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Balance chemical reactions worksheet

The best way to become proficient at balancing chemical equations is practice. This balancing chemical equations worksheet has ten unbalanced equations to practice your skills.Either right-click and save the image or else download the PDF of the worksheet here. The worksheet prints on a standard sheet of printer paper.Grab the solution by right-clicking and saving the image or by downloading the PDF of the answer key.Check out our other Balancing Chemical Equation WorksheetsWe also have other chemistry worksheets and handouts.Related Posts Provide the coefficients to balance the chemical equations shown below. What is the mass of one mole of each of these substances? The proportion of the total mass of a compound that is due to each element can be calculated and is called the mass percent. Provide the formulas for the compounds formed from combining the listed ions. Provide the names for the ionic compounds shown. Name the compounds that share electrons. What compound forms? For extra credit name the compound in words. These are a little more difficult. Make sure to read everything throughly. Write the name of each compound shown here. Write the equation for each formula that you come across. Take another crack at stoichiometry with this worksheet. Write out what happens completely here with these. Classify each chemical reaction as either a decomposition, single replacement, double replacement, or synthesis. Make sure to count your units of oxygen and hydrogen. You will be given an organic compound and asked to structural draw it. Structural isomers are molecules that have the same chemical formula, but different structural formulas. Find all the organic chem. terms in that puzzle. Reactions rates can be sped up with the application of energy like heat, sunlight, or electricity or by increasing the concentration or pressure of the reactants. Alternatively, the addition of a third substance called an inhibitor can close down a reaction. In a synthesis reaction, two substances combine to form a new substance. Are the reactants in a synthesis reaction typically individual elements or compounds? In a decomposition reaction one more complex substance breaks down to form two separate, simpler substances. Most decomposition reactions are endothermic. In an endothermic reaction, energy is applied in the form of heat, electricity, or sunlight in order to break down the bonds of a more complex molecule. Combustion was the first chemical change discovered by man. The ability to use and control fire helped early humans to survive and revolutionized the way that they lived. Once started, how long will a combustion reaction continue? A single displacement reaction is also known as a single replacement reaction or a substitute reaction. In a double displacement reaction, also known as a metathesis reaction, the compounds on the left side of the equation switch substances. A photochemical reaction is a chemical reaction in which the heat needed to induce a chemical reaction comes from molecules of light called photons. What is the name of the structures plants use to capture sunlight? A common way to add a catalyst to a chemical reaction is to add energy in the form of heat, sunlight, or electricity. An inhibitor is the opposite of a catalyst. Adding an inhibitor increases the amount of activation energy that is needed in order for a chemical reaction to occur. A reactant is a substance that is present at the beginning of a chemical reaction and that is changed by the reaction to create a new substance called the product. How and where do you note if a reaction has taken place under certain circumstances? In chemistry, an acid is a substance that can release a proton, and a base is a substance that can receive a proton. The most often performed school science experiment is an acid-base reaction: the volcano experiment in which you add vinegar to baking soda. A redox reaction always take place in two parts: a reduced half and an oxidized half. These two parts always occur together. What kind of reactions are typically (but not always) redox reactions with oxygen being oxidized? Every day, different chemical reactions happen around us – cooking eggs, lighting a fire, and more. Each of them is a unique set of circumstances, but they have a general cause. Chemical reactions are caused by the