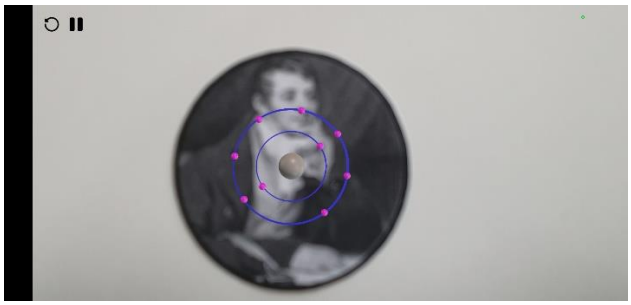
Instructions to Download and Use the BondBuilder App

1. Download and install the BondBuilder app through the following link:
https://github.com/jjimlmg/BondBuilder
https://play.google.com/store/apps/details?id=com.jjimlmg.bondbuilder.augmentedimage
In the repository, you will find the BondBuilder.apk file, which is the app itself, and the element_markers.pptx file, which contains printable markers.

2. Printing elemet_markers.pptx in color (or grayscale) on A4 paper. Then cut out all circular markers with scissors.

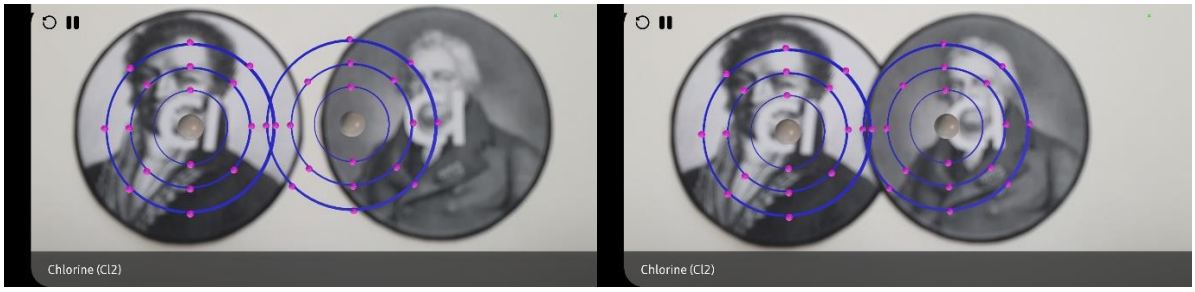
3. Start the app and use it to recognize the markers. If the app has recognized them well, the nucleus and the electrons are augmented on the markers and the electrons will orbit the nucleus.



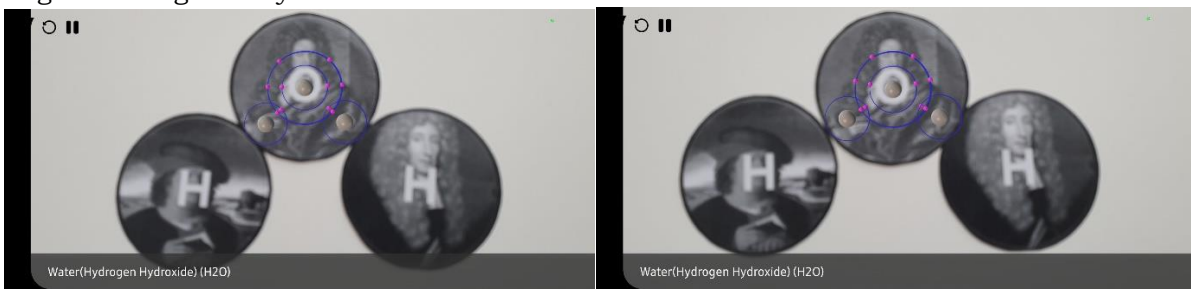
- If the markers are not recognized well, move the camera slightly back and forth or left and right to recognize them.
- If the app is unable to track the markers after initially recognizing them successfully, the electrons have disappeared and only nucleus is visible. In this case, move the camera slightly back and forth or left and right so that the app recognizes the markers again.

- If there are so many untracked markers on the screen, press the 'Reset" button at the top left of the screen to restart the app.

