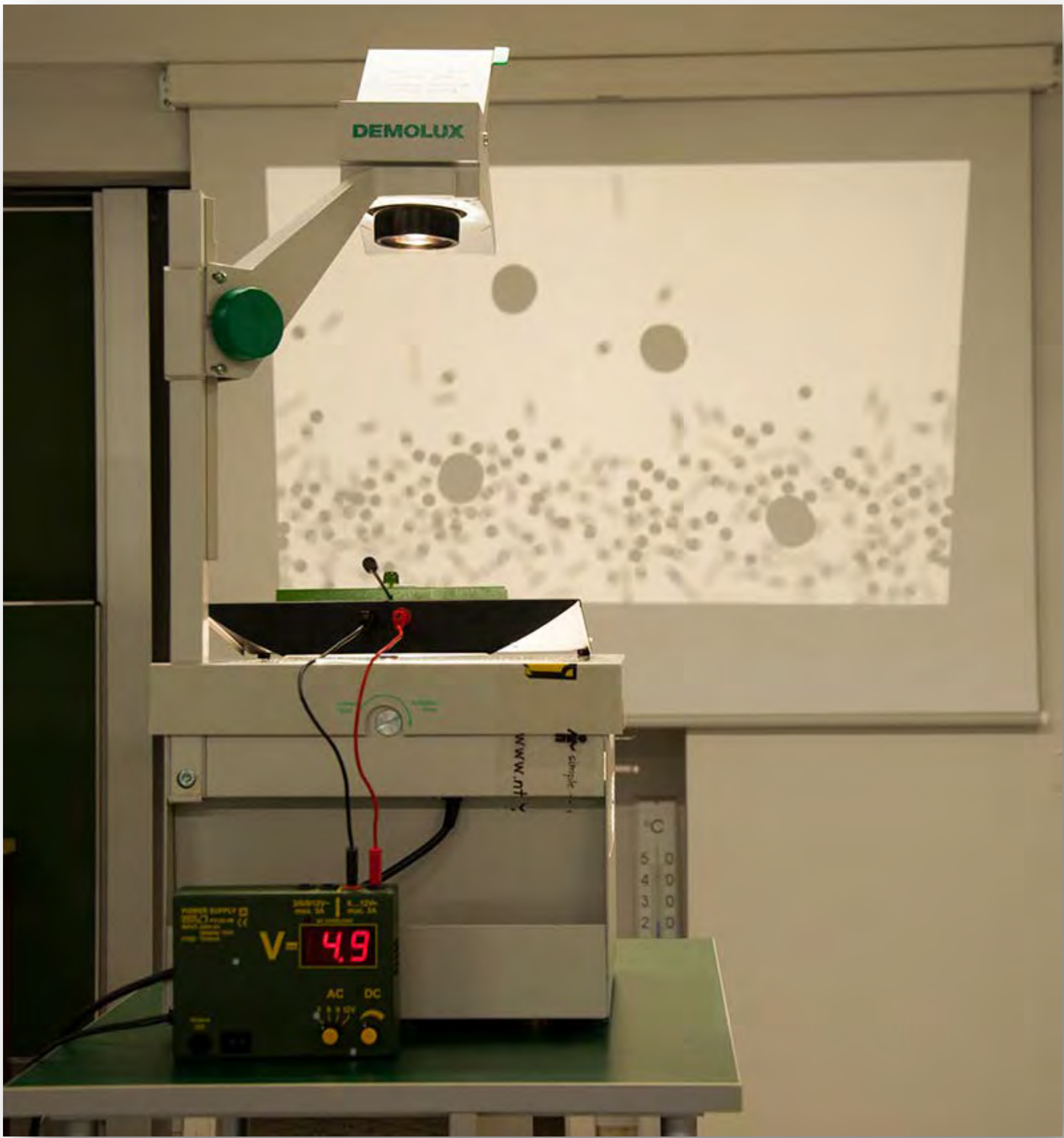
Particle motion model to OHP

DM850-2T

For model experiments on the topic of "Matter - States and behaviour" (particle motion)

Experiment guide



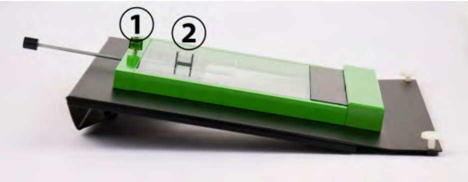
Scope of delivery:

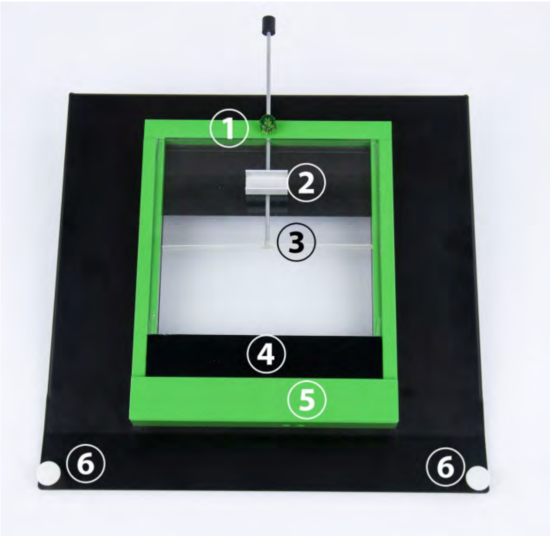
Glass chamber on metal plate, with motor-driven oscillating beam, which sets small metal balls in motion; with an overhead projector, this motion becomes large and bright projected and thereby phenomena made visible for the whole class.
Supply voltage: 1 - 12 V DC, infinitely variable
Dimensions: 270 x 270 x 50 mm
Weight: approx. 500 g

Included in delivery:

60 g	Steel balls 3 mm (approx. 450 pcs.)
5	Steel balls 5 mm
2	Steel balls 6.35 mm
4	Discs made of steel, aluminum, wood and XPS (plastic)
1	Ring for osmosis
1	Magnet 10 x 50 mm
1	Tweezers
1	Work instruction

Detailed description:





① Locking screw for limiting beam

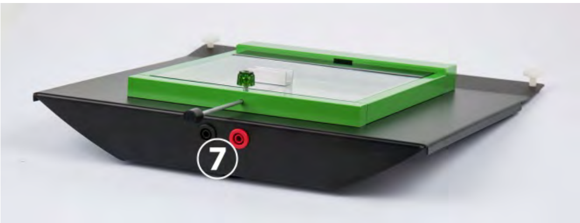
② Handle for glass plate and magnet holder

