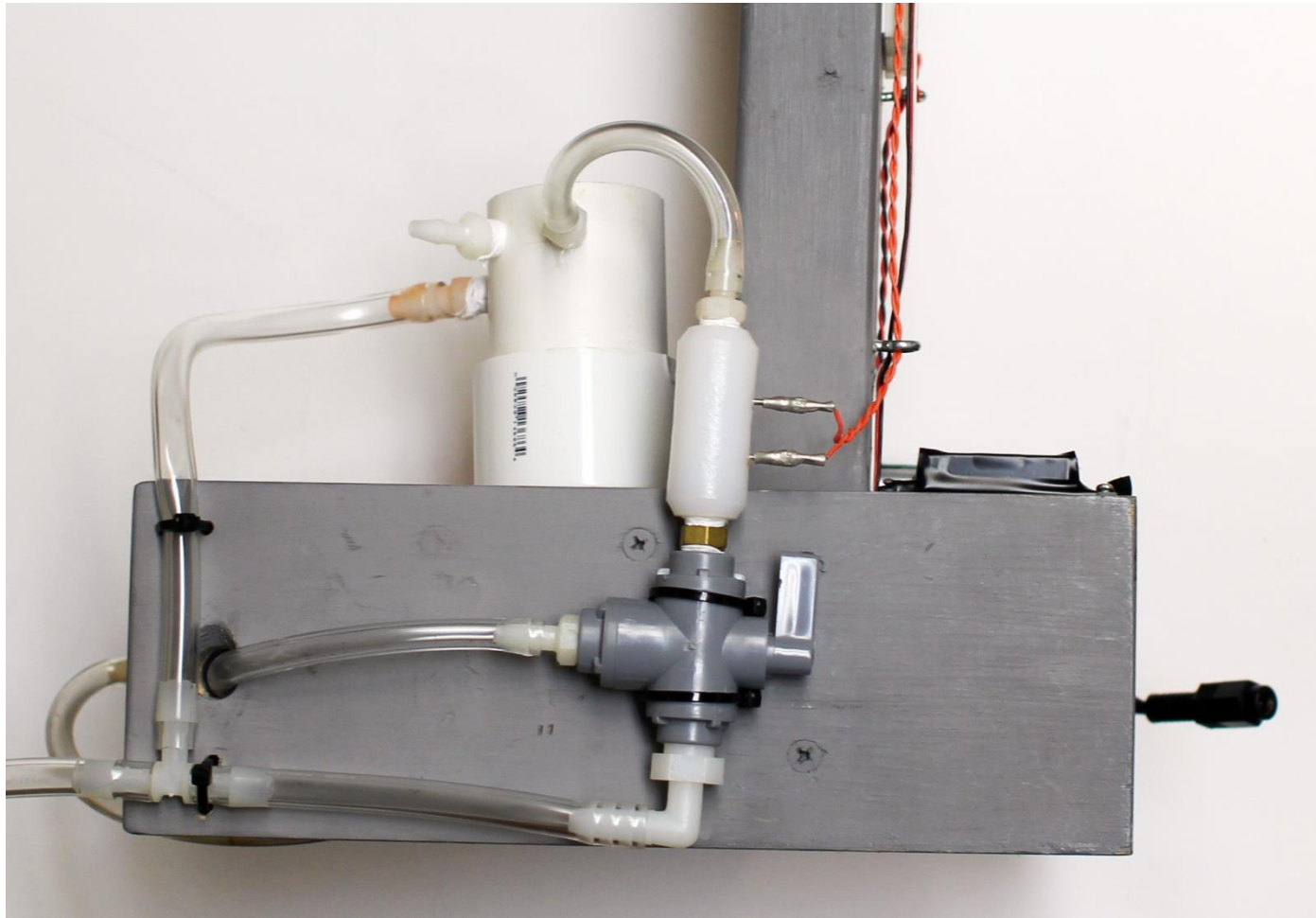


# conductivity sensor implementation



# conductivity measurement circuit

- we use the same voltage divider circuit used earlier for the photoresistor circuit

$$\Delta V_{\text{conductivity sensor}} + \Delta V_{10\text{k}\Omega \text{ resistor}} = 5 \text{ volts}$$

- what happens to the electrical resistance of the water as it becomes more salty?

