



Virtual laboratory



CHEMISTRY

Inorganic Chemistry

User
manual



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Terms and Definitions

The following general terms are used in the User Guide:

Term	Definition
Virtual Laboratory	Application "Virtual Laboratory Chemistry", section "Inorganic Chemistry"
Scene	A virtual three-dimensional space within which the user can interact with the Virtual Laboratory objects. The concept of "scene" also includes the data of the current research (positions of objects, their parameters, etc.)
Workspace	Part of the scene within which the user can place Virtual Laboratory objects and interact with them.
Process simulation	The process of interaction between objects in a scene modeled in the Virtual Laboratory.
Camera	A scene tool with which the user observes everything that happens in the Virtual Laboratory.
Click	To make a click: — when using a mouse, move the mouse pointer to the object, press and release the left mouse button without moving the pointer; — when using a touchscreen, press the object with a finger and release it without moving the finger along the screen.
Toggle Button	A button that changes its state from inactive to active and vice versa after being pressed. The state is retained until the next interaction.

1 System requirements

The minimum system requirements for running the application "Virtual Laboratory "Chemistry", section "Inorganic Chemistry" are:

- **Processor:** Intel Ivy Bridge series / AMD Bulldozer series.
- **RAM:** 4 GB.
- Graphics Card:
 - Integrated: Intel HD Graphics 5000 / Intel Iris;
 - Discrete: GeForce 400 series or newer / Radeon HD 7000 series.
- **Screen Resolution:** 1920x1080 / 1920x1200 and higher (4K and Retina displays require a more powerful graphics card for comfortable operation).
- **Supported Browsers:** Chrome, Yandex.Browser, Opera 44+, Firefox 51+, Edge 79+, Safari 15+.
- **Supported Operating Systems:** Microsoft Windows 7 (x64 versions) with WebGL 2.0 driver support, MacOS X "Snow Leopard" 10.6 with WebGL 2.0 driver support, Linux or Debian with WebGL 2.0 driver support.

2 Interface of the application



Figure 1 – The Interface of the Virtual Laboratory

The interface of the application "Virtual Laboratory "Chemistry", section "Inorganic Chemistry" (hereinafter referred to as the Virtual Laboratory) is presented in Figure 1 and includes the following elements:

- 1) The **Application Header panel** (1) contains the logo and name of the Virtual Laboratory (on the left) and a set of functional buttons (on the right) (see [3 Application Header panel](#)).
- 2) The **Equipment panel** (2) contains cards of objects that can be created in the scene (see [6 Equipment panel](#)).
- 3) **Deletion zones** (see [7.6 Deleting objects](#)).
- 4) **Tools panel** contains buttons that switch instruments (see [7.4 Using tools](#)).
- 5) **Scene Card button** (see [4 Scene card](#)).
- 6) **Scene Control panel** (5) contains buttons for controlling the Virtual Laboratory scene (see [5 Scene Control panel](#)).
- 7) **Workspace** is a part of the scene where you can create items from the list of available equipment, interact with them, and navigate using the camera.

3 Application Header panel

The **Application Header** panel on the left contains the logo and name of the Virtual Laboratory, and on the right — a set of functional buttons (Figure 2):



Figure 2 – Functional buttons of the Application Header panel

- Safety Precautions button  (see [3.1 Safety precautions](#));
- Instruction button  (see [3.2 Instruction](#));
- Tips Mode Activation button  (see [3.3 Interactive tips](#));
- Virtual Keyboard Activation button  (see [3.4 Virtual keyboard](#));
- Fullscreen Mode on/off button  (see [3.5 Fullscreen mode](#));
- Scene Dropdown Menu call button  (see [3.6 Scene menu](#));
- User Profile button  (see [3.7 User profile](#)).

3.1 Safety precautions

Objects in the application interact in the same way as in a real laboratory, so it is necessary to follow safety procedures when conducting experiments.

Press the  button on the **Application Header** panel to open the safety precautions (Figure 3).

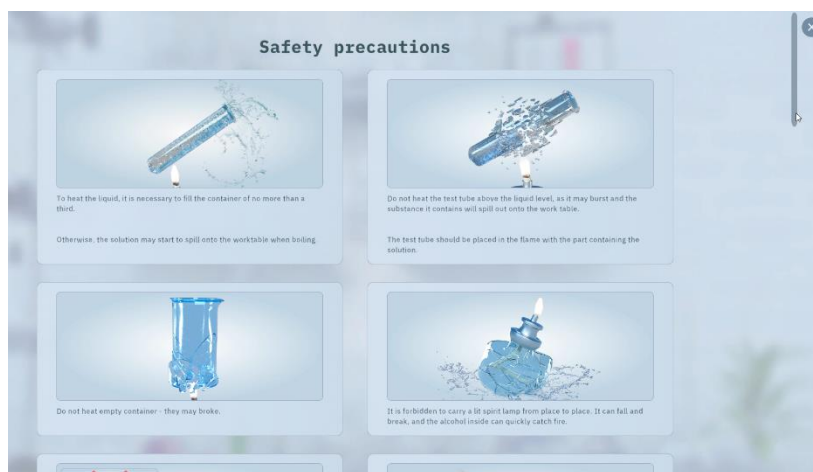


Figure 3 – Safety precautions window

To close the window, press  in the upper right corner. To scroll the instructions up or down, rotate the mouse wheel or press and hold the left mouse button on the scroll bar to the right of the instructions and pull in the desired direction.

If safety procedures are not followed, the experiment will be halted, and a window with a safety violation message will appear on the screen (Figure 4).

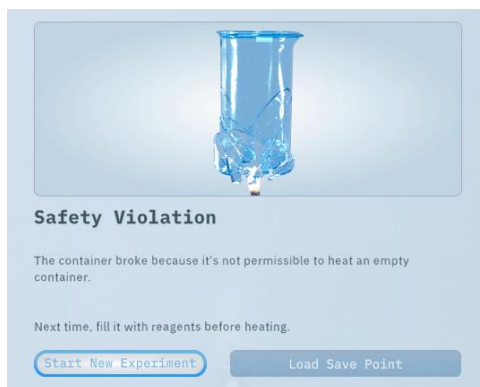


Figure 4 – Safety violation message

Continuing with the current experiment after a safety violation is not possible. Press **Start New Experiment** to clear the workspace and start over. Press the **Load Save Point** button to return to one of the save points (see 5.1.2 [Save Point button](#)). If there are no save points in the scene, the button will be inactive. It is not possible to create a save point after violating safety procedures.

3.2 Instructions

The Virtual Laboratory offers User manual and two video instructions:

- "Introduction video" to get an idea of how to work with objects;
- "Saving and Loading" to get acquainted with the application's saving and loading options.

Press the **Instruction** toggle  button on the **Application Header** panel to choose the instruction. The button will go into active mode (indicated by changed colour: ) , an instruction selection menu will open. Select the instruction you are interested in (Figure 5).

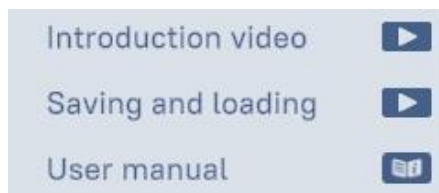


Figure 5 – Instruction selection menu

Click on the title of the instruction that you want to start watching. The video will play on the screen over the scene. Control the playback using the built-in player (Figure 6).



Figure 6 – Player control elements

A **Close** button  is located in the upper right corner of this window.

3.3 Interactive tips

Press the **Tips**  toggle button on the **Application Header** panel to switch to **Tips Mode**. Tip points will appear near the objects in the scene. To view a tip, press the point (Figure 7).



Figure 7 – Tips mode

To close the tip panel, press the tip point again or click on the cross in the upper right corner of the panel.

Tip points change their outline colour depending on whether the user has viewed the tip (Figure 8):

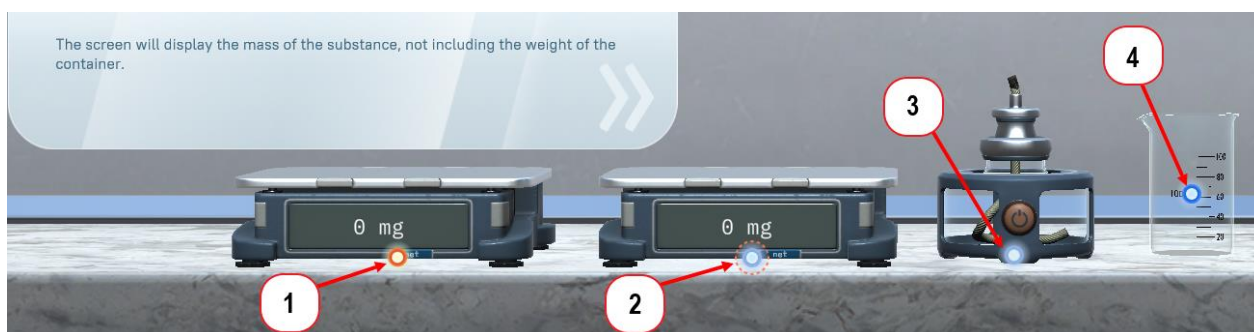


Figure 8 – Different outline colours for tip points

- 1) Dot with orange outline  — the tip is open on the screen (as in Figure 8).
- 2) If several objects have the same tips and one of these tips is currently open, then the tip points of other objects with the same tip will have a double outline: dotted gray and orange .
- 3) Dot with gray outline  — the user previously viewed and closed the tip.
- 4) Dot with blue outline  — the user has not yet viewed this tip.

Moreover, there are three hidden tip icons in the Virtual Laboratory (Figure 9): Moving Objects (1), Navigating the Scene (2), Interaction zones (3). They are only visible in **Tips Mode**.



Figure 9 – Hidden tip icons

To exit the Tips Mode, press the  button on the **Application Header** panel.

3.4 Virtual keyboard

To be able to use the virtual keyboard, press the toggle button  on the **Application Header** panel. In this mode, a virtual keyboard is displayed on the screen after clicking on the text fields in the scene card (Figure 10).

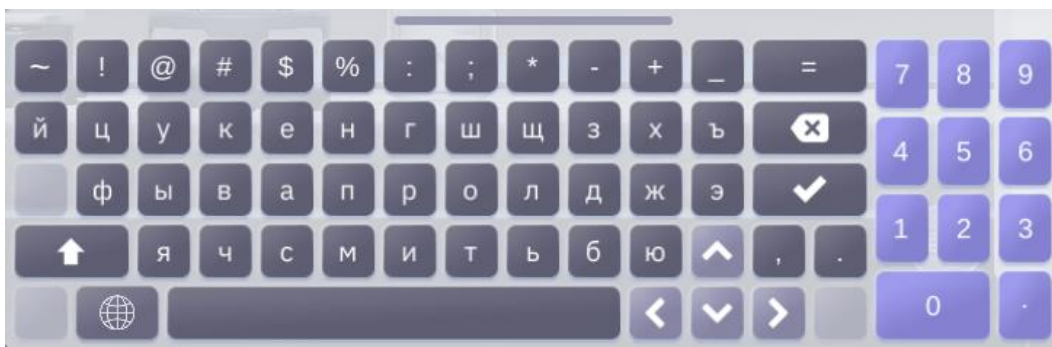


Figure 10 – Virtual Keyboard

The virtual keyboard has two layouts: Latin and Symbolic. The layout is changed using the button  on the virtual keyboard.

To exit the virtual keyboard mode, press the button  on the **Application Header** panel.

3.5 Fullscreen mode

To enable Fullscreen Mode, press the **Fullscreen Mode** button  on the **Application Header** panel. The application will expand to full screen, hiding the browser frame and the OS taskbar. To exit Fullscreen Mode, press the button  again.

3.6 Scene menu

While working in the Virtual Laboratory, you can:

- save the current scene (see [3.6.1 Saving the scene](#));
- save a copy of the current scene (see [3.6.2 Saving a copy of the scene](#));
- create a new scene (see [3.6.3 Creating a new scene](#));
- open the **My Scenes** library (see [3.6.4 Viewing and loading user scenes](#));
- share a link to the current scene (see [3.6.5 Saving a link to a scene](#)).

All these actions can be performed using the drop-down **Scene Menu** (Figure 11). The menu opens when you press the button  on the **Application Header** panel.

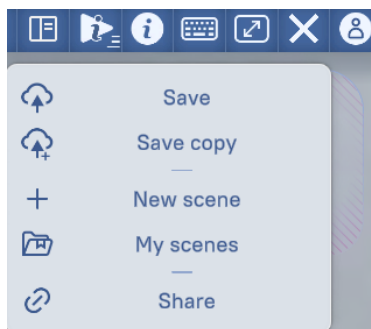


Figure 11 – Scene Menu

To close the menu, press the button  or any free scene area.

3.6.1 Saving the scene

To save the scene to the **My Scenes** library, select **Save** in the **Scene Menu** (Figure 11). If this scene has never been saved before, the saving window will be opened (Figure 12).

