Creating Science – Exploding Water

WARNING!!

High difficulty, high danger activity!

Can we make water? #CreatingScienceExplodingWater or #DangerousScienceExplodingWater

Suggested Outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Science content

- Chemical sciences 5: Solids, liquids and gases have different observable properties and behave in different ways (ACSSU077)
- Physical sciences 3: Heat can be produced in many ways and can move from one object to another (ACSSU049)

Science inquiry skills

- Questioning and predicting 3:With guidance, identify questions in familiar contexts that can be investigated scientifically and make predictions based on prior knowledge (ACSIS053)
- Planning and conducting 3: With guidance, plan and conduct scientific investigations to find answers to questions, considering the safe use of appropriate materials and equipment (ACSIS054)

Science as a human endeavour

- Use and influence of science 5: Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083)

Science vocabulary words

Tier 1 (Everyday words)

- **Explosion.** A rapid increase in volume, usually with a large release of energy such as sound or light.

Tier 2 (dual meanings)

- **Hydroxy gas.** Oxyhydrogen gas is sometimes called Hydroxy gas, but the definition is not standard and is avoided in this document. It can also refer in chemistry to the OH function group, in medicine as an abbreviation for hydroxyzine, or in manufacturing as a gas containing individual hydrogen atoms instead of a pair as in this experiment. With so many meanings, the word 'Hydroxy' is not used here.

Tier 3 (Specialised vocabulary)

- **Oxyhydrogen gas.** A volatile and dangerous gas made up of hydrogen atoms and oxygen atoms that touch but don't join. With a little heat, it can turn into water – water so hot it makes the nearby air glow, and produces a short lived but high pressure pocket of air that quickly collapses to make a loud noise, i.e., an 'explosion'.

- **Electrolyte.** A 'soup' of chemicals, mostly water, but water that also includes some other dissolved materials – usually a mix of positive and negative ions.
- **Ions.** A charged atom or molecule. Atoms have 'hands', and those hands are their electrically charged electrons. They use these to 'hold on to' other atoms. When dissolved in another material (aka a solvent) they can break apart and float around freely while still being electrically charged. This is an ion.
- **Electrode.** A device carrying an electrical charge. You put them into the electrolyte to gather various ions.

Warning

The knowledge gained in this activity is VERY DANGEROUS – and when done with reckless abandon or careless experimentation, can create potentially disastrous effects. Stick to the rules, and you'll be fine.

- Do NOT use glass. The slightest accident is going to turn that glass jar into a glass grenade with the unpleasant side effects that usually accompany such events.
- DO NOT use salt (aka sodium chloride) it may create deadly chlorine gas, and it makes the water all icky and brown.
- DO NOT use bicarb (aka sodium bicarbonate) it may create dangerous carbon monoxide and erodes the stainless steel electrodes.

Furthermore:

- When lighting an oxy-hydrogen flame, it is pale with virtually no colour. This is due to the fact that there is virtually no carbon present, which differs from a traditional hydrocarbon fuel flame. The oxy-hydrogen flame will be difficult to see in daylight or in a brightly lit room, so extra caution is needed – not many things are more dangerous than a flame that cannot be seen.
- Aside from visibility and cost, another drawback to using hydrogen as an alternate fuel is it has a greater tendency to leak. This is due to the fact that it is the thinnest substance available and it can be difficult to contain if not managed properly. Always check for leaks twice before lighting any flame.

And last, but not least;

- Wash everything thoroughly after use, the caustic soda will cause much rust, as well as eye and skin irritant.
- Bring towels to clean up the 'poison water' often.
- DO NOT let the electrodes touch, even under water. After only a few seconds they can become so hot that they melt the wires and ***might start a fire***. Please be careful!

