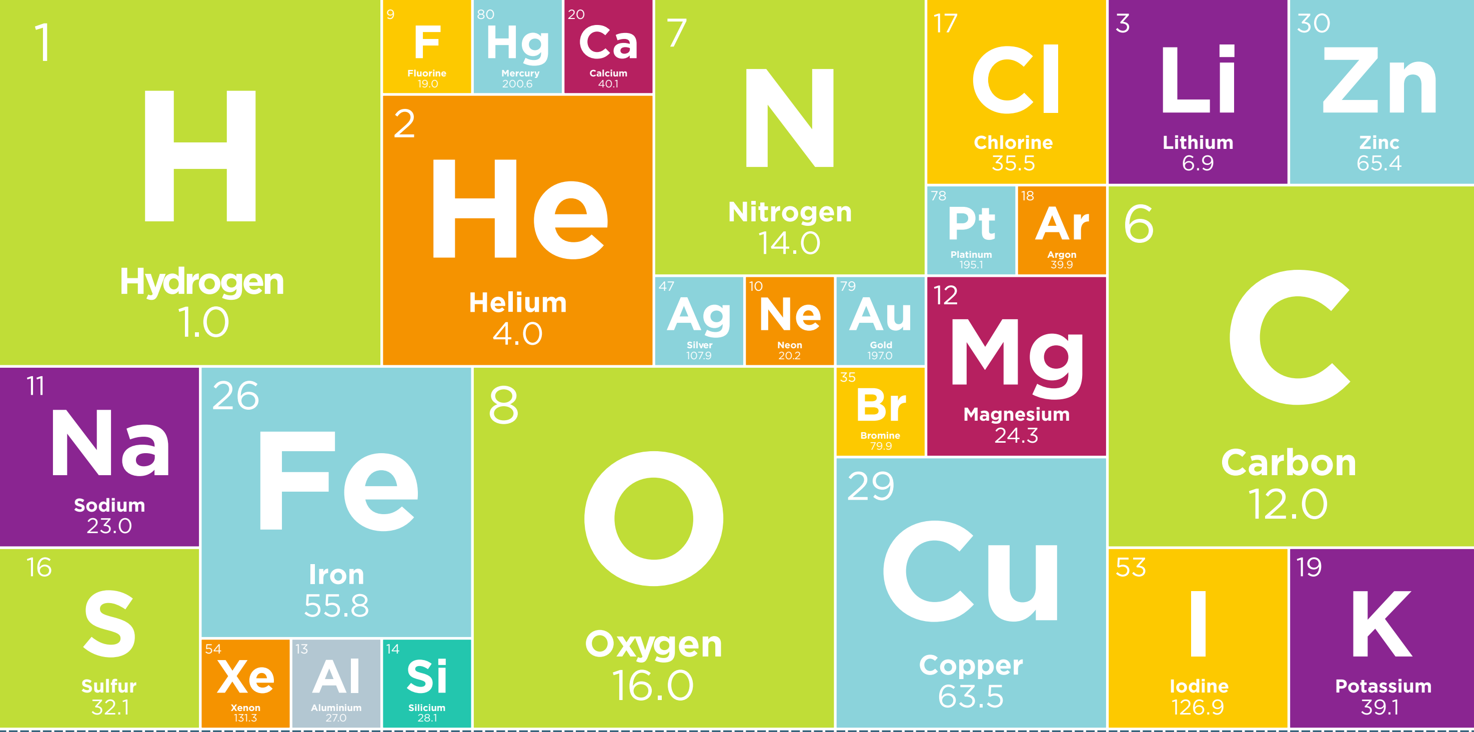


Bilingual Chemistry

Contents

Contents

Die Versuchsvorschriften in dieser Handreichung wurden sorgfältig, auf praktischen Erfahrungen beruhend, entwickelt. Da Fehler aber nie ganz ausgeschlossen werden können, übernehmen die Herausgeber*innen und die Autor*innen keine Haftung für Folgen, die auf beschriebene Experimente zurückzuführen sind. Mitteilungen über eventuelle Fehler und Vorschläge zur Verbesserung sind erwünscht und werden dankbar entgegengenommen.

Herausgeber*innen: Claudia Bohrmann-Linde, Rainer Brunnert, Elisabeth Kiesling
Die Materialien wurden erstellt unter Mitarbeit von Claudia Bohrmann-Linde, Rainer Brunnert, Heidrun Geller, Elisabeth Kiesling, René Landau und Christian Strippel.

Satz: Julian Venzlaff, Anna Strehnisch

Vorwort

Bilingualer Chemieunterricht gilt aktuell im Vergleich zu anderen bilingual unterrichteten Sachfächern als „Orchidee". Ein Grund hierfür liegt darin, dass bisher nur wenige auf die speziellen Belange des bilingualen Chemieunterrichts zugeschnittene Materialien existieren, die lehrplankonform und direkt im Unterricht einsetzbar sind. Dem soll mit der vorliegenden **digitalen Ressource** *Bilingual Chemistry* begegnet werden. Das vorliegende Werk ist für den Einsatz im ersten Lernjahr konzipiert. Es soll Lehrkräfte dabei unterstützen, phasenweise bilingualen Chemieunterricht zu gestalten.

Die Auswahl und Gestaltung der Inhalte wurde in Zusammenarbeit mit Chemielehrkräften vorgenommen, wobei der Fokus auf etablierte Versuche des regulären Chemieunterrichts gelegt wurde. Die Themen und die Progression orientieren sich am **gültigen Lehrplan für das Fach Chemie** in NRW, sind jedoch auch bundeslandunabhängig einsetzbar. Die Handreichung ist nicht als kontinuierliches Lehrwerk gedacht und bewusst nicht als reine Übersetzung eines bestehenden Lehrwerks konzipiert. Damit wird es unerlässlich sein, manche Fachbegriffe und Konzepte zusätzlich einzuführen. Dies kann in Anbindung an deutschsprachige Lehrwerke erfolgen.

Da das Fach Chemie eine experimentelle Wissenschaft ist, wurden zur Einführung neuer Sachinhalte jeweils **Experimente** gewählt, die ausgehend von Beobachtungen mithilfe von Auswertungsaufträgen inhaltlich erschlossen werden können. Fachliche Hintergründe werden in Form von **Informationstexten** und zugehörigen Übungsaufgaben geliefert. Darüber hinaus gibt es **Glossare**, **Concept Maps** und **weitere Übungsblätter**, teils mit sprachlichem Fokus. Zur Förderung sowohl der deutschen als auch der englischen Fachsprache werden an ausgewählten Beispielen Anregungen zu bewussten Sprachwechseln gegeben.

Die Formate können in Kombination oder auch unabhängig voneinander als **Kopiervorlagen** eingesetzt werden. Die Ausgabe der Materialien auf Anfrage auch in **editierbarer Form** ermöglicht einen individuell auf die jeweilige Lerngruppe zugeschnittenen Einsatz bzw. Möglichkeiten der Differenzierung. Sämtliche Materialien sind sprachlich so konzipiert, dass für die Jahrgangsstufe gängige Vokabeln als bekannt vorausgesetzt werden und bei als unbekannt angenommenen Begriffen jeweils am rechten Rand eine deutschsprachige Übersetzung angeboten wird. Damit werden schnelle **Vokabelhilfen** geliefert und der Fokus auf die zu vermittelnden Inhalte beibehalten. Abgerundet wird das Material mit Lösungen zu den Aufgaben, **didaktischen Hinweisen**, auch zu Sprachwechseln oder der Arbeit mit Concept Maps, Vokabellisten sowie einem englischsprachigen Periodensystem.

Das Werk *Bilingual Chemistry* wurde durch ein Team von Fachdidaktiker*innen, Lehrkräften und Lehramtsstudierenden erstellt. Die angebotenen Materialien wurden bereits an Partnerschulen erprobt und anschließend optimiert. Eine Ergänzung bieten interaktive mehrsprachige Animationen und ausgewählte Versuchsvideos, die über die Homepage www.chemiedidaktik.uni-wuppertal.de aufgerufen werden können. Weitere Entwicklungen zum bilingualen Chemieunterricht werden ebenfalls über die genannte Homepage zugänglich gemacht.

Wir wünschen Ihnen viel Erfolg beim bilingualen Chemieunterricht und freuen uns über Ihr Feedback (chemiedidaktik@uni-wuppertal.de).

Die Herausgeber*innen

Safety Rules for the Chemistry Laboratory

1) Your chemistry teacher knows the dangers of the chemicals and the equipment in the laboratory. That is why it is important to **only enter the chemistry laboratory with your teacher!**

2) Mistakes happen! **Tell your teacher if you have spilled something or if you have hurt yourself!** Your teacher decides the next necessary steps.

3) Some chemicals can burn your skin. **Do not touch them!**

4) Make sure that chemicals do not come into contact with your food. **Do not eat or drink in the laboratory!** To avoid contamination with chemicals: **wash your hands after an experiment!**

5) **Follow the exact procedure of your experiment!** If you have questions, ask your teacher.

6) Some materials, like paper or hair, burn quite easily. When working with a gas burner: **clear your table of unnecessary material. Tie long hair into a ponytail. Wear clothes made of cotton!**

7) Protect your eyes: **wear safety goggles during experiments!** They protect you from flames, splinters and splashes.

8) To avoid burns and injuries, make sure to **never hold a test-tube with its open end facing yourself or other students!**

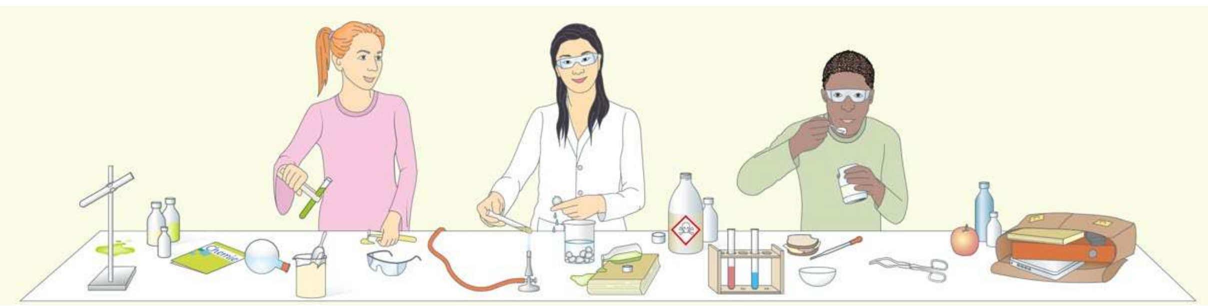
9) Chemicals should not be contaminated. That is why it is important to **only take small amounts of chemicals and always use a clean spatula or pipette!**

10) The environment and other people should not be exposed to harmful substances after an experiment. **Clean your desk and dispose of the chemical waste according to your instructions.**

Your tasks:

1. Look at the picture below. Describe 10 mistakes that the students are making.

2. Explain what they can do better. Refer to the rules mentioned above.



Things You Can Find in a Laboratory

Your task:
On the table you can see different pieces of lab equipment. Take the scraps of paper from the envelope, fold them in the middle and place each of them in front of the respective piece of lab equipment.

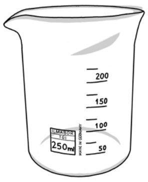
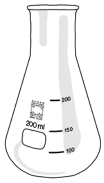
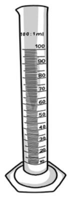
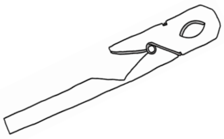
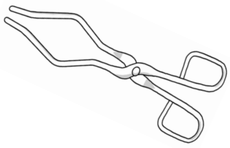
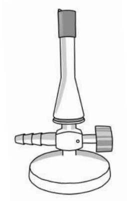
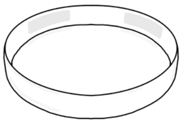
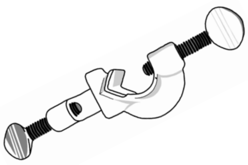
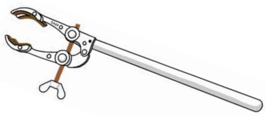
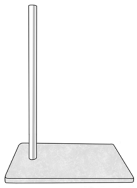
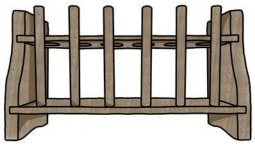
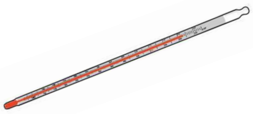
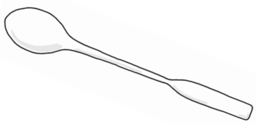
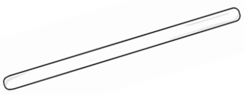
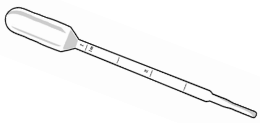
tongs	**measuring cylinder**	**test-tube**	**funnel**
pipette	**stopper**	**beaker**	**test-tube holder**
gas burner	**clamp**	**thermo-meter**	**erlenmeyer flask**
stand	**clamp holder**	**glass rod**	**wash bottle**
petri dish	**spatula**	**watch-glass**	**test-tube stand**

Things You Can Find in a Laboratory

Your task:

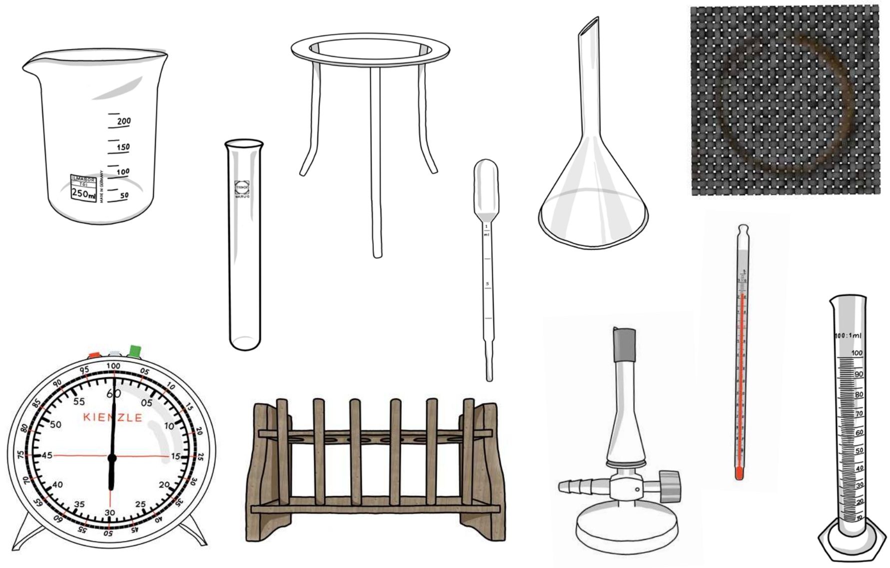
On this worksheet you can see typical lab materials.

Please write down the **E**nglish and the **G**erman names below each picture!

 E:________________ G:________________	 E:________________ G:________________	 E:________________ G:________________	 E:________________ G:________________
 E:________________ G:________________	 E:________________ G:________________	 E:________________ G:________________	 E:________________ G:________________
 E:________________ G:________________	 E:________________ G:________________	 E:________________ G:________________	 E:________________ G:________________
 E:________________ G:________________	 E:________________ G:________________	 E:________________ G:________________	 E:________________ G:________________
 E:________________ G:________________	 E:________________ G:________________	 E:________________ G:________________	 E:________________ G:________________

Chemistry Apparatus (A)

This is a set of apparatus used in many chemical experiments:



Your tasks:

1. Complete the table by adding the appropriate names of the apparatus.

Name of Apparatus	Function	
	to put on the tripod	
	to fill in some substances and let them react with each other	
	to *measure* the exact volume of a liquid	messen
	to heat up substances, to start reactions	
	to measure the temperature	
	to measure the time, e.g., in seconds	
	to fill in with *liquids*	Flüssigkeit
	rack for heating up substances with the gas burner in, e.g., a beaker	
	to separate a *solid* from a liquid	Feststoff
	to put in test-tubes	
	to measure a small amount of a liquid	

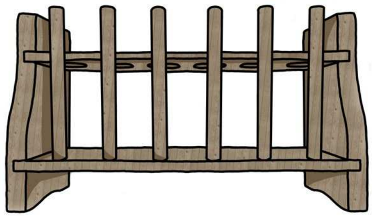
2. Name the apparatus for measuring something.
3. Name the pieces that are made of glass.
4. Describe the apparatus you would need if you wanted to *evaporate* water from a salt *solution.*

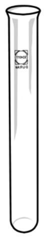
verdampfen, Lösung

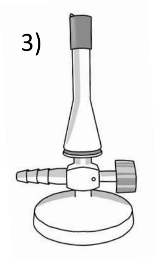
1. Getting Started: In the Laboratory

Chemistry Apparatus (B)

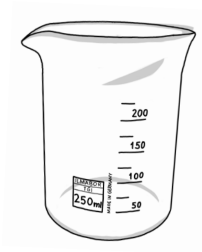
This is a set of apparatus used in many chemical experiments:

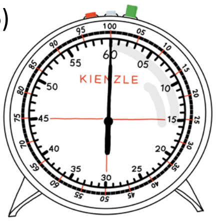
1) 

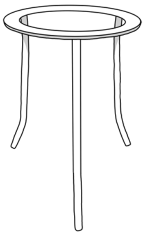
2) 

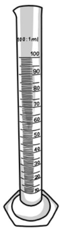
3) 

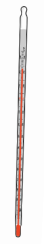
4) 

5) 

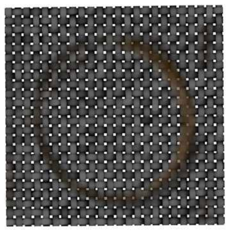
6) 

7) 

8) 

9) 

10) 

11) 

Your task: Complete the table by numbering the apparatus and writing down its main function. One has already been done for you.

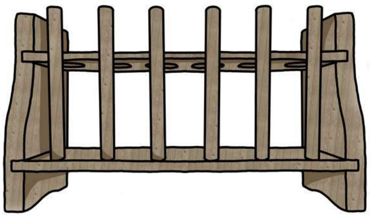
No.	Name of Apparatus	Main Function
	test-tube rack	
	filter funnel (and paper)	
	beaker	
	gas burner	
	heatproof mat	
6	stop clock	to measure the time, e.g. in seconds
	measuring cylinder	
	pipette	
	thermometer	
	test-tube	
	tripod	

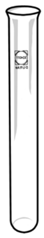
Main function of pieces of chemistry apparatus

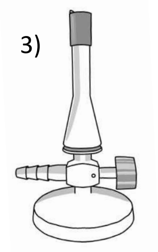
to put on the tripod
to fill in some substances and let them react with each other
to measure the exact volume of a liquid
to heat up substances, to start reactions
to measure the temperature
to measure the time, e.g., in seconds
to fill in liquids
rack for heating up substances with the gas burner in, e.g., a beaker
to separate a solid from a liquid
to put in test-tubes
to measure a small amount of a liquid

Chemistry Apparatus (C)

This is a set of apparatus used in many chemical experiments:

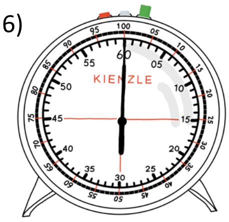
1) 

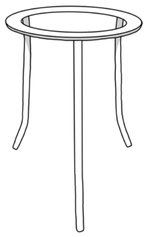
2) 

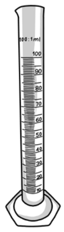
3) 

4) 

5) 

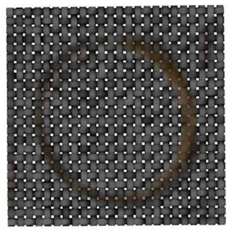
6) 

7) 

8) 

9) 

10) 

11) 

Your task: Complete the table by writing down the main function of each piece of apparatus. One has already been done for you.

Name of Apparatus	**Main Function**
1) test-tube rack	
2) test-tube	
3) gas burner	
4) pipette	
5) beaker	
6) stop clock	to measure the time, e.g., in seconds
7) tripod	
8) measuring cylinder	
9) thermometer	
10) filter funnel and paper	
11) heatproof mat	

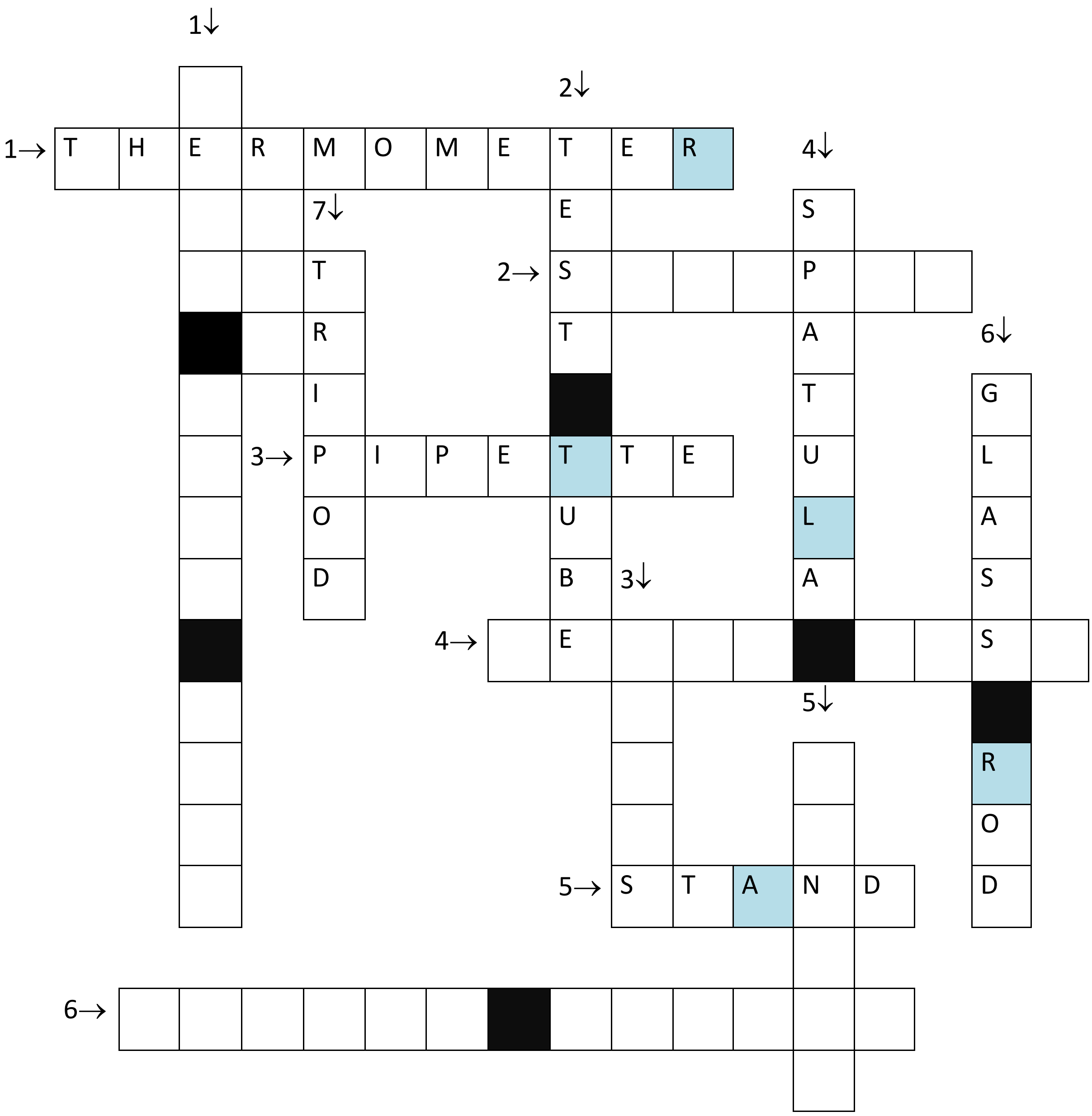
Partner Crossword on Lab Apparatus (A)

Complete your crossword by asking your partner for explanations of his/her pieces of apparatus!

E.g. *What's 7 down?*

- It's made of iron and has three "legs." If you want to heat something, you can place it onto the thing and heat with a burner from below.

What's 6 across? ...



It's all in the _ _ _ _ _ _ _ _ _ _ Y !

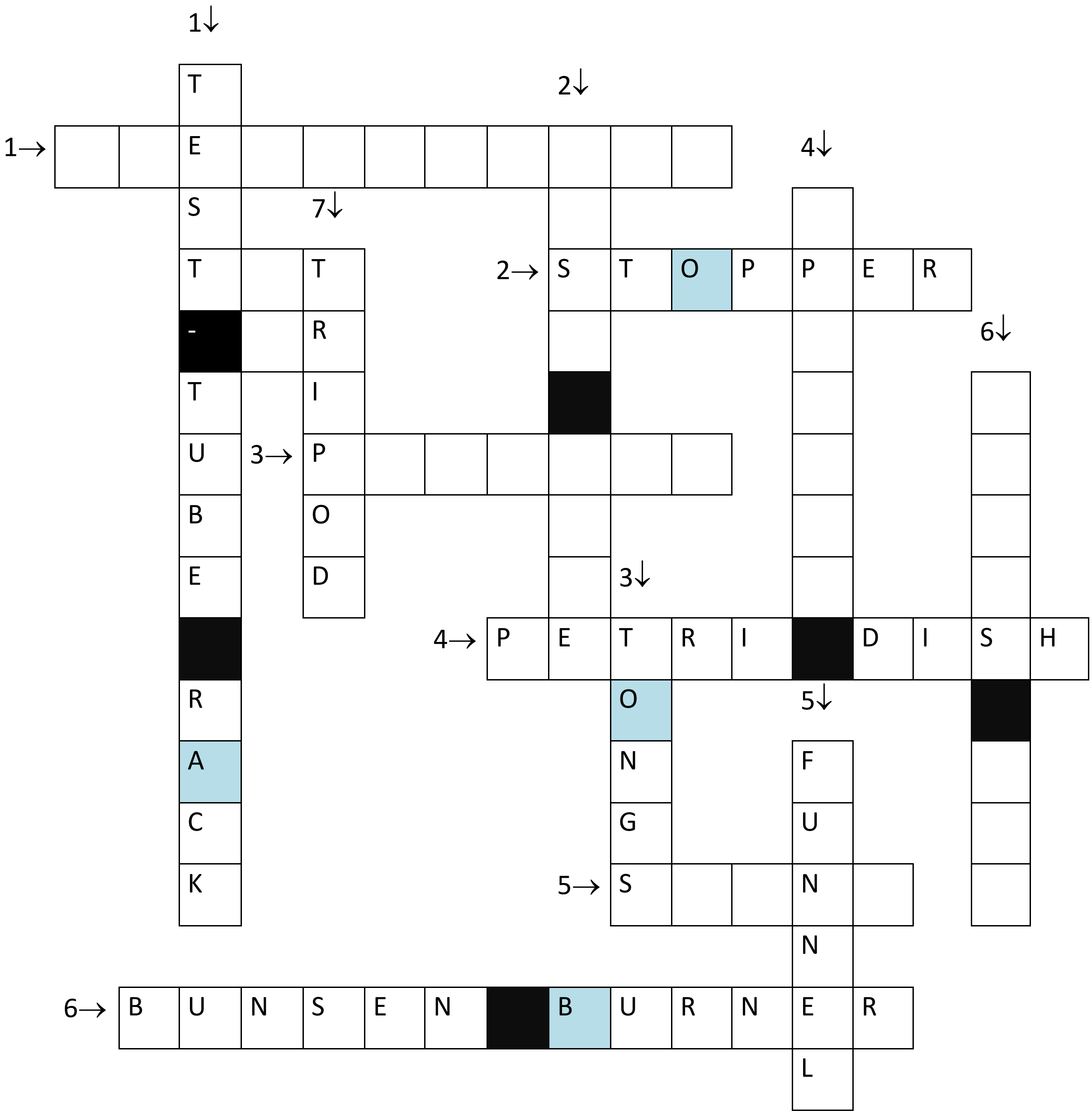
Partner Crossword on Lab Apparatus (B)

Complete your crossword by asking your partner for explanations of his/her pieces of apparatus!

E.g. *What's 7 down?*

- It's made of iron and has three "legs." If you want to heat something, you can place it onto the thing and heat with a burner from below.

What's 6 across? …



It's all in the _ _ _ _ _ _ _ _ _ _ Y !

How to Structure Your Lab Report

1) Intention of the Experiment

Describe the task or question that should be answered in the experiment.

2) Materials

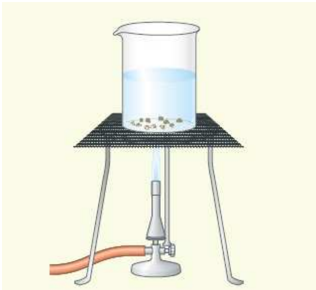
Note down all the lab equipment and chemicals you need for the experiment. Make sure to include hazard symbols. If necessary, add additional safety instructions. Ask your teacher for the correct disposal method of the chemicals, if it is not mentioned in the instruction.

3) Procedure

Describe the experimental procedure as shortly and precisely as possible. Make sure to use simple present.

4) Sketch

Sketch the setup of your experiment and label all important laboratory utensils.



5) Observation

Write down your observations. Use texts, tables or pictures.
You should describe changes in colour or changes of state.
It is also helpful to mention the outward appearance of the reactant and the product ("is it a powder, etc.").
Be careful NOT to explain any of your observations!

6) Conclusion

Evaluate and analyse your observations and data. Interpret your results and refer back to the intention of the experiment.

Your tasks:

Plan an experiment to separate the three components of a mixture of sand, water and ink with the help of separation techniques.

1. Discuss your plans with your teacher before you carry out the experiment.
2. Create a lab report for the experiment and document your findings.

How to Structure Your Lab Report

Intention of the Experiment

We want to find out if…
The intention of the experiment is to find out …

Materials

lab equipment, e.g., beaker, test-tube,
chemicals, water, salt

Procedure

First put …, Then add …,
Afterwards, heat…, Before removing … from …,
As a next step, separate … from …, Finally ….

Observations

Describe changes in colour or changes of state.
It is also helpful to mention the appearance of the reactant and the product (is it like a powder, etc.).
useful verbs: (to) change colour, (to) become, (to) appear, (to) disappear), (to) turn

Conclusions

From … you can conclude / deduce / infer that…
As a result …, In the reaction … and … react to yield …, During the experiment … is produced.
The result… shows that…, The change in colour indicates that…
As a result…, As a result of…

Your tasks:

3. Add more nouns, verbs, and adjectives to the list above that you find helpful when writing a lab report.
4. Use the phrases and form sentences for your lab report.

Example Lab Report

Examination of *Sherbet powder*

Brausepulver

1. Intention of the Experiment/Question

Which components of sherbet powder cause the *bubbling* in water?

Sprudeln

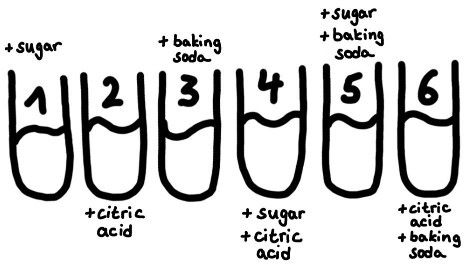
2. Materials

Lab equipment: six test-tubes, test-tube rack, spatula

Chemicals: sugar, *citric acid, baking soda* (sodium hydrogen carbonate), water

Zitronensäure, Backpulver (Natrium-hydrogen-carbonat)

3. Sketch:



4. Procedure

Fill six test-tubes with 10 mL of water and label them with the numbers 1-6.

Give a *spatula-tipful* of the following chemicals into test-tube 1: sugar, in test-tube 2: citric acid and test-tube 3: baking soda.

Fill a spatula-tipful of sugar and citric acid in test-tube 4, sugar and baking soda in test-tube 5 and citric acid and baking soda in test-tube 6.

Spatelspitze

5. Observations

1	2	3	4	5	6
water + sugar	Water + citric acid	Water + baking soda	water + sugar + citric acid	Water + sugar + baking soda	Water + citric acid + baking soda
no bubbling	no bubbling	no bubbling	no bubbling	no bubbling	bubbling

6. Conclusions

Bubbling can only be observed in test-tube 6 when citric acid is given to baking soda and both substances are dissolved in water. One can conclude that these two chemicals (components) cause the bubbling of soda powder in water.

Hazard Symbols

Gefahrstoff-symbole

In the laboratory you can find typical labels on the bottles of chemicals. These signs or *pictograms* warn you about dangers of the chemical in the bottle.

Piktogramme

This sign means ***flammable***. That means that this substance can catch on fire easily. Alcohol or *petrol* carry this symbol. You should never have open flames, e.g., from matches or the gas burner near them.

entzündlich
Benzin

This sign means ***oxidising*.** A substance with this symbol lets other materials burn better because it gives them extra *oxygen*. Pure oxygen is, of course, strongly oxidising. You should not use these substances in combination with any material that burns easily.

brand-fördernd
Sauerstoff

This sign has a very strong warning and it means that the substance is ***toxic****;* that it could kill you. Chlorine is toxic and that is why we use it in swimming pools to kill bacteria. We use very little chlorine so that we can still swim safely.

giftig

These substances are ***harmful***. They will not kill you but they can damage your *health*. Petrol is harmful when you breathe in the *fumes*. You can find this sign at gas stations. Some of these substances can also cause *cancer*, but you will not use them in your chemistry lessons because they are not allowed there.

gesundheits-gefährdend,
Dämpfe,
Krebs

This symbol is used for ***corrosive*** substances. They can damage or even destroy your skin or eyes if you do not protect them. When such a material is on your skin it feels like you have burnt yourself. *Acids* are corrosive, for example, the acid in a car battery.

ätzend
Säuren

This symbol is a general warning for all kinds of dangers. It also means that a substance is an ***irritant***. It can cause an allergy or it can make your skin feel like you have a sunburn. Irritant substances will not give you a *long-term* damage.

reizend
dauerhaft

Your tasks:

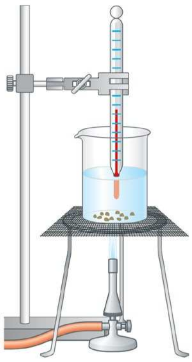
1. Use your textbook to find the hazard symbols for the following chemicals:
- Hydrogen (Wasserstoff), ________________________________
- Ethanol (Ethanol), ________________________________
- Oxygen (Sauerstoff), ________________________________
- xMagnesium (Magnesium), ________________________________
- Sodium (Natrium) ________________________________

2. Research at home: Look for products that have a hazard symbol. Make a list of the products and the symbols.
Hint: Check the kitchen and bathroom and write down the name of the products and the corresponding hazard symbols.

product	**hazard symbol**

Lab Activity: The Boiling Temperature of Water

Sketch:



Materials:

beaker, water, boiling stones, stand, clamp, thermometer, tripod, heatproof mat, gas burner

Your task: Label the sketch with the terms mentioned above.

Procedure: **1.** Fill ca. 100 mL water into the test-tube and add 2-3 boiling stones. Attach the stopper with the thermometer so that the thermometer is in the water but does not touch the glass. Use a stand with clamp to secure your experiment (see sketch).

2. Heat the water and *note* the temperature every minute. You can stop the experiment when the temperature has not changed over a period of 5 minutes. — notieren

Observation: Create a table for your *data* – you might have to extend the table: — Messwerte

Time [s]	0	30	60	90	120	150	180	210	240	270	300
Temp. [°C]											

Hints for your conclusions:

1. Write down the highest temperature you could reach in this experiment.

2. Describe what happens to the water at the highest temperature.

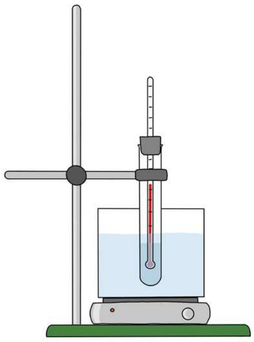
3. Draw a *graph* with the time on the x-axis (1 cm = 1 min) and the temperature on the y-axis (1 cm = 10 °C) and draw the curve. — Diagramm

4. Describe the curve. Try to find an explanation for its shape.

5. Draw the water particles at the beginning and at the end of the experiment (using the particle model).

Lab Activity: The Melting Temperature

Sketch:



Materials:
large test-tube, stopper (one hole), thermometer, beaker, stand, clamp, heating plate, *stearic acid*, water, Stearinsäure,

Procedure:

1. Fill the test-tube 4 cm high with stearic acid. Attach the stopper with the thermometer so that the thermometer *dips* into the stearic acid but does not touch the glass. Use a stand with clamp to secure your experiment (see sketch).

2. Heat the test-tube in a water bath. At the beginning the water bath should have a temperature of about 50 °C. *Note* notieren the temperature of the stearic acid every 30 seconds.

3. Remove the water bath and again note the temperature of the stearic acid every minute until it is completely solid.

Observation: Create a table for your *data* – you might have to extend the Messwerte table:

Time [s]	0	30	60	90	120	150	180	210	240	270	300
Temp. [°C]											

Hints for your conclusions:

1. Write down the highest temperature you could reach in this experiment.
2. Describe what happens to the stearic acid at the highest temperature.
3. Draw a *graph* with the time on the x-axis (1 cm = 1 min) and the Diagramm temperature on the y-axis (1 cm = 10 °C) and draw the curve.
4. Describe the curve. Try to find an explanation for its shape.
5. Draw the stearic acid particles at the beginning, during and at the end of the experiment (using the particle model).

2.1. Properties of Matter

Time to Practice: Water Is All Around Us

Your tasks:

1. Look at the picture and think of the different states of matter water takes.

Fig. 1: Pot with boiling water

Fill the correct words into the gaps:
Nouns: gas bubbles, vaporisation, boiling temperature, melting temperature
Adjectives: solid, liquid
Verbs: (to) boil, (to) melt, (to) freeze, (to) heat up

At normal pressure and room temperature water is always ______________________________ .

It ______________________________ at 0 °C. The ______________________________ water is also called ice. When you ______________________________ water in a pot (see Fig. 1) it starts to form ______________________________ at the bottom of the pot. When you reach 100 °C the water ______________________________ . The result is ______________________________ .

0 °C is called the ______________________________ of water. 100 °C is called the ______________________________ of water.

2. Label the picture of the water cycle with English terms. Challenge: Describe the picture to your partner in German or English.

condensation, groundwater, surface runoff, precipitation, evaporation from oceans lakes and streams, transpiration from plants

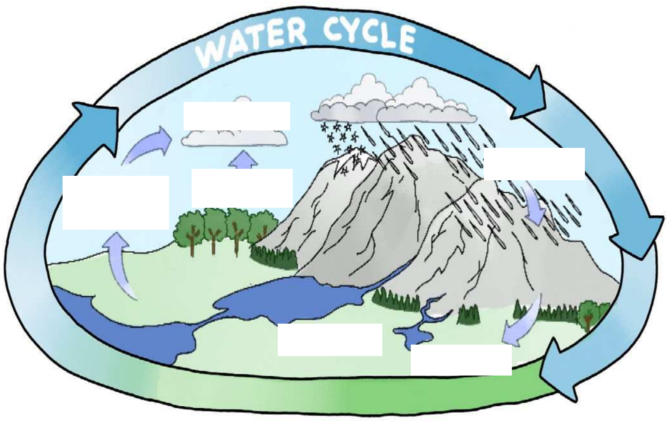


Fig. 2: Water cycle

3. Imagine you are a drop of water. Write a short story in which you describe your journey from the river to clouds and then back to the top of the mountains. Use the correct terms for the states of matter and the changes between them.

Lab Activity: Coke™ and Diet Coke™ – What is the Difference?

Materials: 100 mL of *stale* Coke, 100 mL of the same volume stale Diet Coke, measuring cylinder, *scales*, gas burner, 2 beakers (250 mL)

abgestanden
Waage

Procedure: Coke and Diet Coke must be stale and at room temperature for the experiment.
Take an empty measuring cylinder and *weigh* it. Write down the *mass*. Now fill exactly 100 mL of the stale Coke into the measuring cylinder and weigh again. Repeat the experiment with 100 mL of the stale Diet Coke.

wiegen
Masse

Observation: Create a table for your *measured values*:

Messwerte

	Empty Cylinder	Cylinder + 100 mL Coke	Cylinder + 100 mL Diet Coke
Mass in [g]			

Hints for your conclusions:

1. Calculate the weight of the 100 mL Coke and 100 mL Diet Coke and compare the measured values.

2. Calculate the quotient of the mass in [g] and the volume in [mL], of Coke and of Diet Coke.

2.1. Properties of Matter

3. Explain the term “density” and how it relates to this experiment. Compare the density of Coke and Diet Coke and explain your findings.

