Activity worksheet: balancing equations

Name	Group	Date

What you will learn

With the balancing equations simulation you will see that in a chemical reaction atoms neither appear nor disappear: they are only rearranged. You will learn to balance chemical equations, you will check Lavoisier's and Proust's laws and you will find out what the limiting reactant is.

How to work. Each activity has three steps:

1. **Predict.** Before looking at the simulation, write down what you think will happen and why.
2. **Observe.** Set up the simulation, watch what happens and note down the data.
3. **Explain.** Compare what happened with your prediction and explain why.

If your prediction turns out to be wrong, don't rub it out: getting it wrong and understanding why is the best way to learn.

Each activity has a link that opens the simulation already set up. If you have the worksheet on paper, go to **simulaciencia.es/en/simulations/ajuste-reaccion** and set it up as described under “Set up the simulation”.

Remember. Each ball is an atom and each group of joined balls is a molecule. The small number in a formula (the subscript) tells you how many atoms there are in the molecule; the big number in front (the coefficient) tells you how many molecules there are.

Before you start

What do you think now? Write T (true) or F (false). You will come back to this table at the end.

Statement	T or F
a) To balance an equation you can change the subscripts in the formulas.	
b) The number of molecules is conserved in a chemical reaction.	
c) If a reaction gives off a gas, the total mass decreases.	
d) River water and tap water have different proportions of hydrogen and oxygen.	
e) In a reaction, both reactants are always used up at the same time.	

Activity 1. The formation of water

Set up the simulation: Balancing (Lavoisier) mode, reaction **Formation of water**, with the live count on.
Open the simulation ready to use

Predict. The equation is $H_2 + O_2 \rightarrow H_2O$. Is it balanced? If not, which coefficients would you use?

My prediction

Observe. Press "▶ Show the reaction" with all the coefficients at 1. Then change the coefficients with − and + until the equation is balanced.

Coefficients (H_2, O_2, H_2O)	H atoms (reactants / products)	O atoms (reactants / products)	Mass of each side (u)	Message from the simulation
1, 1, 1				
1, 1, 2				

Explain.

1. Why can't you balance the equation by writing H_2O_2 instead of H_2O?
2. What happens to the balance when the equation is balanced? Why?

My answers

Activity 2. Balance them yourself

Set up the simulation: Balancing (Lavoisier) mode, reaction **Synthesis of ammonia**, with the live count **off**.
Open the simulation ready to use

Predict and observe. Balance each equation on paper. Then enter it in the simulation and press "✓ Check". Change the reaction with the "Reaction" drop-down list.

Reaction	My coefficients	Balanced?
$N_2 + H_2 \rightarrow NH_3$		
$Mg + O_2 \rightarrow MgO$		
$CH_4 + O_2 \rightarrow CO_2 + H_2O$		

Reaction	My coefficients	Balanced?
$C_3H_8 + O_2 \rightarrow CO_2 + H_2O$		

Explain. In the combustion reactions, in what order did you find it easiest to balance the elements? Why is it best to leave oxygen until last?

My explanation

Activity 3. What is conserved?

Set up the simulation: Balancing (Lavoisier) mode, **Formation of water**. Balance it (2, 1, 2). Open the simulation ready to use

Predict. In a balanced reaction, is there the same number of molecules before and after? And of atoms? And the same mass?

My prediction

Observe. Count them in the simulation.

	Reactants	Products
Number of molecules		
Number of atoms		
Total mass (u)		

Explain. State Lavoisier's law and explain it in terms of atoms.

My explanation

Activity 4. Always the same proportion

Set up the simulation: Definite proportions (Proust) mode, compound **Water (H_2O)**, 4 H_2 and 4 O_2. Open the simulation ready to use

Predict. If you add much more hydrogen, will the water that forms have a larger proportion of hydrogen?

My prediction

Observe. Press "▶ React" and write down the experiment. Then press "↺ Restart", change the amounts and repeat.

Starting H_2	Starting O_2	H_2O formed	What is left over?	m(O) / m(H) in the water
4	4			
24	4			
8	12			

Explain. Does the mass ratio between oxygen and hydrogen change? Which law is this? Why is there always some reactant left over?

My explanation

Activity 5. Which reactant runs out first?

Set up the simulation: Limiting reactant and yield mode, **Combustion of methane**, 4 CH_4 and 10 O_2. Open the simulation ready to use

Predict. The equation is $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$. Which reactant will run out? How many molecules of CO_2 will form? Choose your prediction in the "Your prediction" drop-down list.

My prediction and my calculation

Observe. Press "▶ React".

Limiting reactant	Reactant in excess	How much is left over?	CO_2 formed	H_2O formed

Explain. Is it enough to look at which reactant there is less of to know which one is limiting? Press "↺ Restart", try 4 CH_4 and 6 O_2 and explain.

My explanation

Activity 6. Challenge: the yield

Set up the simulation: Limiting reactant and yield mode, **Formation of water**, scale **One mole (mass in g)**, 8 mol of H_2, 5 mol of O_2 and a yield of 75 %. Open the simulation ready to use

Predict. Calculate how much water would form if all the limiting reactant reacted (theoretical product) and how much will form with a 75 % yield.

My calculation

Observe. Press "▶ React".

Theoretical product (mol and g)	Actual product (mol and g)	Yield (%)

Explain. Why do laboratories and factories almost never get 100 % of the theoretical product?

My explanation

Apply what you have learnt

Solve these without the simulation.

1. Balance: $Fe + O_2 \rightarrow Fe_2O_3$ and $C_2H_6 + O_2 \rightarrow CO_2 + H_2O$.
2. 12 g of carbon react with 32 g of oxygen and form carbon dioxide with nothing left over. What mass of CO_2 is formed? Which law are you applying?
3. 9 g of water contain 1 g of hydrogen. How much hydrogen is there in 45 g of water? Which law are you applying?
4. According to $2\ H_2 + O_2 \rightarrow 2\ H_2O$, you mix 6 mol of H_2 with 2 mol of O_2. Which is the limiting reactant? How many moles of water form? What is left over?

Problem	Working and result
1	
2	
3	
4	

Review your ideas

Go back to the “Before you start” table. Would you change any of your answers? Write which one and explain why, using something you saw in the simulation.

What has changed in my ideas

Going further (Year 12)

1. In Proust mode, calculate the percentage composition of water from the data in activity 4 and compare it with the one in the simulation.
2. Compare water (H_2O) with hydrogen peroxide (H_2O_2) in Proust mode. How are the masses of oxygen that combine with the same mass of hydrogen related? Which law is this?

My answers

Self-assessment

Put an X to show how confident you feel at the end.

I can...	Yes	Nearly	Not yet
Balance a chemical equation by changing only the coefficients			
Explain Lavoisier's law in terms of atoms			
Explain Proust's law			
Find the limiting reactant and calculate the product that forms			
Use a prediction and an observation to change an idea I had			

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