$CH_3COO^- + H_2O \rightarrow CH_3COOH + OH^-$
(CH_3COO^- *is a stronger base than* H_2O)

18. *pH of 6 means* $[H^+] = 1 \times 10^{-6}$ *mol* L^{-1} *and a pH of 8 means* $[H^+] = 1 \times 10^{-8}$ *mol* L^{-1} *which is 100 times less than the first concentration.*

19. *(a)* $(NH_4)_2CO_3(s) + \text{water} \rightarrow 2NH_4^+(aq) + CO_3^{2-}(aq)$
This reaction (reaction 1) is an ionisation reaction.
$NH_4^+(aq)$ *produces* H_3O^+ *ions (reaction 2).*
It is from an acidic salt. Anions of basic salts produce H_3O^+ *ions.*
$CO_3^{2-}(aq)$ *produces* OH^- *ions (reaction 3).*
It is from a basic salt. Cations of acidic salts produce OH^- *ions.*
Reactions 2 and 3 are hydrolysis reactions.
NH_4^+ *ion is a weak acid. It does not produce many* H_3O^+ *ions. Although the carbonate ion is in the minority, it has a higher K value so it will react with water to give an excess of* OH^- *ions.*

20. *In a series, acids such as* H_3PO_4, $H_2PO_4^-$ *and* HPO_4^{2-} *the extent of dissociation decreases as* H^+ *ions had to be removed from negative ions and consequently their strength decreases also. (*H_3PO_4 *is the relatively strongest one of the three).*

Set 3 Acids/Base Reactions

Multiple Choice Answers

1. a, 2. e, 3. e, 4. e, 5. b, 6. c, 7. c, 8. e, 9. d, 10. e, 11. b, 12. b, 13. c, 14. c, 15. b, 16. c, 17. c, 18. b, 19. b, 20. c.

Acid Base Calculations

1. *No. of moles of* $Ca(OH)_2 = cV = 0.015 \times 0.02 = 3.0 \times 10^{-4}$ *mol*
$n(OH^-) = 2 \times 3.0 \times 10^{-4}$ *mol* $= 6.0 \times 10^{-4}$ *mol* ($Ca(OH)_2 \rightarrow 2OH^-$).
$n(H^+)$ *from* $HNO_3 = 0.010 \times 0.080 = 8.0 \times 10^{-4}$ *mol.*
OH^- *is the limiting reagent. So* 6.0×10^{-4} *moles of* H_2O *is formed and* $n(H^+)$ *left will be* $8.0 \times 10^{-4} - 6.0 \times 10^{-4} = 2.0 \times 10^{-4}$ *mol.*
Total volume of mixed solution = 20 + 80 = 100 mL so
$[OH^-] = n/V = 2.0 \times 10^{-4}/0.10 = 2.0 \times 10^{-3}$ *mol* L^{-1}
$pH = 2.7$

2. $NaOH(aq) + HNO_3(aq) \rightarrow NaNO_3(aq) + H_2O(l)$
$n(NaOH) = c \times V = 0.0250 \times 0.200$
$= 5.00 \times 10^{-3}$ *mol*
$n\ (HNO_3) = c \times V = 0.030 \times 0.175$
$= 5.25 \times 10^{-3}$ *mol*
From the equation 1 mol of NaOH reacts with 1 mol of HNO_3.
∴ 5.00×10^{-3} *mol of NaOH will react with* 5100×10^{-3} *mol* HNO_3.
→ HNO_3 *is in excess by* 0.25×10^{-3} *mol and* $[H^+] = n/V = (0.25 \times 10^{-3}/ 0.055)$
$= 4.55 \times 10^{-3}$ *mol* L^{-1}
∴ $pH = 2.35$

3. $Ba(OH)_2 + 2HNO_3 \rightarrow Ba(NO_3)_2 + 2H_2O(l)$
$n\ (Ba(OH)_2) = 0.0500 \times 0.200 = 0.0100$ *mol*
$n\ (HNO_3) = 0.200 \times 0.400 = 0.0800$ *mol*
From the equation, 1 mole of $Ba(OH)_2$ *reacts with 2 mols of* HNO_3.
Accordingly, 0.0100 mol of $Ba(OH)_2$ *reacts with 0.0200 mol of* HNO_3.
HNO_3 *is in excess by 0.0600 mol.*
The final concentration after diluting to 6.00 L is [0.0600 /6.00 L] = 0.01 M
$[H^+] = 1.0 \times 10^{-2}$ *M and,* $pH = 2.0$

