1. An industrial plant on the Kwinana strip produces highly acidic waste water of pH 4.8. This waste must be neutralised prior to being discharged into the ocean.

   a) Determine the concentration of $H^+(aq)$ in the untreated waste water.

   b) What mass of $Ca(OH)_2(s)$ is needed to neutralise each kilolitre of waste water?

2. An accidental spillage of caustic soda (NaOH) at an industrial plant resulted in the contamination of a nearby freshwater pond. After several days, tests showed the pond water to have a pH of 9.50. The pond contains 4.70×10^7 L of water which originally had a pH of 7.00.

   a) Calculate the hydrogen ion concentration in the pond before and after the contamination.

   b) Calculate the hydroxide ion concentration in the pond before and after the contamination.

   c) Using your answer from b) determine the moles of hydroxide ion present in the pond before and after the contamination.

   d) If the change in the amount of hydroxide ion in the pond is due to sodium hydroxide only, determine the mass of sodium hydroxide which entered the pond.

   e) What is the concentration of sodium hydroxide in the pond water in ppm (parts per million)? Assume 1.00 L of pond water has a mass of 1.00 kg.

3. A limestone sample contains $CaCO_3$(s), silica (SiO_2) and some plant debris. In order to find the percentage $CaCO_3$(s) in the sample the following procedure was carried out.

5.43 g limestone sample is crushed.

↓

Sample is dissolved in 102 mL of 1.08 mol L^{-1} HCl solution.

Equation
$CaCO_3(s) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l) + Ca^{2+}(aq)$

↓

Mixture is filtered. → Residue is discarded.

↓

Filtrate is neutralised by addition of 28.7 mL of 0.836 mol L^{-1} NaOH solution.

Equation
$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$

a) Calculate the moles of HCl present prior to the addition of the limestone sample.

b) Calculate the moles of HCl neutralised by NaOH solution.

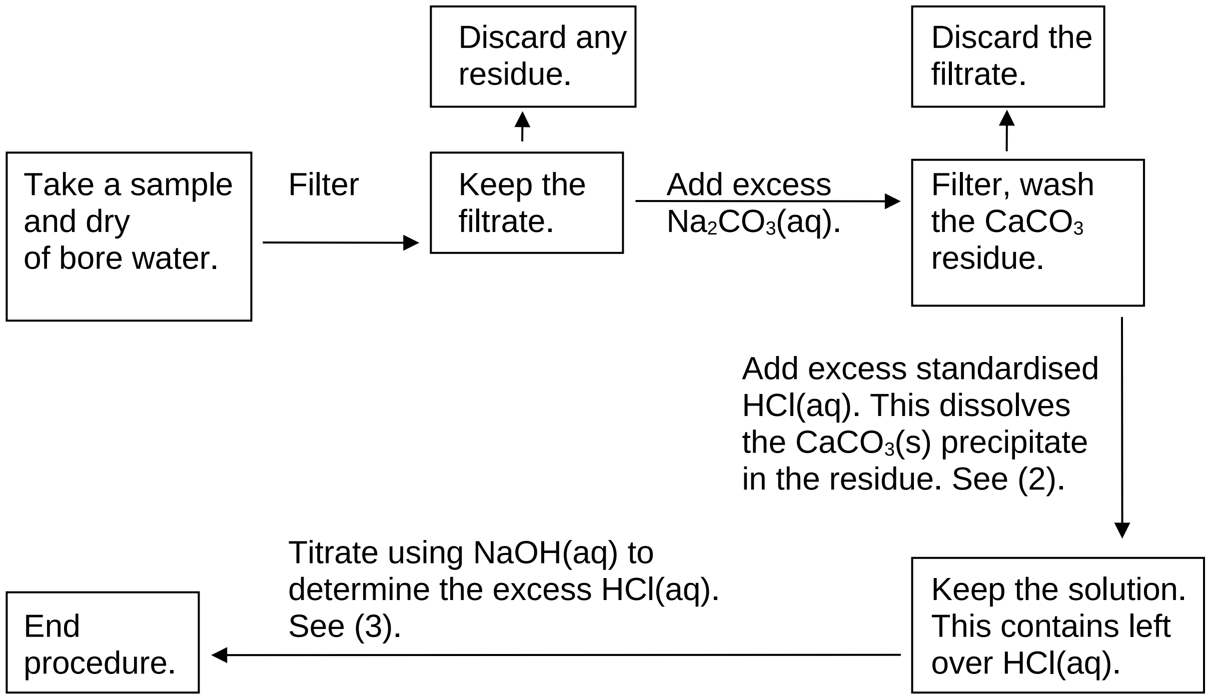
c) Determine the mass of $CaCO_3$(s) in the original limestone sample and hence calculate the percentage of $CaCo_3$(s) in the limestone.

4. A laboratory reagent bottle is labelled as 0.20 mol L^{-1} HNO_3(aq). Analysis of the solution shows a 20.00 mL sample of it produces 59.7 mL of carbon dioxide gas when treated with excess sodium carbonate. All measurements are made at 308 K and 99.5 kPa.

a) How many moles of carbon dioxide gas are produced?

b) Determine the actual concentration of nitric acid in the reagent bottle.

5. A cattle station owner is having problems with water quality from one of his station bores. The water from this particular bore is being used for household consumption and washing. Its high Ca^{2+}(aq) concentration is causing water hardness and its associated problems.
To determine the exact concentration of Ca^{2+}(aq) in his water supply a 2.000 L sample of bore water was collected and analysed as follows.