**it decreases**

- if the resistance of the salt water decreases, then what happens to the voltage drop across the conductivity sensor?

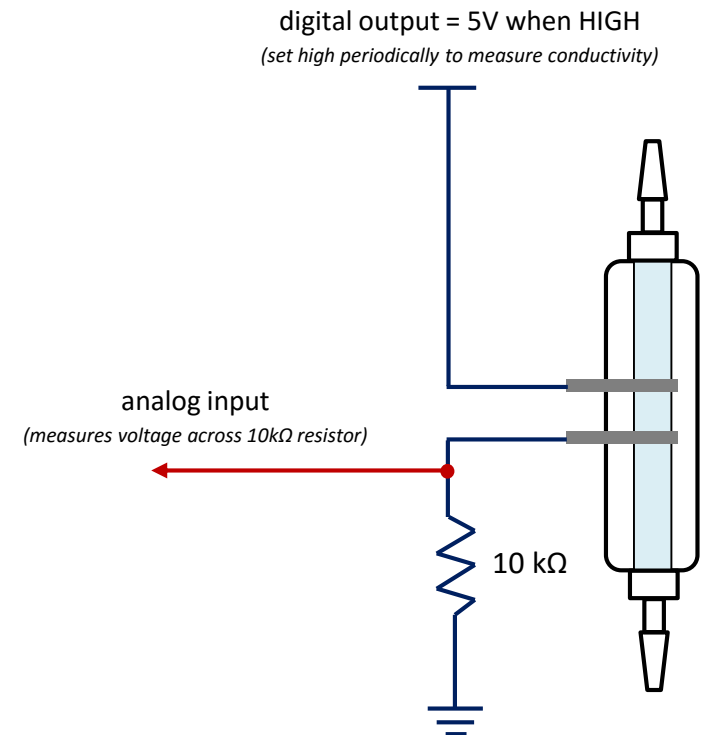
**it decreases**

- if the voltage drop across the conductivity sensor decreases, then how does this influence the voltage drop across the 10kΩ resistor?

**it increases**

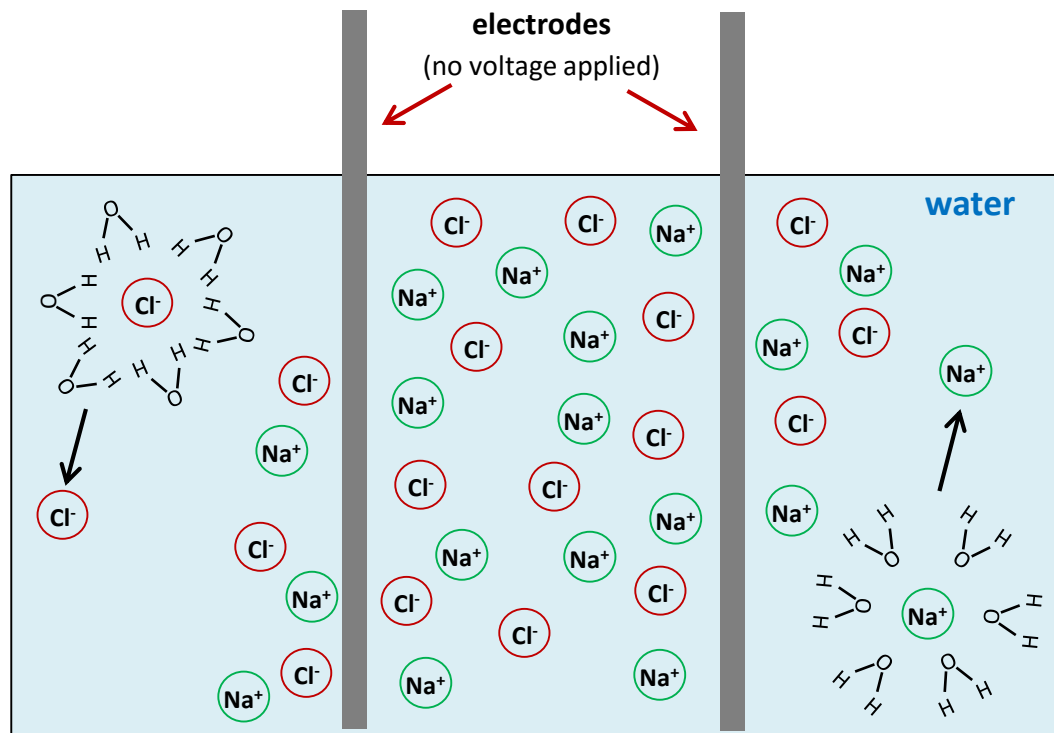
- so, increasing the salinity of the water causes the analog input read by the Arduino to **increase** or **decrease**)?