4.
(a) $pH = 2$
∴ $[H^+] = 1.0 \times 10^{-2}$ *M; volume = 0.300 L*
∴ $n\ (H^+)$ *needed* $= 1.0 \times 10^{-2} \times 0.300$
$= 3.00 \times 10^{-3}$ *mol*
Hence, n *(HCl) needed* $= 3.00 \times 10^{-3}$ *mol*
∴ $m\ (HCl) = 3.00 \times 10^{-3} \times 36.46 = 0.109$ *g*
(b) $n\ (HCl) = 0.0730 / 36.46 = 2.00 \times 10^{-3}$ *mol.*
∴ $n\ (H^+) = 2.00 \times 10^{-3}$ *mol.*
$[H^+] = (2.00 \times 10^{-3} / 2.00\ L) = 1.0 \times 10^{-3}$ *M*
∴ $pH = 3.00$

5.
(a) $pH = 13$*, and hence* $[H^+] = 1.0 \times 10^{-3}$ *M and* $[OH^-] = 1.0 \times 10^{-1}$ *M*
$V = 0.600$ *L and,*
$n\ (NaOH) = c \times v = 1 \times 10^{-1} \times 0.600$
$= 6.00 \times 10^{-2}$ *mol*
$m\ (NaOH) = 6.00 \times 10^{-2} \times 40.0 = 2.40$ *g.*
(b) $m\ (NaOH) = 0.600$ *g and* $n\ (NaOH)$
$= 0.600/40.0 = 0.0150$ *mol*
$[NaOH] = n/V = 0.0150/ 1.500 = 0.01$ *M, and* $[OH^-] = 1.0 \times 10^{-2}$ *M*
∴ $[H^+] = 1.0 \times 10^{-12}$ *M, thus* $pH = 12.0$

6. $n\ (HCl) = 0.100 \times 0.020 = 2.00 \times 10^{-3}$ *mol*
pH required is 3. Therefore, $[H^+]$ *should be* 1.0×10^{-3} *M.*
Since the number of moles are the same before and after dilution,
$0.100 \times 0.020 = 1.0 \times 10^{-3} \times V$
$V = [(0.100 \times 0.020) / 1.0 \times 10^{-3}] = 2.0$ *L.*
∴ *Volume of water to be added*
$= 2.0\ L - 0.020\ L = 1.98\ L$

7. $pH = 4$ *and so* $[H^+] = 1.0 \times 10^{-4}$ *M.* $V = 1.00$ *L*
$n\ (HCl) = n(H^+) = c \times V = 1.0 \times 10^{-4} \times 1.00$
$= 1.0 \times 10^{-4}$ *mol*
V *(HCl @ STP)* $= n \times 22.71$
$= 1.0 \times 10^{-4} \times 22.71 = 2.27$ *mL*

8. *All these hydrolyse to produce* OH^- *ions.*

$CO_3^{2-}(aq) + H_2O(l) \rightarrow HCO_3^-(aq) + OH^-(aq)$
$S^{2-} + H_2O(l) \rightarrow HS^-(aq) + OH^-(aq)$
$CH_3COO^-(aq)+H_2O \rightarrow CH_3COOH+OH^-(aq)$

9.

(a) $[Ca\ (OH)_2] = 0.0050\ M$.
$[OH^-] = 2 \times 0.005 = 0.01$ so $pOH = 2$ and $pH = 12$

(b) Using the dilution formula, $0.010 \times 0.010 = c \times 1.0\ L$.
Therefore, the final $[OH^-]$
$= 0.01 \times 0.010/1.0\ L = 1.00 \times 10^{-4}\ M$
$\therefore [OH^-] = 2 \times 5.00 \times 10^{-5} = 1.00 \times 10^{-4}$
$pOH = 4$ so $pH = 10.00$
Change is from 12.00 to 10.00

(c) $n\ (Ca(OH)_2 = cV = 0.00500 \times 0.010\ L$
$= 0.000050\ mol$
Number of moles of the substance does not alter during dilution.
$n(Ca(OH)_2 = n \times Mr = 0.0000500 \times 74.096$
$= 0.0037\ g$

(d) $Ca(OH)_2\ (aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$
$n(CO_2) = n(Ca(OH)_2 = 0.0000500\ mol$
Using the relationship $PV = nRT$ and $V = nRT/P$:
$V = [(0.000050 \times 8.314 \times 298)/\ 110]$
$= 0.0113\ L = 11.3\ mL$