Preparation

0. Safety gear – gloves, goggles, lab coats, etc are a MUST for this activity.
1. A small container with about 1 litre of water.
2. Thus, you will also need several towels to clean up the water.
3. Some electrolyte (water with sodium hydroxide aka caustic soda), approx. 1tsp per litre.
4. 12 volt battery.
5. A carrier wire.
    a. The red wire attaches to the positive end of the battery.
    b. The black wire attaches the negative end of the battery – LAST.
6. Two electrodes. Simple coat hanger in a V shape wire will do, but it's wise to tape up the part of it going into the water, that will be outside the gathering cup, so that it doesn't waste gas. Also, you can twist and bunch the wire up in order to increase the ***surface area***.
    a. The red one is called the cathode.
    b. The black one is called the anode.
7. Two gathering cups. They need to be small and safe plastic for explosions. Medicine cups are great.

Learning Intent (student friendly)

'We are learning to' (WALT) make water – the explosive way!

Success criteria

'What I'm looking for' (WILF) – careful handling and good technique, as well as several loud pops and explosions.

Student learning goals

Help students make a self-monitored learning goal for this lesson.

Evidence of learning

How will you know when the learning goal is achieved? What EVIDENCE do you have that your students have met or exceeded the learning expectations?

Students will be able to make, identify, and compare:

- Oxygen gas
- Hydrogen gas
- Oxyhydrogen gas

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students questions can and should guide student learning, more material is presented for you convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

Great care will need to be taken at this age. It is recommended as a demonstration.

Middle:

Students rapidly underestimate the dangers of the sodium hydroxide electrolyte. Be aware.

Students will struggle to understand why hydrogen gas forms at one electrode and oxygen at the other. Go into detail as needed.

Teen:

Use the chemical equations as supplied.

Engage

- ⇨ Note the Learning Intention of this lesson for students.
- ⇨ Make sure all students write down any questions they may have generated during this phase regarding the topic for today.

Tell students: One of my (Dr Joe's) most popular questions is 'if you mixed all the chemicals together, what would you get'?

I'm afraid the answer is very boring. You get muddy sea water.

You see, when all the chemicals mix, they cancel each other out, and get pretty boring. If you want to create something interesting, you have to get **pure** chemicals. Chemicals of only one kind of atom or molecule each. *Then* you get some really interesting things!

Today we're going to teach you one of those ways, which means it's DANGEROUS! The ability to get a pure material, while difficult, means we can create some pretty dramatic effects in the right situation – dramatic, and dangerous!

Be careful how you do this activity today, as doing it wrong can make some pretty dangerous things.

Explore

- ⇨ Encourage and validate student explanations of this phenomenon. You may like to ask students to write or draw their explanation personally to avoid embarrassment to students unfamiliar with this material. Remember, 'I don't know' is a valid explanation in science – it is the beginning of learning new things!

Now, they say water is made out of H_2O – that is, two hydrogens and one oxygen.

Can we test that?

Try the activity in the appendix 'making water', with care to follow all safety instructions.

Explain

When you mix the electrolyte with the water, it breaks up into positive and negative charges.

When you place an electric current through the electrolyte, the positive charges flow towards the negative terminal, and the negative ones towards the positive terminal.

There they undergo another change. The negatively charged oxygen atoms join together to form O_2, or oxygen gas, which floats up as bubbles.

The positively charged hydrogen atoms join up to form H_2, and float up as hydrogen gas.

- When you put a glowing splint into the **oxygen gas** the chemical reaction of burning dramatically speed up, releasing more heat, and potentially making the ember burst once more into flame.
- When you set fire to the **hydrogen** gas, it joins with the local oxygen gas in the air to make water, resulting in a fierce pop.
- When you set fire to the oxyhydrogen gas, there is potentially the perfect mix of oxygen to hydrogen molecules, and they are almost all used in the reaction making a much louder explosion! The fire may be brief, but the air will glow orange if there's enough carbon dioxide around – and there almost always is a little.

Remember it's not the water breaking up, but the sodium hydroxide which is already dissolved into the water and floating around as individual ions (charged particles) which we are collecting.

