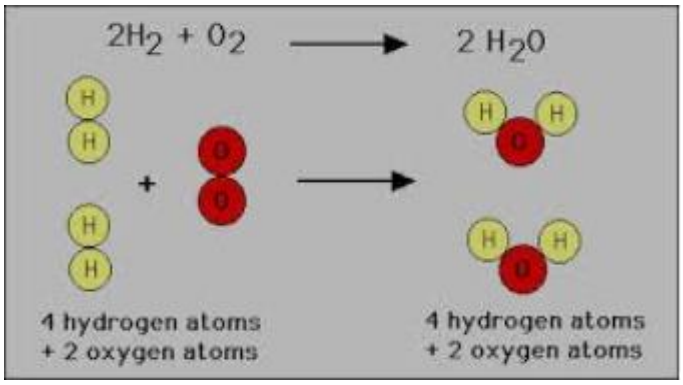
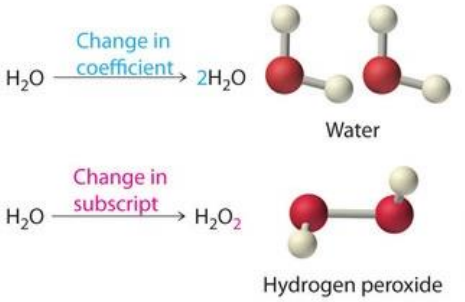
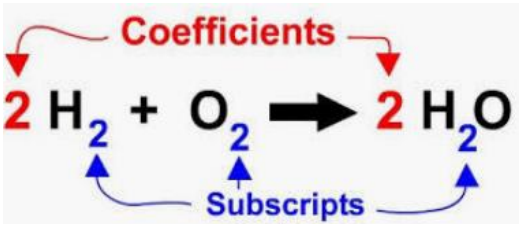
Learning Guide Module

Subject Code	Chem 1	General Inorganic Chemistry
Module Code	2.0	*Nomenclature of Inorganic Compounds*
Lesson Code	2.3	*Balancing Chemical Equations*
Time Limit		30 mins.

Components	Tasks	TA[a]	ATA[b]
Target 	By the end of this module, the students will have been able to balance chemical equations by inspection.	1 min.	
Hook 	In life, almost everyone and everything seeks to achieve a sense of balance. We seem uneasy when things do not go the way they should be. We cannot go on. It is the same with chemical equations. In the previous lesson, you've already learned how to write and translate chemical reaction but we cannot proceed to further study of a chemical reaction unless its chemical equation is balanced. In balancing equations, we will apply the Law of Conservation of Mass, that is, *"In chemical reactions, atoms are never created or destroyed."*  Source: Conservation of Mass in Chemical Reactions. Retrieved from www.expii.com **Figure 1.** Law of Conservation of Mass Exhibited in the Formation of Water Molecules	2 mins.	

Ignite 	Keep in mind that the identities of the reactants and products are defined by the element symbol and subscripts in their chemical formulas. The equation cannot be balanced by changing the subscripts of the reactants or the products because it would change the chemical identity of the species being described just like in Figure 2.  Source: How to Write Balanced Chemical Equations. Retrieved from https://bit.ly/2VP91je **Figure 2.** Balancing Equations. You cannot change subscripts in a chemical formula to balance a chemical equation; you can change only the coefficients. Let's further differentiate important terms in balancing: coefficient and subscripts. **Coefficients and Subscripts** There are two types of numbers that appear in chemical equations. There are *subscripts*, which are part of the chemical formulas of the reactants and products and there are *coefficients* that are placed in front of the formulas to indicate how many molecules of that substance is used or produced.  Source: Chemical Equation. Retrieved from https://www.pinterest.ph/pin/531002612290643631/ **Figure 3.** The equation above states that 2 molecules of H_2 and 1 molecule of O_2 reacts to produce 2 molecules of H_2O Now, we can proceed to balancing proper. The simplest method for balancing chemical equations is through "inspection," which we can also equate to trial and error method. The following are some useful steps for balancing equations:	20 mins.	

Steps in Balancing a Chemical Equation (Petrucci *et al*, 2017)

1. Write down the given equation or the unbalanced equation. Make sure that the formula for each substance is correct where the reactant is written in the left side and the product at the right side.
2. Count and compare the number of atoms of each element on each side of the equation. Determine those that must be balanced.
3. Balance each element one at a time by placing whole number (coefficients) before the formulas containing the unbalanced elements.
4. Check all other elements after some elements are balanced to see if the other elements became unbalanced while balancing the other. Make adjustments as needed.
5. Balance polyatomic ions such as NO_3^- as a unit and not as individual atoms.
6. Do a final check by counting the numbers of atoms of each kind on both sides of the equation to be sure that the chemical equation is balance and that smallest possible set of whole number coefficient has been used.

