Group A: Lime

No one knows exactly when humans discovered that slaked lime ($Ca(OH)_2$) was ideally suited as a binder for producing mortar. To produce slaked lime, lime is burned and the resulting product, burnt lime (CaO), is slaked with water. In the presence of carbon dioxide (CO_2) in the air, the slaked lime hardens, becoming lime mortar. Lime mortar finds in buildings in eastern Turkey show that this knowledge was applied around 14,000 years ago. It was the Romans finally who used slaked lime on a large scale since the raw material limestone was readily available throughout the entire Roman Empire.

Task 1

Name possible environmental influences that can have a negative effect on the resistance of limestone and lime mortars. Take possible chemical reactions into account that calcium carbonate ($CaCO_3$) can undergo in the environment.

Task 2

Write your results on the blackboard in the form of a table. Verify your results by searching for information on the Internet or in the school library.

Task 3

Find out where lime is used as a building material.

Task 4

Discuss in your class afterwards which advantages or disadvantages each of the building materials have when compared.

Group B: Gypsum

Gypsum is a further material that belongs to the oldest group of mineral binders. When and where it was used as a building material for the first time is not known exactly but the oldest proof goes back to around 9,000 B.C: gypsum render was used as a substrate for decorative frescos in the city of Çatalhöyük in Asia minor. When building the pyramids, ancient Egyptians filled voids with a mixture of gypsum and lime. Knowledge of how to produce gypsum then reached Crete: many of the external walls of the palace of Knossos were built with gypsolith. The joints in the gypsum stone masonry were filled with gypsum mortar. This knowledge spread from the Greeks to the Romans and finally reached central and northern Europe but was forgotten for a while after the Romans left. Thanks to the monasteries, gypsum experienced a revival starting in the 11th century.

Task 1

Name possible environmental influences that can have a negative effect on the resistance of gypsum. Take possible chemical reactions into account that gypsum can undergo in the environment.

Task 2

Write your results on the blackboard in the form of a table. Verify your results by searching for information on the Internet or in the school library.

Task 3

Find out where gypsum is used as a building material.

Task 4

Discuss in your class afterwards which advantages or disadvantages each of the building materials have when compared.

Group C: Concrete

When the Romans invented concrete more than 2,000 years ago, it was tantamount to a revolution in building technology. They constructed impressive structures with this material such as the Pantheon in Rome which still stands today. The Latin term for Roman concrete is Opus Caementitium which is made up of the words "opus" (building/work) and "Caementitium" (masonry stone/rubble stone).
Roman concrete was made by mixing stones, sand, water, burnt lime and pozzolanas (volcanic ash that reacts with lime similar to cement) which then hardened to stone, just like concrete today.

Task 1

Name possible environmental influences that can have a negative effect on the resistance of concrete. Take possible chemical reactions into account that concrete can undergo in the environment.

Task 2

Write your results on the blackboard in the form of a table. Verify your results by searching for information on the Internet or in the school library.

Task 3

Find out where concrete is used as a building material.

Task 4

Discuss in your class afterwards which advantages or disadvantages each of the building materials have when compared.

Group D: Wood

Wood is inseparably linked to the development of mankind. Even our earliest ancestors built places to sleep made of branches and leaves, similar to those of chimpanzees and gorillas. The first wood houses were built around the year 10,000 B.C. Wood was the most important building and heating material in ancient times and it was only in places where wood was plentiful that settlements developed. Its stability and strength made wood an ideal building and working material and, together with stone, a structural building material commonly used right up into the 19th century (framework construction). This raw material is more popular than ever today: as an environment-friendly building material and as a CO_2 neutral source of energy.

Task 1

Name possible environmental influences that can have a negative effect on wood. Take possible chemical reactions into account that wood (cellulose is the main ingredient) can undergo in the environment.

Task 2

Write your results on the blackboard in the form of a table. Verify your results by searching for information on the Internet or in the school library.

Task 3

Find out where wood is used as a building material.

Task 4

Discuss in your class afterwards which advantages or disadvantages each of the building materials have when compared.