③ Limiting bar with sliding bar

④ Swing bar (under the cover)

⑤ Gear motor (under the metal bar)

⑥ Plastic levelling screws



⑦ Connection sockets for power supply:
DC 1 - 12 V

Setup:

Put the apparatus on the overhead projector

Lift off glass plate

You need different numbers of balls for the various experiments. We therefore recommend weighing the balls, as counting them is too tedious.

for information:
100 balls have a mass of about 13.12 g

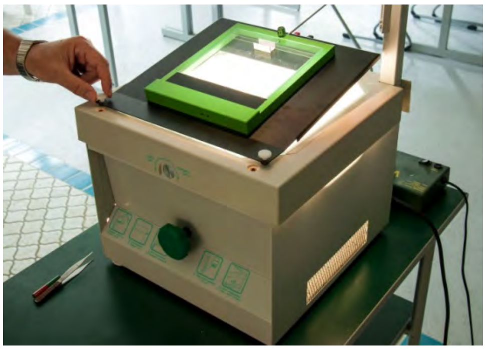
Carefully place the open container with the small balls on the base plate

Dump balls slowly

Put the glass plate back on

Apply supply voltage of 0 - 12 V DC

It can now be experimented.



If you notice that the balls are distributed one-sided in the chamber ….

…. you must level the model accordingly with the screws.

After the experiments, the larger objects can be collected with tweezers or fingers and stowed away again.

The small balls can be picked up with the magnet, and stripped with the fingers into the container.

Experiments - Index

STATES OF AGGREGATION

TB 01

Material:

Item Code	Qty	Description
DM850-2T	1	Particle motion apparatus for OHP
P3130-3D	1	Low-voltage power supply with digital display
P3310-3A	1	Connecting lead SE, 50 cm, red
P3310-3R	1	Connecting lead SE, 50 cm, black
DM125-4A	1	Digital balance 06, 500/0.01 g
	1	Overhead projector

Goal:
How do particles behave in solids, liquids, and gases?

Setup 1:
- Place particle motion apparatus on the projector
- Lift off glass plate
- Pull the limiting bar up to the magnet holder and slightly tighten the sliding bar
- weigh out about 7 g of 3 mm balls and slowly fill them into the glass chamber
- Put the glass plate back on
- Apply supply voltage of 0 - 12 V DC

Experiment 1, „State of aggregation gaseous“:
The power supply is switched on and slowly ramped up to about 4 - 6 V DC.
The movement of the swing bar causes the adjacent particles (small metal balls) to move.

If a larger part of the balls accumulates on one side, the model must be aligned horizontally with the levelling screws.

The balls are to represent gas particles in this experiment. The oscillation frequency of the swing bar is set so that the gas particles move rapidly.

Conclusion:
In a confined space, we find a small number of particles with high kinetic energy.
These move freely and at different speeds.
There is no "cohesion" between the particles.

Note:
The particles are initially spread out over the entire viewing area.
If we reduce the voltage to about 3 - 3.5 V, however, we can see that there are more particles at the bottom and fewer at the top.

Thus, a comparison can be made with the air pressure in the atmosphere:
The higher we ascend in the atmosphere, the fewer air particles we find, therefore the air pressure is also lower.

Experiment 2, „State of aggregation liquid“:

Setup:
- Switch off power supply
- Lift off glass plate
- Weigh out about 30 g of 3 mm balls and slowly fill them into the glass chamber. (or add about 20 g of balls to the preliminary test).
- Put the glass plate back on

The power supply is switched on and slowly ramped up to about 2.5 - 3 V DC.
The movement of the balls is observed.

The balls are to represent liquid particles in this experiment. The oscillation frequency of the bar is adjusted so that the particles now travel less quickly.

Conclusion:
In a limited space, we find a higher number of particles with less kinetic energy.
The motion is slower, but still irregular.
The distances between the particles are smaller therefore one can guess a small "cohesion" of the particles.

Note:
The particles are only spread out over half the visible area.
Here, too, it can be seen that there are more particles at the bottom and fewer at the top.

Thus, a comparison can be made with the pressure in bodies of water:
The deeper we dive into a body of water, the higher the (hydrostatic) pressure becomes.

Experiment 3, „State of aggregation solid“:

Setup:
- Switch off power supply
- Lift off glass plate
- Weigh out about 50 g of 3 mm spheres and slowly fill them into the glass chamber. (or add about 20 g of balls to the preliminary test)
- Put the glass plate back on

The power supply is switched on and slowly regulated up. It is recommended to select a higher voltage first, then to regulate it back to about 2 - 2.5 V DC, so that the swing bar moves as slowly as possible.
The movement of the balls is observed.

In this experiment, the balls are to represent the particles of a solid. The oscillation frequency of the bar is set so that the particles move only very little.

To show the "solid" more clearly, it is more descriptive to slide the limiting bar over the balls.

Conclusion:
In a limited space, we find a large number of particles with almost no kinetic energy.
Many particles do not move at all, only a few hardly move.
The distances between the particles are very small and regular. This can be interpreted as a large "cohesion" of the particles.

Note:
The particles are now spread out over the lower viewing area.
Even in solids, there are particles that move.

PARTICLE MOTION – BROWNIAN MOLECULAR MOTION

TB 02

Material:

Item Code	Qty.	Description
DM850-2T	1	Particle motion apparatus for OHP
P3130-3D	1	Low-voltage power supply with digital display
P3310-3A	1	Connecting lead SE, 50 cm, red
P3310-3R	1	Connecting lead SE, 50 cm, black
DM125-4A	1	Digital balance 06, 500/0.01 g
	1	Overhead projector

PARTICLE MOTION – BROWNIAN MOLECULAR MOTION

TB 02

Goal:
Why does smoke move in the air? And why does it move so irregularly?

Setup:

- Place particle motion apparatus on the projector
- Lift off glass plate
- Pull the limiting bar up to the magnet holder and slightly tighten the sliding bar
- weigh out about 30 g of 3 mm balls and slowly fill them into the glass chamber
- place one of the two 6.35 mm balls in the glass chamber as well
- Put the glass plate back on
- Apply supply voltage of 0 - 12 V DC

Experiment:
The limiting bar is adjusted so that it is about 1 cm above the top edge of the projection image.

