Balancing Chemical Equations

Victor Aguilar www.sniperflashcards.com

Ragnar Benson wishes to determine the correct mixture of ammonium nitrate and nitromethane to achieve complete detonation. A noble endeavor! But let us see how Mr. Benson goes about finding this correct mixture. Benson (1992, p. 136) writes:

> *Despite almost driving our family into poverty by my many costly experiments, I still do not feel I have all the answers pertaining to this process. My experiments indicate that one should use slightly less than one-third nitromethane by volume, but this seems to vary from one gallon of nitromethane to the next and from one bag of ammonium nitrate to the next.*
>
> *Unfortunately, I know of no formula that states precisely how much nitromethane to use. As a rough starting point, try one part nitromethane to three parts of ammonium nitrate by volume or two parts nitromethane to five parts ammonium nitrate by weight.*

In sharp contrast, real science is based on the axiomatic method. Real scientists do not just randomly mix reactants together, stick a blasting cap in the resulting glop and see what – if anything – happens. Calling such guesses "hypothesis" does not make this activity scientific.

Real scientists reason from axioms; in this case, the conservation of mass. Chemical reactions – even very energetic ones like the detonation of high explosives – do not destroy mass. This claim is an axiom; that is, a proposition that is assumed without proof for the sake of studying the consequences that follow from it. An ammonium nitrate/nitromethane explosion just converts a solid and a liquid into three hot gasses; water vapor, carbon dioxide and nitrogen.

The important point here is that we must *assume* that there is exactly the same number of hydrogen, carbon, nitrogen and oxygen atoms in the reactants as there are in these hot gasses. Because water vapor, carbon dioxide and nitrogen are already abundant in the atmosphere, there is really no way that we could catch the products of the explosion, racing away from the blast at 7000 m/s or more, and weigh them. In some endothermic reactions that do not involve gasses, it may be possible to weigh the reactants and products, but even then we must remember that a mechanical scale is limited to only about three significant digits of accuracy.

Yet I claim that mass is conserved *exactly*; to 23 significant digits if we could actually count every molecule in a mole of material. Such a bold assertion *must* be regarded as an axiom. There is no way to test it in the great majority of cases and even when it can be tested the accuracy of our measurements is 20 orders of magnitude short of proving our assertion.

So, having established the axiomatic nature of our line of reasoning, let us apply our axioms one-by-one and see what can be deduced from them, without recourse to any experiments or hidden assumptions. (And, as an added bonus, without blowing ourselves up or getting tossed into prison for possessing illegal explosives.)

NH_4NO_3	CH_3NO_2	→	H_2O	CO_2	N_2	(1)
x	y		?	y	?	

Let x be the number of ammonium nitrate, NH_4NO_3, molecules and let y be the number of nitromethane, CH_3NO_2, molecules. From the axiom that there are as many carbon atoms before as after the reaction, we can deduce that there are y carbon dioxide molecules, as shown in equation (1).

NH_4NO_3	CH_3NO_2	→	H_2O	CO_2	N_2	(2)
x	y		?	y	(2x+y)/2	

From the axiom that there are as many nitrogen atoms before as after the reaction, we can deduce that there are (2x+y)/2 nitrogen molecules, as shown in equation (2).

NH_4NO_3	CH_3NO_2	→	H_2O	CO_2	N_2	(3)
x	y		(4x+3y)/2	y	(2x+y)/2	

From the axiom that there are as many hydrogen atoms before as after the reaction, we can deduce that there are (4x+3y)/2 water molecules, as shown in equation (3).

$$3x + 2y = \frac{4x + 3y}{2} + 2y \qquad (4)$$

From the axiom that there are as many oxygen atoms before as after the reaction, we can deduce equation (4).

$$2x = 3y \qquad (5)$$

By multiplying both sides of (4) by two and then subtracting 4x + 4y from both sides, we can deduce equation (5), which is all the information we need to deduce equation (6), our result.

$$3NH_4NO_3 + 2CH_3NO_2 \rightarrow 9H_2O + 2CO_2 + 4N_2 \qquad (6)$$

And so, using only deductive logic based on the axiom that mass is conserved, we have found the formula for an ammonium nitrate/nitromethane reaction.

But we still do not know the relative weights of the two reactants. For this we must introduce a second axiom: The atomic mass of an element is approximately equal to the sum of its protons and neutrons. This is the simple high school model of the atom without isotopes. Specifically:

Hydrogen has one proton and no neutrons.	The atomic mass of hydrogen is 1.
Carbon has six protons and six neutrons.	The atomic mass of carbon is 12.
Nitrogen has seven protons and seven neutrons.	The atomic mass of nitrogen is 14.
Oxygen has eight protons and eight neutrons.	The atomic mass of oxygen is 16.

Atomic mass is actually the weighted average of the isotopes minus a tiny mass deficit for what is converted into binding energy – the results found in this paper have only three significant digits of accuracy – but the important point is that both this basic high school model of the atom and the more complicated professional model are axiomatic systems.