____

____

____

____

4. Explain why it is important for the experiment that the Coke and Diet Coke are stale.

____

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5. Make a list of the *ingredients* of Coke and of Diet Coke and underline the substances which are different.

Inhaltsstoffe

Coke:____

____

____

____

Diet Coke: ____

____

____

____

6. The *World Health Organisation* (WHO) recommends no more than 25 grams of sugar (6 teaspoons) per day for a healthy diet. Discuss whether the consumption of a glass (250 mL) of Coke per day would be considered “healthy” according to the WHO guidelines.

Weltgesundheits-organisation

____

____

____

____

2.1. Properties of Matter

Info: Matter and Properties of Matter

Sugar, salt, citric acid, baking soda… at first sight it is difficult to *distinguish between* these substances. In order to identify them, it is helpful to look at the typical *properties* of a substance.

unterscheiden zwischen
Eigenschaften

Colour, *odour* and crystal form

Geruch

Some chemical properties can be detected with our *sensory organs*. This includes the odour of a substance, its colour, its surface and crystal form.

Sinnesorgane

***Solubility* in water**

Löslichkeit

Another important property is the solubility of a substance in water. In tables, you can find information on the mass of a substance that is soluble in one litre of water at room temperature, often given in [g/L].

Substance	Solubility in 1 L water at room temperature
salt	360 g
sugar	2039 g
oxygen	0.043 g

Fig. 1: Solubility of different substances

A *sediment* forms when the maximum solubility of a solid substance in a liquid is reached. In most cases, the solubility *increases* with higher temperatures.

Bodensatz
steigt/nimmt zu

Boiling* and *melting temperature

Siedetemperatur,
Schmelztemperatur

On earth we find water as a solid, liquid or gaseous substance. It has three *states of matter* depending on the surrounding temperature. Solid water is called "ice" and gaseous water is called "water vapour". At 0 °C ice melts or solid water turns into liquid. The melting temperature of water is 0 °C. Liquid water evaporates at 100 °C and turns gaseous. This temperature is called boiling temperature.

Aggregatzustände

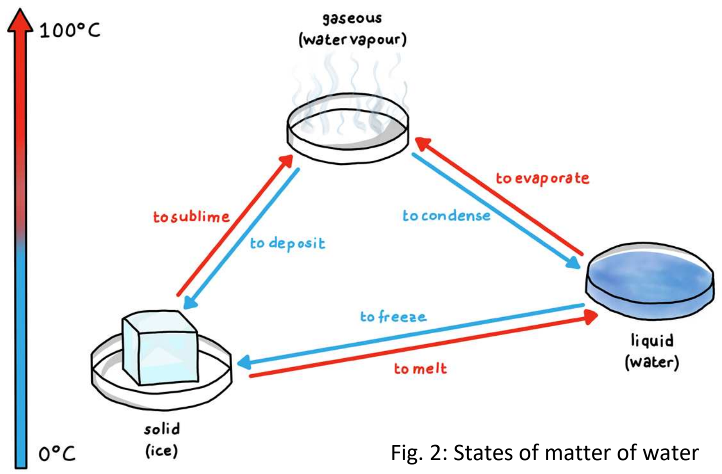


Fig. 2: States of matter of water

2.1. Properties of Matter

Density Dichte

What is lighter: a bag of feathers or a bag filled with iron nails? This question is difficult to answer, as you need a reference. The density (ρ; Greek letter "rho") describes a substance's mass per volume.

Mathematically the density is defined as mass divided by volume $\rho = \frac{m}{V}$.

Coke™ and Diet Coke™, for example, have different densities because one contains more sugar than the other. Consequently, equal volumes of Coke and Diet Coke have different masses. The density of Diet Coke is lower than that of Coke.

Substance	**State of matter at 20 °C**	**Density** (info: 1 mL = 1 cm^3)
water	liquid	1.00000 g/mL
oxygen	gaseous	0.00133 g/mL
hydrogen	gaseous	0.00008 g/mL
salt	solid	2.16 g/cm^3
sugar	solid	1.57 g/cm^3

***Chemical profile* of water** Stoffsteckbrief

Chemists use chemical profiles to characterise substances they are using.

name of the substance	water
state of matter at room temperature	liquid
colour	colourless
odour	*odourless*
soluble in water	yes
boiling temperature	100 °C
melting temperature	0 °C
density	1.0 g/cm^3 (= 1 g/mL)

geruchlos

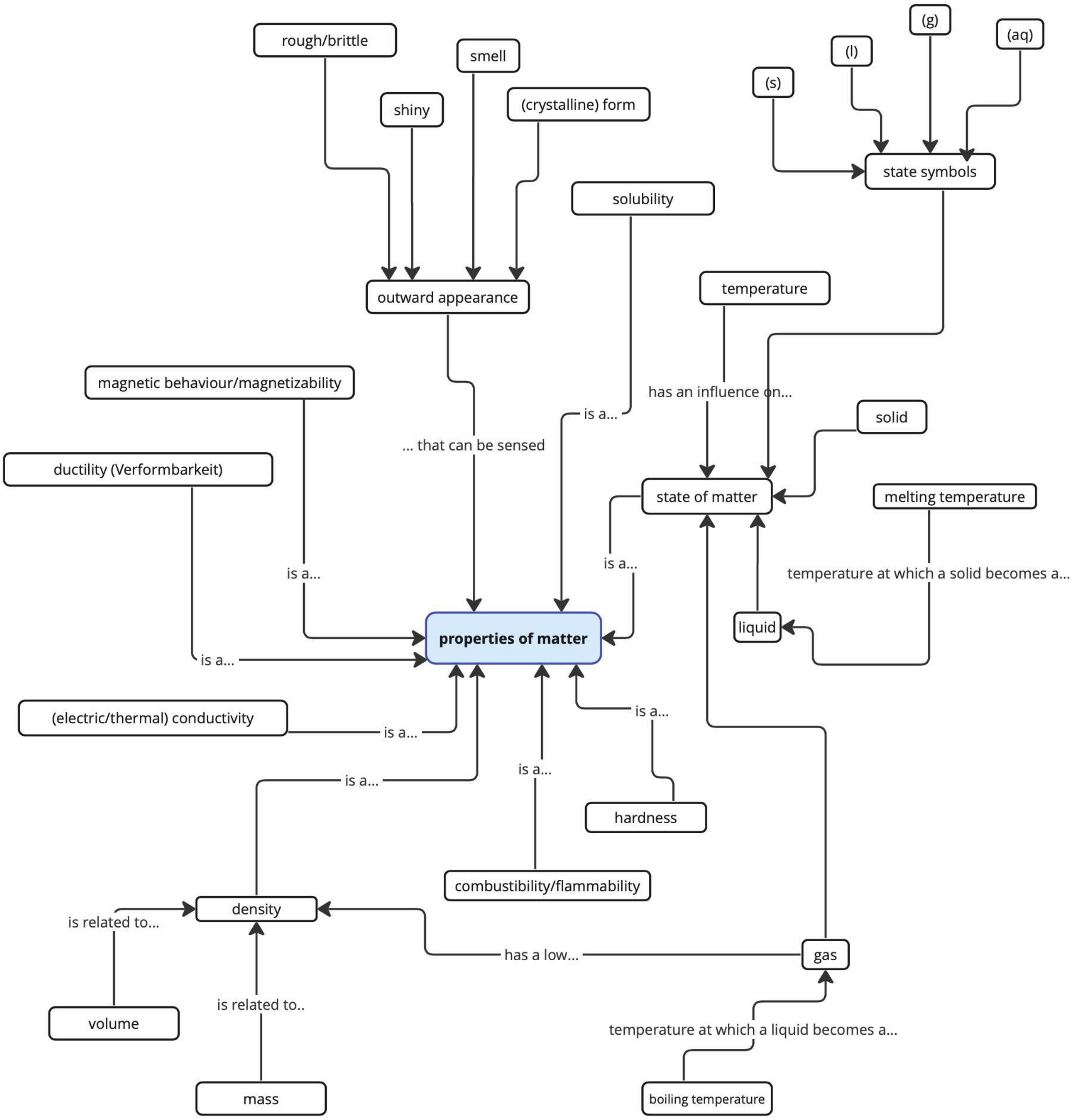
Your tasks:

1. Create a chemical profile of salt or sugar.
2. Explain why *laundry* dries at temperatures below 0 °C. Name the changes in the state of manner that occur during the drying process. Wäsche
3. Correct the statement: "Coke is heavier than Diet Coke".
4. Design experiments to identify a portion of salt and a portion of sugar. Evaluate which chemical properties would be essential to distinguish between the two substances.

2.1. Properties of Matter

Concept Map: Properties of Matter

Your task:
Write down ten sentences using the information from the Concept Map.



2.2. The Particle Model

Lab Activity: Matter Is Made Up of Particles

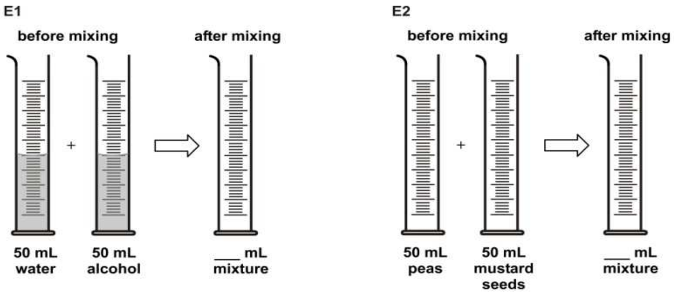
Materials: four 100 mL *measuring cylinders*, 50 mL of alcohol (ethanol), 50 mL of water, *peas*, *mustard seeds*

Messzylinder
Erbsen,
Senfkörner

Procedure: **E1)** Fill exactly 50 mL of water into one measuring cylinder and exactly 50 mL of alcohol into another measuring cylinder.
Pour the complete *amount* of one liquid to the other and note the total volume. (Menge)

E2) Fill one measuring cylinder to the 50 mL mark with peas and another measuring cylinder with to the 50 mL mark with mustard seeds.
Fill all of the peas into the measuring cylinder with mustard seeds, shake the mixture and note the total volume.

Observation:



Hints for your conclusions:

1. Draw the level of the alcohol-water mixture into the picture and explain why the result from E1 must seem strange to a mathematician.
2. Look at the mixture from E2 and describe where the peas and where the mustard seeds are situated in the mixture. Draw them into the three measuring cylinders on the right.
3. According to the ***particle model*** everything is composed of extremely small particles. The particles of one substance are identical in size and mass while the particles of different substances differ in size and mass from each other. Explain what we can conclude from E1 about the size of water particles and alcohol particles. (Teilchen-modell)
4. Make a drawing of the water particles and the alcohol particles in the water-alcohol-mixture and explain the result from E1.
5. Make a hypothesis on what would happen if we took 50 mL of peas and 50 mL of *marbles* of the same size as the peas and mixed them in a measuring cylinder. (Murmeln)

2.2. The Particle Model

Time to Practice: Diffusion of Gaseous Bromine

In the experiment depicted in the image, a *jar* with *bromine* and a jar with air are placed on top of each other. In the left picture there is a glass plate separating both jars.
The right picture shows what happens if the glass plate is taken away.

Gefäß, Brom

Your tasks:

Below you find some explanations from pupils who saw this experiment.

1. Read the different explanations and discuss them with a partner.
2. Find the statement which you think is correct. Name observations which support your decision.
3. Explain why you think the other statements are incorrect.

Billy says:

"Both jars got filled up with the brown gas because the brown gas got hot and it rose."

Rosie says:

"The particles in the air moved and covered up the brown particles which meant the brown colour got lighter and lighter but both jars got filled with the brown gas because there was so much in there."

Sonja says:

"The brown particles start to move to spread out throughout the whole jar. The air particles don't move they just let the brown particles cover the whole jar and that is why it all turns brown."

Melissa says:

"The brown particles move from an area of high concentration to low concentration and spread out evenly. The air particles mix with the brown particles and the colour becomes lighter because there are less brown gas particles than at the start."

Simon says:

"The brown particles diffuse throughout the two jars, moving from an area of high concentration to low concentration. The air particles mix with the brown particles and the colour becomes lighter because overall the gas is less concentrated than to start with."

2.2. The Particle Model

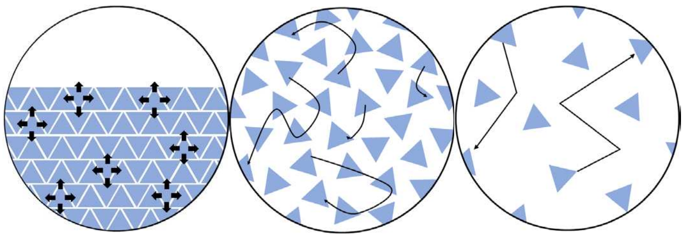
Info: Particle Model

Do sugar and salt disappear when they dissolve in water? How does the smell of perfume reach the other end of the room? How can I smell something but not see it?
We cannot answer these questions with our observations alone. That is why we use **models** to understand and explain our experimental findings. We use models as a help. They are constructed according to some rules, but do not show "the whole truth" and cannot be used to explain everything.

According to the ***particle model,*** all matter consists of extremely small particles; we can neither see them *with the naked eye* nor with the help of microscopes. The smallest particles of a substance are *uniform*; the particles of different substances are different in size and mass.

Teilchenmodell
mit dem bloßen
Auge, gleich

With this particle model, we try to explain some experiments. We observe that the total volume of a mixture of 50 mL of water and 50 mL of alcohol is smaller than 100 mL. According to the particle model, we can say that water particles and alcohol particles are different in size. Imagine that alcohol particles are larger than water particles. Between the alcohol particles, there are gaps. These gaps are big enough for water particles to fit in there. The experiment with peas and mustard seeds can visualize this.



The particle model is helpful for explaining other observations, too. For example: in solid substances, the smallest particles are arranged in a *uniform* way and are very close to each other. If you want to separate such solid substances, you need a lot of force to *overcome* the *attractive forces* between these particles. When you heat up a solid substance, the particles start vibrating more and more. At a specific temperature, the vibration is so strong that the particles cannot stick together anymore. The substance then turns into liquid. Further heating increases the speed of the particles. First, the *ambient pressure* keeps them in the liquid phase. At some point, the particles have enough speed and energy to overcome the ambient pressure. The substance turns gaseous. In a gas, the particles are very far away from each other.

einheitlich
überwinden,
Anziehungs-
kräfte

Umgebungs-
druck

2.2. The Particle Model

In 1827, Robert Brown observed with the help of a microscope that small plant *spores* perform shaky movements on a water droplet. This *proper motion* of particles is named **Brownian movement**. Particles of different substances mix because of their proper motions. We call this process **diffusion**. A finer distribution of the *solute* and additional stirring speeds up this process.

Sporen
Eigenbewegung
gelöster Stoff

Your tasks: Explain with the help of the particle model…

1. …why sugar and salt "disappear" when they dissolve.

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2. …why wet clothes dry on the *drying rack*.

Wäscheständer

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3. …why the smell of a perfume reaches the other side of the room.

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4. …why water boils when it is warm enough.

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5. …why liquids and gases take on the shape of the container that they are stored in, but solids do not.

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2.3. Mixtures and Separation Techniques

Lab Activity: Preparation of Instant Coffee

Materials: coffee beans, water, *mortar with pestle*, filter paper, funnel, three beakers, porcelain dish, gas burner, tripod, wire gauze, spatula — Mörser mit Pistill

Procedure:

1. Use the mortar and pestle and *grind* about 10 coffee beans to a *coarse* powder. — zerstoßen; grobkörnig
2. Put the coffee powder into the beaker and add ca. 50 mL of water. Heat the mixture *to a boil*. — bis zum Sieden
3. Pour your coffee through the filter into a beaker. Pour some of the filtrate into the porcelain dish and heat it up so that all the water evaporates. Let the porcelain dish cool down.
4. Scratch some of the *residue* out of the porcelain dish. Add it to ca. 20 mL of hot water in the beaker and *stir*. — Rückstand; umrühren

Observation:

	Ground coffee beans	Coffee before filtration	Filtrate and residue
Appearance of			

gemahlen; Aussehen

	Residue after evaporation	Final coffee mixture
Appearance of		

Hints for your conclusions:

1. Describe the differences between the two liquid coffee mixtures (steps 2 and 4).
2. Compare the three different stages of the solid coffee: the ground beans, the filtration residue and the evaporation residue.
3. Describe what has happened to the coffee beans during the four steps of the experiment.
4. Name the different separation techniques that you used during the experiment.

2.3. Mixtures and Separation Techniques

Lab Activity: Salt – Out of the Earth and onto Your Table (Part I)

Materials: 3 beakers, spoon, funnel, filter paper, sand, salt, water

Procedure:

1. In a beaker (A) mix one spoonful of salt with one spoonful of sand.
2. Add ca. 150 mL of water, stir and let it stand for a few minutes.
3. Carefully *decant* ca. 30 mL of your solution into another beaker (B). abgießen
4. Take the rest of your salt-sand-water mixture and filter it through the filter paper into another beaker (C).

Observation:

Note your observations in the following table:

Beaker	*Components* of the mixture	Name of the mixture	Appearance
A			
B			
C			

Bestandteile

Hints for your conclusions:

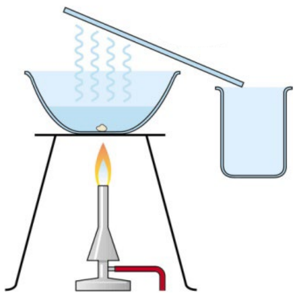
1. Draw a flow chart showing the steps of the procedure.
2. Name the separating techniques which you used in the experiment.
3. Explain which components were separated in each step.
4. Add the names of the separating techniques and of the components to your flow chart.
5. Name the mixtures in beakers A, B and C.
   Use the following terms: heterogeneous, homogeneous, solution and *conglomerate*. Gemenge

Lab activity: Salt – Out of the Earth and onto Your Table (Part II)

E1

Materials:
porcelain dish, beaker, glass plate, tripod, wire gauze, gas burner, boiling stone

Sketch:



Procedure:

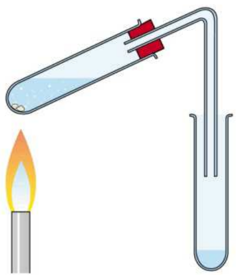
1. Fill the porcelain dish ca. 1 cm high with some of the solution of beaker C from Part I and add a boiling stone. Put the dish on the tripod and heat it *to a boil*. — bis zum Sieden
2. Hold the glass plate over the dish using *tongs* and collect the liquid into the beaker. — Tiegelzange

Observation: Describe the movement of the water through the apparatus.

E2

Materials:
2 test-tubes, stopper, *bent glass tube*, gas burner, boiling stone — gebogenes Glasrohr

Sketch:



Procedure:

1. Fill a test-tube up to about *one third of the way* with a solution of salt in water. Add a boiling stone. Close the test-tube with the stopper with the bent glass tube. The glass tube must not *dip* into the solution. — zu einem Drittel; eintauchen
2. Carefully heat the solution and collect the liquid which evaporates in the other test-tube.

Observation: Describe the movement of the water through the apparatus.

2.3. Mixtures and Separation Techniques

Hints for your conclusion:

1. Describe the states of matter which the water takes during the experiments in E1 and E2.

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2. Describe where you can find which components of the salt solution at the end of the experiments E1 and E2.

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3. Compare the two procedures. Explain if E1 or E2 is easier to carry out and give reasons for your answer.

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2.3. Mixtures and Separation Techniques

Info: From Rock Salt and Salt Water

Salt is an essential substance. It can be *obtained* from rock salt or from sea water. Rock salt is a mixture of rocks and salt. Before we can use the salt for cooking, we must separate the rocks and salt. We use water to achieve that. Salt dissolves in water and the rocks sink to the bottom of the tank because of their higher density. After letting the rocks ***sediment***, the separation of salt and the *insoluble* rocks can take place: We decant the *brine* from the rocks.

Fig. 1: Salt evaporation pond

We get even better results by filtering the sand-salt-suspension. The *pores* of the filter paper work like a *sieve* with very small holes. Only the liquid, known as the ***filtrate***, gets through the pores. From this filtrate, we get the salt after evaporating the water. Pure salt ***crystallises*** (see Fig. 1).

We can separate sand and salt because of their different solubilities, and salt and water because of their different *boiling temperatures*. By letting the water evaporate, we can also produce salt from sea water, and if you condense the vapour and collect the water, you get fresh water as a by-product at the same time.

Desalination of sea water takes place in areas where fresh water is rare even though they are close to the sea. The principle is shown in Fig.2. The sun heats sea water which starts to evaporate. Finally, fresh water *condenses* at the glass roof and flows into collecting tanks.

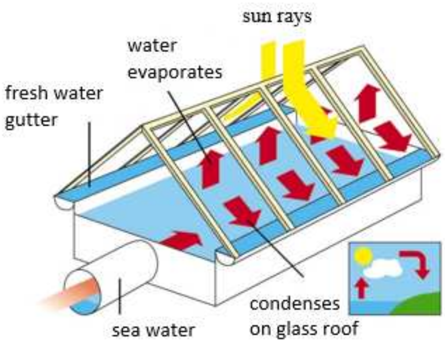


Fig. 2: Desalination of sea water

Distillation means to let a substance first evaporate and then condense again at a different place in order to separate a mixture. When we boil a salt solution, we can see that the boiling temperature rises for some time. A salt solution boils at higher temperatures than pure water. The more concentrated the solution, the higher this temperature gets. With the help of *boiling curves,* we can differentiate between pure substances and mixtures. Pure substances have a *specific* and constant boiling temperature while mixtures do not.

gewonnen
sich absetzen
unlöslich,
Salzlösung
Poren
Sieb
Filtrat
kristallisieren
Siedetemperaturen
Entsalzung
kondensieren
Destillation
Siedekurve,
spezifisch

2.3. Mixtures and Separation Techniques

Your tasks:

1. Look at Fig. 1 and Fig. 2 and explain how we can get salt and fresh water from sea water.

2. Explain why desalination is often carried out in tropic and sub-tropic areas.

3. Read the text and write down all methods of separation you can find. Explain which property is important for these methods.

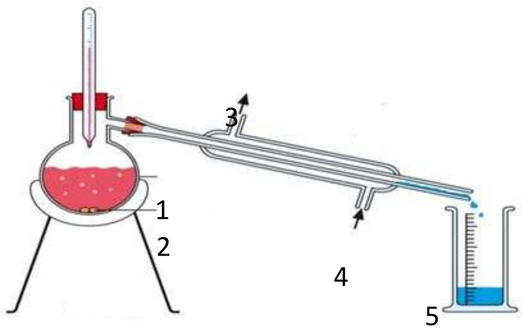
2.3. Mixtures and Separation Techniques

Lab Activity: Distillation of Red Wine

Materials: Thermometer, *round-bottomed flask*, rubber plug with hole, *Liebig condenser*, *heating mantle*, rubber tubes, red wine, *measuring cylinder*, 2 boiling stones

Rundkolben, Liebigkühler, Heizpilz, Messzylinder

Sketch:



Label the sketch!

1.
2.
3.
4.
5.

Procedure: Set up a distillation apparatus as shown in the sketch. With a measuring cylinder, take 100 mL of red wine and fill it into the round-bottomed flask. Add two boiling stones. Use a 25 mL measuring cylinder as *receiver.* Heat the wine until the temperature reaches 80° C. Let it boil for two more minutes.

Vorlage

Observation: ____

____

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____

____

____

Hints for your conclusion:

1) Besides water, wine contains alcohol, sugar, *dyes* and *flavourings*. Suggest which substances we separate by distillation.

Farb- und Geschmacksstoffe

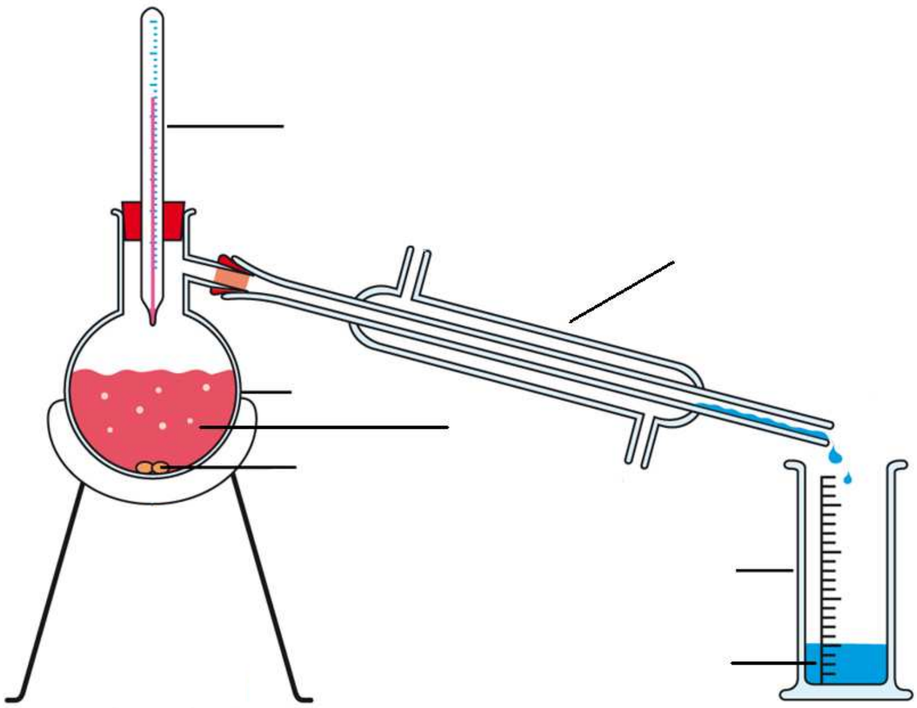
2) **Distillation is a separation technique that is based on the fact that substances have different boiling temperatures.** Find out the boiling temperatures of water and drinking alcohol (ethanol).

3) Wine contains 6-13% vol. of alcohol. Make suggestions as to why there is more liquid in the receiver than 13 mL.

4) Explain why the Liebig condenser is better for this experiment than an air condenser.

2.3. Mixtures and Separation Techniques

Time to Practice: Distillation of Solutions



Look at the sketch and solve the following tasks:

1. Complete the sketch with the following terms:
   boiling stones – distillate – round-bottomed flask – Liebig condenser – receiver – thermometer – liquid mixture
2. Use arrows to describe the *direction of flow* of the cooling water. Fließrichtung
3. The following text describes the process of distillation. Fill in the gaps!
   distillate, (to) condense, liquid 2x, gas 2x, (to) cool, (to) heat, component, thermometer

The distillation is used to separate _______________ mixtures. In the round-bottomed flask, the solution _______________ up to a boil. _______________ rises and passes the _______________ where the temperature is measured. The temperature helps you to see which _______________ of the mixture is evaporating. When the _______________ reaches the _______________ surface of the Liebig condenser it _______________ and runs down the inner tube as a _______________. In the receiver the _______________ is collected.

2.3. Mixtures and Separation Techniques

Lab Activity: The Secret of Being Green

Materials: green leaves (*lettuce*, *spinach*, etc.), sand, *methylated spirit*, mortar and pestle, pipette, 4x7 cm^2 filter paper, *glass jar with lid*

Salat, Spinat, Brennspiritus, Glasgefäß mit Deckel

Sketch:

Procedure:

1. *Crush* the leaves with some sand and methylated spirit in the mortar. — Zerstampfen
2. Using the pipette, draw a thin base line with the *leaf extract* onto the paper (see sketch). — Blattextrakt
3. Pour methylated spirit ca. 1 cm high into the jar. Put the filter paper into the jar and close the lid.
4. Take the filter paper out of the jar when the liquid has almost reached the top of the strip.

Observation: Describe the leaves and the methylated spirit before and after they are crushed in the mortar.
Make a drawing of the dried filter paper (or take a picture).

Hints for your conclusions:

1. Compare the colours of the base line in step 2 with the filter paper in step 4.
2. Natural objects can contain a variety of *dyes*. They have different properties such as solubility or *adhesive power* to some material such as paper. **The separation technique from this experiment is called *chromatography*. It is based on the different solubilities and adhesive powers of different components of a mixture.** Make a ranking of the adhesive power of the different colours to the filter paper. — Farbstoffe, Haftfähigkeit, Chromatographie
3. Explain the function(s) of the methylated spirit in this experiment.
4. Discuss the following statement: "Green leaves contain only green dye."

2.3. Mixtures and Separation Techniques

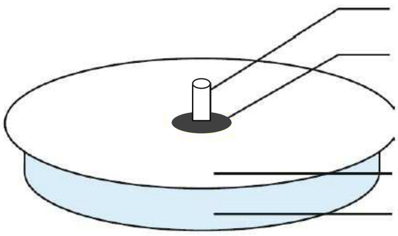
Lab Activity: The Secret Colours of Felt-Tip Pens

Materials: *round filter*, Petri dish, water, black *felt-tip pen*, a *wick* made from filter paper, scissors, other felt-tip pens

Rundfilter, Filzstifte, Docht

Sketch:

Label the sketch!



Procedure:

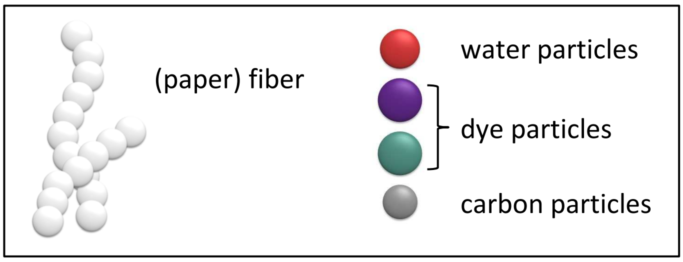
1. Cut out a little hole (ca. 2 mm) in the middle of the round filter.
2. Draw a black spot of about 1 cm in *diameter* around the hole in the middle of the round filter. — Durchmesser
3. Place the wick inside the hole and put the filter paper on a Petri dish filled with water. (Make sure the wick touches the water!)
4. Watch the colour on the paper. Remove the paper shortly before it is completely wet.
5. Let the filter paper dry and write down your observations.
6. Examine different felt-tip colours by repeating steps 1-5 with new round filters.

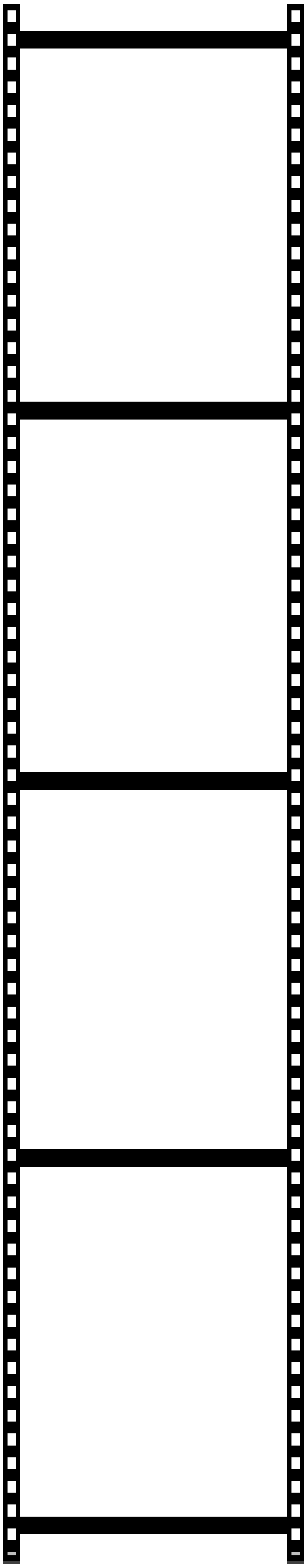
Observation: Describe what happens to the water and the filter paper. Describe the *contents* of the black felt-tip pen. — Inhaltsstoffe

Hints for your conclusion:

1. Explain the phenomenon by using the following words: pure substance, *dye*, mixture, mobile phase: water, stationary phase: filter paper, *adhesive power* — Farbstoff, Adhäsionskraft
2. Watch the animation: https://chemie-interaktiv.net/html5_flash/a140.html .
3. Use the animation in Question 2 to sketch and describe the processes on the particle level with the help of the film strip on the next page.
4. A student wants to investigate which dyes are used in "permanent" markers. The student uses a paper chromatography with water, but realises that the dye spot does not change. Explain how you could help him.

2.3. Mixtures and Separation Techniques





description

2.3. Mixtures and Separation Techniques

Time to Practice: Separation Techniques

Fill in the gaps with some of the following words

pure substance, solid mixture, chromatography, sieving, mud, heterogeneous, heterogeneous mixture, crystallising, solid, homogeneous mixture, gases, decanting, specific, suspensions, solution, fog, transparent, liquids, salt water, emulsion, *alloy*

Legierung

1. In some cases, we use _____________ to find out if a substance is pure or if it is a mixture.
2. When you can see the components of a mixture with your own eyes, then this substance belongs to the group of ____________________ mixtures.
3. Smoke consists of ___________ particles mixed with _____________ .
4. Milk is an example of an _____________ . It is opaque and turbid because it is a ________________________________.
5. Salt water is a ______________.
6. Solutions are homogeneous mixtures of ___________in liquids, ________ in liquids or __________ in liquids.
7. The mixtures in 6. are all clear and ________________.
8. A mixture of liquids in gases is a _______________ .
9. Water colours in water form _______________ and ink is a ____________.
10. Pure substances have a ________________ boiling temperature.

Your tasks:

1. Explain why the method of chromatography cannot be used for a large-scale separation of mixtures. Take the experiments with chromatography as a reference point.
2. Explain what smog consists of and if it is a homogeneous mixture.
3. Describe one way of getting drinking water from sea water.
4. Provide an example of how you would gain sugar from *sugar beets.*
5. Give examples of where the separation of mixtures (of any kind) is carried out on a large scale e.g. waste recycling.

Zuckerrüben

2.3. Mixtures and Separation Techniques

Info: Separating a Mixture

Most of the things we see and use are ***mixtures***. When we drop water onto a stain of a black felt-tip pen on a filter paper, we see that the colour black consists of different colours. The experiment tells us: the colour of black felt-tip pens is not based on one ***pure substance*** but on a mixture of different dyes. The separation technique in the experiment is based on the fact that dyes stick to paper with different adhesive forces. Another aspect is that water moves one dye further than the other because the dyes have different solubilities in water.

Gemische

Reinstoff

This method of separating substances is called ***chromatography*** (Greek: *chromos*, colour and *graphein*: (to) write).

Chromato-grafie

In some cases, we can see that a substance is a mixture of other components just by looking at it. That is the case with a portion of cereals or a block of *granite.* These mixtures of substances, whose different components we can see with the naked eye, are ***heterogeneous*** mixtures. Some heterogeneous mixtures cannot be identified as mixtures right away, e.g. milk. But if you take a look at a droplet of milk under the microscope, you can see very tiny droplets of fat swimming in the milk, because they are not dissolved.

Granit
heterogen

If water drops onto the black spot made by a felt-tip pen, you can see that the black colour is a mix of different dyes, e.g. red, yellow, green and purple. Mixtures like salt water or felt-tip pen colours whose different components we cannot see, even with the help of a microscope, are ***homogeneous*** mixtures. Homogeneous mixtures of liquids or gases are clear and transparent; heterogeneous mixtures are *opaque* and *turbid*.

homogen
undurchsichtig, trübe

Heterogeneous Mixtures		**Homogeneous Mixtures**	
Name	**Mixtures of**	**Name**	**Mixtures of**
emulsion	liquids in liquids	solution	solids in liquids
suspensions	solids in liquids		liquids in liquids
conglomerate	solids in solids		gas in liquids
smoke	solids in gases	*alloy*	solids in solids
fog	liquids in gases	mixtures of gases	gases in gases

Gemenge
Legierung

Fig. 1 Different heterogeneous and homogeneous mixtures

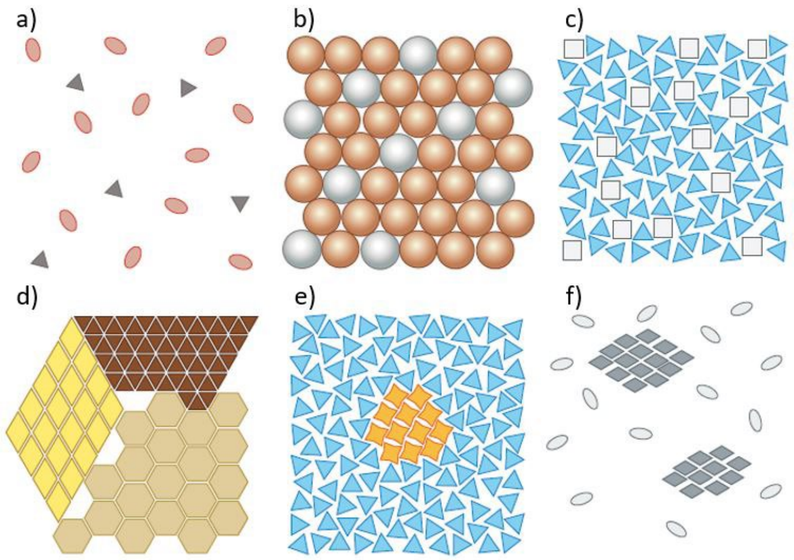
2.3. Mixtures and Separation Techniques

Your tasks:

1) Decide which kind of heterogeneous or homogeneous mixture the following substances belong to. Use Fig. 1 as a help. Fill in the following table.

	Heterogeneous Mixtures	**Homogeneous Mixtures**
tooth paste		
dusty air		
milk		
mineral water		
wine		
clouds		
ink		
water colour		
mud		
washing powder		

2) Name the kind of mixture that is represented by each of the following depictions a) to f) on the particle level.

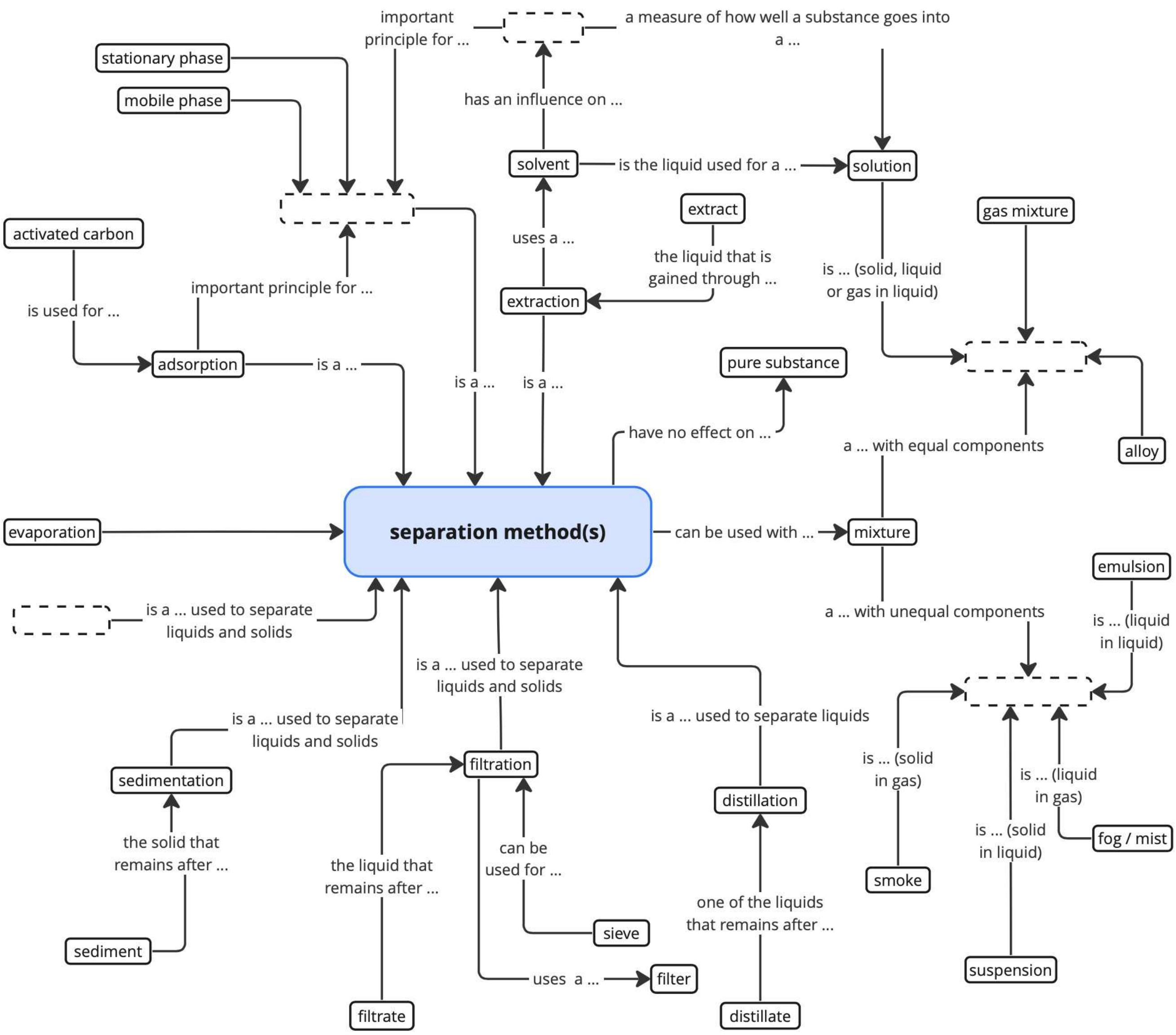


2.3. Mixtures and Separation Techniques

Concept Map: Separation Methods

Your tasks:

1) Fill in the following words to complete the Concept Map:
   homogeneous, solubility, decantation, chromatography, heterogeneous
2) Colour separation techniques in green and examples of mixtures in yellow.
3) Pick ten terms from the Concept Map and explain them in German.