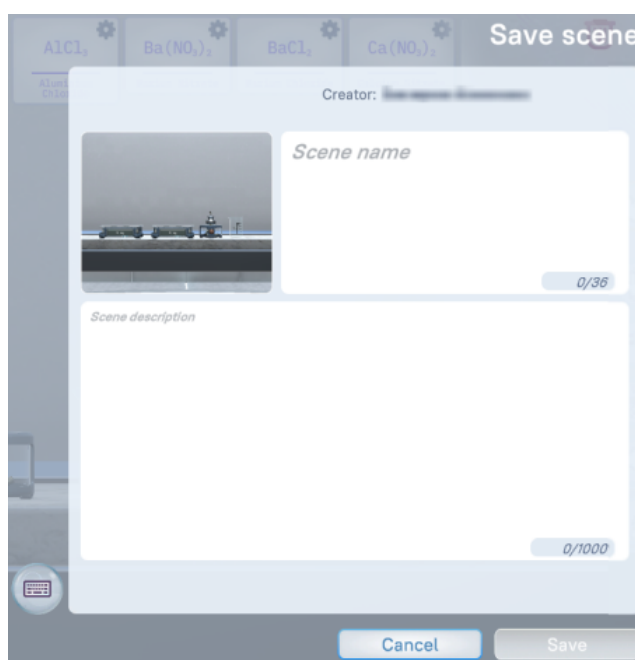


Figure 12 – Scene saving form

Enter the name of the scene to be saved (no more than 36 characters) and its description (no more than 1000 characters) in the appropriate fields of the form and click the button .

If the **Scene Name** and **Scene Description** fields were filled in in the scene card, then these values will be displayed when saving the scene (see **4 Scene card**).

You can use the virtual keyboard if necessary. To do so, use the button , located to the left of the saving form. This button duplicates the button  in the **Application Header** panel (see [3.4 Virtual](#)

keyboard): if the **Application Header** panel had the virtual keyboard mode enabled , then the button next to the scene saving form will also be in the active state  and vice versa.

If you want to cancel the saving of the scene, press the button .

3.6.2 Saving a copy of the scene

To save a copy of the scene in the **My Scenes** library, select **Save Copy** in the **Scene Menu** (Figure 11) This will open the form for saving a copy of the scene, which is similar to the scene saving form (Figure 12).

If the scene is being saved for the first time, you must fill in the **Scene Name** (no more than 36 characters) and **Scene Description** (no more than 1000 characters) fields.

If the scene has already been saved, the previously saved scene name with the copy number in brackets will be displayed in the **Scene Name** field — . The scene name and copy number can be adjusted or left unchanged.

If the **Scene Name** and **Scene Description** fields were filled in in the scene card, then this data will be displayed when saving a copy of the scene (see [4 Scene card](#)).

Click the  button to save a copy of the scene.

After you have saved a copy, you will continue to work with it, and the copy of the scene you worked with before will remain in the state of its last save.

If you do not need to save the scene copy, press the button .

3.6.3 Creating a new scene

To create a new scene, select **New Scene** in the **Scene Menu** (Figure 11). If there are unsaved data, a window with a warning about possible data loss (Figure 13) will open.

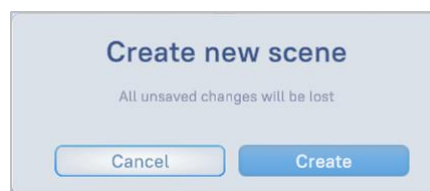


Figure 13 – Create New Scene Window

To avoid losing current data, click the button  and continue working with the scene. If you do not need to save the data, click , after which all unsaved data will be lost and a new empty scene will open.

3.6.4 Viewing and loading user scenes

To view a list of scenes, select **My Scenes** in the **Scene Menu** (Figure 11). The **My Scenes** library page (Figure 14) will open.

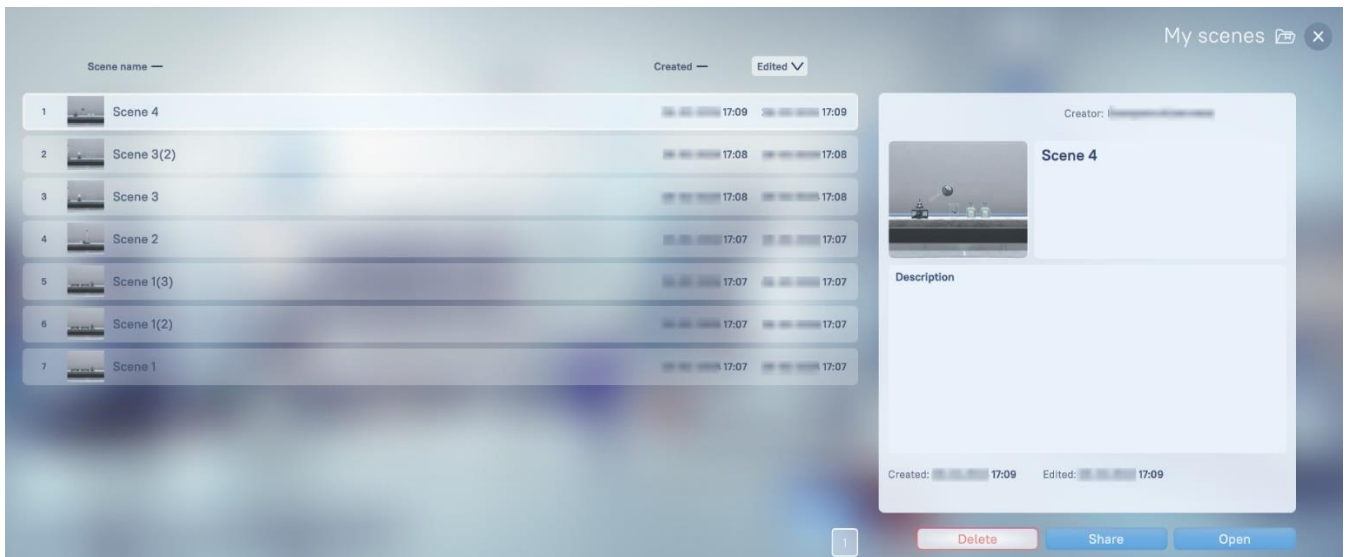


Figure 14 – My Scenes library

On the left side of the screen, a list of all saved scenes will be displayed. You can sort the data by scene name, creation date, and modification date. To sort, click on the name of the corresponding table column (Name, Created or Modified). The "-" icon next to the name will change to a check mark,

indicating the sorting direction .

If the list of scenes does not fit on one screen, it will be split into pages. Navigation through the pages is done using a series of buttons with page numbers, located to the right under the table.

The information about the selected scene is in the scene card to the right of the table. If necessary, you can open, delete, or share the selected scene using the buttons located under the scene card.

3.6.5 Saving a link to a scene

To share a link to the current scene, select **Share** in the **Scene Menu** (Figure 11). The link will be copied to the clipboard, and you can save or share it. At this point, the scene needs to be saved, and if you have not yet saved this scene, the save form (Figure 12) will appear. You can save the link from the clipboard or send it to someone.

3.7 User profile

When you press the **User Profile** button  on the **Application Header** panel, the user's login is displayed and the user menu opens (Figure 15).

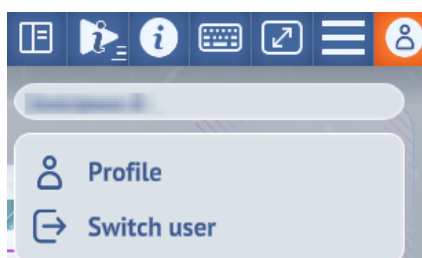


Figure 15 – User Menu

Select the **Profile** to access your profile information. The data will open in a new browser tab.

When you select **Switch User**, two buttons appear under the menu: press , to change the current account, or  to continue working under the current account.

To close the menu, press the button  or click anywhere else on the scene.

4 Scene card

The scene card (Figure 16) allows you to fill in and view the information about the scene that will be required for saving. The scene card opens:

- by clicking on the **Scene Card** button  in the lower right corner of the application window (Figure 1),
- by saving a scene or its copy (see [3.6.1 Saving the scene](#) and [3.6.2 Saving a copy of the scene](#));
- by selecting a scene in the **My Scenes** library (see. [3.6.4 Viewing and loading user scenes](#)).

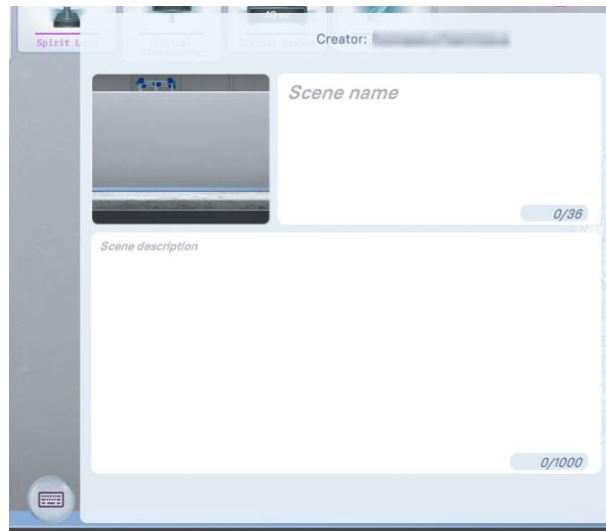


Figure 16 – Scene card

The **Scene Name** and **Scene Description** card fields will be filled in if:

- you have already filled out the scene card,
- you have already saved the scene or a copy of it,
- you opened a scene with a completed card using a link from another user,
- you have opened a public scene with a completed card.

In other cases, the **Scene Name** and **Scene Description** fields will be empty.

Information on the card can be edited and deleted. You can use your device's keyboard or the virtual keyboard to fill out or edit the Scene Title and Scene Description fields. For more information about using the virtual keyboard, see [3.4 Virtual keyboard](#) and [3.6.1 Saving the scene](#).

To close the scene card, press the **Scene Card** button again or click anywhere in the application window outside the card.

5 Scene Control panel

The **Scene Control** panel is located at the bottom of the screen and consists of three sections (Figure 17):

- 1) Scene Control block (see [5.1 Scene Control block](#)),
- 2) Simulation Control block (see [5.2 Simulation Control block](#)),
- 3) Camera Control block (see [5.3 Camera Control block](#)).



Figure 17 – Scene Control panel

5.1 Scene Control block

The **Scene Control** block (Figure 18) contains buttons to clear the scene and save, and later load the current state of the scene.

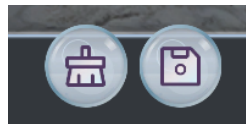


Figure 18 – Scene Control buttons

5.1.1 Clear Scene button

The **Clear Scene**  button is available if there is at least one object placed in the scene. Pressing the button opens a confirmation window (Figure 19).

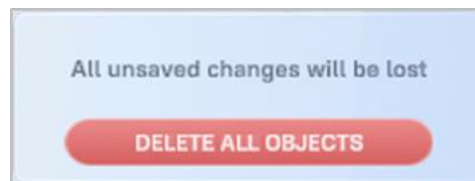


Figure 19 – Confirmation window to clear the scene

Press the **Delete All Objects** button to clear the scene. To cancel the deletion of all objects, click anywhere on the screen outside the window.

5.1.2 Save Point button



Figure 20 – Save Point creation window

A save point is a fixed state of the scene. At a save point, the system creation time, timer time, location, settings and readings of instruments, substances in vessels and their properties, the condition of the vessels, and the indicator paper are all recorded and stored.

To create a save point, press the  button on the **Scene Control** panel, and in the window that opens, press "+" (Figure 20). The "+" button is active if there is at least one object placed in the scene and safety precautions have not been violated.

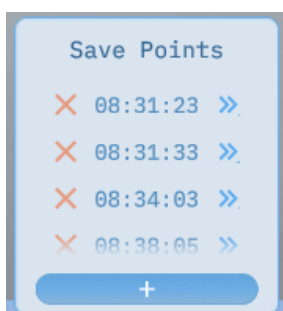


Figure 21– List of save points

To delete a save point, press the  button to the left of the point's creation time (Figure 21). To load a save point, press the  button to the right of the point's creation time.

If there are more than four save points, rotate the mouse wheel to scroll through the list. When using a touchscreen, swipe up or down to scroll through the list.

5.2 Simulation Control block

The simulation of processes begins automatically when the Virtual Laboratory is launched. If a safety protocol violation occurs during operation, the simulation stops. To continue, you must start a new experiment or load a save point (see [3.1 Safety precautions](#)).

The simulation control block (Figure 22) includes:

- 1) **Simulation** button with a timer,
- 2) **Simulation Speed Control** slider.



Figure 22 – Simulation Control block

To halt all processes in the scene, press the **Simulation** button (1). During a pause, the  button changes colour, and the icon changes from a  play to a pause  symbol, halting the timer. Chemical reactions and processes are also paused. To resume, press the **Simulation** button again, create a new object, or click on any object in the scene. The simulation will restart from the point it was paused.

The **timer** displays the passage of time and is used for a relative assessment of the simulation speed. The timer's speed change considers the simulation speed.

The **Simulation Speed Sontrol** slider (2) allows you to adjust the comfortable speed of process simulations. When the application starts, the speed value is set to 1, which corresponds to real-time. To change the speed of the simulation processes, press and drag the slider left or right along the speed scale to the desired value (Figure 23). Release the button — the speed scale will hide, and the set speed will be displayed on the slider.

Fractional values indicate a slowdown relative to real-time, while whole values indicate acceleration. For example, $\frac{1}{4}$ on the speed scale signifies a slowdown to a quarter of real-time, and 4 represents an acceleration by four times.

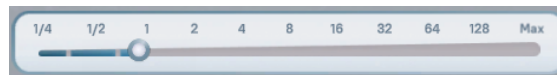


Figure 23 – Speed Adjustment Scale

5.3 Camera Control block

Camera control is managed using the magnifying glass buttons on the **Scene Control** panel (Figure 17), with a mouse, or fingers (when using a touch screen).

