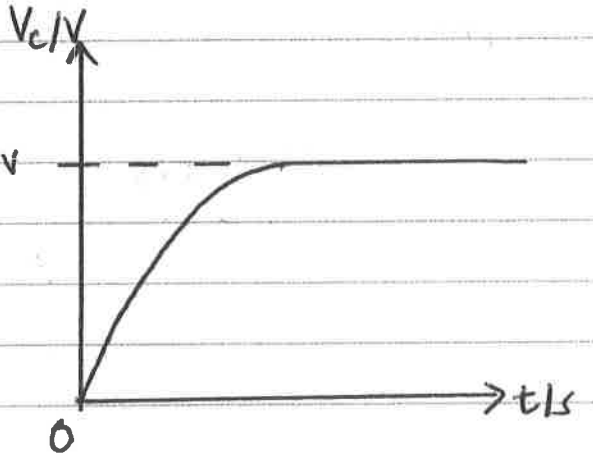
Unit 3: Electricity
3.3 Capacitance

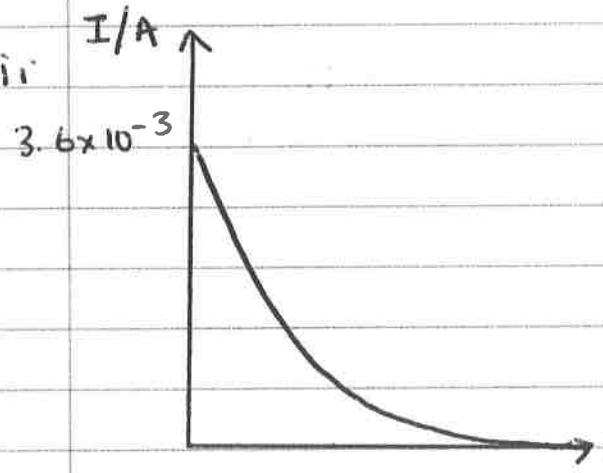
Charging and Discharging

1(a)

(i)



ii



$$I = \frac{V}{R}$$

$$I = \frac{12}{3300}$$

$$I = 3.6 \times 10^{-3} A.$$

(b)

(i) 0V

(ii) 12V.

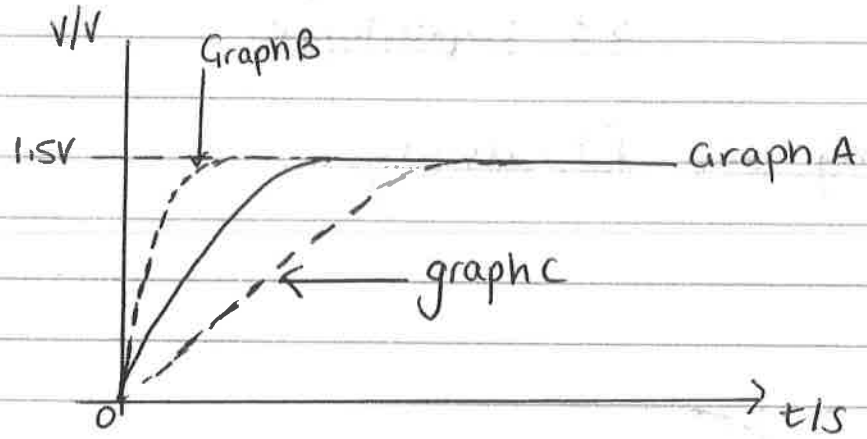
(c) $$I = \frac{V}{R}$$

$$= \frac{12}{3300}$$

$$= 3.6 \times 10^{-3} A$$

2.

