TEMPLATE for BEST PRACTICE EXAMPLES

1. **Name of the project:**
   Hydrogen rocket

2. **Subjects covered from STEAM areas:**
   Science, technology, engineering, arts, mathematics

3. **Target group (age range and size of the group):**
   11-18 y.o.

4. **Duration of the activity:**
   1-3h

5. **Key words:**
   rocket, stoichiometry, mechanics, speed.

6. **Key sentence describing context of the activity, followed by short description (200 words):**
   Study the impact of the stoichiometry of the chemical reaction to the high (and speed) reached by the rocket.
   Students make their own rocket from a plastic bottle by filling it with different ratios of hydrogen and air (or pure oxygen). Students study the effect of chemical reaction stoichiometry to the released energy of the chemical reaction by measuring the height reached by the rocket. The results are plotted as a graph to find the perfect ratio.

7. **Description of the activity environment, including the list of materials and tools needed:**
   Chemistry lab with a possibility to test the rockets (which can also be done outside).

   Materials: Big bottles to house the hydrogen (and oxygen). Materials to prepare the hydrogen (and oxygen). Smaller bottles to make for the rockets. Water container in which the rocket is filled with hydrogen (and oxygen). A stand from which to launch the rocket. A tape measure to measure the height the rocket flies.

8. **Step by step, detailed description of the activity, including teaching and learning strategies:**
   Students are divided into groups.
   Teacher teaches the basics of a rocket and possibly the chemistry behind the rocket. If pure hydrogen and oxygen is used in the bottle, it should be left to the students to find the perfect 2:1 ratio. If hydrogen is mixed with air (only 21% oxygen), the perfect 2:1 ratio can be mentioned beforehand, but the perfect hydrogen to air ratio should be left for the students to find and calculated theoretically after that.
   1. Preparing the hydrogen (and oxygen)

Prepare the hydrogen in advance into big plastic bottles. It can also be left to the students to prepare the hydrogen, but it can take too long with the lower acid concentrations suitable for students. Prepare also the pure oxygen if the students use pure hydrogen-oxygen mixture.

2. Making the rocket

Students get a small plastic bottle to make the rocket from. Students are asked first to decorate the rocket to make the bottle look like a real rocket. Fins can also be added.

3. Filling the rocket

Using the water container, students fill the rocket with a set amount of hydrogen from the big bottle prepared earlier. Starting point could be for example 1 part hydrogen, 9 parts air. Students can also use hydrogen combined with pure oxygen.

4. Testing the rocket

Students put the hydrogen-air filled rocket to the stand in front of the tape measure attached to a wall. One student ignites the rocket with a long match (with ear and eye protection). Other students record the height to which the rocket flies. They can use a video camera. Rockets can fly many meters upwards in the best case scenario. Note that the rocket may not ignite at all if the ratio of hydrogen to air is too far from the optimal.

5. Rinse and repeat

Students repeat the experiment with a different ratios of hydrogen to air, for example first with 2 parts hydrogen, 8 parts air, then with 3 parts hydrogen, 7 parts air and so on.

6. Results

Students collect the results in Excel for example, and plot them into a graph. From the graph it should be possible to deduce the perfect hydrogen to air (or hydrogen to oxygen) ratio.

7. Conclusions

Teacher helps the students to understand why the height of flight of the rocket changed. It is also possible to calculate the theoretical launch speed of the rocket.

9. Learning objectives/competencies:

Learning the concepts of stoichiometry and explosive gas, plotting a graph

10. Evaluation/Assessment guidelines:

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11. Lessons learned:

If the mouth of the bottle is too small, there is a chance that the rocket explodes when ignited. Ear and eye protection is recommended. The bottle rocket should not be very big because of the risk of explosion. Under 200ml bottles should not pose too high a risk.

12. Additional information/Links:

13. Contact person:

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