Experiment Number 4
State Variable Filter
EP3290

Chaganti Kamaraja Siddhartha
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Teaching Assistant: Instructor:	Professor Prem B. Bisht

1 Objective

Design a State Variable Filter which has a corner (natural undamped) frequency, f_C of 2.5 kHz and a quality factor, Q of 10. Assume both the frequency determining resistors and capacitors are equal. Determine the filters DC gain and draw the resulting circuit and Bode plot.

1.1 Definitions

State Variable Filter The state variable filter is a type of multiple-feedback filter circuit that can produce all three filter responses, Low Pass, High Pass and Band Pass simultaneously from the same single active filter design.

Atomic mass The mass of an atom of a chemical element expressed in atomic mass units. It is approximately equivalent to the number of protons and neutrons in the atom (the mass number) or to the average number allowing for the relative abundances of different isotopes.

2 Experimental Data

Mass of empty crucible	7.28 g
Mass of crucible and magnesium before heating	8.59 g
Mass of crucible and magnesium oxide after heating	9.46 g
Balance used	#4
Magnesium from sample bottle	#1

3 Sample Calculation

$$\begin{aligned}
\text{Mass of magnesium metal} &= 8.59\,\mathrm{g} - 7.28\,\mathrm{g} \\
&= 1.31\,\mathrm{g} \\
\text{Mass of magnesium oxide} &= 9.46\,\mathrm{g} - 7.28\,\mathrm{g} \\
&= 2.18\,\mathrm{g} \\
\text{Mass of oxygen} &= 2.18\,\mathrm{g} - 1.31\,\mathrm{g} \\
&= 0.87\,\mathrm{g}
\end{aligned}$$

Because of this reaction, the required ratio is the atomic weight of magnesium: 16.00 g of oxygen as experimental mass of Mg: experimental mass of oxygen or $\frac{x}{1.31} = \frac{16}{0.87}$ from which, $M_{\mathrm{Mg}} = 16.00 \times \frac{1.31}{0.87} = 24.1 = 24\,\mathrm{g\,mol^{-1}}$ (to two significant figures).

4 Results and Conclusions

The atomic weight of magnesium is concluded to be $24\,\mathrm{g\,mol^{-1}}$, as determined by the stoichiometry of its chemical combination with oxygen. This result is in agreement with the accepted value.

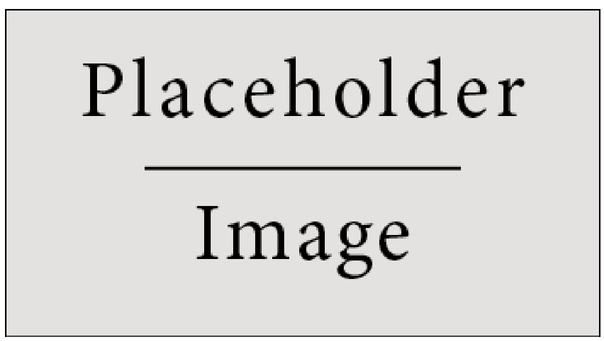

Figure 1: Figure caption.

5 Discussion of Experimental Uncertainty

The accepted value (periodic table) is $24.3\,\mathrm{g\,mol^{-1}}$ (Smith and Jones 2022). The percentage discrepancy between the accepted value and the result obtained here is 1.3%. Because only a single measurement was made, it is not possible to calculate an estimated standard deviation (see Jones and Smith (2021)).

The most obvious source of experimental uncertainty is the limited precision of the balance. Other potential sources of experimental uncertainty are: the reaction might not be complete; if not enough time was allowed for total oxidation, less than complete oxidation of the magnesium might have, in part, reacted with nitrogen in the air (incorrect reaction); the magnesium oxide might have absorbed water from the air, and thus weigh “too much." Because the result obtained is close to the accepted value it is possible that some of these experimental uncertainties have fortuitously cancelled one another.

6 Answers to Definitions

a. The *atomic weight of an element* is the relative weight of one of its atoms compared to C-12 with a weight of 12.0000000. . ., hydrogen with a weight of 1.008, to oxygen with a weight of 16.00. Atomic weight is also the average weight of all the atoms of that element as they occur in nature.

b. The *units of atomic weight* are two-fold, with an identical numerical value. They are g/mole of atoms (or just g/mol) or amu/atom.

c. *Percentage discrepancy* between an accepted (literature) value and an experimental value is:

$$\frac{\text{experimental result} - \text{accepted result}}{\text{accepted result}}$$

References

Jones, A. B. and J. M. Smith (Mar. 2021). “Article Title”. In: *Journal title* 13.52, pp. 123–456. DOI: 10.1038/s41586-021-03616-x.

Smith, J. M. and A. B. Jones (2022). *Chemistry*. 7th. Publisher.