolved material (i.e. passes $0.45\ \mu\text{m}$ filter) of known volume of sample. Reported as mg/L

c) Total Hardness versus Total Alkalinity

Both measure ~~in~~ a portion of the mineral content dissolved in water and often reported as $\frac{\text{mg CaCO}_3}{\text{L}}$ equivalent amounts.

Total hardness measures all divalent metal ions (ie. Ca^{2+} , Mg^{2+}) and can be done volumetrically by titrating sample with standardized EDTA solution



Total alkalinity ~~is~~ measures the acid neutralizing capacity of water sample and can be done ~~by~~ volumetrically by titrating sample with standardized acid solⁿ.



$$[\text{alk}]_T = [\text{HCO}_3^-] + [\text{OH}^-] + 2[\text{CO}_3^{2-}]$$

Q8

$$\text{RF} = \frac{400/[\text{X}]}{600/[\text{S}]} = \frac{4}{6} = 0.6667$$

since $[\text{X}] = [\text{S}]$ ~~in M units~~

$$0.6667 = \frac{650/[\text{X}]}{250/[\text{S}]} \quad \text{where } [\text{S}] = 10.0 \mu\text{M}$$

$$0.6667 \left(\frac{250}{10.0 \mu\text{M}} \right) = \frac{650}{[\text{X}]}$$

$$16.67 \mu\text{M}^{-1} = \frac{650}{[\text{X}]}$$

$$\therefore [\text{X}] = \left(\frac{650}{16.67 \mu\text{M}^{-1}} \right) = 38.99 \mu\text{M} = 39.0 \mu\text{M}$$

$$Q9 \quad \frac{A_x}{A_x + S} = \frac{[X]_f}{[X]_f + [S]_f} \quad \text{both numerator and den}$$

both unspiked and spiked sample have same dilution total volume $\therefore [X]_i = [X]_f$

$$\left(\frac{0.210}{0.342} \right) = \frac{[X]_f}{[X]_f + \left(5.00 \frac{\text{ng}}{\text{mL}} \right)} \quad \text{where } [S]_f = 5.00 \frac{\text{ng}}{\text{mL}}$$

$$0.6034 = \frac{[X]_f}{[X]_f + 5.00 \frac{\text{ng}}{\text{mL}}}$$

$$0.6034 \left([X]_f + 5.00 \frac{\text{ng}}{\text{mL}} \right) = [X]_f$$

$$0.6034 [X]_f + 3.017 \frac{\text{ng}}{\text{mL}} = [X]_f$$

$$3.017 \frac{\text{ng}}{\text{mL}} = [X]_f - 0.6034 [X]_f$$

$$3.017 \frac{\text{ng}}{\text{mL}} = [X]_f (1 - 0.6034)$$

$$\therefore [X]_f = \frac{3.017 \frac{\text{ng}}{\text{mL}}}{(1 - 0.6034)} = 7.607 \frac{\text{ng}}{\text{mL}}$$

from 10.0 mL sample

$$\text{mass } S_f = 7.607 \frac{\text{ng}}{\text{mL}} \times 10.0 \text{ mL} = 76.07 \text{ ng}$$

from 175 mg bone sample

$$\frac{76.07 \text{ ng}}{175 \text{ mg}} = \cancel{0.435} \cdot 0.435 \frac{\text{ng}}{\text{mg}} = 0.435 \text{ ppm}$$

Q 10

- a) determinant \rightarrow negative bias as mass BaCO_3 not counted
- b) indeterminate \rightarrow remove air bubble
- c) indeterminate \rightarrow increase mass & dilute if necessary
- d) determinant \rightarrow positive bias as suspended solids scatter light which appears as 'absorbance'