breaking of bonds in reactants to form new bonds of products. Energy is needed to form bonds but is released when bonds are broken. In a reaction, the amount of matter is preserved regardless of changes in structure. Keep reading to learn more about chemical reactions, such as different types and physical indicators. What Is a Chemical Reaction? Chemical reactions vary a lot. Some occur quickly, while others need a catalyst. Some have apparent changes, while others don't. But they are all processes that lead to products. A chemical reaction is the conversion of substances, called reactants, into new compounds, called products. These products have new structures that are caused by breaking and forming bonds. There are different types of chemical reactions. Reactions can either be reversible or not. In reversible forms, products can reform into the original reactants, given the right conditions. Thus, it can move in two directions: forward into products or backward into reactants. Contrary to reversible forms, irreversible ones can only move forward. Thus, products cannot form back into reactants. Chemical reactions are happening all the time around use and we just don't realize it. Ever clean your kitchen with something other than water? Ever rinse with mouth wash? Have you seen the glorious baking soda and vinegar volcano that is so popular at science fairs? They happen when molecules from one substance break apart and combine, to some degree, with another. This usually is irreversible and forms a new substance all together. Some of them give off heat, like hand warmers. Some take in heat (get colder). Instant ice packs are an example of that. Others give off brilliant colors. Where do you think firework reactions come from? What Are Physical Indicators of a Chemical Reaction? While not applicable to all reactions, many processes display physical indicators of a chemical reaction. These are the most common indicators: Change in color Change in temperature Production of light Production of gas Formation of precipitate These indicators are the result of changes in chemical structure. For instance, exothermic reactions, which involve breaking bonds, are accompanied by signs of increased temperature because energy was released. On the other hand, endothermic types have reduced temperatures because they absorb energy instead of releasing them. What Are the Basic Types of Chemical Reactions? Thousands of them occur every day. While they may be all unique in one way or another, they can still be categorized into general types. The following are general descriptions of the transformation that takes place. Every reaction can be categorized into a basic type. These are the basic types these of chemical reactions: Combination/SynthesisTwo or more reactants combine to form one new product. General Equation: A + B → AB DecompositionA reactant separates into two or more substances. It requires energy. General Equation: AB → A + B Single-ReplacementOne element reactant replaces a similar element in a compound. General Equation: A + BC → AB + C Double-ReplacementIons in a compound exchange places to form new ones. General Equation: AB + CD → AD + CB CombustionCompounds react with oxygen and produce gas and light. General Equation: CwHx + O2 (g) → yH2O (l) + zCO2 (g) What Are Other Types of Chemical Reactions? Other forms, such as acid-base reactions, are more specific regarding the components, mechanisms, and products. These are a few examples of other types of chemical reactions: Acid-baseThese are common and essential reactions. It involves the exchange of ions or electrons to produce new compounds. It may also be a form of neutralization reactions (i.e., bases neutralize acids to form salt and water). PrecipitationDissolved reactants form a solid product in precipitation reactions. A precipitation reaction is a kind of double-replacement reaction. Precipitates will develop depending on the solubility properties of reactants. RedoxRedox reactions, or oxidation-reduction reactions, involve the transfer of electrons that lead to ionic products. A combustion reaction is an example of a redox reaction. HydrolysisHydrolysis reactions use water as one of the reactants. Smaller products are formed from these reactions. Condensation Contrary to hydrolysis, water is a product of condensation. Two substances combine to create a larger compound with water as a byproduct. Final Thoughts Chemical