(a)



(b)

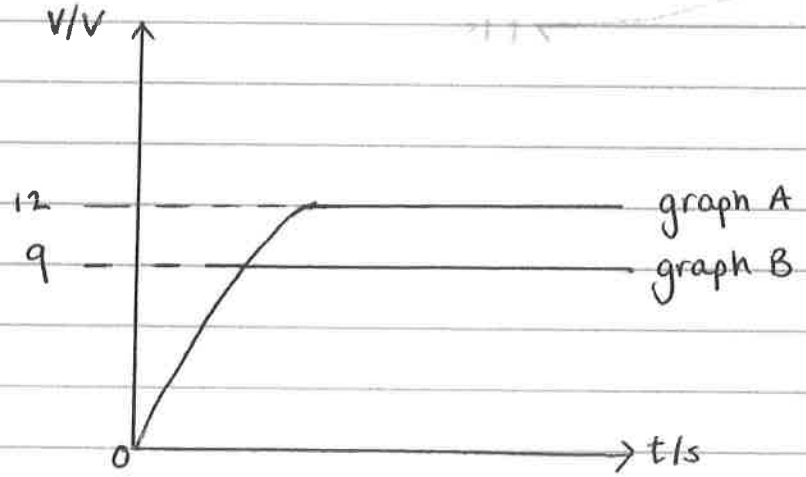
(c) See graph C.

3. $I = \frac{V}{R}$

$I = \frac{1.5}{200}$

$I = 7.5 \times 10^{-3} A$

4(a)



(b) See graph B.

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5. $V = 24V$
$R = 600\Omega$
$I = ?$

$$I = \frac{V}{R}$$

$$I = \frac{24}{600}$$

$$I = 0.04A$$

6. $V = 9V$
$I = 15mA$
$R = ?$

$$R = \frac{V}{I}$$

$$R = \frac{9}{15 \times 10^{-3}}$$

$$R = 600\Omega$$

7(a) $R = 200\Omega$
$V = 24V$
$I = ?$

$$I = \frac{V}{R}$$

$$I = \frac{24}{200}$$

$$I = 0.12A$$

(b) $V_R = 24 - 15$
$= 9V$
$R = 200\Omega$

$$I = \frac{V}{R}$$

$$I = \frac{9}{200}$$

$$I = 0.05A$$

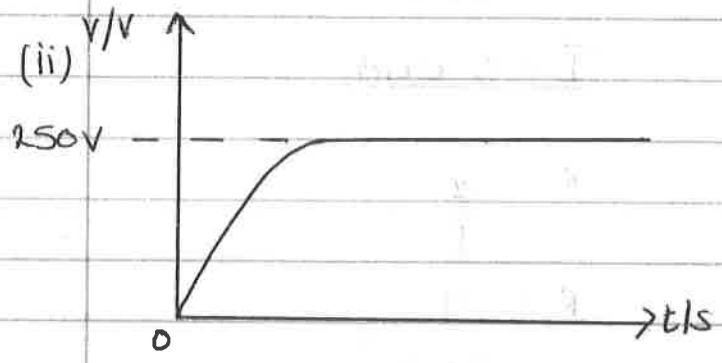
(ii) P.d. across resistor = 9V.

8(a) $I = \frac{V}{R}$

$I = \frac{250}{15 \times 10^3}$

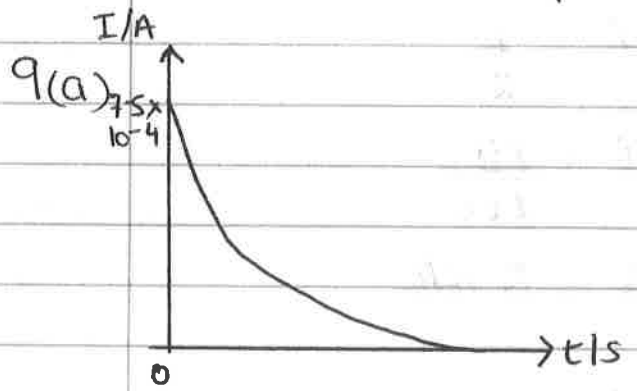
$I = 0.02A$

(ii)



(b) A lower value of resistor could be used.

