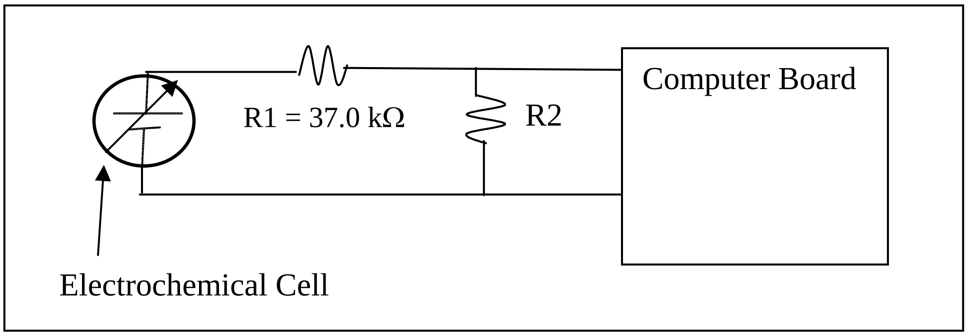
CHEMISTRY 133
Quiz 1 – Solutions

In the circuit shown below, the voltage source is an electrochemical cell. It is desired to use a potential divider to reduce the potential so that it can be accepted by a computer which has a maximum input voltage of 1.00 V.



a) If the range of potentials expected from the cell is from 2.00 to 2.50 V, calculate the maximum resistance value of R2 so that the measured potential across R2 will not exceed 1.00 V.

$V(R2)_{max} = 1.00$ V *V(cell) = 2.00 to 2.50 V*
When V(cell) is at max, we want V(R2) to be at max also – so at V = 2.50 V, we want V(R2) = 1.00 V
Since V(cell) = V(R1) + V(R2) and V(R2) = 1.00 V, V(R1) = 2.50 V – 1.00 V = 1.50 V
V = IR so for R1, V(R1) = IR1 or I = V(R1)/R1 = 1.50 V/37,000 Ω = 4.05×10^{-5} A
V(R2) = IR2 or R2 = V(R2)/I = 1.00 V/(4.05×10^{-5} A) = 2.47×10^{4} Ω = ***24.7 kΩ**.*

b) For some electrochemical cells, the electrochemical cell also has "internal resistance" (or acts as a true voltage source and a resistor in series). If a test cell with known potential of 2.33 V is used, R2 = 20.0 kΩ, and the voltage measured by the computer board is 0.755 V, indicate if you think there is internal resistance affecting the measurement. Explain your answer.

Any internal resistance will cause a drop in voltage within the source (we could redraw the circuit showing a true voltage source and a resistor and then $V_{cell} = IR1 + IR2 + IR_{internal}$)
We can tell if this is the case by one of several methods:
Method 1, Use the measured voltage to calculate the expected cell voltage:
V_{cell} = IR1 + IR2 where IR2 = 0.755 V (the measured voltage). With R2 = 20.0 kΩ, I = V/R = 3.775×10^{-5} A. V_{cell} = I(R1 + R2) = (3.775×10^{-5} A)(57000 Ω) = 2.15 V. Since this is less than expected, we can conclude there must be (significant) internal resistance.
Method 2, we can calculate what voltage we would expect to see at R2 if there is no internal resistance. The expected R2 voltage = $R1 \cdot V_{cell}/(R1 + R2)$ = 0.818 V. The voltage is lower.
Method 3, we can assume that there is an internal resistance and calculate its value
V_{cell} = 2.33 V = $I(R1 + R2 + R_{internal})$ I = 0.755 V/20,000 Ω = 3.775×10^{-5} A
$R_{internal}$ = [2.33 – (3.775×10^{-5} A)(57,000 Ω)]/(3.775×10^{-5} A) = 4.7 kΩ (which is not that much smaller than R1 and R2)