2.3. Mixtures and Separation Techniques

Glossary : Separating Mixtures

English	German	Example
mixture	das Stoffgemisch	A mixture consists of two or more components.
component	der Bestandteil, die Komponente	The components of salt water are water and salt.
homogeneous	homogen	If you cannot see the different components, the mixture is homogeneous.
heterogeneous	heterogen	If you can see the different components, the mixture is heterogeneous.
to separate	trennen	You can separate water from salt by evaporating the water.
(chemical / physical) property	die (chemische / physikalische) Eigenschaft	Each substance in a mixture keeps its individual properties.
to filter	filtrieren	If you filter a mixture of sand and water, the sand stays in the filter paper and the water can be collected in a beaker.
filtration	die Filtration	After a filtration, the solid substance remains in the filter paper.
filtrate	das Filtrat	A filtrate is the liquid you collect after a filtration, e.g., the water from the filtration of a mixture of sand and water.
to decant	dekantieren	If you decant the water from a mixture of water and sand, the sand stays on the bottom of the beaker.
to evaporate	verdampfen	If you heat salt water, after some time all the water has evaporated and the salt stays in the beaker.
evaporation	das Verdampfen	After the evaporation of salt water, there is only salt left in the beaker.
to crystallise	kristallisieren	When a solute crystallises, it turns into solid crystals.
crystallisation (BE)	die Kristallisation	During a crystallization, crystals form from a solution.
to distill	destillieren	If you distill a mixture, the component with the lowest boiling temperature evaporates first and can be collected after condensing.
distillation	die Destillation	If you carry out a distillation, you can collect the water from salt water or alcohol from wine in the receiver.
distillate	das Destillat	The distillate is collected after the evaporation and condensation of a liquid in a distillation, e.g., the alcohol is the colourless distillate first collected in the distillation of red wine.

2.3. Mixtures and Separation Techniques

to extract	extrahieren	If one component of a mixture is soluble in water, you can extract it by adding water to the mixture.
extraction	die Extraktion	Cooking tea is an extraction of the water-soluble components from the mixture inside the tea bag.
extract	der/das Extrakt	If you mash green leaves with methylated spirit, you get a green extract of the dyes from the leaves that are now dissolved in the methylated spirit.
to sieve	sieben	If you sieve a mixture, the bigger components remain in the sieve and the smaller components fall through.
to float	(auf der Oberfläche) schwimmen	Components with a low density float on top of the water.
to sink	(ab)sinken	Components with a high density sink in water.
to attract (magnetically)	magnetisch anziehen	A magnet attracts iron filings.
attraction	die Anziehung	You can separate iron filings from a mixture because of magnetic attraction.
to sort	sortieren	If you have components of different sizes, you can sort them with tweezers.
chromatography	die Chromatografie	Chromatography is a method which uses the interaction of the components of a mixture with a liquid (or gas) and a solid phase.
emulsion	die Emulsion	A heterogeneous mixture of liquid substances.
suspension	die Suspension	A cloudy, heterogeneous mixture containing solid components that will later settle in the solution.
solution	die Lösung	A homogeneous mixture that is formed when a solute dissolves in a solvent.
conglomerate	das Gemenge	A heterogeneous mixture of two or more solid components.
alloy	die Legierung	A homogeneous mixture of two or more elements, one of which must be metal.

2.3. Mixtures and Separation Techniques

Glossary : Chromatography

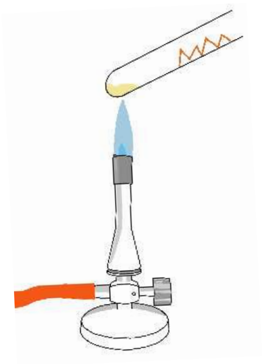
English	German	Example
chromatography	die Chromatografie	Chromatography is a method which uses the interaction of the components of a mixture with a liquid (or gas) and a solid phase.
paper chromatography	die Papierchromatografie	When you are doing paper chromatography, you use filter paper, put your mixture on the paper and place the paper in the container with solvent.
thin-layer chromatography	die Dünnschicht-chromatografie	When you are doing thin-layer chromatography, you use filter paper or other special chromatography plates.
solvent	das Lösemittel	You fill the solvent in the container.
container	das Gefäß	You place your filter paper into the container.
base line	die Startlinie	The base line is the starting point for the separation on the filter paper.
stationary phase	die stationäre Phase	The paper is the stationary phase, the components stick to different spots of the stationary phase.
mobile phase	die mobile Phase	The solvent is the mobile phase, it rises up the paper.
to rise up	aufsteigen	The solvent rises up the paper.
to get carried further	weiter bewegt/getragen werden	Some components get carried further than others.
to move along with	mitlaufen	Some components move along with the mobile phase better than others.
to examine sth.	etw. untersuchen	After some time, you can examine the chromatogram.
to have a great affinity to sth.	eine große Affinität zu etw. haben	The components that are close to the base line have a great affinity to the filter paper.
equilibrium	das Gleichgewicht	Chromatography is based on the equilibrium set up when a component distributes itself between the stationary and the mobile phase.
adhesive force/power	die Adhäsionskraft/ Haftfähigkeit	The electrostatic force of attraction between unlike particles, as shown in chromatography.
solubility	die Löslichkeit	The amount of substance in [g] that can dissolve in 1 L of water.

3.1. Conversion of Materials

Lab Activity: Chemical Reactions

Materials: test-tube, test-tube holder, gas burner, spatula
sulfur powder, folded piece of *copper* (about 1cm x 4cm) Schwefel, Kupfer

Sketch: *Label the sketch with the terms on the right.*



1) test-tube
2) gas burner
3) sulfur powder
4) folded piece of copper

Procedure: Examine the sulfur powder and the copper strip *thoroughly* before placing them into a test-tube as shown in the sketch. gründlich
Make sure the copper and the sulfur do not touch.
Heat the sulfur with a gas burner.
Examine the content of the test-tube after cooling.

Observation:

	Sulfur	Copper
Before heating		
While heating		
After heating		

Hints for your conclusion:

1. Design a table with the properties of copper and sulfur. Write the properties in rows and the substances in columns.

2. Describe the solid strip after cooling down.

3.1. Conversion of Materials

3. Develop ideas of how to find out more about the properties of the solid strip. Carry out your experiment(s) after telling your teacher about your plans. Add a column to your list from question 1 and include your experimental findings.

4. Read the following text and underline the five most important words. Explain these words to a partner.

Sometimes substances undergo physical changes such as melting or boiling but their properties remain the same. In a mixture, the components still have their properties and you can use these properties to separate a mixture.

Sometimes, if you heat a mixture, the components of the mixture can change. They form new substances with new chemical and physical properties. This is called a **chemical reaction**. The substances that react with each other are called **reactants**. The new substances that are formed are called **products**. Reactants react to form products.

In a **word equation,** we write the reactants on the left side and the products on the right side. In the middle, there is a **reaction arrow**.

For the reaction of copper and sulfur, we write the following word equation:

copper + sulfur ⟶ copper sulfide

(Read: "Copper and sulfur react to form copper sulfide.")

To get a better idea about the substances taking part in the reaction, you should add state symbols:

Use the following state symbols:
(s) for solids,
(l) for liquids,
(g) for gases and
(aq) for dissolved substances.

The complete word equation for the reaction of copper and sulfur is:

copper (s) + sulfur (s) ⟶ copper sulfide (s)

(Read: "Solid copper and solid sulfur react to form solid copper sulfide.")

5. Write a conclusion using your observation and the information from the text. Does a chemical reaction take place? Include the reasons for your answer in your conclusion.

Lab Activity: The Copper Envelope

V Kupferbrief

Schutzbrille! Falte aus einem kleinen, quadratischen Stück Kupferblech ein offenes Briefchen. Halte es anschließend mit einer Tiegelzange ca. 30 s in die rauschende Flamme des Gasbrenners. Lass es kurz abkühlen.

Fülle nun grobes Aktivkohlepulver in das Briefchen und erhitze es ohne Schütteln erneut. Lass es abkühlen und schütte das restliche Pulver heraus.

Aufgaben (Partnerarbeit!)

1. Lest die Versuchsvorschrift auf der rechten Seite und besprecht die einzelnen notwendigen Versuchsschritte.

2. Verbindet die Begriffe neben der Versuchsskizze mit den passenden abgebildeten Komponenten.

3. Beschreibt einander auf Englisch, welche Funktion die rechts neben der Skizze genannten Komponenten im Versuch haben.

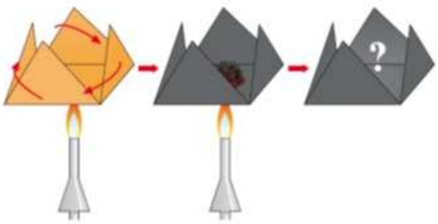
4. Überlegt gemeinsam, welche weiteren Materialien ihr für den Versuch benötigt. Schreibt diese auf Englisch bei „materials“ auf.

5. Verfasst eine englische Versuchsanleitung, die einzelne Arbeitsschritte enthält.

6. Notiert eure Beobachtungen und bearbeitet die Auswertungsfragen.

Materials:

Sketch:



copper sheet,
activated carbon,
gas burner

Procedure: ____

____

____

____

____

____

____

____

3.1. Conversion of Materials

Observation: ____

____

____

____

____

____

____

____

____

Hints for your conclusion:

1. Describe the outer appearance of the copper sheet before and after heating it in the first step.

   ____

   ____

2. Compare the amount of carbon before and after heating.

   ____

   ____

3. Describe the look of the inner and outer side of the envelope after taking out the carbon.

   ____

   ____

4. Make an estimation concerning the reaction partners in both steps.

   ____

   ____

5. Suggest a word equation for 1) the reaction that takes place during the first heating and 2) the reaction that takes place when heating the carbon-filled envelope.

   ____

   ____

3.1. Conversion of Materials

Info: Conversions of Materials During Chemical Reactions

Substances can change under certain conditions. You might know this phenomenon from baking a cake or cooking your favourite meal. When you heat sugar, for example, it becomes caramel (Fig. 1). What happens to the sugar during the heating process?

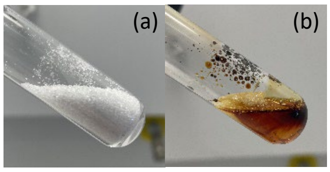


Fig. 1: sugar (a), caramel (b)

Chemical reaction

Every substance has characteristic properties. When you heat sugar, the resulting product looks, smells and tastes differently. A new substance with different properties is formed.

These conversions of matter do not only take place in the kitchen. If you heat chemicals, they can turn into new substances. New substances that are formed from ***reactants*** are called ***products***. The process of the conversion is called a ***chemical reaction.***

Ausgangsstoffe, Produkt
chemische Reaktion

In chemical reactions, new substances with new properties are formed.

If you heat copper, a chemical reaction takes place. Copper is a solid and shiny brown metal (Fig. 2). The metal strip changes its colour when it is heated and becomes a dark solid substance. This substance is called copper oxide (Fig. 3). Copper and copper oxide have different properties.

Chemical properties	**Copper**	**Copper oxide**
colour	metallic, shiny brown	black
boiling temperature	2595 °C	1026 °C
melting temperature	1084 °C	1326 °C
density (at RT*)	8.92 g/cm³	6.48 g/cm³
state of matter (at RT*)	solid	solid
*RT = room temperature	 Fig. 2: copper	 Fig. 3: copper oxide

3.1. Conversion of Materials

Characteristics of chemical reactions

The produced copper oxide cools down and keeps its properties. It does not show characteristics of the reactants, copper and oxygen. This is the major difference between a chemical reaction and a physical change in the state of matter. In a chemical reaction, the change is permanent, whereas changes in the state of matter (e.g. heating liquid water until it becomes *vapour*) are easily *reversible*.

Dampf, umkehrbar

Chemical reactions are used by companies to manufacture new products. If we take *crude oil* as an example, a variety of products, can be produced from it that are the basis for making fuels, drugs, soaps or cell phone cases and other everyday objects. Our world would not exist without chemical reactions. When plants or other living organisms grow, new substances are formed. When we digest food, many chemical reactions take place in our body in order to build new substances needed by our bodies. The oxygen we breathe is one of the products of chemical reactions in plants that turn carbon dioxide and water into sugars and oxygen with the help of sunlight and the green pigment chlorophyll.

Erdöl
Medikamente

Your tasks:

1. Decide and explain if the following processes are chemical reactions:
   a) burning of wood, b) dissolving salt in water, c) rusting of an iron nail.
2. Correct the statement “Sugar is brown after the heating process.”
3. Write a word equation for the reaction in plants that is mentioned in the text.
4. Describe the experiment shown in Fig. 4.

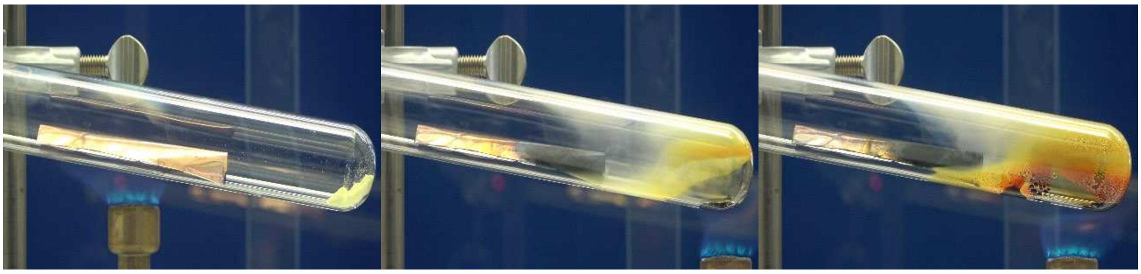


Fig. 4

3.2. Energy in Chemical Reactions

Lab Activity: Energy and Chemical Reactions – Exothermic and Endothermic

Materials: 1 test-tube, test-tube holder, spatula, burner, lighter, *porcelain dish*, pipette, thermometer, 2 g blue *copper sulfate pentahydrate*, distilled water

Porzellanschale
Kupfersulfat-pentahydrat

Procedure: **E1)** Fill the blue copper sulfate into the test-tube and heat it strongly for a minute. After cooling down, wipe the upper part of the inside of the test-tube with a piece of *Watesmo paper*.

Watesmo-Papier

E2) Place a thermometer in the solid product from **E1** and note the temperature. Add 5-10 drops of water to the liquid and *immediately* note the temperature again.

sofort

Observation: **E1)**____

____

____

E2)____

____

____

Hints for your conclusions:

1. Compare the colour of the solid before and after heating in **E1**.

____

____

2. Watesmo paper turns blue if it has contact with water. Apply this information to your observation in **E1**.

____

____

____

____

3.2. Energy in Chemical Reactions

3. Make a hypothesis on where the liquid must have come from in **E1**.

____

____

4. Write down a word equation for the reactions in **E1** and **E2**. (Info: the white substance is called copper sulfate.)

E1)____

E2)____

5. On the basis of your observation in **E1,** suggest how you can regenerate your reactant from **E2**.

____

____

6. **E1** and **E2** show that we do not only have to look at reactants and products when dealing with chemical reactions. Energy is very important, too. In this case, we consider heat energy. There are some reactions which can only take place if you *supply* energy. Other reactions actually *release* energy.

zuführen, freisetzen

Reactions that release energy are called ***exothermic reactions***. Reactions that need energy to be supplied during the reaction are called ***endothermic reactions***. Explain which of the reactions from **E1** and **E2** is exothermic and which one is endothermic.

exotherme Rkt.

endotherme Rkt.

____

____

____

____

____

3.2. Energy in Chemical Reactions

Info: Energy and Chemical Reactions

Exothermic and endothermic reactions

A characteristic quality of each chemical reaction is not only a change of matter, but also an **energetic change**. There are different forms of energy *involved*. There are chemical reactions that need to be started by **heat energy**. In other reactions, heat is released. **Light energy** is another form of energy that can either be used to start a reaction or that can be released in a chemical reaction. Another form of energy is **electric energy** which is made *available* by the reactions that take place in batteries and accumulators.

beteiligt

verfügbar

When energy-rich reactants turn into low-energy products, the reaction is characterized by giving away energy (Fig.1). Reactants contain more energy than the reactants. The ***reaction energy*** that is set free is given away to the surroundings. Chemical reactions like these are called ***exothermic reactions***. On the other hand, if we have to add heat energy during a reaction to keep it going, the chemical reaction is called an ***endothermic reaction***.

Reaktions-energie, exo-therme Rkt.

endotherme Rkt.

We can add “exothermic” or “endothermic” to the word equation to make it clearer whether the overall reaction needs or whether it releases heat energy, e.g. in the synthesis of iron sulfide:

iron (s) + sulfur (s) $\longrightarrow$ iron sulfide (s) | exothermic

Activation energy

Very few exothermic reactions start spontaneously when the reactants are mixed. Most reactions, however, need some energy input to make the reaction start. In these cases, an energetic *hurdle* must be taken. We can think of this hurdle as being an energy-hill. Once this hill has been overcome, the exothermic reaction takes place by its own. The heat energy that helps to overcome the energy-hill is called ***activation energy***.

Hürde

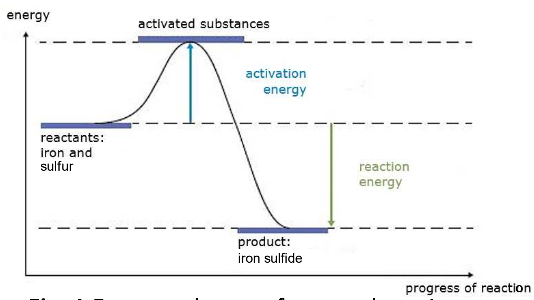


Fig. 1 Energy scheme of an exothermic reaction of iron and sulfur

Aktivierungs-energie

Your tasks:

1. The synthesis of copper sulfide and zinc sulfide are exothermic reactions. The reaction energy of the synthesis of zinc sulfide is greater than that of copper sulfide. Draw an energy diagram which shows this.
2. There are 15 matches spread across a metal plate. Find a way of how to light all matches, even though you are only allowed to light one match in the matchbox.

3.2. Energy in Chemical Reactions

Info: Energy Changes in Chemical Reactions

In a chemical reaction there is always an *energy turnover*. The form of energy involved is neither produced nor destroyed, but *converted*. Chemical energy of the reactants is converted into chemical energy stored in the products and sometimes also other forms of energy e.g. light, heat or electric energy.

Energieumsatz, umgewandelt

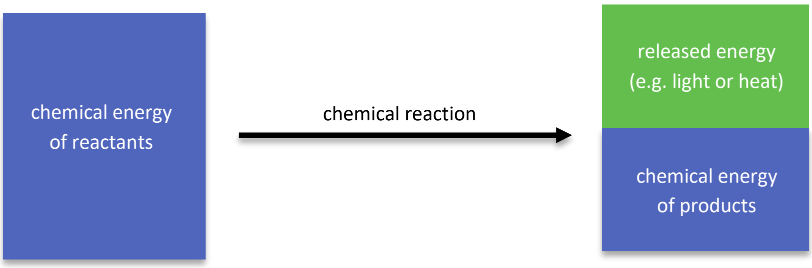


Fig. 1: Energy transformation during a combustion

Electric energy

Electric energy is a form of energy that can be used to start chemical reactions. It can also be the product of a chemical reaction. Think of batteries that supply electric energy because of the chemical reactions taking place inside. In accumulators, like the one in your mobile phone, electric energy is needed to produce the substances that react in a *reversible* chemical reaction, powering your mobile phone once it is loaded.

reversible

Fig. 2: A bonfire

Heat energy

In exothermic reactions, heat energy is given away to the surroundings. In endothermic reactions, energy is taken in from the surroundings.

Exothermic processes include *combustions* and *respiration*. Photosynthesis is considered to be an endothermic reaction.

Verbrennung, Atmung

Light energy

The sun and other light sources emit light and heat energy. Light can be emitted in a chemical reaction in combustions and in glow sticks. The light emitted by glow sticks is called “cold light” or ***chemoluminescence***. In some cases, light is needed to start a chemical reaction. The intensity of the light perceived by the human eye is commonly known as *brightness*.

Chemolumineszenz

Helligkeit

Fig. 3: Combustion of magnesium

3.2. Energy in Chemical Reactions

Your tasks:

1. Write an English procedure for the experiment below.
Use the following words and phrases:

bottom – (to) cover – a spatula tip full of – (to) add – (to) rotate – (to) mix – Erlenmeyer flask - mixing

<u>Lehrerversuch:</u> **Chemolumineszenz von Luminol**

<u>Durchführung:</u> Der Boden eines 1L Erlenmeyerkolbens wird ca. 0,5 cm hoch mit *Kaliumhydroxid*-Plätzchen bedeckt. Es werden 1 mL *Dimethylsulfoxid* und eine kleine Spatelspitze *Luminol* hinzugefügt. Dann wird durch Rotationsbewegungen des offenen Kolbens für eine gute Durchmischung gesorgt.

potassium hydroxide, dimethylsulfoxide, luminol

2. Follow the link:
https://chemiedidaktik.uni-wuppertal.de/index.php?id=4530&L=0
Watch the video and write down your observations.

3. Name the form of energy you can observe as a “product” of the experiment.

4. Find examples where light energy, heat energy or electric energy is released in a chemical reaction.

5. Look at Fig. 4. Name the energy conversions depicted in each picture.

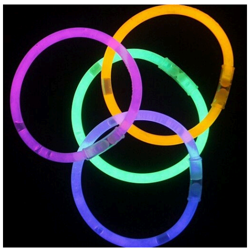
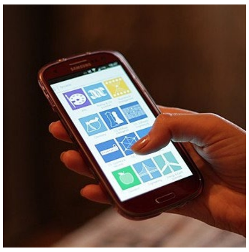
1) 
2) 
3) 
4) 
5) 
6) 

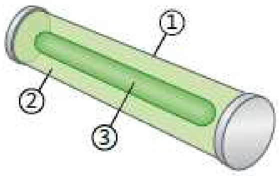
Fig 4. Different forms of energy in chemical reactions

3.2. Energy in Chemical Reactions

Lab Activity: Examination of a Glow Stick

Materials: *glow stick* Knicklicht

Sketch:



Procedure:
1. Examine the set-up and the components of the glow stick.
2. Label the sketch with the following terms:
   dye solution - glass tube with a solution - plastic tube.
3. Activate the glow stick in a dark room by bending it.

Observation:

Before the activation	After the activation

Hints for your conclusion:
1. Explain why it is necessary to bend the glow stick.
2. Describe what happens inside the glow stick.
3. Explain which energy transformation takes place in the experiment.
4. Discuss whether the use of glow sticks as *bracelets* at parties is environmentally friendly. Armreifen

____

____

____

____

____

____

Beyond the experiment:
Some insects, like *fireflies* and marine organisms such as jellyfish, emit cold light. Research the function of this so-called *bioluminescence* for these organisms.

Glühwürmchen

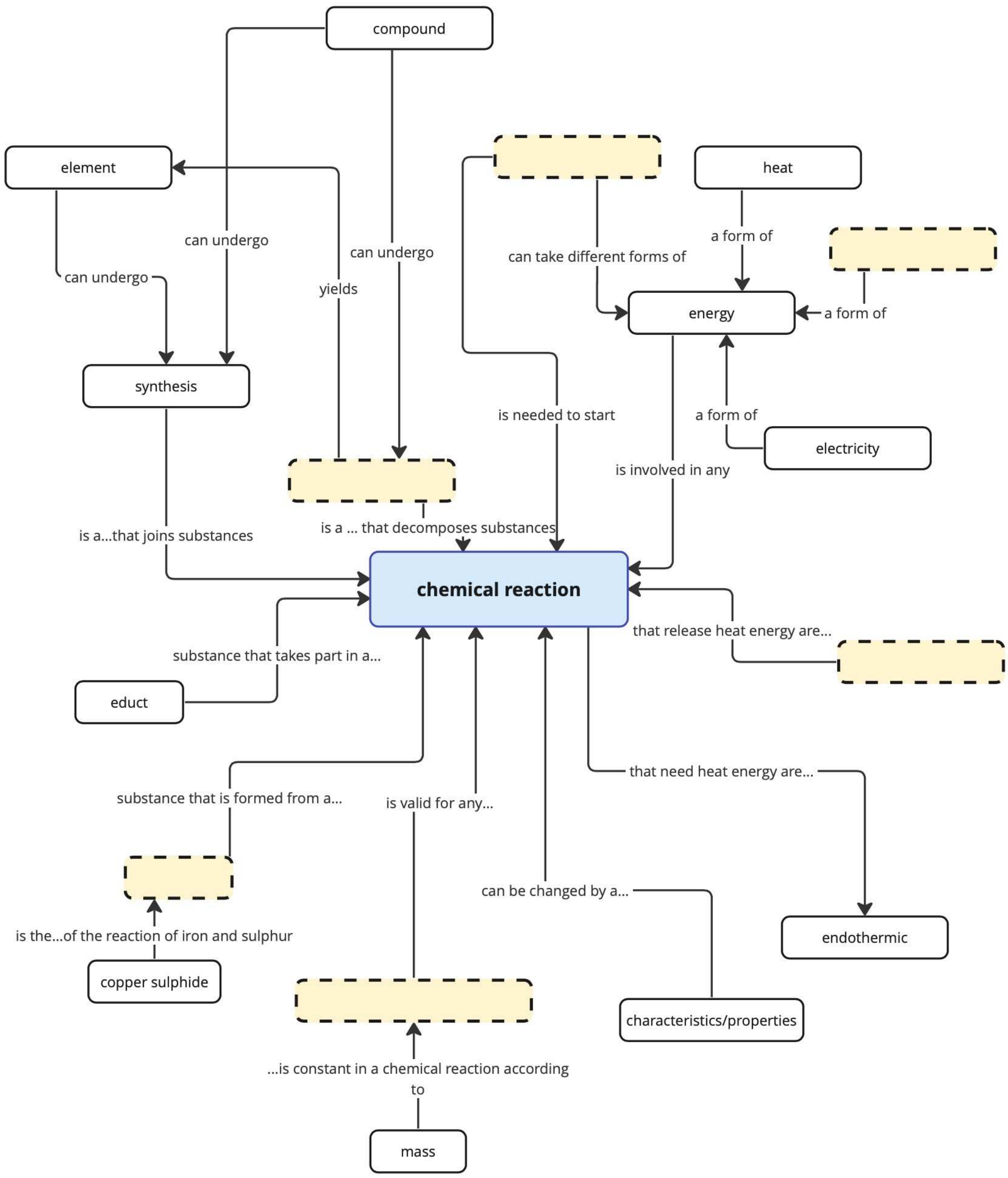
Biolumineszenz

Fig. 1: A firefly

3.2. Energy in Chemical Reactions

Concept Map: Chemical Reactions

Your Task:
Complete the Concept Map. Fill the empty boxes with words that fit the context.



3.2. Energy in Chemical Reactions

Glossary: Chemical Reactions

English	German	Example
chemical reaction	die chemische Reaktion	If substances change their properties, a chemical reaction takes place.
property	die Stoffeigenschaft	Iron has different chemical properties than rust.
chemical change	die chemische Veränderung	Baking a cake is a chemical change, because new substances are formed.
word equation /reaction scheme	die Wortgleichung / das Reaktionsschema	A word equation contains the reactants and the products of a reaction. It can also include the state of matter of the reactants and products. copper (s) + sulfur (s) ⟶ copper sulfide (s)
reaction arrow	der Reaktionspfeil	A reaction arrow is placed between reactants and products in a reaction scheme.
to react to form	reagieren zu	Copper and sulfur react to form copper sulfide.
reactant	der Ausgangsstoff/ das Edukt	Copper and sulfur are reactants.
product	das Produkt	Copper sulfide is the product.
element	das Element	Elements cannot be split into simpler substances.
compound	die Verbindung	Compounds can be formed from different elements.
arrangement of particles	die Anordnung der Teilchen	If you look at the arrangement of particles, you look at how particles in a substance are surrounded by other particles.
analysis	die Analyse	An analysis is a reaction in which a compound reacts to form the elements that it is made up of. Example: silver oxide reacts to form silver and oxygen.
synthesis	die Synthese	A synthesis is a reaction in which a compound is formed from elements. Example: silver and oxygen react to form silver oxide.
exothermic	exotherm	In an exothermic reaction, heat is given away from the reacting system.
endothermic	endotherm	In an endothermic reaction, heat is taken in by the reacting system.
activation energy	die Aktivierungs-energie	Activation energy is the amount of (heat) energy which is needed to start the reaction. It comes in different forms.

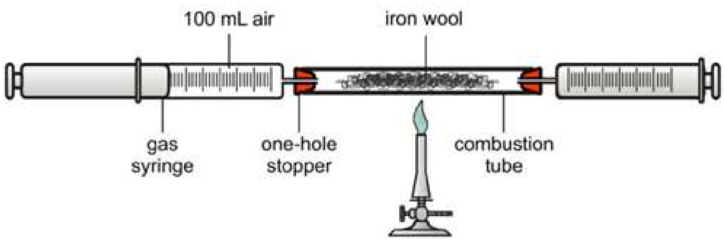
4.1. Air – A Gas Mixture?

Lab Activity: The Composition of Air

Materials: air, *degreased* iron wool, *combustion tube*, stands, clamps, clamp holders, 2 one-hole stoppers, 2 *gas syringes*, gas burner, lighter, glass cylinder, *wooden splint*

entfettet, Verbren-nungsrohr, Kolbenprober, Holzstab

Setup:



Procedure: Fill the combustion tube at least half-full with the iron wool. Fill one of the gas syringes with 100 mL air, the other one stays empty. Connect both gas syringes with the combustion tube and place the burner below the iron wool.

Keep heating the iron wool and move the air from one gas syringe to the other until the total gas volume does not change anymore.

Let the apparatus cool down. Watch the iron wool and note the volume of the gas inside the gas syringe.

Press the remaining gas into a glass cylinder and test the gas with a burning splint.

Observation: a) iron wool before and after heating:

____

____

____

b) gas volume:

before heating: V=_____ mL

after heating: V=_____ mL

c) burning splint:

____

____

____

4.1. Air – A Gas Mixture?

Hints for your conclusion:

1. Explain why we can say that the iron wool reacts to form a new product.

   ____

   ____

2. In the experiment, iron reacts with another substance. Name this substance and explain which observation has led you to this conclusion.

   ____

   ____

3. Write a word equation for the reaction in the combustion tube.

   ____

4. Explain the observation at the burning splint in the remaining gas.

   ____

   ____

5. With this experiment, you can find out how much oxygen there is in a given volume of air. Calculate the *percentage* of oxygen in air from the difference of gas volumes. Prozentsatz

   ____

   ____

   ____

6. Look at the setup of the experiment and explain why the result of the calculation from Question 5 does not lead to the exact percentage of oxygen in the portion of air in the apparatus.

   ____

   ____

7. It is *essential* to put enough iron wool into the combustion tube. Explain why we would get a wrong percentage of oxygen if we had put only very little iron wool into the combustion tube. äußerst wichtig

   ____

   ____

4.1. Air – A Gas Mixture?

Info: The composition of air

The *main components* of air Hauptbestandteil

Having spent long hours in classrooms, you might become slightly tired: It is *stuffy* and the air has become stale. Open the window and you will get fresh air again! stickig

The following situation in the lab is quite similar: Put a beaker upside down over a burning candle. The flame will go out soon. As you can see, candles need air to burn and human beings need air to breathe.

The *composition of air* Luftzusammen-setzung

If you burn iron wool with 100 mL of air in a tightly closed apparatus, there will remain a volume of 80 mL after the reaction has taken place. This means that the iron wool has reacted with only a part of the air. We can *deduce* that air consists of at least two different gaseous substances. One of them is responsible for the combustion of iron wool. It is the substance ***oxygen***. In the reaction, iron and oxygen form iron oxide, which is bluish black. folgern Sauerstoff

The reaction is finished as soon as the whole portion of oxygen has been used up. Since 20 mL of 100 mL of air were used in the experiment, we can deduce that there is approximately 20 % oxygen in the air.

If you insert a *glowing splint* in the remaining portion of gas from the apparatus, it will stop glowing. A burning splint will stop burning, too. The remaining gas *suffocates* the flame, which is why the *major constituent* of this gas is called 'Stickstoff' in German. There is no telling name for this substance in the English language. It is called **nitrogen**. With a *volume fraction* of 78 %, it is the largest component of air (Fig. 1.). However, the remaining gas is not pure nitrogen but a **homogeneous mixture** of different gases such as argon or *carbon dioxide*, whose volume fractions are less than 1 %. Glimmspan ersticken Hauptbestandteil Volumenanteil Kohlenstoffdioxid

component	volume share %
nitrogen	78.08
oxygen	20.95
argon	0.93
carbon dioxide	0.04
neon	0.0018
helium	0.0005
methane	0.00016
krypton	0.00011
hydrogen	0.00005
nitrous oxide	0.00003
carbon monoxide	0.00002
xenon	0.000009

Fig. 1: Air – a homogeneous mixture

4.1. Air – A Gas Mixture?

Nitrogen

Nitrogen is odourless and colourless. At a temperature of 0 °C, it has a density of 1.25 g/L and at a temperature of -196 °C it condenses into a colourless liquid (Fig. 2). Nitrogen is ***inert***, that is, it hardly reacts with other substances. As a consequence, it is *not flammable* and burning flames are suffocated by it. However, this is also the case with other gases therefore you need further tests to *rule* them *out*.

Fig. 2: Liquid nitrogen

reaktionsträge/inert

nicht brennbar

ausschließen

Oxygen

Only approximately one-fifth (21%) of the air consists of the *vitally important* gas **oxygen**. It is colourless, odourless and non-toxic. Its density is 1.43 g/L at a temperature of 0 °C. At -183 °C it condenses into a blue liquid.

lebensnotwendig

Both human beings and animals need oxygen to breathe. It is necessary for ***combustion reactions*** and it forms **oxides** with many other substances. If you want to test a gas portion for oxygen, you must carry out a **glowing splint test**: Insert the glowing splint into the gas. If there is oxygen, it begins to glow brightly or even catches fire.

Verbrennungs-reaktionen

Carbon dioxide

Regular air consists of approximately 0.04% **carbon dioxide**, whose density is 1.98 g/L at a temperature of 0 °C. If you want to test a gas portion for carbon dioxide, you must perform a ***lime water test***: The gas in question is introduced into lime water. A white *precipitate* is formed immediately in the presence of carbon dioxide.

Kalkwasserprobe

Niederschlag

Carbon dioxide can become harmful to human beings and animals if its concentration in air is higher than a volume fraction of 8%. If this is the case, human beings will *faint*. Plants, however, need carbon dioxide in order to perform photosynthesis.

bewusstlos werden

4.1. Air – A Gas Mixture?

Noble gases Edelgase

Almost one percent of the air are **noble gases**. All noble gases are colourless and odourless. Due to the fact that they are **inert**, there are only very few stable compounds formed by noble gases. This is the reason why scientists have discovered them rather late in comparison with other elements. The term **rare gases** is synonymous with noble gases.

Even though noble gases are *rare*, they are important for everyday life. Since they are inert, they are used as shields for delicate food or delicate processes. For example, **argon** helps as a *shielding gas* around the hot metal in a *weld* and in containers for wine storage. Airships are filled with **helium** because it is safer than hydrogen and still *provides lift* as it is much less dense than air. Doctors operating on eyes use lasers based on **krypton.** There are also the many brightly coloured lights in cities which function on the basis of noble gases, e.g. **neon** is responsible for the colour red.

selten

Schutzgas

Schweißnaht,

Auftrieb verleihen

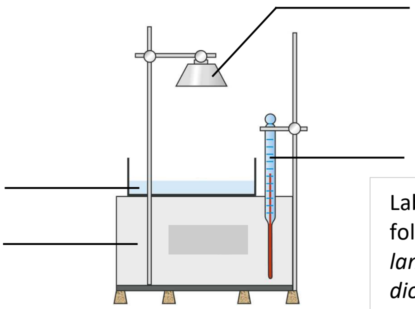
Your tasks:

1. Only four noble gases are mentioned in the text. Write down the remaining ones. Use the periodic table of elements (PSE).
2. Create information posters for the following gases based on the information from this unit: nitrogen, oxygen, carbon dioxide.
3. Draw a series of sketches showing how to carry out a) a glowing splint test and b) a lime water test. Label your sketches with both English and German terms.

4.1. Air – A Gas Mixture?

Lab Activity: The Greenhouse Effect

Sketch:



Label the lines with the following words:
lamp, water, air or carbon dioxide, thermometer

Materials:
stand, clamp holders, clamps, *glass trough*, Glaswanne
thermometer, large petri dish, lamp, water, carbon dioxide, black *card board* Pappe

Procedure:

1. Set up the experiment according to the sketch.
2. Place a piece of black cardboard at the bottom of the glass trough.
3. First, there is air in the glass trough. Measure its temperature. Turn on the lamp and measure the temperature at intervals of 30 s.
4. Fill the glass trough with carbon dioxide and repeat the procedure described in step **3**.

Observation:

1. gas in the glass trough (Step 3): __________________

temperature before turning on the lamp: _____

[s]	30	60	90	120	150	180	210	240	270	300	330	360
[°C]												

2. gas in the glass trough (Step 4): __________________

temperature before turning on the lamp: _____

[s]	30	60	90	120	150	180	210	240	270	300	330	360
[°C]												

3. Make a diagram showing the results of your measurements. Label the axes and find a suitable title. Describe the change in temperature when there is either air or pure carbon dioxide in the glass trough.

Hints for your conclusion:

1. Explain which property of the compound carbon dioxide is shown by this experiment.
2. This experiment is a **model experiment** which **simulates** the greenhouse effect. Try to explain which parts of the experiment stand for:

   land - clouds - sun

3. Imagine someone placed a piece of aluminium foil instead of black cardboard in the glass trough. Make an assumption on the effect this would have.

4.1. Air – A Gas Mixture?

Info: The Greenhouse Effect

The ***natural greenhouse effect*** warms the earth and keeps animals, plants, and human beings from freezing to death. This effect is similar to the one in greenhouses (Fig. 1.) Why does planet earth stay warm – and why is it getting ever warmer? What are greenhouse gases? And what is the role of *humankind*?

natürlicher Treibhauseffekt

Menschheit

Fig. 1: A greenhouse

Greenhouse effect *in a nutshell*

mit wenigen Worten

Let us start with greenhouses in gardens. It is warmer inside a greenhouse than outside. Greenhouses are made of transparent glass walls and glass roofs therefore the *radiation* of the sun, which brings light and heat, can enter easily. Plants and the ground *absorb* the radiation energy. As a consequence, everything inside the greenhouse heats up. Since a greenhouse is closed, the warm air is *trapped* inside.

Strahlung

absorbieren

gefangen

Another process taking place is the **conversion of light energy into heat energy**. A part of the light that touches the ground is converted into heat which is then reflected. Since the heat energy stays inside, the greenhouse is getting warmer and warmer inside. Before it can get too hot inside, the gardeners open the door to cool it down allowing the hot air to leave the building. Alternatively, you can simply leave the greenhouse and enjoy being outside.

