

# Mission Molecule

## Teacher's Guide

### IDENTIFICATION OF THE GAME

**Title :** Mission Molecule

**Subject :** Chemistry

**Target courses :** General chemistry or other course that addresses the game content

**Programs :** Science 200.B1, Science, Computer Science and Mathematics 200.C1 or other

**Objective :** Apply concepts related to molecular structure and ionic compounds: Lewis structures, molecular geometries, types of chemical bonds and hybridization of orbitals to better visualize them.

**Content covered :** Lewis structures, molecular geometries (molecular structures),  $sp$ ,  $sp^2$  and  $sp^3$  hybridizations,  $\sigma$  and  $\pi$  bonds.

**Average length of play :** 20 to 40 minutes

**Average time for all activities in the pedagogical scenario :** 2 hours

### Description of the game (mechanics and purpose)

**The purpose of the game** is to solve riddles related to the **structure of the molecules involved in various ecological disasters in the past.**

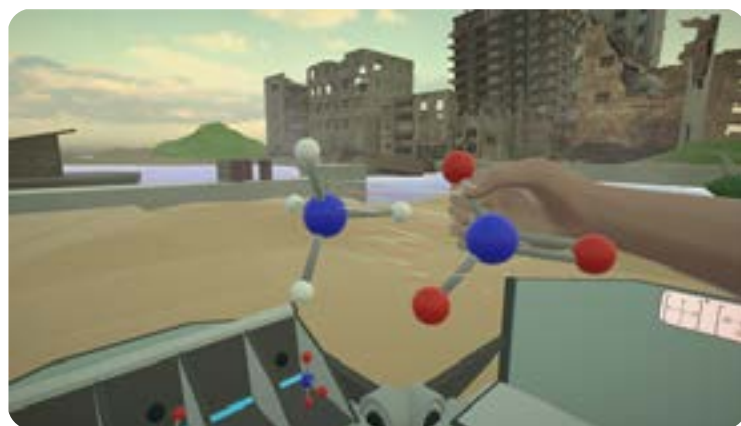
When the students first arrive in the preparation room, they are given the opportunity to get used to the controllers and the 3D immersive virtual reality environment. The participants will have to use the controllers to **place magnetized words on a board**, to teleport from one place to another and to **pick up a key in order to enter the Temporal, Spatial and Digital Projection machine.**



After making the first temporal jump (level 1), **the participants will be inside the pollution cloud that enveloped Beijing during the COP26 meeting (in Scotland).** Using the information in the partner's document, the students **must match the characteristics (number of neighbours of the central atom, molecular geometry, type and number of chemical bonds) of the three molecules presented ( $O_3$ ,  $CO_2$ ,  $SO_2$ )** with the WHMIS pictograms and NFPA codes to place in the teleportation machine. Solving the riddles allows the students to **visualize the molecules in 3D and make the next temporal jump (levels).**



The next temporal jump takes them to the **Port of Beirut, where the presence of ammonium nitrate ( $NH_4NO_3$ ) led to explosions in August 2020.** After choosing the best **Lewis structure** from those proposed, the students have to choose the correct models from among those presented and assemble the ammonium and nitrate ions in order to observe the ionic compound in 3D.



Finally, after the last temporal jump, the participants will assemble the **hybrid orbitals of methyl isocyanate, the molecule responsible for the Bhopal disaster in India in 1984.**



**The steps for advancing through the game are described in detail and illustrated in Appendix 1**

# MATERIALS AND TECHNICAL ASPECTS

## Materials required

Each game requires the use of a **Meta Quest 2 or 3 headset and a tablet or computer** mirroring the image viewed in the headset. The game is designed for teams of two.

The students will also need the *Practice Guide* and the *Support File* to play the games.

The following information can be found in the *Practice Guide* :

- How to adjust and turn on the headset
- How to define the play zone
- How to mirror the game on a computer or tablet (mirroring means casting the virtual reality headset's content to a computer or tablet screen in real time)
- How to start the game
- How to exit the game
- How to turn off the headset

The following information can be found in the *Support File* :

- Context of the game
- Explanation of how to use the controllers to pick up and place objects and to teleport
- Information required to advance through the game: The game requires communication between the partner (the person with the *Support File* who is watching the game on the computer or tablet) and the player, who is wearing the headset. The partner guides their classmate during the game, and also has certain required information, such as the genetic code. It is important for the player to wait for instructions from the partner before advancing, in order to facilitate learning and the completion of all the steps of the game.

The game documentation can be found (<https://novascience.github.io/VR/#Jeux>).

## Technical aspects and logistics

Using virtual reality in a course requires several preparatory logistical steps, including configuring the required accounts, headsets and WiFi, and setting up a space where the game can be played. It is strongly recommended that you read the “Logistics planning for the deployment of immersive virtual reality in a college” appendix.