9(a)



$I = \frac{V}{R}$

$I = \frac{9}{12 \times 10^3}$

$I = 7.5 \times 10^{-4} A$

(b) The charges in the wire (& battery) move towards one side of the capacitor plate. This makes this plate negatively charge. This also happens on the other plate; negative charges move from this plate making that plate positively charged.

c(i) The maximum p.d. will still be 9V (as the battery remains identical)

(ii) The maximum current will increase as R decreases (whilst V remains constant) in the equation:

$$I = \frac{V}{R}.$$

Unit 3: Electricity

3.3 Capacitance

$Q = VC$

10. $Q = 50mC$
$V = 1.5V$
$C = ?$

$C = \frac{Q}{V}$

$C = \frac{50 \times 10^{-3}}{1.5}$

$C = 3.3 \times 10^{-2} F.$

11. $Q = ?$
$C = 2200\mu F$
$V = 12V$

$Q = CV$
$Q = 2200 \times 10^{-6} \times 12$
$Q = 2.6 \times 10^{-2} C.$

12. $C = 470\mu F$
$Q = 500\mu C$
$V = ?$

$V = \frac{Q}{C}$

$V = \frac{500 \times 10^{-6}}{470 \times 10^{-6}}$

$V = 1.06V$

13(a) $Q = ?$
$C = 20\mu F$
$V = 1.5V$

$Q = CV$
$Q = 20 \times 10^{-6} \times 1.5$
$Q = 3 \times 10^{-5} C$

(b) $Q = ?$
$C = 4\mu F$
$V = 400V$

$Q = CV$
$Q = 4 \times 10^{-6} \times 400$
$Q = 1.6 \times 10^{-3} C$

13(c) $Q = ?$
$C = 2200\mu F$
$V = 12V$

$Q = CV$
$Q = 2200 \times 10^{-6} \times 12$
$Q = 2.64 \times 10^{-2} C$

(d) $Q = ?$
$C = 500 \times 10^{-12} F$
$V = 9V$

$Q = CV$
$Q = 500 \times 10^{-12} \times 9$
$Q = 4.5 \times 10^{-9} C$

(e) $Q = ?$
$C = 20 \times 10^{-12} F$
$V = 24V$

$Q = CV$
$Q = 20 \times 10^{-12} \times 24$
$Q = 4.8 \times 10^{-10} C$

14
(a) $C = ?$