The power supply is switched on and slowly ramped up to about 3 - 3.5 V. The movement of the swing bar causes the adjacent balls to start moving.

The tension is selected so that the balls set the larger ball in motion.

Conclusion:
We assume that the larger sphere is our "smoke particle". The surrounding, smaller particles are air particles.
So we can see that the smoke particle is irregularly moved by the surrounding air particles.

Note:
This irregular and jerky motion of small particles in liquids and gases is also called "Brownian motion".

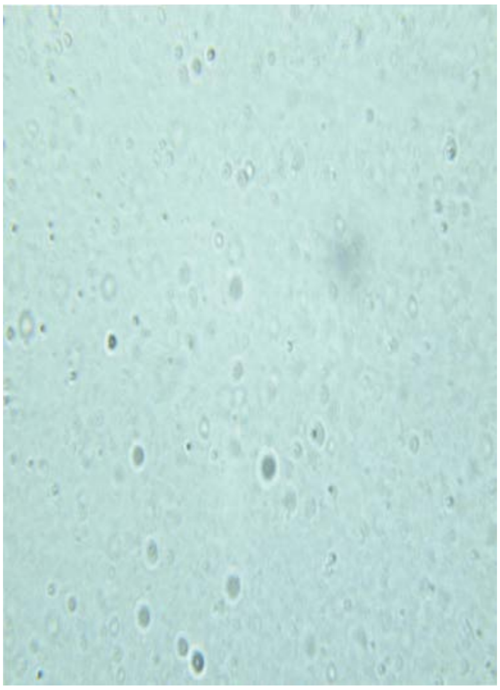
PARTICLE MOTION –
BROWNIAN MOLECULAR MOTION

TB 02

Note:

Brownian motion can also be shown with a microscope.

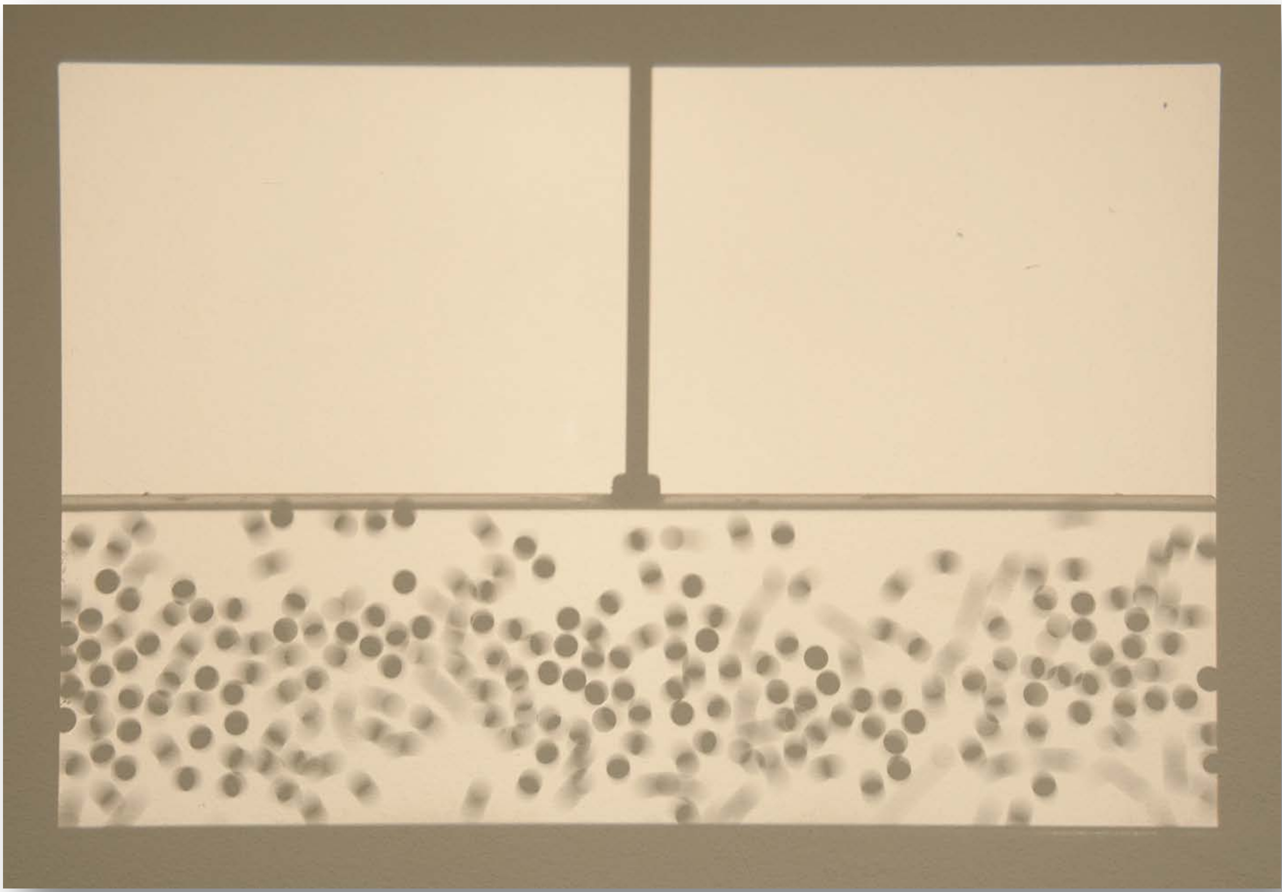
If you put a water-milk mixture on a microscope slide, you can also see particles and their movement.



Detail (image detail)

TEMPERATURE INCREASE

TB 03



Material:

Item Code	Qty	Description
DM850-2T	1	Teilchenbewegungsmodell zur OHP
P3130-3D	1	Low-voltage power supply with digital display
P3310-3A	1	Connecting lead SE, 50 cm, red
P3310-3R	1	Connecting lead SE, 50 cm, black
DM125-4A	1	Digital balance 06, 500/0.01 g
	1	Overhead projector

TEMPERATURE INCREASE

TB 03

Goal:
What happens to particles when a substance is heated?

Setup:
- Place particle motion apparatus on the projector
- Lift off glass plate
- Pull the limiting bar up to the magnet holder and slightly tighten the sliding bar
- weigh out about 25 g of 3 mm balls and slowly fill them into the glass chamber
- Put the glass plate back on
- Apply supply voltage of 0 - 12 V DC

Experiment 1:
The limiting bar is loosened and positioned with the sliding bar about 4 cm above the swing bar, but not screwed tight!
The power supply is switched on and slowly regulated up to about 4 V.

