**Hydrated Formula Practice**

6. The crystalline mineral carnallite has the general formula (MgCl2)x(KCl)y .zH2O.

When a sample of pure carnallite of mass 5.830 g is heated, all the water of crystallisation is driven off and the remaining anhydrous powder weighs 3.561g.

All the magnesium in a further 10.270 g sample of the mineral is converted into "insoluble" magnesium hydroxide which required 35.10 mL of 2.105 mol L-1 hydrochloric acid to dissolve it completely.

(a) Determine the empirical formula of carnallite from the above information,

i.e. find the values of x, y and z.

(b) What total number of moles of ions are present in 1.00 L of solution which contains 5.830 g of dissolved carnallite?

7. A double sulfate of potassium and chromium (III) has the general formula:

KCr(SO4)x .yH2O. where x and y are integers.

36.50 g of the pure hydrated compound is treated with excess sodium carbonate solution and it is found that 10.38 g of highly insoluble chromium (III) carbonate is precipitated.

A further 4.700 g sample of the compound is heated strongly to drive off all the water of crystallisation. A constant mass of 2.665 g of anhydrous powder remains after several heatings. From this information, calculate the empirical formula of the compound.

[Hint: Use percentages].

ANSWERS

6. (a) (MgCl2)x (KCl)y .zH2O  (MgCl2)x (KCl)y + zH2O

5.830g  3.561g + 2.269g

%[H2O] in carnallite = 2.269g/5.830g x 100 = 38.92%

Mg2+(aq) + 2OH-(aq)  Mg(OH)2

Then Mg(OH)2 + 2H+(aq)  Mg2+(aq) + 2H2O(l)

n(Mg2+) = n(H+) = n(HCl) = (c.V) = 0.03694 mol.

n(MgCl2) = 0.03894 mol. (in 10.270g of carnallite)

m(MgCl2) = n.M = (0.03694 mol)(95.2 g mol-1) = 3.5171g.

%MgCl2 = 3.5171g/10.270 g x 100 = 34.25%

%(H2O) = 38.92%, %(MgCl2) = 34.25%, %(KCl) = 26.83%

Hence, in 100g carnallite, m(H2O) = 38.92 g ; n(H2O) = 2.16 mol.

m(MgCl2) = 34.25 g ; n(MgCl2) = 0.3597 mol.

m(KCl) = 26.83 g ; n(KCl) = 0.3599 mol.

By dividing the three mole amounts by 0.3597 to obtain the simplest ratio,

Ans (a): The EF of carnallite is MgCl2.KCl.6H2O (ie x=1; y=1; z=6).

(b) n(carnallite) = 5.830g/277.846g mol-1 = 0.0209828 mol.

Since from the formula, n(ions) = 5n(carnallite) = 5(0.0209828mol).

Ans (b): The number of moles of ions is 0.105 mol.

7. 2Cr3+(s) + 3CO32-(aq) Cr2(CO3)3(s)

m(Cr2(CO3)3) = 10.38g

n(Cr2(CO3)3) = m/M = 10.38g/284.03 g mol-1 = 0.03655 mol.

n(Cr) = 2n(Cr2(CO3)3) = 0.07309 mol.

m(Cr) = n.M = (0.07309 mol)(52.00 g mol–1) = 3.801 g.

n(K) = n(Cr) = 0.07309 mol.

m(K) = n.M = (0.07309 g)(39.10 g mol-1) = 2.858 g.

KCr(SO4)x.yH2O KCr(SO4)x + yH2O

4.70g 2.665g + 2.035g

%K = [m(K) / m(compound)] x 100 = [(2.858 g) / (36.50 g)] x 100 = 7.83%

%Cr = [m(Cr) / m(compound)] x 100 = [3.801 g) / (36.50 g)] x 100 = 10.4%

%H2O = [(m(H2O) / (m(sample)] x 100 = (2.035g)/(4.70g) x 100 = 43.3%

% SO42- = [100 - (%H2O + %K + %Cr)] = 38.5%

Consider 100g of the compound:

m(K) = 7.83g n(K) = m/M = 7.83g/39.10 g mol-1 = 0.200 mol. = 1

m(Cr) = 10.4g n(Cr) = m/M = 10.4g/52.00 g mol-1 = 0.200 mol. = 1

m(SO42-) = 38.5g n(SO42-) = m/M = 38.5g/96.06 g mol-1 = 0.400 mol. = 2

m(H2O) = 43.3g n(H2O) = m/M = 43.3g/18.016 g mol-1 = 2.40 mol = 12

Ans: EF = K1Cr1(SO4)2 .12H2O.