$MgO \rightarrow Mg + O_2$ (unbalanced equation)

$4MgO \rightarrow 4\ Mg + 2O_2$ (incorrect form)
$2MgO \rightarrow 2\ Mg + O_2$ (correct form)

Some useful strategies include: **(Petrucci et.al, 2017)**

a. If an element occurs in only one compound on each side of the equation, try balancing this element first.
b. When one of the reactants or products exists as the free element, balance this element last.
c. It is permissible to use fractional numbers as coefficients and then clearing the fractions by multiplying all coefficients by a common multiplier.

Ignite time! Let's do some sample problems.

A. Balance the chemical equation for production of Ammonia (NH_3)

$$N_2 + H_2 \rightarrow NH_3$$

Step	
1	Write the unbalanced equation. By inspection, both N and H atoms need to be balanced. $\mathbf{N_2} + \mathbf{H_2} \rightarrow \mathbf{NH_3}$
2	We can start with atoms other than H, so let's start balancing N by putting coefficient 2

	before NH_3: $N_2 + H_2 \rightarrow \underline{2}NH_3$ 2 nitrogen atoms on both reactant and product sides
3	After putting 2 before NH_3, there are 6 H atoms now in the product side and 2 in the reactant side, so to balance H atoms, put coefficient 3 before H_2. $N_2 + \underline{3}H_2 \rightarrow \underline{2}NH_3$
4	There are no polyatomic ions involve so this step is not applicable.
5	$N_2 + \underline{3}H_2 \rightarrow \underline{2}NH_3$ The balanced chemical equation has: 2 nitrogen atoms and 6 hydrogen atoms on each side.

Let's have another example, this time, involving polyatomic ions.

B. Balance the chemical equation for the precipitation of Lead(II) Chloride **(Libretextx, 2020)**

$$Pb(NO_3)_2 + NaCl \rightarrow NaNO_3 + PbCl_2$$

Step	
1	Write the unbalanced equation. By inspection, NO_3^- and Cl^- anions need to be balanced. $Pb(\mathbf{NO_3})_2 + Na\mathbf{Cl} \rightarrow Na\mathbf{NO_3} + Pb\mathbf{Cl}_2$
2	There are twice as many nitrate ions in the reactants than in the products so place a 2 in front of the $NaNO_3$ in order to balance the nitrate ions. $Pb(NO_3)_2 + NaCl \rightarrow \underline{2}NaNO_3 + PbCl_2$ 1 Pb atom on both reactant and product sides 2 Na atoms on product side, 1 Na atom on reactant side 2 Cl atoms on product side, 1Cl atom on reactant side
3	The chloride ions are still unbalanced. Place a 2 in front of the NaCl. The result is: $Pb(NO_3)_2 + \underline{2}NaCl \rightarrow \underline{2}NaNO_3 + PbCl_2$

	1 Pb atom on both reactant and product sides 2 Na atoms on both reactant and product sides 2 Cl atoms on both reactant and product sides 2 NO_3^- atoms on both reactant and product sides
4	There is no need to balance the remaining atoms because they are already balanced.
5	$Pb(NO_3)_2 + \underline{2}NaCl \rightarrow 2NaNO_3 + PbCl_2$ The balanced chemical equation has: 1 Pb atom on both reactant and product sides 2 Na atoms on both reactant and product sides 2 Cl atoms on both reactant and product sides 2 NO_3- atoms on both reactant and product sides

Remember, balancing by inspection is a trial and error method. You can always apply other steps and processes which you find more convenient. Also, there are other steps suggested by some resources. The important point is that we arrive to the same balanced chemical equation in the end.

For practice, balance the following chemical equations by filling in the correct coefficient for each blank. **(Brown et.al, 2012)**

1. $\_Fe(s) + \_O_2(g) \rightarrow \_Fe_2O_3(s)$
2. $\_C_2H_4(g) + \_O_2(g) \rightarrow \_CO_2(g) + \_H_2O(g)$
3. $\_Al(s) + \_HCl(aq) \rightarrow \_AlCl_3(aq) + \_H_2(g)$

Navigate 	Formative assessment (Graded exercise 14/14) For your formal assessment, answer the following questions in a ½ sheet of paper, have it scanned and submit through our assigned learning platform. Balance the following chemical equations. (Copy and answer.) (a) $SO_{2(g)}+O_{2(g)} \rightarrow SO_{3(g)}$ (3 pts) (b) $Sc_2O_{3(s)} + H_2O_{(l)} \rightarrow Sc(OH)_{3(s)}$ (3 pts) (c) $H_3PO_{4(aq)}+NaOH_{(aq)} \rightarrow Na_2HPO_{4(aq)}+H_2O_{(l)}$ (4 pts) (d) $C_6H_{10}O_{5(s)}+O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$ (4 pts)	5 mins.	
Knot 	Summary of the lesson Chemical equations must always be balanced which means it must have the same number and type of each atom on both sides of the equation. Furthermore, the coefficients in a balanced equation must be the simplest whole number ratio and mass is always conserved in chemical reactions. Please read about stoichiometry for the next lesson.	2 mins.	

[a] suggested time allocation set by the teacher
[b] actual time spent by the student (for information purposes only)

Endnotes

(1) Balancing Chemical Equations Step by Step. (https://bit.ly/3iHLH0r)

References

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