$Q = 12 \times 10^{-3} C$
$V = 150V$

$C = \frac{Q}{V}$
$C = \frac{12 \times 10^{-3}}{150}$
$C = 8 \times 10^{-5} F$

(b) $C = ?$
$Q = 1.5 \times 10^{-3} C$
$V = 6V$

$C = \frac{Q}{V}$
$C = \frac{1.5 \times 10^{-3}}{6}$
$C = 2.5 \times 10^{-4} F$

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14

(c) $C = ?$
$Q = 3.6C$
$V = 24 \times 10^3 V$

$C = \frac{Q}{V}$

$C = \frac{3.6}{24 \times 10^3}$

$C = 1.5 \times 10^{-4} F$

(d) $C = ?$
$Q = 120 \times 10^{-6} C$
$V = 12V$

$C = \frac{Q}{V}$

$C = \frac{120 \times 10^{-6}}{12}$

$C = 1 \times 10^{-5} F$

(e) $C = ?$
$Q = 50 \times 10^{-6} C$
$V = 25 \times 10^3 V$

$C = \frac{Q}{V}$

$C = \frac{50 \times 10^{-6}}{25 \times 10^3}$

$C = 2 \times 10^{-9} F$

15

(a) $V = ?$
$C = 10,000 \times 10^{-6} F$
$Q = 50 \times 10^{-3}$

$V = \frac{Q}{C}$

$V = \frac{50 \times 10^{-3}}{10,000 \times 10^{-6}}$

$V = 5V$

15(b) $Q = 10\mu C$

$C = 220 \times 10^{-6} F$

$V = ?$

$V = \frac{Q}{C}$

$V = \frac{10 \times 10^{-6}}{220 \times 10^{-6}}$

$V = 0.05V$

(c) $C = 0.01\mu F$

$Q = 500mC$

$V = ?$

$V = \frac{Q}{C}$

$V = \frac{500 \times 10^{-3}}{0.01 \times 10^{-6}}$

$V = 5 \times 10^{7} V$

(d) $C = 240pF$

$Q = 12 \times 10^{-3} C$

$V = ?$

$V = \frac{Q}{C}$

$V = \frac{12 \times 10^{-3}}{240 \times 10^{-12}}$

$V = 5 \times 10^{7} V$

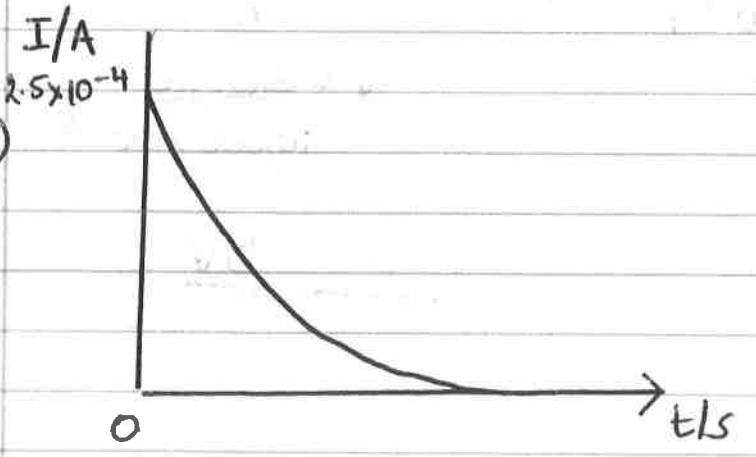
16

(a) $Q = CV$

$= 1.6 \times 10^{-3} \times 4.5$

$= 7.2 \times 10^{-3} C$.

(b)



$I = \frac{V}{R}$

$I = \frac{4.5}{18 \times 10^{3}}$

$I = 2.5 \times 10^{-4} A$.