Group E: Loam

Next to wood, loam is mankind's oldest building material. Made of clay, silt and sand, it has been used for building since time immemorial and was an important building material in practically all ancient cultures. The roots of loam construction go back to the dry areas of the Middle and Near East. The first cities built by humans such as Jericho were built with loam. The fantastic old city of Sana'a in Yemen, a World Heritage Site, fascinates visitors to this day: several hundred years ago, master builders erected high rise buildings and towers up to ten storeys high made of air-dried, loam brick. At the beginning of the 20th century, loam lost its significance in the western world due to the advance of industrial, pre-fab building materials. Only during the period between the two World Wars, when building materials and money for building were in short supply, was loam used again for a short while.

Task 1

Name possible environmental influences that can have a negative effect on the resistance of loam. Take possible chemical reactions into account that loam can undergo in the environment.

Task 2

Write your results on the blackboard in the form of a table. Verify your results by searching for information on the Internet or in the school library.

Task 3

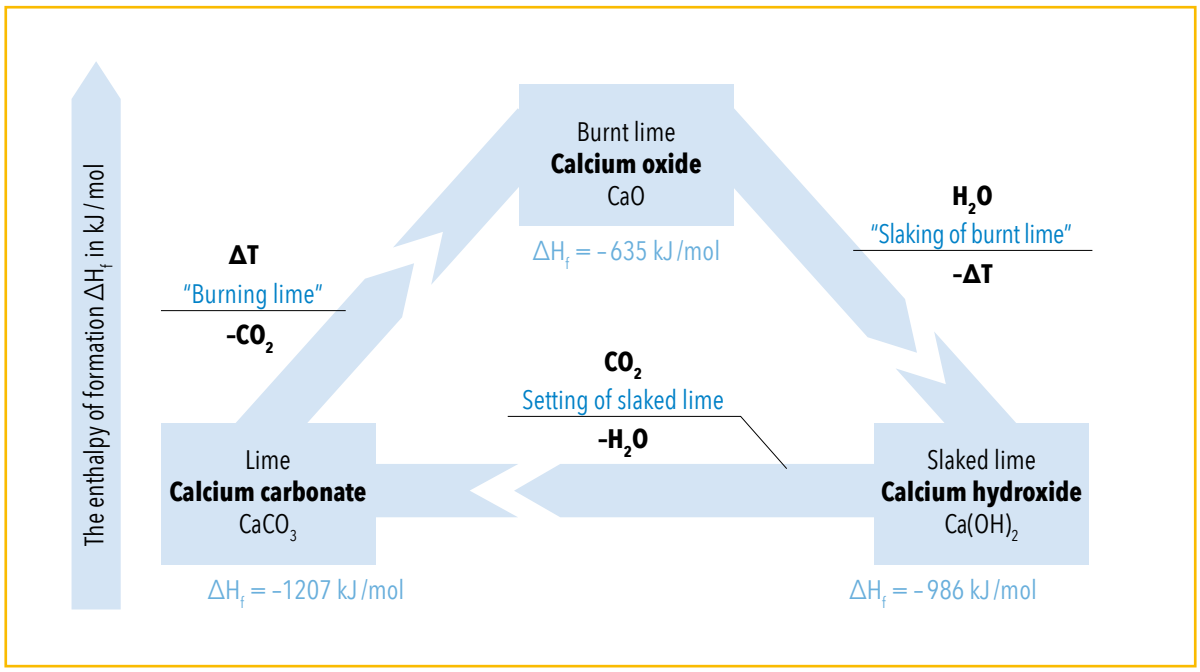
Find out where loam is used as a building material.

Task 4

Discuss in your class afterwards which advantages or disadvantages each of the building materials have when compared.

THE CYCLE OF LIME AND USE OF LIME IN THE CONSTRUCTION OF HOUSES

Lime is the oldest binder for masonry and render mortar. The Romans used lime on a large scale because the raw material limestone was available throughout the entire Roman Empire. Even today, lime is still one of the most important building materials, especially in the area of renders.



Task 1: Lime in Everyday Life and the Cycle of Lime

a) Name all of the meanings and associations you know that have to do with the term "lime".

b) With the aid of the illustration above, summarise the cycle of lime in two to three sentences. Make sure that you use the correct chemical terminology.

Task 2: Production of slaked lime

Place 1 g burnt lime and 2 ml of water in a porcelain crucible and stir with a glass rod. Then measure the temperature in specified intervals over a period of three minutes. The values determined are presented in the table.