Nobody has ever seen an atom and nobody ever will. It is smaller than the wavelength of light one would have to reflect off it onto the lens of one's microscope to observe it. What divides the post-doctoral researcher from the high school chemistry teacher is not that the former has a more powerful microscope for observing atoms – no such microscope exists – but that the former has a more powerful, though also more complicated, axiomatic system.

At this point in the argument, the empiricist will invariably start screeching that he has "refuted" our entire theory by carefully weighing a mole of oxygen and finding that it weighs 15.9994 grams, not 16 as that misguided axiomatist claimed. Well, so it does. But I already noted that the results in this paper were only accurate to three significant digits. Many axiomatic systems describe the same phenomena; some have the virtue of simplicity; some have the virtue of accuracy; and some – like Gerard Debreu's 1959 *Theory of Value* – have no virtue at all. Choose wisely. And do not engage in straw-man attacks by assuming that criticisms of Debreu (1959) apply to Aguilar (1999) just because they are both axiomatists.

If three significant digits of accuracy are sufficient for practical applications, there is nothing wrong with using simple axioms that are known to be approximations. For instance, I developed an Android application for mortar fire control based on three axioms, one of which is that the Earth is flat; that is, gravity is everywhere pointed downwards. In point of fact, the Earth is not flat; it is a sphere. But knowing it to be a sphere is no recommendation to stand calmly on the receiving end of my mortar fire. Howitzers should not be fired at targets over the horizon based on such simplifications, but my app is more than sufficient to hit a Shilka lurking behind a building six blocks away.

So, having dispensed with the empiricist's inevitable criticism that our axioms are not perfect, let us return to our intrepid chemist, Mr. Benson. From our second axiom, we can deduce that the atomic mass of three ammonium nitrate molecules is 3(4 + 28 + 48) = 240 atomic mass units, AMU. Furthermore, we can deduce that the atomic mass of two nitromethane molecules is 2(3 + 12 + 14 + 32) = 122 AMU.

Therefore, using only deductive logic based on two reasonable axioms, we have found that we need 122 parts nitromethane to 240 parts ammonium nitrate, by weight, to achieve complete detonation. This result can be rounded off to one part nitromethane to two parts ammonium nitrate, by weight. And if it fails to detonate? It probably absorbed moisture from the air. Try again. Perfect equations and aesthetic axioms always supersede anecdotal evidence.

Clearly, the axiomatic method is vastly superior to the empirical method of conducting random experiments until something resembling a result appears. But empiricists never learn. Here, Mr. Benson (1992, pp. 139-140) describes a further line of research, conducted with his usual methodology of randomly mixing reactants together to see what happens.

> *The tip-off to a possible solution came while I was researching World War I's Messines Ridge sapper attack… Britain's World War I explosives manufacturers added finely ground aluminum powder to this explosive, called ammonal, to boost its brisance… Having made that discovery, I began to experiment with powdered aluminum. I added it to the ground ammonium nitrate before adding the nitromethane. At a level of about 5 percent (or about 20 grams) mixed thoroughly into 430 grams of NH_4NO_3, the effect was dramatic.*

I leave it as an exercise for the reader to derive equations (7), (8) and (9) employing only deductive logic – no experiments – based on our two axioms. (Note that aluminum has 13 protons and 14 neutrons.) The atomic masses are written below the reactants.

$$6NH_4NO_3 + 2CH_3NO_2 + 2Al \rightarrow 15H_2O + 2CO_2 + 7N_2 + Al_2O_3 \quad (7)$$
480 122 54

$$9NH_4NO_3 + 4CH_3NO_2 + 2Al \rightarrow 24H_2O + 4CO_2 + 11N_2 + Al_2O_3 \quad (8)$$
720 244 54

$$12NH_4NO_3 + 6CH_3NO_2 + 2Al \rightarrow 33H_2O + 6CO_2 + 15N_2 + Al_2O_3 \quad (9)$$
960 366 54

It is truly sad that Mr. Benson nearly drove his family into poverty, spending a lifetime and squandering a fortune attempting to accomplish with random experiments what an axiomatist could have achieved in thirty minutes at no cost. My heart breaks for his wife and children! If I were a Liberal, I might advocate a program of socialized explosives so that poor folks could pick up a brick of C4 at the food bank, just as they can now pick up a loaf of bread or a can of soup.

Lest others drive their families into poverty with their many costly experiments, let us investigate where Mr. Benson got the idea that doing science means randomly mixing reactants together. In spite of all the highfalutin talk about these random mixtures representing "hypothesis" that are to be tested empirically, accompanied by a barrage of statistical "data" if the experiment is conducted more than once, it is obvious that Mr. Benson is not a scientist. Real scientists employ the axiomatic method. But who might have misled this poor man?