0 to 1023



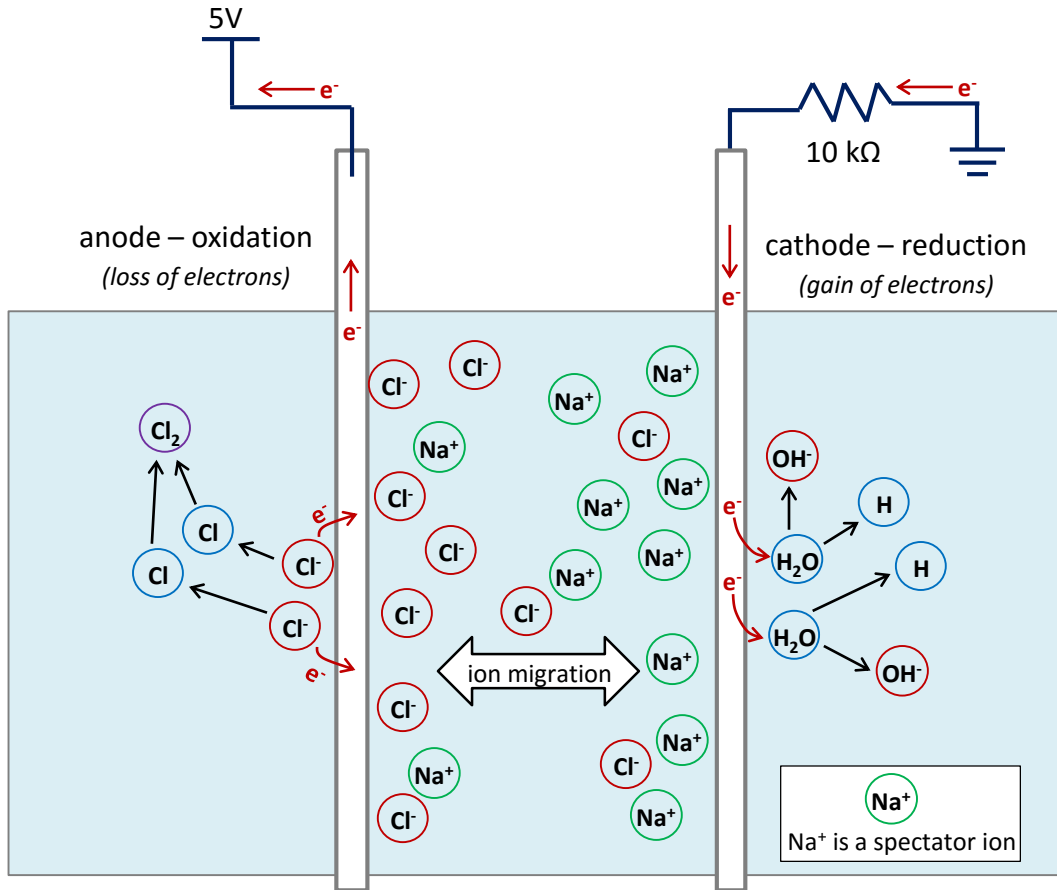
# what happens when salt is added to water????

