

MODIFIED ALGEBRAIC APPROACH



$$\begin{aligned} \therefore Zn: a &= d & N: b+c &= 2d+e \\ H: b &= 3e & O: 3b+c &= 6d \end{aligned}$$

● BE ABLE TO WRITE DOWN SUCH RELATIONSHIPS

● THEREFORE 4 EQUATIONS AND 5 UNKNOWNNS \Rightarrow SOLUTION IS NOT UNIQUE THOUGH LOWEST SET OF INTEGERS IS

● SINCE SOLUTION IS NOT UNIQUE AND WE ARBITRARILY SET A COEFFICIENT TO 1 I FIND IT EASIER TO DO THIS WITH ORIGINAL SET OF EQUATIONS (E.G., $a=c=1$ ON RIGHT)

LET $a=d=1$ THEN $b=3e \Rightarrow$ (N, O EQN BECOME)

$$\left. \begin{aligned} 3e+c &= 2a+e \\ 3(3e)+c &= 6a \end{aligned} \right\} \Rightarrow \begin{aligned} 2e+c &= 2a \\ 9e+c &= 6a \end{aligned}$$

$$\begin{aligned} 7e &= 4a, e = 4/7 \\ 2(4/7)+c &= 2, c = 6/7 \end{aligned}$$

a : b : c : d : e

$$1 : 12/7 : 6/7 : 1 : 4/7 \Rightarrow 7 : 12 : 6 : 7 : 4$$

Algebraic Method for Balancing Equations

(use this only for DIFFICULT equations)

BW 10/86, 9/91, 7/95

Appraisal of difficulty:
H in 3 formulas
O in 3 formulas
N in 2 formulas
I in 2 formulas

Balance this equation: $HNO_2 + HI \rightarrow NO + I_2 + H_2O$

Assign an algebraic unknown (letter) as each coefficient:



These coefficients must be related because of mass balance and non-destruction of atoms in ordinary chemical reactions.

$$\begin{aligned} N: a &= c \\ H: a+b &= 2e \\ O: 2a &= c+e \\ I: b &= 2d \end{aligned}$$

charge : neutral = neutral

Instead of changing coefficients that were previously changed, this method solves simultaneously for all coefficients at once.

Often, this set of equations is easier to solve than the usual high school algebra examples for simultaneous equations.

But only use this algebraic method when you must, because algebra errors in lengthy calculations are common. If you perform unnecessary calculations and do not find the correct answer, it is likely to adversely affect your exam score.

Now we have four independent equations with five unknown variables.

We also have the knowledge that all five unknowns (coefficients a, b, c, d, & e) must be integers.

To solve: e is in only two equations. Solve the O equation for e, and substitute its value into the H eq:

$$O: e = 2a - c$$

$$\text{into H eq: } a+b = 2(2a-c)$$

$$a+b = 4a-2c$$

$$c = a \text{ by H eq: } a+b = 4a-2a$$

$$a+b = 2a$$

$$\text{sub. to I eq, } \therefore b = a \quad (\text{by I eq})$$

$$b = a = c = 2d$$

$$\text{H eq: } a+b = 2e$$

$$\text{but } b=a, \text{ so } 2a = 2e, \therefore a=e$$

$$\boxed{b = a = c = 2d = e}$$

To solve for the 5 integers, we can use the method of simultaneous equations from algebra.

Such problems can also be solved by Cramer's rule (a matrix method) or by other linear algebra methods. See J. Chem. Educ., 6/85, p.507-508. or Chemistry magazine, 3/75, p.19-21.

A Challenge: Write a computer program to balance chemical equations.

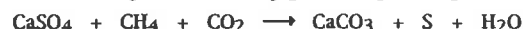
At this point we can find a possible set of integers by finding the LCM (lowest common multiple) of the multipliers in the equation above. Since d has the highest multiplier, d must be the smallest coefficient in the balanced equation,

so we try $d=1$. Then $a=2, b=2, c=2$, and $e=2$



Check balance:
H: $2+2 = 2(2)$ ✓
O: $2(2) = 2+2$ ✓
N: $2 = 2$ ✓
I: $2 = 2$ ✓

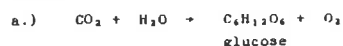
Practise the algebraic method by balancing these as-yet unbalanced equations:



Other Problems:

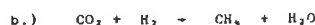
Balance the following equations:

Equation

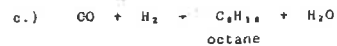


Description
Importance of this equation

formation of sugars by photosynthesis (uses a chlorophyll catalyst).



reaction in methane bacteria (producing swamp gas = CH_4).



a possible prebiotic synthesis of octane (a hydrocarbon) from carbon monoxide.



the reaction which tells us why no free (elemental) iron is found on the earth's crust