Upon loading the application, the camera is in its default position — aimed at the center of the table.

To move the camera, press any free area of the scene with the left mouse button (or one finger when using a touch screen) and, without releasing, drag the pointer in the desired direction.

To zoom in or out, press the zoom in/out  /  buttons or rotate the mouse wheel. When using a touch screen, touch the screen with two fingers and spread them apart to zoom in or bring them together to zoom out.

6 Equipment panel

The **Equipment** panel is located at the top of the Virtual Laboratory screen and consists of the following elements (Figure 24):

- 1) Component Library (see [6.1 Component Library](#));
- 2) Component Search window;
- 3) Buttons for Enabling/Disabling Categories;
- 4) Hide Component Library button.



Figure 24 – Equipment panel

6.1 Component Library

The **Component Library** contains cards for equipment that can be used in the scene. The cards are grouped into categories: "Glassware", "Instruments", "Salts", "Acids", "Oxides", "Bases", "Metals", "Others", "Indicators".

To scroll through the **Component Library**, hover the pointer over one of the cards and rotate the mouse wheel or press the left mouse button and drag right or left.

Above the **Component Library** are the buttons for **enabling/disabling** categories (3 in Figure 24). Click on a button to enable or disable the display of the corresponding component category in the library. Buttons for hidden categories change colour to grey . To hide the cards of all objects, press . To restore the display of cards, press .

For quick search of a specific component, use the **Search** window (2). Using your device's keyboard or the virtual keyboard, enter the search terms into the window and click on the magnifying glass icon or press **Enter**. To clear the search window, press .

The cards for glassware and instruments contain an image and the name of the object, while the cards for chemical elements and compounds display the chemical formula and name. The cards of some objects are marked with a symbol . These objects can be adjusted before being placed in the scene using the Object Constructor (see [6.2 Object Constructor](#)).

Clicking on an **Object Card** (Figure 25) opens an **Info** panel with a description of the selected object (2), and if the object has an associated constructor, the **Constructor** panel (3) as well (see [6.2 Object Constructor](#)). To the right of the constructor panel is a list of keywords for the selected object (4).

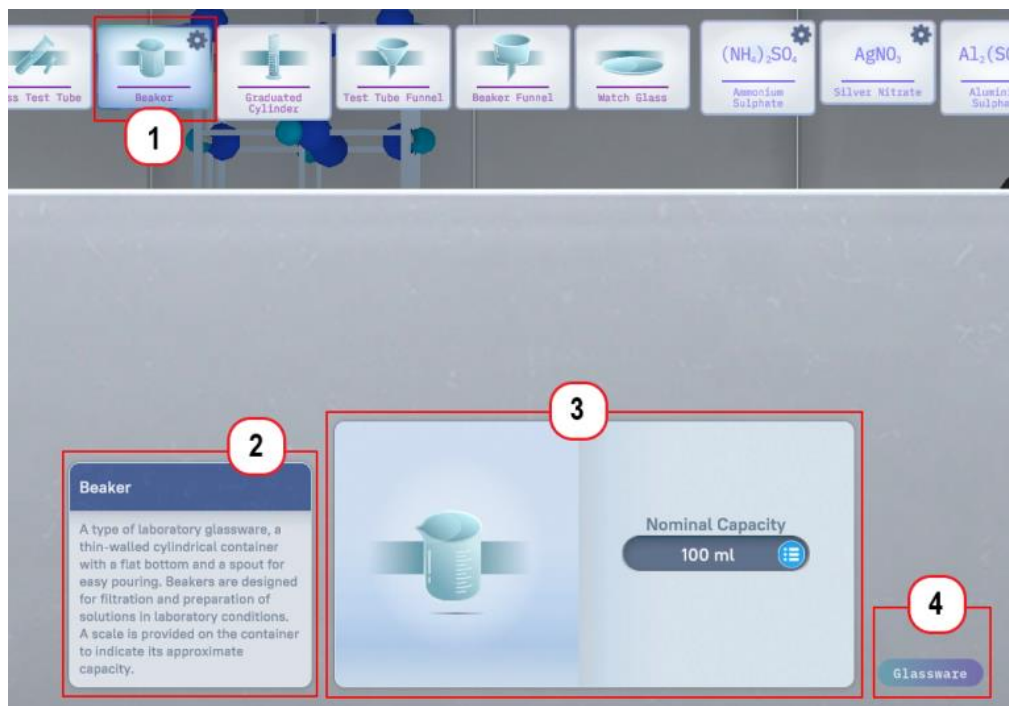


Figure 25 – Activating an Object card

Clicking on the card again closes the **Info** panel, **Constructor** panel, and the list of keywords.

6.2 Object Constructor

The **Object Constructor** is designed for setting parameters of an object before placing it on the workspace. It includes an image of the object or its chemical formula and fields for parameter settings (Figure 26).



Figure 26 – Object Constructor

For each parameter, the name (1), its current value (2), and the method of setting the value (3) are indicated. For parameters with a range setting, the range of permissible values is also specified (Figure 28).

The application provides three options for setting parameters:

- selection from a list ;
- selection within a range ;
- Yes/No selection .

To set a parameter value from the list, click on the  icon in the **Object Constructor** and select the desired option from the menu that appears (Figure 27).



Figure 27 – Selecting a parameter value from the menu

To set an exact parameter value within a range, click on the  icon in the **Object Constructor** and enter the value using the numpad (see [6.3 Numpad](#)).

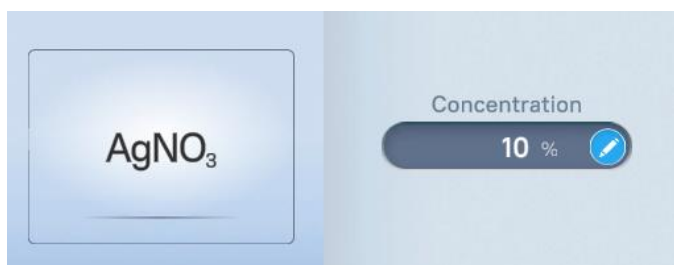


Figure 28 – Example of an Object Constructor with parameter setting using a Numpad

If a parameter has a fixed Yes/No value, it is set using a checkbox. To set the parameter to "Yes", click in the box to the left of the parameter name — a "tick" will be displayed in the box (Figure 29).

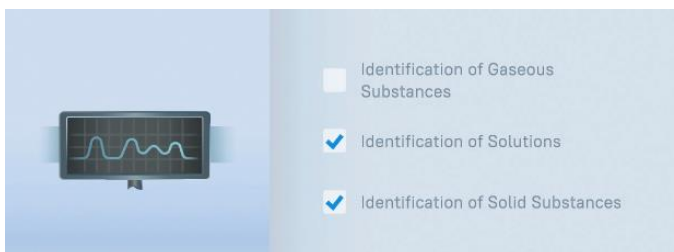


Figure 29 – Selecting a Yes/No value in the Object Constructor

To close the **Object Constructor**, click again on the **Object Card** in the **Component Library** or click outside the constructor. The object settings are saved after the constructor is closed. When another object of the same type is placed in the scene, changes in the constructor will apply to it as well.

6.3 Numpad

The **Numpad** (Figure 30) is used to set an exact parameter value within the available range. To call up the **Numpad**, press the  icon in the **Object Constructor** (see [6.2 Object Constructor](#)).

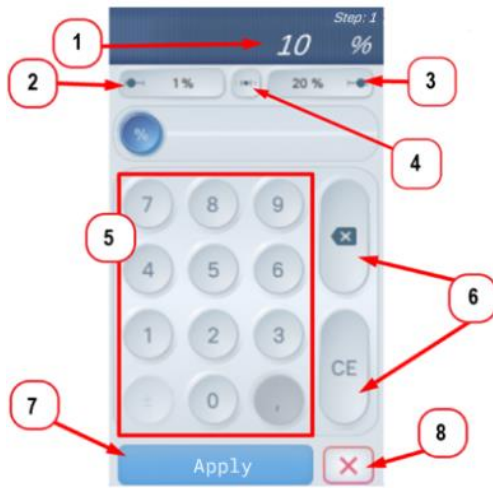


Figure 30 – The numpad

The current parameter value and the value change step are displayed in the input field (1).

Press button (2) to set the parameter's maximum value and button (3) for its minimum value.

To round the entered value to the parameter's allowable precision or to set the closest permissible value when the entered value exceeds the range, use button (4).

Enter values using the virtual numpad keyboard (5) or your device's keyboard.

Use the buttons (6) to clear the input field. To apply changes, press the button (7), to cancel — the button (8)

The  button becomes active when a correct parameter value is entered in the input field.

7 Interacting with objects

7.1 Creating an object

To create an object on the workspace:

- 1) If it's necessary to adjust the parameters of the object being created, click on its card. An **Info** panel and the **Constructor** panel will appear on the screen (Figure 25). Set the parameter values in the **Object Constructor** (Figure 26).
- 2) Drag the object onto the workspace and release it at the desired location. As the pointer moves into the workspace area, a three-dimensional model of the device being created appears under the pointer.

If the pointer is released in a location where the object cannot be placed, the object will automatically move to the nearest available space on the workspace. Test tubes, watch glasses, digital thermometers, and wires are placed on the back panel of the workspace on stands, which are added to the scene automatically (Figure 31).



Figure 31 – Placing objects on the back panel of the workspace

During your work, use the object control elements (buttons, handles, switches, regulators) — press or drag in the needed direction, as in reality.

7.2 Moving objects

To move an object, grasp it and drag it to the desired location on the workspace. Objects on the workspace cannot intersect: during movement, they "move around" each other. Objects on the back panel also cannot intersect with each other and with objects on the workspace. If an object is placed in an unsuitable location on the back panel, a warning will appear (Figure 32), and all objects will be locked. To continue working, move the object to the correct position.



Figure 32 – Incorrect placement of an object

7.3 Rotating objects

Objects on the workspace cannot be rotated. Rotation is only possible for test tubes, digital thermometers and wires. To rotate these objects, hover the pointer over them, press the left mouse button, and turn the mouse wheel. The object will rotate around the pointer.

When using a touch screen, pinch the object with two fingers and rotate one finger around the other. The object will rotate around the stationary finger.

7.4 Using tools

Tools in the Virtual Laboratory are used just as in reality. The **Tools** panel is located on the right side of the screen and consists of buttons for switching between tools (Figure 1). To select the desired tool, press the corresponding button. The outline of the button for the selected tool changes colour from blue to orange . By default, the **Hand** tool is selected.

7.4.1 Hand tool

To select the **Hand** tool, press the  button on the **Tools** panel. The **Hand** is used to move objects in the Virtual Laboratory. The **Hand** cannot be used to move corrosive substances, hot test tubes, or hold objects during heating, as this would violate safety precautions.

7.4.2 Glove tool

To select the **Glove** tool, press the  button on the **Tools** panel. Use the **Glove** to move containers with corrosive substances.



Figure 33 – Moving an object with the Glove tool

7.4.3 Tweezers tool

To select the **Tweezers** tool, press the  button on the **Tools** panel. Use the **Tweezers** to move indicator paper strips (Figure 34) and granules of solid substances (Figure 35).

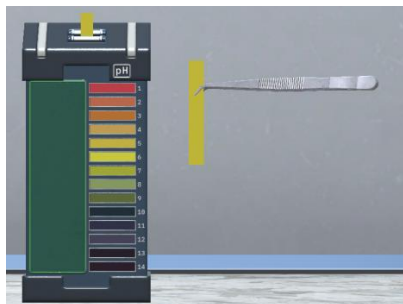


Figure 34 – Moving indicator paper with the Tweezers tool

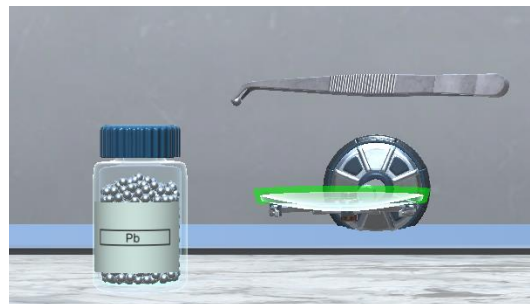


Figure 35 – Moving a granule with the Tweezers tool

7.4.4 Holders tool

To select the **Holders** tool, press the  button on the **Tools** panel. Use the **Holders** to move wires (Figure 36), watch glasses, and test tubes (Figure 37), including during and after heating.



Figure 36 – Moving wire with the Holders tool

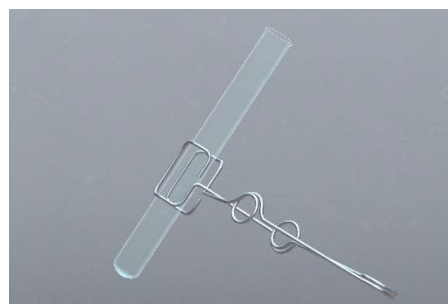


Figure 37 – Moving a test tube with the Holders tool

7.4.5 Spatula tool

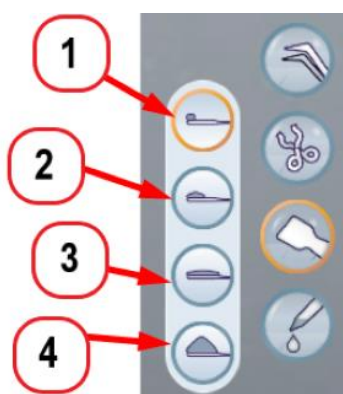


Figure 38 – Selecting the amount of substance on the spatula

The spatula is used for moving solid substances in powder form, collecting gelatinous precipitates, and scraping off soot. To select the **Spatula** tool, press the button on the **Tools** panel and set the amount of substance to be scooped by the spatula (Figure 38):

- 1) on the tip of the spatula;
- 2) half of the spatula;
- 3) full spatula;
- 4) full spatula with a heap.