Data

Volume of bore water analysed	(1)	2.000 L
Volume of standardised HCl(aq)	(2)	50.00 mL
Concentration of standardised HCl(aq)	(2)	2.580 mol L^{-1}
Volume of standardised NaOH(aq)	(3)	29.70 mL
Concentration of standardised NaIH(aq)	(3)	2.034 mol L^{-1}

a) Determine the total moles of HCl(aq) added to dissolve the $CaCO_3$ residue.

b) Determine the moles of NaOH(aq) which neutralised the excess HCl(aq).

c) How many moles of HCl(aq) reacted with $CaCO_3$(s) from the residue?

d) Determine the moles of $CaCO_3$(s) present in the residue.

e) What was the concentration of Ca^{2+}(aq) in the original bore water?

Q1 a) pH = 4·8 wastewater

$[H^+] = 10^{-pH} = 10^{-4.8} = 1.58 \times 10^{-5}$

b) $C_{H^+} = 1.58 \times 10^{-5}$

$V = 1$ kilolitre $= 1000\,L$

$n_{H^+} = CV = (1.58 \times 10^{-5})(1000) = 0.01585$ mol

n_{OH^-} needed $= n_{H^+} = 0.01585$

$n_{Ca(OH)_2} = \frac{1}{2} \times n_{OH^-} = \frac{1}{2} \times 0.01585 = 0.007925$ mol

mass$_{Ca(OH)_2} = 0.007925 \times (40.08 + 2\times16 + 2\times1.008) = 0.587\,g$

Q2 original pond pH = 7.00 $(4.70 \times 10^7\,L)$
then pond pH = 9.50 (became more basic due to NaOH spill)

a) $[H^+]$ before spill $= 10^{-7.00} = 1 \times 10^{-7}$

$[H^+]$ after spill $= 10^{-9.50} = 3.16 \times 10^{-10}$

b) using $1 \times 10^{-14} = [H^+][OH^-]$

$[OH^-]$ before spill $= \dfrac{1 \times 10^{-14}}{1 \times 10^{-7}} = 1 \times 10^{-7}$

$[OH^-]$ after spill $= \dfrac{1 \times 10^{-14}}{3.16 \times 10^{-10}} = 3.164 \times 10^{-5}$

c) $n_{OH^-\,(before)} = CV = (1 \times 10^{-7})(4.70 \times 10^7) = 4.7$ mol

$n_{OH^-\,(after)} = CV = (3.164 \times 10^{-5})(4.70 \times 10^7) = 1487.08$ mol

d) $n_{OH^-\,(entering\ pond)} = 1487.08 - 4.7 = 1482.38$ mol

mass$_{NaOH} = 1482.38 \times (22.99 + 16 + 1.008) = 5.93 \times 10^4\,g$

1.

e) $ppm = \frac{mg \text{ of } NaOH}{kg \text{ of pondwater}}$

$= \frac{5.93 \times 10^4 \times 1000}{4.70 \times 10^7} = 1.26\,ppm$

Q3 a) $V = 102\,mL$

$C = 1.08\,M$

$n_{HCl} = cV = (1.08)(0.102) = 0.110\,mol$

b) $HCl + NaOH \rightarrow H_2O + NaCl$

$V = 28.7\,mL$

$c = 0.836\,M$

$n = cV = (0.836)(0.0287) = 0.02399\,mol.$

$n_{HCl} = n_{NaOH} = 0.02399\,mol$

c) n_{HCl} that reacted with $CaCO_3$ $= 0.110 - 0.02399 = 0.08601\,mol$

$CaCO_3 + 2HCl \rightarrow CO_2 + H_2O + CaCl_2$

0.08601

$n_{CaCO_3} = \frac{1}{2} \times n_{HCl} = \frac{1}{2} \times 0.08601 = 0.043\,mol$

$mass_{CaCO_3} = 0.043 \times (40.08 + 12.01 + 3 \times 16) = 4.30\,g.$

$\% CaCO_3 = \frac{4.30}{5.43} \times 100 = 79.3\,\%\,w/w$

Q4

HNO_3 — $c = 0.20M$ ← not considered accurate

take 20mL sample.

$$2HNO_3 + Na_2CO_3 \rightarrow CO_2 + H_2O + 2NaNO_3$$

$V = 59.7mL$
$T = 308K$
$P = 99.5kPa$

a) $PV = nRT$

$(99.5)(0.0597) = n(8.315)(308)$

$\Rightarrow n_{CO_2} = 2.32 \times 10^{-3} mol$

b) $n_{HNO_3} = \frac{2}{1} \times n_{CO_2} = \frac{2}{1} \times 2.32 \times 10^{-3} = 4.639 \times 10^{-3} mol$

$c_{HNO_3} = \frac{n}{V} = \frac{4.639 \times 10^{-3}}{0.02} = 0.232M$

Q5

a) $n_{HCl} = CV = (2.580)(0.05) = 0.129 mol$

b) $n_{NaOH} = CV = (2.034)(0.02970) = 0.0604 mol$

c) find n_{HCl} leftover after rxn with $CaCO_3$

$$HCl + NaOH \rightarrow H_2O + NaCl.$$

$n_{HCl} = n_{NaOH} = 0.0604 mol$

n_{HCl} that reacted with $CaCO_3$ $= 0.129 - 0.0604 = 0.0686 mol$

d) $CaCO_3 + \underset{0.0686}{2HCl} \rightarrow CO_2 + H_2O + CaCl_2.$

$n_{CaCO_3} = \frac{1}{2} \times n_{HCl} = \frac{1}{2} \times 0.0686 = 0.0343 mol$

$n_{Ca^{2+}} = n_{CaCO_3} = 0.0343$

$c_{Ca^{2+}} = \frac{n}{V} = \frac{0.0343}{2} = 0.0172M$

3.