Can charging a Smartphone or Tablet overnight destroy its battery?

Technical note on why users need a "PhoneFuse" by Lava

Does a Smartphone (Tablet) Charger Stop Charging when the battery is full?

Most articles that describe the charging system of your Smartphone or Tablet will tell you that when you leave your device plugged in to charge, battery charging will turn off once the device determines the battery is full. Although this statement is true (basically) what most articles neglect to tell you is that the charge controller of the device requires the Smartphone or Tablet <u>to be turned off</u> to properly detect the full battery condition. When you leave your Smartphone "on" overnight while it's plugged into its charger (for example, so that your device wakes you up at a certain time), you're actually, slowly, destroying the battery.

If you want to avoid destroying your device's battery, the basic rules are:

- Turn off your device while it is being charged.
- Disconnect your device when charging is complete.
- Do not allow the battery level to drop too low before charging the device. Unlike previous generation Nickel-cadmium batteries, letting the battery discharge to zero <u>decreases</u> the lifespan of Lithium-ion and Lithium-polymer batteries.
- The battery need not be fully charged before disconnecting from a charger. In fact, charging to 100% may be harmful to your battery if you keep the device "on" while it is at full charge.
- Do not operate your device for an extended period of time when it is too hot or too cold.
- Of course, never operate your device if the battery is bloated, or if you detect excessive heat accumulation in the battery.
- Avoid keeping your device inside a pocket close to your body. Many devices refuse to operate when the temperature is too extreme. Leaving a phone in your pocket and using a wireless headset results in the phone running at an elevated temperature because your body (normally at 37 degrees Celsius) heats the phone. Inside the device, the internal temperature will be even higher.

Many User Manuals suggests you disconnect the charger from the device once a full charge has been reached. Some devices periodically beep to remind you to disconnect the charger. This is because keeping a SmartPhone or Tablet "on" while it is connected to a charger, and its battery is at 100%, is harmful to the device battery.

The PhoneFuse by Lava is designed to protect devices from users' bad habits: it effectively disconnects the Smartphone or Tablet from the charger once it detects your device's battery is at or near full charge. If you want to resume charging, press the button on the PhoneFuse, and the device battery will top up. The PhoneFuse will switch off the current again when the battery is at or near full charge. No need to turn your device "off" while charging.

If you want additional details on mobile device batteries, keep on reading. If all you wanted was to know the basics of taking care of your mobile device battery, you're done.

Mobile Device Batteries

Lithium-ion and lithium polymer batteries have many advantages over the older nickel cadmium and nickel metal hydride batteries: they are smaller, hold a larger charge, can be charged relatively quickly, self-discharge slowly, and do not suffer from the "memory effect". Also, the price/performance ratio of these batteries has improved greatly in the last 20 years making them the primary choice for mobile devices – Smartphones and Tablets.

Before Lithium-based batteries took off, mobile devices (e.g. push-button mobile phones and laptop PC's) generally used nickel cadmium batteries which suffered from a "memory effect". This issue required the battery to be cycled between full charge and full discharge to maximize lifespan. Many users still remember this practice from their old phones, and so (wrongly) believe that in order to get most use out of a modern Smartphone or Tablet, its battery should be periodically fully discharged. In fact this practice is mildly destructive for batteries in the latest mobile devices.

Lithium-ion and lithium-polymer batteries do not need to be cycled between the fully charged and discharged state. It is better to not discharge these batteries too low before recharging them. In fact, allowing these batteries to routinely discharge to the minimum value, damages the battery.

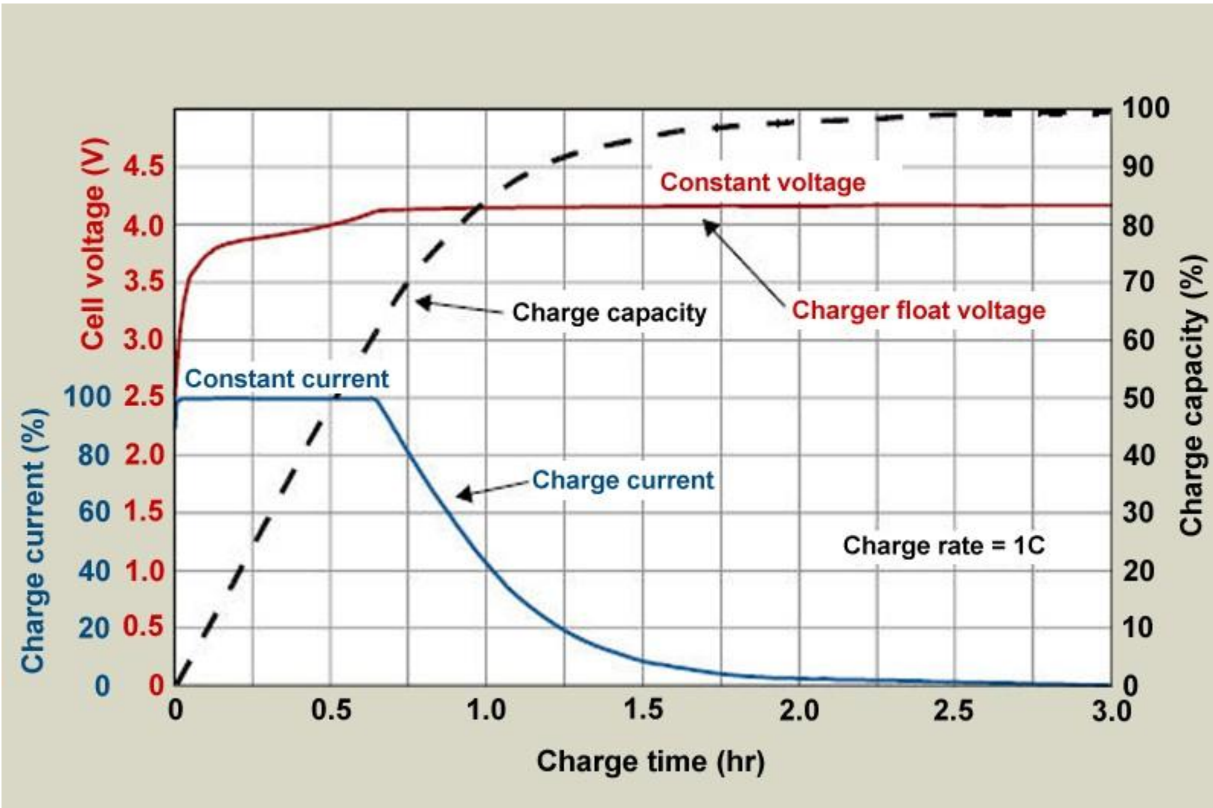
How Lithium-based batteries charge (why trickle charging is a very bad practice)

