**3 F Hydrogen Fuel Cells**

In many ways fuel cells are similar to batteries, in that both contain electrolytes, an anode and a cathode, and both use a chemical reaction to produce electricity. However batteries use chemicals which are stored within the battery itself. This means that a battery will run down, or need recharging, when there is no longer enough stored chemicals available to produce electricity.

Rather than storing chemical energy inside itself, a hydrogen fuel cell receives a supply of hydrogen gas and Oxygen gas (in air) from the outside. A hydrogen fuel cell essentially consumes hydrogen and oxygen. When a fuel cell is continuously supplied with hydrogen and oxygen, and the product water is removed, the fuel cell can generate electricity continuously.

Hydrogen fuel cells are generally constructed using either an acidic or alkaline electrolyte.

**Hydrogen fuel cell under acidic conditions**

One example of a fuel cell based on acidic conditions is a phosphoric acid fuel cell, which uses liquid phosphoric acid (H3P04). Its electrolyte is in the centre compartment (shaded green in Figure 3) at an operating range of 150-200°C. The electrolyte plays a key role in the process. It ideally only permits appropriate ions to pass between the anode and cathode. The anode and cathode are porous and usually coated with finely dispersed platinum as a catalyst to facilitate the reaction.

The function of the fuel cell is as follows. Hydrogen molecules (H2) enter at the anode, where they lose their electrons in a chemical reaction. So, the oxidation half-reaction is:

2 H2 (g) → 4 H+ (aq) + 4 e-

The ionised hydrogen travels through the electrolyte, while the electrons travel through a wire, providing electricity. Oxygen enters the fuel cell at the cathode and combines with the electrons and ionised hydrogen to form water. This is represented in the half-reaction:

O2 (g) + 4 H+ (aq) + 4 e- → 2 H2O

The net chemical reaction is:

2 H2 + O2 (g) → 2 H2O

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**Phosphoric acid fuel cell**

H fuel cell that uses liquid phosphoric acid as an electrolyte, producing water, heat and electricity

# Hydrogen fuel cell under alkaline conditions

Alkaline fuel cells have been used by NASA since the mid-1960s in the Apollo missions. Power is produced through a redox reaction between hydrogen and oxygen. An alkaline solution such as NaOH or KOH is in the centre compartment, which speeds up the reduction of oxygen. An alkaline fuel cell consumes hydrogen, which is oxidised at the anode side (Figure 4), producing water and releasing electrons. This is represented in the half-reaction:

H2 + 2 OH- → 2 H2O + 2e-

The electrons flow through an external circuit and return to the cathode where oxygen is reduced and hydroxide ions are produced:

O2 + 2 H2O + 4e- → 4OH-

The net chemical reaction produces water, electricity and heat. Alkaline fuel cells can include a catalyst, such as nickel or platinum metal, to speed up the reactions occurring at the anode and cathode.

2 H2 + O2 → 2 H2O + heat



***SC******73*** *discuss, using diagrams and relevant half-equations, the operation of a hydrogen fuel cell under acidic and alkaline conditions*

## Describe and explain

1. **Describe** the equations occurring at the anode and cathode within a hydrogen fuel cell under acidic conditions, and alkaline conditions.
2. **Calculate** the cell voltages produced by the hydrogen fuel cellunder acidic conditions, and alkaline conditions (use the data booklet for E0 values). What assumptions are you making in these calculations?