Conclusion:
First, the particles begin with a slow movement. If we increase the voltage, this movement becomes faster and more intense.
At a voltage of 7 - 8 V, the particle movement should be strong enough for them to push the bar upwards.

From the amount of balls filled in, we assume that we have liquid particles.
If we heat the liquid, the occupied space also increases.

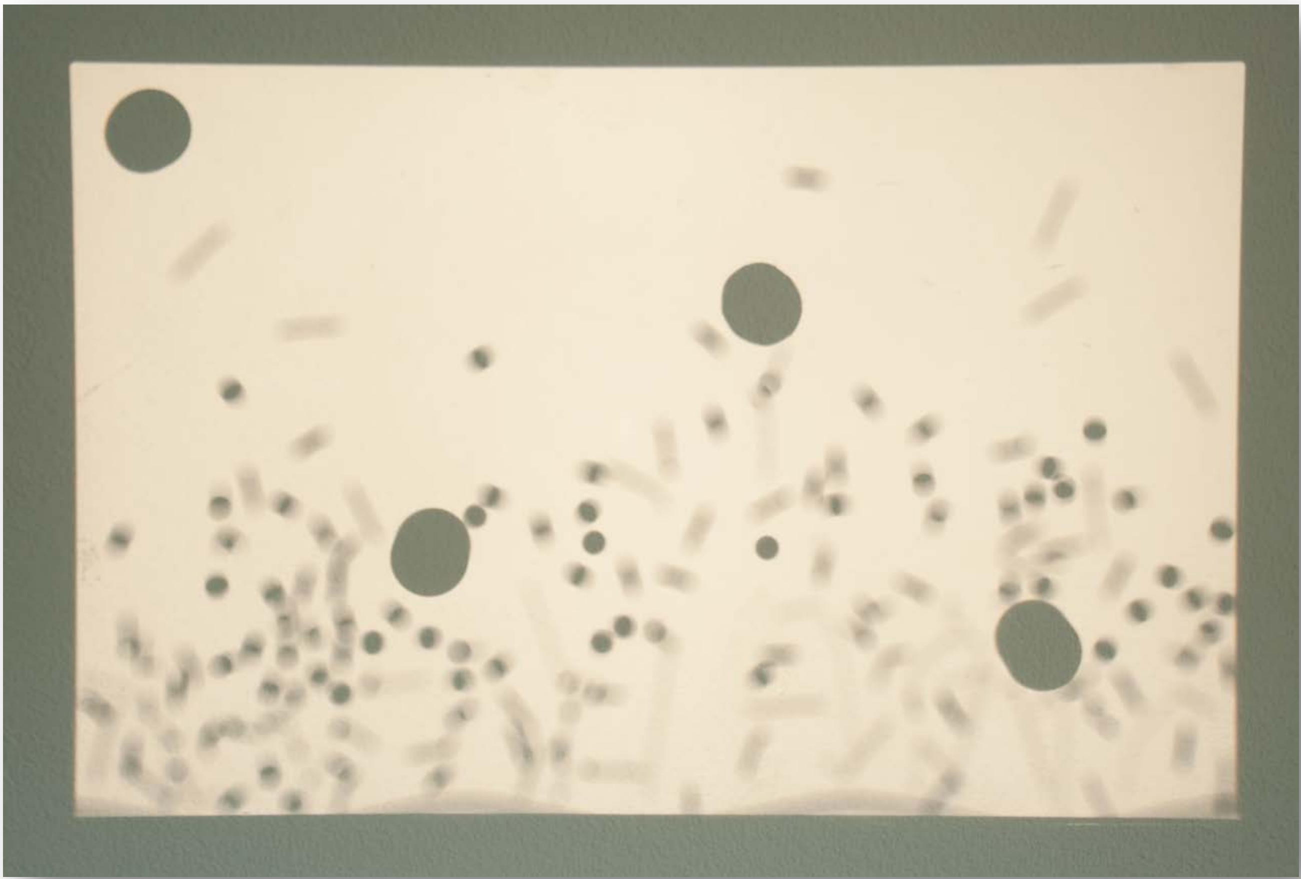
Experiment 2:
If we move the limiting bar slightly downwards again during the experiment, we can see that the smaller paths mean that the movement of the particles becomes increasingly rapid and intense.

This allows an increase in pressure to be represented in a confined space.

Note:
The same phenomenon can be shown with few particles (gaseous substance) or with many particles (solid).
Especially with solids, this experiment makes it easier for students to understand why solids also increase in size (expand) when heated.

BUOYANCY IN LIQUIDS

TB 04



Material:

Item Code	Qty.	Description
DM850-2T	1	Particle motion apparatus for OHP
P3130-3D	1	Low-voltage power supply with digital display
P3310-3A	1	Connecting lead SE, 50 cm, red
P3310-3R	1	Connecting lead SE, 50 cm, black
DM125-4A	1	Digital balance 06, 500/0.01 g
	1	Overhead projector

BUOYANCY IN LIQUIDS

TB 04

Goal:
There are substances that float in water and others that do not. Why is that?

Setup:
- Place particle motion apparatus on the projector
- Lift off glass plate
- Pull the limiting bar up to the magnet holder and slightly tighten the sliding bar
- weigh out about 20 g of 3 mm balls and slowly fill them into the glass chamber
- put the discs of styrofoam, aluminum, wood and steel in the same way in the glass chamber
- Put the glass plate back on
- Apply supply voltage of 0 - 12 V DC

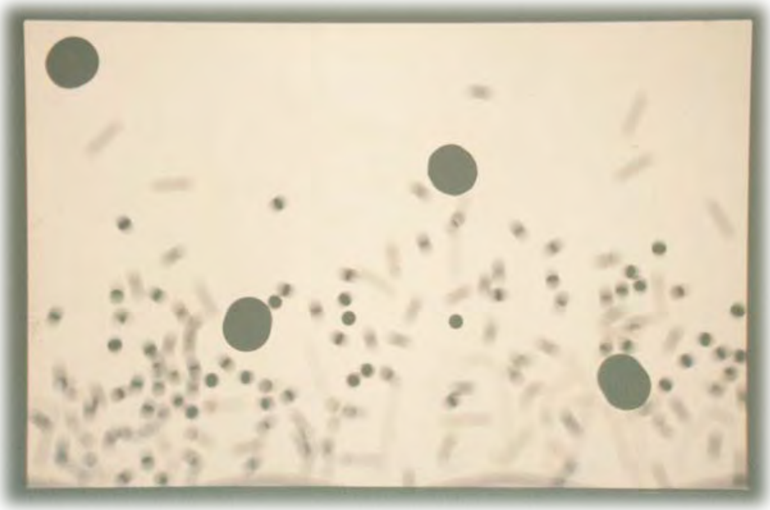
Experiment:
The power supply is switched on and slowly ramped up to about 4.5 - 5 V. First, the particles start with a slow movement. If we increase the voltage, this movement becomes faster and more intense.