Batteries hold charge due to chemical processes that occur inside them. Each battery technology has a unique chemistry that leads to a set of rules that must be followed to recharge them properly and safely. Lithium-based batteries have two primary charging stages: a constant current stage followed by a constant -voltage stage.

The initial stage of charging involves a battery being charged with a constant current until the battery voltage reaches the final charge voltage. So, in the initial stage, when a device battery is connected to a charger, current is input into the battery at a constant rate with increasing voltage depending on the level of the effective resistance of the battery (In case you're interested in the physics of this, remember Ohm's Law V = I * R; So, when I is constant with R increasing, this means V increases)

The battery voltage increases in a gradual “curve” over time, until the final charge voltage is reached. The actual voltage level depends on the battery chemistry, but a level of 4.1 or 4.2 volts is common. This usually occurs when the battery reaches approximately 80% of full charge.

During the second stage a constant voltage is applied to provide a saturation charge. As can be seen by the graph below, the current applied gradually drops off during this stage until full charge capacity is achieved.



Source: http://batteryuniversity.com/learn/article/charging_lithium_ion_batteries

During the second stage, the charge current drops off with a non-linear rate until it reaches a specified level, at which point charging is terminated. Terminating the battery charge at this point is critical to achieve maximum charge without risking damage to the battery. If the current is not terminated, the extra charge results in excess heat generation and incremental battery damage.

Li-ion cannot absorb overcharge. When fully charged, the charge current must be cut off. A continuous trickle charge would cause plating of metallic lithium and compromise safety. To minimize stress, keep the lithium-ion battery at the peak cut-off (full charge) for as short a time as possible.

Although the manufacturer might state the device can be charged while being used, leaving the device in this state for 11 months or so will invariably result in a bloated battery. Leaving the device “on” while charging periodically may not be an issue for casual users, but you should be aware – with the device "on" during charging, your battery life is being reduced, and eventually this practice can lead to catastrophic damage.

Dangers of charging while the device is "on"

Many User Manuals state that you can use your device while it is being charged. This statement may be acceptable to some because actual battery damage is gradual, and may not be immediately noticed in a home or business environment. But, if the device were left in this state for months, the result would be different.

Battery damage is caused when charging while the device is "on" for two reasons:

a) CO_2 pressure can build up inside the Lithium-based cell

b) The device's charge controller can "miss" the full-charge signal due to parasitic load on the battery.

Let's first tackle the CO_2 pressure issue. Lithium-based batteries become unstable if inadvertently charged to a higher than specified voltage. Prolonged charging will lead to metallic lithium plating on the anode. When this happens, the cathode material becomes an oxidizing agent, loses stability and produces carbon dioxide (CO_2) which builds up inside the battery casing as pressure. If charging continues, the cell pressure will rise, and in extreme cases the membrane on the Li-ion cell will burst open. In very extreme cases, the cell could vent with flame.

The above occurs when the charge controller fails to stop charging the battery when charge capacity is reached. Every mobile device is equipped with a charge controller – an electronic circuit that controls the amount of current or voltage that enters the battery from the power supply. This charge controller is inside your Smartphone or Tablet – not in the power supply. The USB Power Supply provided with the device is simply a stable 5-volt power source. Any stable 5-volt source can be used.

The charging current and voltage profile, ambient temperature compensation, and battery temperature compensation are all handled by the charge controller according to a charging algorithm. This algorithm requires the charge controller to be operating on a battery with no parasitic load. If the mobile device is allowed to operate during battery charging, this load makes it difficult for the charge controller to function as intended. A small current may continue to trickle into the battery which is very damaging to a lithium-ion or lithium polymer battery. The excess current results in heat generation within the battery and incremental damage. Remember that these batteries cannot accept an overcharge.

There is a new generation of fast chargers, which negotiate the voltage provided to the device. A high voltage allows more power to be delivered to the device for a faster charge. These chargers have additional "smarts," however the charging profile of the battery is still managed by a controller built into the mobile device.

Operating the device while it is charging presents an unexpected load to the charger controller, which can prevent the end of the charge cycle from being detected. The result is the battery may operate at an elevated voltage resulting in trickle charging of the battery. This will eventually lead to the battery bloating, and in the extreme case, the battery will expand enough to crack the device casing. Any time a battery starts to bloat, use of the device should be terminated.

For details on battery charging and safety issues, there are many technical resources available. The charging issues are described in detail by all chip vendors who make the charge controller parts. A good resource for all battery technologies can be found on the batteryuniversity.com website.