Life on earth made possible by solar radiation

The extremely hot sun ***emits* radiation** in all directions. A part of the solar radiation travels towards the earth. It is absorbed by the atmosphere and by the earth's surface. This helps to heat up the earth, making life possible. A part of the radiation is ***reflected***. This way, a part of the solar energy is radiated back into space. On the one hand, it is important for life on earth that some part of the radiation is absorbed so that the earth is warm enough for our ecosystem. On the other hand, it is equally important that a part of the radiation is reflected because it should not become too hot.

emittieren

reflektiert

Fig. 2: A fragile shell of gas around the planet

4.1. Air – A Gas Mixture?

The atmosphere: the *director* of heat and cold

Regisseur/Diri-gent

The atmosphere (Fig. 2) of the earth is responsible for the perfect amount of heat on earth. If there was no atmosphere, all of the sun's solar energy would leave back into space and the temperature on earth would be as cold as -18 °C! The earth's atmosphere contains some substances, so-called ***greenhouse gases***, which keep radiation from leaving planet earth. Carbon dioxide, *water vapour* and methane are important greenhouse gases. They absorb the reflected radiation and keep the heat in the atmosphere. This is called the **natural greenhouse effect**. The greenhouse effect is a perfectly normal thing and is responsible for life on earth as we know it. However, the problem is that the higher the concentration of greenhouse gases, the more heat that can be absorbed by these gases and the hotter the planet becomes.

Treibhausgas

Wasserdampf

The *anthropogenic* greenhouse effect: a man-made problem

anthropogener

Since the Industrial Revolution in the 19th century, mankind has started burning large amounts of **fossil fuels**. Coal has been burned to *fuel* industrial plants and power plants. Most cars are fueled by petrol, planes need kerosene, and natural gas is burned for heating purposes. Today, it is an accepted fact that **global warming** is mainly caused by the increasing concentrations of greenhouse gases brought into the atmosphere by human beings. It is our task to work on solutions to reduce these emissions.

betreiben

Your tasks:

1. Describe Fig. 3 and explain it using the information from the text. Make guesses what the letters and arrows might represent or indicate.
2. Conduct research on the structure and composition of the earth's atmosphere.
3. Conduct research on the origin of the following gases which are produced as a result of human activity: carbon dioxide, methane, nitrous oxide, f-gases.
4. Make a list of ideas of what can be done to reduce the anthropogenic greenhouse effect:
   a) What can you do yourself?
   b) What do you expect from politicians and business people?

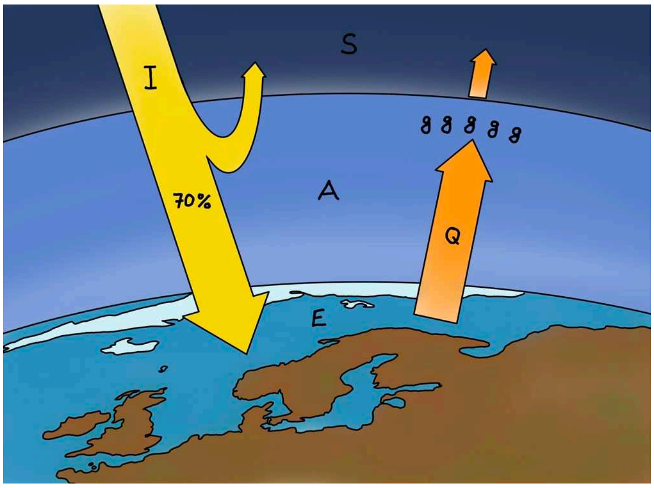


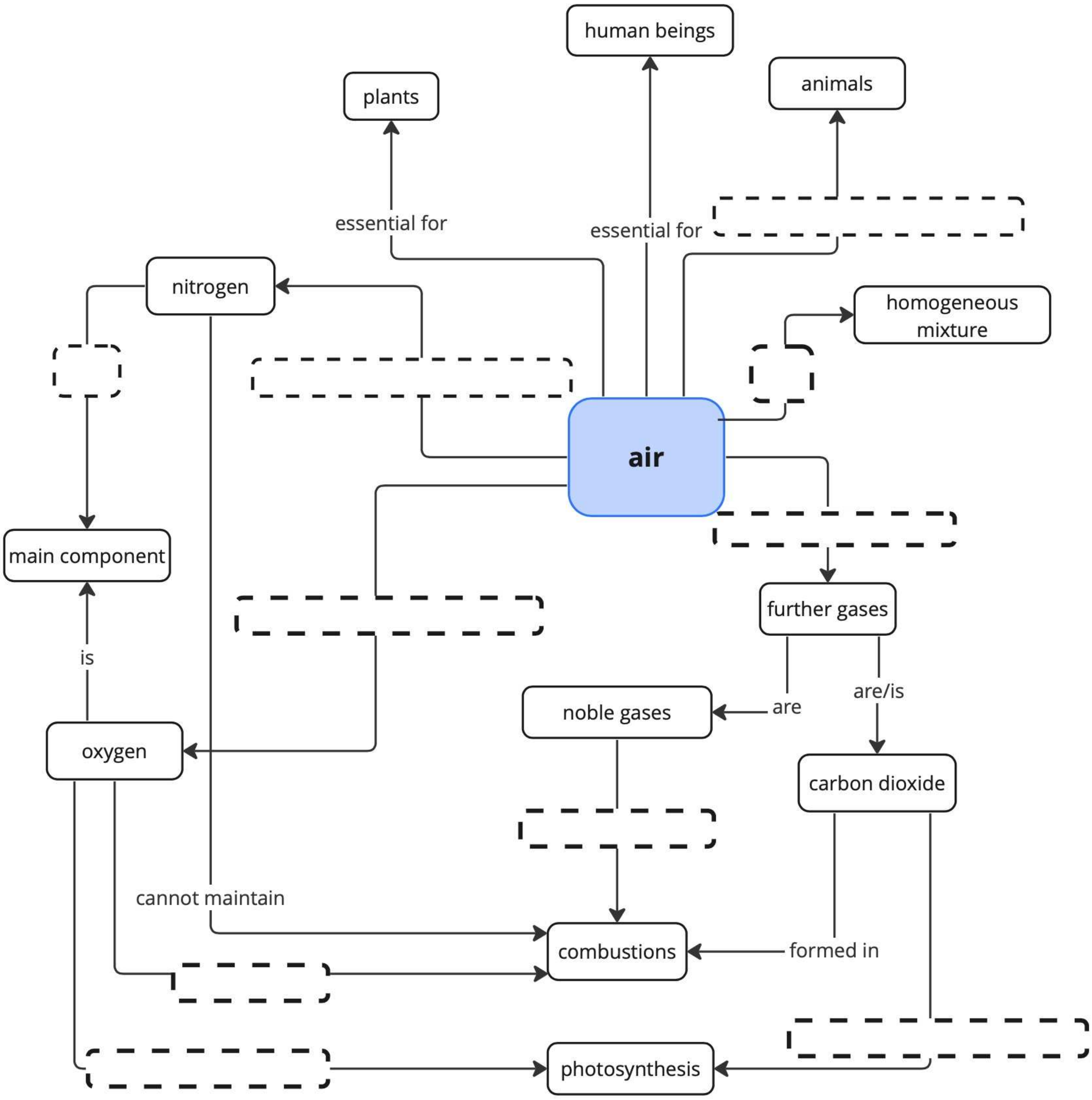
Fig. 3: The natural greenhouse effect.

4.1. Air – A Gas Mixture?

Concept Map: Air – A Homogeneous Mixture

Your tasks:

Using the info text, complete the given Concept Map with the following ten relations: *contains less than 1% of; contains approximately 21% of; contains approximately 78% of; essential for; generated in; is (2x); maintains; cannot maintain; necessary for*



4.1. Air – A Gas Mixture?

Glossary: Air – A Homogeneous Mixture

English	German	Example
(to) absorb sth.	etw. absorbieren	Greenhouse gases absorb radiation.
atmospheric oxygen	der Luftsauerstoff	You can buy oxygen in gas cylinders but there is a lot of oxygen already in the air – it is called atmospheric oxygen.
carbon dioxide	das Kohlenstoffdioxid	When human beings breathe out, it is a gas mixture which is enriched with carbon dioxide.
combustion	die Verbrennung; die Verbrennungsreaktion	The process of burning something is called combustion. There are also combustion engines that burn fuel.
(to) emit	emittieren	The sun emits radiation.
glowing splint test	die Glimmspanprobe	This is a test to identify oxygen.
greenhouse effect	der Treibhauseffekt	The greenhouse effect is responsible for a warm earth. It is vital for the existence of human beings.
greenhouse gas	das Treibhausgas	Carbon dioxide is a greenhouse gas.
homogeneous mixture	das homogene Stoffgemisch	Air consists of different pure gases which make up a homogeneous mixture.
lift	der Auftrieb	The noble gas helium provides lift in airships.
lime water test	die Kalkwasserprobe	You can identify carbon dioxide gas with the lime water test.
nitrogen	der Stickstoff	Air contains 78% of nitrogen. It is its main component.
noble gases	das Edelgas	The term rare gases is synonymous with noble gases.
oxide	das Oxid	Oxides are products of combustions. For example, oxygen reacts with iron to form iron oxide.
oxygen; see also: atmospheric oxygen	der Sauerstoff	Human beings need oxygen to breathe. There is 21% of oxygen in the air.
reactivity	die Reaktivität; die Reaktionsfähigkeit	Oxygen has a high reactivity, whereas noble gases have a very low reactivity.
(to) reflect sth.	etw. reflektieren	The earth reflects a part of the solar radiation.
shielding gas	das Schutzgas	Food is packed in containers which are filled with shielding gas. It is protected because it cannot react with atmospheric oxygen.

4.2. Burnt Does Not Mean "Gone"

Lab Activity: Oxidation

Materials: *high-melting* test-tube, gas burner, lighter, tongs, iron wool

schwer schmelz-bar

Setup:

E1)

E2)

Procedure: Before you start, divide the iron wool into three portions of equal amounts. Put one portion aside. You will need it to compare it with the other portions after the experiments.

E1) Take one portion of the iron wool, pull it apart and form a fuzzy ball. Take tongs and hold one end of the iron wool into the flame of the burner. Compare the iron wool before and after burning.

E2) Put another portion of the iron wool into a high-melting test-tube and heat it up strongly. Take out the iron wool and examine its surface after the experiment.

Observation: Iron wool before burning or heating:_______________________________________

____

E1) During burning:____

____

Iron wool after burning:____

____

E2) During heating: ____

____

Iron wool after heating:____

____

4.2. Burnt Does Not Mean "Gone"

Hints for your conclusion:

1. Compare the outer appearance of the iron wool before and after burning. Give reasons as to why a new substance must have formed in E1.
2. Compare the products from **E1)** and **E2)** and decide if it is the same substance. Name the differences and similarities of the procedures from **E1)** and **E2)**.
3. Evaluate the following statement: "In **E1),** the iron wool reacts with the flame of the burner".
4. If you carried out **E2)** in a test-tube with no air inside, the iron wool would not change at all. With this information try to name the *reactants* in **E1)** and **E2)**. Edukte
5. If a substance reacts with oxygen and forms a compound with oxygen, we call this reaction an **oxidation**. The product is called an **oxide**. If copper reacts with oxygen, it will form copper oxide. Name the product in **E1)** and **E2)**.
6. Try to write a *word equation* for the reactions in **E1)** and **E2)**. Wortgleichung

4.2. Burnt Does Not Mean "Gone"

Info: Combustions Are Everywhere

Oxide formation during *combustions*
If you burn fuels like wood, wax, *natural gas* or petrol, they react with oxygen to form carbon dioxide and other products. Even metals can burn and form metal oxides. When iron wool is burnt, there is an exothermic reaction with oxygen. During this process, the magnetic, flexible iron wool turns from a *shiny* greyish silver to a *bluish* black substance. Furthermore, the new product, which is called *iron oxide,* is not magnetic anymore and it has become *brittle*: It breaks as soon as you try to fold it.

Verbrennungsvorgänge; Erdgas
glänzend; bläulich
Eisenoxid
brüchig

iron (s) + oxygen (g) $\longrightarrow$ iron oxide (s) | exothermic

The products of chemical reactions with oxygen are called ***oxides***. They are formed in each combustion. The technical term for such a reaction is ***oxidation***. You can *prove* that oxygen is necessary for this reaction if you heat iron wool in an *evacuated* test-tube. With no air inside, the iron wool will remain shiny and greyish silver. If you want to prove that the iron wool does not react with the burner flame itself, but that oxygen is one of the reactants, heat up some iron wool in a test-tube so that the flame does not touch the wool. You will see that bluish black iron oxide is formed, too.

Oxide
Oxidation; beweisen
evakuiert

Combustions are exothermic chemical reactions between a *fuel* and oxygen. The energy is released as light and heat (*thermal energy)*. The products of combustions are oxides.

Brennstoff
thermische Energie

Your tasks:

1. These three photos show substances from the chemical reaction described by the word equation above. First, find the correct term (oxygen, iron oxide or iron) for each picture and write it down. Second, write down the term reactant or product.


+

→


______________________ ______________________ ______________________
______________________ ______________________ ______________________

4.2. Burnt Does Not Mean "Gone"

2. Write down the word equation for the reaction of *zinc* and oxygen. Zink

____

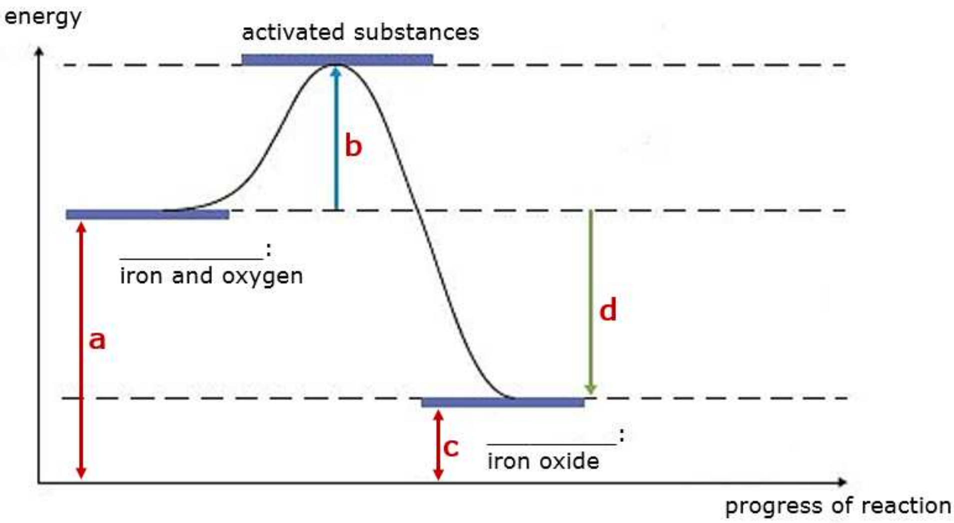


Fig. 1 Energy scheme for the formation of iron oxide

3. In Fig. 1, there is the energy diagram for the exothermic reaction of the formation of iron oxide: Add the words reactants and product to the diagram. Then answer these questions:

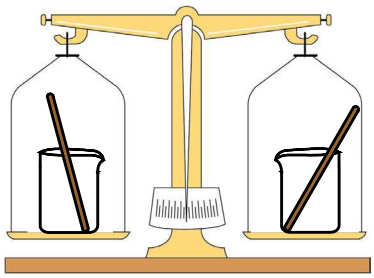
- Which letter **a-d** *represents* the *amount of* chemical energy of the reactants? darstellen, Menge an
- Which letter **a-d** represents the amount of chemical energy of the product?
- Which letter **a-d** *indicates* the amount of activation energy? anzeigen
- Which letter **a-d** indicates the amount of reaction energy in this reaction?

4.2. Burnt Does Not Mean “Gone”

Lab Activity: The Conservation of Mass

E1) Burning Wood

Sketch:



Materials:
beam balance, two beakers with a piece of wood, pocket lighter or matches

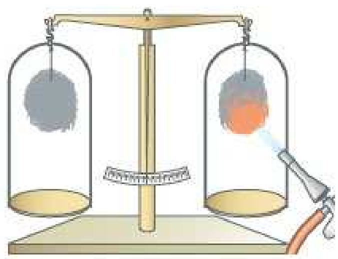
Balkenwaage

Procedure: Take two pieces of wood with identical masses and place them inside the beakers. Put each of the beakers on each side of the balance. Burn one of the wood pieces without taking it out of the beaker.

Observation:

E2) Burning Iron Wool

Sketch:



Materials:
beam balance, iron wool, pocket lighter

Procedure: Take two pieces of iron wool with identical masses and put each one on each side of the balance. Light one of the portions of iron wool without removing it from the balance.

Observation:

4.2. Burnt Does Not Mean “Gone”

Hints for your conclusion:

1. Write down the word equations for **E1)** and **E2)**. Add the state symbols. Hint: Assume that wood mainly consists of carbon.
2. Compare the observations in **E1)** and **E2)** and compare the word equations. Explain the results of your comparison.

E3) Burning Matches in a Closed Test-tube

Sketch:

Materials:

five matches, *high-melting* test-tube, balloon, digital *scale*, burner

schwer schmelzbar; Waage

Procedure: Put the matches *head first* in the test-tube. Close it with the balloon and weigh it. Write down the mass.
Now heat the test-tube until the matches inside it catch fire.
Weigh the closed test-tube after it has cooled down.

kopfüber

Observation:

Hints for your conclusion :

1. Compare the test-tube and its contents before and after heating.
2. Compare the mass of the test-tube before and after heating.
3. Compare **E1)** and **E3)** considering the set-up.
4. Explain the different observations made in **E1)** and **E3)**.

4.2. Burnt Does Not Mean "Gone"

Info: The Law of Conservation of Mass, or: "Nothing Is Ever Lost"

When a wax candle is burnt on a scale, it loses weight because the produced oxides are gaseous, spread in the air and cannot be weighed. The same holds true if charcoal is burnt during a barbecue. Therefore, we have to change the experimental set-up to catch all of the products during combustions.

Combustions of matches in a closed test-tube

If we close the apparatus, neither reactant nor product can leave. This procedure ensures that we can weigh all substances that take part in a chemical reaction. This is called a combustion in a ***closed system***. geschlossenes System

Fig. 1: The conservation of mass in an experiment

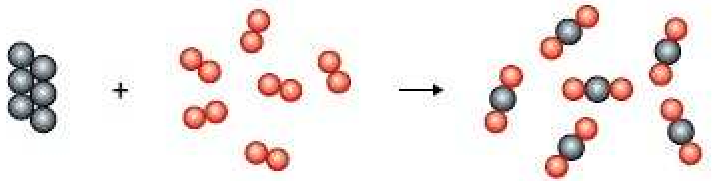
If you burn matches in a test-tube that is closed with a balloon, the mass will be the same before and after the reaction because in this setup all masses can be measured (Fig. 1). The sum of all reactant masses equals the sum of all product masses. This is the ***law of conservation of mass***. Thus, mass can never be created or destroyed. Gesetz der Erhaltung der Masse

During chemical reactions, there is no change in mass. The total mass of reactants and products does not change.

The combustion of carbon using John Dalton's *atomic model* Atommodell

In the diagram below the word equation, there are six carbon atoms in a neatly ordered *cluster* (depicted in **black**) and there are always two oxygen atoms bonded together (depicted in **red**). These react to form carbon dioxide particles, in whose centre you find the carbon atom which is bonded to two oxygen atoms. Teilchenverband

carbon (s) + oxygen (g) ⟶ carbon dioxide (g) | exothermic



Your tasks:

1. Count the atoms on both sides of the reaction arrow and prove that the number of atoms has not changed.
2. Draw the atoms in the test-tube before heating and after heating. (Help: *Assume* that wood only consists of carbon atoms. This will simplify this task.) nimm an

4.2. Burnt Does Not Mean "Gone"

The combustion of iron using Dalton's atomic model

If you now burn iron wool as shown in Fig. 2, the iron wool on the right becomes heavier. Contrary to the combustion before, the product here is a solid. Solid iron reacts with gaseous oxygen from the air to form solid iron oxide.

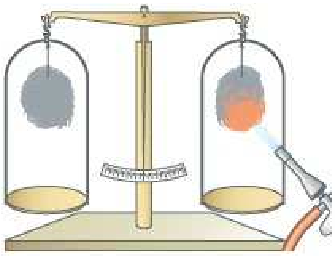
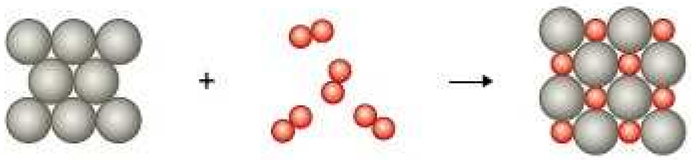


Fig. 2: A fuzzy iron ball is ignited

In this case, the reaction takes place in an ***open system***. In order to prove that the law of conservation of mass is valid, you must close the system: Put a tightly closed test-tube with iron and air on a digital scale. Now you have a closed system. If you heat the test-tube, you can again prove that there is no change in masses during a chemical reaction. offenes System

The chemical reaction can again be written down in a word equation and visualized with Dalton's atomic model in a diagram below the word equation:

iron (s) + oxygen (g) ⟶ iron oxide (s) | exothermic



Iron atoms (depicted in grey), which are in a neatly ordered cluster, react with oxygen particles (depicted in **red**) to form a neatly ordered cluster of iron atoms and oxygen atoms – iron oxide. If you count the atoms on either side of the reaction arrow, you will see that there is no change in number. Thus, the atoms have only been *reordered* and mass has been conserved. This proves the law of the conservation of mass. umsortiert

Your tasks:

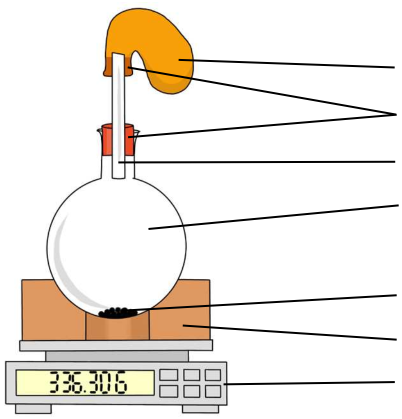
1. Explain why we can deduce that mass has been conserved if we count numbers of atoms in reactants and products.
2. What would the scales display, if the balloon in **E3)** *burst* during the reaction? Give reasons for your answer. platzen

4.2. Burnt Does Not Mean "Gone"

Lab Activity: Boyle's Experiment (to be carried out by the teacher)

Materials: gas burner, oxygen and materials shown in the sketch below

Sketch:



Procedure: First, 0.2g of activated carbon are put in a round-bottomed flask. Afterwards, a balloon, which has been inflated before the experiment a couple of times in order to stretch it, is attached to the glass tube which is stuck in the stopper. If the balloon cannot be attached to the glass tube, the end of the glass tube can be inserted in a small stopper with a hole and the inflated balloon is *fastened* onto it. Finally, the flask is filled with oxygen and closed immediately with the stopper. (befestigen)
Now the weight of the closed and filled flask is measured. The flask is heated with a burner until the activated carbon starts glowing. Doing so, the flask is carefully shaken so that the carbon is moving in the oxygen atmosphere until the glowing vanishes. (It is *advisable* to conduct the experiment in a darkened room.) (empfehlens-wert)

Observation: mass before heating: ________ g

mass after heating: ________ g

Make notes using the following expressions:

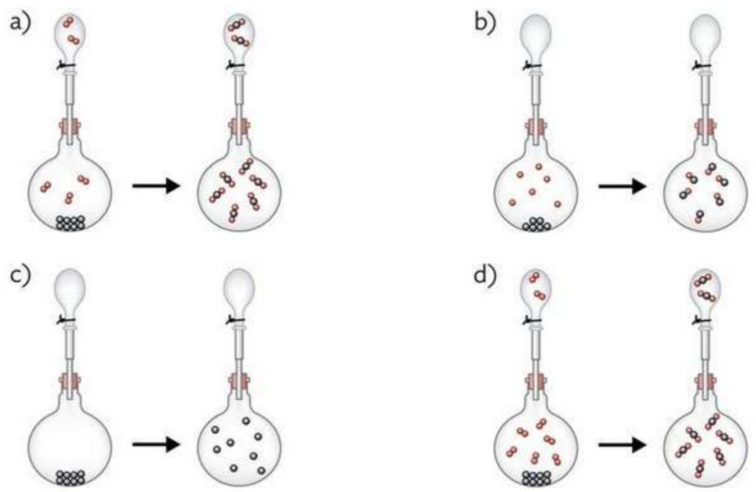
- Inside the round-bottomed flask ...
- After some time, the activated carbon starts ...
- ... inside the round-bottomed flask ... At the end ...

4.2. Burnt Does Not Mean "Gone"

Hints for your conclusion:

1. Explain the observations in the flask. Consider the chemical reaction that takes place and the result from weighing the apparatus before and after.
2. Understanding Boyle's experiment: All of the following tasks refer to the four *diagrams* a) – d).

Schaubilder



2.1: Which of these diagrams represents Boyle's experiment correctly?
2.2: Which of the diagrams does not show a chemical reaction?
2.3: Which of the diagrams show(s) the correct type of reactants and products?

ankreuzen

2.4: *Tick off* the correct statement(s) about Boyle's experiment:

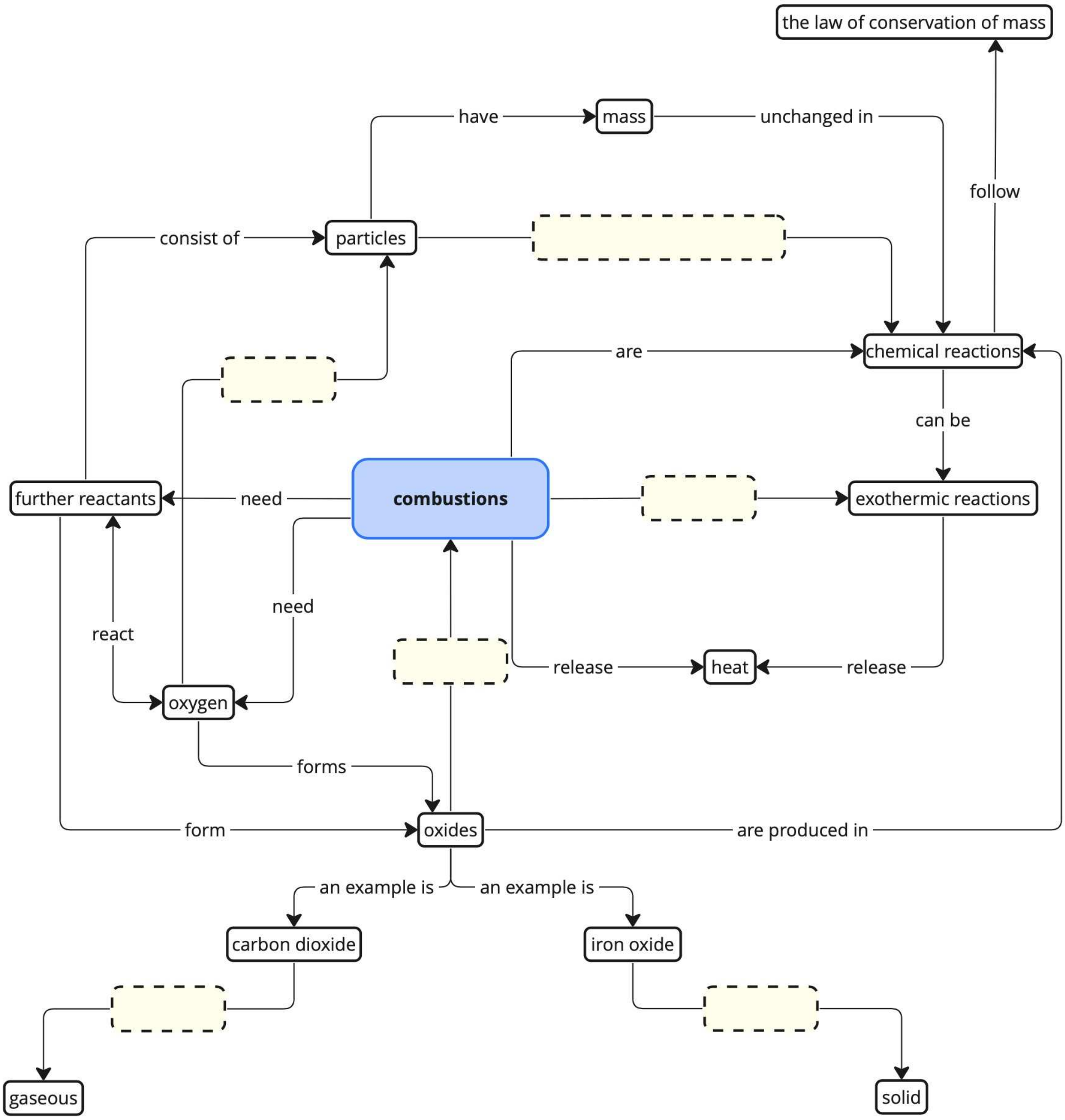
A) The flask is empty after the chemical reaction. ☐
B) The reaction is exothermic. ☐
C) The reaction is endothermic. ☐
D) The mass of the flask remains unchanged. ☐
E) The number of carbon atoms changes. ☐

4.2. Burnt Does Not Mean "Gone"

Concept Map: Combustions

Your task:

Using the info text "The Law of Conservation of Mass", complete the given Concept Map.



4.2. Burnt Does Not Mean "Gone"

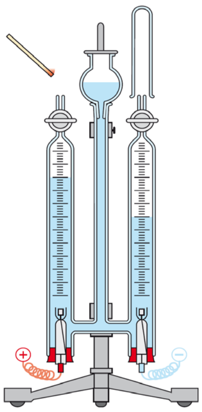
Glossary: Combustions

English	German	Example
carbon dioxide	das Kohlenstoffdioxid	Gaseous carbon dioxide is formed when charcoal reacts with oxygen.
carbon	der Kohlenstoff	Carbon is a chemical element (element symbol: C) and charcoal is made of it.
closed system	das geschlossene System	A test-tube sealed with a stopper is a closed system. No substance can leave the test-tube.
combustion	die Verbrennung	Combustions are exothermic chemical reactions between a fuel and oxygen.
exothermic reaction	die exotherme Reaktion	Energy is released as heat during exothermic reactions. The opposite of an exothermic reaction is an endothermic reaction.
iron oxide	das Eisenoxid	Solid iron oxide is formed when iron reacts with oxygen.
law of conservation of mass	das Gesetz der Erhaltung der Masse	The law of conservation of mass means that the total mass of reactants and products does not change in a chemical reaction.
open system	das offene System	A test-tube that is not sealed with a stopper is an open system because substances can enter and leave the test-tube.
oxide	das Oxid	Oxides are formed during combustions.

4.3. Water – An Element?

Lab Activity: Analysis of Water – Hofmann Apparatus

Sketch:



Connect the following words with the correct part of the apparatus:
glowing splint
diluted sulfuric acid
negative pole
positive pole
test-tube
platinum electrode
stand
cable

Materials:

Hofmann apparatus, funnel, power source, 2 cables, water, diluted *sulfuric acid*, test-tube, wooden splint, lighter

Hofmannscher Zersetzungs-apparat
Schwefelsäure

Procedure:

1. Add some diluted sulfuric acid to water (this *increases* the *conductivity*) and fill the solution into the Hofmann apparatus. Connect the apparatus with the power source. Start the *electrolysis* at U = 6 V. Note the volumes of the gases in the glass tubes every minute.
2. After 10 minutes open the *stopcocks* and test the gases with a glowing splint at the positive pole and with the detonating gas test at the negative pole.

vergrößern
Leitfähigkeit
Elektrolyse
Absperrhähne

Observation:

Time [min]		1	2	3	4	5	6	…	
Volume of gas [mL] formed at the …	Positive pole								
	Negative pole								

colour of the gases: ____

glowing splint: ____

detonating gas test: ____

Hints for your conclusion:

1. Name the gases that are produced and explain the tests.

____

____

____

____

____

4.3. Water – An Element?

2. If we *apply a voltage*, the ***analysis*** of water into the elements takes place. Write a word equation.

eine Spannung anlegen, Analyse

____

3. Decide if the analysis is exothermic or endothermic and give reasons for your decision.

____

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____

4. Find the *ratio* in which the gases are produced from water and relate this to the chemical formula H_2O. Explain what the number in the formula might mean.

Verhältnis

____

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4.3. Water – An Element?

Info: Water – Element or Chemical Compound?

We would not be here without water since life on earth actually originates from it. For us, it is one of the most important substances on earth. The colourless and transparent liquid is ever-present. Greek philosophers made a list of the four elements: water, air, earth, and fire. Do scientists today consider water an element?

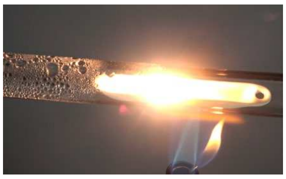


Fig. 1: magnesium burns in water vapour

Flames under water - a paradox?!

Water is used to put out fire. However, you should never try to *extinguish* burning metals such as magnesium with water! It is both surprising and fascinating that magnesium continues burning in water. Accordingly, it also burns in water vapour (Fig 1). We know that fires need oxygen to burn. However, if magnesium is surrounded by liquid or gaseous water, there is no direct contact between elemental oxygen and magnesium. Where does magnesium get oxygen from?

löschen

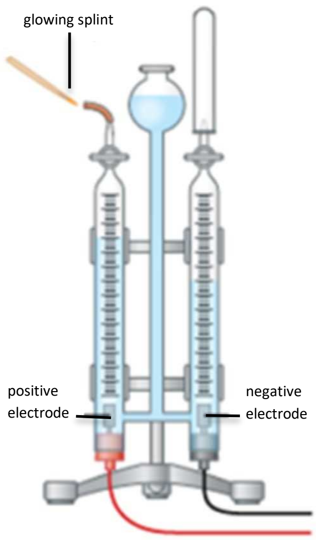
There are metals like magnesium which can react with either elemental oxygen or compounds that contain *chemically bonded* oxygen. Due to the fact that magnesium continues burning in water, we can *conclude* that water contains chemically bonded oxygen. Can we support this with another experiment?

chemisch gebunden, folgern/schließen

Water analysis

One way to find out whether water is a compound is to *run electricity through* it. If you *electrolyse* water in a *Hofmann apparatus* (Fig. 2), you will observe that different volumes of colourless gases are collected in the glass cylinders after a while. At the negatively charged electrode, there is twice as much gas than at the other electrode. We can deduce that these are two different gases.

Strom durchleiten
elektrolysieren,
Hofmannscher Zersetzungsapparat



Using simple tests, we can identify the gases and prove that they are different from each other. A glowing splint lights up (or glows more brightly) when brought into contact with the gas from the positive electrode. The so-called **glowing splint test** is the test for **oxygen**.

The gas collected at the negatively charged electrode burns with a faint 'pop' – or a squeaky pop sound.

4.3. Water – An Element?

This so-called **detonating gas test** is the test for **hydrogen**. As no further substances have formed, we have proved that water can be split up by electrolysis into hydrogen and oxygen.

water (l) ⟶ hydrogen (g) + oxygen (g) | endothermic

As the gases are formed in a *volume ratio* of 2:1, we can assume that this ratio has something to do with the chemical formula of water: H_2O. In one water molecule, there are two hydrogen atoms and one oxygen atom chemically bonded to each other. Thus, water is a compound and not an element.

Volumenverhältnis

Your tasks:

1. Two litres of hydrogen gas and two litres of oxygen gas react with one another. There is one litre of a colourless gas left. Explain which substance it is.

____

____

____

____

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____

2. Evaluate if the following statement is correct: "Water consists of hydrogen and oxygen." Use proper *scientific terms* for your judgement.

Fachbegriffe

____

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4.3. Water – An Element?

Info: Analysis and Synthesis of Water

Self-made water

As shown above, water can be split up into oxygen and hydrogen by electrolysis. *Conversely*, water can be synthesized from these two elements. Simply burn the flammable gas, hydrogen, in air and collect the product in a cold beaker. The combustion product will then condense into a colourless, transparent liquid. This liquid turns Watesmo paper blue. Alternatively, you can use **white copper sulfate**, which also turns blue (Fig. 2). This **test for water** proves that water has formed from the combustion of hydrogen. Hydrogen and oxygen from the air form water in this exothermic reaction.

im umgekehrten Fall

$$\text{hydrogen (g) + oxygen (g)} \longrightarrow \text{water (l)} \qquad | \text{ exothermic}$$

The ***synthesis*** (*formation*) of water is the reverse reaction of water ***analysis*** (*decomposition*).

Synthese (Bildung), Analyse (Zerlegung)

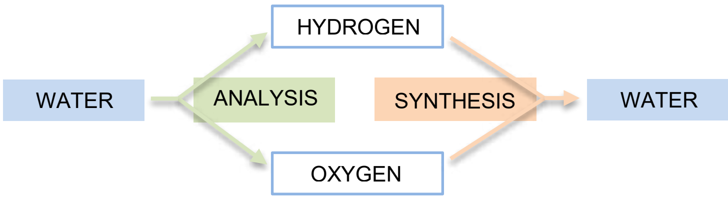


Fig. 1: Water can be chemically split into the elements oxygen and hydrogen (analysis).
The elements, oxygen and hydrogen, react to form water (synthesis).

Due to the fact that water is a compound of chemically bonded oxygen and hydrogen, an alternative name would be *hydrogen oxide*. However, scientists have agreed on using the term water instead.

Wasserstoffoxid

Detonating gas test – a synthesis?

When you carry out a detonating gas test and have a close look at the inside of a test-tube that you have used for the test, you will see tiny drops of a colourless and transparent liquid. They have formed during the test. These are drops of water, which you would again test with Watesmo paper or white copper sulfate.

Fig. 2: White copper sulfate as a detecting agent for water.

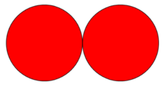
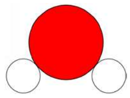
You can even feel the energy released during water synthesis: Touch the test-tube and it is slightly warm. A particularly vigorous reaction takes place if the *ratio* of the gaseous reactants is two to one. Accordingly, the reaction between hydrogen and oxygen can be used to provide energy, e.g. in *fuel cell cars*.

Verhältnis
Brennstoffzellenfahrzeuge

4.3. Water – An Element?

Your tasks:

1. Sketch the analysis and synthesis of water on the particle level.

Help:
hydrogen molecule  oxygen molecule  water molecule 

2. Water is an oxide. Explain this statement.

3. Instead of 'detonating gas test' you can also find the term 'oxyhydrogen test'. List advantages and disadvantages of this term in comparison to the first one.

Reagenzien

4. Copy Fig. 1 and add the names for the detecting methods and *agents*.

5. Write down what you understand by the terms analysis and synthesis. Then look up the meaning of the words and its *linguistic origin* in an *etymological dictionary* and check your first ideas.

sprachliche Herkunft, Herkunftswörterbuch

4.3. Water – An Element?

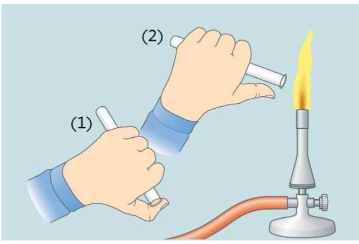
Info: Hydrogen

Profile

Qualities: colourless, odourless gas
Density at 20 °C: 0.000084 g/cm³
Melting temperature: 259.3 °C
Boiling temperature: -252.6 °C

Flammable and easily ignitable, does not maintain the burning process, forms an explosive mixture with oxygen or air: detonating gas

Occurrence: in space as element, on earth only in compounds
Production: in labs from zinc and hydrochloric acid, in industrial dimensions from natural gas and water
Usage: chemical industry, fuel, energy source
Test: detonating gas test (oxyhydrogen test)



The gas hydrogen has the lowest density of all substances. In the past, people used this gas to fill balloons and *airships* because of its huge *lifting capacity* in air. However, hydrogen is *highly flammable*. That is why today we use the *inflammable* yet more expensive helium as a filling gas. Hydrogen is the most common element in space, but on earth it occurs only chemically *bonded* – mainly in the compound water.