10. $NaOH(aq) + HCl(aq) \rightarrow NaCl\ (aq) + H_2O(l)$
$n\ (HCl) = 0.131 \times 0.0236 = 3.091 \times 10^{-3}\ mol$
$n\ (NaOH) = n(HCl) = 3.091 \times 10^{-3}\ mol;$
$V(NaOH) = 0.025\ L$
$\therefore [NaOH] = n/\ V = 3.091 \times 10^{-3}/0.025$
$= 0.124\ L$

11. $m(pure\ Na_2CO_3) = 0.1223 \times 0.9995$
$= 0.1222\ g$.
$n(Na_2CO_3) = 0.1222/105.9$
$= 1.153 \times 10^{-3}\ mol$
$Na_2CO_3(aq) + 2HCl(aq) \rightarrow$
$2NaCl(aq) + H_2O(l) + CO_2(g)$
From the equation, 1 mole of Na_2CO_3 reacts with 2 moles of HCl.
$\therefore n\ (HCl) = 2 \times n\ (NaOH)$
$= 2 \times 1.153 \times 10^{-3} = 2.306 \times 10^{-3}\ mol$
$\therefore [HCl] = n/V = 2.036 \times 10^{-3}/0.02265$
$= 0.090\ M$

12. $CH_3COOH(aq) + NaOH(aq) \rightarrow$
$CH_3COONa + H_2O(l)$
$n(CH_3COOH) = c\ V = 0.100 \times 0.050$
$= 0.0050\ mol$
$n\ (NaOH) = 0.100 \times 0.030 = 0.0030\ mol$
(Since the reacting mole ratio is 1:1), CH_3COOH is in excess by $(00.50 - 0.0030)$
$= 0.0020\ mol$
$\therefore [CH_3COOH]\ final = (0.0020/0.080)$
$= 0.0250\ M$

13. $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$
$n\ (NaHCO_3) = 0.020 \times 0.050$
$= 1.0 \times 10^{-3}\ mol$
$n\ (HCl) = 0.020 \times 0.0250 = 5.00 \times 10^{-4}\ mol$
Since the reacting mole ratio between $NaHCO_3$ and HCl is 1:1, $NaHCO_3$ is in excess by $(1.0 \times 10^{-3} - 5.00 \times 10^{-4})$
$= 5.0 \times 10^{-4}\ mol$
$[NaHCO_3\ left\ over] = (5.0 \times 10^{-4}/\ 0.075)$
$= 6.67 \times 10^{-3}\ M$

14. $n(HNO_3) = 0.0305 \times 0{,}131 = 4.00 \times 10^{-3}\ mol$
Each mole of HNO_3 requires ½ mole of $CaCO_3$ to react $= 2.00 \times 10^{-3}\ mol$
So $n(CaCO_3) = 2.00 \times 10^{-3}\ mol$ and
$m(CaCO_3) = 2.00 \times 10^{-3} \times 105.99 = 0.212\ g$
$\therefore m(H_2O) = 0.561\ - 0.212 = 0.349\ g$
$n(H_2O) = 0.349/\ 18.016 = 0.0194\ mol.$
Ratio of H_2O to $CaCO_3$ is
$1.94 \times 10^{-2}: 2.00 \times 10^{-3}$ which is close to 10:1
Hence formula is $CaCO_3.\ 10H_2O$

15. The general reaction equation is: $NaOH(aq) + HBr(aq) \rightarrow NaBr(aq) + H_2O(l)$

(a) $HBr(1) = 20.0\ mL$ $n\ (NaOH)$
$= 0.100\ M \times 0.0275\ L = 0.00275\ mol$
$\therefore n\ (HBr) = 0.00275\ mol$
$c[HBr] = (0.00275/\ 0.020) = 0.1375\ M$

(b) $HBr(2) = 20.0\ mL$
$n\ (NaOH) = 0.100 \times 0.0218 = 0.00218$
$n\ (HBr) = 0.00218\ mol$
$[HBr] = n \div V = 0.00218/\ 0.020 = 0.109\ M$

(c) $HBr(3) = 20.0\ mL$
$n\ (NaOH) = 0.100\ M \times 0.0489$
$= 0.00489\ mol$
$n\ (HBr) = 0.00489\ mol$
$[HBr] = n/V = 0.00489/\ 0.020 = 0.2445\ M$

(d) $HBr(4) = 20.0\ mL$
$n\ (NaOH) = 0.100 \times 0.0255 = 0.00255\ mol$
$n\ (HBr) = 0.00255$
$[HBr] = n/V = 0.00255 \div 0.020 = 0.1275\ M$

16. The general equation for the reaction is:
$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$
The reacting ratio is 1:1.