reactions occur because of changes in bond structure – either new ones are formed, old ones are broken, or both. In the process, energy may be released or used. There are signs of such reactions, like color or temperature changes, but not all of them have apparent indicators. Each reaction can be categorized into basic or more specific types. To balance a chemical equation in chemistry, you must follow the law of conservation of mass, which stipulates that the total molar mass of the reactants must be equal to the total molar mass of the products. This is done by writing numerical coefficients to indicate how many moles of each substance are present during a chemical reaction.It's important to note that you can only use whole numbers when balancing equations in chemistry. A balanced chemical equation that has whole numbers as coefficients serves as the standard for calculating the proportion of the same substances with variable amounts. This is very useful in laboratory analytical experiments and in chemical manufacturing. Read on to learn more about chemical equations and how to balance an equation in chemistry.What are chemical equations?Chemical equations are symbolic representations of ideal chemical reactions. They typically include the symbols of the elements in chemical formulas, which are usually written with numerical coefficients preceding them to ensure the chemical equation is balanced.Chemical equations also contain plus signs where applicable, such as when there are two or more reactants or two or more products. The reactants are on the left-hand side of the equation while the products are on the right.An arrow symbol (rather than an equals symbol) is normally used to separate the reactants from the products. Although the arrow usually points to the direction of the products, a chemical equation sometimes contains two arrows that point in either direction. This indicates dynamic equilibrium, which means the reaction goes both ways.Other notations may also be written above the arrow to indicate the presence of a catalyst, while small letters in parentheses after the subscripts signal the state or phase of matter e.g solid, liquid or gas.Here is a simple example of a chemical equation representing the reaction between hydrogen and oxygen, which forms water.2H2 + O2 → 2H2OThe balanced chemical equation indicates that two moles of diatomic hydrogen must react with one mole of diatomic oxygen to produce two moles of water.Balancing equations in chemistryBalancing equations in chemistry is akin to accounting or bookkeeping in finance; the credit side must equal the debit side. This is crucial for establishing the standard ideal proportional relationship between the reactants and products based on the law of conservation of mass.The basic assumptions in balancing chemical equations are the following:The law of conservation of mass – this states that "mass can neither be created nor destroyed" in chemical reactions, so the total mass of the reactants is equal to the total mass of the productsThe substances involved are 100% pure – in actual experiments, it would be very difficult or even virtually impossible to obtain 100% pure reactants; there will always be some contaminants or impurities. In chemical equations, however, you can theoretically assume that the reactants are absolutely pureThe reaction occurs under standard conditions – the standard conditions refer to the temperature, pressure, and concentration of the reactants. These are 25°C, 1 atm and 1M, respectively.Examples of chemical equationsNot all chemical equations are written as balanced chemical reactions when it comes to elements or molecules. Some are half equations, such as those representing electrochemical reactions in batteries. Here are some examples:Zn = Zn2+ + 2e– (oxidation reaction)2H+ + 2e– = H2 (reduction reaction)HCl + NaOH → NaCl + H2O (acid-base neutralisation) 6CO2 + 6H2O + light → C6H12O6 + 6O2 (photosynthesis)C12H22O11 (s) + H2SO4 (aq) + 1/2 O2 (g) → 11C (s) + CO2 (g) + 12H2O (g) + SO (dehydration of sucrose)2Na + Cl2 → 2NaClCH4 + 2O2 → 2H2O + CO2 (complete combustion of methane)Steps to balance a chemical equation In most cases, balancing chemical equations is a case of trial and error. It may involve some degree of intuition, although you can also be methodical in your approach. Put simply, it's about ensuring that the corresponding coefficients would result in equal numbers