Zeppeline, Auftrieb
hochentzündlich
nicht brennbar
gebunden

Detonating gas

With the oxygen in the air, hydrogen forms a ***detonating gas mixture***. It ignites explosively as the reaction takes place everywhere inside the gas mixture at the same time. Because of the great amount of heat, the gases expand rapidly and the mixture explodes. Pure hydrogen, on the other hand, ignites only with a faint "plop". We must handle hydrogen very carefully. Before we ignite the hydrogen, we have to carry out the detonating gas test to be sure that there is no explosive mixture. When the detonating gas test is negative, we can ignite the gas.

Knallgas-Gemisch

A "magic" candle?

If you hold a burning candle to a balloon or a glass cylinder filled with pure hydrogen, the hydrogen will *ignite*. The flame of burning hydrogen is almost colourless and therefore difficult to see. In the experiment displayed in Fig. 1, the flame of the candle extinguishes inside the cylinder: hydrogen does not *maintain* the burning process. When the candle is taken out of the cylinder and thus exposed to the air again, it is lit by the burning hydrogen at the rim of the cylinder. We can tell from the foggy cylinder that the reaction produces water.

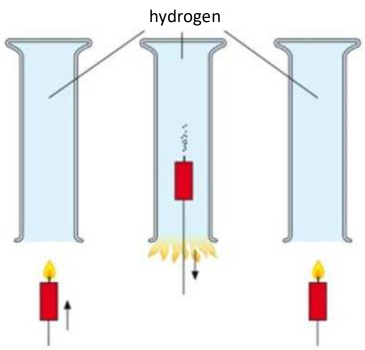


Fig. 1: ‚magic' candle

zünden
unterhalten

4.3. Water – An Element?

Hydrogen - an energy source

Hydrogen is an energy source and can be used as fuel. For example, there are cars with engines in which a hydrogen-oxygen mixture ignites. Electric cars can drive by using electricity from a hydrogen-oxygen *fuel cell*. The engines of some rockets also use hydrogen and oxygen. We have to keep in mind that before we can actually use hydrogen for technical applications, we first have to produce it, which consumes energy. Brennstoffzelle

That is in contrast to energy sources we can find in nature such as *crude oil*. The raw material for hydrogen is still mostly *natural gas,* a fossil fuel. A better way would be the use of solar energy for the production of hydrogen by *electrolysis* of the easily available raw material, water. Rohöl Erdgas Elektrolyse

Your tasks:

1. The most common element in the universe is hydrogen. Explain why there is no pure hydrogen on earth.

___

___

___

2. Name the exhaust gas from hydrogen-powered cars and write down the word equation for the chemical reaction.

___

___

3. We can produce hydrogen according to the chemical reaction shown by the following word equation:

hydrochloric acid (aq) + zinc (s) ⟶ hydrogen (g) + zinc chloride (aq)

Describe what you can do to find out if your gaseous product is pure hydrogen.

___

___

___

___

4. Hydrogen petrol stations offer gaseous and liquid hydrogen. Explain which one appears to be more favourable to you.

___

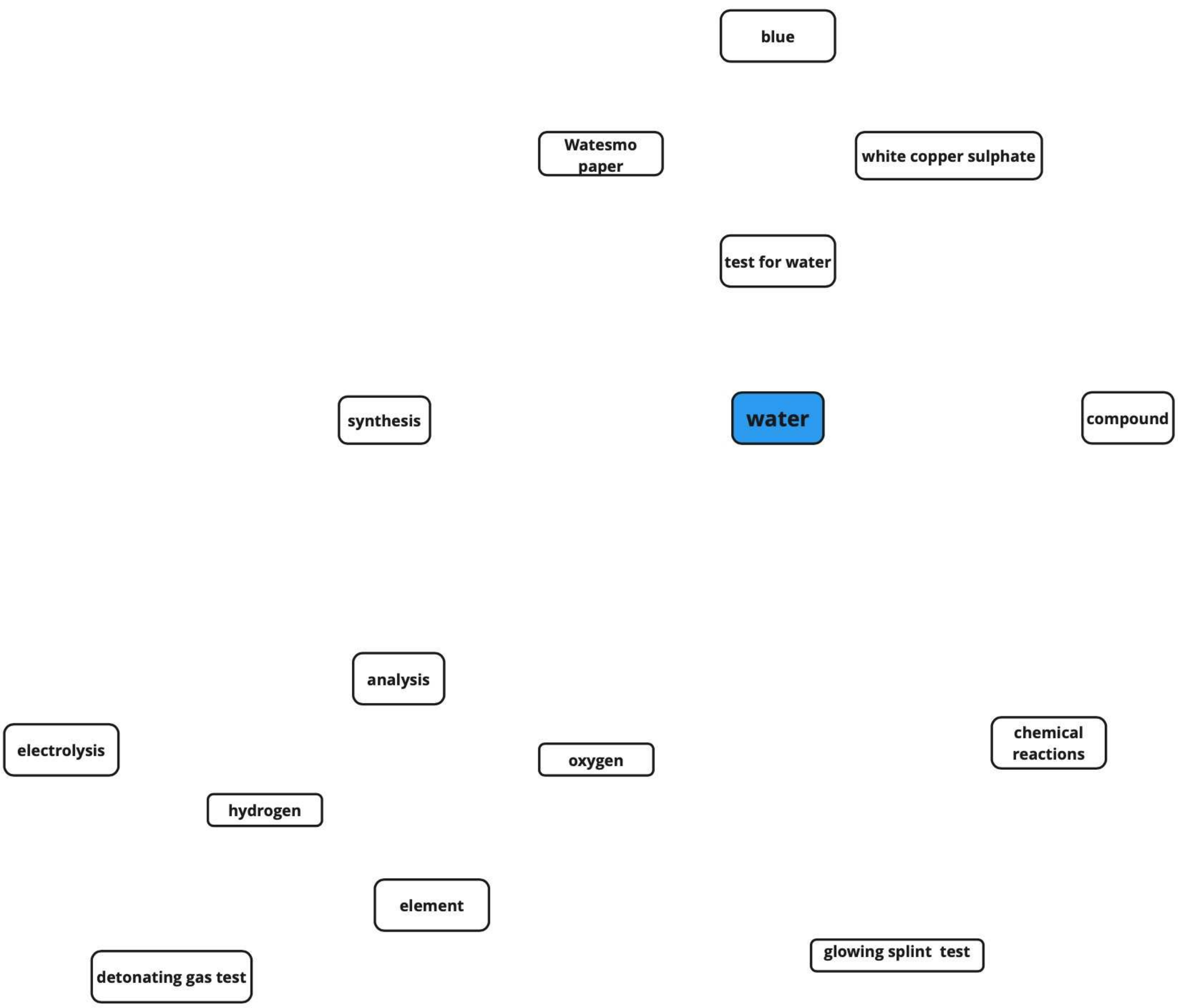
___

___

4.3. Water – An Element?

Concept Map: Water

Your task:
First, connect the terms with arrows. Secondly, write appropriate relations on the arrows. You may want to read the info texts again.



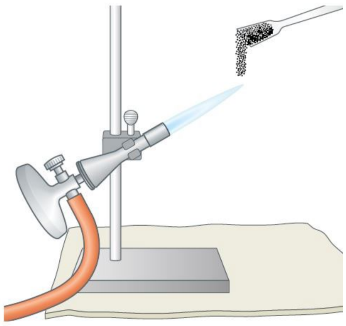
4.3. Water – An Element?

Glossary : Water

English	German	Example
analysis (plural: analyses)	die Analyse	The process of splitting up a compound into its elements is called analysis.
aqueous	wässrig	Salt water is an aqueous solution of salt.
bonded oxygen	der chemisch gebun-dene Sauerstoff	Metal oxides like magnesium oxide contain chemically bonded oxygen.
compound	die chemische Ver-bindung	Elements react with one another to form compounds.
detonating gas test	die Knallgasprobe	The element hydrogen can be identified by the detonating gas test.
electrolysis (plural: electrolyses)	die Elektrolyse	You can split up water by means of electrolysis.
element	das Element	Elements consist of only one sort of atoms.
elemental oxygen	der elementare Sauerstoff	Magnesium and elemental oxygen react to form magnesium oxide.
glowing splint test	die Glimmspanprobe	The element oxygen can be identified by the glowing splint test.
Hofmann apparatus	der Hofmannsche Zersetzungsapparat	The Hofmann apparatus can be used for the electrolysis of water. The gaseous products can be collected inside the apparatus.
hydrogen	der Wasserstoff	Hydrogen is the element with the lowest density.
oxygen	der Sauerstoff	You need oxygen to breathe. It is an element.
synthesis (plural: syntheses)	die Synthese	In a chemical reaction called synthesis, elements react with one another and form compounds.
tap water	das Leitungswasser	It is safe to drink tap water in Germany as it is controlled regularly.
water	das Wasser	Water is a liquid at room temperature.
Watesmo paper	das Watesmo-Papier	A Watesmo paper strip turns blue in the presence of water.
white copper sulfate	das weiße Kupfersulfat	White copper sulfate turns blue in the presence of water.

Lab Activity: Burning Different Metal Powders

Sketch:



Materials:

stand, clamp, clamp holder, *heat resistant* mat, burner, spatula, iron powder, magnesium powder, copper powder (note: the powders should have similar *grain sizes*)

hitzebeständig

Korngrößen

Procedure: Set up the experiment according to the sketch. Adjust the burner so you have a roaring flame. Using the spatula, *sprinkle* small portions of the following metal powders *onto* the flame: a) iron powder, b) magnesium powder, and c) copper powder.

herunterrieseln
auf

Observation: ____

____

____

____

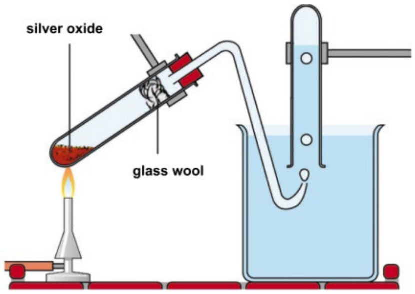
Hints for your conclusion:

1. Compare the observations of each metal powder.
2. In *combustions*, metals react with oxygen from the air. Write down word equations for the three combustions. The products are called *iron oxide*, *magnesium oxide* and *copper oxide*.
3. Sort the different metal powders according to their reaction intensity. Give reasons for your choice.
4. Write down a hypothesis why similar grain sizes of the metal powders are used and suggest experiment(s) that help prove it.

Verbrennungs-reaktion, Eisen-oxid, Magnesi-umoxid, Kupfer-oxid

Lab activity: Analysis of Silver Oxide

Sketch:



Materials:

spatula, 2 test-tubes, *glass wool*, plug with *bent glass tube*, container filled with water, stand, clamp, clamp holder, burner, lighter, *wooden splint*, silver oxide

Glaswolle
gebogenes Glasrohr
Holzstab

Procedure: Put three spatula tips of silver oxide into a test-tube. Set up the experiment according to the sketch.
Heat the test-tube *vigorously* with a gas burner. Let the first gas bubbles from the apparatus escape through the water. Then collect the produced gas in a test-tube. Test the collected gas with a *glowing splint*.
After no more gas is produced and the solid rest in the test-tube has cooled down, *scrape* the solid rest *out* of the test-tube on a paper towel and press it firmly with a spatula.

kräftig
Glimmspan
herauskratzen

Observation: During the reaction:___________________________________

____

Glowing splint:____

____

Solid rest after pressing:_______________________________

____

Hints for your conclusion:

1. Compare the colours of the reactant and the products.
2. Analyse the result of the glowing splint test and explain where the gas has come from.
3. Based on your observations, explain which two products must have formed.
4. An ***analysis*** gives us information about the components which make up a chemical compound. This experiment is entitled “Analysis of silver oxide”. Explain this title and write down a word equation that represents the reaction.
5. A ***synthesis*** is the opposite of an analysis. Explain what happens during the synthesis of silver oxide.

Analyse
Synthese

5. Metals and Metal Production

Info: Metals and Metal Oxides

In nature, gold and silver can be found as elements. Other metals usually *occur* in *compounds*. How can pure metals be *obtained from* naturally occurring compounds?

vorkommen, Verbindung, gewinnen aus

Not all metal powders burn violently: the reactivity series of metals

If you burn different metal powders in the burner flame, they will *light up with different intensities.* All of them, however, react with oxygen from the air to form ***metal oxides***. The more violently a metal reacts with oxygen, the higher its reactivity and its ability to form oxides. The ability to be oxidised *decreases* from magnesium to silver as shown in the following reactivity series:

unterschiedlich grell aufleuchten
Metalloxide
abnehmen

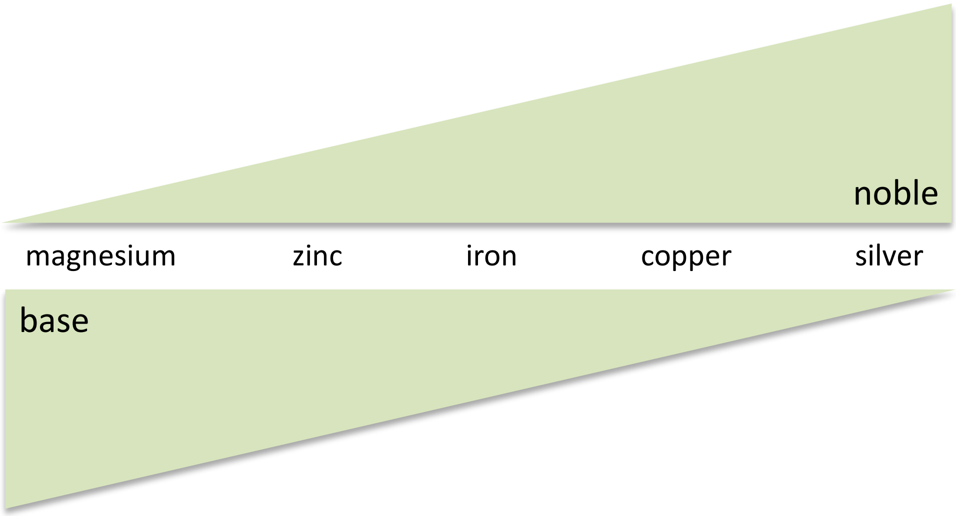


Fig. 1: The reactivity series

Metals like magnesium or zinc, which easily form ***oxides***, are called ***base metals***. In contrast, there are ***noble metals*** like silver and gold, whose ability to form oxides is relatively low.

Oxide, unedle Metalle, edle Metalle

Base metals react violently with oxygen and have a high *reactivity*, whereas noble metals react less violently -or not at all- with oxygen and have a low reactivity.

Reaktionsfähigkeit

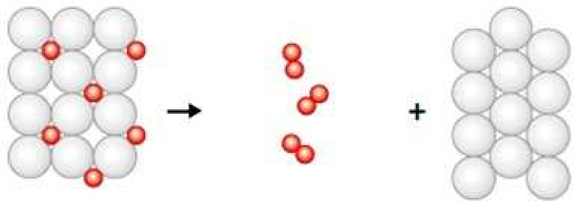
Silver from silver oxide

The combustion of metals *results in* the formation of metal oxides. *Conversely*, if you heat up oxides of noble metals, they will split up into the elements, metal and oxygen, quite easily.

führt zu
im umgekehrten Fall

As the word equation and the particle model show, silver can be obtained from its metal oxide called silver oxide:

silver oxide (s) ⟶ oxygen (g) + silver (s) | endothermic



The particle model above shows that silver atoms are separated from oxygen atoms. Elemental oxygen and silver are produced. The reactant silver oxide is ***reduced***. A *reduction* can be considered the back reaction of an oxidation. *Oxidation* and reduction are reversible processes.

reduziert, Reduktion, Oxidation

In chemical reactions where metals are obtained from their oxides, reductions take place. Metal oxides are reduced.

Your tasks:

1. “Let’s take gold to have a golden sparkling firework.” Discuss this suggestion.
2. Iron and zinc are hardly ever used for jewelry. Explain this.
3. In Fig.2 you can see a gold-plated statue. Give reasons why one chooses the element gold for this.

Fig. 2: A gold-plated statue in Berlin

Lab Activity: Copper and Its Compounds I

Materials: black copper oxide, iron powder, test-tube, burner

Procedure:

E1)

Heat 2 g of black copper oxide strongly for about 2 min.

E2)

1. Mix 2 g of black copper oxide and 1 g of iron powder and fill the mixture into a test-tube.
2. Heat the mixture strongly until it begins to glow. Take the test-tube out of the flame.
3. Let the test-tube cool down and examine its content closely. You might have to *shatter* the test-tube to get the content out. zerschlagen

Observation: Describe your observations directly after you have removed the test-tube from the flame:

____

____

____

____

____

____

____

____

Hints for your conclusion:

1. Compare the mixture in **E2** before and after heating.
2. Suggest a name or several names for the product(s) in **E2**. Give reasons based on the appearance of the identified product(s).
3. Compare **E1** and **E2**. Make a suggestion concerning the role of iron in **E2**. Support the suggestion with *suitable evidence* from your observations. geeigneten Beweisen, Energieumsatz
4. Suggest a word equation for **E2** that also considers the *energetic turnover*. Draw a particle model for this experiment, too.

Lab Activity: Copper and Its Compounds II

Materials: black copper oxide, activated carbon *Holzkohle,*
lime water (aqueous solution of calcium hydroxide), *Kalkwasser*
4 test-tubes, stopper with one hole, bent glass tube, burner

Procedure: **E1)**

1. Mix 2 g of black copper oxide and 0.5 g of charcoal and fill the mixture into a test-tube.
2. Heat the mixture strongly for about 2 min.
3. Let the test-tube cool down and examine its content closely.

E2)

1. Again, mix 2 g of black copper oxide and 0.5 g of charcoal and fill the mixture into a test-tube.
2. *Fasten* the stopper *to* the bent glass tube. befestigen
3. Fill a second test-tube half-full with lime water.
4. Heat the mixture strongly for about 2 min. Lead the *generated* gas into the lime water. entstanden

Observation: colour of copper oxide and charcoal before mixing:

____

while heating the mixture:

____

appearance of the solid product after it has cooled down (**E1** and **E2**):

____

Hints for your conclusion:

1. Suggest a name for the product.
2. Explain the function of the lime water in **E2**.
3. Suggest a word equation and draw a particle model for **E1**.
4. Explain where an oxidation and where a reduction takes place. Add this information to the word equation and the drawing.

5. Metals and Metal Production

Info: Producing Copper by Means of a Redox Reaction

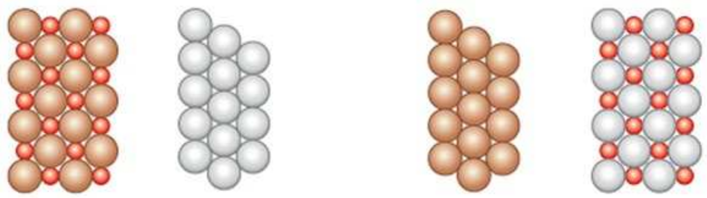
In nature, elemental copper is hardly ever found. However, there are large amounts of *copper ores*, which are chemical compounds of copper and *oxygen* or copper and *sulfur*. The reason for this is simple: copper reacts easily with other *reactants* such as oxygen to form copper oxide or with sulfur to form copper sulfide. In order to produce *pure* copper from copper oxide, chemically bonded oxygen has to be removed from the compound. This process is called **reduction**. A reduction is possible, for example, by heating up a mixture of copper oxide and iron. The reactants form the products copper and iron oxide as presented in the word equation and in the particle model below:

Kupfererze
Sauerstoff, Schwefel
rein/gediegen

reduction

copper oxide (s) + iron (s) ⟶ copper (s) + iron oxide (s) | exothermic

oxidation



Oxidation and reduction always take place simultaneously. The reaction is called **redox** reaction.

In the ***redox reaction*** of copper oxide and iron, iron is the ***reducing agent*** since it reduces the copper oxide to elemental copper. We can say that it makes the reduction possible. Copper oxide, on the other hand, functions as the ***oxidising agent***. It makes an oxidation possible: It oxidises the iron to iron oxide.

Redoxreaktion,
Reduktionsmittel
Oxidationsmittel

In the example above, a metal (iron in this case) is the reducing agent. However, non-metals such as carbon can be used too, as presented in this word equation:

reduction

copper oxide (s) + carbon (s) ⟶ copper (s) + carbon dioxide (g) | exothermic

oxidation

There are *advantages* if the redox reaction of copper oxide is carried out with carbon or even hydrogen instead of iron. In the case of carbon, gaseous carbon dioxide is formed and there are no further solid products. This is different from the reaction using iron as reducing agent where we get solid iron oxide mixed with solid copper. Therefore, a *laborious separation* of the products is not necessary. Moreover, carbon is a cheap alternative to iron. In cases where hydrogen is used as a reducing agent, water vapour is formed as gaseous oxidation product. Not only copper, but other metals, such as pure iron, can be produced by reducing their oxides. Carbon is often used as the reducing agent in these cases.

Vorteile

aufwändige Trennung

Transfer of oxygen takes place in redox reactions

The described redox reactions are ***oxygen transfer reactions*** because chemically bonded oxygen is transferred from one reactant to another. For example, oxygen is transferred from copper oxide to iron forming iron oxide. In general, one reactant donates oxygen, while the other one accepts it. Redox reactions follow the ***donor-acceptor-principle***.

Sauerstoffübertragungsreaktion

Donator-Akzeptor-Prinzip

Choose a partner for oxygen transfer

Several reducing agents can be used to accept oxygen, but only *on the condition that* they are *less noble* than the metal in the metal oxide. For example, both metals, iron and zinc (as well as the non-metal carbon), are less noble than copper, which is why all of them can be used as reducing agents in this case. The greater the difference in nobility, the more vigorous the exothermic reaction.

unter der Bedingung, dass…, unedler

Your tasks:

1. Write down the word equation and the particle model for the reaction between a) copper oxide and zinc, and b) copper oxide and carbon. Make sure that the law of the conservation of mass applies.
2. Identify and label oxidising agents and reducing agents in all of the reactions so far.
3. Have a look at the reactivity series of metals and say which metals can be used as reducing agents for the reduction of iron oxide.
4. “Zinc oxide reacts with aluminium to form zinc and aluminium oxide. Magnesium oxide does not react with aluminium.” Use these statements to find the correct place for aluminium in the reactivity series of metals.
5. Carbon and hydrogen can be used as reducing agents for producing copper. Evaluate their use concerning criteria such as availability, cost, and safety.

Skills: Creating Concept Maps (Paper Slip Method)

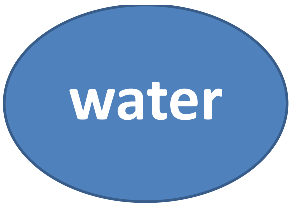
Concept Maps represent *mental maps* of a certain topic. They consist of a **central term** and a number of **related terms**. In contrast to mind maps, in Concept Maps these terms are connected to each other with an **arrow** which carries a written explanation of the **relationship** between those terms.

innere Landkarten

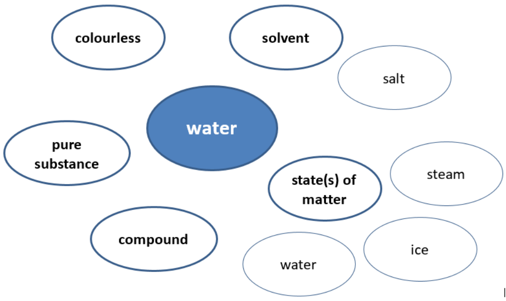
This is how you create your own Concept Map:

1. Write the central term in the middle of a big piece of paper.

2. Collect important terms that are related to the central term. Write each term on a separate *slip of paper*.



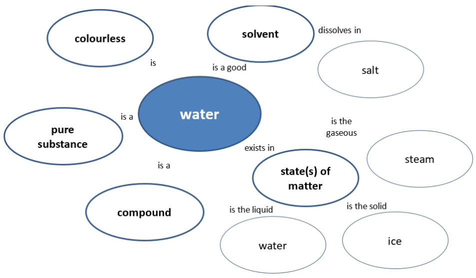
Stück Papier



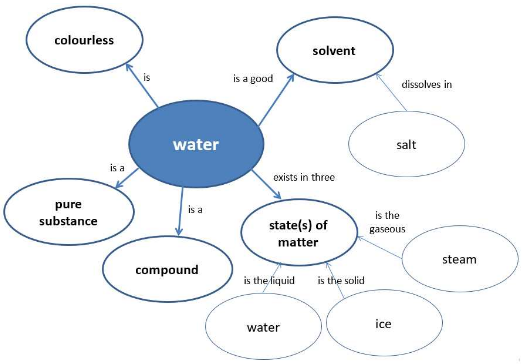
3. *Arrange* the related terms *around* the central term. Place those terms closely together which belong together. You may have to rearrange some of the terms.

um etw. anordnen

4. Think about how the central term *relates* to each of the other terms. Write a short *relation* on a small piece of paper. Use one piece of paper for each relation. If you 'read' your terms and the relation, you should get some kind of sentence. **But do not write complete sentences.**



in Beziehung stehen zu..., Verbindung



5. Decide about the *kind of arrow* that you need to *depict* the relation *properly*: ←, or→, or ↔ . Draw it on the paper slip with the relation.

Pfeilart angemessen dar-stellen

6. Arrange the final version of your Concept Map and draw it on the piece of paper with the central term on it. The arrows should not cross each other.

7. Check your Concept Map.

Creating a Concept Map: Redox Reactions

Create your own Concept Map on the topic 'redox reactions' (individual & pair work).

The **central term** is 'redox reactions'. Write it in the center of a sheet of paper.

Step 1 (individual work!):
Read your notes about redox reactions or read the informational texts provided by your teacher. Find the **eight** most important **related terms** and write down reasons for your choice. You may use key words.

Step 2 (pair work from now on):
Present your terms to a partner and explain why you have chosen these terms. After that, your partner presents his/her terms to you.

Step 3:
Discuss with your partner which of the presented terms you should place on a *common Concept Map* with **only six** related terms. Write each of these terms on a different slip of paper and arrange them in a logical way around the central term.

gemeinsames Begriffsnetz

Steps 4 and 5:
Formulate the **relations** between each of the six related terms and the central term. Write each of them on a slip of paper. Decide on the **kind of arrow** between your terms and add it accordingly.

Step 6:
Check your Concept Map. Finally, stick the paper slips onto the paper.

Step 7:
Present your Concept Map to your classmates.

5. Metals and Metal Production

Glossary: Redox Reactions

English	German	Example
base metal	das unedle Metall	Base metals like magnesium or aluminium are very reactive. They drive less reactive metals out of their ores. Base metals are the opposite of noble metals.
combustion	die Verbrennung	Combustions are rapid exothermic reactions, e.g., the burning of a fuel. Usually heat and/or light are set free and new substances are produced.
donor-acceptor-principle	das Donator-Akzeptor-Prinzip	The donor-acceptor-principle is the principle of giving and taking. In the production of copper from its ore, one reactant gives oxygen and the other one accepts it. This is an example of an oxygen transfer reaction. The principle of giving and accepting applies to many other chemical situations.
endothermic	endotherm	A reaction is endothermic if heat is needed to keep the reaction going. Mostly reductions are endothermic.
exothermic	exotherm	A reaction is exothermic if heat is given off. Oxidations are exothermic.
to extract metals from ores	Metalle aus Erzen gewinnen	In nature, iron occurs chemically bonded in ores. In order to get pure iron you have to extract it from its ore.
to form an oxide	ein Oxid bilden	If copper is heated in air, copper oxide is formed.
redox reaction	die Redoxreaktion	In a redox reaction, oxidation and reduction take place at the same time.
to reduce	reduzieren	Copper oxide is reduced. The copper oxide loses its oxygen.
reducing agent	das Reduktionsmittel	A reducing agent helps the reduction to take place. It is oxidised.
reduction	die Reduktion	Reduction is the loss of oxygen. In a reduction, chemically bonded oxygen is removed from a compound.
oxidation	die Oxidation	Oxidation is the gain of oxygen. In an oxidation, an oxide is produced.

5. Metals and Metal Production

oxidising agent	das Oxidationsmittel	An oxidising agent helps the oxidation to take place. It is reduced.
to oxidise	oxidieren	Carbon is oxidised in a combustion.
oxygen	der Sauerstoff	Oxygen is in the air around us. It is also involved in many redox reactions.
oxygen transfer	die Sauerstoff-übertragung	In the reaction of copper oxide with iron, one reactant gives oxygen to the other reactant. This process is called oxygen transfer.
oxygen transfer reactions	die Sauerstoff-übertragungsreaktion	A chemical reaction in which oxygen is transferred from one reactant to the other is called oxygen transfer reaction.
metal	das Metall	Metals are elements. They conduct electricity and heat. Metals can be obtained from their oxides via reduction reactions. Examples: copper, iron, silver.
metal oxide	das Metalloxid	Metal oxides are formed in the reaction of a metal with oxygen. Base metals have to be extracted from their metal oxides.
noble metal	das edle Metall	Noble metals like silver or gold have little reducing power. They do not drive base metals out of their ores. Noble metals are the opposite of base metals.
non-metal	das Nichtmetall	Non-metals do not usually conduct electricity. Some examples are oxygen, sulfur and chlorine.
ore	das Erz	Many ores contain metal oxides or metal sulfides.
reactivity	die Reaktionsfähigkeit	Base metals oxidise easily. Their reactivity is high.
reactivity series	die Redoxreihe	The reactivity series is like a ‘league table’ for metals. The most reactive metals (like the base metal potassium) are at the top of the table, the least reactive metals (like the noble metal platinum) are at the bottom. The metals are put in order by looking at their reactivity.

Einführende Hinweise zur Arbeit mit Concept Maps, Glossaries und zu Möglichkeiten des Sprachwechsels

a.) CONCEPT MAPS

Concept Maps eigenen sich hervorragend, um einen Überblick über einen zu behandelten Themenbereich zu erhalten. Sie können z.B. als Wiederholung, Übung oder zur gezielten Wortschatzarbeit im Unterricht eingesetzt werden.
In dieser Handreichung sind verschiedene Vorschläge für Arbeitsblätter mit Concept Maps enthalten, in denen die Schüler:innen gezielt mit den Materialien arbeiten können.
Diese Arbeitsblätter sind zu Beginn der Handreichung als geschlossene (siehe Kapitel 2.1) und in späteren Kapiteln mit zunehmend offeneren Aufgabenstellungen konzipiert. Zu Kapitel 2.3 finden sie eine Concept Map zum Themenbereich Separation techniques, bei der die Schüler:innen fünf vorgegebene Begriffe einfügen müssen. Im Kapitel 4.1 zum Thema Air sollen die Schüler:innen z.B. die Concept Maps selbstständig um Relationen ergänzen. Für Kapitel 5 zum Thema Redox reactions besteht die Aufgabe für die Schüler:innen dann darin, mit Hilfe eines Skill-Arbeitsblatts: Creating Concept Maps selbst eine Concept Map zu erstellen. Diese können sie in Papierform oder digital ausarbeiten lassen. Eine Möglichkeit für die digitale Umsetzung bietet z.B. das Freeware-Programm cmap tools.
Ihrer Kreativität sind keine Grenzen gesetzt! Wir wünschen Ihnen viel Freude beim Arbeiten mit unseren Concept Maps.

b.) GLOSSARIES

Die zweispaltige Vokabelliste ist Ihnen sicher aus Ihrem eigenen Fremdsprachenunterricht bekannt. Wir haben die bekannte Wortliste um eine Spalte erweitert. So wird das neue Wort nicht losgelöst vermittelt, sondern direkt in einen Kontext eingebettet. Diese Form der Glossaries finden Sie am Ende jedes thematischen Kapitels. Wir haben uns bemüht zentrale Begriffe zu inkludieren, die Sie selbstverständlich gerne erweitern und nach den jeweiligen Bedürfnissen Ihrer Lerngruppen adaptieren können.
Glossaries bieten eine Vielzahl von Einsatzmöglichkeiten in Ihrem Unterricht. Sie können Ihren Schüler:innen z.B. das Glossar als Nachschlagewerk zur Verfügung stellen und als Wortschatzbasis einsetzen. Die Glossare können natürlich auch von den Schüler:innen selbst erarbeitet werden. Geben Sie Ihren Schüler:innen die Grundstruktur des Glossars vor und lassen Sie die Schüler:innen weitere Inhalte selbst ergänzen und eigene Beispielsätze finden. Vielleicht stellen Sie den Schüler:innen ein Glossar mit Lücken zur Verfügung, die die Schüler:innen dann füllen müssen oder Sie lassen aus dem Glossar eine Concept Map oder ein Cluster erstellen? Ihrer Fantasie sind keine Grenzen gesetzt!
Eine weitere Möglichkeit wäre, den in den Glossaren enthaltenen Wortschatz spielerisch in Ihren Unterricht zu integrieren. Verwenden Sie die Begriffe und entwerfen Sie z.B. ein Taboo- oder Memory-Spiel.

Bei weiteren spielerischen Übungen wie „Montagsmaler" oder „Pantomime" werden einzelne Begriffe gezeichnet bzw. pantomimisch dargestellt, die dann von der Klassengemeinschaft erraten werden müssen. Das sorgt für Spaß und eine hohe Aktivierung Ihrer Lerngruppe. Probieren Sie es aus!

c.) ANREGUNGEN ZU SPRACHWECHSELN

Die Ausbildung einer doppelten Sachfachliteralität ist Ziel und Grundlage des heutigen bilingualen Unterrichts. Idealerweise sollen beider Sprachen, also Muttersprache und Fremdsprache, als gleichberechtigte Partner agieren. Um dies zu erleichtern, bieten sich gezielte Sprachwechsel an, die eine fachliche Konzeptvermittlung in beiden Sprachen ermöglichen. Unsere Impulse, wie Sie diese Sprachwechsel in Ihren bilingualen Unterricht integrieren können, finden Sie in den Lehrerhandreichungen. Alle Ausführungen, die mit folgendem Symbol versehen sind ⟺, zeigen Ihnen Möglichkeiten für Sprachwechsel auf.

Bisher sind noch wenige Methoden zum Sprachwechsel erprobt. Es gibt jedoch einige hilfreiche Vorschläge z.B. aus dem Artikel von Heimes [1] aus dem Jahr 2010. Er beschreibt u.a. die Methode der Bilingual Poster Production. Bei dieser Methode werden die Ergebnisse der Erarbeitungsphase von den Schüler:innen auf einem Poster festgehalten. Dabei verwenden sie die Unterrichtssprache Englisch (L2). Anschließend vollziehen die Schüler:innen einen Sprachwechsel, indem sie ihr Poster in der Muttersprache Deutsch (L1) präsentieren. Dabei stellt der Sprachwechsel keine bloße Wiederholung dar, sondern fordert die Schüler:innen heraus, neu erworbenes Wissen in der Muttersprache richtig zu verbalisieren.

Bei einer anderen Methode des classroom translanguaging nach Williams durchlaufen die Lernenden aufeinander folgende Input- und Output-Phasen, die abwechselnd die L1 und die L2 berücksichtigen. So werden Unterrichtssprache und Schulsprache funktional eingebunden. In [2] hat Bohrmann-Linde das oben genannte Prinzip implizit aufgegriffen und für experimentelle Erarbeitungsphasen mit einem Wechsel der Darstellungsformen kombiniert. Dadurch erfolgt eine intensive Auseinandersetzung mit der üblicherweise sowohl sprachlich als auch inhaltlich dichten Versuchsvorschrift. Einige Beispiele hierfür finden Sie in den Kapiteln 3.1 und 3.2 in dieser Handreichung.

Anregungen zur praktischen Umsetzung von Sprachwechseln mit diesen erwähnten Methoden finden Sie außerdem auf unserer Homepage https://chemiedidaktik.uni-wuppertal.de/ und in [3], [4].

Beispielbeiträge zum Sprachwechsel im Chemieunterricht:

[1] A. Heimes. „Bilinguale Methoden für den mehrsprachigen Sachfachunterricht." Praxis Fremdsprachenunterricht, 2010, 7, 7-10.

[2] C. Bohrmann-Linde. „Wechsel der Darstellungsformen und funktionale Sprachwechsel im bilingualen Chemieunterricht." In B. Diehr, G. Preisfeld und L. Schmelter (Hrsg.). Bilingualen Unterricht weiterentwickeln und erforschen. S. 165-181. Frankfurt am Main: Peter Lang, 2016.

[3] E. Kiesling, R. Brunnert, und C. Bohrmann-Linde. „Bioethanol im bilingualen Chemieunterricht mithilfe der Methode Bilingual Poster Production." Aachen: GDCh-FGCU-Tagung/WIFO, September 2019.

[4] R. Brunnert, E. Kiesling, und C. Bohrmann-Linde. „Bioethanol im bilingualen Chemieunterricht per classroom translanguaging." Aachen: GDCh-FGCU-Tagung/WIFO, September 2019.

Chapter 1: Getting Started: In the Laboratory (S. 1-13)

Safety Rules for the Chemistry Laboratory

Auf dem ersten Arbeitsblatt finden die Schüler:innen eine Übersicht zu Sicherheitsregeln im Chemieunterricht. Diese behandeln sowohl den Umgang mit Chemikalien, als auch das Verhalten beim Experimentieren. Die konkreten Regeln sind **fett** markiert. Ggf. kann man die Regeln im Unterricht noch einmal von den Schüler:innen notieren lassen, um lokale Schul- oder Klassenregeln bzw. räumliche Bestimmungen zu ergänzen.

Your tasks: (Beispielantworten, andere Schülerantworten sind möglich)

No	Students' mistakes	Improvements
1	The girl in the pink t-shirt is not wearing safety googles.	Rule 7
2	The boy is eating something.	Rule 4
3	There is a bag on the table.	Rule 10
4	There are water bottles, a sandwich and an apple on the table.	Rule 10, Rule 4
5	The girl with the dark hair is touching chemicals with her bare hands.	Rule 3
6	Both girls are pointing the opening of their test-tubes at a classmate.	Rule 8
7	The girl with the dark hair is not using a test-tube holder to heat up her substances with the gas burner.	Rule 5
8	The girl with the dark hair does not have her hair in a ponytail.	Rule 6
9	A green chemical is leaking over a book on the table.	Rule 6, Rule 9, rule 2
10	A bottle with a toxic substance has no lid.	Rule 5, Rule 10

Das Arbeitsblatt bietet für Schüler:innen die Möglichkeit, die Laborregeln zu verstehen.

Things You Can Find in a Laboratory

AB 1 Die einzelnen Zettel werden von den Schüler:innen ausgeschnitten und anschließend als Beschriftung für ausliegende Laborgeräte benutzt.

AB 2 Hier erfolgt eine Zuordnung von englischen und deutschen Fachbegriffen in eine Tabelle.

Die Lösungen sind von links nach rechts angegeben:
test-tube (Reagenzglas), beaker (Becherglas), Erlenmeyer flask (Erlenmeyerkolben), measuring cylinder (Messzylinder)
test-tube holder (Reagenzglasklammer), tongs (Zange), gas burner (Gasbrenner), wash bottle (Spritzflasche)
funnel (Trichter), watch glass (Uhrglas), Petri dish (Petrischale), stopper (Stopfen)
clamp holder (Muffe), clamp (Stativklammer), stand (Stativ), test-tube stand (Reagenzglasgestell)
thermometer (Thermometer), spatula (Spatel), glass rod (Glasstab), pipette (Pipette)

⟺ Nutzen Sie die erarbeiteten Begriffe zum Sprachwechsel und üben Sie das neue Vokabular mit Ihren Schüler:innen ein. Spielen Sie z.B. mit der gesamten Klasse ein “Menschenmemory”. Die deutschen und englischen Begriffe werden unter den Lernenden aufgeteilt. Nacheinander steht eine Person auf und spricht ihren deutschen Begriff laut aus. Eine andere Person muss ebenfalls aufstehen und dann den passenden englischen Fachbegriff laut aussprechen. Das Plenum entscheidet, ob die zwei Begriffe zusammenpassen. Die Begriffspaare können dann bei Bedarf in einer Concept Map, in einem Glossar oder in einer eigenen Vokabeldatei der Schüler:innen festgehalten werden.

Chemistry Apparatus (A)

Der Lehrkraft stehen drei Arbeitsblattvarianten zur Benennung von Laborgeräten und Zuordnung ihrer Funktionen zur Auswahl. Dabei wird aufsteigend von A-C immer mehr sprachliche Eigenleistung von den Schüler:innen eingefordert.