## Safety measures

Using an immersive virtual reality headset entails a low risk of cybersickness, a feeling similar to motion sickness. To minimize the potential discomfort and other risks, **we recommend following these instructions :**

1. A member of the teaching staff must be present at all times when the headsets are being used.
2. The play zones must be clearly marked and free of obstacles. They must remain free of obstacles for the entire duration of play.
3. The headsets should never be used for more than 30 minutes at a time.
4. We recommend removing the headset as soon as any discomfort occurs (headache, nausea, dizziness, for example). In this situation, the player can change places with the partner who is not using the headset.
5. A virtual reality headset should not be used by anyone with any of the following conditions: **heart or blood pressure problems, anxiety, post-traumatic stress, pregnancy, epilepsy**. In these cases, the participant should play the role of the partner so they can continue to take part in the pedagogical activity. The same precaution applies to people who tend to suffer from motion sickness.

If minor symptoms occur, encourage the student to remain in the room and rest for a while, until the symptoms subside. A chair should be provided quickly to anyone who starts to feel ill.

**If more serious symptoms appear, immediately contact security, which will contact the educational institution’s first aid workers or emergency services, if necessary.**

# PEDAGOGICAL PLANNING

## Outline of the activity

To optimize learning, it is important for the game to be part of a complete pedagogical scenario. Time to review the game afterward should also be provided.

In general, the pedagogical scenario should include the following:

Before the game	A preparatory activity can be planned to prepare the students for the content covered in the simulation and to activate their prior knowledge.
During the game	<p>When the students arrive, they should be given information related to :</p> <ul style="list-style-type: none"><li>▪ Game objectives</li><li>▪ Session outline</li><li>▪ Instructions</li></ul> <p>The game is played in teams of two. It is important for the students to be supported (both technologically and conceptually) by a sufficient number of people during play. In the preparation room, which is the first game activity, the students will have the opportunity to get to know the controllers and the 360 gaming environment.</p>
After the game	A debriefing should be held after the game to make sure that the students internalize and absorb the target learning. First, you can gather the participants' impressions by asking them to describe their experience. Then you can go over the mistakes and most difficult concepts. Finally, a summary should be given, ideally by the students, and feedback should be provided by the teacher.

You can view a sample pedagogical scenario in *Appendix 3*

## Practical tips

1. It is crucial for the teacher to be comfortable with the virtual reality headset and the game, to be able to intervene if the students encounter any problems. It is therefore strongly recommended that you familiarize yourself with the headset and the game before holding the activity with the students.
2. The students must receive clear and **specific instructions on using the headset and playing the game (for specific manipulations, such as picking up and putting down items and teleporting). The operation of the first part of the game, with the riddles and pictograms to be placed, must be clearly explained.** Time must be set aside for these instructions. The students should also be encouraged to closely follow the instructions in the Equipment Introductory Guide and the Support File.

# APPENDIX 1 – Detailed description of the steps of the game

## The game, step by step

### Emergency exit

#### Restart the level :

- If a problem occurs during the game, you can always restart the level by holding the green button at the bottom of the screen on the player's left arm for 3 seconds.

#### Restart the game :

- If a problem occurs during the game, you can always exit the game or press on the red button at the bottom of the screen on the player's left arm for 3 seconds or press the Oculus button in the player's right hand.



## Task 1 Preparation room

### Step 1.1: Getting to know the game and the controls

- Read the chart on the left describing the mission.
- Refer to the hologram on the table, which describes how to use the controls.
  - To pick up an item, use the button controlled by the middle finger (toward the centre of the hand).
  - To teleport, use the button controlled by the index finger (toward the edge of the hand).
- Refer to the bracelet on the left arm, which provides instructions during the game.

### Step 1.2: Place the magnetized labels on the blank boxes to put the ecological disasters in chronological order.

- Pick up each magnetized label from the table and place it in the appropriate place on the timeline.
- To pick up a label, move your hand toward the item and press the button controlled by the middle finger (toward the centre of the hand). Hold the button down until you want to let the item go.



- Once the exercise has been successfully completed, the chart will slide to the left.

### Step 1.3: Pick up the access card

- Teleport to the rectangular key located near the lab machine.
- To teleport, press the button controlled by the index finger (toward the edge of the hand) until a blue laser appears and then point the laser at the area outlined in blue (point the laser toward the floor) and then let go.
- To pick up the card, use the button controlled by the middle finger (toward the centre of the hand).



### Step 1.4: Open the door Open the door to access the Temporal, Spatial and Digital Projection machine (player teleports to next level).