If the particle motion is strong enough, one can see that the discs are lifted to different heights.

From the amount of balls filled in, we assume that the small balls are liquid particles.

On the projection image, all material slices appear the same. But how can you tell which disc is which material?

We turn off the power and the discs remain at different heights.



We lift off the glass plate and weigh the discs one after the other with an accurate balance (resolution at least 0.1 g). We start with the highest disc.
The results are entered in the table below.

Conclusion:

	Mass (in g)	Material
Disc 1	0,03	Styrofoam
Disc 2	0,40	Wood
Disc 3	1,70	Aluminium
Disc 4	4,95	Steel

The lighter a substance is, the higher it is lifted by the small particles.

The mass of the materials may vary slightly, as they are not precision bodies. In addition, the degree of drying must be taken into account for wood.

Note:
If we assume that the small balls are liquid particles, we can see through this experiment that some substances would swim, others would float, and still others would sink.

A direct comparison of the specific weight of our used materials of the discs to water is not useful here, because we do not use water.

GAS PRESSURE

TB 05

Material:

Item Code	Qty.	Description
DM850-2T	1	Particle motion apparatus for OHP
P3130-3D	1	Low-voltage power supply with digital display
P3310-3A	1	Connecting lead SE, 50 cm, red
P3310-3R	1	Connecting lead SE, 50 cm, black
DM125-4A	1	Digital balance 06, 500/0.01 g
	1	Overhead projector

GAS PRESSURE

TB 05

Goal:
What happens to the particles of gases when they are heated?

Setup:

- Place particle motion apparatus on the projector
- Lift off glass plate
- Pull the limiting bar up to the magnet holder and slightly tighten the sliding bar
- weigh out about 7 g of 3 mm balls and slowly fill them into the glass chamber
- Put the glass plate back on
- Apply supply voltage of 0 - 12 V DC

Experiment:
The limiting beam is loosened and positioned with the sliding bar about 6 cm above the swing bar, but not screwed tight!
The power supply is switched on and slowly regulated up to 4 V.

First, the particles begin with a slow movement. If we increase the voltage, this movement becomes faster and more intense. At a voltage of about 9 V, the particle motion should be strong enough to push the bar upwards.

If the side parts were movable, they would of course also be moved away, the pressure is the same in all directions.

Conclusion:
From the filled balls quantity we assume that we have gas particles.
If we heat them, the translational motion increases.
The faster movement causes more intensive impacts, which we can compare with the pressure of a gas on the vessel walls.

The higher the temperature rises, the greater the pressure in a confined space also becomes.

Note:
It is important to point out the effects of such processes, as vessels under high pressure can be very dangerous.

In thermal power plants, very high pressure is generated by hot steam. This is then used to drive large turbines.

EVAPORATION

TB 06

Material:

Item Code	Qty.	Description
DM850-2T	1	Particle motion apparatus for OHP
P3130-3D	1	Low-voltage power supply with digital display
P3310-3A	1	Connecting lead SE, 50 cm, red
P3310-3R	1	Connecting lead SE, 50 cm, black
DM125-4A	1	Digital balance 06, 500/0.01 g
	1	Overhead projector

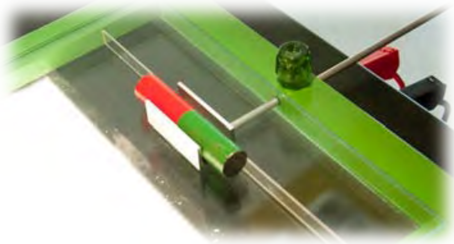
EVAPORATION

TB 06

Goal:
What happens to water particles during evaporation?

Setup:
- Place particle motion apparatus on the projector
- Lift off glass plate
- Pull the limiting bar up to the magnet holder and slightly tighten the sliding bar
- weigh out about 20 g of 3 mm balls and slowly fill them into the glass chamber
- Put the glass plate back on
- Apply supply voltage of 0 - 12 V DC

Experiment:
The round bar magnet is placed in the magnet holder. The limiting bar is adjusted so that it is approximately directly above the magnet holder.

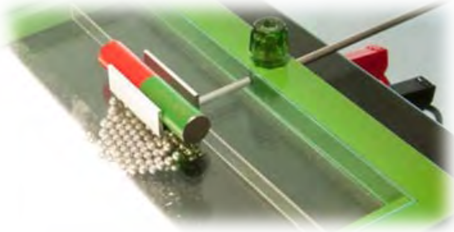


The power supply is switched on and slowly ramped up to about 4 V.
The movement of the swing bar sets the adjacent balls in motion.

The voltage is increased so far (about 6 V) that the balls bump against the limiting bar.

Conclusion:
Some of the particles are repelled violently by collisions and come into the attraction range of the round bar magnet.
They therefore disappear from the visible range.