To scoop powder or a gel-like precipitate with a spatula, press and hold the left mouse button on the container with the substance — the container's lid will open (Figure 39), and drag upwards — a spatula with the scooped substance will appear (Figure 40).



Figure 39 – Beginning to scoop substance with the spatula: left mouse button pressed on the container



Figure 40 – Spatula with scooped substance

To move the spatula with the substance, drag it to the desired location without releasing the left mouse button. If the left mouse button is released during the move, the operation of the Virtual Laboratory will be blocked, and a warning about the incorrect placement of the object will appear (Figure 41). To continue working, hover the mouse pointer over the spatula, press and hold the left mouse button, and move it to one of the green interaction zones (see [7.5.1 Object Interaction zones](#)) on the workspace or delete it.

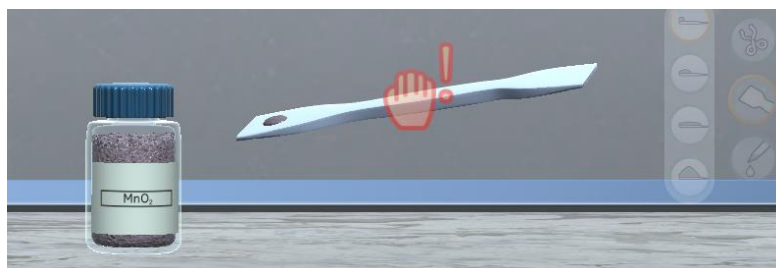


Figure 41 – Incorrect placement of the spatula

To completely empty the substance from the spatula, move the mouse pointer to the green interaction zone of the desired object and release (Figure 42). To gradually pour the substance from the spatula into the container, move the mouse pointer to the green interaction zone of the desired object and, without releasing the left mouse button, rotate the mouse wheel downwards.

To clean the soot off a wire, select the **Spatula** tool, press and hold the left mouse button on the wire — a spatula image will appear, and move the pointer right-left or up-down (Figure 43).



Figure 42 – Dropping substance from the spatula

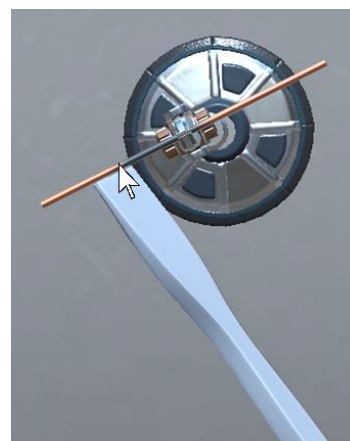


Figure 43 – Scraping soot from wire with the spatula: left mouse button pressed on the wire

To remove the spatula with the substance, drag it to one of the deletion zones (see. [7.6 Deleting objects](#)) and release.

7.4.6 Pipette tool

The pipette is used for transferring small amounts of liquid. The volume of the pipette in the Virtual Laboratory is 3 ml. To select the **Pipette** tool, press the  button on the **Tools** panel.

To draw liquid from a storage container into the pipette, press and hold the left mouse button on the container with the substance — the container's lid will open, and a pipette will appear (Figure 44), rotate the mouse wheel upwards — the liquid will gradually be drawn into the pipette. It's possible to draw liquid from different containers with different substances.

To draw liquid from a glassware, press and hold the left mouse button on the green interaction zone (see [7.5.1 Object Interaction zones](#)) at the bottom of the glassware and rotate the mouse wheel upwards (Figure 45).



Figure 44 – Drawing liquid into the pipette: left mouse button pressed on the container

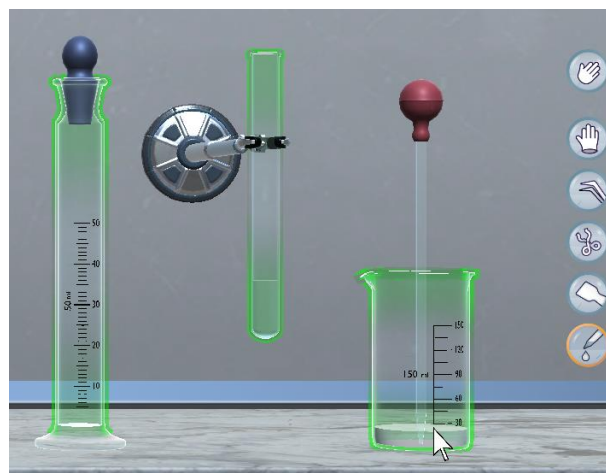


Figure 45 – Drawing liquid into the pipette: left mouse button pressed at the bottom of the glassware

It's impossible to draw liquid into one pipette from different glassware — after drawing liquid from one vessel, the interaction zones at the bottom of the other vessels in the scene will become inaccessible, and a blue indicator of these zones will light up (Figure 46).

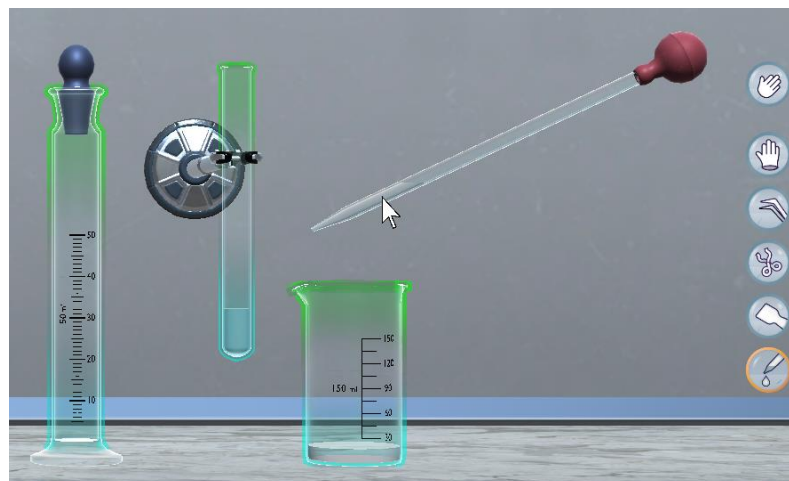


Figure 46 – Blue indication at the bottom of the glassware after drawing liquid into the pipette

To move the pipette, drag it to the desired location without releasing the left mouse button. If the left mouse button is released during the move, the operation of the Virtual Laboratory will be blocked, and a warning about the incorrect placement of the object will appear (Figure 47). To continue working, hover the mouse pointer over the pipette, press and hold the left mouse button, and move the pipette to one of the green interaction zones on the workspace or delete it.

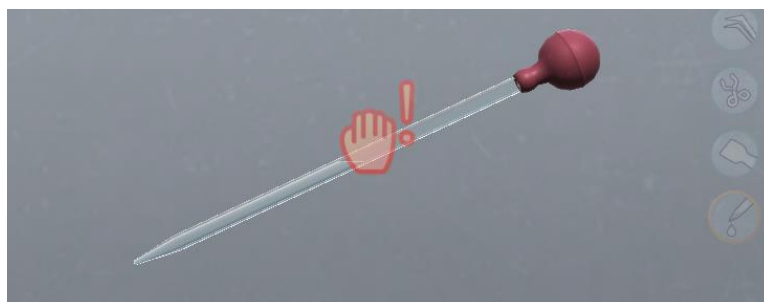


Figure 47 – Incorrect placement of the pipette

To completely empty the substance from the pipette, move the mouse pointer to the green interaction zone at the top edge of the vessel and release (Figure 48). To gradually pour the liquid from the pipette, move the mouse pointer to the green interaction zone at the top edge of the vessel and, without releasing the left mouse button, rotate the mouse wheel downwards. Similarly, liquid from the pipette can be dropped onto indicator paper (Figure 49).

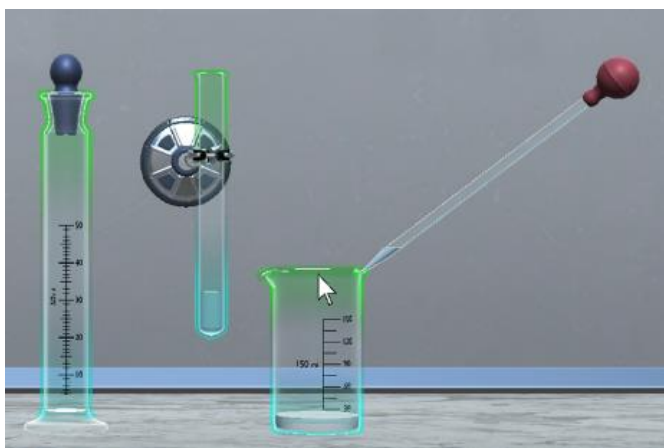


Figure 48 – Transferring liquid from the pipette into a glassware

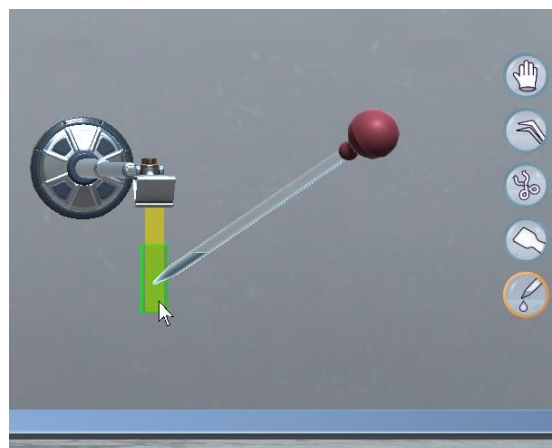


Figure 49 – Transferring liquid from the pipette onto indicator paper

To remove the pipette with liquid, drag it to one of the deletion zones (see [7.6 Deleting objects](#)) and release.

7.5 Object interactions

7.5.1 Object Interaction zones

Objects in the Virtual Laboratory interact with each other, as in reality. The possibility of interaction between objects is indicated by colour coding. When moving an object on the workspace, colour indication appears on the objects that can interact with the moving object (Figure 50). If the objects cannot interact, the colour indication does not appear. For example, a test tube cannot be placed on the scales but can be placed in a shaker (Figure 50).

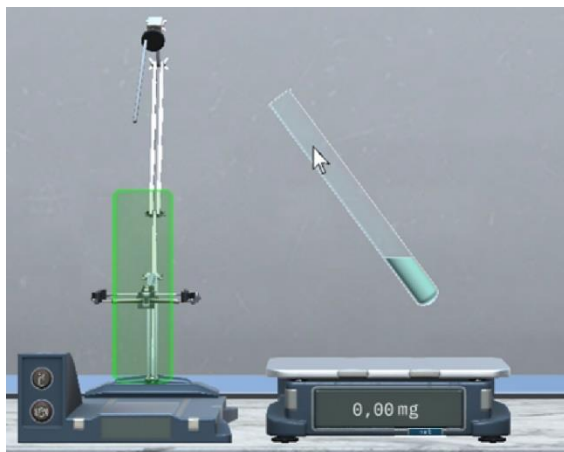


Figure 50 – Colour indication of Interaction zones

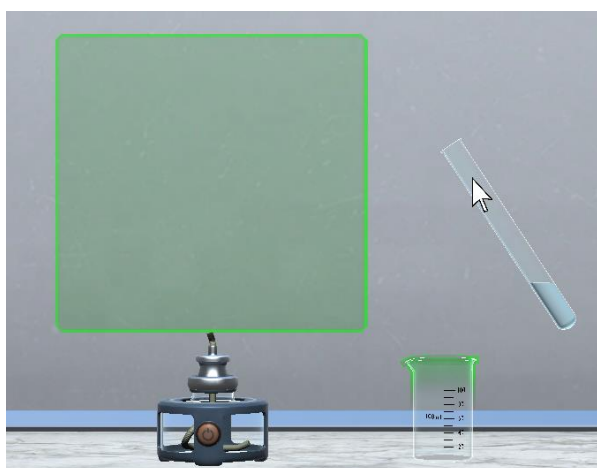


Figure 51 – Examples of Interaction zones with green indication

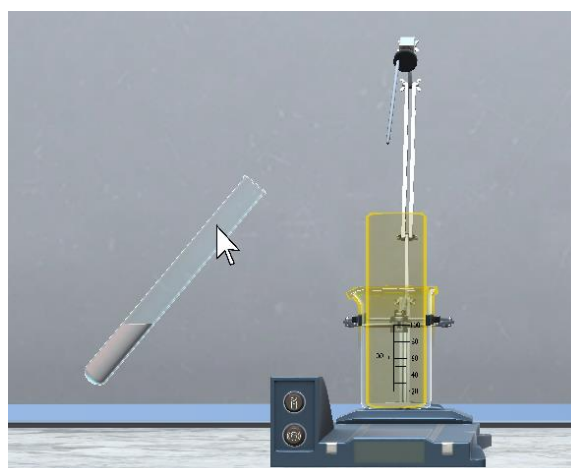


Figure 52 – Example of an Interaction zone with yellow indication

Green indication on objects means that they can interact with the moving object (Figure 51). For example, in Figure 51, a test tube can be placed in the interaction zone with an spirit lamp to heat it, or in the interaction zone with a chemical beaker to transfer its contents into the beaker.

