CALCULATE MOLES

1 (a) The elements in Group VII are known as the halogens. Some halogens react with aqueous solutions of halides.

(i) Complete the table by adding a ✓ to indicate when a reaction occurs and a ✗ to indicate when no reaction occurs.

	aqueous potassium chloride	aqueous potassium bromide	aqueous potassium iodide
chlorine	✗	✓	
bromine		✗	
iodine			✗

[3]

(ii) Write a chemical equation for the reaction between chlorine and aqueous potassium bromide.

.... [1]

(b) A sample of vanadium chloride was weighed and dissolved in water. An excess of aqueous silver nitrate, acidified with dilute nitric acid, was added. A precipitate of silver chloride was formed. The ionic equation for this reaction is shown.

$$Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$$

The mass of silver chloride formed was 2.87 g.

(i) State the colour of the precipitate of silver chloride.

.... [1]

(ii) The relative formula mass of silver chloride, $AgCl$, is 143.5.

Calculate the number of moles in 2.87 g of $AgCl$.

moles of $AgCl$ = ... mol [1]

(iii) Use your answer to **(b)(ii)** and the ionic equation to deduce the number of moles of chloride ions, Cl^{-}, that produced 2.87 g of $AgCl$.

moles of Cl^{-} = ... mol [1]

(iv) The amount of vanadium chloride in the sample was 0.01 moles.

Use this and your answer to **(b)(iii)** to deduce the **whole number** ratio of moles of vanadium chloride : moles of chloride ions.
Deduce the formula of vanadium chloride.

moles of vanadium chloride : moles of chloride ions .... : ....

formula of vanadium chloride ....

[2]

MARKING SCHEME:

<table>
<tr><td>(a)(i)</td><td>
<table>
<tr><td></td><td>aqueous potassium chloride</td><td>aqueous potassium bromide</td><td>aqueous potassium iodide</td></tr>
<tr><td>chlorine</td><td></td><td></td><td>✓</td></tr>
<tr><td>bromine</td><td>✗</td><td></td><td>✓</td></tr>
<tr><td>iodine</td><td>✗</td><td>✗</td><td></td></tr>
</table>
5 cells completed correctly = [3]
3 or 4 cells completed correctly = [2]
2 cells completed correctly = [1]
</td><td>3</td></tr>
<tr><td>(a)(ii)</td><td>$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$
OR
$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$</td><td>1</td></tr>
<tr><td>(b)(i)</td><td>white</td><td>1</td></tr>
<tr><td>(b)(ii)</td><td>0.02 (mol)</td><td>1</td></tr>
<tr><td>(b)(iii)</td><td>0.02 (mol)</td><td>1</td></tr>
<tr><td>(b)(iv)</td><td>1:2</td><td>1</td></tr>
<tr><td></td><td>VCl_2</td><td>1</td></tr>
</table>

2 Copper(II) sulfate crystals, $CuSO_4.5H_2O$, are hydrated.

Copper(II) sulfate crystals are made by reacting copper(II) carbonate with dilute sulfuric acid.

The equation for the overall process is shown.

$$CuCO_3 + H_2SO_4 + 4H_2O \rightarrow CuSO_4.5H_2O + CO_2$$

step 1 Powdered solid copper(II) carbonate is added to 50.0 cm^3 of 0.05 mol / dm^3 sulfuric acid until the copper(II) carbonate is in excess.

step 2 The excess of copper(II) carbonate is separated from the aqueous copper(II) sulfate.

step 3 The aqueous copper(II) sulfate is heated until the solution is saturated.

step 4 The solution is allowed to cool and crystallise.

step 5 The crystals are removed and dried.

(a) Calculate the maximum mass of the copper(II) sulfate crystals, $CuSO_4.5H_2O$, that can form using the following steps.

- Calculate the number of moles of H_2SO_4 in 50.0 cm^3 of 0.05 mol / dm^3 H_2SO_4.

.... mol

- Determine the number of moles of $CuSO_4.5H_2O$ that can form.

.... mol

- The M_r of $CuSO_4.5H_2O$ is 250.

  Calculate the maximum mass of $CuSO_4.5H_2O$ that can form.

.... g
[3]

(b) **Steps 1–5** were done correctly but the mass of crystals obtained was less than the maximum mass.

Explain why.

.... [1]

(c) State **two** observations that would indicate that the copper(II) carbonate is in excess in **step 1**.

1 ....

2 ....

[2]

MARKING SCHEME:

(a)	**M1** 0.0025 / 2.5 × 10^{-3} (moles of H_2SO_4) (1) **M2** 0.0025 / 2.5 × 10^{-3} (moles of $CuSO_4$•$5H_2O$) (1) **M3** 0.625(g) (1)	**3**
(b)	some copper(II) sulfate remains in solution / some copper(II) sulfate does not form crystals **OR** some of the crystals decomposed **OR** some crystals lost in transfer	**1**
(c)	**M1 no more** bubbling / fizzing / effervescence (1) **M2 solid** or **powder** stops dissolving (1)	**2**