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Energy Stored

17. $E = ?$
$Q = 50 \times 10^{-3} C$
$V = 12V$

$E = \frac{1}{2} QV$

$E = \frac{1}{2} \times 50 \times 10^{-3} \times 12$

$E = 0.3J$

18. $E = 25 \times 10^{-3} J$
$V = 100V$
$Q = ?$

$E = \frac{1}{2} QV$

$25 \times 10^{-3} = \frac{1}{2} \times Q \times 100$

$25 \times 10^{-3} = 50Q$

$Q = 5 \times 10^{-4} C$

19. $E = 0.04J$
$Q = 200mC$
$V = ?$

$E = \frac{1}{2} QV$

$0.04 = \frac{1}{2} \times 200 \times 10^{-3} \times V$

$0.04 = 0.1V$

$V = 0.4V$

13

20. (a) $E = \frac{1}{2} CV^2$

$E = \frac{1}{2} \times 20 \times 10^{-6} \times 1.5^2$

$E = 2.25 \times 10^{-5} J$

(b) $E = \frac{1}{2} CV^2$

$E = \frac{1}{2} \times 4 \times 10^{-6} \times 400^2$

$E = 0.32J$

(c) $E = \frac{1}{2}CV^2$

$E = \frac{1}{2} \times 2200 \times 10^{-6} \times 12^2$

$E = 0.16J$

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

$E = \frac{1}{2} \times 500 \times 10^{-12} \times 9^2$

$E = 2 \times 10^{-8} J$

(e) $E = \frac{1}{2}CV^2$

$E = \frac{1}{2} \times 20 \times 10^{-12} \times 24^2$

$E = 5.76 \times 10^{-9} J$

20. 14

(a) $E = \frac{1}{2}QV$

$E = \frac{1}{2} \times 12 \times 10^{-3} \times 150$

$E = 0.9J$

(b) $E = \frac{1}{2}QV$

$E = \frac{1}{2} \times 1.5 \times 10^{-3} \times 6$

$E = 4.5 \times 10^{-3} J$

(c) $E = \frac{1}{2}QV$

$E = \frac{1}{2} \times 3.6 \times 24 \times 10^{3}$

$E = 43\,200\ J$

(d) $E = \frac{1}{2}QV$

$E = \frac{1}{2} \times 120 \times 10^{-6} \times 12$

$E = 7.2 \times 10^{-4} J$

(e) $E = \frac{1}{2}QV$

$E = \frac{1}{2} \times 50 \times 10^{-6} \times 25{,}000$

$E = 0.63J$

15

(a) $E = \frac{Q^2}{2C}$

$E = \frac{(50 \times 10^{-3})^2}{2 \times 10{,}000 \times 10^{-6}}$

$E = \frac{2.5 \times 10^{-3}}{0.02}$

$E = 0.13J$

(b) $E = \frac{Q^2}{2C}$

$E = \frac{(10 \times 10^{-6})^2}{2 \times 220 \times 10^{-6}}$

$E = \frac{1 \times 10^{-10}}{4.4 \times 10^{-4}}$

$E = 2.3 \times 10^{-7} J$

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20. 15

(c) $E = \frac{Q^2}{2C}$

$E = \frac{(500\times10^{-3})^2}{2\times0.01\times10^{-6}}$

$E = \frac{0.25}{2\times10^{-8}}$

$E = 12.5\times10^{6}\,J$

(d) $E = \frac{Q^2}{2C}$

$E = \frac{(12\times10^{-3})^2}{2\times240\times10^{-12}}$

$E = \frac{1.44\times10^{-4}}{4.8\times10^{-10}}$

$E = 3\times10^{5}\,J$

21

(a) $C = 1000\times10^{-6}\,F$

$E = 0.5\,J$

$V = ?$

$E = \frac{1}{2}CV^2$

$0.5 = \frac{1}{2}\times1000\times10^{-6}\times V^2$

$0.5 = 5\times10^{-4}V^2$

$V^2 = 1{,}000$

$V = 32\,V$

(b) $C = 220\times10^{-6}\,F$

$E = 4\,J$

$V = ?$

$E = \frac{1}{2}CV^2$

$4 = \frac{1}{2}\times220\times10^{-6}\,V^2$

$V^2 = \frac{4}{1.1\times10^{-4}}$

$V^2 = 36{,}364$

$V = 19.1\,V$ 190.7 V

22. $C = ?$

$E = 400 \times 10^{-3} J$

$V = 12 V$

$E = \frac{1}{2} C V^2$

$400 \times 10^{-3} = \frac{1}{2} \times C \times 12^2$

$400 \times 10^{-3} = 72C$

$C = 5.6 \times 10^{-3} F$

23. $C = ?$

$E = 720 \times 10^{-3} J$

$Q = 60 \times 10^{-3} C$

$E = \frac{Q^2}{2C}$

$720 \times 10^{-3} = \frac{(60 \times 10^{-3})^2}{2C}$

$2C = \frac{3.6 \times 10^{-3}}{720 \times 10^{-3}}$

$2C = 5 \times 10^{-3}$

$C = 2.5 \times 10^{-3} F$

24

(a) $Q = ?$

$C = 470 \times 10^{-6} F$

$E = 50 \times 10^{-3} J$

$E = \frac{Q^2}{2C}$

$50 \times 10^{-3} = \frac{Q^2}{2 \times 470 \times 10^{-6}}$

$Q^2 = 4.7 \times 10^{-5}$

$Q = 6.9 \times 10^{-3} C$

(b) $C = 5000 \times 10^{-6} F$

$E = 10 J$

$Q = ?$

$E = \frac{Q^2}{2C}$

$10 = \frac{Q^2}{2 \times 5000 \times 10^{-6}}$

$Q^2 = 0.1$

$Q = 0.32 C$