ACTIVITY WORKSHEET · SIMULACIENCIA

Activity worksheet: chemical bonding

Name	Group	Date

What you will learn

With the chemical bonding simulation you will join atoms one by one: you will see how they give, gain or share electrons to form ions, molecules and lattices. Then you will test the substances they form with experiments using electric current, knocks and temperature, and you will link their properties to their structure.

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/enlaces-quimicos** and set it up as described under “Set up the simulation”.

How to read the data. Under the drawing there are three slots, “Atom A”, “Atom B” and “Atom C”. Each one shows the charge of the atom and how many electrons it has in its outer shell, for example “Valence e^-: 7 / 8”. An atom is stable when it reaches 8 electrons in its outer shell (octet), or 2 if it is hydrogen (duet).

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) The ionic bond is the electron that moves from one atom to the other.	
b) Table salt is made of NaCl molecules.	
c) Ionic compounds conduct electricity when solid because they contain ions.	
d) All covalent substances melt at low temperatures.	
e) In a metal, the electrons only move when a current flows.	
f) Diamond and graphite behave in the same way because both are carbon.	

Activity 1. What holds sodium and chlorine together?

Set up the simulation: Ionic Bonding mode with Atom A = Na (sodium) and Atom B = Cl (chlorine). Open the simulation ready to use

Predict. Look at how many electrons each atom has in its outer shell. Which of the two do you think will give away an electron and which will gain it? Why?

My prediction

Observe. Write down the data in each slot before and after pressing “Give an electron to B”. Also look at the message that appears between the two atoms.

Moment	Charge of Na	Valence e^- of Na	Charge of Cl	Valence e^- of Cl	Message between the atoms
Before giving					
After giving					

Explain.

1. What is a cation? And an anion? Which is which here?
2. What holds Na and Cl together: the electron that has moved from one to the other, or something else? Use the message you wrote down.

My answers

Activity 2. When more electrons are needed

Set up the simulation: build each compound with the links. Start with magnesium chloride: A = Cl, B = Mg, C = Cl. Open with Cl, Mg and Cl · Open with Na, O and Na · Open with Ca and O

Predict. Before pressing any button, look at the valence electrons and fill in the prediction columns.

Observe. Give electrons with the buttons until all three atoms (or both) reach an octet. Write down the ions and the formula shown on the “Bond formed” card.

Atoms	How many e^- will each metal give? (prediction)	Formula I expect	Ions formed	Formula on the card
Cl, Mg, Cl				
Na, O, Na				

Atoms	How many e^- will each metal give? (prediction)	Formula I expect	Ions formed	Formula on the card
Ca, O				

Explain.

1. Why are two chlorine atoms needed for one magnesium atom, and two sodium atoms for one oxygen atom?
2. Add up the charges of the ions in each compound. What do you always get? Why does that make sense?

My answers

Activity 3. Do salt molecules exist?

Set up the simulation: Ionic Bonding with A = Na and B = Cl. Press "Give an electron to B" and then the "View crystal lattice →" button that appears on the drawing. Open the simulation ready to use

Predict. In a grain of salt, how many Cl^- ions do you think surround each Na^+ ion? Is each Na^+ joined only to "its own" Cl^-?

My prediction

Observe. In the "3D unit cell" view, click on an Na^+ and then on a Cl^-: their neighbours are highlighted. Then switch to "2D layer" and do the experiments in the table. Remove the voltage before applying the force.

Experiment	What happens (copy the message)
Click on an Na^+: how many Cl^- neighbours does it have?	
Click on a Cl^-: how many Na^+ neighbours does it have?	
"Apply voltage"	
"Applied sideways force" at 80 %	
"Applied sideways force" at 120 %	

Explain.

1. Are there NaCl molecules in salt? What does the formula NaCl mean, then?

2. Why does solid salt not conduct electricity even though it is made of ions?
3. Tick “Forces between the two blocks”, press “Restore the crystal” and raise the force again. Why does the crystal break when a layer slides?