(a) $n\ (HCl) = 0.200 \times 0.020 = 4.00 \times 10^{-3}\ mol$
$n\ (NaOH) = c \times V = 0.200 \times 0.0050$
$= 1.00 \times 10^{-3}\ mol$
HCl is in excess by $(4.00 \times 10^{-3} - 1.00 \times 10^{-3})$
$3.00 \times 10^{-3}\ mol$
$\therefore n\ (H^+)$ is in excess by $3.00 \times 10^{-3}\ mol$
$[H+] = (n/\ v) = (3.00 \times 10^{-3}/0.025) = 0.12\ M$
$\therefore pH = -\log 0.12 = 0.921$

(b) $n\ (HCl) = c \times v = 4.00 \times 10^{-3}\ mol$
$n\ (NaOH) = c \times V = 0.200 \times 0.015$
$= 3.00 \times 10^{-3}\ mol$
HCl is in excess by $(4.00 \times 10^{-3} - 3.00 \times 10^{-3})$
$= 1.00 \times 10^{-3}\ mol$
$\therefore n\ (H^+)$ in excess $= 1.00 \times 10^{-3}\ mol$
$[H^+] = (n/\ v) = (1.00 \times 10^{-3}/0.035)$
$= 0.0286\ M$

$pH = -\log 0.0286 = 1.54$

(c) $n\ (HCl) = 4.00 \times 10^{-3}$ mol
$n\ (NaOH) = 0.200 \times 0.0199$
$= 3.98 \times 10^{-3}$ mol
HCl is in excess by $(4.00 \times 10^{-3} - 3.98 \times 10^{-3})$
$= 0.02 \times 10^{-3} = 2.0 \times 10^{-5}$ mol
$\therefore n\ (H^+)$ is in excess by 2.0×10^{-5} mol
$[H^+] = (n/v) = (2.0 \times 10^{-5}/ 0.0399)$
$= 5.01 \times 10^{-4}$ M
$pH = -\log 5.01 \times 10^{-4} = 3.30$

17. The stated claim is that each contains 300 mg of aspirin. The equation for the reaction is: $C_6H_4(OCOCH_3)COOH + 2NaOH(aq) \rightarrow C_6H_4(OH)COONa(aq) + CH_3COONa(aq) + HCl(aq)$

(a) The tablets are reacted with 50.0 mL of 0.5090 M NaOH.
n (NaOH) used in the first titration = c × V
$= 0.5090 \times 0.050 = 0.02545\ mol = n_1$
On back titration, the original 50.0 mL was diluted to 100.0 mL and 20.0 mL aliquot was used for the second titration.
Equation for the second titration:
$NaOH + HCl \rightarrow NaCl + H_2O$
n (HCl) that reacted with the 20.0 mL aliquot
$= 0.1232 \times 0.02510 = 3.09232 \times 10^{-3}$ mol in 20 mL
$= 3.09232 \times 10^{-3}$ mol (reactant ratio is 1 to 1)
$\therefore n$ (NaOH) in the 100.0 mL
$= 3.09232 \times 10^{-3} \times (100/20)$
$= 0.0154616\ mol = n_2$
$\therefore n$ (NaOH) that reacted in the first reaction (equation is supplied in the problem)
$= n_1 - n_2 =$ 0.02545 mol – 0.0154616 mol
= 0.0099884 mol
According to the balanced equation supplied,
$n\ [C_6H_4(OCOCH_3)COOH] = n\ (NaOH)/2$
= 0.0099884/2
$= 4.9942 \times 10^{-3}$ mol
$m\ [C_6H_4(OCOCH_3)COOH]$
$= 4.9942 \times 10^{-3} \times 180.154 = 0.8997$ g
$\therefore$ Mass of this compound in one tablet = 0.8997/ 3 = 0.2999 g.
The average mass of the compound in each tablet = 299.9 mg.

(b) Within the limits of experimental or rounding off error, the claim is true.

18.