of atoms on both sides of the equation. Here are some steps that you can follow to balance a chemical equations:Step 1: Write the reactants and the products.Step 2: Count the number of atoms on both sides of the equation. If they are already equal then there's no need to balance the equation. However, if they aren't, you'll need to proceed to the next step.Step 3: You may want to tabulate the number of atoms for easy comparison. It's important that you don't alter the subscripts as this will automatically change the chemical identities of the substances involved.Step 4: Change the numerical coefficients relating to the atoms or groups of atoms. There may be some cases when atoms are grouped together. Instead of treating them individually, you can treat them as groups.Step 5: Repeat step 2. If the equation is still not balanced, you'll need to try other coefficients.The steps outlined above follow the traditional "trial and error" method. However, another way to balance a chemical equation is by using the algebraic method. Although similar to the trial and error method, it involves some basic algebra of assigning symbols to the unknown coefficients. For example, if you want to balance the chemical equation C6H12O6 + O2 → CO2 + H2O, follow these steps: SummaryBalancing chemical equations is important for two main reasons – it allows us to make comparisons in analytical experiments and it helps with efficiency in manufacturing. The main methods of balancing chemical equations are the traditional "trial and error" technique and the algebraic method. Symbolic representation of a chemical reactionThis article includes a list of general references, but it lacks sufficient corresponding inline citations. Please help to improve this article by introducing more precise citations. (October 2023) (Learn how and when to remove this message) A chemical equation is the symbolic representation of a chemical reaction in the form of symbols and chemical formulas. The reactant entities are given on the left-hand side and the product entities are on the right-hand side with a plus sign between the entities in both the reactants and the products, and an arrow that points towards the products to show the direction of the reaction.[1] The chemical formulas may be symbolic, structural (pictorial diagrams), or intermixed. The coefficients next to the symbols and formulas of entities are the absolute values of the stoichiometric numbers. The first chemical equation was diagrammed by Jean Beguin in 1615.[2] A chemical equation (see an example below) consists of a list of reactants (the starting substances) on the left-hand side, an arrow symbol, and a list of products (substances formed in the chemical reaction) on the right-hand side. Each substance is specified by its chemical formula, optionally preceded by a number called stoichiometric coefficient.[a] The coefficient specifies how many entities (e.g. molecules) of that substance are involved in the reaction on a molecular basis. If not written explicitly, the coefficient is equal to 1. Multiple substances on any side of the equation are separated from each other by a plus sign. As an example, the equation for the reaction of hydrochloric acid with sodium can be denoted: 2HCl + 2Na → 2NaCl + H2 Given the formulas are fairly simple, this equation could be read as "two H-C-L plus two N-A yields[b] two N-A-C-L and H two." Alternately, and in general for equations involving complex chemicals, the chemical formulas are read using IUPAC nomenclature, which could verbalise this equation as "two hydrochloric acid molecules and two sodium atoms react to form two formula units of sodium chloride and a hydrogen gas molecule." Different variants of the arrow symbol are used to denote the type of a reaction:[1] → {\displaystyle \rightarrow } net forward reaction ⇌ {\displaystyle \rightleftarrows } reaction in both directions[c] ⇋ {\displaystyle \rightleftharpoons } equilibrium[d] = {\displaystyle =} stoichiometric relation ↔ {\displaystyle \leftrightarrow } resonance (not a reaction) To indicate physical state of a chemical, a symbol in parentheses may be appended to its formula: (s) for a solid, (l) for a liquid, (g) for a gas, and (aq) for an aqueous solution. This is especially done when one wishes to emphasize the states or changes thereof. For example, the reaction of aqueous hydrochloric acid with solid (metallic) sodium to form aqueous sodium