Your tasks:

1) Lösungstabelle siehe AB Time to practice: Chemistry Apparatus (C)
2) measuring cylinder, (stop clock, beaker)
3) test-tube, measuring cylinder, thermometer, beaker, funnel
4) Individuelle Antwort z.B.: Bunsen burner, beaker, heatproof mat, tripod

Chemistry Apparatus (B)

Der Lehrkraft stehen drei Arbeitsblattvarianten zur Benennung von Laborgeräten und Zuordnung ihrer Funktionen zur Auswahl. Dabei wird aufsteigend von A-C immer mehr sprachliche Eigenleistung von den Schüler:innen eingefordert.

Lösungstabelle siehe AB Time to practice: Chemistry Apparatus (C)

Chemistry Apparatus (C)

Der Lehrkraft stehen drei Arbeitsblattvarianten zur Benennung von Laborgeräten und Zuordnung ihrer Funktionen zur Auswahl.

Name of apparatus	Main function
1. test-tube rack	to put in test-tubes
2. test-tube	to let some substances react with each other
3. measuring cylinder	to measure the exact volume of a liquid
4. gas burner	to heat up substances, to start reactions
5. thermometer	to measure the temperature
6. stop clock	to measure the time in seconds
7. beaker	to fill in with liquids
8. tripod	rack for heating up substances with the Bunsen burner in, e.g., a beaker
9. heatproof mat	to put on the tripod
10. filter funnel and paper	to separate a solid from a liquid
11. pipette	to measure a small amount of a liquid

Partner Crossword on Lab Apparatus (A)

Tandem-Aktivität: Die Schüler:innen (A & B) ergänzen sich das Kreuzworträtsel in Partnerarbeit gegenseitig. Dabei benennen sie die Laborgeräte.

Lösungswort: It’s all in the LABORATOR(Y)

Partner Crossword on Lab Apparatus (B)

Tandem-Aktivität: Die Schüler:innen (A & B) ergänzen sich das Kreuzworträtsel in Partnerarbeit gegenseitig. Dabei benennen sie die Laborgeräte.

Lösungswort: It's all in the LABORATOR(Y)

How to Structure Your Lab Report

Die beiden Seiten können einzeln oder als Einheit eingesetzt werden, um die Schüler:innen mit der Protokollierung ihrer Arbeitsergebnisse im Chemieunterricht vertraut zu machen.

Die erste Seite enthält eine Erläuterung zum strukturellen Aufbau eines Protokolls.

Your tasks:

1. Separating a sand, water, ink mixture: possible separation techniques (decantation, filtration, distillation or filtration with active carbon)

2. Example lab report

Die Inhalte des Beispielprotokolls sind von der Vorgehensweise während der Versuchsdurchführung abhängig. Hier ein Beispiel:

<u>Title:</u> Separating a Sand-Water-Ink-Mixture

<u>Intention of the experiment</u>: A mixture of sand, water and ink should be separated in this experiment.

<u>Materials</u>:
Chemicals

- *sand-water-ink-mixture*
- *active carbon*

Lab equipment

- *filter paper*
- *beaker*
- *filter*

<u>Procedure</u>:
Leave the beaker with the mixture on the table until all solid particles have set on the bottom. Decant the liquids into a filter filled with filter paper and active carbon.
<u>Observation</u>:
After the decantation process, sand remains in the beaker.
The decanted blue-brownish liquid is filtered through a filter paper with active carbon. The final filtrate is a colourless liquid.

Conclusion:

The sand-water-ink-mixture can be separated by using the seperation techniques decantation and filtration. Both techniques rely on certain properties of matter. Sand is a solid substance with a higher density than ink-water and forms a sediment on the bottom of the beaker. The ink-water mixture can be separated by using filtration and adsorption processes. Smaller ink particles are adsorbed by active carbon and remain in the filter paper, leaving the remaining colourless water as a filtrate and final product of the separation process.

Die zweite Seite bietet Formulierungshilfen für ein solches Protokoll.

Your tasks:

1. Example sentences for a lab report: Then add two grams of sugar. The reactant is a solid, green substance. The change in colour indicates that a chemical reaction has occurred.
2. ample sentences for a lab report: Then add two grams of sugar. The reactant is a solid, green substance. The change in colour indicates that a chemical reaction has occurred.
3. Other useful nouns, verbs, adjectives e.g.: (to) form a chemical bond, (to) build a setup, (to) draw and label a sketch, particle level (Teilchenebene)

Example Lab Report

Das Arbeitsblatt kann einzeln oder in Verbindung mit „Info: How to structure your lab report“ eingesetzt werden, um die Schüler:innen mit der Protokollierung ihrer Arbeitsergebnisse im Chemieunterricht vertraut zu machen. Dieses Arbeitsblatt enthält ein exemplarisches englisches Beispielprotokoll zur Untersuchung von Brausepulver.

⟺ Nutzen Sie die Möglichkeit für eine kontrastive Betrachtung. Stellen Sie die Struktur eines deutschen und eines englischen Versuchsprotokolls gegenüber und besprechen Sie die Gemeinsamkeiten und Unterschiede mit Ihren Schüler:innen .

Hazard Symbols

Dieses Arbeitsblatt dient als ein Informationsblatt zu den Gefahrensymbolen nach GHS.

Your tasks:

1. Hydrogen (Wasserstoff): Danger! compressed gas, flammable
   Ethanol (Ethanol): Danger! flammable, harmful
   Oxygen (Sauerstoff): Danger! oxidising, compressed gas
   Magnesium (Magnesium): Danger! flammable
   Sodium (Natrium): Danger! flammable, corrosive

2. Individuelle Schüler:innenlösung (mögliche Produkte mit GHS-Symbolen könnten z.B. Spülmittel, Rohrreiniger, Waschmittel, Nagellackentferner und Reinigungsmittel sein)

⟺ Nutzen Sie die Möglichkeit für eine kontrastive Betrachtung. Lassen Sie die deutschen und englischen Fachbegriffe mit Hilfe einer Matching-Aufgabe durch die Schüler:innen zuordnen. Halten Sie die Ergebnisse tabellarisch an der Tafel fest.

Chapter 2 Matter and Properties of Matter

2.1. Properties of Matter (S. 14-21)

Lab Activity: The Boiling Temperature of Water

Die Schüler:innen erhalten eine Versuchsvorschrift zur Erstellung einer Siedekurve von Wasser.

Hints for your conclusion:

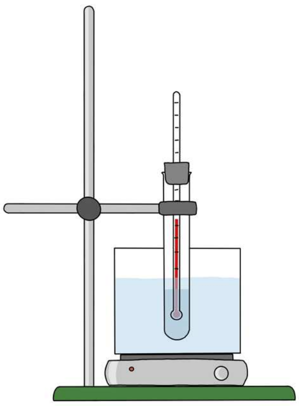
1. individuelle Lösung je nach Versuchsdurchführung
2. At the highest temperature water reaches its boiling temperature. At that temperature, water changes from a liquid to gas.
3. individuelle Lösung je nach Versuchsdurchführung
4. individuelle Lösung je nach Versuchsdurchführung
5. Kann ausgelassen werden, wenn das Teilchenmodell noch nicht eingeführt wurde; Teilchen sollen als Flüssigkeit (vor) und Gas (nach) dem Experiment dargestellt werden.

Lab Activity: The Melting Temperature

Das Arbeitsblatt beinhaltet eine Versuchsvorschrift zur Erstellung einer Schmelz- und einer Erstarrungskurve von Stearinsäure.

Hints for your conclusion:

1-3. individuelle Lösung je nach Versuchsdurchführung
4. Bitte beachten Sie, dass hier umgekehrte Prozesse betrachtet werden und man die Schüler:innen auf verschiedene Aufheiz- und Abkühlraten hinweisen kann.



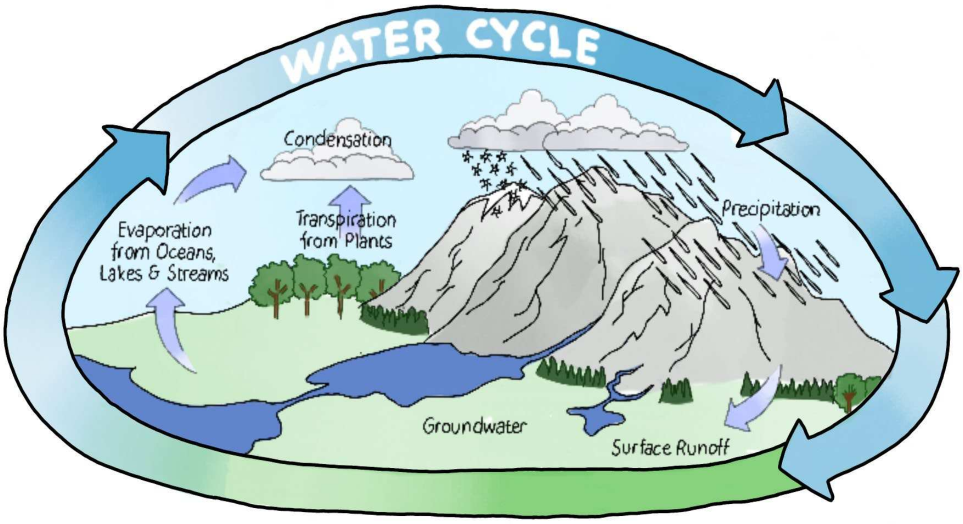
Time to Practice: Water Is All Around Us

Das Übungsblatt enthält einen Lückentext, in dem die Aggregatzustände des Wassers thematisiert werden und eine Aufgabe zur Erstellung eines Textes zur Reise eines Wassertropfens.

Your tasks

1. Lösungen Lückentext: liquid, melts o. freezes, solid, heat up, gas bubbles, boils, vaporisation, melting temperature, boiling temperature

2.



3. Individuelle Lösung (Essay)

Lab Activity: Coke™ and Diet Coke™ – What Is the Difference?

Das Arbeitsblatt enthält eine Versuchsvorschrift zur Untersuchung der Dichte von Cola und Cola light. Beachten Sie bitte, dass Sie abgestandene Colaprodukte für den Versuch benötigen!

Hints for your conclusion:

1. Individuelle Lösungen je nach Versuchsdurchführung und Colaprodukt
2. Individuelle Lösungen je nach Versuchsdurchführung und Colaprodukt. Schüler:innen berechnen die Dichte (Masse: Volumen).
3. Density of a substance is defined as its mass per volume. This chemical property can be determined in this experiment. The density of Diet Coke is less than the one of regular Coke, because it contains less sugar (considering equal volume).
4. It is important to use stale drinks. That way the carbon dioxide does not influence the measurements.
5. Inhaltsstoffe können von den Etiketten der Flaschen/Dosen entnommen werden: die Schüler:innen sollten feststellen, dass Cola light im Gegensatz zu Cola keinen Zucker enthält, sondern Süßstoffe (sweeteners). Die jeweils gelösten Massen an Zucker und Süßstoff sind dann entscheidend für die Dichte.
6. Coke contains 10.6 g of sugar per 100 mL. A glass of Coke (250 mL) would equal 26.5 g sugar per day. The recommended sugar consumption of 25 grams per day is exceeded by drinking 250 mL of Coke.

Info: Matter and Properties of Matter

Das Arbeitsblatt enthält einen Informationstext und Abbildungen zu verschiedenen Stoffeigenschaften. Darüber hinaus können die Schüler:innen Aufgaben bearbeiten, um ihr Wissen zu testen.

Your tasks:

1. Individuelle Lösung (die Informationen können den Daten auf dem AB entnommen werden, oder durch eine kurze Internetrecherche gesammelt werden)
2. When laundry "dries" below 0 °C, water changes its state of matter from a liquid to a solid. The laundry freezes. Afterwards the water sublimates, it turns gaseous.
3. That statement is only partially true. "Heavier" only refers to the mass of both drinks. It should refer to the density which includes a substances mass per volume. So we also have to consider the volume of the coke drinks.
4. Individuelle Lösung (Ideas could include: using a magnifying glass, heating it, dissolving it in water and tasting it)

Concept Map: Properties of Matter

Hier wird eine Wortschatzübersicht zu Stoffen und Stoffeigenschaften für die Lernenden zur Verfügung gestellt. Die Concept Map kann beliebig ergänzt werden.

Your tasks:

Die Schüler:innen nutzen die Concept Map und verschriftlichen 10 Sätze in englischer Sprache, z.B.:

1. Temperature has an influence on the state of matter.
2. A gas has a low density.
3. Mass is related to density.
4. Volume is related to density.
5. Magnetic behaviour is a property of matter.
6. Solubility is a property of matter.
7. Flammability is a property of matter.
8. Solid (s) is a state symbol.
9. A chemical has a specific smell.
10. Some chemicals have a crystalline form.

⟺ Lassen Sie die Schüler:innen eine Concept Map mit den deutschen Begriffen erstellen und erweitern oder die englischsprachige Concept Map auf Deutsch kommentieren.

Weitere Informationen zur Arbeit mit Concept Maps finden Sie unter „Lösungen und didaktische Hinweise für Lehrkräfte" auf Seite 102.

2.2. The Particle Model (S. 22-25)

Lab Activity: Matter Is Made Up of Particles

Das Arbeitsblatt enthält eine Versuchsvorschrift zum Mischen von 50 mL Wasser und 50 mL Alkohol und einen Modellversuch mit Erbsen und Senfkörnern.

Hints for your conclusion:

1. Even though 50 mL of two liquids were added the final amount does not equal 100 mL.
2. Mustard seeds and peas differ in mass and size. Smaller particles fill gaps that the bigger particles create. So the mixture forms a smaller volume.
3. Water and alcohol are different substances, which is why their particles differ in size and mass.
4. Water and alcohol particles must have different sizes.
5. We would probably observe a volume of 100 mL.

Time to Practice: Diffusion of Gaseous Bromine

In diesem Arbeitsblatt wird die Diffusion von Bromdampf beschrieben wird. Die Schüler:innen sollen zu fünf Erklärungsansätzen Stellung nehmen und diese bewerten.

Your tasks:

1. Individuelle Lösungen.
2. Simon's statement is correct.
3. Individuelle Lösungen.

⟺ Die Schüler:innen formulieren am Ende der Bearbeitung des AB einen Glossareintrag bzw. eine Definition zum Teilchenmodell auf Deutsch. So stellen Sie als Lehrkraft sicher, dass die Fachsprache sowohl in der L1 als auch in der L2 gesichert ist.

Info: Particle Model

Dieses Arbeitsblatt enthält einen Informationstext und Aufgaben zum einfachen Teilchenmodell.

Your tasks:

1. When salt and sugar dissolve, salt and sugar particles move because of Brownian movement in the solution and diffuse into the water. They only seem to disappear.
2. The heat of the surrounding environment forces the particles to move faster. So water changes its state of matter from a liquid to a gas.

3. Particles in gases have a higher Brownian movement and diffusion rate than in other states of matter. The particles keep moving, so after some time one can detect this by smell.
4. Heat speeds up the movement of the particles, they move further apart so water becomes water vapor.
5. The particles in gases and liquids have a higher Brownian movement and fewer attractive forces than the particles in solids.

2.3. Mixtures and Separation Techniques (S. 26-43)

Lab Activity: Preparation of Instant Coffee

Das Arbeitsblatt enthält eine Versuchsvorschrift eines Schülerversuches zu verschiedenen Trennverfahren am Beispiel der Kaffeebohne. Die Kaffeebohnen werden gemahlen, der Bohnen-Extrakt filtriert, eingedampft und anschließend gelöst.

Hints for your conclusion

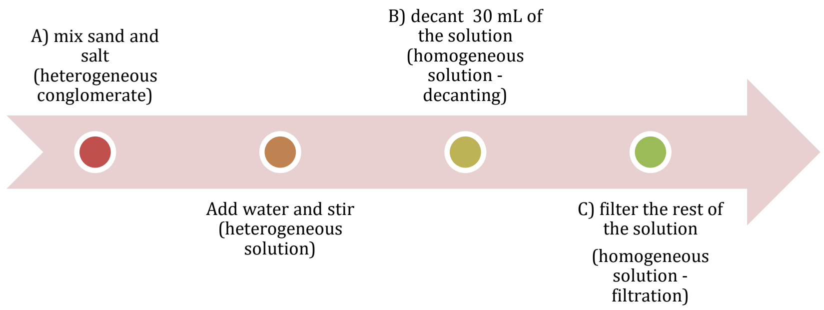
1. The mixture in step 2 is liquid and brown. The mixture in step 4 is solid and brown.
2. Die Schüler:innen sollen hier besonders ihre Beobachtungen aus dem Versuch mit einbeziehen. Die Farbe, der Geruch und die Oberflächenstruktur der verschiedenen festen Kaffeeprodukte können hier genauer beobachtet werden.
3. Hier sollen die Schüler:innen die einzelnen Schritte der Versuchsdurchführung in den Blick nehmen und beschreiben, was mit den Kaffeebohnen in den einzelnen Schritten passiert, e.g.: *The coffee beans are first ground into a powder. After that, a liquid coffee mixture is brought to a boil. It is then filtrated and heated again for the water to evaporate. The residue is mixed with water to create a final mixture.*
4. filtration (step 3), evaporation (step 3)

Lab Activity: Salt – Out of the Earth and onto Your Table

In diesem Arbeitsblatt wird eine Versuchsvorschrift zu verschiedenen Trennverfahren am Beispiel eines Sand-Salz-Gemisches behandelt.

1. + 4.+ 5. Flow Chart

Hints for your conclusion . Part I



2. Decanting, filtering
3. The sand is separated from the salt/water mixture by decanting. Filtration is used to separate the sand from the salt/water mixture.

Hints for your conclusion Part II

1. The liquid water is heated until evaporation. The water vapour (gaseous) is then cooled on the glass plate and liquified again.
2. The salt remains in the test-tube/porcelain dish and water evaporates and is collected in test-tube/beaker.
3. The students compare both experimental set-ups and describe which of them they prefer.

Info: From Rock Salt and Salt Water

Das Arbeitsblatt enthält einen Infotext zur Entsalzung von Salzwasser sowie passende Aufgaben.

Your tasks:

1. Sea water is desalinated in special basins via sedimentation and evaporation with the help of sunlight. By letting the water evaporate, pure salt crystallises. If you condense the water vapour and collect the water, you get fresh water as a by-product.
2. The high temperatures in the tropics and sub-tropics are needed to enable the evaporation of water.
3. Sedimentation: separation because of different densities, Decantation: separation because of different states of matter (a liquid and a solid substance), filtering: separation because of different states of matter (solid and liquid substances), distillation: separation because of different boiling temperatures

⟺ Exkurs: Lassen Sie die Schüler:innen die deutsche Salzproduktion recherchieren und ein kleines Referat auf Deutsch halten bzw. darauf basierend ein englischsprachiges Infoposter erstellen (e.g. Lüneburg – A salt city).

Lab Activity: Distillation of Red Wine

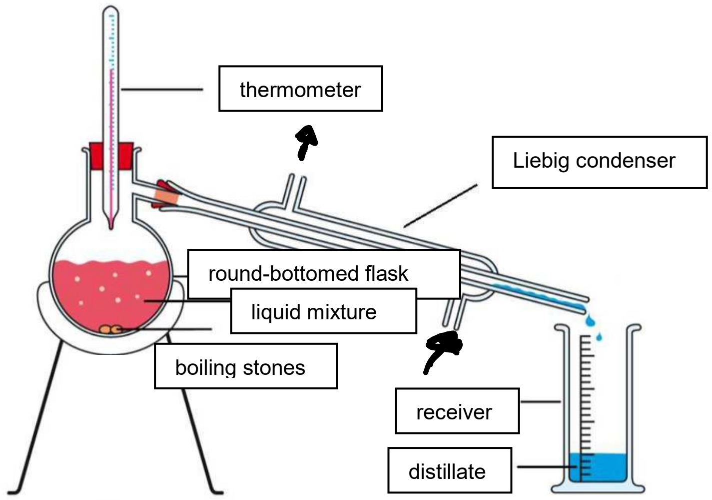
Das Arbeitsblatt enthält eine Versuchsvorschrift zur Destillation von Rotwein.
Der Versuchsaufbau ist zunächst mit der Intention der Auseinandersetzung mit der Versuchsapparatur zu beschriften: 1.round-bottomed flask, 2. boiling stone, 3. water out, 4. water in, 5. measuring cylinder

Hints for your conclusion

1. Ethanol and water are separated in the distillation process.
2. Boiling temperature of water: 100 °C, Boiling temperature of ethanol: 78 °C.
3. The mixtures might not have been separated completely because we heat it up to 80 °C.
4. The water used for cooling is well below 100 °C.

Time to Practice: Distillation of a Solution

Anhand des Übungsblattes kann der Aufbau einer Destillationsapparatur und deren Funktion erarbeitet werden.
1.+2.



3. Lückentext Reihenfolge: liquid, is heated up o. heats up, gas, thermometer, component, gas, cool, condenses, liquid, distillate

Lab Activity: The Secret of Being Green

Das Arbeitsblatt enthält eine Versuchsvorschrift zur Chromatografie von Blattgrün.

Hints for your conclusion:

1. Depending on the leaves you have chosen, one could probably observe three coloured spots (chlorophyll a and b- green, carotenoids – yellow, phaeophytin – grey).
2. Individuelle Schülerantwort, richtet sich nach verwendeten Blättern
3. Methylated spirit functions as a solvent. The solvent rises on the paper, where some components of the leaf extract move along better than others according to their solubility in methylated spirit and their adhesion to the cellulose molecules of the paper.
4. Diskutiert die Aussage kritisch, indem er/sie Bezug zu seinen/ihren Versuchsbeobachtungen nimmt, aus denen hervorgeht, dass verschiedenfarbige Komponenten im Extrakt enthalten sind.

Lab Activity: The Secret Colour of the Felt-Tip Pen

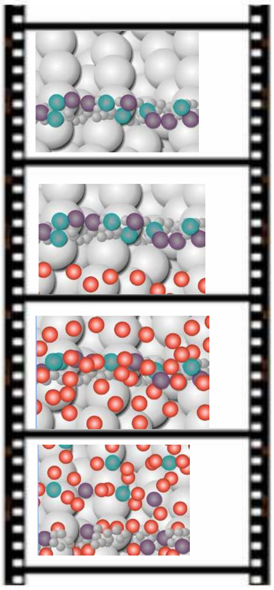
Das Arbeitsblatt enthält eine Versuchsvorschrift zur Papierchromatografie von Filzstiften.

Hints for your conclusion:

1. Chromatography is a method to separate dye mixtures. Black felt-tip pens contain a mixture of dyes. If one uses the filter paper as a stationary phase to place the dye on, the mobile phase water transports the colours to different spots on the filter paper depending on the solubility of the dyes and their adhesive powers.

2. (Betrachtung der Animation)

3.



4. The colours in permanent markers are not soluble in water. That is why the experiment does not work. The student should use another mobile phase, e.g., an organic solvent such as ethanol or acetone.

Time to Practice: Separation Techniques

Das Übungsblatt enthält einen Lückentext zu Stoffgemischen und –trennung mit vorgegebenen Auswahlmöglichkeiten sowie fünf Aufgaben.
Lösungen Lückentext:

1. In some cases, we use chromatography to find out if a substance is pure or if it is a mixture.
2. When you can see with your own eyes that a substance is a mixture then this substance belongs to the group of heterogeneous mixtures.
3. Smoke consists of solid particles mixed with gases.
4. Milk is an example of an emulsion. It is opaque and turbid because it is a heterogeneous mixture.
5. Salt water is a solution.
6. Solutions are homogeneous mixtures of solids in liquids, liquids in liquids or gases in liquids.
7. The mixtures in 6. are all clear and transparent.
8. A mixture of liquids in gases is fog.
9. Water colours in water form suspensions and ink is a solution.
10. Pure substances have a specific boiling temperature.

Tasks:

1. Chromatography is merely concerned with the separation of very small quantities of substances. The primary aim is to get an overview of whether the substance in question is a pure substance or a mixture. Therefore, the method of chromatography is not meant to separate substances on a large scale. See experiments on chromatography "The Secret of Being Green," "The Secret Colour of the Felt-Tip Pen" for reference.
2. Smog forms in densely populated areas. In such areas the solid particles of exhaust gases from cars and companies mix with water vapour that is in the air naturally. Depending on weather conditions, this mixture of solid particles, condensed water and air can stay above the area of origin. Smog most often appears in summer time when there is hardly any rain and only weak winds. Smog constitutes a heterogeneous mixture. This fact can be deduced by reduced visibility and the fact that at sunset the sky is dyed orange. Therefore, smog is not transparent.
3. One option would be to evaporate the water, condense and later collect it.
4. Sugar is soluble in water. Therefore, I would cut the sugar beets into small pieces and add these pieces to water. To speed up the process and to get as much sugar out of the plant, I would boil the suspension. After some time, I would separate the remnants of the plant and the sugar-water solution by filtrating it. The filtrate is heated up again so that all the water evaporates. The residue is sugar. Yet the sugar is not chemically pure and therefore most likely not white, but one could already consume it.
5. Iron production, paper and glass recycling, production of sugar and salt,...

Info: Separating a Mixture

Your tasks

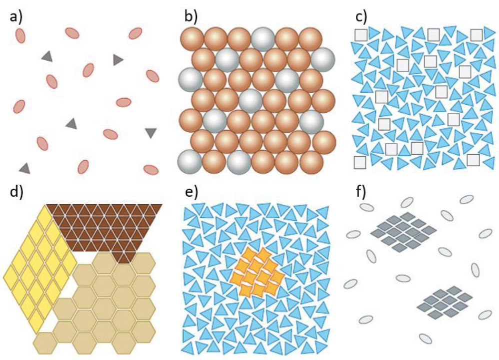
Das Arbeitsblatt enthält einen Infotext über homogene und heterogene Stoffgemische sowie passende Aufgaben für die Schüler:innen.

1)

	Heterogeneous mixtures	**Homogeneous mixtures**
toothpaste	X	
dusty air	X	
milk	X	
mineral water		x
wine		x
clouds	X	
ink		x
water colour	X	
mud	X	
washing powder	X	

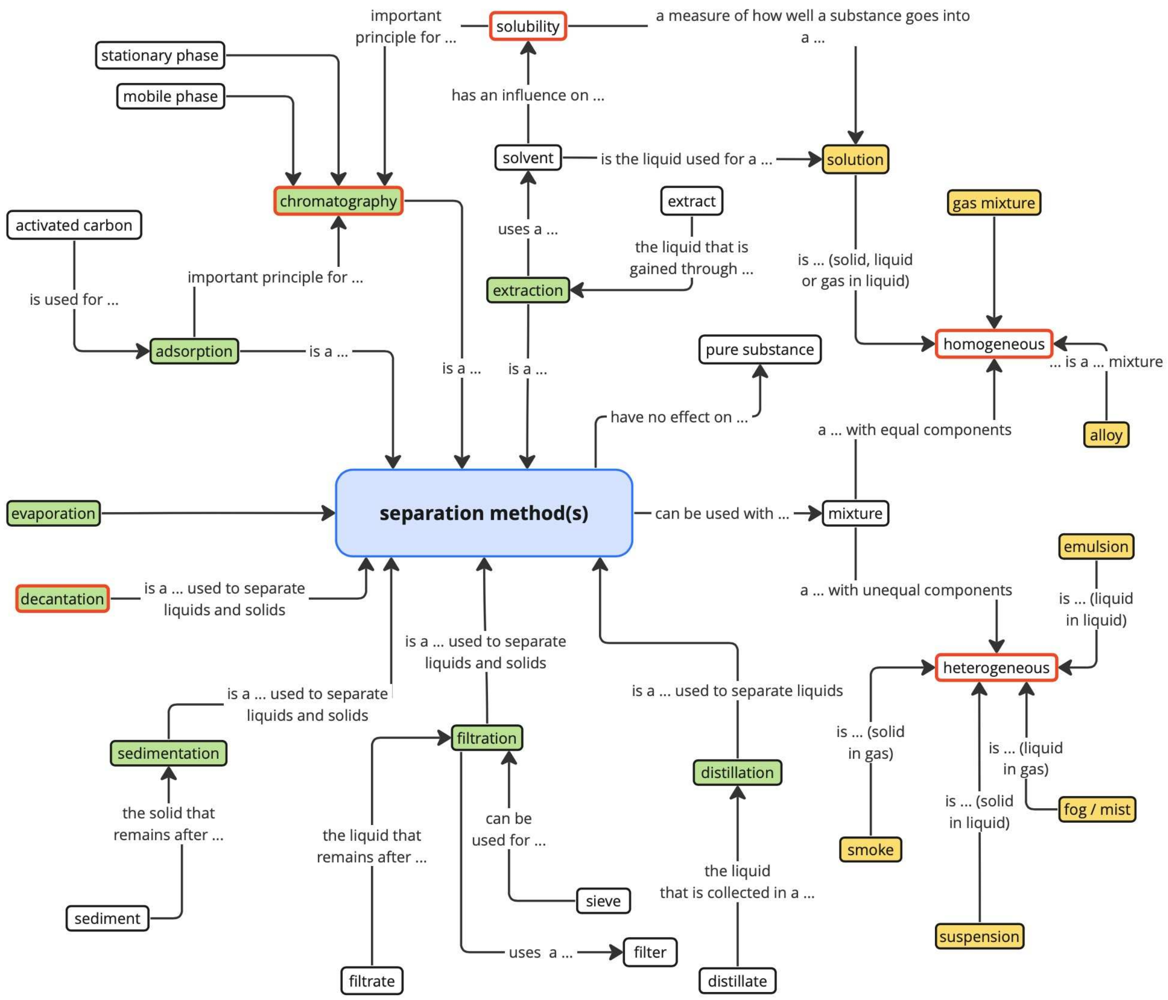
2)

Zuordnung der Abbildungen zu Stoffgemischen:
a) gaseous mixture b) alloy, c) solution,
d) agglomerate, e) suspension, f) smoke



Concept Map: Separation Techniques

Hier finden Sie eine Wortschatzübersicht zu Stofftrennverfahren mit Formulierungshilfen. Die Schüler:innen sollen die Begriffe in an die richtige Position in die Übersicht eintragen und anschließend Trennverfahren und Stoffgemische farbig markieren. Anschließend sollen Sie auf Deutsch zehn frei gewählte Begriffe erklären (Sprachwechsel).



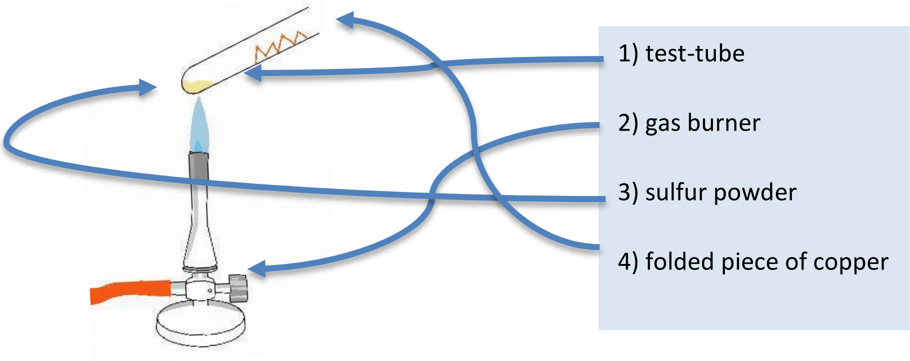
Chapter 3 Chemical Reactions

3.1. Conversion of Materials (S. 44-49)

Lab Activity: Chemical Reactions

Die Schüler:innen lernen mit Hilfe der Reaktion von Kupfer und Schwefel die grundlegenden Aspekte der chemischen Reaktion kennen und werden angeleitet, ihr Wissen in einer Wortgleichung auszudrücken.

Sketch



Hints for your conclusion:

antizipierte Schülerantworten (z.B.)

1.

	Copper	Sulfur
Properties	solid, metal strip, coppery, brown and shining	solid, non-metal powder, yellow

2. The cooled down copper strip displays characteristics of a solid, black - sometimes powdery - substance.

3. Some ideas might include: examining the substance under a microscope, heating it, cooling it, weighing it and checking whether it is magnetic.

4. Individuelle Schüler:innenantworten. Wichtige Begrifflichkeiten wären z.B. properties, new substance, chemical reaction, reactants, products.

5. A chemical reaction took place because the properties of the product are different from those of the reactants. A new substance with new chemical and physical properties was formed (black solid material– copper sulfide).

Lab Activity: The Copper Envelope

Das Experiment wird mit einem offenen Kupferbrief und mit einem offenen Kupferbrief mit Kohlenstoff (Aktivkohle) durchgeführt, etwas anders als bei dem klassischen Kupferbriefversuch.

⟺ Die Schüler:innen übertragen eine deutsche Versuchsanleitung zum Kupferbrief ins Englische und führen den Versuch durch.

Procedure

Mögliche Versuchsbeschreibung auf Englisch:
Fold an open sachet from a small, square piece of copper sheet
Then hold it with pliers for about 30 s in the rushing flame of the gas burner. Let it cool briefly. Now fill activated carbon powder into the letter and heat it again without shaking. Let it cool and pour out the remaining powder.

Hints for your conclusion

1. The copper sheet before the reaction is solid and coppery. After the reaction, the sheet is a black and solid substance.
2. There is less carbon in the envelope after heating it.
3. The inner envelope is coppery and shiny. The outer envelope is black.
4. Step 1: copper and oxygen; Step 2: oxygen and carbon
5. Step 1: copper(s) + oxygen(g) → copper oxide (s), Step 2: oxygen(g) + carbon(s) → carbon dioxide(g)

Info: Conversions of Materials During Chemical Reactions

In diesem AB lesen die Schüler:innen einen Informationstext zur chemischen Reaktion und bearbeiten anschließend Übungsaufgaben. Hierbei liegt der Fokus auf einer anfänglichen Betrachtungsweise der chemischen Reaktion als Prozess der Stoffumwandlung.

Your tasks:

1. a) Burning wood is a chemical reaction because new substances, coal and carbon dioxide, are formed.
   b) Dissolving salt in water is not a chemical reaction. If you heat the resulting salt solution, you can separate the components, salt and water, from each other.
   c) The rusting of an iron nail is a chemical reaction because a new substance, iron oxide, is formed.

2. The statement is wrong. The change of colour is a sign that a new substance, namely caramel, has formed. Sugar does not change its state of matter, but it takes part in a chemical reaction.

3. carbon dioxide (g) + water (l) → oxygen (g) + sugars (s)
   (with the help of sunlight and chlorophyll)

4. The experiment shows the heating of a copper and sulfur mixture. Both substances are heated in a test-tube. The reaction is complete when sulfur is no longer visible. The copper sheet is then extracted from the test-tube.

3.2. Energy in Chemical Reactions (S. 50-57)

Lab Activity: Energy and Chemical Reactions – Exothermic and Endothermic

Die Schüler:innen erhalten eine Versuchsvorschrift zur Reaktion von $CuSO_4 \cdot 5H_2O$ (blaues Kupfersulfat) und $CuSO_4$ (weißes Kupfersulfat), sowie eine kurze Einführung der Begriffe exotherm und endotherm.

Hints for your conclusion

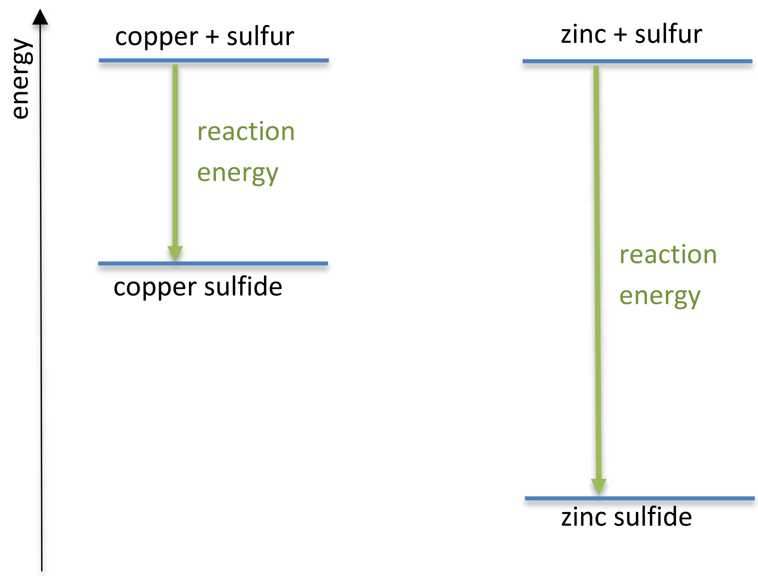
1. The colour of the solid before the reaction is blue. After the reaction it is light blue.
2. Water must be present as a product of the reaction in E1.
3. Water could come from the copper sulfate pentahydrate.
4. **E1:** copper sulfate pentahydrate(s) → copper sulfate(s) + water(l);
   E2: copper sulfate(s) + water(l) → copper sulfate pentahydrate(s)
5. One can regenerate the reactant from E2 by heating.
6. E1 is an endothermic reaction and E2 is an exothermic reaction.

Info: Energy and chemical reactions

Das Arbeitsblatt enthält einen Informationstext und Aufgaben zur Energiebeteiligung bei chemischen Reaktionen. Begrifflichkeiten, wie z.B. exotherm, endotherm und Aktivierungsenergie werden erläutert.

Your tasks:

1. Energiediagramm Kupfersulfid/Zinksulfid



2. The matches must be close together so the match heads are close enough to light each other.

Info: Energy Changes in Chemical Reactions

In dem Informationstext werden Energieänderungen bei chemischen Reaktionen und verschiedene Energieformen behandelt. Wenn Sie den geschilderten Versuch selbst durchführen, können Sie den Schüler:innen die freigesetzte Lichtenergie demonstrieren. Wenn Sie den Kolben von außen berühren, werden sie keine Temperaturveränderung bemerken, da es sich um kaltes Leuchten handelt.
Die Didaktik der Chemie der Universität Wuppertal stellt auf Ihrer Homepage noch weiteres Material zur Verfügung, z.B. wird dort die Reaktion mit der Wärmebildkamera gezeigt und im Ebook „Keeping track of the heat" erläutert, dass es sich um kaltes Licht handelt. Letzteres liegt als Ebook als Schüler- und Lehrerversionen vor.

⟺ Die Schüler:innen übertragen eine deutsche Versuchsanleitung zur Chemolumineszenz von Luminol ins Englische und schauen sich ein Video des Versuchs an. Eine mögliche Zusatzaufgabe für die Schüler:innen wäre, das Video mit englischen Untertiteln zu versehen.

Your tasks:

1. Beispielhafte Formulierung für die Durchführung des Experiments:
   The bottom of a 1L Erlenmeyer flask is covered with potassium hydroxide about 0.5 cm high. 1 mL of dimethyl sulfoxide and a small spatula tip of luminol are added. Then a good mixing is ensured by rotating the flask.

2. Observations for the experiment: The sample emits a bright, cool, white/bluish light.
3. In the reaction, chemical energy is partially transformed into light energy.
4. Light energy is released in a bonfire. Heat energy is released in a pocket warmer. Electric energy is released through a battery.
5. Picture 1: chemical energy in light energy
   Picture 2: light energy in chemical energy
   Picture 3: heat energy in chemical energy
   Picture 4: chemical energy in heat energy
   Picture 5: chemical energy in electrical energy
   Picture 6: chemical energy in electric energy

Lab Activity: Examination of a Glow Stick

Das Experiment enthält ein Schüler:innenexperiment mit einem Knicklicht. Die Erkenntnisse zu verschiedenen Energieformen und deren Umwandlung bei chemischen Reaktionen werden hier noch einmal thematisiert und kontextualisiert.

Sketch Label 1- plastic tube, Label 2-dye solution, Label 3- glass tube with a solution

1. To crack the glass tube inside the glow stick, it is necessary to bend it. Thus activating the reaction by mixing the chemicals involved.

Hints for your conclusion:

2. The reactants mix and react with each other. In the reaction, cold light is emitted.
3. Chemical energy is transformed into light energy.
4. Glow stick bracelets are not environmentally friendly because they can only be used once and are not recyclable.

Beyond the experiment

Die Schüler:innen recherchieren die Funktion von Biolumineszenz in Organismen.

