Where did all the water on Mars go?

If we look at Mars today, its temperature range and air pressure actually prohibit the presence of liquid water on the surface. It could be frozen in ice form, or it could be as water vapor, but not liquid. (Like carbon dioxide is here on Earth: frozen carbon dioxide is what we call dry ice. Dry ice doesn't go through a liquid phase when it warms up: it goes from solid straight to gas.)

So let's get some "wrong" answers out of the way:

It's not frozen in the Martian ice caps. Mars's ice caps are mostly frozen carbon dioxide, with only some frozen water. And there's not enough frozen water in the ice caps to account for all the water-carved features we see. (Maybe a small portion of the water is now there, but the majority isn't.)

- **It didn't just "dry up."** Water (or any other material) doesn't just disappear all by itself. When we see water seem to dry up on Earth, it actually seeps into the ground, evaporates into the air, or (if we're talking about long-term climate change) goes elsewhere on the planet.
- **It didn't evaporate.** Or at least, evaporation isn't the full story. When water evaporates, it is still H2O, but in gaseous form. If I flipped a switch and caused all of the Earth's oceans to evaporate, then we'd have a whole lot of water vapor in our atmosphere. If we look at Mars's atmosphere, we don't see enough water vapor to account for all of the water features we see.

So what did happen? We have two plausible theories; either (or both) may be correct.

1. The water could have seeped into the ground and is now in a permanent ice layer beneath the surface.

2. (This one's more complicated.) Since Mars's atmosphere is so thin, more of the Sun's higher-energy rays can get through to the surface. And when a high-energy photon (like UV) hits a water molecule, the water molecule can be broken apart. Since each water molecule is composed of two hydrogen atoms and one oxygen atom (H2O), we now have loose hydrogen and oxygen floating about.

   Since hydrogen is so light compared to the other molecules in the atmosphere, it can easily gain enough speed from bumping around to escape Mars for good. (Think of jostling around a box with marbles and baseballs. Which balls move faster?)

   Oxygen is very reactive, and likes to react with the first thing it sees. So if it encountered some carbon compounds, it might have formed carbon dioxide with the carbon. Mars had plenty of iron on its surface (probably from lots of asteroid impacts), so the oxygen joined with the iron atoms to form rust: FeO2. (Fe is the chemical symbol for iron, for some strange reason.)

   Note here that the oxygen itself didn't change into a different substance. It joined with other materials to form these new compounds.

   So now with the hydrogen gone for good and the oxygen locked up in carbon dioxide and iron oxide, water is not available on the Martian surface (even if local conditions would've allowed liquid water).