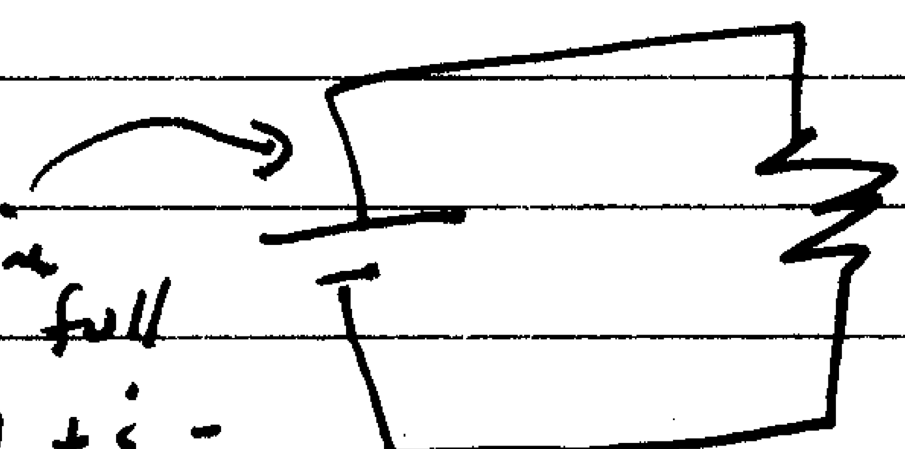
Exam #2

1) An electric current is a flow of charged particles

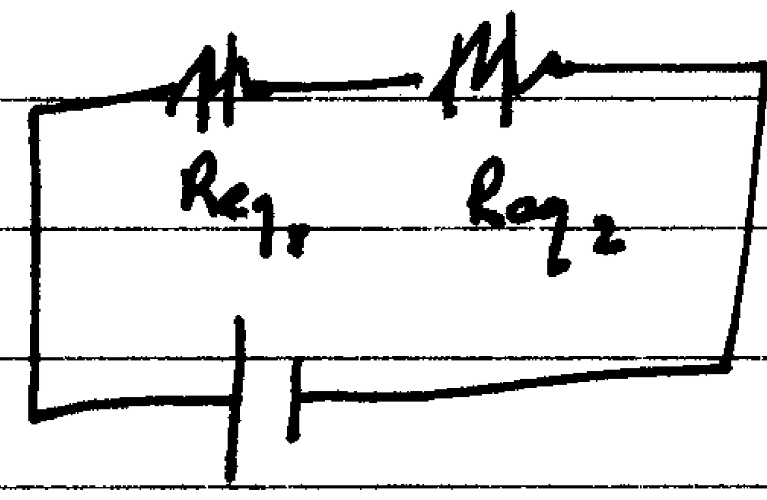


the wire is full of + & -

a) charges, the current is the average movement of the charged ptcls that are free to move.

b) The battery provides the oomph but without the path for the ptcls to move along & a wealth of pre existing charged ptcls in the wire & resistor no current would flow.

2 This circuit can be thought of as



parallel resistors

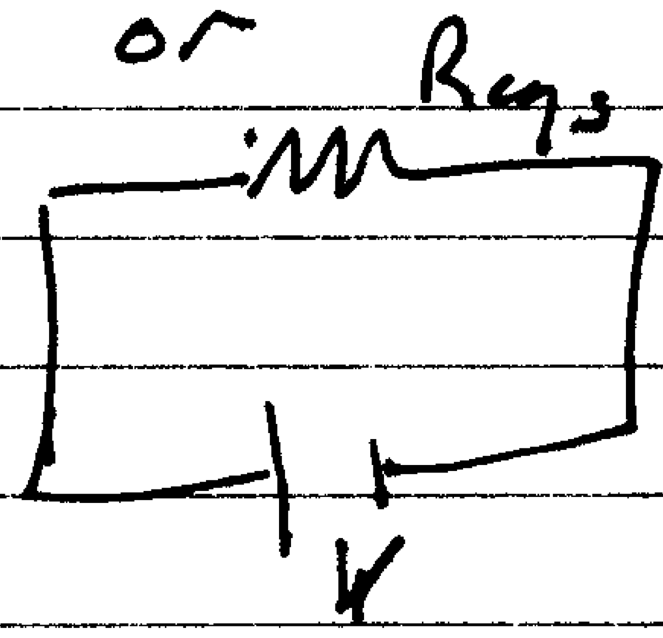
w/ $$\frac{1}{R_{eq_1}} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} + \frac{1}{R} = \frac{4}{R}$$