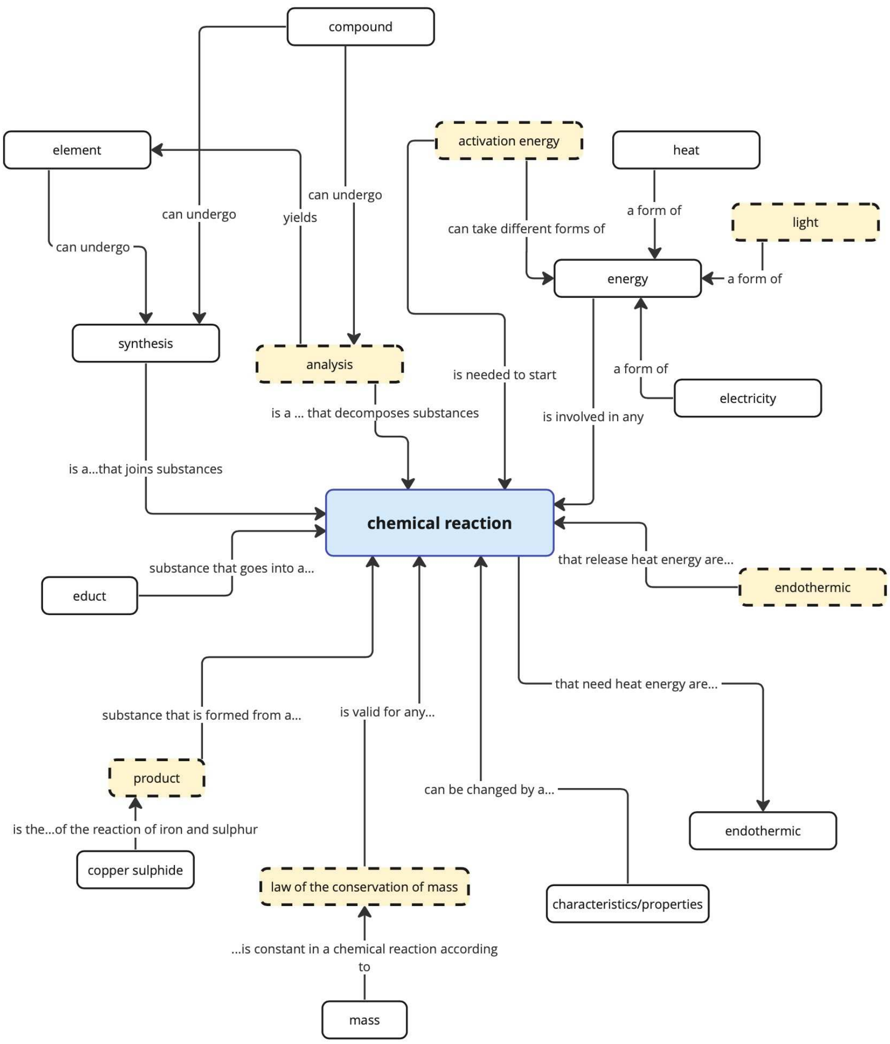
Mögliche Links für die Recherche:

Wissenschaft aktuell
https://www.wissenschaft-aktuell.de/extra_rubriken/Biolumineszenz__Wenn_Lebewesen_leuchten.html (letzter Zugriff 23.09.24).

Spektrum
https://www.spektrum.de/lexikon/biologie-kompakt/biolumineszenz/1553 (letzter Zugriff 23.09.24).

Concept Map: Chemical Reactions

Eine Wortschatzübersicht zu chemischen Reaktionen. Die Schüler:innen sollen hier die Lücken mit passenden englischen Begriffen füllen.



Chapter 4 Combustions
4.1. Air – A Gas Mixture? (S. 58-67)

Lab Activity: The Composition of Air

Allgemeines:

Versuchsvorschrift zur Zusammensetzung der Luft (Reaktion von Eisenwolle im geschlossenen Versuchsraum; Volumendifferenz ermitteln und auf Sauerstoffanteil schließen).
Die Eisenwolle muss zunächst mit einem Lösemittel wie Aceton entfettet und anschließend getrocknet werden. Für den Fall, dass noch Lösemittelreste anhaften, wird dieses beim Erhitzen mit erhitzt und verbrannt, was den Versuchsverlauf und das -ergebnis stören würde.

Observation:

a. *before*: shiny, grey, metallic; flexible; *after*: bluish black, dull, brittle or short ('short' is the technical term for 'spröde'; it is important to point out that parts of the iron wool remain unchanged).
b. the volume is supposed to decrease from 100% to approximately 80%, e.g., from 100 mL to 80 mL
c. The flame of the burning splint dies.

Hints for your conclusion:

1. A new substance with new properties has formed (cf. observations above). However, not all of the iron wool has reacted due to the fact that there is so much of it and only a little air. The amount of iron exceeds by far the amount of oxygen. (Die Lehrkraft könnte dieses später aufgreifen und Experimente mit unterschiedlichen Portionen Eisenwolle in Luft oder reinem Sauerstoff durchführen lassen bzw. selbst durchführen.)
2. Atmospheric oxygen must have been the reactant as only a minor part - one fifth - of the surrounding air inside the syringe has reacted. It is known that nitrogen makes up the greatest part in air, i.e. slightly less than four-fifths.
3. word equation: iron (s) + oxygen (g) → iron oxide (s)
4. Oxygen is vital for combustions. After the reaction, there is no more oxygen in the apparatus as the observation of the dying flame proves. Therefore, oxygen and iron have reacted to form a new compound called iron oxide.
5. individuelle Berechnungen
6. There is air in both the gas syringes and the glass cylinder. In total, there is a greater volume of air in the whole apparatus, i.e. more than 100 mL. The oxygen in the whole portion of air will react with iron, whereby the syringe volume will be reduced by far more than the expected amount of 20 mL.
7. The goal of this experiment is to let the whole amount of oxygen react. In order to reach this goal, sufficient iron is needed. If there was too little iron, we would not be able to let all oxygen particles react. Thus, we would not be able to let the complete amount of oxygen react to form the new compound iron oxide.

6. Didaktische Hinweise und Lösungen für Lehrkräfte

Info: The Composition of Air

Your tasks:

1. These are the noble gases: helium, neon, argon, krypton, xenon, radon, (oganesson; for further information consult: “Oganesson” https://www.britannica.com/science/element-118 (Access: 23.09.24).
2. Individuelle SuS’-Lsg. Die inhaltlichen Kriterien für das Poster können gemeinsam erarbeitet werden (vgl. auch Info: Hydrogen)
3. Individuelle SuS‘-Lsg., bei denen folgende Paare genannt werden können:

Glowing splint test	**Glimmspanprobe**
test-tube	Reagenzglas
wooden splint	Holzspan
Lighter	Feuerzeug
to glow	Glühen
Gas	Gas
Oxygen	Sauerstoff
to catch fire	anfangen zu brennen

Lime water test	**Kalkwasserprobe**
test-tube	Reagenzglas
lime water	Kalkwasser
rubber tube	Gummischlauch
to lead gas in the solution	Gas in die Lösung einleiten
carbon dioxide	Kohlenstoffdioxid
formation of a white precipitate	Bildung eines weißen Niederschlags

Lab Activity: The Greenhouse Effect

Allgemeines: Versuchsvorschrift zum Modellversuch zum Treibhauseffekt mit Luft und Kohlenstoffdioxid mit Leitfragen.

Ein allgemeiner Grundsatz, doch hier besonders wichtig, damit der Versuch gelingt: Das Experiment muss zuvor unbedingt hinsichtlich Materialienauswahl, Durchführung und Auswertung durchdacht werden, da nur geringe Temperaturveränderungen von ca. 2 °C zu erwarten sind. Insbesondere Petrischalen- und Glaswannengröße müssen aufeinander abgestimmt werden. Für ein Gelingen ist auch das ausreichende Fluten mit Kohlenstoffdioxid-Gas sicherzustellen. Es hat sich bewährt, große Erlenmeyerkolben entsprechender Volumina vorab mit Kohlenstoffdioxid-Gas zu fluten und dann vor dem Experiment die Glaswanne zu beschicken. Mit einem brennenden Span lässt sich ermitteln, wie hoch die Glaswanne mit Kohlenstoffdioxid befüllt ist.

Hints for your conclusion:

1. The lamp emits light and heat energy. Carbon dioxide can absorb parts of the radiation emitted by the lamp therefore there is a higher temperature to be measured in the glass trough in comparison to the set-up with air.
2. LAND: cardboard (and snow-covered land: aluminium foil) – this solid matter either absorbs or reflects radiation and the black cardboard gets warmer while emitting infrared radiation and heating up the surroundings; CLOUDS: Petri dish

with water – both Petri dish and clouds 'contain' water, but whereas clouds contain water vapour or fog, the Petri dish contains liquid water; SUN: lamp – both sources emit electromagnetic waves of a certain spectrum (light and heat energy).

3. This part of the experiment is comparable to the albedo effect as this metallic, shiny surface reflects the radiation whereas the black cardboard absorbs it.

Info: The Greenhouse Effect

Your tasks:

1. **Zuordnung der Buchstaben**: sunlight – I; earth – E; heat – Q; greenhouse gases – g; atmosphere – A; S – space;

   Beispieltext: Figure 3 contains a schematic procedure which helps explain the greenhouse effect. From top to bottom, there are three layers of slightly curved, somewhat semicircular shapes: a dark blue one, a light blue one and a brown one with bluish parts. They represent (outer) space (S), the atmosphere (A) and planet earth which comprises of land (E) and water (i.e. seas and rivers).
   This tripartite structure serves as the context in which arrows indicate a kind of action: On the left, there is a big yellow arrow (I). It cuts through the two blue layers and points directly at or even into the brown shape. Within the light blue layer, a part of the big yellow arrow bends in the opposite direction and extends into the dark blue layer. On the right, an orange arrow (Q) takes its point of origin in the brown shape at the bottom and points at a semicircular line of lower-case letters "g" in the upper part of the light blue layer, just neighbouring on the dark blue layer. A second orange arrow of smaller size seemingly continues the way the big orange arrow has taken towards the line of "g's." It is located in the dark blue layer in the top right corner.
   The yellow arrow represents solar radiation which enters the atmosphere. 70% of it reaches the surface of the earth, whereas 30%, i.e. approximately one third, are reflected back into space. This is shown by means of the small yellow arrow pointing upwards.
   When the sun's radiation reaches the ground, it is absorbed by it and by plants. As a result, two processes take place. First of all, ground and plants heat up. Second, a part of the light touching the ground is converted into heat, which is then reflected. This process is depicted by the orange arrow, which is slightly smaller than the yellow arrow. Thereby, the two aforementioned processes are indicated.
   The line of "g's" represent greenhouse gases, which keep a part of the radiation from leaving the planet. This is the reason why there is a smaller orange arrow right behind the "g's." It stands for the amount of radiation which has finally been reflected into space. As a consequence, a part of the original energy contained in solar radiation is trapped as heat, thereby keeping planet Earth warm.
   (The figure cannot answer the questions as to why a part of the sun's radiation is reflected and what happens to the greenhouse gases when in contact with the heat reflected from the earth. Nevertheless, the figure presents the integral parts which are most important for relatively mild temperatures on the earth's surface.)

⟺**Idee für einen Sprachwechsel**: Erarbeiten Sie eine deutsch-englische Mindmap mit zentralen Begrifflichkeiten und Redewendungen zum natürlichen und anthropogenen Treibhauseffekt. Es bietet sich an, nach sprachlichen Stolpersteinen, d.h. mehrdeutigen Begriffen zu schauen und diese mit Ihren Schüler:innen zu analysieren. Beispielsweise können Sie mithilfe des Oxford English Dictionary die unterschiedlichen englischen sprachlichen Realisationsformen von "Lichtstrahl" untersuchen: beam vs. ray. Ferner bietet es sich an zu untersuchen, wie der Begriff Kohlenstoffdioxid im Englischen in unterschiedlichen Kontexten realisiert werden kann. Auch hier ist eine Recherche im Oxford English Dictionary gewinnbringend. Die Orientierung des Sprachvergleiches anhand von Stolpersteinen geht auf Christa Rittersbacher zurück, vgl. z.B. diesen Link zu einem open access-Artikel, der Grundlegendes beschreibt:
https://phka.bsz-bw.de/frontdoor/deliver/index/docId/92/file/Dialog+-+2.+Jahrgang+2015+Heft+1+-+BILDUNG+UND+MEHRSPACHIGKEIT.pdf (S. 19ff).

⟺**Idee für einen Sprachwechsel**: Überdies bietet es sich an, auf Basis des zusammengestellten Vokabulars einen Erklärtext in deutscher Sprache zu Abbildung 3 anzufertigen.

2. Structure and composition of the atmosphere

The lower and middle parts of the atmosphere

Part	**Altitude/km**	**Comment/further information**
Thermosphere	80+	
Mesosphere	50-80	Mesosphere and thermosphere belong to ionosphere, which extends up to 550 km
Stratosphere	15-50	Concorde flew at 15 km; ER-2 research planes fly at 18 km
Troposphere	0-15	8,850 m height of Mount Everest* The higher you go, the less dense the atmosphere becomes. The troposphere comprises approximately 90 % of all of the molecules.

*Möglicher interkultureller Exkurs zum Mount Everest:
In 1865, the mountain previously referred to as Peak XV was named after Sir G. Everest (1790-1866), who was Surveyor-General of India from 1830-1843. Alternative names for the mountain are: Sagarmatha (Sanskrit and Nepali), Chomolungma (Tibetan), Qomolangma Feng (Chinese). Hier können Bezüge zum Kolonialismus, heutigen Bedingungen in der Region und im Sinne von BNE hergestellt werden.

Sources:
"Chomolungma" in:
https://www.collinsdictionary.com/de/worterbuch/englisch/chomolungma (23.09.24)
University of York Science Education Group, i.e. Otter, Chris, et al. (2015). A Level Salters Advanced Chemistry for OCR. 4th ed. Oxford University Press, pp. 194-198.

"Mount Everest" in: https://www.britannica.com/place/Mount-Everest (Access: 23.09.24)

3. Sources of some gases produced as a result of human activity

Gas	Main source as a result of human activities
carbon dioxide	combustion of hydrocarbon fuels (e.g., in power stations, motor vehicles); deforestation
methane	cattle farming; landfill sites; rice paddy fields; natural gas leakage
nitrous oxide (Lachgas, N_2O)	fertilised soils; changes in land use (e.g., from the soil when land is ploughed up)
f-gases (fluorinated greenhouse gases)	broken refrigeration and air condition equipment (usage as cooling agents); from insulating foam or components in fire-extinguishers (usage as blowing agents)

Further information:

Source of "carbon dioxide", "methane", and "nitrous oxide":
University of York Science Education Group, i.e. Otter, Chris, et al. (2015). A Level Salters Advanced Chemistry for OCR. 4th ed. Oxford University Press, p. 197.

F-gases
"The impacts of climate change are now being felt everywhere around the globe. Renowned international experts say that the rise in temperature will have disastrous consequences for mankind, which is why climate action is one of our greatest ecological and economic challenges. The Kyoto Protocol is the most important and most prominent milestone of global climate action. It includes not only carbon dioxide (CO_2) but also fluorinated greenhouse gases as their impact on the climate is 100 to 24,000 times the impact of CO_2. […] While greenhouse gases are usually undesired by-products, for example, of the combustion of fossil fuels, fluorinated greenhouse gases are generally produced and released intentionally. They are used in similar ways as were *chlorofluorocarbons* (CFCs; dt. Fluorchlorkohlenwasserstoffe FCKWs) or *halons* (dt. Halogenkohlenwasserstoffe), which are responsible for destroying the stratospheric ozone layer."
Source: "Fluorinated greenhouse gases (f-gases)"
https://www.bmuv.de/en/themen/luft/ozonschicht-ozonloch/fluorinated-greenhouse-gases-f-gases (Access: 23.09.24)

4. The answers are subdivided into two sections, i.e. A) and B):
Section A) What can you do yourself?
- reconsider one's role as a consumer (cf. the terms consumption/overconsumption/consumerism in Annie Leonard's *The Story of Stuff*, of which an extract can be found in some Secondary English text book, e.g. ask an English teacher), ultimately resulting in purchasing less and thereby saving the earth's resources
- repair broken things, i.e. extending their lives thereby countering their planned obsolescence
- reconsider one's attitude towards the concept of perceived obsolescence
- decrease the emission of carbon dioxide and nitrogen oxides by using public transport or cycling
- eat less meat; refrain from purchasing goods from intensive livestock farming

- avoid energy waste by switching off electronic devices instead of using stand-by functions
- prefer electricity providers whose energy is based on renewable energy sources
- separate waste and dispose of hazardous waste according to the regulations
- buy fruits that are sold loose
- buy products/grocery without packaging
- refrain from buying equipment containing f-gases
- reconsider one's travel habits: soft tourism vs. hard tourism
- live sustainably: consume environmentally friendly, socially compatible produce which also takes animal welfare in consideration
- refrain from fertilizing your garden or moderate the usage of fertilizers

Section B) What do you expect from politicians and businesspeople?

- increase the price for products and goods that have been produced ignoring aforementioned sustainability aspects (i.e. environmental issues, social compatibility, animal welfare)
- ban on planned obsolescence -> products can be used longer
- introduce laws ensuring that certain devices must be repairable -> repairing rather than throwing away
- tax privileges for environmentally friendly companies and their products
- are supposed to rethink the worldwide reliance on growth economy and consider alternative movements such as post growth economy
- leaders should lead by example, e.g. by driving environmentally friendly cars based on renewable energy
- town planning has to find alternatives to *floor sealing* (dt. Bodenversiegelung) by refraining from opening new construction areas/development areas; instead, they could enhance public transport and enable and encourage commuters to live in different cities rather than moving to one city
- in Germany, old-fashioned car industry has been one of the economic driving forces; politicians are supposed to reconceptualise German economy.

"Soft tourism": https://www.bfn.de/en/activities/tourism-and-sports/tourism/ecotourism/soft-tourism.html (Access: 23.09.24)

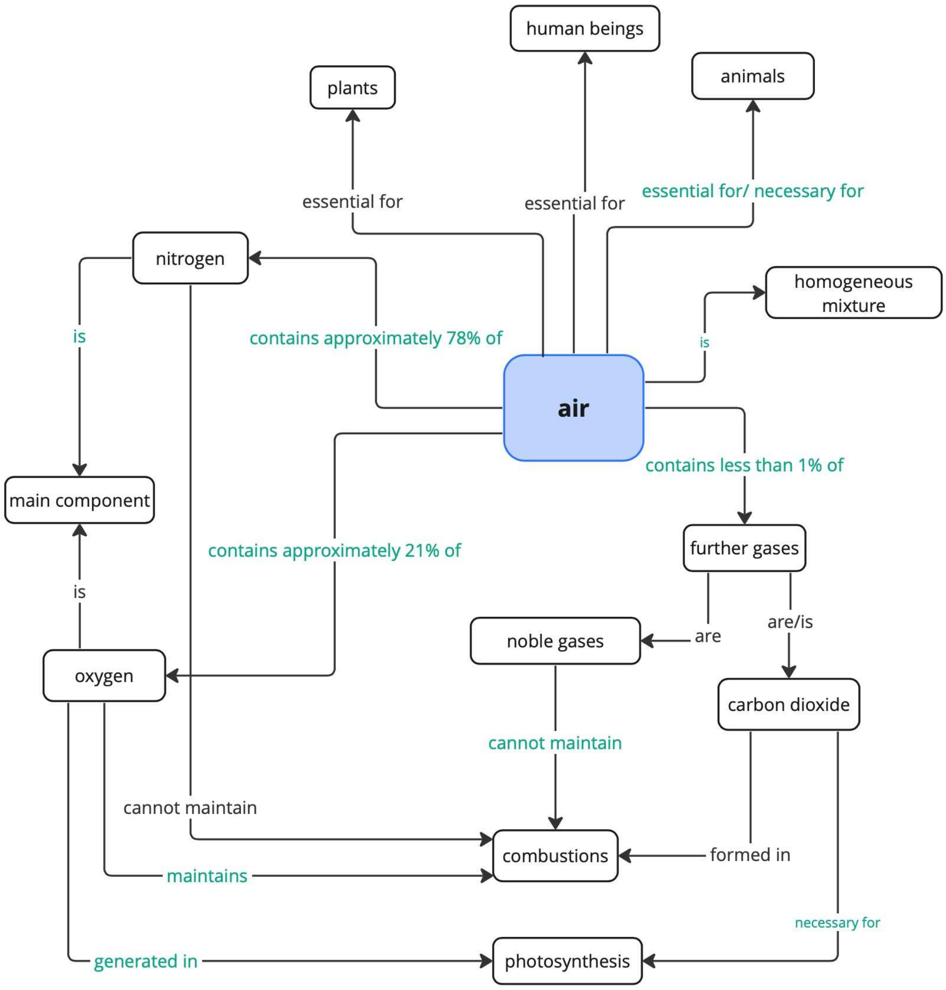
Concept Map: Air – A Homogeneous Mixture

Allgemeines: Auf eine Durchnummerierung der Lücken in der Kopiervorlage für die Schüler:innen wurde verzichtet, damit die Orientierung in der Concept Map ein Kommunikationsanlass bleibt. In den Gesprächen kann man sich dann einerseits inhaltlich, d.h. an den zentralen Vokabeln, orientieren. Andererseits kann eine Orientierung über klassisches (Bild-) Beschreibungsvokabular erfolgen, z.B. "I would like to fill the gap which is located between the words air and homogeneous mixture. I suggest the relation 'is'.". Zu Ihren Händen finden Sie aber zur raschen Orientierung eine durchnummerierte Concept Map mit den zehn Auslassungen und eine Liste zu den zehn einzusetzenden Wörtern.
Die schnellen Schüler:innen können z.B. Synonyme zu den gefundenen Relationen finden, deutsche Begriffe hinzuschreiben, ein Kreuzworträtsel oder Quiz erstellen sowie das Concept Map mit selbstgewählten Wörtern und Pfeilen erweitern.

Lösungsvorschlag: Relationen

1. essential for / necessary for
2. contains less than 1% of
3. essential for / necessary for
4. cannot maintain
5. maintains
6. generated in
7. is
8. contains approximately 21% of
9. contains approximately 78% of
10. is

Concept Map (incl. nummerierter Leerstellen):



4.2. Burnt Does Not Mean "Gone" (S. 68-79)

Lab Activity: Oxidation

Allgemeines: Das Experiment führt das Thema Verbrennungen anhand der Oxidation von Eisenwolle ein. Es liefert klare Beobachtungen. Der möglichen Schüler:innenvorstellung, dass die Flamme an sich für die Oxidation verantwortlich ist, also wie ein Edukt wirkt, wird mit Experimentteil E2 Rechnung getragen.

Observation:

E1
before burning: shiny, grey, bendable
while being burnt: glows yellow, sparks fall on lab table, turns bluish black
after burning: matte, bluish black, brittle/short

E2
before burning: shiny, grey, bendable
while being burnt: glowing , turns bluish black
after burning: matte, bluish black, brittle/short

Hints for your conclusion:

1. before burning: shiny, grey, bendable
   after burning: matte, bluish black, brittle/short
   A new substance with new properties is formed.
2. Products look similar, both are brittle. As a consequence, they must be the same substance.

   <u>similarities of E1 and E2:</u>
   - iron wool is heated in air
   - heated by burner
   - identical/similar masses of iron wool portions
   - fuzzy iron balls appear similar in shape before the experiments

   <u>differences:</u>
   - in E2, the burner flame does not touch the iron wool
   - in E1, wool is held by a pair of tongs (→ für Eingeweihte ist das unbedeutend, doch aus Schüler:innenperspektive ist es verständlich, dass auch die Metallzange einen Einfluss haben kann; ggf. durch ein Folgeexperiment bestätigen, z.B. Eisenwolle auf einer Glaskeramikplatte erhitzen oder von zwei schwer schmelzbaren RG gehalten o.ä., Stichwort Faktorenkontrolle)
3. The statement is wrong because the iron wool reacts in both experimental set-ups of which one ensures that the flame does not touch the wool at all. Therefore, the chemical reaction does not necessitate the contact between flame and iron wool.
4. If there is no air inside, the reaction does not take place. From this, one can infer that air or a part of air (oxygen), is one of the reactants. The other reactant is iron.
5. Based on the information that copper forms copper oxide, a corresponding pair for this experiment would be iron and iron oxide.
6. iron (s) + oxygen (g) → iron oxide (s)

Info: Combustions Are Everywhere

Your tasks:

1. reactant: iron (s), oxygen (g)
   product: iron oxide (s)
   The pictures must be matched appropriately. Iron belongs to the photo depicting a grey, slightly shiny solid, whereas iron oxide belongs to the one depicting a matte, bluish black solid. Oxygen belongs to the picture depicting a glass syringe containing a colourless gas.
2. zinc (s) + oxygen (g) → zinc oxide (s)
3. Which letter a-d represents the amount of chemical energy of the reactants? **a**
   Which letter represents the amount of chemical energy of the product? **c**
   Which letter indicates the amount of activation energy? **b**
   Which letter indicates the amount of reaction energy in this reaction? **d**

Lab Activity: The Conservation of Mass

Allgemeines:

Der erste Balkenwaagenversuch bestätigt scheinbar das Präkonzept, dass beim Verbrennen etwas vernichtet wird – die Holzstäbe verlieren an Masse – nur um vom zweiten Balkenwagenversuch in Frage gestellt zu werden: Hier wird ein kognitiver Konflikt, ausgelöst durch die Massenzunahme, erzeugt, der über das Teilchenmodell und die Produktarten gelöst werden kann. Ein Transfer findet in Versuch E3 statt, bei dem die gasförmigen Verbrennungsprodukte im geschlossenen System verbleiben und so das Gesetz der Erhaltung der Masse nachvollzogen werden kann.

Online Animationen (Deutsch und Englisch):

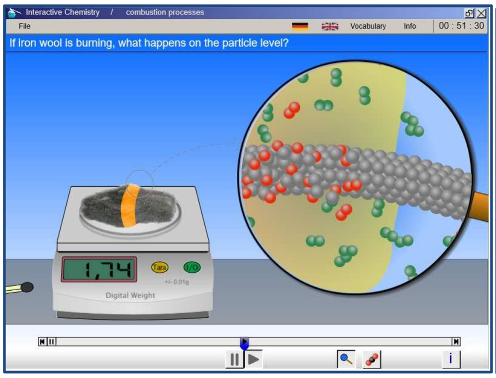
Auf https://www.chemie-interaktiv.net gibt es Animationen, die die beiden Verbrennungsvorgänge auf makroskopischer und submikroskopischer Ebene nachvollziehen lassen. Hier sind es nun digitale Waagen, auf denen die Stoffportionen verbrannt werden. Die Animationen, die an der Wuppertaler Chemiedidaktik entwickelt wurden (Schmitz/Bohrmann-Linde/Tausch 2007) liegen in deutscher und englischer Sprache vor:

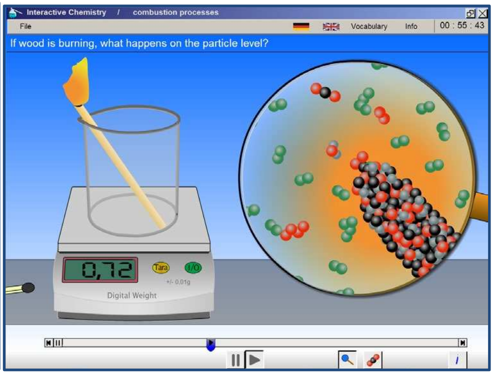
Links:

Verbrennungsvorgänge: Eisenwolle (Zugriff: 23.09.24)
https://www.chemie-interaktiv.net/html5_flash/a142.html bzw.
https://chemiedidaktik.uni-wuppertal.de/fileadmin/Chemie/chemiedidaktik/files/html5_animations/rp-schmitz/verbrennung_eisen/verbrennung_eisen.html

Verbrennungsvorgänge: Holz (Zugriff: 23.09.24)
https://chemiedidaktik.uni-wuppertal.de/fileadmin/Chemie/chemiedidaktik/files/flashlist/flash/verbrennung/index.html

Screenshots: Mit Hilfe dieser Schnappschüsse können erste Einblicke gewonnen werden. Links im Bild wird der Verbrennungsprozess in Augenschein genommen. Rechts, über die zuschaltbare Lupenfunktion, wird die Teilchenebene visualisiert. Über die Deutschlandfahne und den Union Jack kann die Sprache gewählt werden. Eine aufrufbare Legende und eine Vokabelliste (nicht in der HTML5-Version) komplettieren die Animationen.





Versuch E1 Observation: The piece of wood burns with a small yellow, slightly sooty flame. The longer the piece of wood burns, the smaller it becomes. The burned wood becomes black. The side at the scale with the burning piece of wood raises.

Versuch E2 Observation: The iron wool glows and slightly burns with a yellow colour. The formerly shiny grey substance turns into a matte, bluish black solid. The side at the scale with the burning wool sinks.

Your tasks:

1. carbon (s) + oxide (g) → carbon dioxide (g)
   iron (s) + oxide (g) → iron oxide (s)

⟺ **Idee für einen Sprachwechsel**: Lassen Sie stop-motion-Filme erstellen, die von obigen Animationen angeregt sein können. Beschriftungen der Abläufe und der verwendeten „Protagonisten“ sollten in deutscher Sprache erfolgen. Ggf. kann dann ein englischer Kommentar eingesprochen werden oder umgekehrt. Zuvor sollte das zentrale Vokabular in beiden Sprachen erarbeitet werden incl. der Aussprache.

2. Oxides are formed in both reactions. The first reaction results in gaseous oxides, whereas the second results in solid oxides.
   Iron is a metal, while carbon is a non-metal. It can be assumed that metals form solid oxides, while non-metals form gaseous oxides. This assumption has to be substantiated by further experiments or further research.
   Carbon dioxide is gaseous. It is formed from chemically bonded carbon in the piece of wood and oxygen from the air. The gas mixes with the surrounding air because there is nothing to stop it. There is neither a barrier nor a substance that can absorb it. It cannot be weighed; only the remaining piece of wood can be weighed. Therefore, this side goes up.
   Iron oxide is a solid. It has formed from iron and oxygen from the air. Since it is a solid, it cannot leave the burning iron wool, it simply remains where it has been produced. Thus, it can be weighed. When burning, more and more oxygen

particles react with iron particles. This side goes down, because oxygen from the air and iron are chemically bonded to each other.
A “problem” of the set-up with the beam balance is that one of the two reactants, the oxygen, cannot be weighed at all.
⇔ **Idee für einen Sprachwechsel:** Untersuchen Sie u.a. mithilfe des Oxford English Dictionary die unterschiedlichen Bedeutungen der Worte carbon und carbon dioxide und setzen Sie diese mit deutschen Entsprechungen ins Verhältnis.

Versuch E3
Your tasks:

1. *Before heating*: The matches have red heads and a wooden body; the balloon is slack. *After heating*: The matches are black and brown, in some parts they are grey and somewhat white, especially at the tip where the red head was. Some sooty, brownish liquid has condensed in the test-tube. There is some smoke in it. The balloon has inflated.
2. Once the test-tube has cooled down, the mass after heating equals the mass before heating.
3. In E1, the glass container (the beaker) is open. The setup considers only solid (or liquid) reactants – gaseous reactants cannot be weighed. Furthermore, gaseous reaction products can leave it. In E3, the glass container (the test-tube) is sealed with the balloon. It is closed. Gaseous reaction products cannot leave the apparatus. The matches have burned inside this closed container.
4. A chart visualizes these aspects (add further aspects/feel free to particularize the aspects further):

A comparison of the setups in E1 and E3

	E1 “beaker”	E3 “test-tube”
container is open	x	
container is closed		x
mass of all reactants can be weighed		x
mass of all products can be weighed		x

In E3, all reactants and all products can be weighed because none of them can leave the closed test-tube. There is a closed system. We see that the mass before and after the chemical reaction remains the same. No mass has been destroyed. In E1, only solid (or liquid) reactants and products can be considered. Neither gaseous reactants nor gaseous products can be weighed, which is why it seems as if the products are lighter than the reactants. If the gaseous products were caught and weighed, the result would have been similar to the one in E3.

6. Didaktische Hinweise und Lösungen für Lehrkräfte

Info: The Law of Conservation of Mass, or: "Nothing Is Ever Lost"

Allgemeines: Der Text liefert schlüssige Informationen, um die Beobachtungen der beiden Balkenwaagenversuche auf der Teilchenebene zu erklären. Da in der Regel an dieser Stelle des Chemieunterrichts der Molekül-Begriff noch nicht eingeführt ist, wird die Bezeichnung oxygen particles statt oxygen molecules verwendet. Analoges gilt für carbon dioxide particles

The combustion of carbon using John Dalton's atomic model

Your tasks:

1. With regard to the reaction between carbon and oxygen, there are six carbon atoms on the left and on the right side of the reaction arrow. In each case, there are twelve oxygen atoms.
2. Diese Aufgabe kann wie die Reaktionsgleichung „Kohlenstoff reagiert mit Sauerstoff" umgesetzt werden (siehe Versuch "Conservation of mass" E2). Zudem kann die o.g. Animation (Verbrennungsvorgänge → Holz) Verwendung finden. Dort wird Holz als Kohlenhydrat angesehen – eine chemische Verbindung aus Kohlenstoff, Sauerstoff und Wasserstoff. Auch die Rauchbildung wird visualisiert.

The combustion of iron using John Dalton's atomic model

Your tasks

1. With regard to the reaction between iron and oxygen, there are **eight iron atoms** and **eight oxygen** atoms in each case. As each atom has a specific mass and the number of atoms does not change, we can say that the masses of reactants equals the masses of products. (Hinweis: Es ist empfehlenswert Schüler:innen darauf hinzuweisen, dass die betrachteten Stoffportionen deutlich höhere Zahlen an Atomen enthalten.)
2. Hier soll thematisiert werden, dass die gasförmigen Reaktionsprodukte das geschlossene System nicht verlassen können, das offene System hingegen schon. The mass would be much lighter than before heating the test-tube. This is due to the fact that the balloon as well as the gaseous products cannot be weighed anymore. The closed system has become an open system.

Lab Activity: Boyle's Experiment

Allgemeines: Das Experiment entspricht in gewisser Weise dem Verbrennen von Streichhölzern im verschlossenen Reagenzglas. Nun wird mit Aktivkohle in reinem Sauerstoff gearbeitet. Die Aktivkohle verbrennt restlos – der Feststoff reagiert komplett zu gasförmigen Produkten. Es ist hilfreich, in einem abgedunkelten Raum zu arbeiten und den Kolben kräftig zu schwenken, sobald die Aktivkohle zu glühen beginnt. Am Ende des Experiments ist der Kolben scheinbar leer. Das Wiegen vorher und nachher zeigt, dass es keine Masseänderung gibt. Mit diesem Lehrerversuch wird die kleine Sequenz abgerundet und die Vorgänge werden mit Aufgaben, die wieder die Teilchenebene aufgreifen, durchdrungen. In diesem Experiment kann man auch gut das entstandene (unsichtbare) Kohlenstoffdioxid nachweisen (Kalkwasserprobe).

Text für die Beobachtung:
Inside the round-bottomed flask there is oxygen and a small amount of activated carbon. The apparatus is heated with a burner. *After some time,* the activated carbon starts glowing with a white and yellow light which becomes fainter and fainter until it vanishes. *Inside the round-bottomed flask* there is nothing to be seen anymore. *At the end,* lime water is added, which becomes cloudy white / milky white. (The sample turns cloudy white / milky white.)

⟺**Idee für einen Sprachwechsel:** Diese schriftlichen englischsprachigen Ausführungen können stichworthaft in die deutsche Fachsprache übertragen und mit einem selbst entworfenen Ablaufschema visualisiert werden. Z.B. kann dann der englische Text in der linken Hälfte der Seite stehen und rechts wäre das Ablaufschema mit deutschem Vokabular.
⟺**Idee für einen Sprachwechsel:** Interessant ist sicher auch das Verbalisieren des ‚Verschwindens' bzw. des ‚Nachlassens' ‚Schwächerwerdens'. Oben wurde für das eine ‚to vanish' genannt, für das andere ‚to become fainter and fainter' (alternative Formulierung z.B. ‚to become ever fainter'). Es ist eine inhaltliche Diskussion um das mehrdeutige Wort ‚schwach' (weak vs. faint) möglich, z.B. mithilfe eines Kollokationswörterbuches.

Your tasks:

1. Carbon has reacted rather violently in the oxygen-filled container. Colourless carbon dioxide is formed, which could be detected by the lime water test. Word equation see above.
2. Fragen und Lösungsbuchstaben:
   2.1: Which of these diagrams represents Boyle's experiment correctly? **D**
   2.2: … does not show a chemical reaction? **C**
   2.3: … show(s) the correct type of reactants and products? **A, D**
   2.4: *Tick off* the correct statements about Boyle's experiment:
   B) The reaction is exothermic. **CORRECT**
   The mass of the flask remains unchanged. **CORRECT**

Concept Map: Combustions

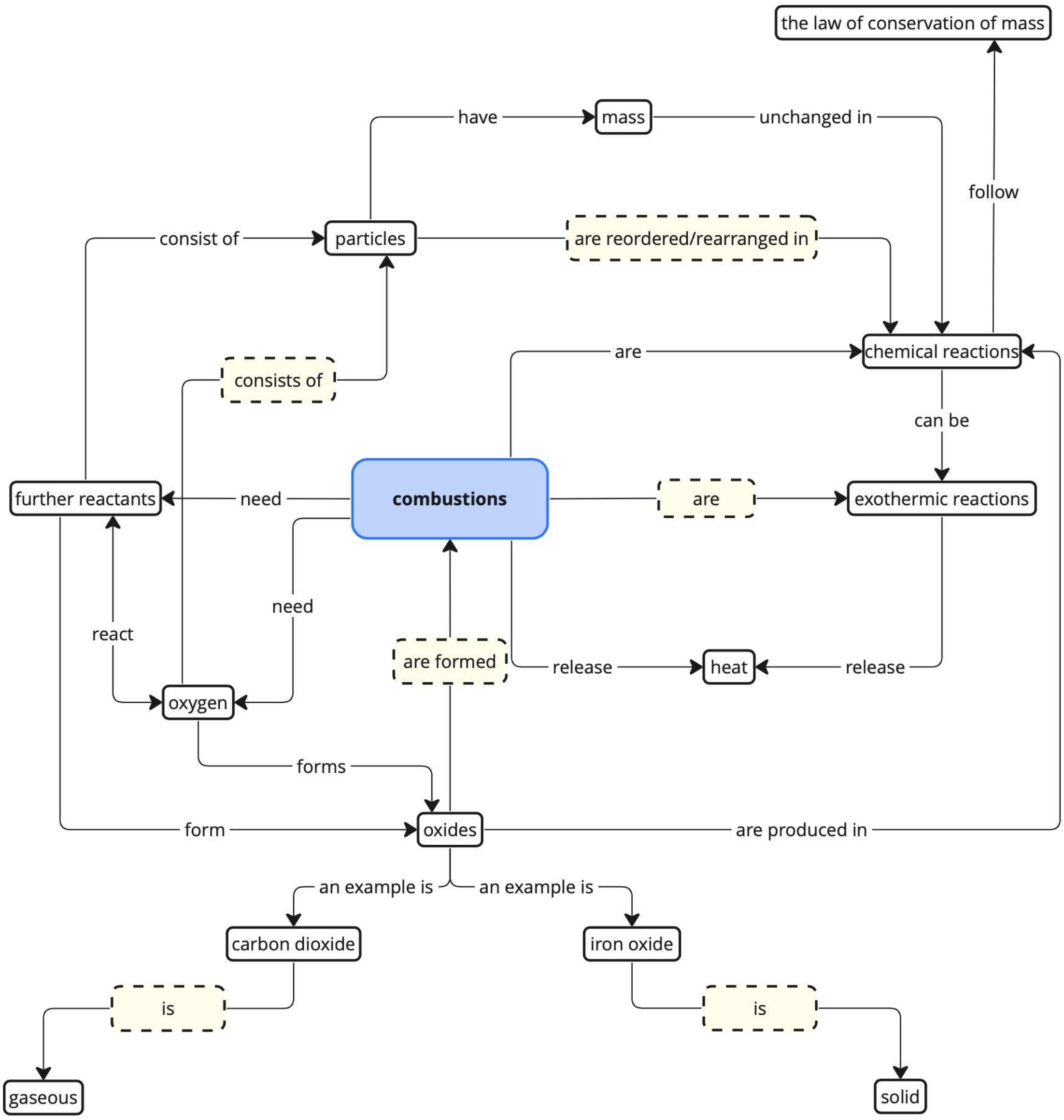
Allgemeines:

Auf eine Durchnummerierung der Lücken in der Kopiervorlage für die Schüler:innen wurde verzichtet, damit die Orientierung in der Concept Map ein Kommunikationsanlass bleibt. In den Gesprächen kann man sich dann einerseits inhaltlich, d.h. an den zentralen Vokabeln, orientieren. Andererseits kann eine Orientierung über klassisches (Bild-) Beschreibungsvokabular erfolgen, z.B. "I would like to fill the gap which is located between the words combustions and oxides. I assume the phrase 'are formed in' would be a suitable one.". Zu Ihren Händen finden Sie aber zur raschen Orientierung eine durchnummerierte Concept Map mit den sechs Auslassungen und eine Liste zu den sechs möglicherweise einzusetzenden Wörtern.
Die schnellen Schüler:innen können z.B. Synonyme zu den gefundenen Relationen finden, deutsche Begriffe hinzuschreiben, ein Kreuzworträtsel oder Quiz erstellen sowie das Concept Map mit selbstgewählten Wörtern und Pfeilen erweitern.