(a) Acid added to this cloudy ammonia
= 100.0 mL of 0.6342 M, HCl.
The mixture volume is made up to
= 250.0 mL.
Aliquot taken for titration purpose
= 20.0 mL.
The first reaction is between NH_3 in the "cloudy ammonia" and HCl.

(b) The reaction is $NH_3 + HCl \rightarrow NH_4Cl$
The second reaction is between the left over HCl and NaOH
The second reaction is
$HCl + NaOH \rightarrow NaCl + H_2O$

(c) n (NaOH) that reacted with 20.0 mL of the excess HCl in reaction 2,
[Since, n (HCl) = n (NaOH)] = c × V =
$0.6342 \times 0.01875 = 0.00205875$ mol
n (NaOH) that would have reacted with 250.0 mL of the excess HCl in reaction 2,
$= 0.00205875 \times (250/ 20.0)$
$= 2.5734 \times 10^{-2}$ mol
n (HCl) initially present before the reaction commenced,
$cV = 0.6342 \times 0.100 = 0.06342$ mol
$\therefore n$ (HCl) that actually reacted with 250.0 mL of original solution,
= 0.06342 – 0.025734 = 0.037686 mol
From the equation for the first reaction, $n\ (NH_3) = n\ (HCl) = 0.037686$ mol
$\therefore m\ (NH_3) = n \times Mr = 0.037686 \times 17.034$
= 0.642 g
% of NH_3 in the cloudy ammonia
= (0.642/ 15.4) × 100
= 4.24%

(d) Not necessarily. If the calculated value is less than the claimed value and falls with in the limits of experimental error, the claim could still be true.

19.

(a) $H_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$

(b) The back-titration reaction is: $Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O(l)$
n (HCl) used = c × v = 0.100 × 0.0345
= 0.00345 mol
Therefore, according to the reacting mole ratio, the number of moles of $Ba(OH)_2$ that reacted in the back titration is (0.00345/2)
= 0.001725 mol

(c) Any indicator will be suitable for this back titration because the change of pH occurs over a pH range of 3 to 11. Any indicator with an end point change that occurs in this range would be suitable.

(d) Since the amount of $Ba(OH)_2$ used in the back titration is 0.001725 mol (0.2955 g), the mass of $Ba(OH)_2$ that reacted in the first titration is = (3.0 – 0.2955) = 2.7045 g.
n $(Ba(OH)_2$ that reacted in the first titration
$= (2.7045/ 171.316) = 1.58 \times 10^{-2}$ mol.
According to the mole ratio in equation 1,
$n\ (H_2SO_4) = n(Ba(OH)_2$
$= 1.58 \times 10^{-2}$ mol
$[H_2SO_4] = (n/V) = (1.58 \times 10^{-2}/ 0.020)$
= 0.79 M

20.

(a) The burette should be rinsed with the filling solution (HCl). Rinsing with distilled water reduces the concentration of the filling solution. This makes [HCl] appear greater.

(b) This is not a mistake and there is no effect as there are the same no. of moles, even if diluted.

(c) The pipette should be rinsed with the filling solution (Na_2CO_3). Rinsing it with water will dilute the concentration of the filling solution. This makes [Na_2CO_3] appear weaker and less HCl will be used so [HCl] appears greater.

(d) The correct indicator – methyl orange, should be used. Using phenolphthalein would produce colour change soon, so the volume of HCl needed would decrease. This makes [HCl] appear greater.

21.

(a) i) Calculate the amount of Na_2CO_3 needed (106 g).

ii) Weigh out close to 1.06 g; not necessarily the exact mass.

iii) Transfer the Na_2CO_3 to a clean 250.0 mL volumetric flask. Often this is done using a clean, dry funnel, carefully rinsing all traces of solid into the flask using distilled water.

iv) Fill the flask about one half with distilled water and swirl until all the solid is dissolved.

v) Add distilled water exactly up to the 250 mL calibration mark. Often the last few drops are added from a pipette or eye-dropper.

vi) Mix the solution thoroughly by inverting the flask. Then calculate the exact concentration from the actual mass used.

(b) Note: The dilution is ten times the original volume. Remember that you should always add acid to water and not the other way otherwise 'spitting' occurs!

i) Put a small amount of water in the flask first.

ii) Transfer the 25.0 mL of 5.0 M sulfuric acid to a graduated cylinder, which has a volume of 250.0 mL.

iii) Add distilled water to about half the volume of the flask. Stopper it and swirl it a few times until the bubbles die out.

iv) Add distilled water up to the 250 mL calibration mark. Add the last few drops with a pipette or eye-dropper.