Time [s]	T [°C]	Time [s]	T [°C]
15	38.9	90	68.3
30	48.7	120	66.0
45	55	150	64.2
60	61.6	180	64.0

a) Write down the reaction equation for the reaction of slaked lime with water!

b) Explain whether the reaction is an exothermic or an endothermic reaction.

Task 3: Slaked lime and job safety

Slaked lime was already used in ancient Rome as a binder for concrete. Transfer your knowledge on the progression of the reaction of slaked lime with water to the situation at a "real" building site. Keep the aspect of occupational safety especially in mind!

Important: Today you are allowed to choose by yourself! Read both suggestions carefully and decide which task you think sounds more interesting.

Task 1: Create a **building material dictionary**

In this task you take part in creating a building material dictionary. For this you need to find technical terms and their meanings and then compile the most important terms into a dictionary.

a) Read pages 1, 2, 4 and 5 of the **house building magazine "Novitas Caementitia" [see downloads]** and look especially for technical terms that have to do with concrete and other building materials, buildings and application areas.
b) Note five technical terms and underline their meaning in the text.
c) As soon as you are finished, go to bus stop No. 1.

Task 2: Create a **marketing folder**

No company can survive the brutal competition on the market today without a good marketing strategy. That is why you are going to help create an especially convincing advertisement for a newspaper.

a) Read pages 1, 3, 5 and 6 of the **house building magazine "Novitas Caementitia" [see downloads]** and concentrate on the advantages of concrete, for example when compared to other building materials, and also the different possibilities for use.
b) Note five important aspects.
c) As soon as you are finished, go to bus stop No. 2.

Task 1: Create a **building material dictionary** – Partner work phase

1) Present the five technical terms you selected to your partner and explain their meaning. The two of you are now the experts in your group for these ten technical terms.
2) With the aid of the meanings you underlined in the text, write down a brief explanation for each of the ten technical terms. Then compile these terms in alphabetical order in a table that can be printed. You should also designate a general category under which the technical terms fall (for example: application area, building material, type of building material, historical, …).

	Category	Technical term	Explanation
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Homework: Enter your results in a Word file and send it via email to your teacher. When all entries have been compiled and the building material dictionary is complete, a printed version can be placed the school/class library.

Task 2: Creating a **marketing folder** – partner work phase

1) Present the application areas and advantages you found to your partner and explain in detail, why they are advantages. Afterwards, discuss which aspects are the most important and give reasons for your decisions.
2) The building material supplier Leading & Edge would like to gain a competitive advantage over its rival, Romer Ltd. You and your partner should come up with a convincing draft for an advertisement with text and a photograph and then produce a final version in a DIN A4 format for the marketing folder. Think creatively – everything is possible – brainstorm for the best advantages and arguments!

An example:

Modern and Versatile – Leading & Edge Can Fulfil Your Dreams

Your house could look like this! Modern homes are built with concrete from Leading & Edge.
Pleasantly cool in summer, cosy warm in winter and the noise from your neighbours is kept out.
Why wait any longer – build the house of your dreams now!

At the end of the hour, the funniest, most creative, most convincing and the most serious advertisements are chosen!

Homework: Look at newspapers, magazines and flyers at home for advertisements placed by housing providers and compare them with your own advertisement.

VERSATILE CONCRETE THANKS TO ADMIXTURES

More than 90 percent of all concretes today contain concrete admixtures that are added to the classic raw materials: binder, aggregates and water. These admixtures influence not only the properties of fresh concrete but also hardened concrete by chemical as well as physical means.

Task 1

Based on your conclusions from observing the instructions for Experiment II ("The Effect of Admixtures on Concrete"), assign the admixtures to the different functions and explain why.

- Retarders
- Air entraining agents
- Stabilisers
- Accelerators

Task 2

The following photographs show situations in which concrete has been influenced by admixtures. Decide which type of admixture should be selected for the respective situation, giving reasons why.

TRANSPORT OF THE EMMAUS CHURCH

Task 1

Search the Internet for information on the transport of the Emmaus Church Borna! Try to find reliable information by entering selected search words in search engines. (If you have problems: check out websites on the city of Borna in Germany and the Emmaus Church Borna as well as Wikipedia and YouTube).
Together with a friend in your class, answer the following questions:

When was the church built?	
Where did the Emmaus Church stand?	
Where was it transported?	
What are the dimensions of the church? How much does the church weigh?	
Why did the church have to "move"?	
When was the church transported and how long did it take?	
How much did the transport cost?	
How was the church stabilised for transport?	

