BATTERIES

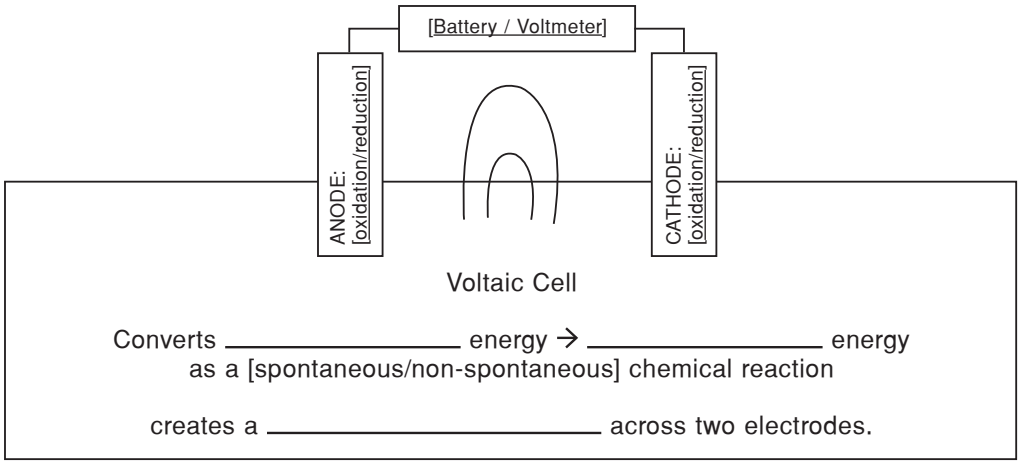
Types of cells

1 Complete / choose from the options to summarise the types of cells.

	Primary	**Secondary**
Rechargeable?	[rechargeable / non-rechargeable]	[rechargeable / non-rechargeable]
Voltaic / Electrolytic?	[only voltaic / voltaic and electrolytic]	[only voltaic / voltaic and electrolytic]
Name some examples		

Voltaic cells

2 On the following diagram:
   a Add these labels: electrolyte, salt bridge, + electrode, - electrode
   b Complete / choose from the options to summarise the composition of a voltaic cell.



3 Answer concerning the salt bridge:
   a What is its purpose?

_____

_____

   b What kind of substance must it be made of?

_____

   c Why must it be made of this type of substance?

_____

_____

4 Choose from the options for a **voltaic cell**.

VOLTAIC CELL	
Anode	**Cathode**
[oxidation / reduction]	[oxidation / reduction]
[positive / negative]	[positive / negative]

5 Circle the correct option (True / False) for each of the following referring to a **voltaic cell**.

VOLTAIC CELL:

a A battery makes one electrode positive and the other negative, and this causes a chemical reaction to occur. [True / False]

b A chemical reaction occurs, and this causes one electrode to be made positive and the other negative. [True / False]

c As oxidation happens, chemicals lose electrons, which then go onto the anode, making it negative. [True / False]

d The anode is made to be negative, and this makes chemicals lose electrons there, causing oxidation to happen. [True / False]

e As reduction happens, chemicals accept electrons, taking them from the cathode, causing it to become positive. [True / False]

f The cathode is made to be positive, and this makes chemicals gain electrons there, causing oxidation to happen. [True / False]

Lead acid battery (Car battery)

Overview

6 A lead acid battery consists of [primary / secondary] cells.

7 Complete / choose from the options.

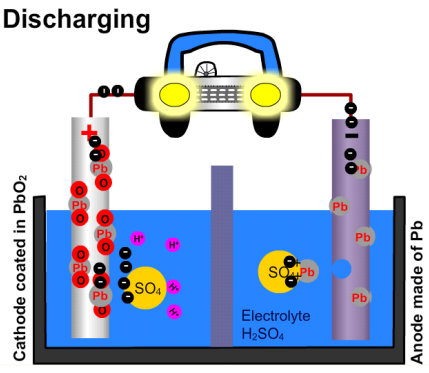
	Discharging	**Charging**
	[electrolytic / voltaic] cells	[electrolytic / voltaic] cells
	[produces / requires] electrical energy	[produces / requires] electrical energy
Chemical reaction	[spontaneous / non-spontaneous]	[spontaneous / non-spontaneous]
	[exothermic / endothermic]	[exothermic / endothermic]
Energy conversion	_____ energy → _____ energy	_____ energy → _____ energy
Anode	[Pb / PbO_2]	[Pb / PbO_2]
Oxidation ½ reaction		
Cathode	[Pb / PbO_2]	[Pb / PbO_2]
Reduction ½ reaction		
Net redox reaction		

Discharging

8 Complete the explanation by filling the gaps or choosing from the options. Do this before, or after, but not during, watching the animations. Mark during re-watching.

