Modeling Modes of Operation Using AADL and AGREE

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April 16, 2019

1 The Point of it All

In critical system development, it's important to have redundancy in the system and introduce modes of operation. For instance when everything works properly, we are in normal mode. If a failure occurs in normal mode, we can switch to a backup or alternate mode, and so on. When modeling this in AADL and AGREE for a large scale Wheel Brake System, we ran into some issues once we generated minimal cut sets. For minimal cut sets of cardinality 1, faults were showing up in normal and alternate mode. This shouldn't be happening if the behavior of the components is modelled correctly. If a fault occurs in normal mode, the system should automatically switch to alternate mode and still provide the service as intended. For a system with n backup modes (or redundancy plans), we should see tolerance up to n faults.
First I will describe the Wheel Brake System (briefly) and then describe the small scale system created to sort out what contracts are needed to enforce switching modes and testing such behavior. The system in question is located in repository: `https://github.com/dkstewart/University-Research` and is titled *Modes of Operation*.

1.1 Definitions

Stoichiometry The relationship between the relative quantities of substances taking part in a reaction or forming a compound, typically a ratio of whole integers.

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

Mass of magnesium metal	= 8.59 g - 7.28 g
	= 1.31 g
Mass of magnesium oxide	= 9.46 g - 7.28 g
	= 2.18 g
Mass of oxygen	= 2.18 g - 1.31 g
	= 0.87 g

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.

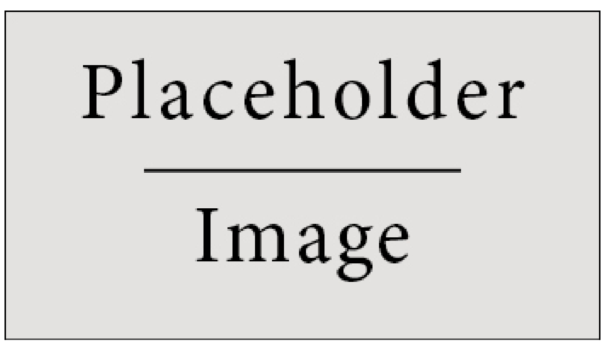

Figure 1: Figure caption.

5 Discussion of Experimental Uncertainty

The accepted value (periodic table) is $24.3\,\mathrm{g\,mol^{-1}}$ Smith and Jones (2012). 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.
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

Smith, J. M. and Jones, A. B. (2012). *Chemistry*. Publisher, 7th edition.