Task 2

Foam mortar – what is that? Explain the term and describe how foam mortar was used for the transport of the Emmaus Church.

ALL-PURPOSE CONSTRUCTION CHEMICAL ADHESIVE: MORTAR

Just like concrete, mortar consists of the raw materials water, sand (aggregate) and a binder (cement), but in mortar the grains are clearly smaller than in concrete and have a maximum size of four millimetres. By using different additives, mortars can be formulated to meet the most different requirements. Find the right definition for each mortar and give an example for application!

Masonry mortar	Basic form of mortar that is used as an adhesive to join bricks or natural stone to each other.	Damage & spalling
Render mortar	Cement mortar with the addition of polymers which makes it adhere especially well to different substrates and can even be used for overhead work.	Spaces between tiles in kitchens and baths
Pre-mixed mortar	None of the components are larger than one millimetre. A very high polymer content of up to 40 percent makes this extremely elastic but very crack resistant mortar seem more like a layer of rubber.	Baths & swimming pools
Joint mortar	Through the addition of polymers or resins, this mortar can be subjected to especially heavy loads. Whether mechanical loads or strong weathering, elastic polymer bridges between the brittle, mineral components ensure optimal adhesion.	Swimming pool floors, balconies & terraces
Repair mortar	This type of mortar revolutionised use. Raw materials and admixtures no longer need to be mixed (sometimes inaccurately) by hand at the building site because this product is an industrially produced mixture that only needs to be mixed with water before using.	Repair & stabilisation of heritage buildings
Grouting foam mortar	This mortar should be water vapour permeable so that it can take up moisture and vapours, especially in indoor areas, and thus ensure a pleasant room climate and prevent the formation of condensation. Applied to the exterior, it protects buildings from the influence of water and is also attractive.	House & room walls
Waterproofing grouts	Air pores replace the sand content and a stabiliser gives this mortar strength. That is why this lightweight mortar is especially suitable for filling hollow cavities and spaces which ensures greater stability.	Production of masonry work
Tile laying mortar	A flexible variation of mortar that is water repelling through so-called hydrophobizing agents. The latest additives with an anti-bacterial effect even prevent ugly bacterial growth.	Basis for all special mortars

POLYURETHANES

Otto Bayer, whose name bears no relationship to the family that founded the international Bayer company and is purely coincidental, never dreamed that he would experience anything exceptional when he mixed a diol with an diisocyanate and a little water in a beaker back in 1935. But within seconds the mixture began to foam and rise like milk boiling in a pot, creating what looked like a foam mushroom above the beaker. The foam ran down onto the worktop and immediately hardened, making a terrible mess! The researcher Bayer from the city of Leverkusen was amazed when he realised that the volume of the quickly strengthening, feather-light foam was 30 times greater than the original liquid. The reason: the diol combines with the diisocyanate in record time, forming a polymer network (polyurethane). Carbon dioxide is also set free from the water which acts as a propellant and turns the cross-linking polymer into foam. It did not take the researcher very long to realise the potential of his discovery.

Task 1

Write the term equation for the chemical reaction (polyaddition) between a diol and a diisocyanate of your choice.

Task 2

Supplement the missing substance names (IUPAC nomenclature) and structural formulae of the illustrated polyaddition reaction. Identify the polyurethane group of the reaction product.

Diphenylmethane–4,4–diisocyanate

Polyurethane

Task 3

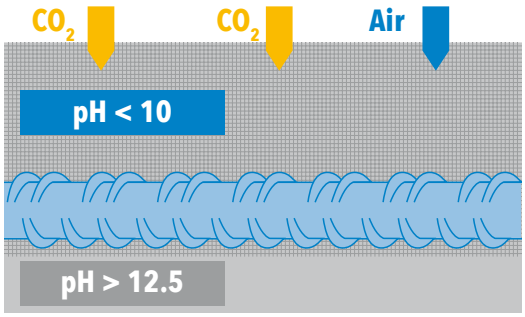
Find out in which construction chemical product the polyaddition described in Task 2 takes place and describe the use of the product.