The equation

$$2H_2 + O_2 \rightarrow 2H_2O$$

Taken 14 june 2018 from http://www.mikeblaber.org/oldwine/chm1045/notes/Stoich/Equation/Stoich01.htm

Which means:

Two hydrogen molecules (of two hydrogen atoms each, so 4) mix with one oxygen molecule (made up of 2 oxygen atoms) will react to create 2 molecules of water (of 6 atoms in total)

However, there's something missing from this equation:

$$2H_2 + O_2 \rightarrow 2H_2O + Energy!!$$

High school

Try Stoichiometry, the science of measuring chemical reactions – see appendix.

Elaborate

- ⇨ Ask students if they can design new ways to test this explanation, is it really sufficient? Can they think of further or better explanations, and the experiments needed to test them?

What do we use oxyhydrogen for?

- Rocket fuel. As one of the highest mass to energy ratios of all chemical reactions, and some reasonable simplicity in getting the reactants, it's really the only choice so far.
- Welding – it leaves no waste but water molecules.
- As a fuel for cars – however, the hydrogen is difficult to contain, and the explosion if the two chemicals accidentally mix can level an entire house – that's FAR more dangerous than petrol! However, at least the main waste product is water!

Evaluate

- ⇨ Review with students what they felt they learnt from this lesson. Did they have any questions at the start that they feel were answered?

Success criteria

- ⇨ Review the Learning Intentions of this lesson with students. Was it met?

At the end of each class, review the learning objective and see how we did. Ask:

- Did you achieve your learning goal?
- What did You learn?
- What worked to help you achieve it?
- What might you do better next time?
- (If needed) where can you go for extra help or information?

Assessment

Prior Learning:

Take time to focus on planned content material during the engage phase, for example,

- What is a gas?
- What is water made out of?
- What is hydrogen, and oxygen?

Formative:

As students are learning, help them self-monitor their own learning and achievements.

Do they understand the underlying theory, and safety procedures?

- Why are bubbles forming at the electrodes?
- Why is one cup of air twice the size of the other?
- Which electrode is making oxygen gas? How can we tell? (and again for hydrogen)
- If the oxygen goes to the positive electrode, what electric charge must oxygen have?

Be sure to watch out for the following common alternative conceptions:

- What happens to the chemicals after they have reacted? [They are still there, only with new friends].
- Do chemical reactions absorb energy, or do they make energy? [Both, the gas reactions today are exothermic.]
- Can chemical reactions make so much heat, or need so much heat, that they can hurt us? [Yes they can, that's what explosions are!]

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do. Can they present a report on the uses and dangers of oxyhydrogen gas?

Make up a 'snakes and ladders' game of trivia questions regarding this activity – if they get the question wrong they must go down the snake, if they're right they go up a ladder, and if they're not, they simply progress as normal.

So what?

Oxyhydrogen gas is dangerous!

Some gasses look exactly like air, but they're not!

Electrolysis is a simple yet effective way to gather pure elements.

Creating science

Science content

As we gathered, identified, and tested various gasses, we saw that:

- Chemical sciences 5: Solids, liquids and gases have different observable properties and behave in different ways (ACSSU077)
- Physical sciences 3: Heat can be produced in many ways and can move from one object to another (ACSSU049)

Science inquiry skills

As we carefully and safely engaged with electrolysis, we found that;

- Questioning and predicting 3:With guidance, identify questions in familiar contexts that can be investigated scientifically and make predictions based on prior knowledge (ACSIS053)

- Planning and conducting 3: With guidance, plan and conduct scientific investigations to find answers to questions, considering the safe use of appropriate materials and equipment (ACSIS054)

Science as a human endeavour

As we learnt about the uses of Hydroxy gas and electrolysis in society, we saw that;

- Use and influence of science 5: Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083)

Appendix: Stoichiometry

Kindly supplied 14th of June, 2018, © 1996 Michael Blaber, from http://www.mikeblaber.org/oldwine/chm1045/notes/Stoich/Equation/Stoich01.htm,

What happens to matter when it undergoes chemical changes?