Yellow indication on an object means that the moving object cannot interact with it while that object is interacting with another object. For example, a test tube cannot be placed in a shaker while it contains a chemical beaker (Figure 52).

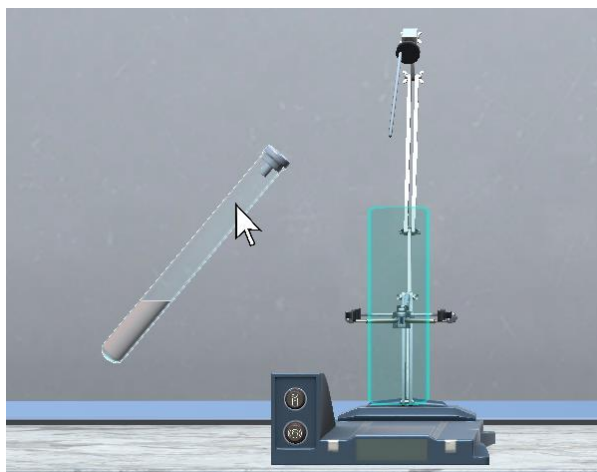


Figure 53 – Example of an Interaction zone with blue indication



Figure 54 – Examples of Interaction zones with purple indication

Blue indication on an object means that the moving object is already interacting with another object and cannot interact with an additional object. For example, a test tube cannot be placed in a shaker while it is sealed with a gas discharge tube (Figure 53).

Purple indication on objects means that they cannot interact with each other because each of them is already interacting with another object. For example, a test tube cannot be placed in a shaker while a funnel is inserted into it, and the shaker already contains a chemical beaker (Figure 54).

7.5.2 Transferring liquids

Liquids in the Virtual Laboratory can be in glassware (1), source containers (2), or drippers (3) (Figure 55).

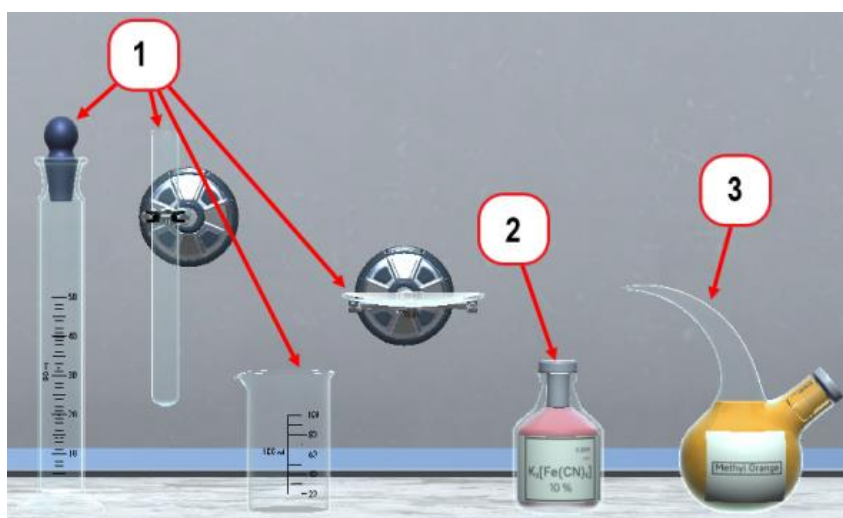


Figure 55 – Different types of containers for liquids

To transfer a liquid substance from source container to glassware or from one glass to another, press and hold the left mouse button on the item from which you want to pour the liquid, drag the pointer to the green interaction zone (see [7.5.1 Object Interaction zones](#)) at the top edge of the item into which you want to pour the liquid, and rotate the mouse wheel upwards (Figures 56 and 57). The faster and further you scroll the mouse wheel, the faster the liquid pours. To stop the pouring, rotate the mouse wheel downwards.



Figure 56 – Transferring liquid from a source container into a chemical beaker

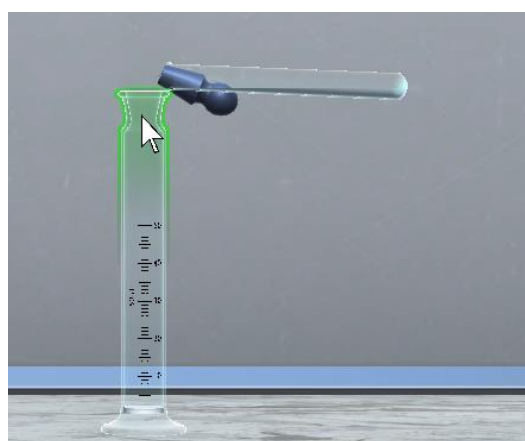


Figure 57 – Transferring liquid from a test tube into a measuring cylinder

To transfer liquid from a dripper into a container, press and hold the dripper with the left mouse button, drag the pointer to the green interaction zone at the top edge of the vessel, and rotate the mouse wheel downwards (Figure 58).

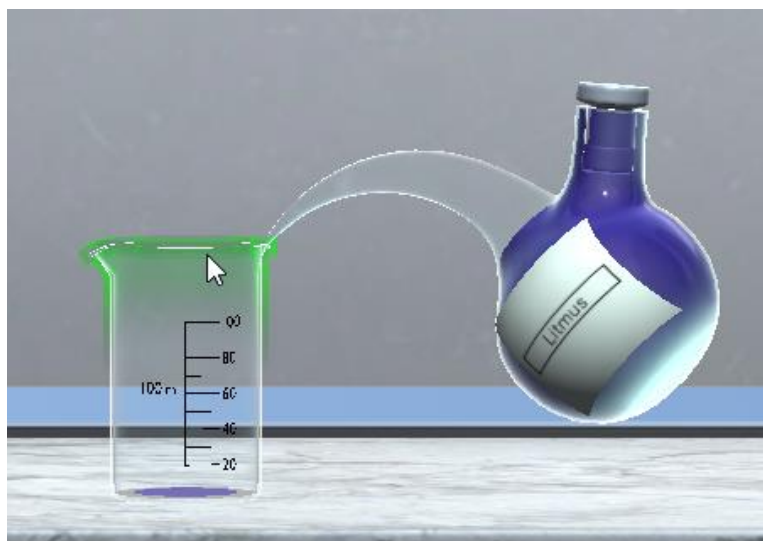


Figure 58 – Transferring liquid from a dripper into a chemical beaker

7.6 Deleting objects



Figure 59 – Deleting an object

To delete an object, press and hold it with the left mouse button, drag the mouse pointer to one of the **Deletion zones** at the top of the workspace, and release (Figure 59).

If the object to be deleted is interacting with other objects, then all the objects involved will be deleted together. For example, when deleting a shaker with a test tube, the shaker, the test tube, and its contents will be removed.

8 Object description

8.1 Containers

8.1.1 Test tube stand

A test tube stand is a desktop holder for test tubes.

To select the contents of the stand before placing it in the scene, click on the object card in the **Component Library** (Figure 60) and set the desired value in the constructor (see [6.2 Object Constructor](#)). By default, a stand with test tubes will be created.



Figure 60 – Test Tube Stand card

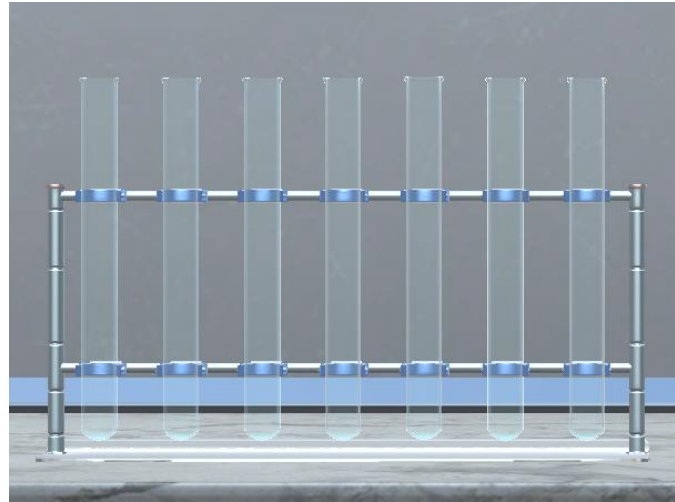


Figure 61 – Test Tube Stand

To remove a test tube from the stand, press and hold it with the left mouse button, drag it to the desired location, and release. To place a test tube in the stand, press and hold it with the left mouse button, drag the pointer to the stand's green interaction zone (1) (see [7.5.1 Object Interaction zones](#)) and release (Figure 62).

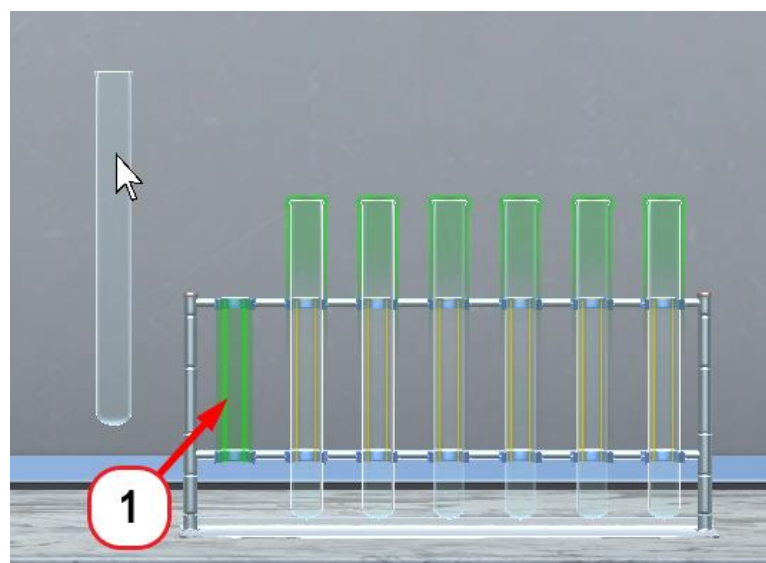


Figure 62 – The green interaction zone of the stand for placing a test tub

8.1.2 Glass test tube

A glass test tube is a narrow glass vessel of cylindrical shape with a semi-circular bottom for conducting chemical reactions. The test tube is placed in a stand on the workspace (see [8.1.1 Test tube stand](#)) or attached to the back panel of the workspace using a wall rack. A wall stand is automatically added to the scene.



Figure 63 – Glass Test Tube card

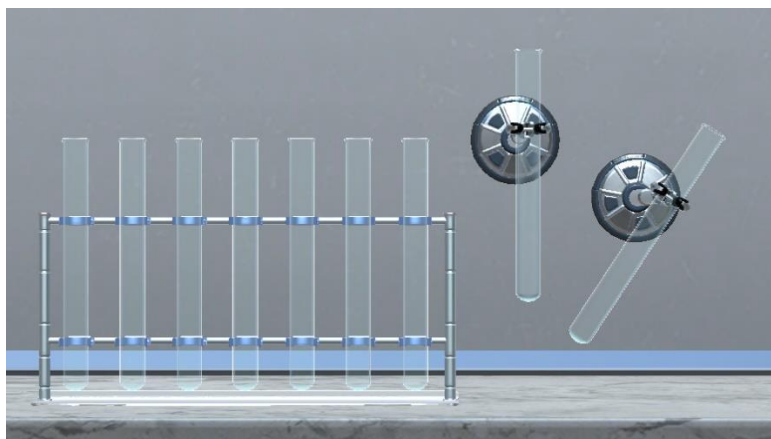


Figure 64 – Test Tubes in desktop and wall stands

To rotate the test tube, press and hold it with the left mouse button and rotate the mouse wheel: downwards to rotate clockwise, upwards to rotate counterclockwise. The test tube will rotate around the mouse pointer. Alternatively, you can use the right and left arrow keys on your device's keyboard to rotate.

An  icon appears on the test tube after all substances have been removed from it. It indicates that the glassware has been used in the course of work, and further use will lead to a breach of safety precautions.

To add or draw substances from the test tube, use the interaction zones of the glassware: at the top edge — for adding substances from other containers, at the bottom — for drawing substances from the test tube (see [7.5.1 Object Interaction zones](#)).

8.1.3 Chemical beaker

A chemical beaker is a glass vessel of cylindrical shape with a flat bottom, a spout for pouring, and a measuring scale. The beaker is used for preparing and filtering solutions.

To select the nominal capacity of the beaker before placing it in the scene, click on the object card in the **Component Library** (Figure 67) and set the required value in the constructor (see [6.2 Object Constructor](#)). By default, a 100 ml beaker will be created.



Figure 65 – Chemical Beaker card



Figure 66 – Chemical Beakers of various capacities

An  icon appears on the beaker after all substances have been removed from it. It indicates that the glassware has already been used in the course of work, and further use will lead to a breach of safety precautions.

To add or draw substances from the beaker, use the interaction zones of the glassware: at the top edge — for adding substances from other containers, at the bottom — for drawing substances from the beaker (see [7.5.1 Object Interaction zones](#)).

8.1.4 Measuring Cylinder

A measuring cylinder is a narrow glass vessel of cylindrical shape with a flat bottom, a tight lid, and a measuring scale. The cylinder is used for measuring the volume of liquids, storing volatile and strongly smelling substances, and working with them. When interacting with other objects, the cylinder's stopper opens and closes automatically.