CORROSION OF REINFORCED CONCRETE CAUSED BY CARBONATION

As a rule, water cannot harm a reinforced concrete building that is intact, especially when it has been built with water impermeable concrete. An essential ingredient in concrete is calcium hydroxide ($Ca(OH)_2$) which is responsible for creating an alkaline environment in concrete with a pH value of 12.6. In intact reinforced steel structures, the alkaline environment in concrete protects steel reinforcement from corrosion (passive protection). Environmental influences such as the effect of carbon dioxide (CO_2) from the air can neutralise this protection. The process that then takes place is called carbonation.

Task 1

a) Ill. 1 shows the process of carbonation in concrete in a diagram. Describe this process in your own words, using the following technical terms: **carbonation, carbon dioxide, calcium hydroxide, calcium carbonate (CaCO3), lime, water, pH value, alkaline environment**.



Ill.1: Process of carbonation

Ill. 2: Steel corrosion

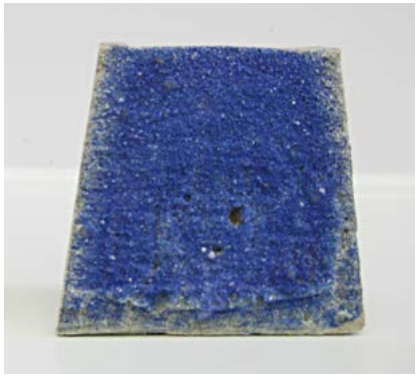
b) In Ill. 2 you can see the changes on the reinforcement steel as a result of carbonation. Describe the changes in your own words, using the following (technical) terms: **reinforcement steel, passive protection, air, rust ($Fe(OH)_3$), dark spots, rust-red leaking areas, reduction of the pH value, corrosion, damage to the structure**.

Task 2

Formulate the complete reaction equations a) for the carbonation of concrete and b) for steel corrosion caused by carbonation.

Task 3

Keeping Ill. 3 in mind, design an experimental approach with which the carbonation depth in a concrete sample can be determined.



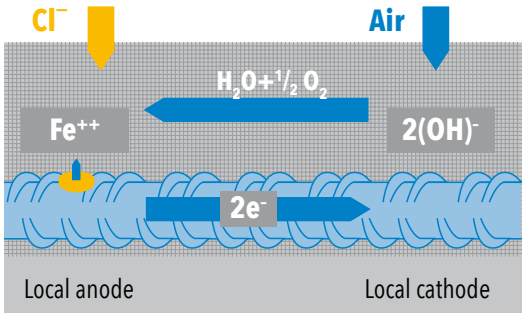
Ill.3: Determination of carbonation depth

CORROSION OF REINFORCED CONCRETE CAUSED BY CHLORIDE IONS

Reinforced concrete is a composite material made of concrete and steel. As a rule, water cannot harm a reinforced concrete building that is intact, especially when it has been built with water impermeable concrete. An essential ingredient of concrete is calcium hydroxide ($Ca(OH)_2$) which is responsible for an alkaline environment with a pH value of 12.6 in concrete.
The alkaline environment protects the steel reinforcement from corrosion in intact reinforced steel structures (passive protection). Environmental influences such as the effect of carbon dioxide (CO_2) from the air can neutralise this protection. Through the release of chloride ions from de-icing salts in the environment or sea water, it is possible for chloride ions to penetrate several centimetres deep into the concrete surface and react in direct contact with the reinforcement steel.

Task 1

a) Ill. 1 shows the chemical reaction of chloride ions with reinforcement steel in a diagram. Describe this process in your own words, using the following technical terms: *anode, cathode, oxidation, reduction, electron transfer, cation, anion, elementary iron, iron atoms, iron(II) ions, iron(II) hydroxide, iron(II) chloride, iron(III) hydroxide (rust), water, atmospheric oxygen, hydroxide ions*



Ill.1: Chloride corrosion

Ill.2: Steel corrosion through chloride ions

b) In Ill. 2 the changes on the reinforcement steel due to chloride corrosion are visible. Describe the changes in your own words using the following (technical) terms: *reinforcement steel, pitting, sodium chloride solution, rust, dark spots, rust-red leaking areas, bridge piers, corrosion, damage to the structure*.

Task 2

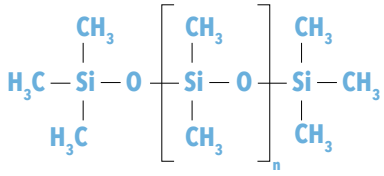
Formulate the complete reaction equation for chloride corrosion.