$$R_{eq_1} = 25\Omega$$

and $$\frac{1}{R_{eq_2}} = \frac{1}{R} + \frac{1}{R}$$

$$\Rightarrow R_{eq_2} = \frac{R}{2}$$

or



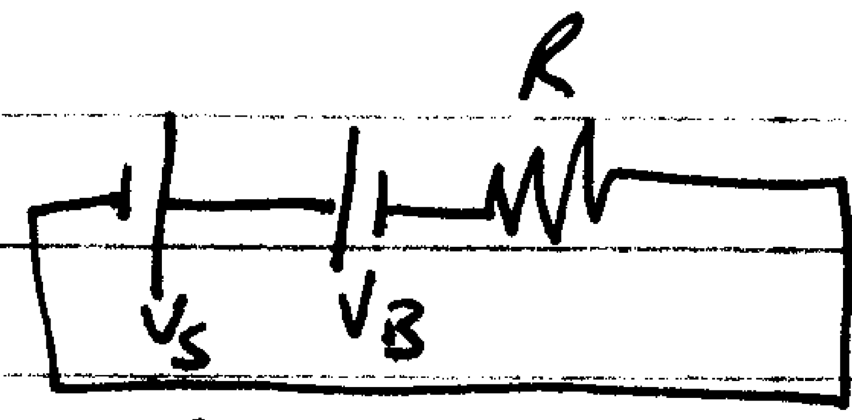
series resistors and $R_{eq_3} = R_{eq_1} + R_{eq_2}$

$$= \frac{3R}{4} = 75\Omega$$

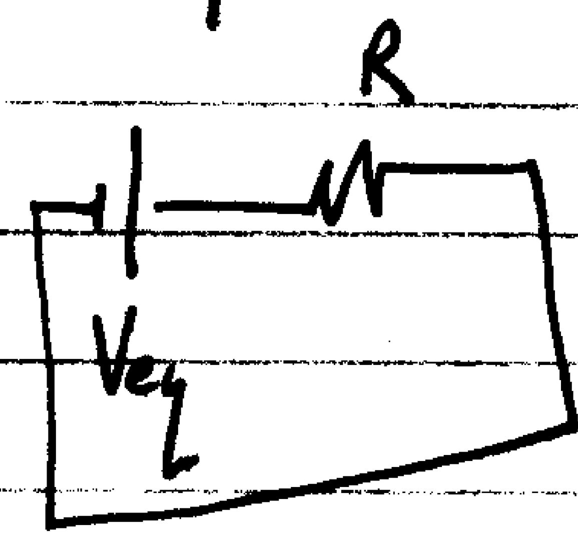
Since $V = iR$

$$i = V/R = 12V/75\Omega = 0.16\,A$$

3)