(c) Note: Because the concentration of this solution does not need to be accurately known, you can use a graduated cylinder for measuring.

i) Place about 50 mL of distilled water into a graduated cylinder.

ii) Measure 1 mL of 10 M HCl using a clean, dry, graduated cylinder or graduated pipette.

iii) Add the acid to the water in the graduated cylinder, stir and make up volume up to 100.0 mL.

22.

(a) methyl orange
(b) phenolphthalein
(c) any indicator
(d) phenolphthalein

23.

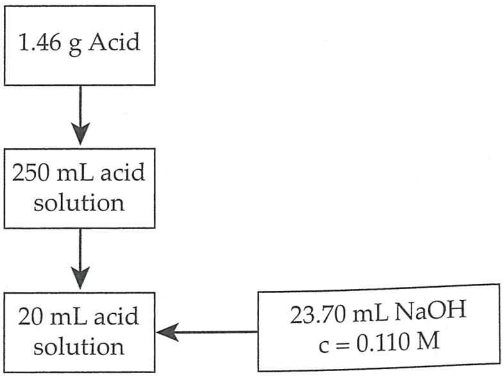
(a) $CO_2(g) + H_2O(l) \rightarrow H_2CO_3(aq)$

(b) Since H_2CO_3 is a very weak acid, it can be analysed volumetrically using NaOH and a phenolphthalein indicator following the usual volumetric analysis procedure – or use a pH meter.

24. (i) Loss of mass of hydrated acid
$= 0.808 - 0.576 = 0.232$ g of H_2O
% water $= (0.232/0.808) \times 100 = 28.71\%$
% Anhydrous acid $= 71.29\%$

(ii) 2.05 g of hydrated acid will contain 0.7129×2.05 g of anhydrous acid $= 1.46$ g

Flow chart:



$n(NaOH) = 0.110 \times 0.02370$
$= 2.607 \times 10^{-3}$ mol
Ratio of acid to NaOH = 2 : 1
$n(Acid) = \frac{1}{2} \times n(NaOH)$
$= 1.3035 \times 10^{-3}$ mol in 20 mL
In 250 mL $n(Acid) = 1.3035 \times 10^{-3} \times \frac{250}{20}$
$= 0.01629$ mol

$$M_r = \frac{m}{n} = \frac{1.46}{0.01629} = 89.6 \text{ g mol}^{-1}$$

(iii) Empirical mass of $CHO_2 = 45.01$ which is ½ of 89.6 approx, so molecular = 2 × empirical mass
Molecular formula is $C_2H_2O_4$ possible isomer is HOOCCOOH (oxalic acid).

(iv) Mass of water in 2.05 g sample
$= 2.05 \times 0.2871 = 0.588$ g

$n(H_2O) = 0.588/18.016 = 0.03267$ mol
Ratio of H_2O to $C_2H_2O_4$ is 0.03267: 0.01629
= 2.005:1
So hydrated acid formula is $C_2H_2O_4.2H_2O$.

25\. $n(NaOH) = 0.698 \times 0.0107$
$= 7.469 \times 10^{-3}$ mol = total $n(H^+)$ in the solution.
$n(BaSO_4) = 0.541/233.37 = 2.318 \times 10^{-3}$ mol
which must equal $n(H_2SO_4)$ in 25 mL
$n(H_2SO_4)$ in 20 mL is which would contribute double the H^+
$2 \times 1.855 \times 10^{-3}$ mol of $H^+ = 3.71 \times 10^{-3}$ mol.
$\therefore$ n(HCl) in solution X
$= 7.469 \times 10^{-3} - 3.710 \times 10^{-3}$ mol
$= 3.759 \times 10^{-3}$ mol.
$[HCl]$ in solution X $= \dfrac{3.759 \times 10^{-3}}{0.020}$
$= 0.188$ mol L^{-1}