Overview

When the lead acid battery is discharging it behaves as a set of [electrolytic/voltaic] cells. Each lead acid battery consists of six cells. Only one of these is shown here. Each cell converts _____ energy into _____ energy, as a [spontaneous/non-spontaneous] chemical reaction [requires/creates] a potential difference across two electrodes. A lead acid battery has one electrode made of lead dioxide and another of lead. These are inside a _____ acid electrolyte.



Anode

Lead atoms in the lead electrode are [oxidised/reduced]: they [gain/lose] two electrons each. This changes them into [positively/negatively/neutrally] charged lead [atoms/ions] of formula _____. Since [oxidation/reduction] occurs at this electrode, we call it the anode. The Pb^{2+} ions move away from the electrode, leaving the electrons they had just lost behind on the electrode. This makes this electrode, the anode, [positively/negatively/neutrally] charged, creating a _____ between it and the other electrode, which is positive relative to it. This causes electricity to flow between the two electrodes.

Cathode

Electrons move from the [lead/lead dioxide] anode to the [lead/lead dioxide] cathode. There the electrons are [accepted/released] by positively charged _____ ions in the lead dioxide electrode. The lead ions here have a [4+/2+] charge. Each lead [4+/2+] ion accepts two _____ and is reduced to a lead [4+/2+] ion. [Oxidation/Reduction] occurs at this electrode. It is therefore called the [cathode/anode]. Because electrons are removed from the electrode in this way, it is charged [negatively/positively]. These lead ions combine with _____ ions from the sulfuric acid electrolyte to form _____. Hydrogen ions from the sulfuric acid electrolyte combine with _____ ions from the lead dioxide electrode to form _____.

Overall reaction

The overall reaction of the discharging lead acid battery is the reaction of _____ and _____ electrodes with _____ acid to form _____ and _____. This is a spontaneous, redox reaction which converts chemical into electric energy.

- It is spontaneous because _____.
- It is a redox reaction: it involves the transfer of _____ from one chemical to another.
- It converts _____ into _____ energy as _____ _____.

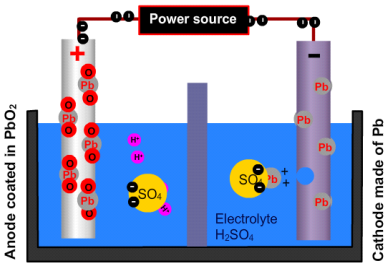
Charging

9 Complete the explanation by filling the gaps or choosing from the options. Do this before, or after, but not during, watching the animations. Mark during re-watching.

Overview

When the lead acid battery is charging it behaves as a set of [electrolytic/voltaic] cells. It converts _____ energy into _____ energy as a [spontaneous/non-spontaneous] chemical reaction is forced to occur due to an external potential difference being placed across two electrodes.

Charging



To charge a lead acid battery, the lead dioxide electrode must be connected to the [positive/negative] terminal of an external power source, e.g. another battery. The lead electrode must be connected to the [positive/negative] terminal of this other battery. This pulls electrons from the [lead/lead dioxide] electrode and forces electrons into the [lead/lead dioxide] electrode. This causes the reactions which had occurred in the discharging reaction to take place [in the same direction/in reverse].

Anode

The battery pulls electrons out of the electrode connected to its [positive/negative] terminal. Because of this, electrons are pulled out of the Pb^{2+} ions in the _____ around this electrode. This produces [Pb^{2+}/Pb^{4+}] ions. Because the [Pb^{2+}/Pb^{4+}] ions [gain/lose] electrons as they become Pb^{4+} ions, [oxidation/reduction] is taking place. This electrode is therefore called the [anode/cathode]. Notice that in an electrolytic cell, such as this one, the anode is [positively/negatively] charged. This is opposite to the case of a voltaic cell. In an electrolytic cell the external _____ charges the anode positively, which forces oxidation to occur there.

Cathode

The external battery [pushes electrons into/pulls electrons out of] the electrode connected to its negative terminal, charging that electrode [positively/negatively]. This forces lead ions, of formula _____, to accept two electrons each, changing them into lead atoms, of formula _____. This is called [oxidation/reduction], since it involves _____. Grey lead metal is formed through this reduction reaction. The electrode at which reduction happens is called the cathode. Therefore in an electrolytic cell, such as this one, the [positively/negatively] charged electrode is the cathode.

Overall reaction

The overall reaction of the charging lead acid battery is the reaction of _____ ions in lead sulfate to form _____ at the cathode and _____ at the anode. This is a non-spontaneous, redox reaction which converts electrical into chemical energy.

- It is non-spontaneous because _____ .
- It is a redox reaction: it involves the transfer of _____ from one chemical to another.
- It converts _____ into _____ energy as _____.