CHEM131 HOMEWORK #5 KEY

4-40. The titration data and knowing that there is just 1 acidic H in carminic acid (CA) allows us to calculate the molar mass of CA.

(0.0406 mol NaOH/L sol)(18.02*10^{-3} L sol) = 7.32*10^{-4} mol NaOH = 7.32*10^{-4} mol CA in 0.3602 g

molar mass of CA = (0.306 g)/(7.32*10^{-4} mol CA) = 492 g/mol CA.

We also know CA is 53.66% C, 4.09% H, and 42.25% O, and in principle this info permits calculation of hte empirical formula. BUT 492 is a quite large molar mass; depending on how many H atoms are present, there could easily be 50 atoms in one molecule of CA! Chances are good that the usual procedure of looking for simple mole fractions will give ambiguous results. Let's start with the usual 100 g sample.

53.66/12.011 = 4.468 mol C; 4.09/1.008 = 4.06 mol H; 42.25/15.999 = 2.641 mol O

Dividing each by the smallest to get C:H:O gives 1.692:1.54:1, and indeed it is not obvious what the common multiplier should be. A brute force approach works, just try every number until you find one that works, but this is a procedure that is best done with a computer spread sheet program , such as Excel. A quite useful clue is gained by noting that the 4.468 C number is very nearly 10% larger than the H number, 4.468/4.06 = 1.101 or 4.468 is 11 times larger than 0.406. Dividing each number by 0.406 gives 11:10:6.50 or 22:20:13. The empirical formula is $C_{22}H_{20}O_{13}$. 22*12 + 20*1 + 13*16 = 492 and the empirical formula is correct.

4-42. (0.1082 g KHP)/(204.22 g KHP/mol KHP) = 5.298*10^{-4} mol KHP = 5.298*10^{-4} mol NaOH

(5.298*10^{-4} mol)/(34.67*10^{-3} L) = 1.528*10^{-2} M

4-44. mol H_3PO_4 = (14.2 * 10^{-3} L)(0.141 mol/L) = 2.002 * 10^{-3} mol. Since phosphoric acid has 3 acidic protons per molecule, we know mol H^+ = 3 * mol H_3PO_4 =6.007 * 10^{-3} mol H^+. For exact neutralization mol H^+ = mol OH^- so mol OH^- = 6.007 * 10^{-3} mol.
However, $Ba(OH)_2$ has 2 OH^- per molecule, so mol $Ba(OH)_2$ = (1/2)* mol OH^- = 3.003 * 10^{-3} mol.
If we have a volume V, the mol of $Ba(OH)_2$ = V*0.0521 M $Ba(OH)_2$. Solve for V: V = 3.003 *10^{-3} mol/(0.0521 mol/L) = 57.6 mL of solution.

4-49. (75.0*10^{-3} L)(0.250 mol H^+/L) = 1.875*10^{-2} mol H^+

(225.0*10^{-3} L)(0.0550 mol $Ba(OH)_2$/L)(2.000 mol OH^-/mol $Ba(OH)_2$) = 2.475*10^{-2} mol OH^-

$2.475*10^{-2} - 1.875*10^{-2} = 6.0*10^{-3}$ mol OH^- in 300 mL solution

$(6.0*10^{-3}$ M $OH^-)/(300*10^{-3}$ L$) = 2.0*10^{-2}$ M OH^-

Next H.W. assignment Ch.4; 55, 56, 57, 58, 60, 65