The law of **conservation of mass**:

Atoms are neither created, nor destroyed, during any chemical reaction

Thus, the same collection of atoms is present after a reaction as before the reaction. The changes that occur during a reaction just involve the *rearrangement* of atoms.

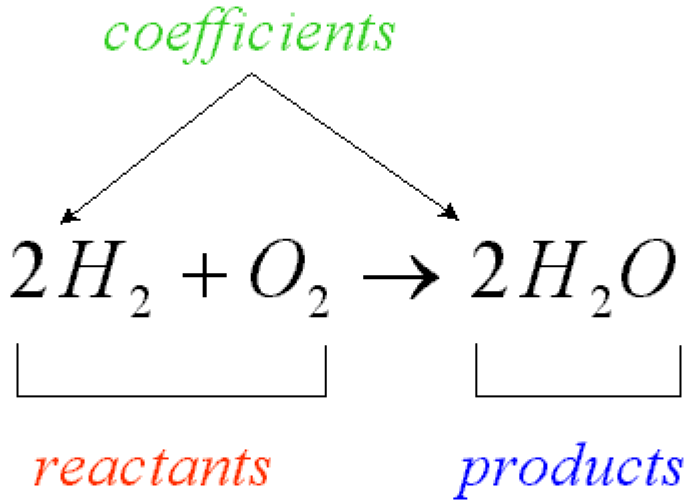
In this section we will discuss ***stoichiometry*** (the "measurement of elements").

Chemical equations

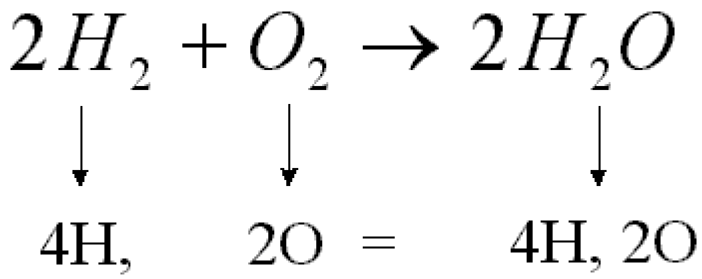
Chemical reactions are represented on paper by ***chemical equations***. For example, hydrogen gas (H_2) can react (burn) with oxygen gas (O_2) to form water (H_20).
The *chemical equation* for this *reaction* is written as:

$$2H_2 + O_2 \rightarrow 2H_2O$$

The '+' is read as 'reacts with' and the arrow " means 'produces'. The chemical formulas on the **left** represent the starting substances, called **reactants**. The substances produced by the reaction are shown on the **right**, and are called **products**. The numbers in front of the formulas are called **coefficients** (the number '1' is usually omitted).



Because atoms are neither created nor destroyed in a reaction, ***a chemical equation must have an equal number of atoms of each element on each side of the arrow*** (i.e. the equation is said to be 'balanced').



Steps involved in writing a 'balanced' equation for a chemical reaction:

1. Experimentally determine reactants and products
2. Write 'un-balanced' equation using formulas of reactants and products
3. Write 'balanced' equation by determining coefficients that provide equal numbers of each type of atom on each side of the equation (generally, whole number values)

Note! Subscripts should never be changed when trying to balance a chemical equation. Changing a subscript changes the actual identity of a product or reactant. Balancing a chemical equation only involves changing the relative amounts of each product or reactant.

Appendix: Making Oxyhydrogen Gas

Equipment

1. A small container with about 1 litre of water.
2. Some electrolyte (water with sodium hydroxide aka caustic soda), approx. 1tsp per litre.
3. 12 volt battery.
4. A carrier wire.
    a. The red wire attaches to the positive end of the battery.
    b. The black wire attaches the negative end of the battery – LAST.
5. Two electrodes. Simple coat hanger in a V shape wire will do, but it's wise to tape up the part of it going into the water, that will be outside the gathering cup, so that it doesn't waste gas. Also, you can twist and bunch the wire up in order to increase the ***surface area***.
    a. The red one is called the cathode.
    b. The black one is called the anode.
6. Two gathering cups. They need to be small and safe plastic for explosions. Medicine cups are great.