is equivalent to



w/ $V_{eq} = V_S - V_B = 0.8V$

a) so $i = V/R = \frac{0.8V}{2\Omega} = 0.4A$

b) The rate at which Energy is being stored is

$$iV_B = 0.4A \times 4.5V = 1.8W$$

c) The rest of the power supplied by the charger is lost to heat

$$iV_R = 0.4A\,(0.8V) = 0.32W$$

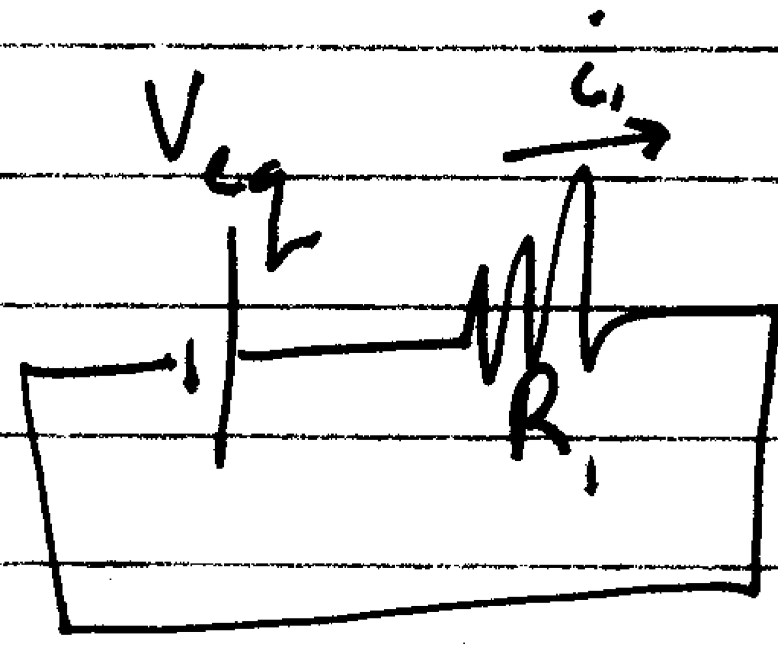
d) If the battery can store 3kJ of energy it will take