Figure 67 – Measuring Cylinder card



Figure 68 – Measuring Cylinder

An  icon appears on the cylinder after all substances have been removed from it. It indicates that the glassware has already been used in the course of work, and further use will lead to a breach of safety precautions.

To add or draw substances from the cylinder, use the interaction zones of the glassware: at the top edge — for adding substances from other containers, at the bottom — for drawing substances from the cylinder (see [7.5.1 Object Interaction zones](#)).

8.1.5 Test tube funnel

A test tube funnel is a glass funnel with a paper filter for a test tube. The filtration speed of solutions without sediment is 0.4 ml/s. Each gram of sediment in the solution reduces the filtration speed by 5%.



Figure 69 – Test Tube Funnel card



Figure 70 – Test Tube Funnel

A funnel can only be placed in a test tube within the scene. To place the funnel in a test tube, press and hold it with the left mouse button, move the pointer to the green interaction zone (see [7.5.1 Object Interaction zones](#)) at the top edge of the test tube, and release (Figure 71). If the funnel is incorrectly placed, the operation of the Virtual Laboratory will be blocked, and a warning about the incorrect placement of the object will appear (Figure 72). To continue working, hover the mouse pointer over the funnel, press and hold the left mouse button, and move it to the green interaction zone of the test tube or delete it.

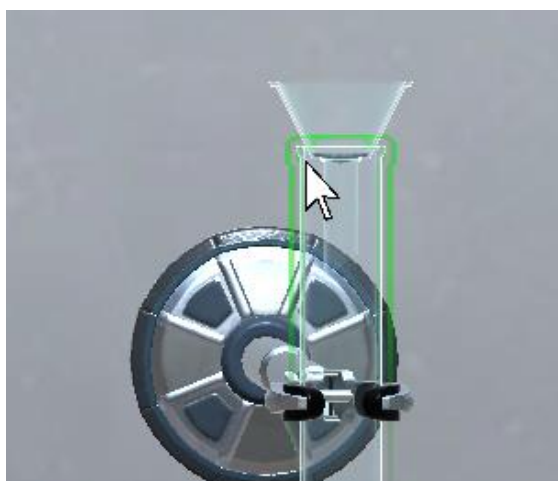


Figure 71 – Placing a funnel in a test tube



Figure 72 – Incorrect placement of a test tube funnel

An  icon appears on the funnel after the glassware has been used in the course of work. Further use of the used funnel will lead to a breach of safety precautions.

8.1.6 Beaker funnel

A beaker funnel is a glass funnel with a paper filter for a beaker. The filtration speed of solutions without sediment is 0.8 ml/s. Each gram of sediment in the solution reduces the filtration speed by 5%.

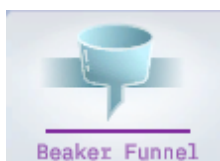


Figure 73 – Beaker Funnel card

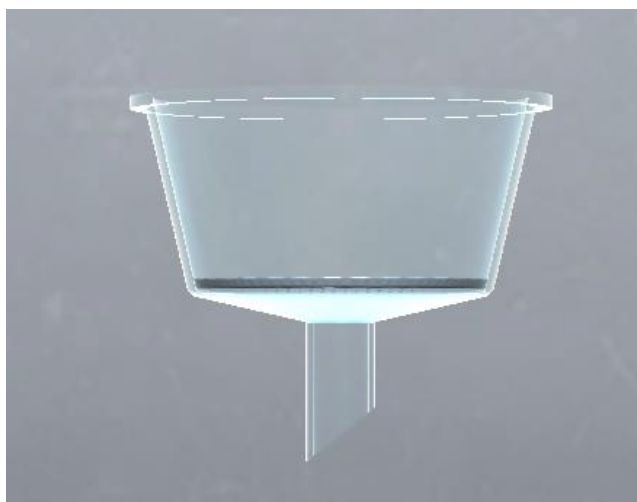


Figure 74 – Beaker Funnel

A funnel can only be placed in a beaker within the scene. The funnel fits all beaker variants in the Virtual Laboratory. To place the funnel in a beaker, press and hold it with the left mouse button, move the pointer to the green interaction zone (see 7.5.1 Object Interaction zones) at the top edge of the beaker, and release (Figure 75). If the funnel is incorrectly placed, the operation of the Virtual Laboratory will be blocked, and a warning about the incorrect placement of the object will appear (Figure 76). To continue working, hover the mouse pointer over the funnel, press and hold the left mouse button, and move it to the green interaction zone of the beaker or delete it.

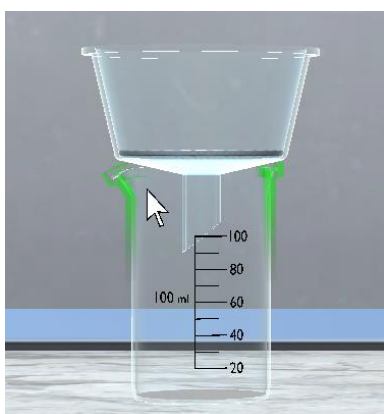


Figure 75 – Placing a funnel in a beaker



Figure 76 – Incorrect placement of a beaker funnel

An  icon appears on the funnel after it has been used during the work. Continuing to use the funnel after it has been used will lead to a breach of safety precautions.

8.1.7 Watch glass

A watch glass is a round, convex-concave glass used for evaporating solutions, placing, and weighing substances. The watch glass is attached to the back panel of the workspace using a wall rack, which is automatically added to the scene. A watch glass can also be placed on digital scales (Figure 78).



Figure 77 – Watch Glass card



Figure 78 – Watch Glasses on scales and wall stand

Solid substances can be placed on the watch glass using tweezers and a spatula, and liquids can be transferred using a pipette or a dropper.

An  icon appears on the glass after all substances have been removed from it. It indicates that the glassware has already been used during the work, and further use will lead to a breach of safety precautions.

8.2 Instruments

8.2.1 Gas collection cork

A gas collection cork is a stopper with a hole for venting gas from a test tube. A tube can be attached to the cork to divert gas into another container. A gas collection cork can only be placed in a test tube.



Figure 79 – Gas Collection Cork card



Figure 80 – Gas Collection Cork

To place the cork in a test tube, press and hold it with the left mouse button, move the pointer to the green interaction zone (see [7.5.1 Object Interaction zones](#)) at the top edge of the test tube, and release (Figure 81). If the cork is placed incorrectly, the operation of the Virtual Laboratory will be blocked, and a warning about the incorrect placement of the object will appear (Figure 82). To continue working, hover the mouse pointer over the cork, press and hold the left mouse button, and move it to the green interaction zone of the test tube or delete it.



Figure 81 – Placing a gas collection cork in a test tube



Figure 82 – Incorrect placement of a gas collection cork

To attach a gas vent tube to the cork, press and hold the left mouse button over the cork, extend the pointer to the green interaction zone (see [7.5.1 Object Interaction zones](#)) of another test tube or beaker, and release (Figure 83). Gas vent tubes can be extended from a test tube with a cork to another test tube with or without a cork, or to a chemical beaker (Figure 84).

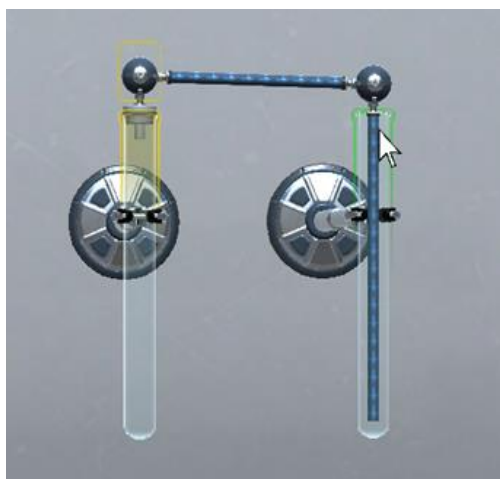


Figure 83 – Attaching a tube to the gas collection cork

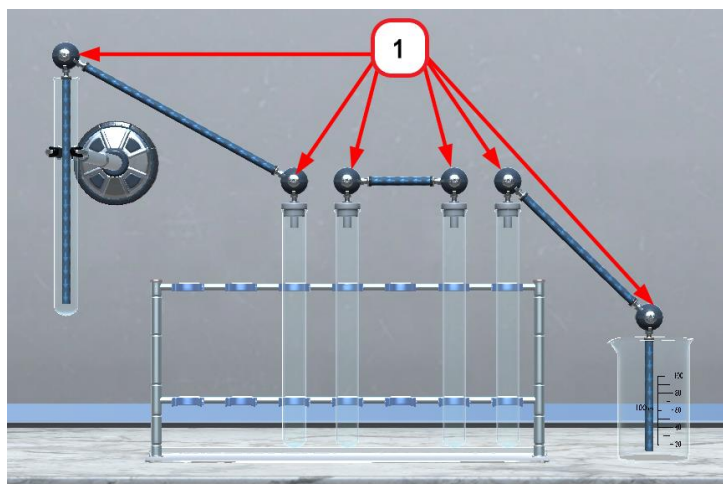


Figure 84 – Examples of installing gas vent tubes

To move the gas vent tube, drag the tube's connector element (Figure 84) to the green interaction zone of another container and release. To remove the tube, drag the connector element to the deletion zone.

8.2.2 Spirit Lamp

A spirit lamp is a burner for liquid fuel, designed for heating, melting, and evaporating substances. Substances in test tubes and on watch glasses, as well as wire, can be heated over the flame of a burner. Safety precautions must be observed when working with a spirit lamp.



Figure 85 – Spirit Lamp card

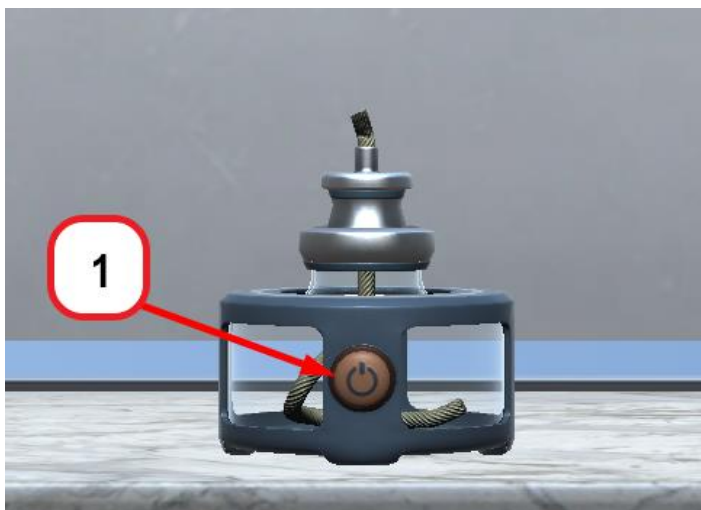


Figure 86 – Spirit Lamp

To turn the lamp on or off, press the button (1) on the device (1) (Figure 86). To start heating, place the container in the green interaction zone (see [7.5.1 Object Interaction zones](#)) of the burner (Figure 87). Multiple containers with substances can be heated simultaneously in the heating zone.

When placing objects in the heating zone of the spirit lamp, the color rings on the lamp and racks automatically match in color (Figure 88). For example, a spirit lamp with purple rings on its body will heat a test tube with purple rings on its rack and at the top edge of the container; a spirit lamp with blue rings will heat objects with blue rings on the stands — wire and watch glass; a test tube with a gray ring on its stand will not be heated, as it is outside the heating zones of both spirit lamps (Figure 88).

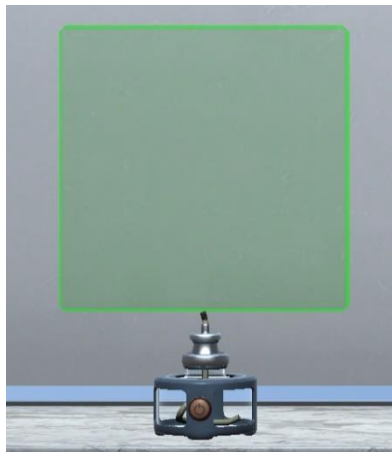


Figure 87 – Green indication of the spirit lamp interaction zone

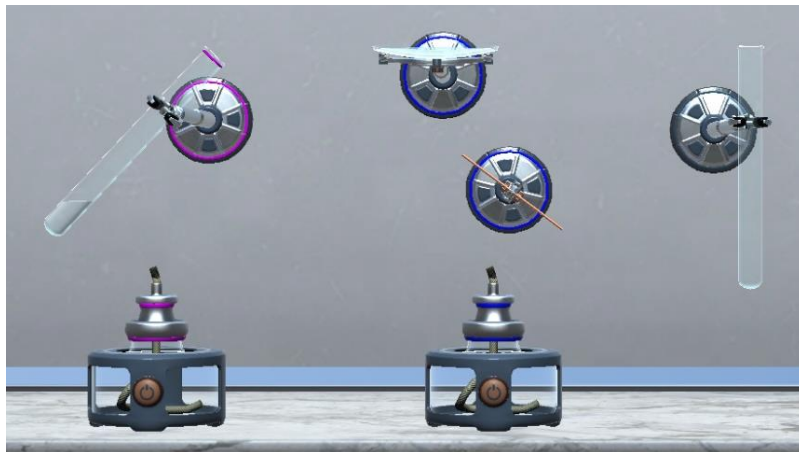


Figure 88 – Examples of color indication on spirit lamps and stands in the heating zone

8.2.3 Digital Thermometer

A digital thermometer is an instrument for measuring the temperature of substances in a test tube or chemical beaker. The data in degrees Celsius are displayed on the device's screen with precision to tenths. Outside of containers, the digital thermometer displays the ambient temperature of 20°C and is placed on a rack on the back panel of the workspace, which is automatically added to the scene.



