To determine the atomic weight of a metal sample

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Introduction:

Very early in their school career, students are introduced to the concept of atomic weight. The following simple experiment deals with measurement of atomic weight in the class room. This experiment may not be a precise measurement technique but does provide a curiosity element and students usually find it a thrilling experience to be able to measure the atomic weight of a metal. This experiment is also about teaching and training safe methods to be employed in all chemistry experiments.

Caution: *This experiment uses 1 M HCl solution and hence should be conducted by the students under close supervision, or by the teacher alone.*

Theory: A reactive metal can react with a strong acid to evolve hydrogen. The volume of evolved hydrogen can be used to calculate the atomic weight of the metal. One mole of an ideal gas at STP occupies 22.4 L. The basic idea of the experiment is given by the equation,

$$M + 2HCl \longrightarrow MCl_2 + H_2$$
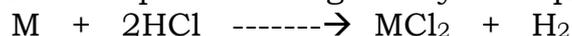
where M is a divalent metal like Zn or Mg

Apparatus and Chemicals:

Plastic tub, Plain glass lid, 100 mL measuring cylinder, pair of forceps, 1N HCl solution, Given metal piece, 1 pair of rubber gloves.

CAUTION: *It is essential that there are no fire or electrical sources or mobile phones, very close to the experimental set-up while conducting the experiment. The experiment should be done in an non-AC environment, preferably not too far from open windows and doors.*

Procedure :

1) Wear a pair of rubber gloves and goggles to avoid touching the solution that is provided.
2) Weigh the given piece of metal as precisely as possible. [Ensure that the metal piece is clean with no oxidation or other surfaces developed on the metal. If required, clean the metal surface with sandpaper before weighing.]
3) Pour 500 mL of 1 M HCl solution into the plastic tub. (Caution: *Avoid skin*

contact with HCl).

4) Fill the 100 ml measuring cylinder to the brim with HCl solution, cover it with a glass lid, carefully invert it in the tub so that the solution remains within the cylinder. Gently remove the glass lid and note the level of solution in the cylinder.

5) Using forceps carefully insert the given metal piece through the lip of the measuring cylinder. [Note: teacher should observe that the time taken to insert the metal in the solution INSIDE the measuring cylinder is as small as possible. If the reaction occurs while the metal is being transported, and gases escape into air, the volume of gas collected will be smaller, resulting in an error in the final value of At. Wt.]

6) Due to the reaction taking place, bubbles of hydrogen will be seen, and gradually the gas will collect in the upper portion of the cylinder. Wait till the metal piece has completely disappeared, and note the new level of solution in the measuring cylinder.
[In case of slow reaction, the remaining piece of metal can be removed from the solution, dried and remaining metal piece weighed again to determine the amount of metal which has reacted with the HCl Solution]

7) Calculate the atomic weight (A_w) of the metal from the volume of hydrogen gas collected.

This process is different from an experiment published by W.Earle Waghorne and Andrew J Rous, titled ``Determination of the Relative Atomic Masses of Metals by Liberation of Molecular Hydrogen", in J. Chem. Educ. 2009, 86(3), p 350.
https://doi.org/10.1021/ed086p350
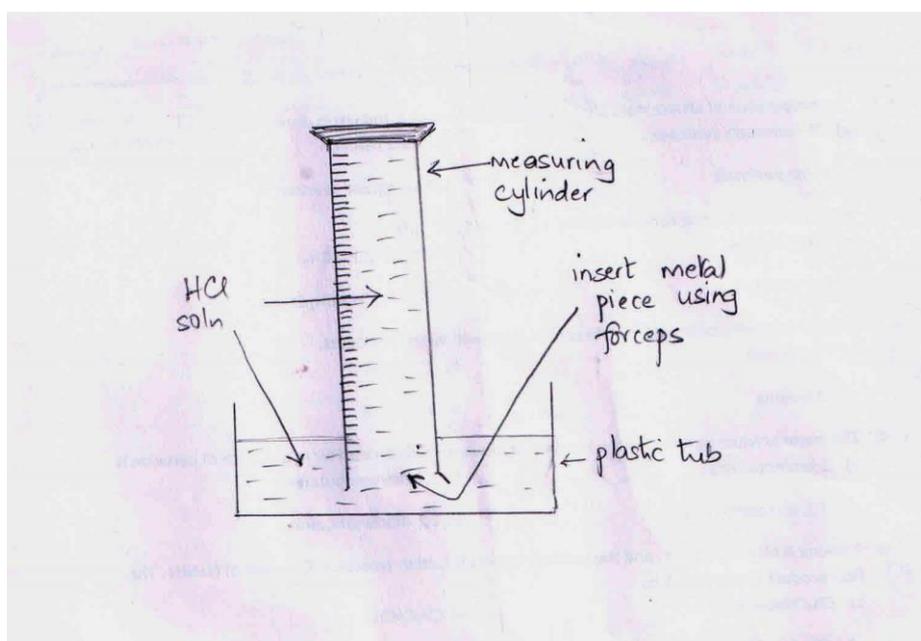
Observations :
(7 points)

1	Initial level of HCl in cylinder	mL

2	Final level of HCl in cylinder	mL	
3	Volume of hydrogen collected at room temperature	mL	
4	Room temperature	^oC	

Weight of given metal piece W(g)= _____
Valency of the given metal = n (val) _____
Let V mL be the volume of hydrogen evolved at room temperature (T) and room pressure (P)
Calculate the corresponding volume at STP ie T_0=273K and P_0 =1 atm using the ideal gas equation, $PV/T = P_0V_0/T_0$.
V_0 mL of hydrogen is evolved by W g of metal V_0=_____

A_w g of metal will release 22400 ml of H_2 gas. Then $A_w = \frac{22400\ W\ n}{2\ V_0}$

[The teacher can be selective on what information is to be provided and what information is left to the students to obtain from their other reading sources. This can be a method to encourage students to read reference books or text books to gather information needed for the experiment. Depending on the information provided, the following questions may be modified as per the requirement. Teachers are also encouraged to carry out this experiment at lower concentrations and verify the results. The equation for calculation and timing process will have to modified as per the requirement.]

Calculations:

1) Write the relevant balanced chemical equation (x marks)

2) Calculate the volume of hydrogen gas at STP: (X points)

Optional question. Nita performed the above experiment using 1 g of a mixture of aluminium and zinc. The volume of hydrogen obtained by her was 1427cm³ . Calculate the individual weights of the metals in the mixture.