$$Pt = \text{Energy} = E$$

$$t = E/P = 3000J/1.8W = 1{,}667s$$
$$\approx 28 min$$
$$\approx 1/2 hr.$$

4 The voltage across R_2 must be $= V_2$ (voltage of battery)

This means that we could have the eq. circuit



$V_{eq} = V_1 + V_2 + V_3 = 15V$

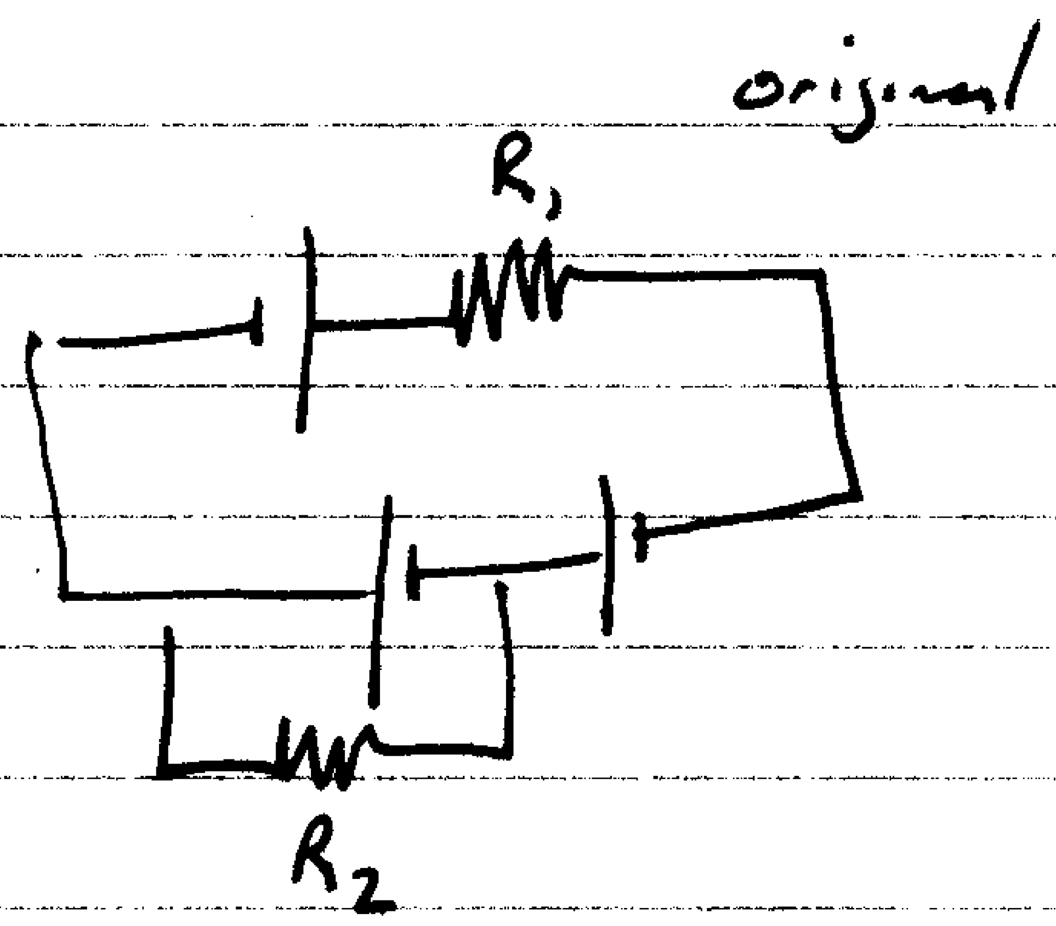
so $i_1 =$

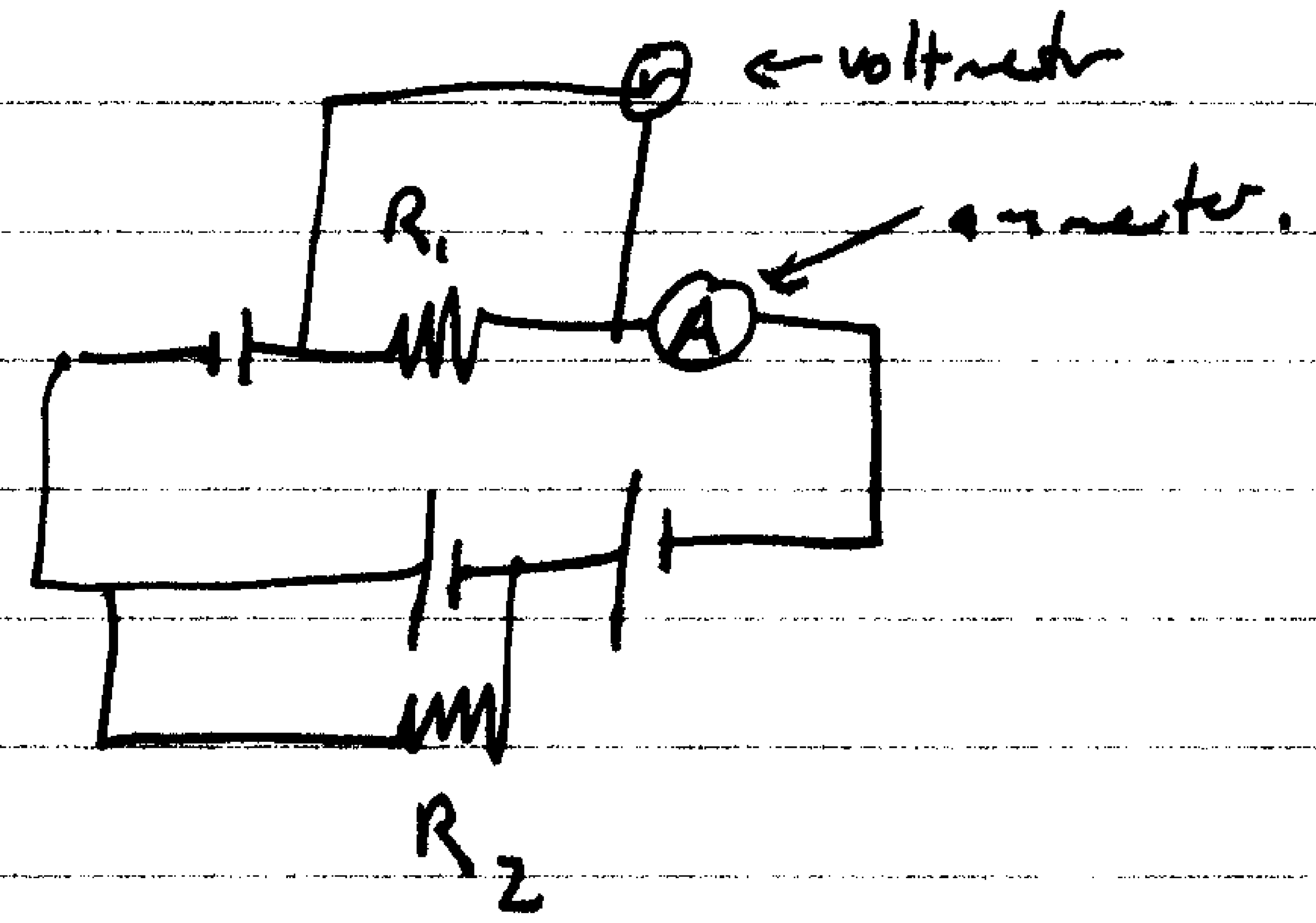
$= \frac{V}{R} = \frac{15V}{100\Omega} = .15A$