James Devine writes:

> *The original statements by the rebellious French economics students define autistic economics in terms of its one-sided and exclusionary interest in "imaginary worlds," "uncontrolled use of mathematics" and the absence of pluralism of approaches in economics. The hard-core autistic walling off from the societal environment can be seen most strongly in the specific, highly abstract, axiomatic school that the students protested against.*

This paper begins "As an economist with a son having heavy autistic leanings,…" Then, based on this fact, Devine establishes himself as someone with the ability to diagnose autism in people whom he has never met, based only on their academic writing. And what criterion does he use to make this diagnosis? According to James Devine and the Post-Autistic Economics Network, the mark of the autistic is use of the axiomatic method – what we have done in this paper – the opposite of pluralism, which means giving every yahoo the authority to suggest a mixture of reactants and then sticking blasting caps in them all to see what happens.

Why would James Devine make such a repugnant accusation of people whom he has never met? Because he is an avowed Marxist. Since 1898, when Böhm-Bawerk published *Karl Marx and the Close of His System*, Marxists have understood that logic is not on their side. The labor theory of value simply does not make sense. Driven into a corner by the irrefutable logic of free-market economists, the Marxists have embarked on a desperate gambit: They would conspire to purge the economics community of anybody with a geometry class on his transcript, claiming that this is evidence of "axiom-happy behavior," as they call it.

The Real World Economics Review writes:

> *It is accepted fact that the economics profession through its teachings, pronouncements and policy recommendations facilitated the Global Financial Collapse (GFC). To date, however, the world's major economics associations have declined to censure the major facilitators of the GFC or even to publicly identify them. This silence, this indifference to causing human suffering, constitutes grave moral failure. It also gives license to economists to continue to indulge in axiom-happy behavior.*

Since these associations are funded entirely by the Federal Government, this is tantamount to government censorship. Indeed, their use of the word censure, rather than censor, implies a formal reprimand issued to an individual by an authoritative body. This is highly reminiscent of the Soviet practice of denouncing dissidents as mentally ill. If preventing autistic people from getting published becomes government policy, it is only a short step to forcibly institutionalizing anybody who has studied geometry or otherwise shown an aptitude for the axiomatic method.

This is not the first time that the economics profession has purged axiomatists. Historian Ludwig von Mises writes:

> *Economics in the second German Reich, as represented by the government-appointed university professors, degenerated into an unsystematic, poorly assorted collection of various scraps of knowledge borrowed from history, geography, technology, jurisprudence, and party politics, larded with deprecatory remarks about the errors in the "abstractions" of the Classical School.*
>
> *After 1866, the men who came into the academic career had only contempt for "bloodless abstractions." They published historical studies, preferably such as dealt with labor conditions of the recent past. Many of them were firmly*

convinced that the foremost task of economists was to aid the "people" in the war of liberation they were waging against the "exploiters."

This was the position Gustav Schmoller embraced with regard to economics. Again and again he blamed the economists for having prematurely made inferences from quantitatively insufficient material. What, in his opinion, was needed in order to substitute a realistic science of economics for the hasty generalizations of the British "armchair" economists was more statistics, more history, and more collection of "material." Out of the results of such research the economists of the future, he maintained, would one day develop new insights by "induction."

I should not have to remind the reader of what path this philosophy led the Germans down. If you do not want America to go down this same path, then you must stand up now and speak out in favor of the axiomatic method in economics.

For reference, here are the three axioms that modern (post-Debreu) economics is based on, comparable to the conservation of mass and the model of the atom employed in this paper:

1) One's value scale is totally (linearly) ordered:

i)	Transitive;	$p \leq q$ and $q \leq r$ imply $p \leq r$
ii)	Reflexive;	$p \leq p$
iii)	Antisymetric;	$p \leq q$ and $q \leq p$ imply $p = q$
iv)	Total;	$p \leq q$ or $q \leq p$

2) Marginal (diminishing) utility, u(s), is such that:

- **i)** It is independent of first-unit demand.
- **ii)** It is negative monotonic; that is, $u'(s) < 0$.
- **iii)** The integral of $u(s)$ from zero to infinity is finite.

3) First-unit demand conforms to proportionate effect:

- **i)** Value changes each day by a proportion (called $1+\varepsilon_j$, with j denoting the day), of the previous day's value.
- **ii)** In the long run, the ε_j's may be considered random as they are not directly related to each other nor are they uniquely a function of value.
- **iii)** The ε_j's are taken from an unspecified distribution with a finite mean and a non-zero, finite variance.

REFERENCES

Aguilar, Victor. 1999. ***Axiomatic Theory of Economics***. Hauppauge, NY: Nova Science Publishers, Inc.

Benson, Ragnar. 1992. ***Big Book of Homemade Weapons***. Boulder, CO: Paladin Press

Böhm-Bawerk, Eugen von. [1898] 1984. ***Karl Marx and the Close of His System***. New York, NY: Augustus M. Kelley

Debreu, Gerard. 1959. ***Theory of Value: An Axiomatic Analysis of Economic Equilibrium***. New York, NY: John Wiley & Sons, Inc.