Task 3

Look for information with the goal of finding a method for proving iron(II) ions and iron (III) ions.

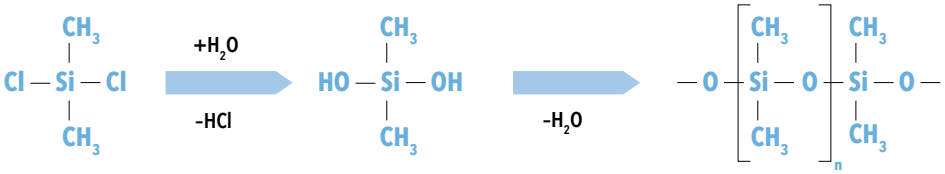
SYNTHESIS OF POLYSILOXANS

Silicones are working materials with versatile possibilities for application and are available in the form of oils and resins. Further silicone products such as fats, release agents, de-foaming agents, additives for lacquers, paper coating agents, hydrophobizing agents for buildings, textiles and leather as well as hot or cold vulcanising rubber can be derived from these basic products.
Silicone oils are glass clear, tasteless and odourless liquids that have special properties as a result of their molecular structure. They are linear, unbranched polysiloxane chains made up of consecutively alternating silicon and oxygen atoms. The free valences are saturated with organic side groups (e.g. methyl groups) which give them their specific properties.



Ill.1: Basic structure of polysiloxanes

The synthesis of polysiloxanes takes place according to the reaction equation given in Ill. 2.



Ill.2: dimethyldichlorosilane — dimethylsilanediol — polydimethylsiloxane

Task 1

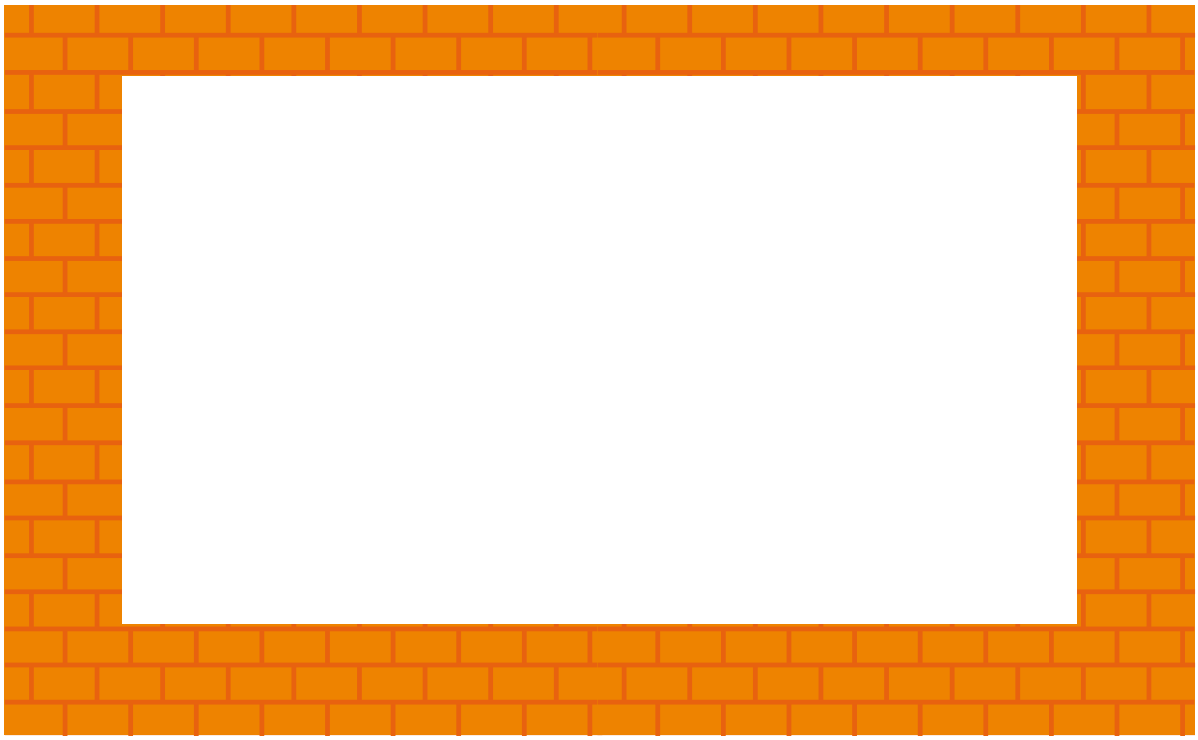
Describe the reaction mechanism in the synthesis of polydimethylsiloxane from dimethyldichlorosilane and name the illustrated reaction types. Remember that silicon is a chemical element analogous to carbon.

