

1. a)  $C_c = \frac{Kq}{r^2}$   $K = 9 \cdot 10^9 \text{ Nm}^2 \cdot \text{C}^{-2}$   $q = \text{charge}$   $r = 1 \text{ mm}$

$$2 \cdot 10^{-3} = \frac{(9 \cdot 10^9) q}{(10^{-3})^2} \implies q = \frac{2 \cdot 10^{-3} (10^{-3})^2}{9 \cdot 10^9} \implies 2.22 \cdot 10^{-19} \text{ C}$$

$E_c = \frac{Kq}{r^2} = \frac{(9 \cdot 10^9)(2.22 \cdot 10^{-19})}{(5 \cdot 10^{-3})^2} \text{ V/m} \implies 8 \cdot 10^{-5} \text{ V/m}$

b)  $E_c = 8 \cdot 10^{-5} \text{ V/m}$   $q = 1 \mu\text{C}$   $K = 9 \cdot 10^9 \text{ Nm}^2 \cdot \text{C}^{-2}$   $r = \text{dist.}$

$$r^2 = \frac{Kq}{E_c} \implies r = \sqrt{\frac{Kq}{E_c}} \implies r = \sqrt{\frac{(9 \cdot 10^9) \cdot 1 \cdot 10^{-6}}{8 \cdot 10^{-5}}} \text{ m}$$

$$\implies 1060.66 \text{ m}$$

$q = 3 \text{ nC} = 3 \cdot 10^{-9} \text{ C} \implies E_c = \frac{Kq}{r^2} \implies \frac{9 \cdot 10^9 \cdot 3 \cdot 10^{-9}}{(1060.66)^2}$

$$\implies 2.4 \cdot 10^{-3} \text{ V/m}$$

2.  $\begin{array}{c} + & + & + & + \\ \downarrow & \uparrow & \downarrow & \\ - & - & - & - \end{array}$   $E = 6131.25 \text{ N/C}$   $m = 4 \cdot 10^{-16} \text{ kg}$   $g = 9.81 \text{ m/s}^2$

a)  $F_E = mg \implies qE = mg \implies q = \frac{mg}{E} = \frac{4 \cdot 10^{-16} \cdot 9.81}{6131.25}$

$$= 0.0064 \cdot 10^{-16} = 6.4 \cdot 10^{-19} \text{ C} \implies \frac{6.4 \cdot 10^{-19}}{1.6 \cdot 10^{-19}} = 4$$

b)  $q_p = (4-1) \cdot 1.6 \cdot 10^{-19} \text{ C} = 4.8 \cdot 10^{-19} \text{ C}$

a)  $\begin{array}{c} \uparrow q_0 E \\ \downarrow m g \end{array}$   $mg - q_0 E = ma \implies a = \frac{mg - q_0 E}{m}$

$$= \frac{(4 \cdot 10^{-16} \cdot 9.81) - (4.8 \cdot 10^{-19} \cdot 6131.25)}{4 \cdot 10^{-16}}$$

$$= \frac{(39.24 \cdot 10^{-16}) - (29.43 \cdot 10^{-16})}{4 \cdot 10^{-16}} = 2.4525 \text{ m/s}^2$$

3

1. a)  $KE = q(\Delta V)$  Hydrogen:  $q = e$  Helium:  $q = 2e$

$$KE_H = 1.602 \cdot 10^{-19} \cdot 4000 \text{ J} = 6.408 \cdot 10^{-16} \text{ J}$$

$$KE_{He} = 2 \cdot 1.602 \cdot 10^{-19} \cdot 4000 \text{ J} = 12.816 \cdot 10^{-16} \text{ J}$$

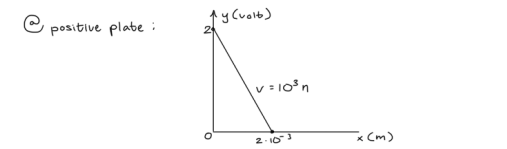
b)  $E = \left| \frac{\Delta V}{\Delta x} \right| = \frac{4000}{0.05} = 8000 \text{ V/m}$  or  $8 \cdot 10^3 \text{ V/m}$