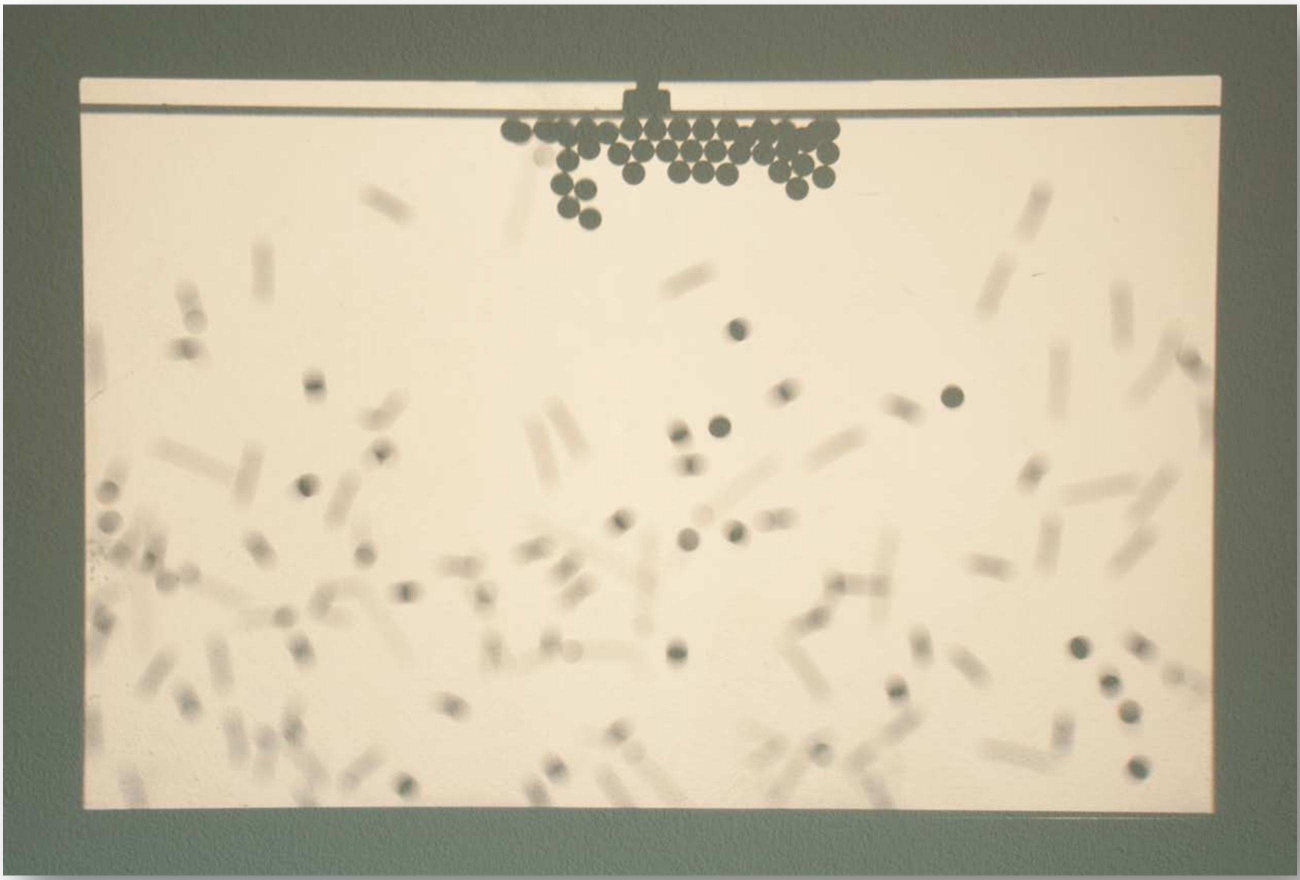
With a sufficiently long observation time, all particles eventually "disappear".



Note:
Water particles are visible to us. If water is heated, water vapour is produced and these particles "seem to dissolve into thin air". However, if this is cooled down again, a cloud is formed in nature and the water particles are then visible again.

CONDENSE

TB 07



Material:

Item Code	Qty.	Description
DM850-2T	1	Particle motion apparatus for OHP
P3130-3D	1	Low-voltage power supply with digital display
P3310-3A	1	Connecting lead SE, 50 cm, red
P3310-3R	1	Connecting lead SE, 50 cm, black
DM125-4A	1	Digital balance 06, 500/0.01 g
	1	Overhead projector

CONDENSE

TB 07

Goal:
What happens to water particles during condensation?

Setup:

- Place particle motion apparatus on the projector
- Lift off glass plate
- Pull the limiting bar up to the magnet holder and slightly tighten the sliding bar
- weigh out about 30 g of 3 mm balls and slowly fill them into the glass chamber
- Put the glass plate back on
- Apply supply voltage of 0 - 12 V DC

Experiment:
The limiting bar is adjusted so that it is at the top of the projection image. The bar should still be visible in the projection image.

The power supply is switched on and slowly ramped up to about 4 V.
The movement of the swing bar sets the adjacent balls in motion.

The voltage is increased so far (about 5 V) that the balls bump against the limiting bar.

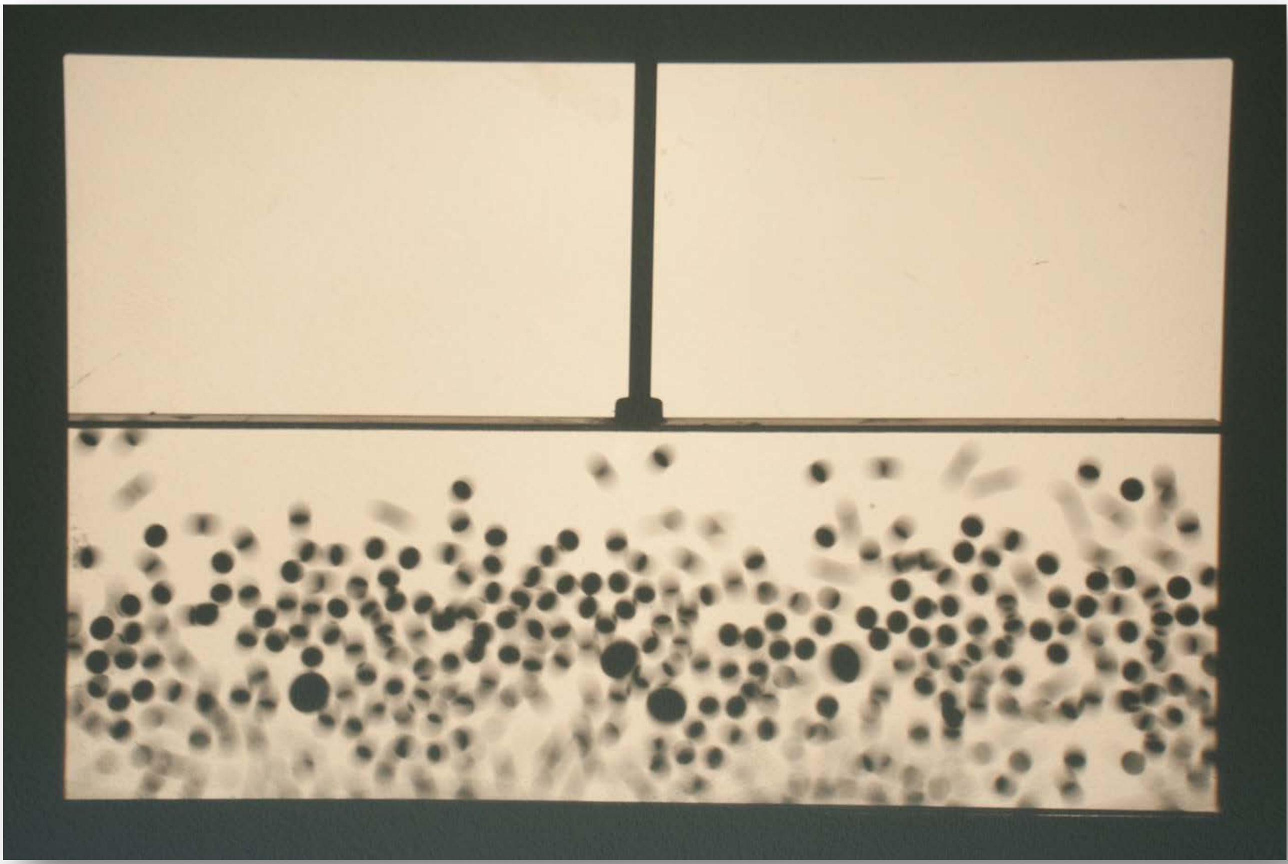
The round bar magnet is held below the magnet holder.