Task 2

Among other applications, silicon oils are used to hydrophobize the surfaces of buildings made of concrete. Using molecular structures, explain the manner by which mineral building materials based on silicon dioxide are given hydrophobic properties when treated with silicon oils.

GRAFFITI AS FIELD OF CONFLICT

You and a friend are out late at night and happen to see a full box of used paint spray cans in a corner of a neighbour's empty garage. Since you don't have anything better to do and always wanted to spray a graffiti, you spontaneously decide to take the cans with you. After thinking about where you could spray the graffiti, you decide to go to an industrial area that is not far away and immortalise yourselves on one of the brick walls. While you are trying out your artistic talent on a brick wall, your friend keeps a lookout.



For some people like you and your friend, graffiti is modern street art – for others they are nothing but annoying defacements in public places.

Task 1

Discuss in your class what the central problems are in conjunction with graffiti.

Task 2

In your group, find information on the solutions available for removing graffiti and what means of prophylaxis are available.

Unfortunately, you and your friend were caught during your risky adventure while spraying the brick wall and brought to the next police station.

Task 3

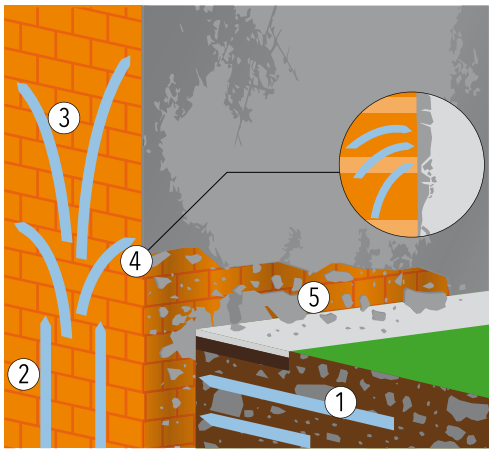
Find out what legal consequences such actions will have for you. Are there any consequences for your friend, even though he was only on the lookout? Or maybe none of it matters because "parents are liable for their children"?

SALT LOADED WALLS – APPLICATIONS FOR RESTORATION RENDER

In the case of poorly waterproofed old buildings, for example, moisture from the outside can penetrate into the walls and transport dissolved salts through the masonry to the surface of the wall (salination of the masonry work) because they do not have a horizontal barrier. If the salts crystallise, large areas of the render spall. Actually, there is a good solution for this kind of problem: Restoration render. The effect of restoration render is based on its inability to conduct moisture through capillaries which means that the water carrying the salts from the masonry work is not able to reach the surface of the wall. The water evaporates at the render base and escapes through the pores. The dissolved salts crystallise and remain in the pore space of the layer of render. Because of its pore geometry, a restoration render is basically a render that has the ability to store salts and prevent them from reaching the surface. Thanks to this property, the render remains dry and damage is prevented. However, it is not possible to dry out damp walls with restoration render.

Task 1

Based on the information given in the text above, explain the numbered processes shown in the two illustrations.



Damage mechanism

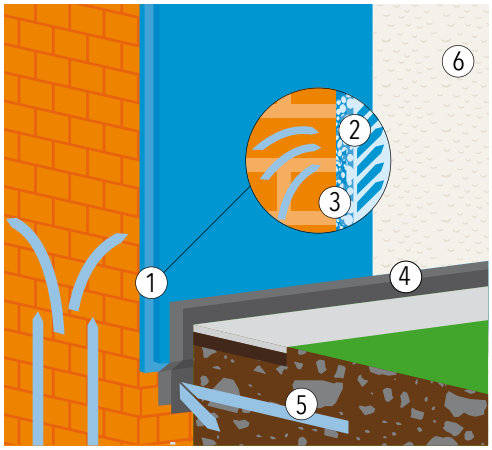
① _____

② _____

③ _____

④ _____

⑤ _____



Repair of the damage

① _____

② _____

③ _____

④ _____

⑤ _____

⑥ _____