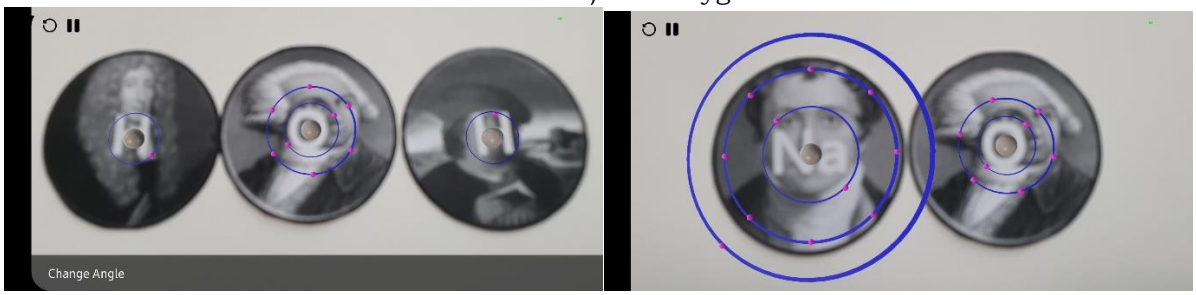
4. When markers come into contact with each other, simulating real chemical bonding, the Bohr atomic model transforms into the Bohr bonding model.
- Please use landscape mode rather than portrait mode. Portrait mode is too small to capture multiple markers in one screen.
- It does not matter whether the markers touch exactly or overlap slightly. However, if markers overlap too much, the app will not be able to recognize bonding.



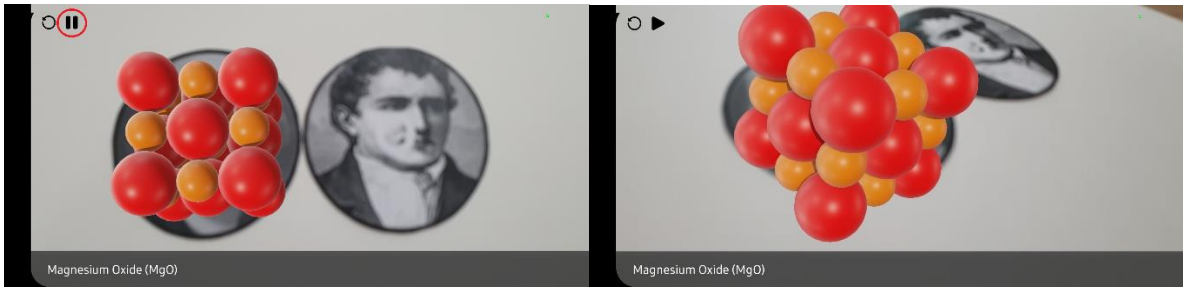
- As long as the arrangement of the atoms resembles the Lewis electron dot structures, bonding is formed.
- Though bonding is formed considering real angle of bonding, but it does not have to be the exact angle. Ex.) For H_2O, the correct bond angle is 104.5', but the app allows bond angles as long as they are between 94.5'~114.5'



- The app guides user when bond angle is incorrect by showing 'Change angle' on the bottom of screen. However, the app does not display a message if incorrect markers or an insufficient number of markers are used. Ex.) one "oxygen card" and one "sodium card".



5. When the user touches the Bohr bonding model on the screen, it changes from the Bohr bonding model to the ball-and-stick model in three dimensions, and when the user touches it again, it changes back to the Bohr bonding model.
- to switch bond model, the user must touch the central atom of the molecule, otherwise, it will not work. If the molecule consists of two atoms, the user must touch the atom where model is augmented.
- 'Pause' button to the right of 'reset' button has the function of temporarily pausing the camera recognition. This is useful if the users want to observe the model in the different view without worrying about the instability of the camera.
- 'Resume' button which is toggled from 'pause' button has the function of resuming camera recognition.



6. When the markers touching each other are separated, the Bohr bonding model or ball-and-stick model disappears and is converted into the Bohr atomic model prior to bonding.
 - If the user want to try other molecules, press 'Reset' button at the top left of the screen to restart the app.

Reported Issues
- Occasionally, the application encounters significant difficulties in accurately tracking the marker. At present, we are uncertain whether this issue stems from the ARCore platform developed by Google or our own application. In any case, if such a situation arises, we kindly request you to uninstall the update of Google Play Services for AR and proceed with reinstalling it. How to do is below:
Uninstall update: Settings → Apps → Google Play Services for AR(or ARCore) → Uninstall updates
Update: Run our app → This application requires the latest version of Google Play Services for AR → Continue → Update