chloride and hydrogen gas would be written like this: 2HCl(aq) + 2Na(s) → 2NaCl(aq) + H2(g) That reaction would have different thermodynamic and kinetic properties if gaseous hydrogen chloride were to replace the hydrochloric acid as a reactant: 2HCl(g) + 2Na(s) → 2NaCl(s) + H2(g) Alternately, an arrow without parentheses is used in some cases to indicate formation of a gas ↑ or precipitate ↓. This is especially useful if only one such species is formed. Here is an example indicating that hydrogen gas is formed: 2HCl + 2Na → 2 NaCl + H2 ↑ The Baker–Venkataraman rearrangement needs a base as a catalyst. If the reaction requires energy, it is indicated above the arrow. A capital Greek letter delta (Δ) or a triangle (△)[e] is put on the reaction arrow to show that energy in the form of heat is added to the reaction. The expression hν[f] is used as a symbol for the addition of energy in the form of light. Other symbols are used for other specific types of energy or radiation. Similarly, if a reaction requires a certain medium with certain specific characteristics, then the name of the acid or base that is used as a medium may be placed on top of the arrow. If no specific acid or base is required, another way of denoting the use of an acidic or basic medium is to write H+ or OH− (or even "acid" or "base") on top of the arrow. Specific conditions of the temperature and pressure, as well as the presence of catalysts, may be indicated in the same way. This illustration of a mechanism for acid-catalyzed hydrolysis of an amide puts some reactants and products above the arrows and to their branches to allow chaining of the chemical "equations". The standard notation for chemical equations only permits all reactants on one side, all products on the other, and all stoichiometric coefficients positive. For example, the usual form of the equation for dehydration of methanol to dimethylether is: 2 CH3OH → CH3OCH3 + H2O Sometimes an extension is used, where some substances with their stoichiometric coefficients are moved above or below the arrow, preceded by a plus sign or nothing for a reactant, and by a minus sign for a product. Then the same equation can look like this: 2 CH 3 OH → − H 2 O CH 3 OCH 3 {\displaystyle {\ce {2CH3OH->[{\overset {}{\ce {-H2O}}}]CH3OCH3}}} Such notation serves to hide less important substances from the sides of the equation, to make the type of reaction at hand more obvious, and to facilitate chaining of chemical equations. This is very useful in illustrating multi-step reaction mechanisms. Note that the substances above or below the arrows are not catalysts in this case, because they are consumed or produced in the reaction like ordinary reactants or products. Another extension used in reaction mechanisms moves some substances to branches of the arrow. Both extensions are used in the example illustration of a mechanism. Use of negative stoichiometric coefficients at either side of the equation (like in the example below) is not widely adopted and is often discouraged.[5][6] 2 CH 3 OH − H 2 O ⟶ CH 3 OCH 3 {\displaystyle {\ce {2 CH3OH \;-\; H2O -> CH3OCH3}}} Main article: Stoichiometry Because no nuclear reactions take place in a chemical reaction, the chemical elements pass through the reaction unchanged. Thus, each side of the chemical equation must represent the same number of atoms of any particular element (or nuclide, if different isotopes are taken into account). The same holds for the total electric charge, as stated by the charge conservation law. An equation adhering to these requirements is said to be balanced. A chemical equation is balanced by assigning suitable values to the stoichiometric coefficients. Simple equations can be balanced by inspection, that is, by trial and error. Another technique involves solving a system of linear equations. Balanced equations are usually written with smallest natural-number coefficients. Yet sometimes it may be advantageous to accept a fractional coefficient, if it simplifies the other coefficients. The introductory example can thus be rewritten as HCl + Na ⟶ NaCl + 1 2 H 2 {\displaystyle {\ce {HCl + Na -> NaCl + 1/2 H2}}} In some circumstances the fractional coefficients are even inevitable. For example, the reaction corresponding to the standard enthalpy of formation must be written such that one molecule of a single product is formed. This will often require that some reactant coefficients be fractional, as