Conclusion:
Some of the particles are repelled violently by collisions.
More and more particles finally stick to the limiting bar, in the magnet's area of attraction.

Note:
The limiting bar can represent, for example, the lid over a pot.
The water particles in the pot are heated and begin to evaporate (see experiment 06).
If you hold a (cold) lid over the pot, water drops form there.
Water particles become gaseous during evaporation, and when they cool down they become liquid again.
This process is also called condensation.

DIFFUSION

TB 08



Material:

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P3130-3D	1	Low-voltage power supply with digital display
P3310-3A	1	Connecting lead SE, 50 cm, red
P3310-3R	1	Connecting lead SE, 50 cm, black
DM125-4A	1	Digital balance 06, 500/0.01 g
	1	Overhead projector

DIFFUSION

TB 08

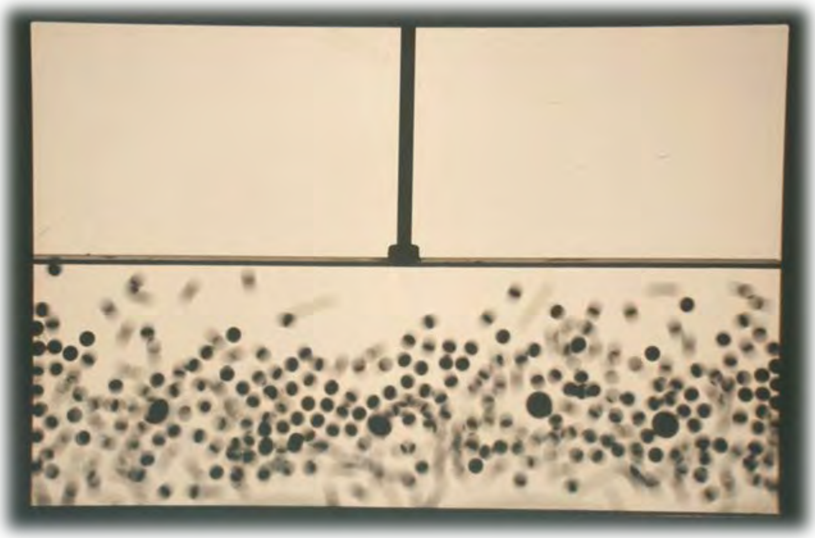
Goal:
If you spray fragrant aromas from a can into the air, they also spread over a larger room. Why is that?

Setup:

- Place particle motion apparatus on the projector
- Lift off glass plate
- Pull the limiting bar up to the magnet holder and slightly tighten the sliding bar
- weigh out about 40 g of 3 mm balls and slowly fill them into the glass chamber
- Place the 4 larger 5 mm balls in the glass chamber in the same way, but these should be lined up as close as possible to each other
- Put the glass plate back on
- Apply supply voltage of 0 - 12 V DC

Experiment:
The power supply is switched on and slowly regulated up to about 4 - 5 V.
The movement of the swing bar sets the adjacent balls in motion.

Conclusion:
If the small particles are moving briskly, you can see that they separate the larger particles from each other.
The more vigorous the movement of the small particles, the better one can see an almost even distribution of the large particles.