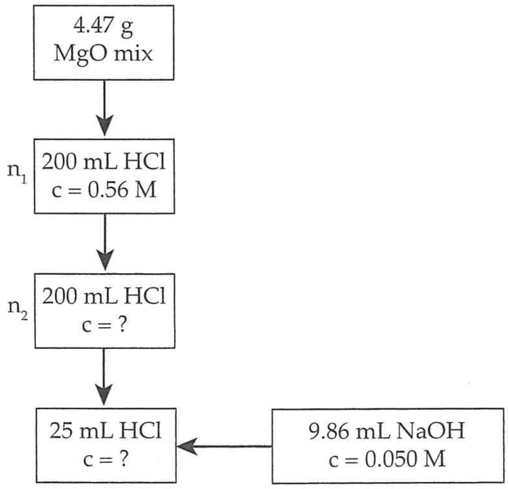
26\. (i) Mass of NaOH = 4000 × 0.2 = 800 g
$n(NaOH) = 800/39.998 = 20.0$ mol
$m(CuSO_4.5H_2O) = 45000 \times 0.05 = 2250$ g
$n(CuSO_4.5H_2O) = 2250/\ 249.7 = 9.01$ mol

Reaction: $CuSO_4 + 2NaOH$
$\rightarrow Cu(OH)_2 + Na_2SO_4$
So 9.01 mol of $CuSO_4$ would need 18.02 mol of NaOH to be completely used up.
20.0 mol of NaOH is available so all the $CuSO_4$ is used up = Limiting Reagent
Hence NaOH and OH^- ion is in excess.
Amount of excess NaOH is 20 – 18.02
= 1.978 mol
(ii) HCl could be used to neutralise the OH^- ions. The farmer would need to add 1.978 mol
m(HCl) needed = 1.978 × 36.458 = 72.1 g.

27\.
(a) $2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$
(b) $HCl + NaOH \rightarrow NaCl + H_2O$
(c) n (NaOH) = c × V
$= 0.150$ mol $L^{-1} \times 0.01966 = 2.94 \times 10^{-3}$ mol
Therefore, n (HCl) $= 2.94 \times 10^{-3}$ mol
(d) Initial moles of HCl that was added to washing soda = cV
= 1.00 × 0.0200 = 0.0200 mole
(e) Therefore, n(HCl) that actually reacted = Initial moles of HCl – Excess moles of HCl Left over
$= 0.02$ mol $- 2.94 \times 10^{-3}$ mol $= 0.01706$ mol
Therefore, n (Na_2CO_3) = n (HCl/2) = 0.01706/2 = 0.00853 mol
Therefore, $m(Na_2CO_3)$ = n × M
= 0.00853 × 105.99 = 0.904 g
(f) % of Na_2CO_3 in the sample
= [(0.904/1.682) × 100] = 53.7 %
(g) Sodium hydroxide absorbs both H_2O and CO_2 from air when exposed and this alters its concentration. Therefore, NaOH should be used as soon as it is standardised.
(h) There won't be any effect since HCl (a strong acid) is titrated with NaOH (a strong base).

28\.
(a) The mass of aspirin tablet = 0.4376 g
(The tablet contains acetylsalicylic acid, $[C_6H_4(OCOCH_3)COOH)]$
The number of moles of HCl added = cV
$= 0.298 \times 0.01864$ L $= 5.555 \times 10^{-3}$ mol
Since, $HCl + NaOH \rightarrow NaCl + H_2O$
The number of moles of NaOH reacted
$= 5.555 \times 10^{-3}$ mol
(b) Initial amount of NaOH added to aspirin
= n (NaOH)
$= c \times V = 0.196$ mol $L^{-1} \times 0.050$ L
$= 9.800 \times 10^{-3}$ mol
(c) Therefore, n(NaOH) that actually reacted with the acetylsalicylic acid in the tablet,
= [initial moles of NaOH – left over excess moles of NaOH]
$= (9.800 \times 10^{-3} - 5.555 \times 10^{-3})$
$= 4.245 \times 10^{-3}$ mol
$C_6H_4(OCOCH_3)COOH + 2NaOH \rightarrow$
$C_6H_4(OH)COONa + CH_3COONa + H_2O$
$nC_6H_4(OCOCH_3)COOH = \frac{1}{2} \times n\ (NaOH)$
$= 2.123 \times 10^{-3}$ mol
Therefore, $m[C_6H_4(OCOCH_3)COOH]$
$= n \times M = 2.123 \times 10^{-3} \times 180.164$
= 0.3825 g
Therefore % mass of the acid in the tablet
= [(0.3825/ 0.4376) × 100]
= 87.4%

29\.



n(NaOH) = 0.05 × 0.00986
$= 4.93 \times 10^{-4}$ mol
1:1 ratio $\therefore$ n(HCl)
$= 4.93 \times 10^{-4}$ mol in 25 mL
$\therefore$ in 200 mL n(HCl)
$= 4.93 \times 10^{-4} \times \dfrac{200}{25} = 3.944 \times 10^{-3}$ mol

