

The Wonders of the Olympic Torch

The Story

On 10 May, 2012 the **Olympic flame** will be started in the temple of Hera in **Olympia**, Greece by concentrating the **sun's rays** with a lens and creating enough heat to start a fire. In Greek mythology, fire was given to humans by the gods. The sun is regarded as a god, so even today the Olympic flame is given to humans by the gods.

The Olympic flame will travel to Britain in a gold painted British Airways aeroplane. During this journey, the flame will travel in a special safety lantern, similar to the Davy Safety Lamps originally used in mines. This requires permission from the Civil Aviation Authority because normally you cannot carry a flame on a plane.

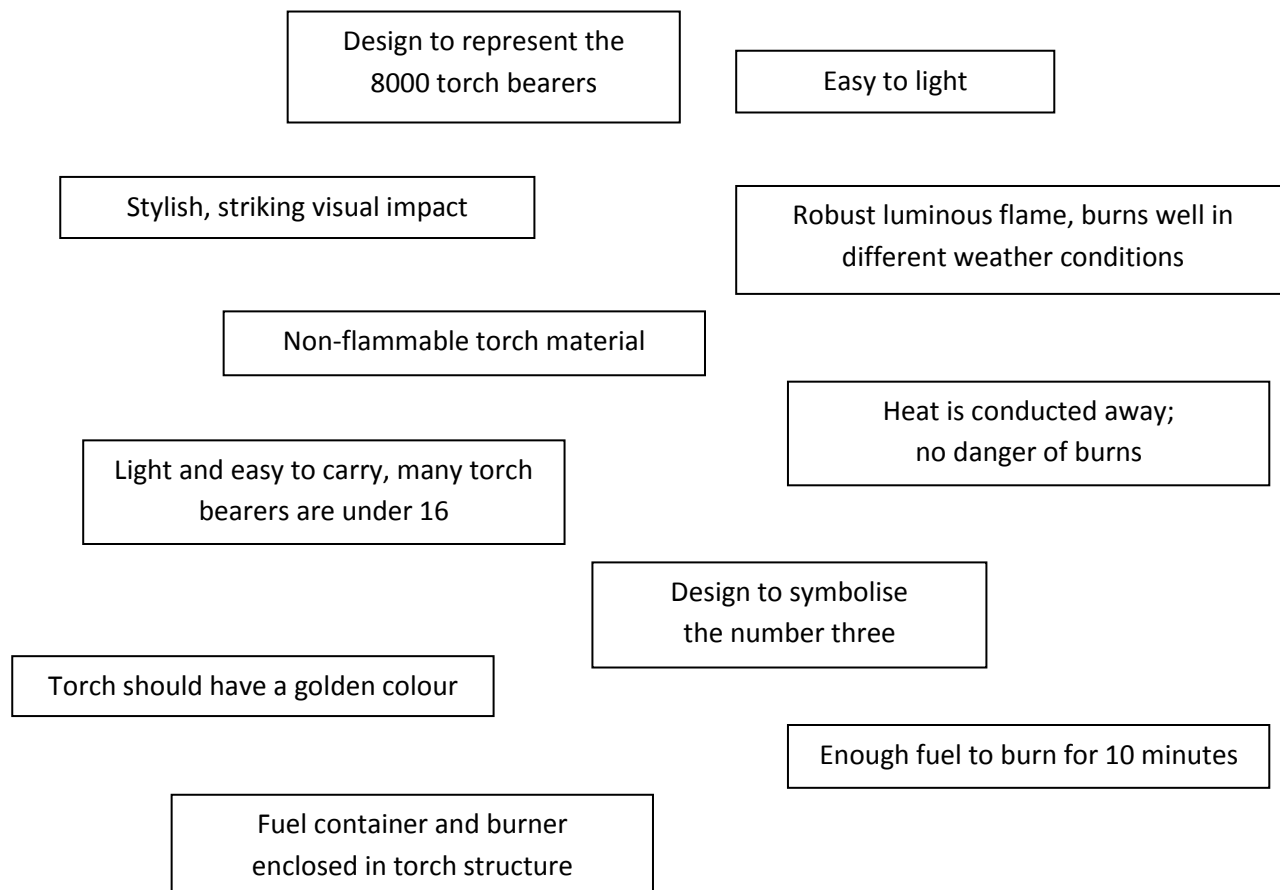
The Torch Relay

The Olympic flame will be carried around Britain in 8000 torches by 8000 torch bearers and will arrive in the Olympic stadium during the **opening ceremony** to light the cauldron with the Olympic fire which will burn for the 16 days of the Olympic Games.

