Hydrated copper sulfate, $CuSO_4.\boldsymbol{x}H_2O$ (***x*** represents an unknown amount of water), is blue, however, the anhydrous form ($CuSO_4$) is white. A sample of hydrated copper sulfate was weighed and fully dehydrated by heating. The results of the experiment are shown below.

Note: Two additional blank lines have been left in the table below for rough working out only. You may or may not wish to use these lines.

Table 3: **Masses For Calculating the Water of Crystallisation in $CuSO_4.\boldsymbol{x}H_2O$**

Item Measured	Mass (grams)
Crucible and lid	29.30
Crucible, lid and hydrated sample	39.49
Crucible, lid and sample after heating	35.87
Crucible, lid and sample after additional heating	35.85

(a) Calculate the percentage by mass of water in the original hydrated sample.

(3 marks)

(b) Find the number of moles of water in the hydrated sample.

(1 mark)

(c) Calculate the value of '***x***' in the hydrated sample and thus determine its empirical formula.

(4 marks)

(d) What was the purpose of providing additional heating to the final hydrated sample?

(1 mark)

ANSWER

4. (a) mass of original $CuSO_4.xH_2O_{(s)}$ = mass (crucible, lid & hydrate) – mass (crucible & lid)
mass of original $CuSO_4.xH_2O_{(s)}$ = 39.49g – 29.30g
mass of original $CuSO_4.xH_2O_{(s)}$ = 10.19g [1]

mass of water = mass (crucible, lid & hydrate) – mass (after further heating)
mass of water = 39.49g – 35.85g
mass of water = 3.64g [1]

percentage of water by mass:

$\frac{3.64}{10.19}$ x 100 = $\underline{3.57 \times 10^{1}\%}$ [1]

(b) $n(H_2O) = \frac{m}{M}$

$n(H_2O) = \frac{3.64}{18.016}$

$n(H_2O) = \underline{2.02 \times 10^{-1} \text{ mol}}$ [1]

(c) mass ($CuSO_4$) = mass hydrated $CuSO_4$ – mass H_2O
mass ($CuSO_4$) = 10.19g – 3.64g
mass ($CuSO_4$) = 6.55g [1]

$n(CuSO_4) = \frac{m}{M}$

$n(CuSO_4) = \frac{6.55}{159.61}$

$n(CuSO_4) = 4.10 \times 10^{-2}$ mol [1]

Find ratio of $n(H_2O):n(CuSO_4)$

$2.02 \times 10^{-1} : 4.10 \times 10^{-2}$
1 : 4.9 (5)

Empirical formula of hydrate: $\underline{CuSO_4.5H_2O}$ [2]

(d) The purpose of heating the hydrated sample, weighing and then heating further is to ensure that all water has been detached from the ionic lattice so that the mass of pure $CuSO_{4(s)}$ can be determined. Heating and weighing can continue until consistent masses are obtained. [1]