

Teachers' notes – Flames

Curriculum links

Combustion features in the English national curriculum science (2014) in the chemistry content under 'Chemical reactions'. It also appears in the Scottish N3 Chemistry curriculum under 'Nature's chemistry' in 'Fuels and energy'.

The science of combustion

Flames can be extinguished by removing oxygen, fuel or heat from the system. These requirements are sometimes portrayed by the 'fire triangle' diagram.

In this engineering video, we see Yusuf developing a sprinkler system for use in the home. Water sprayed as a mist into a flame will cool the system, as considerable amounts of heat are needed to vaporise the water, thus extinguishing the flames.

In this activity students explore different ways of extinguishing a candle flame. They are asked to predict what will happen before they use a range of different methods. They are then asked to explain their observations before suggesting an overarching explanation of how to extinguish candle flames. A predict – observe – explain sequence is used as it helps to uncover misconceptions, and to engage students' imagination when explaining unexpected results.

Expected outcomes

Students will be able to:

- explain different methods of extinguishing flames
- describe how scientific principles can be used to create engineering solutions
- recognise the personal attributes and motivations of people choosing a career in engineering.

Introducing the activity

Use the video clip of [Yusuf Muhammad](#) to introduce the lesson.

Video clips are an effective way of familiarising students with a topic, and can provide a useful introduction at the start of a lesson. You could choose one of these four activities to help to direct attention to specific points, or to ensure that students have an opportunity to consider key messages.

1. Adapting for different audiences

Working in small groups of two to three students, suggestions are made on how the video clip could be repurposed for a different audience, such as a class of children in primary school, aged 10 and 11.

Watch the entire video clip as a class, and then set the task to small groups, asking them to consider different modifications, such as:

- What content needs to be removed?
- What additional content could be helpful?
- What changes should be made to the language used?
- What additional images would help convey the key messages?



The video clip should then be made available for groups to review whilst making their suggestions. Set a time limit for the activity after which groups feed back their main points.

2. Going further

Generate questions that could be put to the presenter to find out more about the topic.

Watch the entire video as a class, and then ask students individually to generate one question that they would like to ask the presenter. In addition, you could ask individuals to generate one question that could be answered from the video clip. Students could then exchange questions with a partner, and attempt to answer each other's questions after watching the clip a second time.

3. Designing a quiz

Individual students generate questions and these are used as a quiz for the class.

Watch the video clip as a class. Set each student the task of generating one question that can be answered from the clip, and which has a single word answer.

Collect up the questions and insert the initial letter from each answer into a cell in the Blockbuster grid template. This will work best if each student is allocated a different letter of the alphabet as the initial letter of their answer.

To play the quiz, you take on the role of question master. Divide the class into teams. Two teams can take part in the quiz at once – one team moves from A to B on the grid, the other from C to D. The team that reaches their destination first is the winner. To move on the grid the team select a letter, and you read out the corresponding question. If they answer correctly, they 'own' that cell, which can be filled in a specific colour to indicate ownership. A team's cells must touch to make a pathway from their start point to their destination. Use presentation software such as Keynote to display the grid to the class and to fill cells with different colours.

4. Supporting evidence

Does the presenter use evidence (verbal, visual, implied) to give the key messages credibility?

Watch the video clip as a class, and then ask the class to suggest the key messages that they took from the video. Refine the list of suggestions using discussion to reach a class consensus, and agree on a list of no more than three key messages.

Watch the video for a second time, and ask the class to note any evidence used to support the three key messages. Finally, have a brief class discussion to share views on the evidence presented.

Practical activity

A student sheet is provided for this activity.

The class will need candles (tea lights are recommended) and several ways of extinguishing a candle flame. Students are asked to predict what will happen using each of the methods, to note their observations and then generate an explanation for each of the observations. Finally, they are asked to write an overall explanation for how flames can be extinguished.

This activity could be carried out individually, but would be easier to resource, and would produce helpful discussion, if it could be carried out in groups of two or three students.

Requirements (for each group of students)

- Student activity sheet
- Tea light candle on heatproof surface
- Gas lighter
- 250cm³ heatproof beaker
- 6 x 50g masses

- Coil of copper or steel wire (around ten turns with internal diameter of coil 5-10mm)
- Tongs
- Atomiser containing water
- Large syringe or squeezable plastic wash bottle
- Sodium hydrogen carbonate
- 0.2M hydrochloric acid
- 2 x 250cm³ beakers and 25cm³ measuring cylinder
- Safety glasses

The different methods that are suggested for extinguishing a flame are:

1. Inverting a beaker over the candle. The beaker needs to be made of heatproof glass and needs to have at least 6cm clearance between the top of the candle flame and base of the beaker (when inverted).
2. Inverting a beaker over a candle flame but leaving a gap between the rim of the beaker and the table surface to allow gases to escape. The same beaker may be used as in step 1. The gap should be less than the height of the candle. The beaker may be held above the table surface or could be supported, for example, by a stack of coins, or 50g masses. Using a support allows students to investigate the effect of increasing the gap size.
3. Holding a coiled wire around the flame (see student sheet photograph). The coil is made from a 15cm length of heavy gauge copper wire or steel wire such as that used to support garden plants. Strong pliers can be used to twist the wire into a coil. This should not be carried out by students themselves. Students will need tongs to hold the wire around the flame.
4. Spraying water from an atomiser.
5. Blowing a jet of air. Students could use their own breath to blow out the flame, but this introduces misconceptions around the carbon dioxide content of exhaled air. A better method is to use an 'empty' (ie contains air, not water) wash bottle or a large syringe. A syringe containing 20cm³ of air can easily extinguish a candle flame from a distance of 15cm.
6. Pouring carbon dioxide onto the flame. Carbon dioxide can be generated in a beaker or flask containing a few grams of sodium hydrogen carbonate and 0.2M hydrochloric acid. The gas should then be decanted into a beaker, which can be used to pour the gas over the flame. This avoids acid being poured over the flame.

Health and safety issues

Tea lights are more stable than traditional candles when placed on a heatproof surface. If using traditional candles, they need to be firmly supported.

Using a gas lighter to relight candle flames is preferable to using matches or splints from a Bunsen burner.

Each of the activities will require a risk assessment to be carried out locally.

Videos are available showing different methods of extinguishing flames.

The video by Physics Girl is recommended: <https://youtu.be/WainnKktGZI>

Further activity

Demonstrating what happens when water is poured on a chip pan fire is a spectacular way of illustrating that budding firefighters need to understand the causes of fire as well as how to put them out.

A video showing the correct way to [demonstrate chip pan fires](#) in the school laboratory is available on the STEM Learning website and the relevant safety information available from CLEAPSS (CLEAPSS L195 Safer chemicals, safer reactions).

Extension activity

There are many misconceptions about candle flames and how they burn. One such misconception is that flames go out when all the oxygen is used up.

This can be seen in the following video from the American Chemical Society:

<https://www.acs.org/content/acs/en/education/whatischemistry/adventures-in-chemistry/experiments/flame-out.html>

The misconception has given rise to ideas about calculating the percentage of oxygen in air by burning a candle and inverting a gas jar or bell jar over the flame in a trough of water. When the flame is extinguished, water rises inside the gas jar to a height of about 20% of the jar, suggesting that air consists of 20% oxygen. In fact, water rises because of heat causing expansion of gases which then cool.

This can be investigated by the class by using different numbers of candles in the gas jar.

For an explanation of some of the myths surrounding candle flames, and an explanation of how carbon dioxide can extinguish a flame, see:

<http://misconceptions.science-book.net/wp-content/uploads/2011/09/Chap2-1.pdf>

As an extension activity try enclosing an oxygen sensor in a closed container with a candle flame, to measure changes in flame characteristics with changing oxygen concentration. An aquarium makes a suitable sealed container. For further interest, you could include a carbon dioxide sensor in the system if you have one.

Convection currents are very important in maintaining a candle flame. To illustrate this, place an open glass cylinder or tube over a lighted tea light. The flame goes out, even though the tube is open at the top. Repeat the investigation but insert a metal foil strip into the tube that hangs down to the flame, and the flame stays alight, as the foil disrupts the convection currents.

Summary activity

A suggested summary activity is included to help focus students on the characteristics of this sort of engineering career.

Provide students with the sheet with Yusuf's photo in the centre and three coloured pens. You may find it useful to print this in A3, or stick the photograph in the centre of a larger sheet.

Working in small groups or pairs, give students five minutes to discuss and write down what they think they know about engineering and Yusuf's career in one colour around the photo.

Watch the film of Yusuf again and see if they can add anything to their sheets.

Then give students a further five minutes to discuss and write down what they would like to find out in another colour.

Draw out some of the ideas about his career/work as an engineer. Ask groups to feed back some of the questions they would like to find out more about. Elicit ideas of how and where they could find this out. They can then carry out research to find out what they wanted to know.

You could provide prompt questions to scaffold the activity:

- Yusuf does not work in isolation. What are the jobs involved in developing new products?
- What do you think excites Yusuf about his job?
- What qualifications do you need to be an engineer?
- How much do engineers earn?
- What personal skills do you think Yusuf uses in his job?
- How is engineering changing people's lives?

Useful sources of information on careers in engineering include:

<https://www.borntoengineer.com>

<http://www.tomorrowsengineers.org.uk/students/career-finder/>

<http://faraday.theiet.org/careers/case-studies/index.cfm>

<http://www.raeng.org.uk/education/what-is-engineering/engineer-case-studies>