- Teleport to the door by pointing the laser at the area outlined in blue.
- Place the card in the slot in the machine under the red button, with the black part facing out.
- Press the red button. The door will open and the game will automatically pass into the next room.





## Task 2: Pollution cloud in Beijing

### Step 2.1: Ozone – Lewis structure, molecular geometry, hybridization and bond angle.

- The player must now select the most plausible Lewis structure for ozone ( $O_3$ ) among the three choices offered on the blue table.
  - **Correct answer = structure in the middle**
- Then the partner with the Support File has to solve the ozone puzzles in order to determine which WHMIS and NFPA pictograms to play on the control panel.
  - First, from the choices offered in the Support File, the partner must determine the number of neighbours (effective pairs) and the molecular geometry of the central atom, in order to choose the correct WHMIS pictogram. They then communicate the information obtained – that is, the selected pictogram – to the player. The player scrolls through the pictograms on the console until the correct one appears, at which point they pick it up and place it on the dashboard.
  - Next, from among the combinations proposed on the next page of the Support File, the partner has to determine the appropriate type of hybridization and the bond angle of the central ozone atom. The pictogram associated with the correct answer must be placed on the dashboard by the player, as previously. The NFPA symbol (colour and number) is obtained by selecting the correct colour (selecting the yellow, blue or red lozenge) and the correct number (pressing the + or – symbol). The symbol is then inserted in the appropriate location (designated by a question mark) on the dashboard.
  - The answers to the ozone questions are as follows:



3	Angular		
$sp^2$	 $< 120$		




- Completed dashboard (order may differ):



- Finally, the molecule must be inserted in the capsule on the left.

### Step 2.2: Carbon monoxide – Lewis structure, hybridization, bond angle and chemical bonds.






- The player must now select the most plausible Lewis structure for carbon monoxide (CO) among the three choices offered on the blue table.
- Then the player and the partner have to solve the carbon monoxide puzzles to determine which WHMIS pictograms and NFPA symbols to insert on the dashboard, as explained previously.
  - The answers to the carbon monoxide questions are as follows:

sp	-	4	
Number of $\pi$ bonds	2		0
Number of $\sigma$ bonds	1		3

- Finally, the molecule must be inserted in the capsule on the left.

### Step 2.3: Sulphur dioxide – Lewis structure, hybridization, bond angle and chemical bonds.

- The player must now select the most plausible Lewis structure for sulphur dioxide ( $\text{SO}_2$ ) among the three choices offered on the blue table.
- Then the player and the partner have to solve the sulphur dioxide puzzles to determine which WHMIS pictograms and NFPA symbols to insert on the dashboard, as explained previously.
  - The answers to the sulphur dioxide questions are as follows:

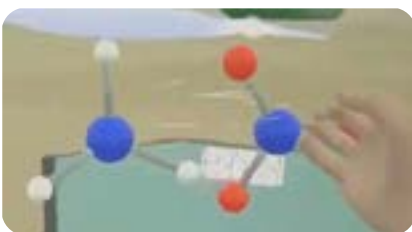
3	Angular		
$sp^2$	 $< 120$	0	
Number of $\pi$ bonds	2		0
Number of $\sigma$ bonds	2		3

- Finally, the molecule must be inserted in the capsule on the left.

## Task 3: Bhopal disaster

### Step 3.1: Ammonium nitrate – 3D structure and bond angle

- The player must now select the most plausible Lewis structure for ammonium nitrate ( $\text{NH}_4\text{NO}_3$ ) among the three choices offered on the blue table.
- **Correct answer = structure at the top right**
- Then, without the Guidance File, the player and the partner have to determine the geometry of the ammonium ion from the 3D structures on the right and the geometry of the nitrate ion from those on the left.
  - The two ions must be bonded by assembling them so that one ion is in the grey sphere associated with the other ion.



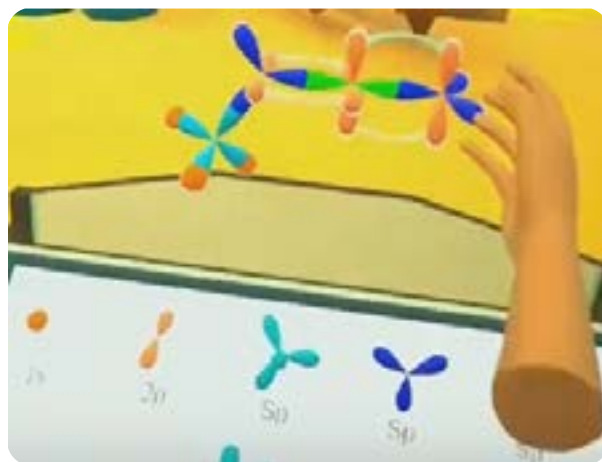
- Finally, the molecule must be inserted in the capsule on the left.



