2. Cell Phone Battery

(a) 35.1 hours

Since $P = I \cdot V$, so we have

$$I = \frac{P}{V} = \frac{0.3W}{3.8V} = 7.89 * 10^{-2}A = 78.9mA$$

Then, with $C = I \cdot t$, so we have

$$t = \frac{C}{I} = \frac{2770mAh}{78.9} = 35.1hr$$

Thus, a Pixel's full battery will last 35.1 hours under regular usage conditions.

(b) $6.22 * 10^{22}$ electrons

Since 2770 mAh = 2770 mAh $\cdot \frac{3600s}{1h} = 9.972 \cdot 10^6$ mAs, and given that 1 mC = 1 mAs,

so $C_{pixel} =$ 2770 mAh $= 9.972 \cdot 10^6$ mAs $= 9.972 \cdot 10^6$ mC

So, there are $\frac{C_{pixel}}{C_{electron}} = \frac{9.972 \cdot 10^3 C}{1.602 \cdot 10^{-19} C} = 6.22 * 10^{22}$ usable electrons worth of charge.

(c) $3.79 \cdot 10^4$ J

Since we could calculate that:

$$E_{discharge} = P \cdot t = 0.3\ W \cdot 35.1\ hr \cdot \frac{3600\ s}{1\ hr} = 3.79 \cdot 10^4\ Ws = 3.79 \cdot 10^4\ J$$

Thus, we have that

$$E_{charge} = E_{discharge} = 3.79 \cdot 10^4\ J$$

So, $3.79 \cdot 10^4$ J is the energy necessary for recharging a completely discharged cell phone battery.

(d) $0.04

The total energy used by recharging for 31 days is:

$$E_{total} = E_{charge} \cdot 31 = 3.79 \cdot 10^4\ J \cdot 31 = 1.175 \cdot 10^6\ J = 1.175 \cdot 10^6\ Ws$$

So, we can transform its unit to get:

$$E_{total} = 1.175 \cdot 10^6\ Ws \cdot \frac{1\ kW}{1000\ W} \cdot \frac{1\ hr}{3600\ s} = 0.326\ kWh$$

Thus, I would need to pay $0.326\ kWh \cdot \frac{\$0.12}{1\ kWh} = \$0.04$ for recharging for the month of October.

(e)

First, $R = 200m\Omega = 200m\Omega \cdot \frac{1\Omega}{1000m\Omega} = 0.2\ \Omega$. We consider $R_{bat} = 1m\Omega, 1\Omega, 10k\Omega$ separately below.

Case 1 ($R_{bat} = 1\ m\Omega$): With $R_{eq} = R + R_{bat} = 200m\Omega + 1m\Omega = 201m\Omega$, so

$$I_{bat} = I = \frac{V}{R_{eq}} = \frac{5V}{201m\Omega} = 24.88A$$

So the power dissipated across R_{bat} is:

$$P_{bat} = I_{bat}V_{bat} = I_{bat}^2 R_{bat} = (24.88A)^2 \cdot 1m\Omega = 0.62\ W$$

Thus, using the results we got from part (d), so it takes the battery

$$t = \frac{E_{total}}{P} = \frac{3.79 \cdot 10^4\ Ws}{0.62W} = 6.11 \cdot 10^4 s = 6.11 \cdot 10^4 s \cdot \frac{1hr}{3600s} = 16.98\ hr$$

Case 2 ($R_{bat} = 1\ \Omega$): With $R_{eq} = R + R_{bat} = 0.2\Omega + 1m\Omega = 1.2m\Omega$, so

$$I_{bat} = I = \frac{V}{R_{eq}} = \frac{5V}{1.2\Omega} = 4.17A$$

So the power dissipated across R_{bat} is:

$$P_{bat} = I_{bat}V_{bat} = I_{bat}^2 R_{bat} = (4.17A)^2 \cdot 1\Omega = 17.39\ W$$

Thus, using the results we got from part (d), so it takes the battery

$$t = \frac{E_{total}}{P} = \frac{3.79 \cdot 10^4\ Ws}{17.39W} = 2.18 \cdot 10^3 s = 2.18 \cdot 10^3 s \cdot \frac{1hr}{3600s} = 0.605\ hr = 36.3\ min$$

Case 3 ($R_{bat} = 10\ k\Omega$): With $R_{eq} = R + R_{bat} = 0.2\Omega + 10k\Omega = 10000.2\ \Omega$, so

$$I_{bat} = I = \frac{V}{R_{eq}} = \frac{5V}{10000.2\Omega} = 5.00 \cdot 10^{-4}\ A$$

So the power dissipated across R_{bat} is:

$$P_{bat} = I_{bat}V_{bat} = I_{bat}^2 R_{bat} = (5.00 \cdot 10^{-4} A)^2 \cdot 10k\Omega = 2.5 \cdot 10^{-3}\ W$$

Thus, using the results we got from part (d), so it takes the battery

$$t = \frac{E_{total}}{P} = \frac{3.79 \cdot 10^4\ Ws}{2.5 \cdot 10^{-3} W} = 1.52 \cdot 10^7 s = 1.52 \cdot 10^7 s \cdot \frac{1hr}{3600s} = 4.22 \cdot 10^3\ hr$$