is the case with the formation of lithium fluoride: Li (s) + 1 2 F 2 (g) ⟶ LiF (s) {\displaystyle {\ce {Li(s) + 1/2F2(g) -> LiF(s)}}} As seen from the equation CH4 + 2 O2 → CO2 + 2 H2O, a coefficient of 2 must be placed before the oxygen gas on the reactants side and before the water on the products side in order for, as per the law of conservation of mass, the quantity of each element does not change during the reaction P4O10 + 6 H2O → 4 H3PO4This chemical equation is being balanced by first multiplying H3PO4 by four to match the number of P atoms, and then multiplying H2O by six to match the numbers of H and O atoms. The method of inspection can be outlined as setting the most complex substance's stoichiometric coefficient to 1 and assigning values to other coefficients step by step such that both sides of the equation end up with the same number of atoms for each element. If any fractional coefficients arise during this process, the presence of fractions may be eliminated (at any time) by multiplying all coefficients by their lowest common denominator. Example Balancing of the chemical equation for the complete combustion of methane ? CH 4 + ? O 2 ⟶ ? CO 2 + ? H 2 O {\displaystyle {\ce {{\mathord {?}}\,{CH4}+{\mathord {?}}\,{O2}->{\mathord {?}}\,{CO2}+{\mathord {?}}\,{H2O}}}} is achieved as follows: A coefficient of 1 is placed in front of the most complex formula (CH4): 1 CH 4 + ? O 2 ⟶ ? CO 2 + ? H 2 O {\displaystyle {\ce {1{CH4}+{\mathord {?}}\,{O2}->{\mathord {?}}\,{CO2}+{\mathord {?}}\,{H2O}}}} The left-hand side has 1 carbon atom, so 1 molecule of CO2 will balance it. The left-hand side also has 4 hydrogen atoms, which will be balanced by 2 molecules of H2O: 1 CH 4 + ? O 2 ⟶ 1 CO 2 + 2 H 2 O {\displaystyle {\ce {1{CH4}+{\mathord {?}}\,{O2}->1{CO2}+2H2O}}} Balancing the 4 oxygen atoms of the right-hand side by 2 molecules of O2 yields the equation 1 CH 4 + 2 O 2 ⟶ 1 CO 2 + 2 H 2 O {\displaystyle {\ce {1 CH4 + 2 O2 -> 1 CO2 + 2 H2O}}} The coefficients equal to 1 are omitted, as they do not need to be specified explicitly: CH 4 + 2 O 2 ⟶ CO 2 + 2 H 2 O {\displaystyle {\ce {CH4 + 2 O2 -> CO2 + 2 H2O}}} It is wise to check that the final equation is balanced, i.e. that for each element there is the same number of atoms on the left- and right-hand side: 1 carbon, 4 hydrogen, and 4 oxygen. For each chemical element (or nuclide or unchanged moiety or charge) i, its conservation requirement can be expressed by the mathematical equation ∑ j ∈ reactants a i j s j = ∑ j ∈ products a i j s j {\displaystyle \sum _{j\,\in \,{\text{reactants}}}\!\!\!\!\!a_{ij}s_{j}\ =\!\!\!\!\!\sum _{j\,\in \,{\text{products}}}\!\!\!\!\!a_{ij}s_{j}} where aij is the number of atoms of element i in a molecule of substance j (per formula in the chemical equation), and sj is the stoichiometric coefficient for the substance j. This results in a homogeneous system of linear equations, which are readily solved using mathematical methods. Such system always has the all-zeros trivial solution, which we are not interested in, but if there are any additional solutions, there will be infinite number of them. Any non-trivial solution will balance the chemical equation. A "preferred" solution is one with whole-number, mostly positive[g] stoichiometric coefficients sj with greatest common divisor equal to one. Let us assign variables to stoichiometric coefficients of the chemical equation from the previous section and write the corresponding linear equations: s 1 CH 4 + s 2 O 2 ⟶ s 3 CO 2 + s 4 H 2 O {\displaystyle {\ce {{\mathit {s}}_{1}{CH4}+{\mathit {s}}_{2}{O2}->{\mathit {s}}_{3}{CO2}+{\mathit {s}}_{4}{H2O}}}} C: s 1 = s 3 H: 4 s 1 = 2 s 4 O: 2 s 2 = 2 s 3 + s 4 {\displaystyle \quad \;\;{\begin{aligned}{\text{C:}}&&s_{1}&=s_{3}\\ {\text{H:}}&&4s_{1}&=2s_{4}\\{\text{O:}}&&2s_{2}&=2s_{3}+s_{4}\end{aligned}}} All solutions to this system of linear equations are of the following form, where r is any real number: s 1 = r s 2 = 2 r s 3 = r s 4 = 2 r {\displaystyle {\begin{aligned}s_{1}&=r\\s_{2}&=2r\\s_{3}&=r\\s_{4}&=2r\end{aligned}}} The choice of r = 1 yields the preferred solution, s 1 = 1 s 2 = 2 s 3 = 1 s 4 = 2 {\displaystyle {\begin{aligned}s_{1}&=1\\s_{2}&=2\\s_{3}&=1\\s_{4}&=2\end{aligned}}} which corresponds to the balanced chemical equation: CH 4 + 2 O 2 ⟶ CO 2 + 2 H 2 O {\displaystyle {\ce {CH4 + 2 O2 -> CO2 + 2 H2O}}} The system of linear equations introduced in the previous section can also