My answers

Activity 4. Sharing instead of giving

Set up the simulation: Covalent Bonding mode. Build each molecule and press “Share” between neighbouring slots until all the atoms reach an octet or a duet. Open with H and H · Open with H, O and H · Open with N and N

Predict. In this mode there are only non-metals. Why do you think two chlorine atoms or two oxygen atoms cannot form an ionic bond with each other?

My prediction

Observe. Before sharing, predict how many times you will have to press “Share”. Then check it.

Atoms	Effective e^- at the start	Presses of “Share” (prediction)	Presses needed	“Bonds formed” of atom B	Formula
H, H					
H, O, H					
N, N					

Explain.

1. Does any of the atoms have a charge when the covalent bond forms? How is it different from the ionic bond?
2. Why does nitrogen need to share three pairs of electrons? What is that bond called?

My answers

Activity 5. A sea of electrons

Set up the simulation: Metallic Bonding mode with the metal Na. Open the simulation ready to use

Predict. If you hit a piece of metal, it gets dented but does not break; if you hit a salt crystal, it splits. What do you think will happen in the metal lattice if you slide one layer over another?

My prediction

Observe. Press “Apply voltage” and then “Deform lattice”. Then change the metal and fill in the table using the “Bond status” card.

Metal	Valence electrons	e^- in the sea	Melting point (°C)
Na			
Mg			
Al			

Experiment with Na	What happens
No voltage: how do the electrons move?	
“Apply voltage”	
“Deform lattice”	

Explain.

1. Why do metals conduct electricity when solid, but salt does not?
2. Why does the metal not break when deformed, while the ionic crystal does? Compare with what you saw in activity 3.
3. What link do you see between the electrons in the sea and the melting point of the metal?

My answers

Activity 6. Diamond, graphite and dry ice

Set up the simulation: Covalent Bonding mode, “View covalent crystals” button. Open diamond · Open graphite · Open dry ice

Predict. Diamond and dry ice (solid CO_2) both have covalent bonds. Which of the two do you think can stand a higher temperature without changing state? Why?

My prediction

Observe. For each crystal, write down the type shown on the “Structure” card, move the “🌡️ Temperature” slider until it changes state and press “Apply voltage”.

Crystal	Type of crystal	Which particles make up the lattice?	Temperature at which it changes state	Does it conduct?
Diamond				
Graphite				
Dry ice				

Explain.

1. When dry ice sublimes, are the bonds between C and O broken? What is broken, then?
2. Why does diamond melt at such a high temperature?
3. Diamond and graphite are pure carbon. Why does graphite conduct electricity and diamond does not?

My answers

Apply what you have learnt

Solve these without the simulation. Justify each answer using the number of electrons in the outer shell or the structure.

1. Write the electron arrangement by shells of potassium (Z = 19) and sulfur (Z = 16). Which ion does each one form? What is the formula of the compound they form?
2. State the type of bonding in each substance: KCl, Cl_2, Cu, CO_2 and CaO.
3. A white substance melts at 801 °C, does not conduct as a solid and does conduct when dissolved in water. What type of bonding does it have? Why does it conduct when dissolved?

4. Draw the Lewis structure of HCl and of O_2. How many pairs does each one share?

Problem	Answer
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. Build Na_2O (A = Na, B = O, C = Na), form the bond and open “View crystal lattice →”. How many O^{2-} surround each Na^+, and how many Na^+ surround each O^{2-}? Why is it not 6 : 6 as in NaCl?
2. Build SO_2 (A = O, B = S, C = O): press “Share” twice between A and B and “Dative” once between B and C. What is special about the dative bond? Which atom provides the two electrons?
3. In “View covalent crystals”, choose “Silica” and take it above 1713 °C. Compare what breaks with what broke in dry ice.

My answers

Self-assessment

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

I can...	Yes	Nearly	Not yet
Explain how cations and anions form			
Work out the formula of an ionic compound from the valence electrons			
Tell ionic, covalent and metallic bonding apart			
Explain why ionic compounds form lattices and not molecules			
Link conductivity, brittleness and melting point to structure			
Use a prediction and an observation to change an idea I had			

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