

Revision Exercise on the 1st Half-term of A-Level Chemistry

This activity is designed to test many of the skills that you have been taught over the first half-term of A-Level Chemistry lessons. These are **fundamental skills** that will be repeatedly applied during future chemistry lessons.

20
Ca
calcium
40.1

- Calcium, Ca, is a reactive metal in group 2 of the periodic table.
 - What is the atomic number of Ca?
 - Calcium has a relative atomic mass of 40.1
Define *relative atomic mass*.
.....
.....
 - What is the electronic configuration of the calcium, atom. Give the full configuration.
.....
 - What block of the periodic table is Ca in?
 - Calcium has 26 known isotopes. After Ca-40, the isotope Ca-44 is the second most abundant with an abundance of 2.09%.
 - How many protons does Ca-44 have?
 - How many neutrons does Ca-44 have?
 - How many electrons does $^{44}\text{Ca}^{2+}$ have?
- Calcium is a reactive metal in group 2 of the periodic table. It reacts in water to give a solution of calcium hydroxide and hydrogen.
 - Write a word equation for the reaction between calcium and water.
.....
 - Write a symbol equation for the reaction between calcium and water. Include state symbols.
.....
 - 2.44g of calcium was added to 750cm³ of de-ionised water. The hydrogen that was evolved was collected.
 - Calculate the number of moles present in 2.44g of calcium. Give your answer in **standard form** and to the appropriate number of **significant figures**. Include the **units**

Answer.....
 - Calculate the concentration of the calcium hydroxide solution produced if you assume that all of the calcium hydroxide is dissolved in the 750cm³ of water.

Answer.....
 - The hydrogen gas was collected at 26°C and the pressure of the hydrogen was recorded as 102kPa. Calculate the volume of hydrogen collected under these conditions. Give the units in your answer. **R=8.314 J mol⁻¹ K⁻¹**

Answer.....

3. You realise that the calcium hydroxide produced has not all dissolved because you observe large amounts of white precipitate which you correctly assume to be undissolved calcium hydroxide. You decide to work out the solubility of calcium hydroxide in water at 20°C.

Solubility is typically measured in g/100cm³ of solution

One method to do this could be to filter off the precipitate of calcium hydroxide, wash it and dry it to constant mass. You could then work out how much remained in solution. However, the precipitate is very difficult to filter. And, washing the precipitate with water washes away some the calcium hydroxide by dissolving it.

So, you decide to determine the concentration of the calcium hydroxide solution (also known by the familiar name, lime water) by titration with sulfuric acid.

- concentration of sulfuric acid is 0.0240 mol dm⁻³
- volume of calcium hydroxide solution used in each titration was 25.0 cm³

Your results are shown below:

	Run 1	Run 2	Run 3	Run 4
Final volume/ cm ³	24.35	47.50	26.60	49.85
Initial volume/ cm ³	0.00	24.35	0.50	26.60
Titre/ cm ³				

- a) Complete the table by entering the missing titre values.
 b) Calculate the mean titre value.

Answer.....

- c) Write a word equation for the reaction between calcium hydroxide and sulfuric acid.

.....

- d) Write a symbol equation for the reaction between calcium hydroxide and sulfuric acid.

.....

- e) You now have sufficient information to calculate the **solubility** of calcium hydroxide in **g/100cm³**.

You will probably not have learned about solubility, but you should try to think scientifically. Look at these **units** of solubility; this should be a hint about.

Attempt to do this without further prompting.

If you need **more guidance**, follow the steps (i)-(v), on the following page.

Solubility of calcium hydroxide g/100cm³

i) Calculate the number of moles of sulfuric acid used in each titration.

Answer.....

ii) Calculate the number of moles of calcium hydroxide used in each titration.

Answer.....

iii) Calculate the number of moles of calcium hydroxide in each 100cm³ of solution.

Answer.....

iv) Calculate the mass of calcium hydroxide in each 100cm³ of solution.

Answer.....

v) So, what is the solubility of calcium hydroxide?

Solubility of calcium hydroxide g/100cm³

4. 100cm^3 of the calcium hydroxide solution were neutralised with sulfuric acid to produce a solution of calcium sulfate. This solution was heated **gently** to evaporate the solution to give crystals of constant mass.

If you didn't manage to obtain an answer for the solubility of calcium hydroxide, assume that the solubility of the calcium hydroxide is $0.165\text{ g per }100\text{cm}^{-3}$.

- a) Calculate the theoretical mass of pure anhydrous calcium sulfate that you should obtain.

Answer.....

- b) The actual mass of dry crystals that was obtained was 0.383g .

You decide that the calcium sulfate has crystallised as a hydrate. Determine the formula of the hydrate.

Answer.....

- c) *Plaster of Paris* is traditionally used to coat bandages in casts for broken bones.

Plaster of Paris is the hemi hydrate of calcium sulfate. It has the chemical formula $\text{CaSO}_4 \bullet 0.5 \text{H}_2\text{O}$.

You decide to produce a small sample of *Plaster of Paris* by gently dehydrating the original hydrate (0.383g) until it achieves the desired mass of the hemi hydrate.

Calculate the mass of the sample that you would need to achieve before you stop the dehydration.

If you didn't manage to work out the formula of the original hydrate, it was $\text{CaSO}_4 \bullet 2 \text{H}_2\text{O}$.

Answer.....

5. You take another 100cm³ of the original saturated calcium hydroxide solution. You decide to exhale through the solution to fully react the calcium hydroxide solution with carbon dioxide gas (from exhaled air) by conversion to the precipitate of calcium carbonate.

a) Write a word equation for the reaction between the base, calcium hydroxide solution and carbon dioxide which is as acidic oxide.

.....

b) Write a symbol equation for the reaction between calcium hydroxide solution and carbon dioxide.

.....

c) The percentage of CO₂ in exhaled air is around 4%.

The molar gas volume under these conditions is 25.2 dm³ mol⁻¹.

The average volume of exhaled air, at rest, is 500cm³. Assume that you are average. (Sorry!)

Calculate the minimum number of full breaths that you would need to exhale in order to fully neutralise the calcium hydroxide solution.

Answer.....

6. Calculate the atom economy for the process that produces calcium carbonate as the desired product.

Answer.....

7. You decide to filter and wash the calcium carbonate precipitate produced by exhaling through the 100cm³ of saturated calcium hydroxide solution.

After drying to constant mass, you have a mass of 164mg of calcium carbonate.

Calculate the percentage yield.

Answer.....