Physics Final 1B

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Winter 2020 Gutperle 105 114 897

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1a. Parallel $\left(\frac{1}{R}+\frac{1}{R}+\frac{1}{R}\right)^{-1} = \frac{R}{3}$

$\boxed{(2) \quad \frac{1}{3}R}$

1b. $\vec{J} = \frac{I}{A} = nq\vec{v}_d$

$\frac{2}{9\pi} = nq\vec{v}d_{left}$ $\qquad \frac{\cancel{2}}{\cancel{9\pi} v_L} = \frac{\cancel{2}}{\frac{36\cancel{\pi}}{4} v_R}$

$\frac{2}{36\pi} = nq\vec{v}d_{right}$ $\qquad 4v_R = v_L$

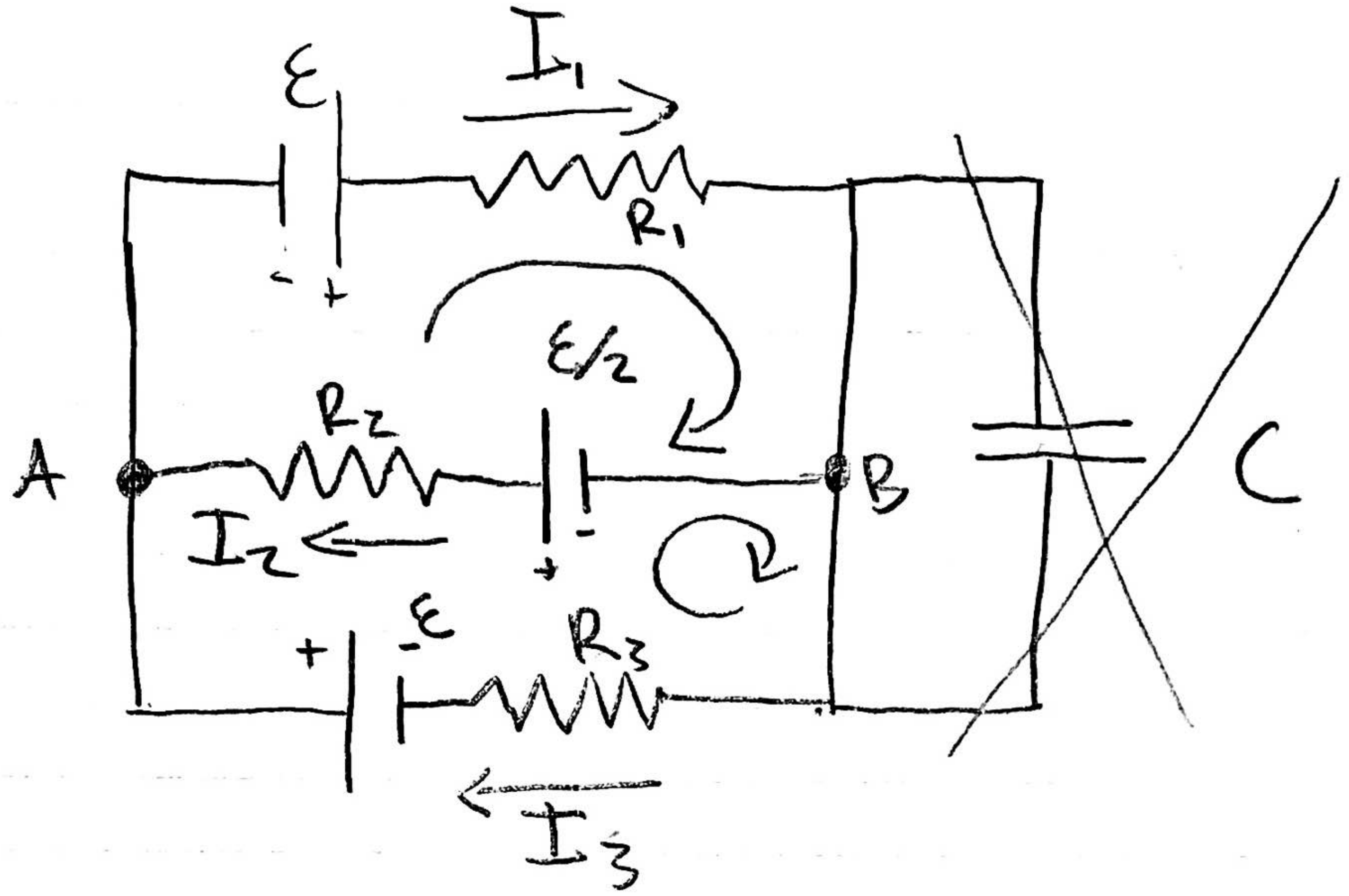
$\boxed{v_R = \frac{1}{4}v_L} \quad (4)$