be written using an efficient matrix formalism. First, to unify the reactant and product stoichiometric coefficients sj, let us introduce the quantity ν j = { − s j for a reactant + s j for a product {\displaystyle u _{j}={\begin{cases}-s_{j}&{\text{for a reactant}}\\+s_{j}&{\text{for a product}}\end{cases}}} called stoichiometric number,[h] which simplifies the linear equations to ∑ j = 1 J a i j ν j = 0 {\displaystyle \sum _{j=1}^{J}a_{ij}u _{j}=0} where J is the total number of reactant and product substances (formulas) in the chemical equation. Placement of the values aij at row i and column j of the composition matrix A = [a 1 , 1 a 1 , 2 ⋯ a 1 , J a 2 , 1 a 2 , 2 ⋯ a 2 , J ⋮ ⋮ ⋱ ⋮] {\displaystyle {\begin{bmatrix}a_{1,1}&a_{1,2}&\cdots &a_{1,J}\\a_{2,1}&a_{2,2}&\cdots &a_{2,J}\\\vdots &\vdots &\ddots &\vdots \end{bmatrix}}} and arrangement of the stoichiometric numbers into the stoichiometric vector ν = [ν 1 ν 2 ⋮ ν J] {\displaystyle {\begin{bmatrix}u _{1}\\u _{2}\\\vdots \\u _{J}\end{bmatrix}}} allows the system of equations to be expressed as a single matrix equation: Aν = 0 Like previously, any nonzero stoichiometric vector ν, which solves the matrix equation, will balance the chemical equation. The set of solutions to the matrix equation is a linear space called the kernel of the matrix A. For this space to contain nonzero vectors ν, i.e. to have a positive dimension JN, the columns of the composition matrix A must not be linearly independent. The problem of balancing a chemical equation then becomes the problem of determining the JN-dimensional kernel of the composition matrix. It is important to note that only for JN = 1 will there be a unique preferred solution to the balancing problem. For JN > 1 there will be an infinite number of preferred solutions with JN of them linearly independent. If JN = 0, there will be only the unusable trivial solution, the zero vector. Techniques have been developed[7][8] to quickly calculate a set of JN independent solutions to the balancing problem, which are superior to the inspection and algebraic method[citation needed] in that they are determinative and yield all solutions to the balancing problem. Example Using the same chemical equation again, write the corresponding matrix equation: s 1 CH 4 + s 2 O 2 ⟶ s 3 CO 2 + s 4 H 2 O {\displaystyle {\ce {{\mathit {s}}_{1}{CH4}+{\mathit {s}}_{2}{O2}->{\mathit {s}}_{3}{CO2}+{\mathit {s}}_{4}{H2O}}}} C: H: O: [1 0 1 0 4 0 0 2 0 2 2 1] [ν 1 ν 2 ν 3 ν 4] = 0 {\displaystyle {\begin{matrix}{\text{C:}}\\{\text{H:}}\\{\text{O:}}\end{matrix}}\quad {\begin{bmatrix}1&0&1&0\\4&0&0&2\\0&2&2&1\end{bmatrix}}{\begin{bmatrix}u _{1}\\u _{2}\\u _{3}\\u _{4}\end{bmatrix}}=\mathbf {0} } Its solutions are of the following form, where r is any real number: [ν 1 ν 2 ν 3 ν 4] = [− s 1 − s 2 s 3 s 4] = r [− 1 − 2 1 2] {\displaystyle {\begin{bmatrix}u _{1}\\u _{2}\\u _{3}\\u _{4}\end{bmatrix}}={\begin{bmatrix}-s_{1}\\-s_{2}\\s_{3}\\s_{4}\end{bmatrix}}=r{\begin{bmatrix}-1\\-2\\1\\2\end{bmatrix}}} The choice of r = 1 and a sign-flip of the first two rows yields the preferred solution to the balancing problem: [− ν 1 − ν 2 ν 3 ν 4] = [s 1 s 2 s 3 s 4] = [1 2 1 2] {\displaystyle {\begin{bmatrix}-u _{1}\\-u _{2}\\u _{3}\\u _{4}\end{bmatrix}}={\begin{bmatrix}s_{1}\\s_{2}\\s_{3}\\s_{4}\end{bmatrix}}={\begin{bmatrix}1\\2\\1\\2\end{bmatrix}}} An ionic equation is a chemical equation in which electrolytes are written as dissociated ions. Ionic equations are used for single and double displacement reactions that occur in aqueous solutions. For example, in the following precipitation reaction: CaCl 2 + 2 AgNO 3 ⟶ Ca (NO 3) 2 + 2 AgCl ↓ {\displaystyle {\ce {CaCl2 + 2AgNO3 -> Ca(NO3)2 + 2 AgCl(v)}}} the full ionic equation is: Ca 2 + + 2 Cl − + 2 Ag + + 2 NO 3 − ⟶ Ca 2 + + 2 NO 3 − + 2 AgCl ↓ {\displaystyle {\ce {Ca^2+ + 2Cl^- + 2Ag+ + 2NO3^- -> Ca^2+ + 2NO3^- + 2AgCl(v)}}} or, with all physical states included: Ca 2 + (aq) + 2 Cl − (aq) + 2 Ag + (aq) + 2 NO 3 − (aq) ⟶ Ca 2 + (aq) + 2 NO 3 − (aq) + 2 AgCl ↓ {\displaystyle {\ce {Ca^2+(aq) + 2Cl^{-}(aq) + 2Ag+(aq) + 2NO3^{-}(aq) -> Ca^2+(aq) + 2NO3^{-}(aq) + 2AgCl(v)}}} In this reaction, the Ca2+ and the NO3− ions remain in solution and are not part of the reaction. That is, these ions are identical on both the reactant and product side of the chemical equation. Because such ions do not participate in the reaction, they are called spectator ions. A net ionic equation is the full ionic equation from which the spectator ions have been removed.