ACTIVITY WORKSHEET · SIMULACIENCIA

Activity worksheet: atomic spectra

Name	Group	Date

What you will learn

With the spectra simulation you will see how an atom absorbs and emits light. You will find out that the electron can only be in certain energy levels and that this is why each element emits particular colours, which are like its fingerprint.

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/espectros** and set it up as described under “Set up the simulation”.

Data. The wavelength (λ) of light is measured in nanometres (nm). Visible light goes from about 380 nm (violet) to about 780 nm (red). Energy is measured in electronvolts (eV). The energy of a photon is $\mathbf{E = h \cdot c / \lambda}$, with $h = 6.63 \cdot 10^{-34}$ J·s, $c = 3.00 \cdot 10^{8}$ m/s and $1\ \text{eV} = 1.60 \cdot 10^{-19}$ J.

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) An atom absorbs light of any colour that reaches it.	
b) The electron can be at any distance from the nucleus.	
c) If lots of photons arrive, the atom will end up absorbing one, even if it is not the right colour.	
d) All gases give the same light when they glow in a tube.	
e) Red light carries more energy than blue light.	

Activity 1. Which light does hydrogen absorb?

Set up the simulation: Photons mode, hydrogen, **Monochromatic** light at 550 nm and “Single photon”. Open the simulation ready to use

Predict. You are going to fire photons of different colours at a hydrogen atom. Do you think it will absorb all of them?

My prediction

Observe. Click the source on the canvas to fire a photon. Change the wavelength and repeat.

Wavelength (nm)	Colour	Is it absorbed?	If it is absorbed, jump (from n = ... to n = ...) and energy (eV)
550			
600			
656			
486			
434			

Explain. Why does the atom only absorb photons of particular wavelengths?

My explanation

Activity 2. What goes up comes down

Set up the simulation: Photons mode, hydrogen, monochromatic light at **656 nm**. Open the simulation ready to use

Predict. When the electron absorbs the photon and moves up a level, will it stay up there for ever?

My prediction

Observe. Fire a photon and wait a few seconds. Repeat with 486 nm.

Photon absorbed (nm)	What does the atom emit afterwards?	In which direction does the emitted photon leave?	Where does it appear in the spectrum?
656			

Photon absorbed (nm)	What does the atom emit afterwards?	In which direction does the emitted photon leave?	Where does it appear in the spectrum?
486			

Explain. Sometimes, after absorbing 486 nm, the atom emits two photons: an infrared one of 1879 nm and a red one of 656 nm. Add up their energies using the energy level diagram. What is conserved?

My explanation

Activity 3. Colour and energy

Set up the simulation: Photons mode, hydrogen, monochromatic at 656 nm. Open the “Atomic transitions” drop-down. Open the simulation ready to use

Predict. Which do you think carries more energy, a red photon or a violet one?

My prediction

Observe. Find the energy of each jump on the energy level diagram.

Line	Wavelength (nm)	Colour	Energy of the jump (eV)
H-α	656		
H-β	486		
H-γ	434		

Explain. How is the wavelength related to the energy of the photon? Does it agree with $E = h \cdot c / \lambda$?

My explanation

Activity 4. Each element's fingerprint

Set up the simulation: Ionised Gas mode, hydrogen, voltage 5.0 eV. Open the simulation ready to use

Predict. If we switch on a tube with a different gas, will the same lines appear?

My prediction

Observe. Wait for the emission spectrum to light up and change the element. Press "↺ Clear" between one and the next.

Element	Visible lines (nm)	Main colour
Hydrogen		
Helium		
Sodium		
Neon		

Explain.

1. Why do we say that the spectrum is an element's "fingerprint"?
2. How can astronomers know what a star is made of without going there?

My answers

Activity 5. Exciting atoms with collisions

Set up the simulation: Collision mode, hydrogen, electron energy 1.5 eV and "Single shot". Open the simulation ready to use

Predict. An electron collides with the atom. What is the minimum energy it needs to excite it?

My prediction

Observe. Click on the gun to fire. Change the energy and repeat. Look at the "With ... eV you can reach" panel.

Electron energy (eV)	What happens in the collision?	Levels that can be reached
1.5		
2.0		
3.0		

Explain. A photon is only absorbed if it has exactly the energy of the jump. Is the same true for an electron that collides? What is the difference?

My explanation

Activity 6. Challenge: absorption spectrum

Set up the simulation: Photons mode, hydrogen, **white** light and a continuous stream at maximum flux. Open the simulation ready to use

Predict. White light contains all the colours. After passing through the hydrogen, will any colour be missing?

My prediction

Observe. Wait a minute and compare the “Absorption spectrum” (top) with the “Emission spectrum” (bottom).

Dark lines in the absorption spectrum (nm)	Bright lines in the emission spectrum (nm)

Explain. Why are the dark lines and the bright lines in the same place?

My explanation

Apply what you have learnt

Solve these without the simulation. Use $h = 6.63 \cdot 10^{-34}$ J·s, $c = 3.00 \cdot 10^{8}$ m/s and $1\ \text{eV} = 1.60 \cdot 10^{-19}$ J.

1. Calculate the energy in joules and in eV of a 656 nm photon.
2. An electron drops between two levels that are 2.10 eV apart. What is the wavelength of the photon it emits? What colour is it? Which element in the simulation could it be?
3. Explain why old sodium street lamps gave a yellow light and neon signs are red.
4. Why is a 600 nm photon not absorbed by hydrogen, even if a huge number of them arrive?

Problem	Working and result
1	
2	
3	

Problem	Working and result
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 13)

1. According to Bohr, $E_n = -13.6 / n^2$ eV. Calculate $E_3 - E_2$, $E_4 - E_2$ and $E_5 - E_2$ and compare them with the energy level diagram for hydrogen.
2. In Ionised Gas mode with hydrogen, find the minimum voltage at which each visible line appears. What does the existence of a threshold for each one show?

My answers

Self-assessment

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

I can...	Yes	Nearly	Not yet
Explain that the electron can only be in certain energy levels			
Link absorbing with moving up a level and emitting with moving down			
Link the colour of light with the energy of the jump			
Explain why each element has its own spectrum			
Use a prediction and an observation to change an idea I had			

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