$n_2 = 3.944 \times 10^{-3}$ mol
$n_1 = 0.56 \times 0.2 = 0.112$ mol

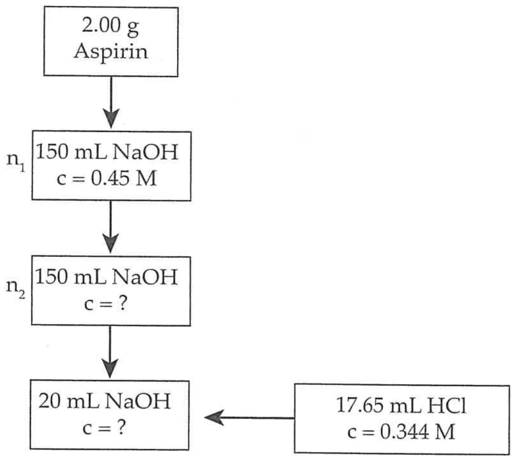
Amount of HCl used $= n_1 - n_2$
$= 0.112 - 3.944 \times 10^{-3}$
$= 0.1081$ mol

Ratio MgO : HCl is 2:1 so
$n(MgO) = \frac{1}{2} \times 0.1081 = 0.05403$ mol

$m(MgO) = 0.05403 \times (24.31 + 16)$
$= 2.18$ g
$\% \text{ of MgO} = \frac{2.18}{4.47} = \times 100\%$

% Purity = 48.7%

30.
(i)



$n(HCl) = 0.344 \times 0.01765$
$= 6.072 \times 10^{-3}$ mol
Ratio NaOH to HCl is 1:1 so
$n(NaOH) = 6.072 \times 10^{-3}$ mol in 20 mL
$\therefore$ in 150 mL $n(NaOH) =$
$6.072 \times 10^{-3} \times \frac{150}{20} = 0.0455$ mol
$n_2 = 0.0445$ mol
$n_1 = 0.45 \times 0.15 = 0.0675$ mol

Amount of HCl used $= n_1 - n_2$
$= 0.0675 - 0.0455$
$= 0.0220$ mol

Ratio Aspirin to NaOH is 1:2
So $n(\text{Aspirin}) = \frac{1}{2}\, n(NaOH)$
$= 0.0110$ mol
$m(\text{Aspirin}) = 0.0110 \times 168.144 = 1.85$ g
$\% \text{ of Aspirin} = \frac{1.85}{2.00} \times 100\%$

% Purity = 92.5%

(ii) This value exceeds the 90% set value and so conforms to the law.

Chapter 3.
Redox Reactions

Set 1 Oxidation and Reduction

1.	Species Oxidised	Na
	Species reduced	O_2
	Oxidant	O_2
	Reductant	Na
2.	Species Oxidised	Zn
	Species reduced	Cr^{3+}
	Oxidant	Cr^{3+}
	Reductant	Zn
3.	Species Oxidised	H_2
	Species reduced	O_2
	Oxidant	O_2
	Reductant	H_2
4.	Species Oxidised	H_2S
	Species reduced	$Cr_2O_7^{2-}$
	Oxidant	$Cr_2O_7^{2-}$
	Reductant	H_2S
5.	Species Oxidised	Cl^-
	Species reduced	H_2O_2
	(ON of Cl is $^{+}1$ in HClO)	
	Oxidant	H_2O_2
	Reductant	Cl^-
6.	4+ 7. 5+ 8. 4+ 9. 2+ 10. 7+	
7.	Species Oxidised	HBr
	Species reduced	H_2SO_4
8.	Species Oxidised	$SnCl_2$
	Species reduced	O_2
9.	Species Oxidised	Fe^{2+}
	Species reduced	$Cr_2O_7^{2-}$
10.	Species Oxidised	None
	Species reduced	None
11.	Species Oxidised	I^-
	Species reduced	Cl_2

Set 2 Oxidation

Multiple Choice Answers

1. d, 2. b, 3. d, 4. b, 5. c, 6. c, 7.a, 8. b, 9. a, 10. a, 11. e, 12. b

Written Answers

1.
(a) S = +6
(b) Mn = +7
(c) N = +5
(d) C = +4,
(e) N = +4
(f) S = +6
(g) S = +6
(h) S = -2
2.
(a) H = +1, S = -2
(b) P = +5, O = -2
(c) Na = +1, P = -3