[9] The net ionic equation of the proceeding reactions is: 2 Cl − + 2 Ag + ⟶ 2 AgCl ↓ {\displaystyle {\ce {2Cl^- + 2Ag+ -> 2AgCl(v)}}} or, in reduced balanced form, Ag + + Cl − ⟶ AgCl ↓ {\displaystyle {\ce {Ag+ + Cl^- -> AgCl(v)}}} In a neutralization or acid/base reaction, the net ionic equation will usually be: H + (aq) + OH − (aq) ⟶ H 2 O (l) {\displaystyle {\ce {H+ (aq) + OH^{-}(aq) -> H2O(l)}}} There are a few acid/base reactions that produce a precipitate in addition to the water molecule shown above. An example is the reaction of barium hydroxide with phosphoric acid, which produces not only water but also the insoluble salt barium phosphate. In this reaction, there are no spectator ions, so the net ionic equation is the same as the full ionic equation. 3 Ba (OH) 2 + 2 H 3 PO 4 ⟶ 6 H 2 O + Ba 3 (PO 4) 2 ↓ {\displaystyle {\ce {3Ba(OH)2 + 2H3PO4 -> 6H2O + Ba3(PO4)2(v)}}} 3 Ba 2 + + 6 OH − + 6 H + + 2 PO 4 3 − ⟶ phosphate ⟶ 6 H 2 O + Ba 3 (PO 4) 2 ↓ ⟶ barium phosphate {\displaystyle {\ce {{3Ba^{2}+}+{6OH^{-}}+{6H+}}}+\underbrace {\ce {2PO4^{3}-}}_{\ce {phosphate}}{\ce {->{6H2O}+\underbrace {Ba3(PO4)2(v)}_{barium~phosphate}}}} Double displacement reactions that feature a carbonate reacting with an acid have the net ionic equation: 2 H + + CO 3 2 − ⟶ carbonate ⟶ H 2 O + CO 2 ↑ {\displaystyle {\ce {2H+}}+\underbrace {{\ce {CO3^2-}}}_{\ce {carbonate}}{\ce {-> H2O + CO2 (^)}}} If every ion is a "spectator ion" then there was no reaction, and the net ionic equation is null. Generally, if zj is the multiple of elementary charge on the j-th molecule, charge neutrality may be written as: ∑ j = 1 J z j ν j = 0 {\displaystyle \sum _{j=1}^{J}z_{j}u _{j}=0} where the νj are the stoichiometric coefficients described above. The zj may be incorporated[7][8] as an additional row in the aij matrix described above, and a properly balanced ionic equation will then also obey: ∑ j = 1 J a i j ν j = 0 {\displaystyle \sum _{j=1}^{J}a_{ij}u _{j}=0} This section is empty. You can help by adding to it. (June 2022) This section is empty. You can help by adding to it. (June 2022) Mathematical notation Comparison of TeX editors TeX extentions for science and chemistry notation Chemistry notation in TeX ^ Not to be confused with a related quantity called stoichiometric number. ^ Not to be confused with yield (chemistry), a quantification of synthesis efficiency. ^ The notation ⇄ was proposed in 1884 by the Dutch chemist Jacobus Henricus van 't Hoff. Van 't Hoff called reactions that didn't proceed to completion "limited reactions". He wrote (translation from French):[3] Now Mr. Pfaundler has joined these two phenomena in a single concept by considering the observed limit as the result of two opposing reactions, driving the one in the example cited to the formation of sea salt [i.e., NaCl] and nitric acid, [and] the other to hydrochloric acid and sodium nitrate. This consideration, which experiment validates, justifies the expression "chemical equilibrium", which is used to characterize the final state of limited reactions. I would propose to translate this expression by the following symbol: HCl + NO3 Na ⇄ NO3 H + Cl Na. I thus replace, in this case, the = sign in the chemical equation by the sign ⇄, which in reality doesn't express just equality but shows also the direction of the reaction. This clearly expresses that a chemical action occurs simultaneously in two opposing directions. ^ The notation ← − − − → {\displaystyle {\ce {}}} was suggested by Hugh Marshall in 1902.[4] ^ Triangle (△) was originally the alchemical symbol for fire. ^ This expression comes from the Planck equation for the energy of a photon, E = hν. The Greek letter ν ("nu") is sometimes mistakenly replaced with a Latin letter v ("vee"). ^ A negative stoichiometric coefficient signifies a substance placed on the incorrect side of the chemical equation. ^ An equivalent approach is flipping the signs of aij for reactants instead of replacing the stoichiometric coefficients sj with stoichiometric numbers νj. ^ a b IUPAC, Compendium of Chemical Terminology, 2nd ed. (the "Gold Book") (1997). Online corrected version: (2006–) "chemical reaction equation". doi:10.1351/goldbook.C01034 ^ Crosland, M.P. (1959). "The use of diagrams as chemical 'equations' in the lectures of William Cullen and Joseph Black". 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