2.  $E = 1 \text{ kV/m}$   $E = 1 \cdot 10^3 \text{ V/m}$   $d = 2 \text{ mm} = 2 \cdot 10^{-3} \text{ m}$   $E = \frac{\Delta V}{x}$

$$10^3 = \frac{\Delta V}{x} \implies \Delta V = 10^3 x$$

Assume voltage  $\odot$  negative plate = 0  $\Delta V = 10^3 x$   $V - 0 = 10^3 x$

$V = 10^3 x$



3. a) Capacitance  $C = \frac{\epsilon_0 A}{d}$

$$C = \frac{(8.85 \cdot 10^{-12} \text{ C}^2/\text{Nm}) (1 \cdot 10^{-4} \text{ m}^2)}{2 \cdot 10^{-3} \text{ m}} = 4.425 \cdot 10^{-13} \text{ F} = 0.4425 \text{ pF}$$

b) Energy in C

$$U_C = \frac{1}{2} C V^2 = \frac{1}{2} (4.425 \cdot 10^{-13} \text{ F}) (5 \text{ V})^2 = 5.53 \cdot 10^{-12} \text{ J}$$

4.  $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{C_2 + C_1}{C_1 \cdot C_2}$   $C_1 = C_2 = C \implies C_{eq} = \frac{C \cdot C}{C + C} = \frac{C}{2} = 0.5 \text{ C}$

$U = \frac{1}{2} C_{eq} V^2$  In parallel:  $C_{eq} = C_1 + C_2 + C_1 + C_2$   $C_{eq} = 2C \implies$  capacitance  $\uparrow$

$U = \frac{1}{2} C_{eq} V^2 \implies$  energy stored  $\uparrow \implies$  identical capacitors must be connected in parallel with first capacitor

4

1.  $\begin{array}{c} r_1 = 2 \Omega \\ E_1 = 1.5 \text{ V} \\ r_2 = 2 \Omega \\ E_2 = 1.5 \text{ V} \end{array}$   $R = 50 \Omega$   $I = ?$

$$-E_2 + I r_2 + I r_1 - E_1 + I R = 0$$

$$-1.5 + I(2 + 2 + 50) - 1.5 = 0$$

$$I = \frac{3 \text{ V}}{54} = \frac{3}{54} = \frac{1}{18} = 55.56 \text{ mA}$$

Power:  $P_{\text{total}} = P_{r_1} + P_{r_2} + P_R \implies I^2 r_1 + I^2 r_2 + I^2 R$

$$= (55.56 \text{ mA})^2 \cdot 2 + (55.56 \text{ mA})^2 \cdot 2 + (55.56 \text{ mA})^2 \cdot 50$$

$$= 6.17 \text{ mW} + 6.17 \text{ mW} + 154.34 \text{ mW} = 166.68 \text{ mW}$$

2.  $\begin{array}{c} r_1 = 2 \Omega \\ E_1 = 1.5 \text{ V} \\ r_2 = 2 \Omega \\ E_2 = 1.5 \text{ V} \end{array}$   $R = 50 \Omega$   $I_1 = ?$   $I_2 = ?$

$$\frac{V_1 - 1.5}{2} + \frac{V_1 - 1.5}{2} + \frac{V_1}{50} = 0$$

$$\frac{25V_1 - 37.5 + 25V_1 - 37.5 - V_1}{50} = 0$$

$$51V_1 = 75 \implies V_1 = 1.47 \text{ Volts}$$

$$I_1 = \frac{1.5 - 1.47}{2} = 15 \text{ mAmp}$$

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

$$I = I_1 + I_2 = 15 \text{ mAmp} + 15 \text{ mAmp} = 30 \text{ mAmp}$$

$P_{\text{total}} = P_{r_1} + P_{r_2} + P_R \implies I_1^2 r_1 + I_2^2 r_2 + I^2 R$

$$= (15 \text{ mAmp})^2 \cdot 2 + (15 \text{ mAmp})^2 \cdot 2 + (30 \text{ mAmp})^2 \cdot 50 = 0.45 \text{ mW} + 0.45 \text{ mW} + 45 \text{ mW}$$

$$= 45.9 \text{ mW} \implies P_R = I^2 R \implies (30 \text{ mA})^2 \cdot 50 = 45 \text{ mW}$$

