

Class Delivery Plan

Preparation (A few months before the class)

- For the purpose of research publication, the proposal was reviewed by institutional review board (IRB) and student informed consent was completed before the class.
- In addition to the laboratory room, a dance room and a computer room were booked in advance for the delivery of the activity.
- Study materials for students and instructor notes were developed and tested beforehand. Relevant materials such as worksheet and study guides were posted to class learning management system (LMS) before the actual experiment date.
- Instructor wants to speak facing the students. It is possible to pull the headset out temporarily and move to a new position and put it back to reorient the instructor in the virtual/physical space. A lot of practice in the actual setting is helpful. Alternatively, a second person can assist the instructor to make sure that the action in VR is properly seen by the audience.

The actual experiment date (Week 3 – Friday, 26 January 2024)

- Bring Wifi router + Meta Quest II + USB drive containing the materials to the room.
- Tell students the URL of MolecularWebXR after the class so that the server is not unintentionally crowded by students.

time		activity	location/ personnel
sec 1	sec 2		
8:00-8:20	13:00-13:20	Pre-test and short briefing	lab room/ All
8:20-10:00	13:20-15:00	<p style="text-align: center;">Instructor's live demonstration for Tasks 1-4 & Bonus</p> <p>Instructor #1 is on VR and Instructor #2 is on the computer to</p> <ul style="list-style-type: none"> Operate the "VR room" as a camera person and Make screen/video recording as needed. <p>Introduction: (Presentation of the two scientists work is in a PowerPoint file.)</p> <ul style="list-style-type: none"> Mention that Jacobus Henricus van 't Hoff (1852 – 1911) formulated the theory of the tetrahedral carbon atom and laid the foundations of stereochemistry. He won the first Nobel Prize for Chemistry in 1901. We see him in the lesson of colligative properties (van 't Hoff's factor in ICCH102) Mention that Friedrich August Kekule von Stradonitz (1829 – 1896) proposed the structure of benzene contained a six-membered ring of carbon atoms with alternating single and double bonds. It is interesting to note that: (1) His death is before 1900 so he had no chance for Nobel Prize. Three of his former students won the prize. van 't Hoff is obviously the first for developing from flat structure of benzene to 3D tetrahedral structure. (2) His dream interpretation of benzene structure in 1862 is obviously before Sigmund Freud and Martin Luther King Jr. As a physical scientist (chemist, physicist and mathematician) – rather than biological or social scientists – we should be inspired by his story rather than the latter two. <p>Delivery of tasks by the instructor: (List of links are in an MS Excel file.)</p> <ul style="list-style-type: none"> Install screen recoding plugin to browser. Launch MolecularWebXR and load objects into an empty room one by one and make the recording from the web browser on the computer. At the end of each task [5 min video recording], we encourage questions and discussion. <p>We expect to finish early and allow students to have a short break before two hours of class. Also, charge the headset, if time permits</p>	dance room/ All
10:00-11:50	15:00-16:50	Complete one-page worksheet (Work in pair for two hours – submit one A4 per pair.) Students submitted the lab report at the laboratory room staffed by Lab assistance #2. + Give souvenir in return of completion of the post-activity survey.	computer room [unstaffed]
Following supplementary activities were delivered as one-on-one on a strict scheduled.			
10:00-11:00	15:00-16:00	Individual 3-min interaction with VR goggles (Please standby 2 minutes before your time. Make sure that your watch read the same time as timeanddate.com now. If next person does not come, you can play with VR a litter further up to a total of five minutes.) * AR alternative ca be offered if VR is not comfortable or does not work. [Recharge as soon as possible between two sessions.]	dance room Instructor #1 Lab assistance #1
10:00-11:00	15:00-16:00	Identification of carvone by smell (double-blind test) – immediately after the VR session * Identification of plastic models as R or S is offered to those who cannot smell carvone enantiomers for any reasons.	dance room Instructor #2 Lab assistance #1

- Video recording is made in advance as a backup plan. If the technology fails for any reasons (e.g. internet connection or hardware malfunctions), we can still continue the class as usual with standard audio-visual equipment. Note that the mobile internet can become congested when there are relatively many students and visitors on campus when compared to the practice date during holiday period/term break.
- Based on observation/feedback from Section 1, the operation of Section 2 may be changed/improved to make a better deliver of the class.