## Task 4: Explosions in the Port of Beirut

### Step 4.1: Methyl isocyanate – 3D structure and molecular orbitals

- The player must now select the 3D structure that corresponds to the chemical formula of methyl isocyanate ( $\text{CH}_3\text{NCO}$ ) from among the five choices offered.
  - **Correct answer = 4th structure**
  - The structure must be inserted in the capsule on the left.
- Then the methyl isocyanate structure must be assembled from its hybrid orbitals, using the choices displayed on the dashboard.
  - The orbitals must be placed in the shaded sphere, one after the other.
  - Don't forget to use the  $1s$  orbitals for the methyl's hydrogen atoms.
  - Don't forget to use the  $2p$  orbitals for the pi bonds.
- **Answer**



### Step 5: End of the game.

- Launch the next temporal leap to view the congratulations animation.
- Teleport to the podium and press the green button to end the game.
- Bravo!

## APPENDIX 2 – Logistics planning for the deployment of immersive virtual reality in a college

### To do before the first use

Purchase headsets	You will need a set of Oculus Quest 2 or 3 headsets, enough for one for every two people. <b>Plan to have 14 to 15 headsets.</b>
Transport and charge the headsets	You will need a <b>cart</b> to transport and charge the headsets.
Set up Meta accounts	<p>To use mirroring, which allows the students who do not have a headset to see the image, each headset must be linked to a separate Meta account.</p> <p>You therefore need to create as many institutional (or other) email addresses as there are headsets and <b>create a Meta account for each of these addresses</b>. Creating pseudonyms on an institutional email server may simplify email management. For example: <a href="mailto:metaheadset1@dawsoncollege.qc.ca">metaheadset1@dawsoncollege.qc.ca</a>; <a href="mailto:metaheadset2@dawsoncollege.qc.ca">metaheadset2@dawsoncollege.qc.ca</a>, etc.</p> <p>The procedure for creating a Meta account from an email address can be found <a href="#">ici</a>.</p>
Configure the headsets	Each new headset must be configured before linking it to the corresponding Meta account and connecting it to the right WiFi network.
Install the game	To install the game, you have to download the Meta app on a mobile device and log in using the identifiers for the Meta account linked to the headset. Then select Search and enter Novascience in the search tool. Then click on the image of the game and select Download. The detailed procedure can be found <a href="#">ici</a> .
Configure the WiFi network	The institution's WiFi network must permit mirroring on multiple headsets simultaneously on a tablet, computer or phone. These permissions are generally managed by the institution's IT team, so it is important to check with them in advance.
Prepare for mirroring (tablet or cell phone)	If the mirroring is done on a tablet or phone, the Meta Quest app must be installed on it and connected to the same account as the corresponding headset. The device must be connected to the same WiFi network as the headset.
Prepare for mirroring (computer)	If the mirroring is done on a computer, it must be connected to the Meta account that corresponds to the address <a href="https://oculus.com/casting">oculus.com/casting</a> . The computer must be connected to the same WiFi network as the headset.

## To do for every session

<b>Reserve a room</b>	To have enough space to safely run the game, every team must have a space measuring 1.5 m by 2.1 m with no furniture and no obstructions other than the equipment required for the students not using the headsets. Please ensure with your institution's IT services that the WiFi allows headset mirroring in that room.
<b>Provide equipment for mirroring</b>	Provide the equipment required for headset mirroring: computers, tablets or phones. If you will be using tablets or phones, make sure that the Meta app is already installed on them.
<b>Provide support</b>	Make sure to have enough qualified people to support the students technologically and conceptually. These people must be able to help the students use the headsets, choose the application and set up the mirroring at the beginning. From then on, the assistance may relate to technical support, but ideally the assistants will know the content of the game well enough to be able to answer questions about content that is challenging for the students or at least to point them in the direction of solutions.
<b>Recharge the headsets</b>	Make sure the headsets are recharged after every use.
<b>Recharge the controller batteries</b>	Make sure the controller batteries are recharged.
<b>Update</b>	Make sure the headsets and the game are updated before use.
<b>Distribute the preparatory documents</b>	Give the students the preparatory documents in advance, so they can familiarize themselves with the game and the equipment.
<b>Cleaning</b>	Provide wet wipes to clean the outside of the headsets and a microfibre cloth to clean the lenses, if necessary.
<b>Safety</b>	Provide a space where participants who are feeling ill can sit down.
<b>Answers</b>	Make sure that the answers to the game questions (or riddles) are easily accessible.

## APPENDIX 3 – Sample pedagogical scenario

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[Click here to open link](#)