b since we know the voltage across R_2 is V_2

$$i_2 = \frac{V_2}{R_2} = \frac{5V}{50\Omega} = 0.1 \text{ Amp}$$

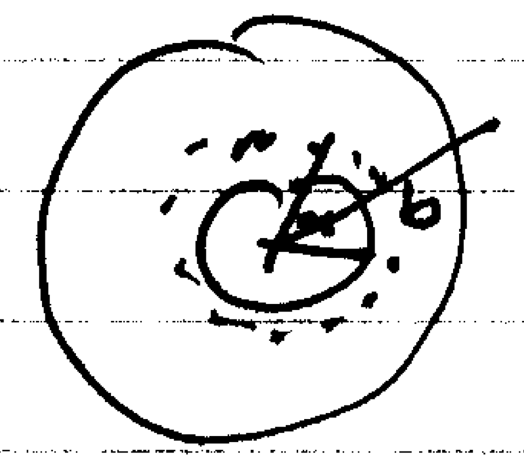
c)





5 $Q = CV$

Now according to Gauss' law



$$\frac{q_{enc}}{\epsilon_0} = \oint_{\substack{\text{closed} \\ \text{surface}}} \vec{E} \cdot d\vec{A}$$

$$= \oint_{\text{closed surface}} \|\vec{E}\| \, dA$$

$$= |\vec{E}| \, 4\pi r^2$$

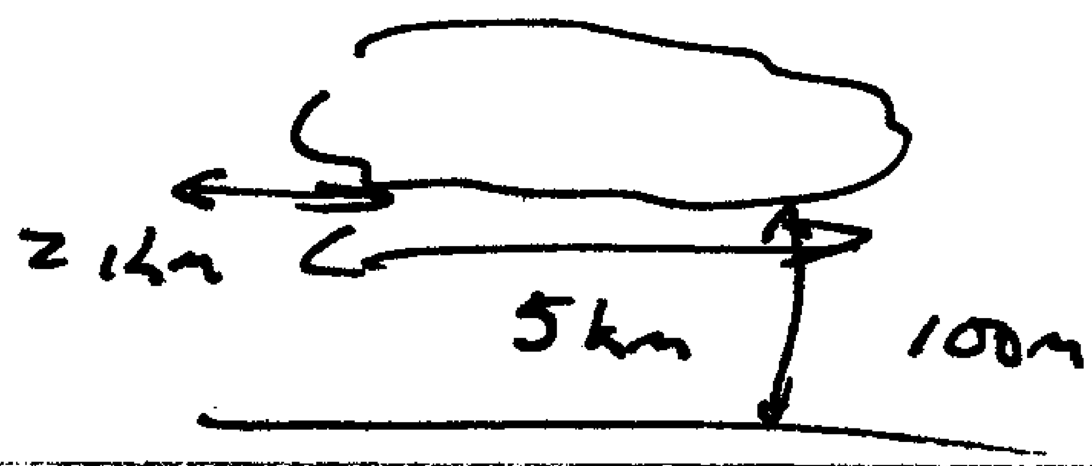
$$|\vec{E}| = \frac{q_{enc}}{4\pi \epsilon_0 r^2} = \frac{Q}{4\pi\epsilon_0 r^2}$$