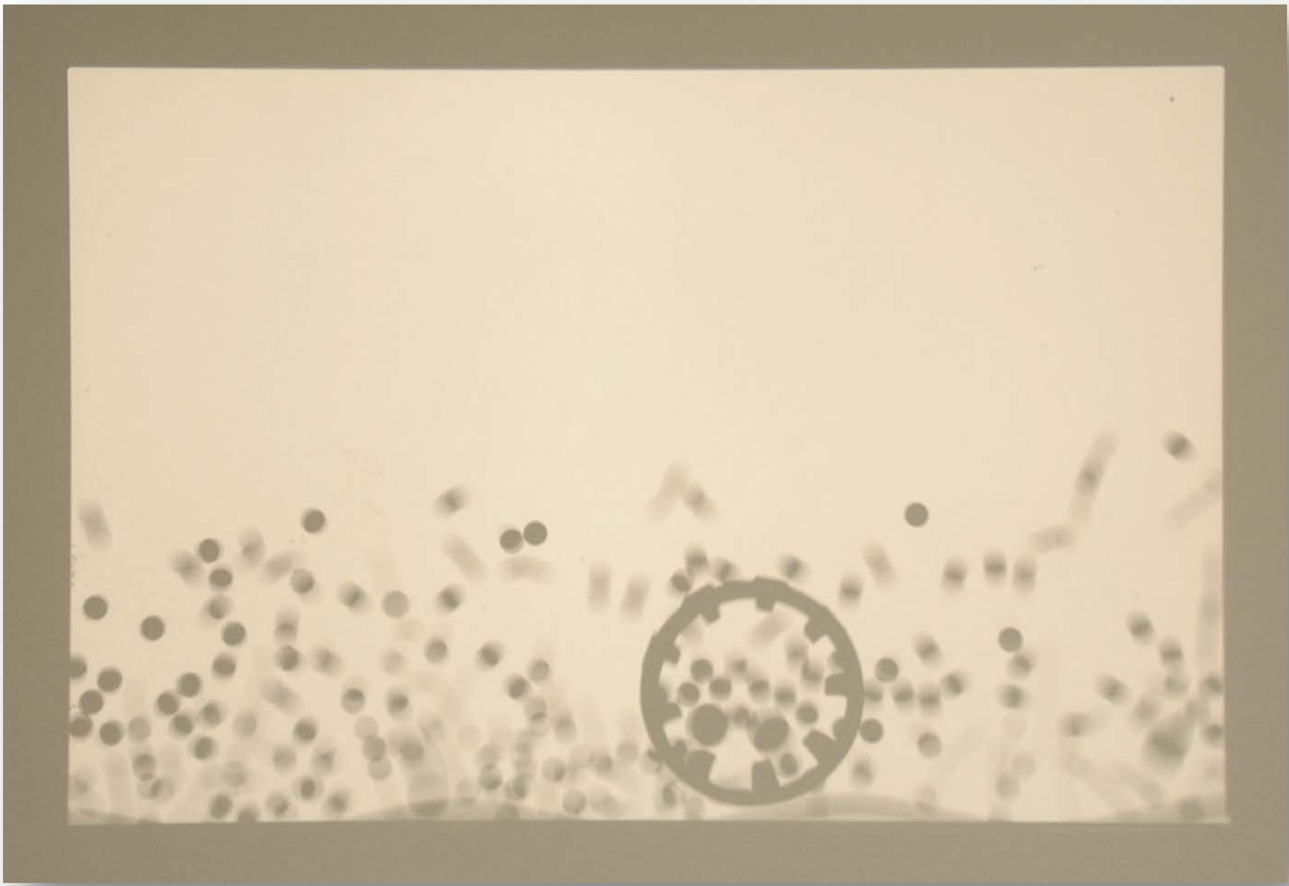


The complete mixing of two or more substances through the even distribution of the particles involved is also called diffusion.

Exhilarated note:
If you have eaten a lot of beans, it can also happen that less pleasant scents spread throughout the room. This is not pleasant, but it is also diffusion.

OSMOSIS

TB 09



Material:

Item Code	Qty.	Description
DM850-2T	1	Particle motion apparatus for OHP
P3130-3D	1	Low-voltage power supply with digital display
P3310-3A	1	Connecting lead SE, 50 cm, red
P3310-3R	1	Connecting lead SE, 50 cm, black
DM125-4A	1	Digital balance 06, 500/0.01 g
	1	Overhead projector

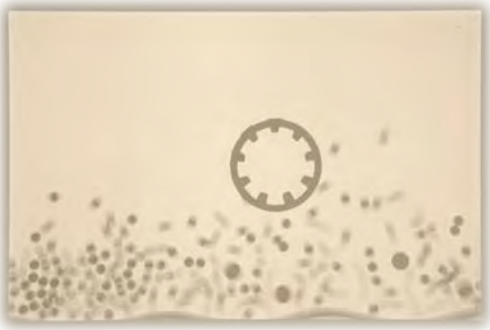
OSMOSIS

TB 09

Goal:
How do we regulate the water balance in our body? There are media that only allow particles to pass "in one direction". We show how something like this works.

Setup:

- Place particle motion apparatus on the projector
- Lift off glass plate
- Pull the limiting bar up to the magnet holder and slightly tighten the sliding bar
- weigh out about 20 g of 3 mm balls and slowly fill them into the glass chamber
- Place the 4 larger 5 mm balls and also the osmosis ring (metal ring with slots) in the glass chamber as well.
- Put the glass plate back on
- Apply supply voltage of 0 - 12 V DC



Experiment:
The power supply is switched on and slowly regulated up to about 3 V.
The movement of the swing bar sets the adjacent balls in motion.

Conclusion:
We increase the voltage to about 3.5 - 4 V. If the small particles move briskly, we can see after a short time that the small particles penetrate into the inside of the ring.
If one of the larger particles also reaches the wall of the ring, it also penetrates the ring.

Those large particles that have penetrated the inside of the ring, however, do not leave the inside again. The penetration of "the wall of the ring" is therefore only possible in one direction for the large particles. Such a process is called "osmosis".

Mediums that only allow particles to pass "in one direction" are also called "semi-permeable" substances.

Note on the explanation (Wikipedia):
Osmosis is often described as the spontaneous passage of water or another solvent through a semi-permeable membrane that is permeable to the solvent but not to the substances dissolved in it.

Osmosis is of central importance in nature, especially for the regulation of the water balance of living organisms and their cells.
As a separation process, it is used in medicine and process engineering.

DISSOLVING A CRYSTAL IN WATER

TB 10

Material:

Item Code	Qty.	Description
DM850-2T	1	Particle motion apparatus for OHP
P3130-3D	1	Low-voltage power supply with digital display
P3310-3A	1	Connecting lead SE, 50 cm, red
P3310-3R	1	Connecting lead SE, 50 cm, black
DM125-4A	1	Digital balance 06, 500/0.01 g
	1	Overhead projector

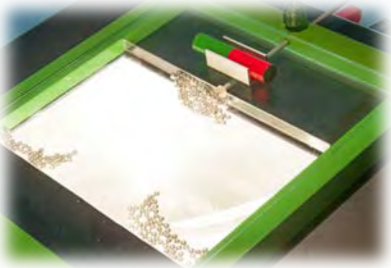
DISSOLVING A CRYSTAL IN WATER

TB 10

Goal:
How do salt particles dissolve in water?

Setup:
- Place particle motion apparatus on the projector
- Lift off glass plate
- Pull the limiting bar up to the magnet holder and slightly tighten the sliding bar
- weigh out about 30 g of 3 mm balls and slowly fill them into the glass chamber
- Put the glass plate back on
- Apply supply voltage of 0 - 12 V DC

Experiment:
With the help of the round bar magnet, some of the balls are pulled upwards to the limiting bar. The balls are thereby magnetised and thus represent a model crystal.



The magnet is carefully placed in the magnet holder. The limiting bar is adjusted so that the lower part of the crystal is visible in the projection image.

The power supply is switched on and slowly regulated up to about 4 V DC.
The movement of the swing bar sets the balls in motion. The voltage is increased further so that the balls bump against the model crystal.

Conclusion:

Due to the impacts, the particles of the crystal model are knocked out of the structure (caused by residual magnetism) in a short time. Depending on the intensity of the movement, this happens faster or slower. As a result, they now also become part of the model liquid.

References:
Dissolving salts in water (electrolytic dissociation)