Hydrogen Atom Game Simulator Rules

This exciting game is simple to play and teaches a number of important ideas about the interactions between light and atoms, including the following:

- Quantum Atomic Energy Levels
- Atomic Emission of Light
- Atomic Absorption of Light
- Calculating Wavelength and Frequency
- Calculating the Energy of a Photon
- Converting Units of Length and Energy

Players form teams of two and play against another team of two. Several students and the teacher are referees. The playing board shows the energy levels of a hydrogen atom, marked with the energy an electron has at each level. Each team also has a sheet showing two kinds of spectra: an emission spectrum and an absorption spectrum. Players move an electron marker from one energy level to another as instructed by cards drawn from a pile. The spectra page is used by each team to mark their progress. Play works as follows:

1. Set up the playing board with an electron marker in the ground state (energy level 1). Use a hole punch to create a suitable electron marker from a piece of paper.
2. Shuffle the cards.
3. Each team draws one card. The team with the highest energy value for their card goes first. The first two cards are set in the discard pile.
4. The team going first draws a card and must determine what happens.
   a. If the card is an Emission card then the team places the electron in the upper energy level, moves it to the lower level shown on the card, and calculates the energy in Joules, frequency in Hz, wavelength in m, and wavelength in μm or nm of the photon. These values are filled in on the score sheet. When finished, the team draws a line on the Emission Spectrum showing where the photon would appear in the spectrum.
   b. If the card is an Incoming Photon card then the team must determine whether the photon can be absorbed. *The photon can only be absorbed if the energy on the card matches the gap from the electron's present position on the playing board to a higher level.*
      - If and only if the photon is absorbed then the team moves the marker to the higher level and calculates the energy in Joules, frequency in Hz, wavelength in m, and wavelength in μm or nm of the photon. These values are filled in on the score sheet. When finished, the team draws a line on the Absorption Spectrum showing where the photon would appear in the spectrum.
      - If the photon is not absorbed then the turn is over and the opposing team (who did not go first) now has control of the playing board and draws a card.

   The team gets one point for each **correctly calculated** filled in box on the scoresheet. The team also gets one point for each **correctly drawn** line on the spectra page. There is a maximum of seven points to earn per line.
5. The team who did not go first (the opposing team) makes the same set of calculations but can only earn points if the team whose turn it is (the first team) makes an error. Both teams must compare their answers and if the first team made a mistake then the opposing team gets the point for that box, if they calculated it correctly. This should be recorded on the opposing team's score sheet. The opposing team must initial the first team's score sheet to validate the score and vice versa.
6. Disputes about correct calculations or other matters must be brought to a referee or the teacher for arbitration. Players must present evidence to make their case in a way that is respectful of other players or they risk losing the arbitration.
7. Play continues in the same way until either time is called or a score sheet is completely full. The winning team is the one with the most valid points. A referee or a teacher must confirm the winner in every contest.
8. Play should start over again if a score sheet is filled but there is still time left to play.
9. If at any time four cards are drawn in a row without the atom absorbing or emitting any photons then the teams enter a Spontaneous Emission race. Call a referee or the teacher over to time the race. If the electron

is at any energy level other than the ground level then the teams race to fill in the score sheet for the emission of a photon that results from the electron jumping down to the ground level. If the electron is in the ground level then the referee chooses the higher starting level. The winner of the race must have all calculations correct (checked by referee) and gets to draw the next card.

10. In case of a tie a referee will choose an emission transition and time a race between the teams for a tie breaker. The first team to finish with all correct answers wins the tie breaker.
11. If all cards have been drawn and placed in the discard pile then reshuffle use them again.
12. Academic credit is awarded as follows:
    - A score sheet with your name, team-mate's name and the spectra sheet is worth a homework grade as long as it has a minimum of ten entries on it and all lines marked on the spectra page.
    - The winning team earns 5 points on the next quiz.
    - Referees keep track of calculations done to settle disputes for their homework grade.
    - Referees earn 3 points on the next quiz.

There are eighteen possible transitions between energy levels in this game/simulation. There are 46 cards in the deck. Here is an inventory of the cards in the deck:

Emission Cards				**Incoming Photon (Absorption) Cards**			
Number of Cards	**Transition From**	**Transition To**	**Change in Energy (eV)**	**Number of Cards**	**Transition From**	**Transition To**	**Change in Energy (eV)**
1	7	1	13.328	1	1	7	13.328
1	6	1	13.228	1	1	6	13.228
1	5	1	13.062	1	1	5	13.062
1	4	1	12.756	1	1	4	12.756
1	3	1	12.094	1	1	3	12.094
1	2	1	10.204	1	1	2	10.204
2	7	2	3.124	2	2	7	3.124
2	6	2	3.024	2	2	6	3.024
2	5	2	2.858	2	2	5	2.858
2	4	2	2.552	2	2	4	2.552
2	3	2	1.890	2	2	3	1.890
1	7	3	1.234	1	3	7	1.234
1	6	3	1.134	1	3	6	1.134
1	5	3	0.968	1	3	5	0.968
1	4	3	0.662	1	3	4	0.662
1	7	4	0.572	1	4	7	0.572
1	6	4	0.472	1	4	6	0.472
1	5	4	0.306	1	4	5	0.306