- The ionically bonded NaCl molecules dissociate into  $\text{Na}^+$  and  $\text{Cl}^-$  ions and become mobile
- they are surrounded by polar water molecules (they are hydrated)

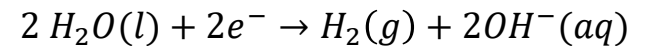


# applying voltage to induce electron flow

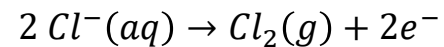
electrons are really not directly conducting through the water from one electrode to the other (like when electrons move through a copper wire)



reduction occurs at the negatively charged cathode:



oxidation occurs at the positively charged anode:

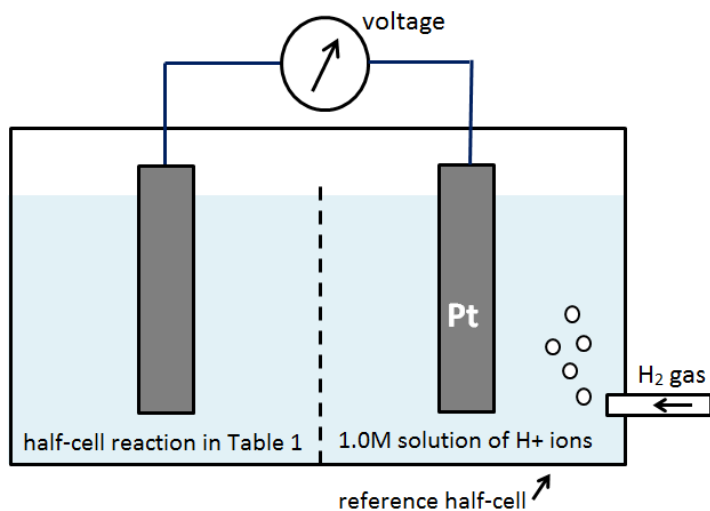


*It seems like an Na<sup>+</sup> would accept an electron and be reduced . . . why not???*

# why is H<sub>2</sub>O reduced and not Na<sup>+</sup> ???

	Electrode Reduction Half-Reaction	Voltage Output <i>(when electrode is coupled with a 1.0M H<sup>+</sup> ion solution using a platinum electron)</i>
increasingly inert	$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	+2.87 V
	$H_2O_2(aq) + 2H^+ + 2e^- \rightarrow 2H_2O(l)$	+1.78 V
	$Au^{3+}(aq) + 3e^- \rightarrow Au(s)$	+1.52 V
	$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36 V
	$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$	+0.40 V
	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34 V
	$2H^+ + 2e^- \rightarrow H_2(g)$	0.00 V
increasingly active	$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	-0.25 V
	$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.83 V
	$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	-1.66 V
	$Na^+(aq) + e^- \rightarrow Na(s)$	-2.71 V
	$Li^+(aq) + e^- \rightarrow Li(s)$	-3.04 V

reactions further down in the table are less likely to occur



- reactions with positive voltages will occur spontaneously
- you must apply external voltage across the electrodes to make a reaction with a negative potential occur

# the net reaction of conductivity system

	Possible Half-Reaction	Reference Voltage
1	$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.83 V
2	$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$	-1.36 V ( <i>direction &amp; sign swapped</i> )
3	$Na^+(aq) + e^- \rightarrow Na(s)$	-2.71 V

the net reaction occurring in the system is . . .

anode	$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$	-1.36 V
cathode	$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.83 V
<b>net reaction</b>	$2Cl^-(aq) + 2H_2O(l) \rightarrow Cl_2(g) + H_2(g) + 2OH^-(aq)$	<b>-2.19 V</b>

- we must apply at least 2.19 V to the conductivity circuit to drive the reaction
- applying 5 V is sufficient, and higher voltages will increase the rate of oxidation & reduction reactions

# system wiring