Experiment:

1. Set up your equipment as demonstrated. Do not attach the black –ve terminal yet.
2. Fill your cups with the electrolyte and place them upside down, full of electrolyte, over your electrodes. Wear gloves!!
3. Now attach your black cathode electrode.
4. **Observe** what happens… now, can you **explain** it?

Try to find out:

- What is the red anode creating?
- What is the black cathode creating?

If you're making oxygen, it will cause a fire to glow momentarily brighter, or a glowing ember to burst again into flames.

If you're making hydrogen, it will make a small explosion, usually a loud 'pop'.

Advanced material; making oxyhydrogen gas

We know water is made up of hydrogen and oxygen, but what if you had a gas that was made up of only hydrogen atoms and oxygen atoms? Usually they'd just bounce of each other, but if you add a little heat, they will actually combine to form water – trouble is, just as it took energy to break water up, it will release energy (and lots of it) to turn back into water. Stand back!

Place your container with oxyhydrogen gas upside down (so the gas cannot get out, since it is less dense than the surrounding air). Carefully put it on the edge of the table, and while standing well back, set fire to the gas. IT WILL BLAST UPWARDS KEEP YOU HEAD WELL AWAY!

Scientist name:

Date of research:

Page for young scientists

How do we know it's;

- Hydrogen – when you set fire to it, it will mix with oxygen in the air and make a loud 'pop'. This is called the pop test.
- Oxygen – when you put a lit splint or glowing ember inside, it will usually burst back into fire. This is called the splint test.
- Oxyhydrogen – when you add fire, the free hydrogens and oxygens will mix almost immediately in the perfect ratio to make water – not rain water, burning hot steam. SO HOT, it might make the air glow, and might set off a fairly loud BANG!

Which cup collected hydrogen gas?

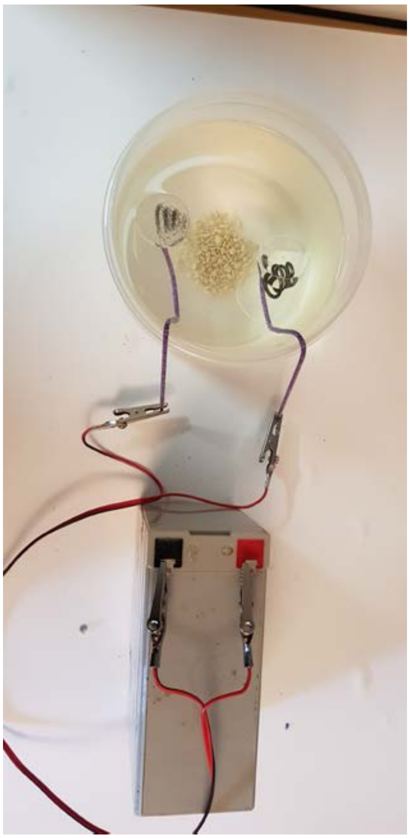
Which cup collected Oxygen gas?

What happens if you combine them into oxyhydrogen gas, and set fire?

What are the uses of oxyhydrogen gas?

Appendix: Tips from the Masters to make it work

- Don't let the electrodes touch, they will stop conducting water through the electrolyte and the chemical changes will stop.
- Especially don't let the electrodes touch in the small containers – they might make a spark and set off your explosives a little too soon!

Resources

With thanks to http://www.instructables.com/id/Hydroxy-Gas-Generator/ and http://www.harrisproductsgroup.com/en/Expert-Advice/tech-tips/oxy-hydrogen-fuel-applications.aspx, taken 14 june 2018