1c. $f_a = \frac{v}{v-v_s}f_s \qquad f_b = \frac{v+v_L}{v}f_s$

$f_a = \frac{343}{313}f_s = 1.095f_s \qquad f_b = \frac{373}{343}f_s = 1.087f_s$

$\boxed{f_a > f_b > f_s \quad (2)}$

2.
a)



capacitors are treated as open switches

(A) $I_2 + I_3 - I_1 = 0$
(B) $I_1 - I_2 - I_3 = 0$

$$\boxed{I_1 = I_2 + I_3}$$

(B) Top Loop: $I_1 R_1 - \mathcal{E}/2 + I_2 R_2 - \mathcal{E} = 0$

$$(I_2 + I_3) R_1 + I_2 R_2 - \frac{3\mathcal{E}}{2} = 0$$

Bottom Loop: $-I_2 R_2 + \mathcal{E}/2 + I_3 R_3 - \mathcal{E} = 0$

$$I_2 R_1 + I_3 R_1 + I_2 R_2 - \frac{3\mathcal{E}}{2} = 0$$

$$-I_2 R_2 + I_3 R_3 = \frac{\mathcal{E}}{2}$$ plug in

$$\Rightarrow I_2 R_1 + I_3 R_1 + I_2 R_2 - 3(-I_2 R_2 + I_3 R_3) = 0$$

$$\Rightarrow I_2 R_1 + I_3 R_1 + I_2 R_2 + 3 I_2 R_2 - 3 I_3 R_3 = 0$$

$$\Rightarrow I_2 (R_1 + 4R_2) + I_3 (R_1 - 3R_3) = 0$$

$$\boxed{I_2 = \frac{-I_3 (R_1 - 3R_3)}{R_1 + 4R_2}}$$

2c) Current through R_2 can vanish

Current from left must equal current from right

So $I_1 = I_3$ this is the case when $\boxed{R_1 = R_3}$ because both sections of the circuit have a battery ε & one resistor

$I_1 = I_2 + I_3 \Rightarrow I_1 = I_2 + I_1 \quad I_2 = 0$ ✓

3a) Capacitors in series $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$

$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} \qquad Q = CV$

$$\boxed{q_1 = q_3 = \varepsilon\left(\frac{C_1 C_2}{C_1 + C_2}\right) \qquad q_2 = q_4 = -\varepsilon\left(\frac{C_1 C_2}{C_1 + C_2}\right)}$$

$q_2 + q_3 = 0$ because for capacitors in series the charge is the same for both capacitors. In this case, q_2 is the negative side of C_1 and q_3 is the positive side of C_2. Since q_2 & q_3 have same magnitude, but opposite signs, their sum is zero

3b. yes the charge changes

$V = q\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$ now $\Rightarrow$ $V = q'\left(\frac{1}{C_1} + \frac{1}{KC_2}\right)$

$q\left(\frac{C_2 + C_1}{C_1 C_2}\right) = q'\left(\frac{KC_2 + C_1}{KC_2 C_1}\right)$

$q' = q\left(\frac{C_2 + C_1}{\cancel{C_1} \cancel{C_2}}\right)\left(\frac{K\cancel{C_2}\cancel{C_1}}{KC_2 + C_1}\right)$ $\boxed{q' = q\left(\frac{C_2 + C_1}{KC_2 + C_1}\right)}$

new Charge

Energy : $U = \frac{Q^2}{2C} = \boxed{\frac{CV^2}{2}} = \frac{QV}{2}$

$C_{eq} = \frac{KC_2 + C_1}{KC_2 C_1}$ $V = \mathcal{E}$ $\boxed{U = \frac{1}{2}\left(\frac{KC_2 + C_1}{KC_2 C_1}\right)\mathcal{E}^2}$

3c) Charge splits in half at a then for each side $\frac{2}{3}$ of charge go to the 2C & $\frac{1}{3}$ of charge go through each of the $\frac{1}{3}$C capacitors

Because of symmetry, charge is zero through 2C, so voltage $\boxed{V_{cb} = 0}$

$\mathcal{E} = \underbrace{\frac{Q}{2C}}_{V_{ba}} + \underbrace{\frac{Q}{6C}}_{V_{db}} = \frac{3Q + Q}{6C} = \frac{2\cancel{4}Q}{3\cancel{6}C} = \mathcal{E}$ $Q = \frac{3C\mathcal{E}}{2}$

$V_{db} = \frac{Q}{6C} = \frac{1}{{}_2\cancel{6}\cancel{C}} \cdot \frac{\cancel{3}C\mathcal{E}}{2}$ $\boxed{V_{db} = \frac{\mathcal{E}}{4}}$

4a) $J = \frac{I}{A} = nqV_d \quad J = \sigma \vec{E} \quad \rho = \frac{1}{\sigma} \quad R = \frac{\rho \cdot l}{A}$

$V = IR \quad \frac{\varepsilon}{R} = I \quad R = \frac{(1{,}68 \times 10^{-8})(1)}{6 \times 10^{-8}} = 0{,}28\Omega$

$$\frac{1{,}5\,V}{0{,}28\,\Omega} = \frac{5{,}357\,A}{(6 \times 10^{-8}\,m^2)(1{,}602 \times 10^{-19})} = \boxed{5{,}57 \times 10^{26} \text{ electrom } m/s}$$

4b) $R' = 4R \quad \frac{I' = \frac{1}{4} I}{A'} = J' = J$

$A' = \frac{1}{4} A$

$\boxed{\text{Same number of electrons } 7 \times 10^{18}}$