$$\Delta V = -\int \vec{E} \cdot d\vec{r} = -\int_a^b \frac{Q}{4\pi\epsilon_0 r^2} dr = \frac{Q}{4\pi\epsilon_0 r}\Big|_a^b = \frac{Q}{4\pi\epsilon_0}\left(\frac{1}{b} - \frac{1}{a}\right)$$

So $$Q = \frac{4\pi\epsilon_0}{\frac{1}{b} - \frac{1}{a}} \Delta V$$

$$= \left| \frac{4\pi\epsilon_0 \, ab}{a-b} \right| \Delta V$$

$$C = \frac{4\pi\epsilon_0 \, ab}{a-b}$$



6 for parallel plate capacitors

a) $C = \frac{\epsilon_0 A}{d} = \epsilon_0 \frac{5\times10^3 m \times 2\times10^3 m}{10^2 m}$

$= 8.85\times10^{-12} \times10^5$

$= 8.85\times10^{-7}\,F$

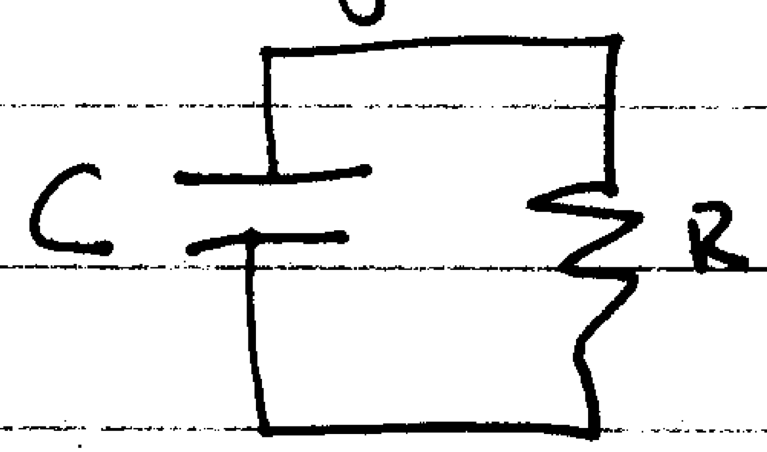
$= .885\,\mu F$

b) $\Delta V = 3\times10^8\,V$ so

$Q = 8.85\times10^{-7}F \times 3\times10^8 V$

$= 266\,C$

c) through a resistor we have $V = iR$ where V = voltage drop



$Q = CV$

The voltage across the capacitor will be $-iR$ so that

$Q = -iRC$

$-\frac{1}{RC} Q = \frac{dQ}{dt}$

$\frac{dQ}{dt} = -\frac{Q}{\tau}$ $\quad \ln Q - \ln Q_0 = -\frac{t}{\tau}$

$Q/Q_0 = e^{-t/\tau}$

$Q = Q_0 e^{-t/\tau}$

$= 266\,C\, e^{-t/885\,ms}$

d) $U = \frac{1}{2}CV^2$

so $U/U_0 = \frac{1}{2}CV^2 / \frac{1}{2}CV_0^2$

$\frac{1}{2} = V^2/V_0^2$

$V = V_0/\sqrt{2}$

or $Q = Q_0/\sqrt{2}$

$e^{-t/\tau} = \frac{1}{\sqrt{2}}$

$t = \tau \ln\sqrt{2} = 30.7\,ms$