A Special Design

For each Olympic Games, a new torch design is commissioned.

Criteria



Questions for the Torch Designer

Participation is everything...

1. What type of material conducts heat well and is non-flammable?

Metal

2. Which metal is light?

Aluminium

3. Which type of fuel is light and easy to ignite?

Gas

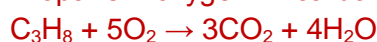
Bronze medal

4. Which gases are commonly used as fuel?

Methane, propane and butane

5. Write an equation for the combustion of propane.

Propane + oxygen → carbon dioxide + water



Silver medal

6. How can you stop the torch from getting too hot and at the same time make it lighter?

Construct the torch out of an aluminium alloy mesh. The fuel canister, valve and burner are contained within the aluminium mesh structure. This makes the torch light and conducts away the heat.

7. The fuel container is filled with a mixture of propane and butane. Why is methane not used?

Methane cannot be liquefied easily. Propane and butane are usually stored as liquids and require only a small storage volume for a large amount of gas.

The mixture of the two gases gives the right flame temperature to produce an orange flame under the conditions in the torch.

8. The torch is made of aluminium. How can the golden colour be achieved?

Two possibilities: mixing the aluminium with another metal like copper would produce an alloy with a golden colour.

Alternatively, coat a powder on the mesh structure in a golden coloured substance.

Gold medal

9. The torch is designed to burn for 10 minutes. How much gas is needed to burn for 10 minutes?

We need to some extra information; we need to know the flow rate of the gas through the valve.

Let's assume that the flow rate is 40 cm³ per second.

- What volume of gas will flow in 10 minutes?

$$10 \text{ minutes} = 10 \times 60 \text{ s} = 600 \text{ s}$$

$$600 \times 40 = 24,000 \text{ cm}^3$$

- How many moles of propane is this?

1 mole, because the volume of 1 mole of gas is 24,000 cm³ per mole.

- What mass of propane does the gas canister contain?

44 g (mass of 1 mole of propane), if the canister only contains propane.

- The canister of gas actually contains a mixture of propane and butane.

Let's assume that it is a 1:1 mixture.

$$44 + 58 \text{ (mass of 1 mole of butane)} / 2 = \frac{102}{2}$$

This is 51 g of gas.

10. What is a flame? What gives the colour of the flame?

When the combustion reaction is started and a sufficiently high temperature is reached, the molecules break up and form intermediates and free radicals. Electrons become excited and are raised to a higher energy level. As the electrons fall back to their original energy level, the excess energy is emitted as light.

11. A propane/butane flame with a plentiful supply of air is blue. A gas flame with a slightly insufficient supply of air is orange.

- What could explain the difference in colour? Think in terms of energy and temperature.

Blue light has higher energy than orange light. When there is a plentiful supply of oxygen, the flame burns at a higher temperature than a flame with a less plentiful supply of oxygen. In a hotter flame, electrons are raised to a higher energy level than in a cooler flame. Higher energy light is emitted. This is blue light.

12. For a flame to work well, molecules have to be vaporised and heated up. Hot gases rise. This means that a flame always rises upwards and comes into contact with a fresh supply of oxygen. Experiments in space have shown that flames don't work, even if there is oxygen.

What explanation would you give for this?

In space there is zero gravity. Gases do not rise upwards, they dissipate. The same happens with the oxygen, so the fuel and the oxygen don't really meet and the flame cannot burn.

The Olympic torch design

The triangular structure represents the power of 3.
2012 is the third time the games have come to London.
The three Olympic values are faster, stronger, higher.

Made from aluminium alloy mesh,
making the torch strong and light.

The 8000 circles in the structure
represent the 8000 torch bearers
who will carry the Olympic flame
around Britain.



The torch is 800 mm high.
It looks stylish and
makes a striking visual impact.

The fuel canister, valve and
burner are housed in the
centre of the torch.

The mesh structure makes the torch
light and allows heat to escape.