Lösungsvorschlag:

1. are reordered/rearranged in
2. are
3. is
4. are formed in
5. is
6. consists of

Concept Map (incl. nummerierter Leerstellen):



4.3. Water – An Element? (S. 80-89)

Lab Activity: Analysis of Water – Hofmann Apparatus

Allgemeines: Dieser Versuch ist ein weiterer Klassiker, der sich auf die Spuren des gängigen Ausdrucks des „nassen Elements Wasser“ macht.

Hints for your conclusion:

1. The detonating gas test is a detection test for hydrogen.
   The glowing splint test is a detection test for oxygen.
2. water (l) → hydrogen (g) + oxygen (g)
3. It must be endothermic because a form of energy, electricity, must be applied at all times for the reaction to take place.
4. The ratio of the volume of the gases, hydrogen and oxygen, is 2:1. According to Avogadro's law, equal volumes of gases have the same number of particles (at the same temperature and pressure). If being applied here, it can be said that the particle ratio of hydrogen and oxygen is 2:1 – a water molecule is thus a compound in which hydrogen atoms and oxygen atoms are chemically bonded to one another in the ratio of 2:1. This is reflected in the formula H_2O, as two hydrogen atoms are chemically bonded to one oxygen atom. The index '2' seems to refer to the number of atoms within a water molecule. There is no index for the oxygen atom, which might mean that there is only one oxygen atom.

Info: Water – Element or Chemical Compound?

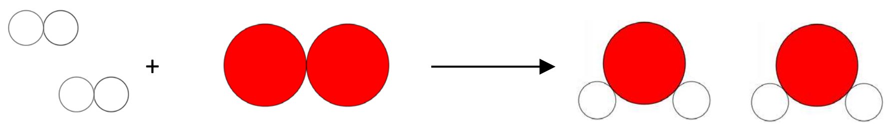
Your tasks:

1. Water is formed by hydrogen and oxygen in a volume ratio of 2:1. In this case, the two hydrogen litres have reacted with one litre of oxygen, which means that the remaining colourless gas must be oxygen. A glowing splint test would prove it.
2. Water does not consist of these gases, but water is a chemical compound containing water molecules. In a water molecule, hydrogen atoms and oxygen atoms are chemically bonded to one another.
   The statement in the task means that hydrogen and oxygen are merely mixed – there would be a homogeneous mixture of two colourless gases. This is obviously not water.

Info: Analysis and Synthesis of Water

Your tasks:

1. Two hydrogen molecules react with one oxygen molecule to form two water molecules.



2. We have learned that metals such as iron and non-metals such as carbon form oxides in chemical reactions with oxygen: iron oxide and carbon dioxide. If we have a look at a water molecule, we see that two hydrogen atoms are chemically bonded to one oxygen atom, similar to iron atoms that are chemically bonded to oxygen atoms and carbon atoms that are chemically

bonded to oxygen atoms. According to these considerations, it can be said that H_2O can be called **hydrogen oxide**. The ratio of hydrogen atoms to oxygen atoms in a water molecule is 2:1, while the ratio of iron atoms and oxygen atoms in an iron oxide crystal structure is 1:1 and the ratio of carbon atoms and oxygen atoms in a carbon dioxide molecule is 1:2. In this sense, it could even be argued that H_2O must be named **di<u>hydrogen oxide</u>**

3. Eine Übersichtstabelle zu 'oxyhydrogen':

Advantages	***Disadvantages***
alludes to the fact that there is a mixture of oxygen and hydrogen *other mixtures can detonate/ explode, too, presenting a similar result (e.g. a mixture of petrol and air)*	*the term can be misunderstood as a chemical substance itself, e.g. OH^-, rather than a mixture* *German students will have to learn a new term for a concept they have already labelled completely different in German*

4. Diese in tabellarischer Übersicht zusammengestellten Informationen können genutzt werden, um sie ins Heft/die Tafel übertragene Fig. 4 zu schreiben:

Compound	**Detecting method**	**Detecting agents**
water	add a few drops of water on white copper sulfate or WATESMO paper (turns blue in presence of water)	white copper sulfate or WATESMO paper
hydrogen	detonating gas test (oxyhydrogen test)	none (only lighter and test-tube)
oxygen	glowing splint test	none (only wooden splint and test-tube)

5. Diese Definitionen entstammen keinem englischen Herkunftswörterbuch, sondern der Encyclopaedia Britannica („Synthesis“ und „Analysis“, Zugriff: 23.09.24) bzw. Wikipedia (Zugriff: 23.09.24), doch transportieren sie das Wesentliche:
Encyclopedia Britannica:
https://www.britannica.com/topic/synthesis-philosophy
"Synthesis, in philosophy, the combination of parts, or elements, in order to form a more complete view or system."
Wikipedia:
https://en.wiktionary.org/wiki/synthesis
https://en.wikipedia.org/wiki/Analysis
"Analysis: Ancient Greek "analisis", a breaking-up.
Synthesis: Ancient Greek "sunthesis", a putting together; composition; from "suntithemi", put together, combine, from "sun-" together", from "tithemi", set, place.

Info: Hydrogen

Your tasks:

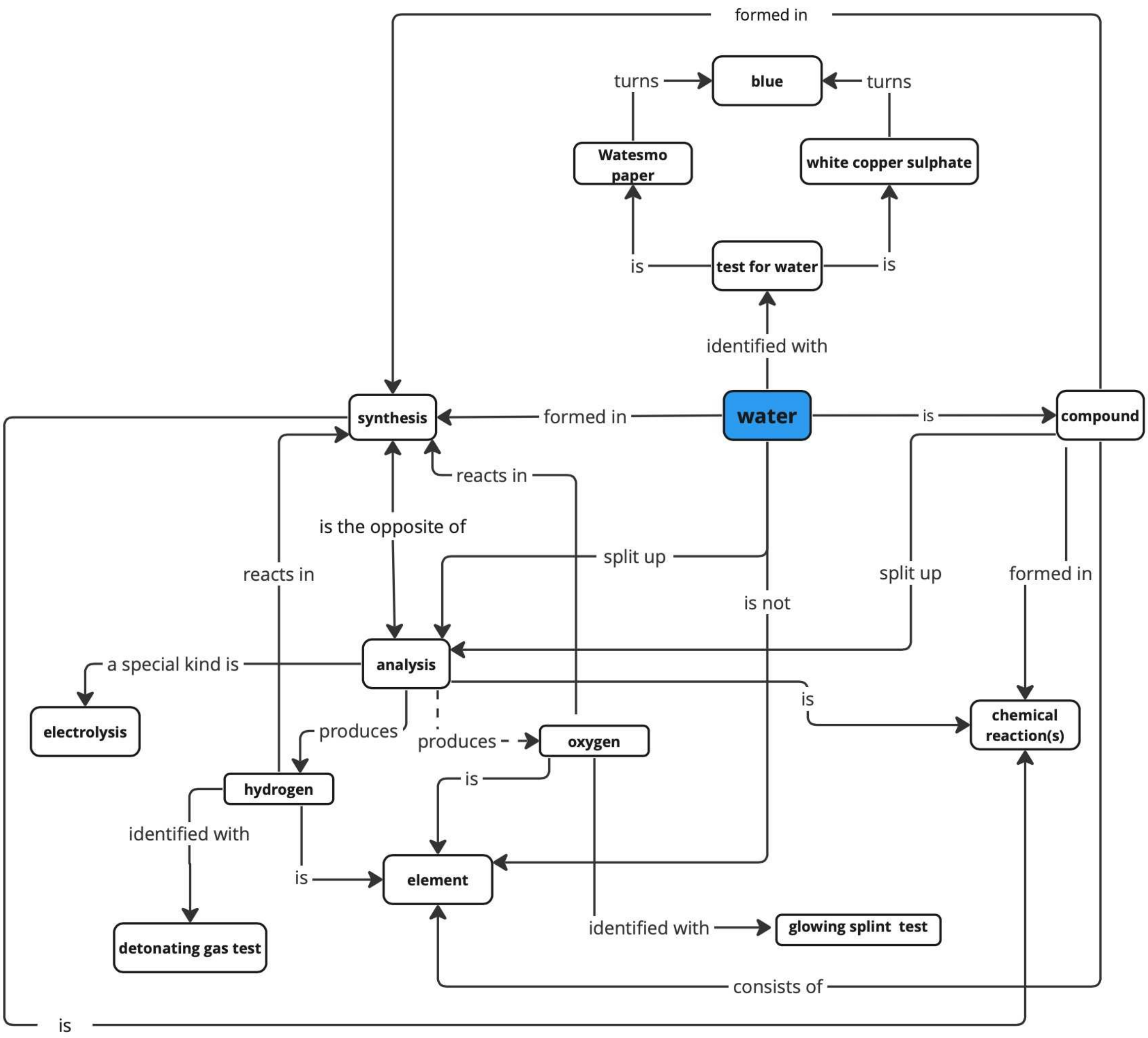
1. For one thing, hydrogen reacts with other substances in the lower parts of the earth's atmosphere, mainly with oxygen to form water. This reaction is often set off by sunlight. For another, hydrogen particles move at a very high speed. Often, they reach the minimum speed needed to leave earth, called the escape velocity (Fluchtgeschwindigkeit). If they are in the upper parts of the earth's atmosphere and have reached escape velocity, they are finally able to leave into outer space.
2. Hydrogen reacts with atmospheric oxygen (oxygen from the air) to form water.
   hydrogen (g) + oxygen (g) → water (l) | exergonic
3. Perform detonating gas test.
4. It is more advisable to fill liquid hydrogen in the tanks rather than gaseous hydrogen. Liquid hydrogen is compressed. This way, much more hydrogen can be transported. This fact can be underpinned with data from regular steel bottles used in school laboratories: A regular steel bottle has a volume of 10 L. If being filled with compressed hydrogen at a pressure of 200 bar, you can take a maximum of 1,780 L gaseous hydrogen from it. Source: https://static.prd.echannel.linde.com/wcsstore/DE_REC_Industrial_Gas_Store/datasheets/pds/wasserstoff_5.0.pdf (Access: 23.09.24).

   ⟺**Idee für einen Sprachwechsel:** Es geht hier um die Stoffe Wasserstoff, Sauerstoff und Wasser. Ergründen Sie mit Ihren SuS unterschiedliche englische Äquivalente für den deutschsprachigen Begriff „Stoff" bzw. das Suffix „-stoff" und identifizieren Sie, in welchem Kontext sich welcher Begriff als tragfähig erweist. Hier sei auf C. Rittersbacher und den Grundlagentext verwiesen, der frei unter folgender Adresse zugänglich ist: https://phka.bsz-bw.de/frontdoor/deliver/index/docId/92/file/Dialog+-+2.+Jahrgang+2015+Heft+1+-+BILDUNG+UND+MEHRSPACHIGKEIT.pdf (S. 19ff).

Concept Map: Water

Allgemeines: Nach der vollständigen Concept Map zum Thema combustions kommt hier nun eine noch zu ergänzende Concept Map zum Thema Wasser. Im Bereich Metals, Kapitel 5, folgt dann ein Skills File, mithilfe dessen eine eigenständige Concept Map erstellt werden soll.

Lösungs-
vorschlag:



Chapter 5
5. Metals and Metal Production (S. 90-101).

Lab Activity: Burning Different Metal Powders

Allgemeines:

Mithilfe dieses Experiments kann die Reaktivität verschiedener Metalle und deren edler Charakter erkundet werden. Anhaltspunkte liefern die Heftigkeit der Reaktion, die sich in akustisch und optisch Wahrnehmbarem manifestiert. Besonders wichtig ist der Unterschied in der jeweiligen Intensität der Leuchterscheinungen.
Bei Magnesium gibt es eine sehr grelle Lichterscheinung. Die Schüler*innen sollten nicht direkt in die Flamme schauen (Augenschutz). Sind Epileptiker*innen unter den Schüler*innen, muss besondere Vorsicht walten, da ein epileptischer Anfall dadurch ausgelöst werden kann.

Hints for your conclusion:

1. iron: bright orange-yellow/golden light perceptible, a slight crackling sound is audible
   magnesium: glaring light perceptible, loud cracks audible
   copper: (faint) green, absence of sound
2. iron (s) + oxygen (g) → iron oxide (s)
   magnesium (s) + oxygen (g) → magnesium oxide (s)
   copper (s) + oxygen (g) → copper oxide (s)
3. The reaction intensity increases in this sequence: copper, iron, magnesium.
   The reaction intensity correlates with the intensity of the perceptible light (green, bright orange-yellow, glaring white).
   There is some crackling sound when iron and magnesium react in the flame. It is greater in the case of magnesium.
4. In order to compare the different metals' reactivity, it is necessary to ensure a comparable grain size. As a hypothesis, one could suggest: The finer the powder, the greater the reaction intensity. An experiment to explore this hypothesis would be sprinkling portions of copper powder of different grain sizes onto the flame. Furthermore, one could even go so far as employing powder, chips, and thick wire or pieces.

Lab Activity: Analysis of Silver Oxide

Allgemeines:

Hier geht es um die thermische Zersetzung von Silberoxid in die Elemente als Beispiel einer Analyse.

Hints for your conclusion:

1. reactant: brownish grey, matt(e) (i.e. absence of shine; not shiny) solid matter
   products: 1. colourless gas collected in test-tube 2. grey, slightly shiny solid matter in the heated test-tube
2. - The glowing splint test is positive, i.e. the splint catches fire: proof of the presence of oxygen / proof that oxygen is present
   - Due to the fact that after driving out the air more gas is formed and there has only been silver oxide in the test-tube, the oxygen must have come from the silver oxide.
3. - In addition to the arguments in 2, the solid portion has been moving while being heated. Furthermore, the solid portion has changed colour. These observations substantiate that a chemical reaction has taken place, which must have released

oxygen.
- The shiny grey of the product indicates the formation of elemental silver. A shiny greyish surface is characteristic of metals. Silver is a metal.

4. - The compound silver oxide is split up in its elements, silver and oxygen. For this analysis, it is sufficient to apply heat.
   - Silver oxide is a compound consisting of chemically bonded silver atoms and oxygen atoms. The two elements have been identified above.
   - silver oxide (s) → silver (s) + oxygen (g)
5. - In this synthesis, two elements react with one another to form a new compound in which the two are chemically bonded to one another. Here, the metal silver reacts with the non-metal oxygen to form silver oxide. It is the reverse process to the one from answer 4.
   silver (s) + oxygen (g) → silver oxide (s)

Info: Metals and Metal Oxides

Your tasks:

1. Gold is a noble metal. Its reactivity is low. Accordingly, it does not engage in chemical reactions like oxidations as it has a low ability to form oxides. If it was used in a firework, it would simply fall back to the ground. Instead, it is better to use base metals such as iron to create golden sparks. All in all, the colours visible in a firework do not correlate with the shine visible on a metal's surface. Furthermore, gold is a precious and rather expensive metal.
2. Iron and zinc are base metals. Their ability to form oxides is high. When in contact with atmospheric oxygen (oxygen from the air), their particles would react with it to form oxides. These processes already take place in normal conditions, i.e. room temperature. This slow process results in the elements losing their shine as their surfaces are coated by iron oxide or zinc oxide, respectively.
   The corresponding word equations are:
   - iron (s) + oxygen (g) → iron oxide (s)
   - zinc (s) + oxygen (g) → zinc oxide (s)
3. Some reasons are: It is very decorative and shiny. It can be applied in relatively thin layers. Due to its low reactivity, gold can keep its shine for a long time.

Lab Activity: Copper and Its Compounds I

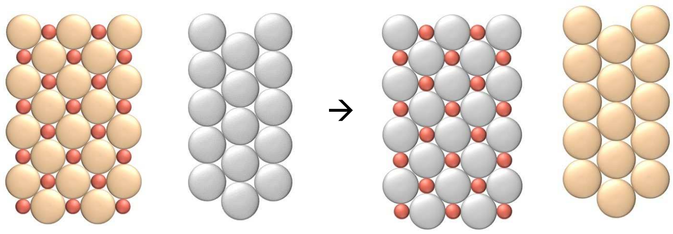
Allgemeines:

Hier geht es darum, dass man Kupfer(II)-oxid im Gegensatz zu Silberoxid (s.o.) nicht thermisch zersetzen kann, sondern, dass man dafür ein Reduktionsmittel benötigt. Analog zum Informationstext wird also auf ein unedleres Metall zurückgegriffen, was zur Folge hat, dass ein Gemisch aus Edukten und Produkten entsteht. Das entstehende elementare Kupfer lässt sich daraus schwer abtrennen.

⟺**Idee für einen Sprachwechsel:** Probieren Sie zum Anbahnen eines funktionalen Sprachwechsels die von Bohrmann-Linde (2016) vorgeschlagene Sprachwechselmethode aus. Ein konkretes Beispiel wie sie funktioniert, finden Sie oben in Kapitel 3.1 beim Versuch „The copper envelope".

Hints for your conclusion:

1. Before: A mixture consisting of grey and black powder. After: The mixture has formed a kind of cake. Some parts have turned coppery, other parts have turned grey-brown.
2. The coppery solid must be elemental copper. The grey-brown solid should be iron oxide.
3. Iron reduced copper oxide. Iron accepts the chemically bonded oxygen from copper oxide to form iron oxide. Iron is a reducing agent because it is less noble than copper, making it a good partner in the oxygen transfer reaction. That is, copper has transferred oxygen to iron.
4. copper oxide (s) + iron (s) → iron oxide (s) + copper (s), exothermic: energy emission (light, heat)



Lab Activity: Copper and Its Compounds II

Allgemeines:

Alternativ zu einem Metall können auch Nichtmetalle als Reduktionsmittel eingesetzt werden. Diesem wird hier nachgegangen und auf bekannte Nachweise zurückgegriffen. Erfahrungsgemäß ist das Metall nicht direkt als kupferfarben glänzender Feststoff im Reagenzglas vorliegend. Es ist eher erkennbar als rotbrauner, matter Feststoff. Überführt man diesen auf ein Papier und presst ihn fest mit einem Spatel, ist der metallische Glanz des rotbraunen Kupfers gut erkennbar. Das Konzept Redox-Reaktion als Elektronentransferreaktion wird erst später thematisiert.

⟺**Idee für einen Sprachwechsel:** Probieren Sie zum Anbahnen eines funktionalen Sprachwechsels die von Bohrmann-Linde (2016) vorgeschlagene Sprachwechselmethode aus. Ein konkretes Beispiel wie sie funktioniert, finden Sie oben in Kapitel 3.1 beim Versuch „The copper envelope".

Observation:

1. copper oxide: greyish black solid; activated carbon: black solid
2. - starts glowing; first, a matt(e) red solid is visible through the test-tube; later on, this red solid turns into a coppery solid
3. a coppery solid

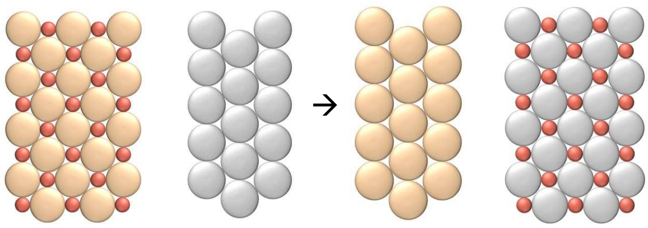
Hints for your conclusion:

1. The coppery solid (powder): copper
2. - lime water: detection agent for carbon dioxide
   - helps identify carbon dioxide as a product next to elemental copper
3. word equation:
   copper oxide (s) + carbon (s) → copper (s) + carbon dioxide (g)
4. - reduction: from copper oxide to copper
   - oxidation: from carbon to carbon dioxide

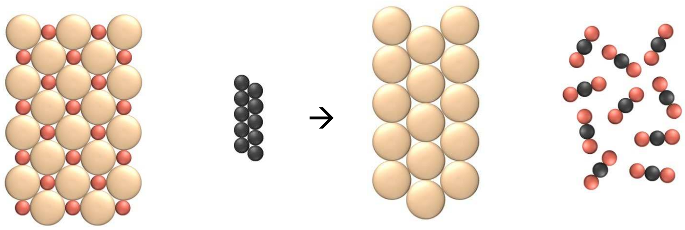
Info: Producing Copper by Means of a Redox Reaction

Your tasks:

1. a) copper oxide (s) + zinc (s) → copper (s) + zinc oxide (s)



b) copper oxide (s) + carbon (s) → copper (s) + carbon dioxide (g)

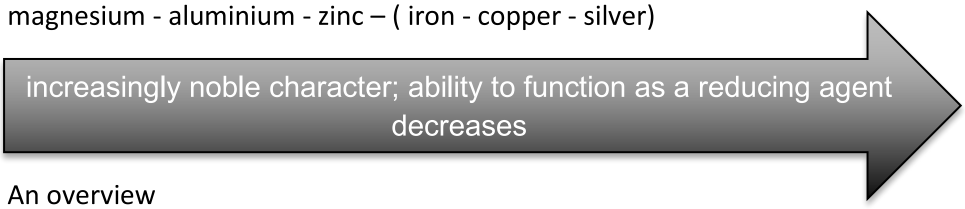


Im Fall b) muss auf die richtige Darstellung von Kohlenstoffdioxid geachtet werden, d.h. sie muss gesetzt werden.
Das Durchzählen der Teilchen ist für die Teilchenbilanz, die proportional zur Massenbilanz ist, notwendig.

2. OA: oxidising agents (Oxidationsmittel)
   RA: reducing agents (Reduktionsmittel)

   - copper oxide reacts with iron: OA copper oxide, RA iron
   - copper oxide reacts with carbon: OA copper oxide, RA carbon
   - copper oxide reacts with zinc: OA copper oxide, RA zinc
3. - magnesium and zinc can be used for the reduction of iron oxide
   - reason: they are less noble than iron

4. - crucial information 1: aluminium reduces zinc oxide -> aluminium is less noble than zinc
   - crucial information 2: aluminium cannot reduce magnesium -> aluminium is less basic than magnesium
   magnesium - aluminium - zinc – (iron - copper - silver)



5. An overview

	Carbon	Hydrogen
Availability	coal mines, many naturally occurring graphite deposits, different degrees of purity	production based on water, electrolysis, energy costs (electricity); production also based on the fossil fuel, methane
Safety	no safety issues	highly explosive gas (cf. the information texts about hydrogen)
Costs	relatively low, depend on purification steps	depend on electricity provision
Sustainability	its composition, which is necessary to produce thermal energy, emits greenhouse gases	product is water; assessment of 'green' production must be based on the reactant (water; methane: by-product is carbon dioxide) and electricity provision

Die Tabelle versammelt einige Ideen, die als Ausgangspunkte für eine Internetrecherche dienen können. Auf Basis seriöser Quellen können sie weiter untermauert und ausdifferenziert werden. Hier bieten sich Bezüge zu Bildung für nachhaltige Entwicklung, BNE, an. So können neben der ökologischen auch die ökonomische, politische und soziale Dimension adressiert werden. Im Zusammenhang der großtechnischen Produktion von Verbrauchsmetallen kann der Abbau von Metallerzen in Lagerstätten, die Förderbedingungen, Arbeitsschutz, Transportwege, staatliche Subventionen für Produktionsprozesse und weitere Aspekte thematisiert werden.

Creating a Concept Map: Redox Reactions

Allgemeines: Die Skills-Seiten finden hier ihren Abschluss in der selbsttätigen Erstellung einer Concept Map. Die Anlage als Einzel- und Partnerarbeit ermöglicht die Eigentätigkeit und das gemeinsame Aushandeln, welche Begriffe verwendet werden. Als Grundlage können die Infotexte ‚Metals and metal oxides' und ‚Producing copper by means of reduction' sowie die verschiedenen Versuche dienen. Je nach Grundlage entstehen unterschiedliche Concept Maps. Es spricht nichts dagegen, zu den unterschiedlichen Texten jeweils eine Concept Map erstellen zu lassen und diese ggf. anschließend inhaltlich zu verknüpfen.

Nützliche Internetseiten

(letzter Zugriff 07.06.24)

Inspirationen aus der MINT-EC Praxis:

- https://www.mint-ec.de/fileadmin/content/titelbilder_schriftenreihe/B_I_16_c.pdf

Homepage zum Zeichnen von Versuchsaufbauten mit englischen Bezeichnungen

- https://chemix.org/

Englischsprachiges Material aus Großbritannien

- https://edu.rsc.org/

Englischsprachiges Material aus USA

- https://de.khanacademy.org/

Englischsprachige Erklärvideos

- https://thecrashcourse.com/

Homepage Bergische Universität Wuppertal

Animationen in deutscher und englischer Sprache:

- https://chemie-interaktiv.net/ff.html
- https://chemiedidaktik.uni-wuppertal.de/index.php?id=4388&L=0

Arbeitsmaterial – Beispiele zum Download:

- https://chemiedidaktik.uni-wuppertal.de/index.php?id=4235&L=0

E-Books

- https://chemiedidaktik.uni-wuppertal.de/en/digital-media/e-books/

Englische Versuchsvideos

- https://chemiedidaktik.uni-wuppertal.de/en/digital-media/videos-and-educational-films/

Literatur zum bilingualen Unterricht und Sprachwechseln

(alphabetisch nach Autor*innen)

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Vokabelliste Deutsch-Englisch

Deutsch	Englisch
Adsorption	adsorption
Aggregatzustandsänderungen	changes of state
Aggregatzustände	states of matter
Aktivierungsenergie	activation energy
Aktivkohle	activated carbon
Albedo	albedo effect
Aluminium	aluminium
Aluminiumoxid	aluminum oxide
Analyse (Zerlegung)	analysis
Anziehungskräfte	attractive forces
Arbeitsanweisung	instruction
Argon	argon
Atmosphäre	atmosphere
Atommodell	atomic model
Atommodell nach John Dalton	Dalton's atomic model
Auftrieb	lift
Auswertung	conclusion
Avogadro, Gesetz/Satz von	Avogadro's law
Balkenwaage	beam balance
Begriffsnetz	Concept Map
Beobachtung	observation

Bestandteile	components
Biolumineszenz	bioluminescence
Bodensatz	sediment
Boyles Experiment	Boyle's experiment
Brennstoff; Treibstoff	fuel
Brennstoffzelle	fuel cell
Brownsche Molekularbewegung	Brownian movement
Bunsenbrenner	gas burner
Chemikalien	chemicals
chemische Reaktionen	chemical reaction
Chomolungma	Chomolungma
Chromatografie	chromatography
Concept Map (siehe Begriffsnetz)	
Concorde (Überschallflugzeug)	Concorde (supersonic aircraft)
Dalton, John	Dalton, John
Dämpfe	fumes
Destillat	distillate
Destillation	distillation
Diagramm	diagram / graph
Dichte	density
Diffusion	diffusion
Donator-Akzeptor-Prinzip	donor-acceptor-principle
Edelgas	noble gase

Edelmetall	noble metal
edler Charakter von Metallen	nobility / noble character of metals
Edukte, Ausgangsstoffe	reactants
Eisen	iron
Eisenoxid	iron oxide
elektrische Energie	electric energy
Elektrolyse	electrolysis
Element	element
Emulsion	emulsion
endotherm	endothermic
Energieänderung	energetic change
Energieumsatz	energetic turnover
Energieumsatz	energy turnover
Entsalzung	desalination
Erderwärmung	global warming
Erdgas	natural gas
Erz	ore
Etikett	label
exergonisch	exergonic
exotherm	exothermic
exotherme Reaktion	exothermic reaction
Extraktion	extraction
Farbstoff	dye

Farbveränderungen	changes in colour
Feststoff	solid
Feuerwerk	firework
F-Gase (fluorierte Treibhausgase)	f-gases (fluorinated greenhouse gases)
Filtration	filtration
Fluchtgeschwindigkeit	escape velocity
Flüssigkeit	liquid
fossiler Brennstoff	fossil fuel
Gefahrensymbole	hazard symbols
Gesetz der Erhaltung der Masse	law of conservation of mass
Gewicht	weight
Glimmspan	glowing splint
Glimmspanprobe	glowing splint test
glow stick	Knicklicht
Gold	gold
Helium	helium
heterogenes Stoffgemisch	heterogeneous mixture
Hofmannscher Zersetzungsapparat	Hofmann apparatus
Holz	wood
homogenes Stoffgemisch	homogeneous mixture
Intention	intention
Kalkwassertest	lime water test
Klebe/Haltekraft	adhesive power

Knallgasprobe	detonating gas test (auch: oxyhydrogen test)
Kohlenstoff	carbon
Kohlenstoffdioxid	carbon dioxide
Korngröße	grain size
Kristallisierung	crystallisation
Krypton	krypton
Kupfer	copper
Kupferoxid, rot	copper oxide, red
Kupferoxid, schwarz	copper oxide, black
Kupfersulfat	copper sulphate
Labor	laboratory (short: lab)
Laborgeräte	lab equipment
Lachgas	nitrous oxide
Licht	light
Lichtenergie	light energy
Lösemittel	solvent
Löslichkeit	solubility
Lösung	solution
Luft	air
Luftsauerstoff	atmospheric oxygen
Luftschiff, Zeppelin	airship
Magnesium	magnesium
Masse	mass

Messwerte	data, measured values
Metall	metal
Metalloxid	metal oxide
Metallpulver	metal powder
Methan	methane
Mount Everest	Mount Everest
Nachhaltigkeit	sustainability
Natron	sodium hydrogen carbonate
Neon	neon
Nichtmetall	non-metal
Oganesson	oganesson
Oxid	oxide
Oxidation	oxidation
Oxidationsmittel	oxidising agent
Oxidbildung	oxide formation
oxidieren	to oxidise
Photosynthese	photosynthesis
Piktogramme	pictograms
Produkte	products
Reagenzglas	test-tube
Reaktionsfähigkeit, vgl. auch Redoxreihe	reactivity
Reaktionsgleichung	reaction equation
Reaktionspfeil	reaction arrow

Reaktionsschema	reaction scheme
Reaktivität; Reaktionsfähigkeit	reactivity
Redoxreaktion	redox reaction
Redoxreihe	reactivity series
Reduktion	reduction
Reduktionsmittel	reducing agent
reduzieren	to reduce
Reinstoff	pure substance
Rohöl	crude oil
Rückstand	residue
Sagarmatha	Sagarmatha
Salzsäure	hydrochloric acid
Sauerstoff	oxygen
Sauerstoff; vgl. Luftsauerstoff	oxygen; cf. atmospheric oxygen
Sauerstoffübertragung	oxygen transfer
Sauerstoffübertragungsreaktion	oxygen transfer reactions
Säuren	acids
Schmelztemperatur	melting temperature
Schmuck	jewelry (AE), jewellery (BE)
Schutzgas	shielding gas
Schwefel	sulfur
Schwefelsäure	sulfuric acid
Sicherheitsregeln	safety rules

Siedetemperatur	boiling temperature
Silber	silver
Silberoxid	silver oxide
Solarenergie, Sonnenenergie	solar energy
Spatel	spatula
Stickstoff	nitrogen
Stoffeigenschaften	properties of matter
Stoffgemisch, heterogen	mixture, heterogenous
Stoffgemisch, homogen	mixture, homogenous
Stoffgemische	mixtures
Strahlung	radiation
Streichhölzer	matches
Substanz	substance
Sulfid	sulphide
Suspension	suspension
Synthese (Bildung)	synthesis
System, geschlossen	system, closed
System, offen	system, open
Teilchen	particle
Teilchenmodell	particle model
Treibhauseffekt	greenhouse effect
Treibhauseffekt, anthropogen	greenhouse effect, anthropogenic
Treibhauseffekt, natürlich	greenhouse effect, natural

Treibhausgas	greenhouse gas
Trennverfahren	separation techniques
Umgebungsdruck	ambient pressure
unedles Metall	base metal
Verbindung	compound
Verbrennung	combustion
Verbrennungsreaktion	combustion reactions
Verdampfen	evaporation
Versuchsdurchführung	procedure
Versuchsprotokoll	lab report
Versuchsskizze	sketch
Wärmeenergie	thermal energy
Wasser	water
Wasserdampf	water vapour
Wasserstoff	hydrogen
Wasserstoffoxid	hydrogen oxide
wässrig	aqueous
Watesmo-Papier	Watesmo paper
weißes Kupfersulfat	white copper suphate
Wortgleichung	word equation
Zink	zinc
Zitronensäure	citric acid

Vokabelliste Englisch-Deutsch

Englisch	Deutsch
acids	Säuren
activated carbon	Aktivkohle
activation energy	Aktivierungsenergie
adhesive power	Klebe/Haltekraft
adsorption	Adsorption
air	Luft
airship	Luftschiff, Zeppelin
albedo effect	Albedo
aluminium	Aluminium
aluminum oxide	Aluminiumoxid
ambient pressure	Umgebungsdruck
analysis	Analyse (Zerlegung)
aqueous	wässrig
argon	Argon
atmosphere	Atmosphäre
atmospheric oxygen	Luftsauerstoff
atomic model	Atommodell
attractive forces	Anziehungskräfte
Avogadro's law	Avogadro, Gesetz/Satz von
base metal	unedles Metall
beam balance	Balkenwaage

bioluminescence	Biolumineszenz
boiling temperature	Siedetemperatur
Boyle's experiment	Boyles Experiment
Brownian movement	Brownsche Molekularbewegung
carbon	Kohlenstoff
carbon dioxide	Kohlenstoffdioxid
changes in colour	Farbveränderungen
changes of state	Aggregatzustandsänderungen
chemical reaction	chemische Reaktionen
chemicals	Chemikalien
Chomolungma	Chomolungma
chromatography	Chromatografie
citric acid	Zitronensäure
combustion	Verbrennung
combustion reactions	Verbrennungsreaktion
components	Bestandteile
compound	Verbindung
Concept Map	Begriffsnetz (Conept Map)
conclusion	Auswertung
Concorde (supersonic aircraft)	Concorde (Überschallflugzeug)
copper	Kupfer
copper oxide, black	Kupferoxid, schwarz
copper oxide, red	Kupferoxid, rot

copper sulphate	Kupfersulfat
crude oil	Rohöl
crystallisation	Kristallisierung
Dalton, John	Dalton, John
Dalton's atomic model	Atommodell nach John Dalton
data, measured values	Messwerte
density	Dichte
Desalination	Entsalzung
detonating gas test (auch: oxyhydrogen test)	Knallgasprobe
diffusion	Diffusion
distillate	Destillat
distillation	Destillation
donor-acceptor-principle	Donator-Akzeptor-Prinzip
dye	Farbstoff
electric energy	elektrische Energie
electrolysis	Elektrolyse
element	Element
emulsion	Emulsion
endothermic	endotherm
energetic change	Energieänderung
energetic turnover	Energieumsatz
energy turnover	Energieumsatz

escape velocity	Fluchtgeschwindigkeit
evaporation	Verdampfen
exergonic	exergonisch
exothermic	exotherm
exothermic reaction	exotherme Reaktion
extraction	Extraktion
f-gases (fluorinated greenhouse gases)	F-Gase (fluorierte Treibhausgase)
filtration	Filtration
firework	Feuerwerk
fossil fuel	fossiler Brennstoff
fuel	Brennstoff; Treibstoff
fuel cell	Brennstoffzelle
fumes	Dämpfe
gas burner	Bunsenbrenner
global warming	Erderwärmung
glowing splint	Glimmspan
glowing splint test	Glimmspanprobe
gold	Gold
grain size	Korngröße
graph	Diagramm
greenhouse effect	Treibhauseffekt
greenhouse effect, anthropogenic	Treibhauseffekt, anthropogen
greenhouse effect, natural	Treibhauseffekt, natürlich

greenhouse gas	Treibhausgas
hazard symbols	Gefahrensymbole
helium	Helium
heterogeneous mixture	heterogenes Stoffgemisch
Hofmann apparatus	Hofmannscher Zersetzungsapparat
homogeneous mixture	homogenes Stoffgemisch
hydrochloric acid	Salzsäure
hydrogen	Wasserstoff
hydrogen oxide	Wasserstoffoxid
instruction	Arbeitsanweisung
intention	Intention
iron	Eisen
iron oxide	Eisenoxid
jewelry (AE), jewellery (BE)	Schmuck
Knicklicht	glow stick
krypton	Krypton
lab equipment	Laborgeräte
lab report	Versuchsprotokoll
label	Etikett
laboratory (short: lab)	Labor
law of conservation of mass	Gesetz der Erhaltung der Masse
lift	Auftrieb
light	Licht

light energy	Lichtenergie
lime water test	Kalkwassertest
liquid	Flüssigkeit
magnesium	Magnesium
mass	Masse
matches	Streichhölzer
melting temperature	Schmelztemperatur
metal	Metall
metal oxide	Metalloxid
metal powder	Metallpulver
methane	Methan
mixture, heterogenous	Stoffgemisch, heterogen
mixture, homogenous	Stoffgemisch, homogen
mixtures	Stoffgemische
Mount Everest	Mount Everest
natural gas	Erdgas
neon	Neon
nitrogen	Stickstoff
nitrous oxide	Lachgas
nobility	edler Charakter von Metallen
noble gase	Edelgas
noble metal	Edelmetall
non-metal	Nichtmetall

observation	Beobachtung
oganesson	Oganesson
ore	Erz
oxidation	Oxidation
oxide	Oxid
oxide formation	Oxidbildung
oxidising agent	Oxidationsmittel
oxygen	Sauerstoff
oxygen transfer	Sauerstoffübertragung
oxygen transfer reactions	Sauerstoffübertragungsreaktion
oxygen; cf. atmospheric oxygen	Sauerstoff; vgl. Luftsauerstoff
particle	Teilchen
particle model	Teilchenmodell
photosynthesis	Photosynthese
pictograms	Piktogramme
procedure	Versuchsdurchführung
products	Produkte
properties of matter	Stoffeigenschaften
pure Substance	Reinstoff
radiation	Strahlung
reactants	Edukte, Ausgangsstoffe
reaction arrow	Reaktionspfeil
reaction equation	Reaktionsgleichung

reaction scheme	Reaktionsschema
reactivity	Reaktionsfähigkeit, vgl. auch Redoxreihe
reactivity	Reaktivität; Reaktionsfähigkeit
reactivity series	Redoxreihe
redox reaction	Redoxreaktion
reducing agent	Reduktionsmittel
reduction	Reduktion
residue	Rückstand
safety rules	Sicherheitsregeln
Sagarmatha	Sagarmatha
sediment	Bodensatz
separation techniques	Trennverfahren
shielding gas	Schutzgas
silver	Silber
silver oxide	Silberoxid
sketch	Versuchsskizze
sodium hydrogen carbonate	Natron
solar energy	Solarenergie, Sonnenenergie
solid	Feststoff
solubility	Löslichkeit
solution	Lösung
solvent	Lösemittel
spatula	Spatel

states of matter	Aggregatzustände
substance	Substanz
sulphide	Sulfid
sulphur	Schwefel
sulphuric acid	Schwefelsäure
suspension	Suspension
sustainability	Nachhaltigkeit
synthesis	Synthese (Bildung)
system, closed	System, geschlossen
system, open	System, offen
test-tube	Reagenzglas
thermal energy	Wärmeenergie
to oxidise	oxidieren
to reduce	reduzieren
water	Wasser
water vapour	Wasserdampf
Watesmo paper	Watesmo-Papier
weight	Gewicht
white copper sulphate	weißes Kupfersulfat
wood	Holz
word equation	Wortgleichung
zinc	Zink

9. Bildnachweis

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9. Periodic Table of Elements