BATTERIES MEMO

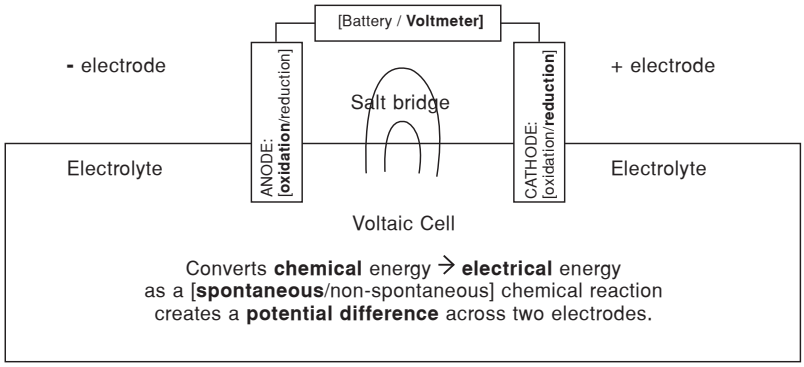
Types of batteries

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

	Primary	Secondary
Rechargeable?	[rechargeable / **non-rechargeable**]	[**rechargeable** / non-rechargeable]
Voltaic / Electrolytic?	[**only voltaic** / voltaic and electrolytic]	[only voltaic / **voltaic and electrolytic**]
Name some examples	**Leclanche (zinc-chloride / dry) cell, mercury cell, alkaline cell**	**Lead acid, nickel-cadmium, nickel-metal hydride and lithium ion**

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? **It completes the electric circuit and it prevents a build-up of charge in either half-cell, by allowing the movement of ions between them.**
- b What kind of substance must it be made of? **Ionic solution**
- c Why must it be made of this type of substance?
  Ionic solutions consist of charged particles (ions) which are free to move under the influence of a potential difference, therefore they can conduct electricity.

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**.
- 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)

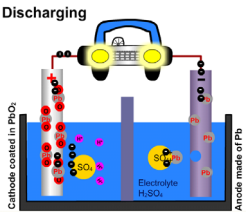
Overview

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	**chemical** energy → **electrical** energy	**electrical** energy → **chemical** energy
Anode	[**Pb** / PbO_2]	[Pb / **PbO_2**]
Oxidation ½ reaction	**$Pb \rightarrow Pb^{2+} + 2e^-$**	**$PbSO_4 + 2H_2O \rightarrow PbO_2 + 4H^+ + SO_4^{2-} + 2e^-$**
Cathode	[Pb / **PbO_2**]	[**Pb** / PbO_2]
Reduction ½ reaction	**$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$**	**$Pb^{2+} + 2e^- \rightarrow Pb$**
Net redox reaction	**$PbO_2 + Pb + 4H^+ + 2SO_4^{2-} \rightarrow 2PbSO_4 + 2H_2O$**	**$2PbSO_4 + 2H_2O \rightarrow PbO_2 + Pb + 4H^+ + 2SO_4^{2-}$**

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 **chemical** energy into **electrical** 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 **sulfuric** 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 **Pb^{2+}**. 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 **potential difference** 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 **lead** ions in the lead dioxide electrode. The lead ions here have a [**4+**/2+] charge. Each lead [**4+**/2+] ion accepts two **electrons** 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 **sulfate** ions from the sulfuric acid electrolyte to form **lead sulphate**. Hydrogen ions from the sulfuric acid electrolyte combine with **oxide** ions from the lead dioxide electrode to form **water**.

Overall reaction

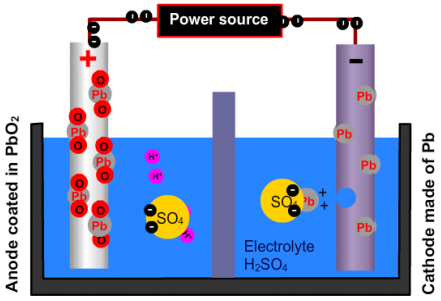
The overall reaction of the discharging lead acid battery is the reaction of **lead** and **lead dioxide** electrodes with **sulfuric** acid to form **lead sulfate** and **water**. This is a spontaneous, redox reaction which converts chemical into electric energy.

- It is spontaneous because **the reaction will occur on its own**: **you don't need to heat it or provide an external potential difference to force it to occur.**
- It is a redox reaction: it involves the transfer of **electrons** from one chemical to another.
- It converts **chemical** into **electrical** energy as **the chemical reaction creates a potential difference across the electrodes.**

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.

Charging



Overview

When the lead acid battery is charging it behaves as a set of [**electrolytic**/voltaic] cells. It converts **electrical** energy into **chemical** energy as a [spontaneous/**non-spontaneous**] chemical reaction is forced to occur due to an external potential difference being placed across two electrodes. 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 **lead sulfate** 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 **power supply (e.g. battery)** 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 **Pb^{2+}**, to accept two electrons each, changing them into lead atoms, of formula **Pb**. This is called [oxidation/**reduction**], since it involves **the acceptance of electrons**. 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 **lead** ions in lead sulfate to form **lead** at the cathode and **lead dioxide** at the anode. This is a non-spontaneous redox reaction which converts electrical into chemical energy.

- It is non-spontaneous because **the reaction will not occur on its own**: **you need to heat it or provide an external potential difference to force it to occur**.
- It is a redox reaction: it involves the transfer of **electrons** from one chemical to another.
- It converts **electrical** into **chemical** energy as **a potential difference forces a non-spontaneous chemical reaction to occur.**