Figure 89 – Digital Thermometer card



Figure 90 – Digital Thermometer

To place the thermometer in a test tube or chemical beaker, hover the mouse pointer over the thermometer's screen, press and hold the left mouse button, drag the pointer to the green interaction zone (see [7.5.1 Object Interaction zones](#)) at the top edge of the container, and release (Figure 91). Adding substances to the container after placing the thermometer in it is not possible.

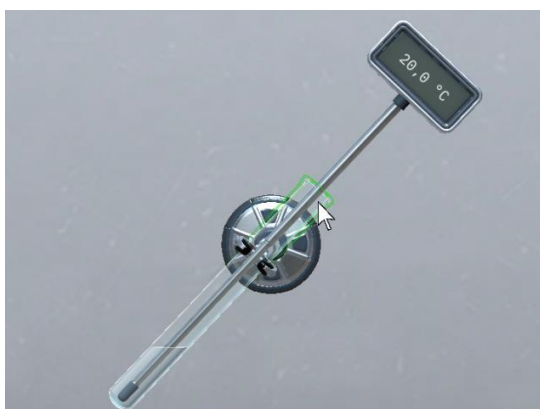


Figure 91 – Placing a digital thermometer in a test tube

8.2.4 Digital Scales

Digital scales are an instrument for measuring the mass of substances without accounting for the container. The data, displayed in grams, are shown on the device's screen with precision to the hundredths. Substances can only be weighed in a chemical beaker or on a watch glass, both of which can be placed on the scales simultaneously.



Figure 92 – Digital Scales card

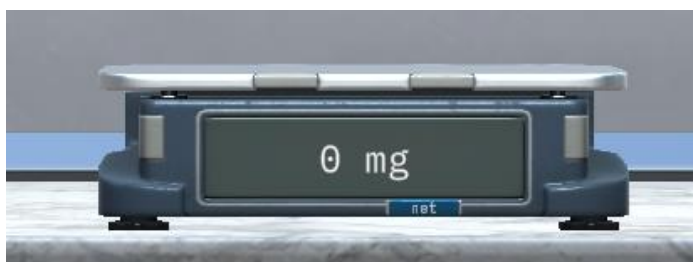


Figure 93 – Digital Scales

To place a container on the scales, press and hold it with the left mouse button, drag the pointer to the green interaction zone of the scales (see [7.5.1 Object Interaction zones](#)), and release (Figure 94).

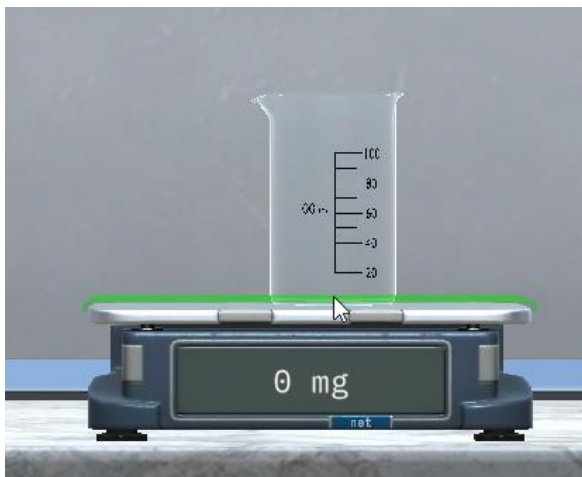


Figure 94 – Placing a Chemical Beaker on the Scales

8.2.5 Shaker

A shaker is a device for mixing substances. Substances can be mixed in the device in a test tube or chemical beaker.

To place a container in the shaker, press and hold it with the left mouse button, drag the pointer to the green interaction zone of the shaker (see 7.5.1 Object Interaction zones), and release. It is not possible to add substances to the container once it is placed in the shaker.



Figure 95 – Shaker card

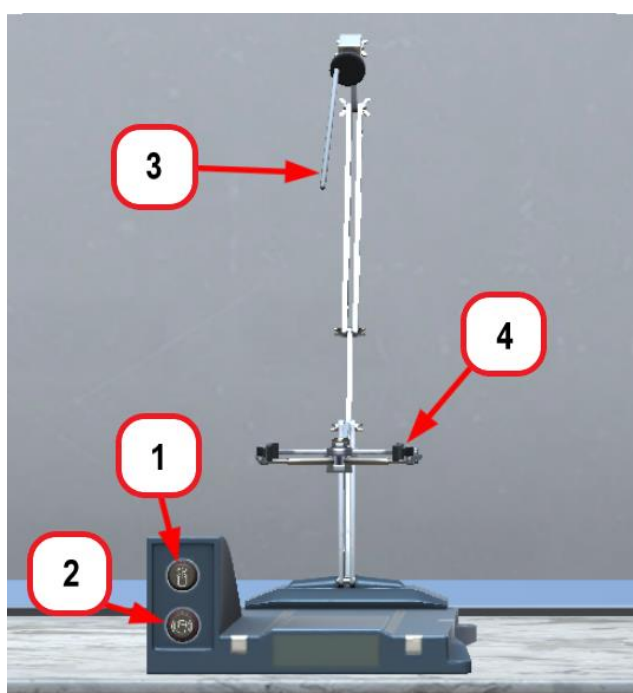


Figure 96 – Shaker

The device can mix substances in two ways: stirring and shaking.

To stir the substances in the container, press and hold the  button on the device's body (1) with the left mouse button (Figure 96). Stirring is performed by circular movements of the stick (3) in the container.

To shake the substances in the container, press and hold the  button on the device's body (2) with the left mouse button (Figure 96). Shaking is performed by moving the container from side to side using the holder (4).



Figure 97 – Stirring substances in the shaker



Figure 98 – Shaking substances in the shaker

8.2.6 Analyser

An analyser (spectrometer) is an instrument for determining the composition and properties of chemical substances.

To select which substances the analyser can detect, click on the object card in the **Component Library** (Figure 99) before placing the instrument in the scene and set the required values in the constructor (see [6.2 Object Constructor](#)).

By default, an instrument for determining solutions, solid, and gaseous substances will be created. The selected categories of substances for detection are displayed at the top of the screen (Figure 100).



Figure 99 – Analyser card

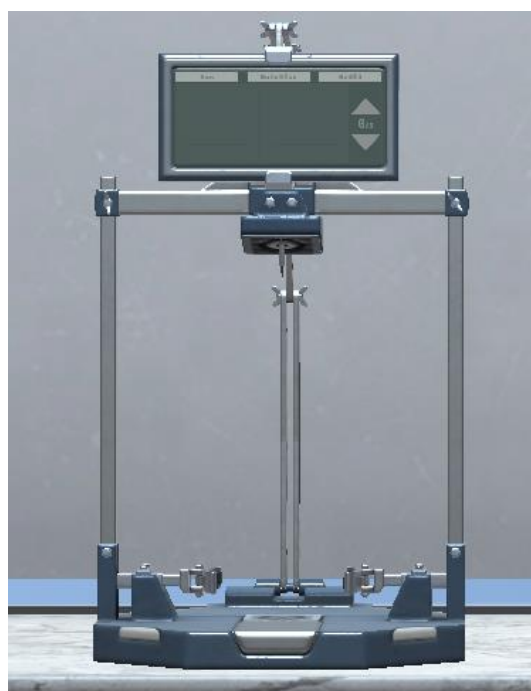


Figure 100 – Analyser

Substances can be placed in the analyser in a test tube or chemical beaker. To place the container in the analyser, press and hold it with the left mouse button, drag the pointer to the green interaction zone of the analyser (see 7.5.1 [Object Interaction zones](#)), and release (Figure 101). It is not possible to add substances to the container once it is placed in the analyser.

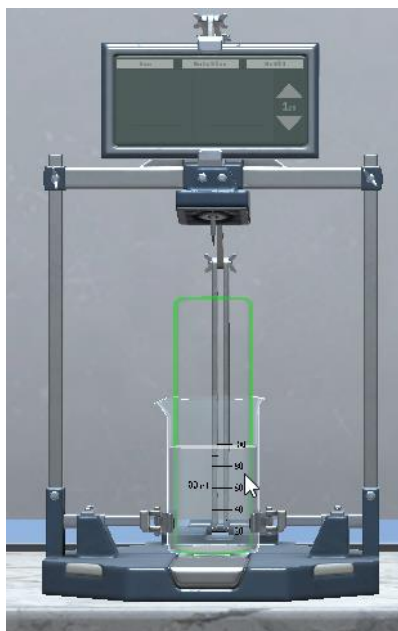


Figure 101 – Placing a chemical beaker in the analyser

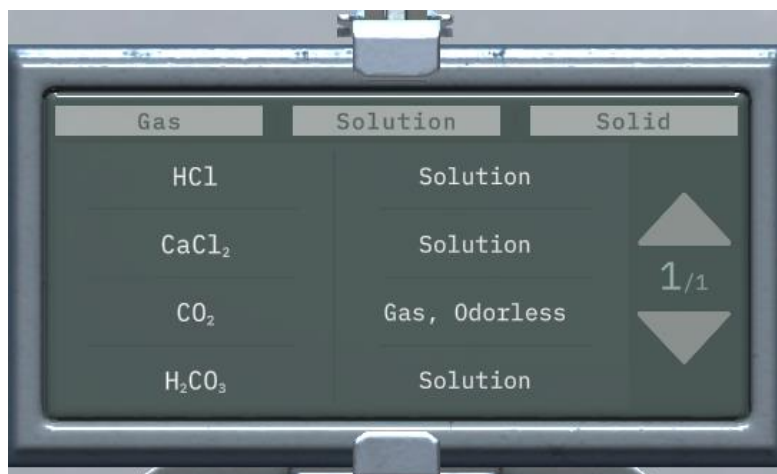


Figure 102 – Display of analysis results

After the container has been placed in the analyser, a probe will descend into it for a few seconds to conduct the analysis. The data obtained are displayed on the device's screen (Figure 102). The formulas of the substances are displayed in alphabetical order. To scroll through the lines on the screen, press the "up" or "down" arrow on the right side of the screen.

Next to each formula, the state of the substance is indicated:

- The **"Solid" state** is displayed for substances insoluble in water: solid reagents or substances formed as a result of the reaction. For partially soluble substances (e.g., calcium hydroxide Ca(OH)₂), two states are displayed: solid and solution. The solid state is also indicated for soluble substances if they are in the analyser without a solvent.
- The **"Solution" state** is displayed for soluble substances in the presence of a solvent.
- The **"Liquid" state** is displayed for water if there are no soluble substances in the container.
- The **"Gas" state** is displayed for gaseous substances. If a gaseous or evaporating substance evaporates, the line with its formula becomes gray. The smell is also indicated for gases.

8.2.7 Indicator Paper Dispenser

Indicator paper is a type of filter paper treated with a chemical reagent for determining the acidity (pH) of liquids and gases. Strips of indicator paper are stored in a dispenser (Figure 104).



Figure 103 –Indicator Paper Dispenser card

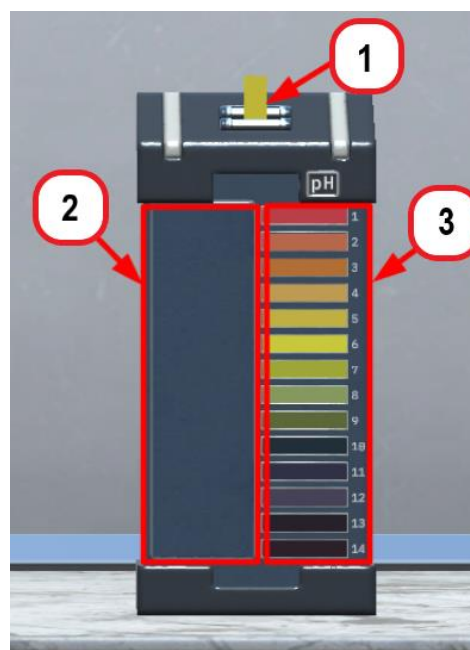


Figure 104 – Indicator Paper Dispenser

To extract a strip of indicator paper (1) from the dispenser and move it, press and hold it with the left mouse button, drag it to the desired location, and release. Strips of indicator paper can be placed on a rack on the back panel of the workspace, in a chemical beaker, and in a test tube (Figure 105).

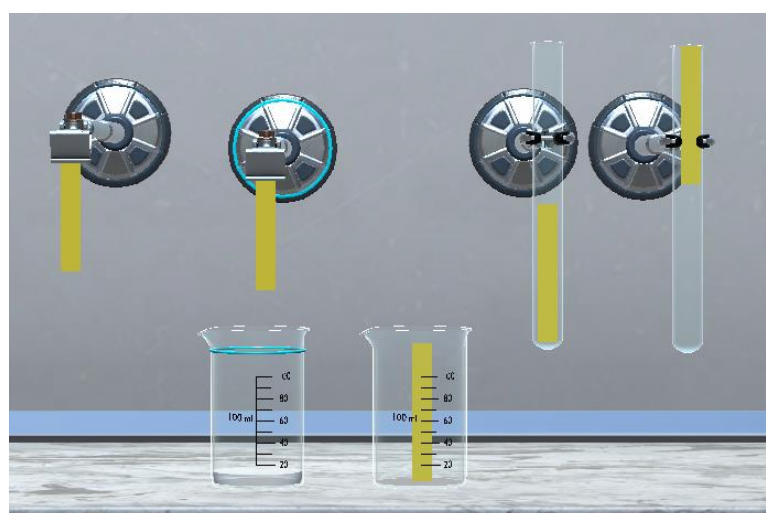


Figure 105 – Examples of placing indicator paper

Indicator paper can be moved using the **Hand** (see [7.4.1 Hand tool](#)) and **Tweezers** tools (see [7.4.3 Tweezers tool](#)).