Individual appointment time for VR and olfactory activity

section 1				section 2			
seat	time	seat	time	seat	time	seat	time
1	10:00	2	10:03	1	15:00	2	15:03
3	10:06	4	10:09	3	15:06	4	15:09
5	10:12	6	10:15	5	15:12	6	15:15
7	10:18	8	10:21	7	15:18	8	15:21
9	10:24	10	10:27	9	15:24	10	15:27
11	10:30	12	10:33	11	15:30	12	15:33
13	10:36	14	10:39	13	15:36	14	15:39
15	10:42	16	10:45	15	15:42	16	15:45
17	10:48	18	10:51	17	15:48	18	15:51
19	10:54	20	10:57	19	15:54	20	15:57
21	11:00	22	11:03	21	16:00	22	16:03

Troubleshooting

- The VR headset will automatically turn off and will not be functioning if it cannot detect a person wearing it. Two out of forty students had long hairs on their forehead that could block the proximity sensor of the headset. They were recommended to tie their hairs properly.
- The VR headset is to be worn on top of reading glass if the correction is at least 1.00 dioptres.
- These actions may lead to weird behaviours.
 - Deleting an object that is being manipulated.
 - Walking beyond the set boundary of the VR headset.
 - Entering a room before the green light is shown on the top left corner of the web.
- In case of weird behaviours (i.e. black out, freeze, the room is upside down or the /hand disappeared but molecules can still move), exit the VR mode and re-enter it again. Otherwise, exit the room and clear browser cached before re-entering the room. In an extreme case, restart all connected devices (VR headset, computer and network router).
- One may not see or manipulate an object by hand controllers if it is too big or too small. There are buttons on the panel to re-centre and resize the object directly in MolecularWebXR.

Brief description of the tasks

1. Valence shell electron pair repulsion theory (VSEPR): Molecular geometry is determined by the numbers of bond pairs (bp) and lone pairs (lp). The sum of these two numbers is the steric number (sn). Twelve representative structures covered in the VSEPR theory are shown in the table.

2. Atomic orbitals: Orbitals are the solutions of the Schrödinger equation. The relative energy levels and shapes of orbitals are important basis to understand electrons in atoms and molecules.

3. Molecular orbitals: In Lewis acid-base theory, the highest occupied molecular orbital (HOMO) of Lewis base overlaps with the lowest unoccupied molecular orbital (LUMO) of Lewis acid to form an adduct. The example of BNH_6 is shown in the table.

4. 2D representations: Twelve representative 2D drawing (bond-line structures) are shown in the exercise. Our task is to match them with the 3D molecules in virtual reality.

Bonus. Enantiomers: Molecules are pair of molecules that are mirror image but are not identical. (They cannot be superimposed on the other.) Two pairs of enantiomers with well-known properties are shown in the table.

Internet materials for students to review concepts before/after classes – These are posted on class LMS

concepts	videos	readings
1. VSEPR	https://www.youtube.com/watch?v=Q9-JjyAEqnU	https://en.wikipedia.org/wiki/VSEPR_theory
2. Atomic orbitals	https://www.youtube.com/watch?v=Aoi4j8es4gQ	https://en.wikipedia.org/wiki/Atomic_orbital
3. Molecular orbitals	https://www.youtube.com/watch?v=nTujP4jCbqg	https://en.wikipedia.org/wiki/Molecular_orbital_diagram
4. Representations	https://www.youtube.com/watch?v=pMoA65Dj-zk	https://en.wikipedia.org/wiki/Skeletal_formula
5. Enantiomers	https://www.youtube.com/watch?v=dGyM4I_sSgQ	https://en.wikipedia.org/wiki/Enantiomer