

Midterm

2. Electric Charge and Electric Fields

$$\textcircled{1} \text{ a) } E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1}{r^2}$$

$$2.00 \times 10^{-3} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1}{(1 \times 10^{-3})^2}$$

$$2.00 \times 10^{-3} \times 1 \times 10^{-6} = \frac{q_1}{4\pi\epsilon_0}$$

$$\text{b) } E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_2}{r^2}$$

$$8.00 \times 10^{-3} = \frac{1}{4\pi\epsilon_0} \cdot \frac{1 \times 10^{-6}}{r^2}$$

$$8.00 \times 10^{-3} = \frac{1}{4\pi\epsilon_0 r^2}$$

$$F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1}{(5 \times 10^{-3})^2}$$

$$F = 7.00 \times 10^{-3} \times 10^{-6} \cdot \frac{1}{25 \times 10^{-6}}$$

$$E = 0.08 \times 10^{-3} \text{ or } 8 \times 10^{-5} \text{ V/C}$$

$$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{3 \times 10^{-6}}{r^2}$$

$$= 8.00 \times 10^3 \cdot 3 \times 10^{-6}$$

$$E = 2.4 \times 10^{-3} \text{ N/C}$$

$$\textcircled{7} \text{ a) } qE = mg \Rightarrow q = \frac{mg}{E}$$

$$= \frac{(4 \times 10^{-14})(9.8)}{6131.25}$$

$$q = 6.39348 \times 10^{-19}$$

$$q = nc \Rightarrow n = \frac{q}{e}$$

$$= \frac{(6.39348 \times 10^{-19})}{(1.6 \times 10^{-19})}$$

$$n = 3.99 \approx 4$$

$$\text{b) } q = q - e$$

$$= 6.39348 \times 10^{-19} \text{ C} - 1.60 \times 10^{-19} \text{ C}$$

$$q = 4.79348 \times 10^{-19} \text{ C}$$

$$F_e = q_e E$$

$$= (4.79348 \times 10^{-19} \text{ C})(6131.25 \text{ N/C})$$

$$F_e = 2.939 \times 10^{-15} \text{ N}$$

$$F_g = (4 \times 10^{-16} \text{ kg})(9.81 \text{ m/s}^2)$$

$$F_g = 3.92 \times 10^{-15} \text{ N}$$

$$a = \frac{F_g - F_e}{m}$$

$$= \frac{(3.92 \times 10^{-15} \text{ N}) - (2.939 \times 10^{-15} \text{ N})}{4 \times 10^{-16} \text{ kg}}$$

$$a = 2.4525 \text{ m/s}^2$$

3. Potential Energy and Voltage, Capacitors

$$\textcircled{1} \text{ a) } KE = qV$$

$$KE_{HYD} = (1.6 \times 10^{-19} \text{ C})(4 \times 10^3 \text{ V})$$

$$KE_{HYD} = 6.4 \times 10^{-16} \text{ J}$$

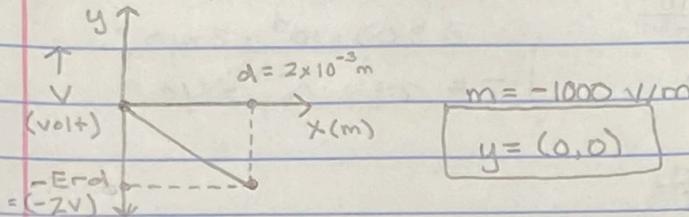
$$KE_{HE} = 2(1.6 \times 10^{-19} \text{ C})(4 \times 10^3 \text{ V})$$

$$KE_{HE} = 12.8 \times 10^{-16} \text{ J}$$

$$\text{b) } F = \frac{\Delta V}{\Delta x} \\ = \frac{4 \times 10^3 \text{ V}}{5 \times 10^{-2} \text{ m}}$$

$$E = 8 \times 10^4 \text{ V/m}$$

$$\textcircled{2} \quad F = 1000 \text{ V/m}$$



$$\textcircled{3} \quad \text{a) } C = \frac{\epsilon_0 A}{d} \\ = \frac{(8.85 \times 10^{-12} \text{ F/m})(1 \times 10^{-9} \text{ m})}{2 \times 10^{-3} \text{ m}}$$

$$C = 4.425 \times 10^{-13} \text{ F}$$

$$\text{b) Energy} = \frac{1}{2} C V^2 \\ = \frac{1}{2} (4.425 \times 10^{-13}) (5)^2$$

$$\text{Energy} = 55.31 \times 10^{-13} \text{ J}$$

$\textcircled{4}$ We should connect the identical capacitor to the first in parallel because capacitance adds up in parallel combination, $C_{\text{net}} = C_1 + C_2 = 2C$.

4. Current, Resistance, and DC Circuits

$$\textcircled{1} \quad \text{a) } -F_2 + IR_2 + TR_1 - F_1 + IR = 0$$

$$-1.5 \text{ V} + I(2 \Omega + 2 \Omega + 50 \Omega) - 1.5 \text{ V} = 0$$

$$I = \frac{3 \text{ V}}{54 \Omega} = 55.56 \text{ mA}$$

$$\frac{V_R - 1.5}{2} + \frac{V_B - 1.5}{2} + \frac{V_R}{50} = 0 \\ \frac{25V_R - 37.5 + 25V_B - 37.5 + V_R}{50} = 0$$

$$I = \frac{1.5 - 1.47}{2 \Omega} = 15 \text{ mA}$$

$$I_2 = \frac{1.5 - 1.47}{2 \Omega} = 15 \text{ mA}$$

$$51V_R = 75$$

$$I = 30 \text{ mA}$$

$$V_R = 1.47 \text{ V}$$

$$\begin{aligned}
 b) P_{\text{TOT}} &= P_{R_1} + P_{R_2} + P_R \\
 &= I^2 R_1 + I^2 R_2 + I^2 R \\
 &= (55.56 \text{ mA})^2 \times 2 + 2(55.56 \text{ mA})^2 + 50(55.56 \text{ mA})^2 \\
 &= 6.17 \text{ mW} + 6.17 \text{ mW} + 154.34 \text{ mW} \\
 P_{\text{TOT}} &= 177.51 \text{ mW}
 \end{aligned}$$

$$\begin{aligned}
 P_{\text{TOT}} &= P_{R_1} + P_{R_2} + P_R \\
 &= I_1^2 R_1 + I_2^2 R_2 + I^2 R \\
 &= 2(15)^2 + 2(15)^2 + 50(30)^2 \\
 &= 0.45 \text{ mW} + 0.45 \text{ mW} + 45 \text{ mW} \\
 P_{\text{TOT}} &= 45.9 \text{ mW}
 \end{aligned}$$