To determine the acidity of a liquid, place a strip of indicator paper in a test tube or chemical beaker with the liquid for a few seconds. Remove the paper, place it on the dispenser panel (2 in Figure 104) and compare the color with the samples on the dispenser scale (3). Next to the color samples, the corresponding pH value is indicated.

To determine the acidity of a gas, place a water-moistened strip of indicator paper in the green interaction zone (see [7.5.1 Object Interaction zones](#)) above the container emitting the gas, ensuring that the items do not overlap (Figure 106). When correctly placed, the indicator paper on the rack and the

container will display rings of the same color (Figure 105). After reacting, place the paper on the dispenser panel (2 in Figure 104) and compare the color with the samples on the dispenser scale (3).

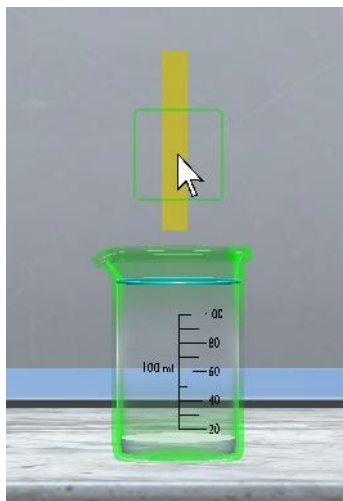


Figure 106 – Placing indicator paper above a container

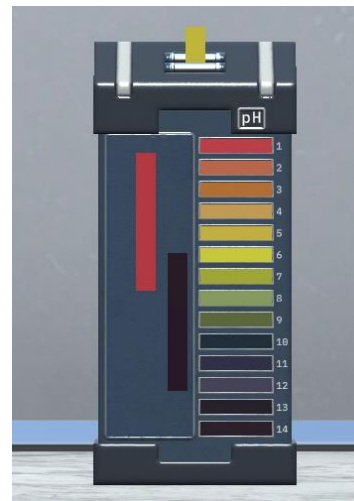


Figure 107 – Reacted indicator paper on the dispenser panel

8.3 Chemical substances

Substances in the Virtual Laboratory are available in gaseous (1), solid (2, 3, 4), and liquid (5, 6) states (Figure 108).

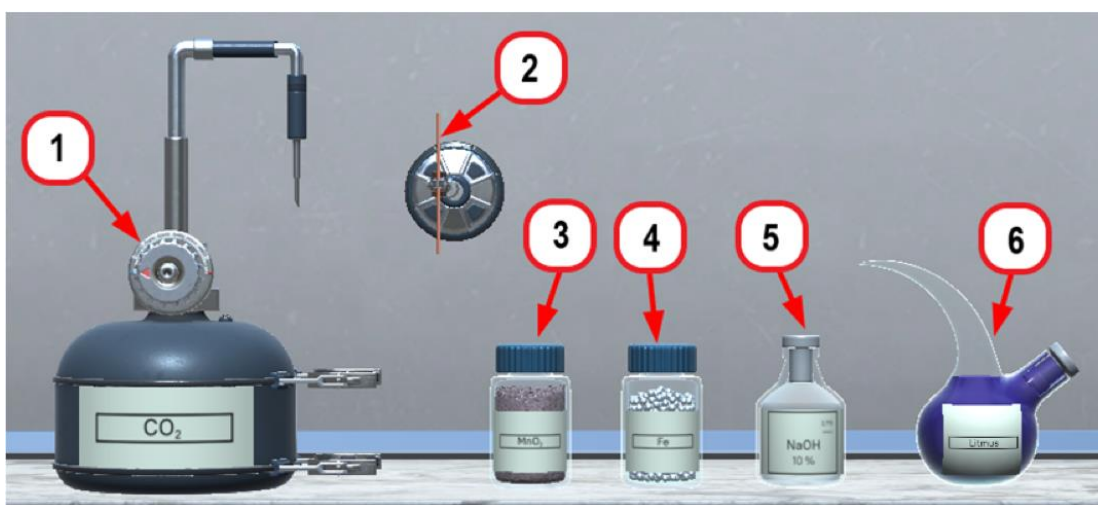


Figure 108 – Substances in different states on the workspace

The state of the substance determines which tools, glassware, and devices are used for interaction with it. All substances in the laboratory are stored in closed source containers in an unlimited amount. Source containers automatically open and close when interacting with tools and glassware. Substances can only be mixed in glassware; it is not possible to mix substances in source containers.

8.3.1 Gaseous substances

Gaseous substances are stored in gas cylinders (Figure 109). To start supplying the gas, hover the mouse pointer over the regulator (1) and pull to the right to the desired supply speed. Regulate the gas supply speed: the more to the right the regulator is positioned, the faster the gas is supplied from the cylinder.

To stop the gas supply, press the regulator and return it to its original position.

To supply gas to a test tube or chemical beaker, place the container in the holder (2). To do this, press and hold it with the left mouse button, drag the pointer to the green interaction zone (see [7.5.1 Object Interaction zones](#)) of the cylinder, and release (Figure 110). A gas supply tube will descend into the container placed in the holder. It is not possible to add substances to the container placed in the holder.

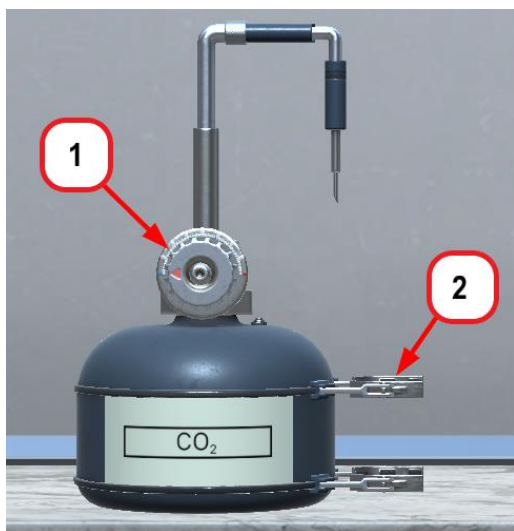


Figure 109 – Gas cylinder



Figure 110 – Placing a test tube in the gas cylinder holder

8.3.2 Solid substances

8.3.2.1 Wire

Solid substances in the form of wire can be placed on a rack on the back panel of the workspace, in a test tube, and in a chemical beaker (Figure 111).

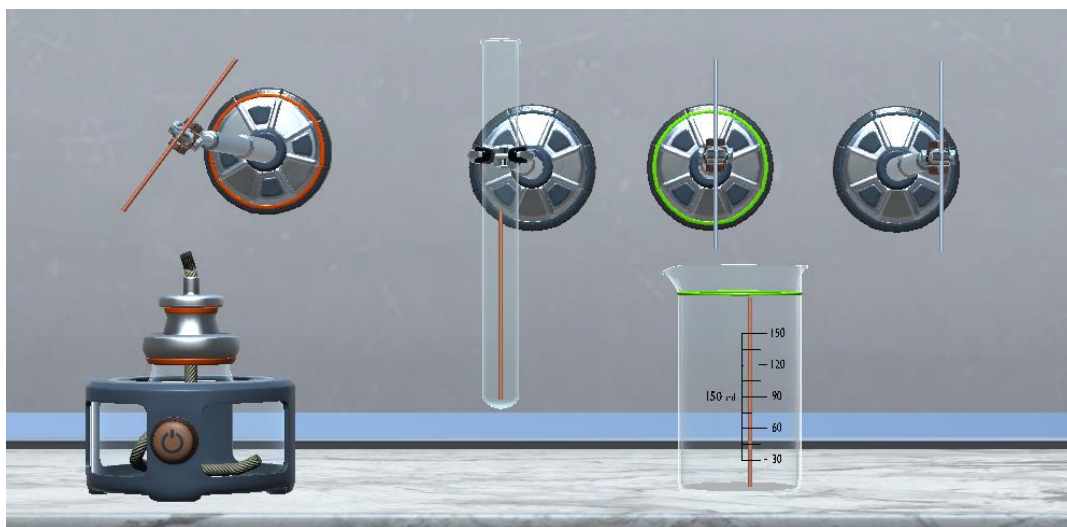


Figure 111 – Examples of placing wire

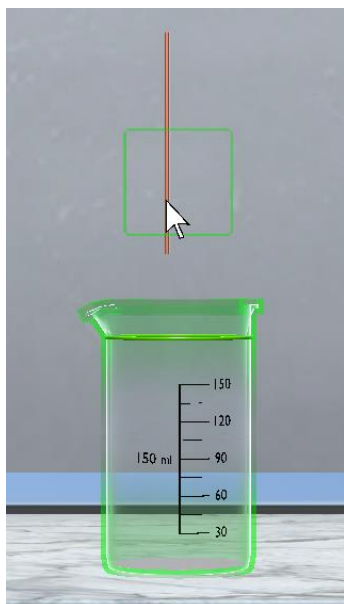


Figure 112 – Placing wire above a container

To move the wire, you can use the **Hand**, **Glove**, and **Holders** tools (see [7.4 Using tools](#)). To heat the wire, place it in the heating zone of the spirit lamp (see [7.5.1 Object Interaction zones](#)).

The **Spatula** tool can be used to scrape off the coating from the wire (see [7.4.5 Spatula tool](#)). To collect the coating from the wire into a chemical beaker, test tube, or on a watch glass, place the wire in the green interaction zone above the container so that the items do not overlap (Figure 112). If the wire is placed correctly, rings of the same color will appear on the stand and on the glassware (Figure 111).

8.3.2.2 Powder

Solid substances in the form of powder can be placed in a test tube, chemical beaker, or on a watch glass (Figure 113). To move the powder, use the **Spatula** tool (see [7.4.5 Spatula tool](#)).

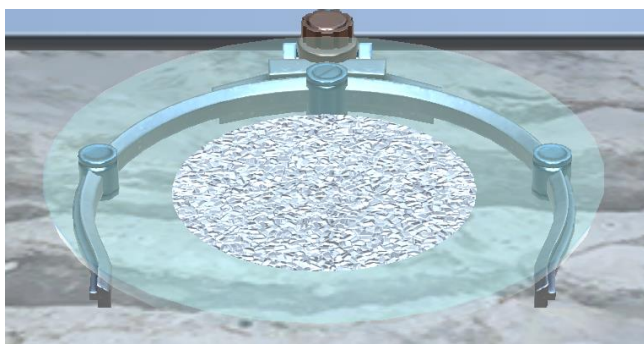


Figure 113 – Solid substance in powder form on a watch glass

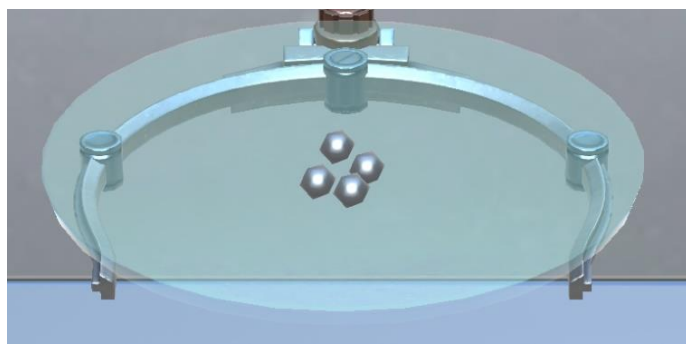


Figure 114 – Solid substance in granule form on a watch glass

8.3.2.3 Granules

Solid substances in the form of granules can be placed in a test tube, chemical beaker, or on a watch glass (Figure 114). To move the granules, use the **Tweezers** tool (see [7.4.3 Tweezers tool](#)).

8.3.3 Liquid substances and solutions

Liquid substances and solutions are stored in source containers (Figure 115) and drippers (Figure 116). The label on the container specifies the substance's formula, its concentration, and density.

To select the concentration before placing a container with the substance on the workspace, click on the object card in the **Component Library** and set the required value in the constructor (see [6.2 Object Constructor](#)).

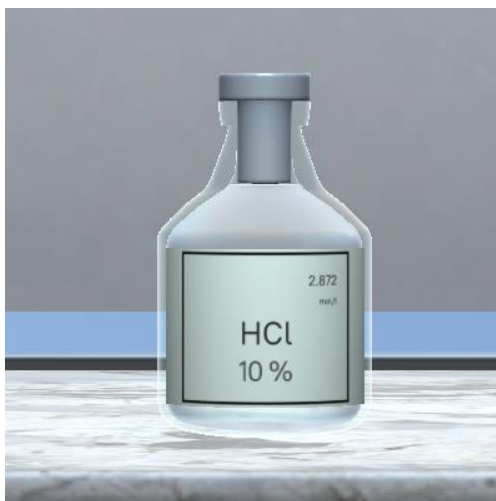


Figure 115 – Liquid substance in a source container



Figure 116 – Liquid substance in a dropper

Substances can be transferred from a container to a test tube, measuring cylinder, and chemical beaker; from a dropper — into any glassware. For more details on transferring liquids, see. [7.5.2 Transferring liquids](#).