How to balance a challenging reaction

Consider the following problem.

Balance the following reaction and indicate the sum of the coefficients of the reactants and products.

$$\_\_\ Se + \_\_\ BrF_5 \rightarrow \_\_\ SeF_6 + \_\_\ BrF_3$$

a. 6 b. 7 c. 8 d. 9

My approach:

The only source of F on the reactant side is BrF_5. On the product side, SeF_6 and BrF_3 both have numbers of F atoms that are multiples of three. I need to choose a coefficient of BrF_5 that will make the number of F atoms a multiple of three, otherwise I will never be able to balance the F on the product side. Starting with that, I use a coefficient of 3 in front of BrF_5:

$$\_\_\ Se + 3\ BrF_5 \rightarrow \_\_\ SeF_6 + \_\_\ BrF_3$$

Now I need to place a three in front of the BrF_3 to balance the Br.

$$\_\_\ Se + 3\ BrF_5 \rightarrow \_\_\ SeF_6 + 3\ BrF_3$$

At this point, the F atoms are balanced. That was lucky! Selenium is also balanced, so the entire equation is balanced.

$$Se + 3\ BrF_5 \rightarrow SeF_6 + 3\ BrF_3$$

The sum of the coefficients is 8.

Another approach:

One student looked at the numbers of fluorine atoms in each fluorine-containing species. The least common multiple of 5, 6 and 3 is 30. So choosing coefficients to make 30 F atoms on the left, while balancing the bromine yields:

$$\_\_\ Se + 6\ BrF_5 \rightarrow \_\_\ SeF_6 + 6\ BrF_3$$

This makes 30 F atoms on the left and 24 F atoms on the right (18 from BrF_3 and 6 more from SeF_6.) Placing a 2 in front of SeF_6 (and balancing the Se on the left yields:

$$2\ Se + 6\ BrF_5 \rightarrow 2\ SeF_6 + 6\ BrF_3$$

The total of the coefficients at this point is 2 + 6 + 2 + 6 = 16. But this is not one of the choices on the quiz! (Nertz!) Aha! But … the numbers can be simplified by dividing everything by 2. Remember – **the properly balanced equation has the smallest whole-number coefficients that do the job**. As such, the properly balanced equation looks as follows:

$$Se + 3\ BrF_5 \rightarrow SeF_6 + BrF_3$$

And notice – even if your methodology produces coefficients that are not the smallest whole number coefficients, you can always simply at the end (in this case by dividing everything by 2.) Oftentimes, this can be the easiest approach!

<u>Yet another approach</u>:

Another student used a very clever application of algebra to solve the problem.

$$\_\_\ Se + \_\_\ BrF_5 \rightarrow \_\_\ SeF_6 + \_\_\ BrF_3$$

Noting that the coefficient in front of Se has to be the same as that in front of SeF_6 and that the coefficient in front of BrF_5 has to be the same as that in front of BrF_3, he wrote the following.

$$x\ Se + y\ BrF_5 \rightarrow x\ SeF_6 + y\ BrF_3$$

he then created the equation relating x and y using the numbers of fluorine atoms on each side. The only way the F atoms balance is if

$$5y = 6x + 3y$$

(5, 6 and 3 coming from the number of F atoms in BrF_5, SeF_6 and BrF_3 respectively.) Simplifying the equation yields

$$2y = 6x$$
$$y = 3x$$

Choosing a value of y = 1 (so that x = 3), the final equation is

$$1\ Se + 3\ BrF_5 \rightarrow 1\ SeF_6 + 3\ BrF_3$$

Remember that the 1s are assumed, so it is normally written

$$Se + 3\ BrF_5 \rightarrow SeF_6 + 3\ BrF_3$$

Which approach is best?

The best approach is the one that works for you! If a particular method is too complicated or too confusing, use a different method. Further, the only way to find a comfortable approach is through practice. Work lots of examples so you get good at this skill!

There are a number of very good tutorials available on the web (many of which contain an extensive list of practice problems.)

http://richardbowles.tripod.com/chemistry/balance.htm
http://members.aol.com/profchm/balance.html
http://dbhs.wvusd.k12.ca.us/webdocs/Equations/Balance-Worksheet1.html

other great sources of practice problems (in addition to your textbook) include the Schaum Outline for College Chemistry, Cliff's Notes Chemistry reviews and others.

Additionally, here are a few for you to practice (with the sum of the coefficients indicated in parentheses.) Try balancing them before considering the sum of the coefficients!

__ NCl_3 + __ H_2O → __ NH_3 + __ HOCl (8)

__ $SbCl_3$ + __ H_2O → __ SbOCl + __ HCl (5)

__ FeS_2 + __ O_2 → __ Fe_2O_3 + __ SO_2 (25)

__ BCl_3 + __ P_4 + __ H_2 → __ BP + __ HCl (27)

__ $C_2H_2Cl_4$ + __ $Ca(OH)_2$ → __ C_2HCl_3 + __ $CaCl_2$ + __ H_2O (8)

__ Zn_3Sb_2 + __ H_2O → __ $Zn(OH)_2$ + __ SbH_3 (12)

__ Sb_2S_3 + __ HCl → __ H_3SbCl_6 + __ H_2S (18)

__ IBr + __ NH_3 → __ NI_3 + __ NH_4Br (11)

__ Na_2CO_3 + __ C + __ N_2 → __ NaCN + __ CO (11)

__ KrF_2 + __ H_2O → __ Kr + __ O_2 + __ HF (11)