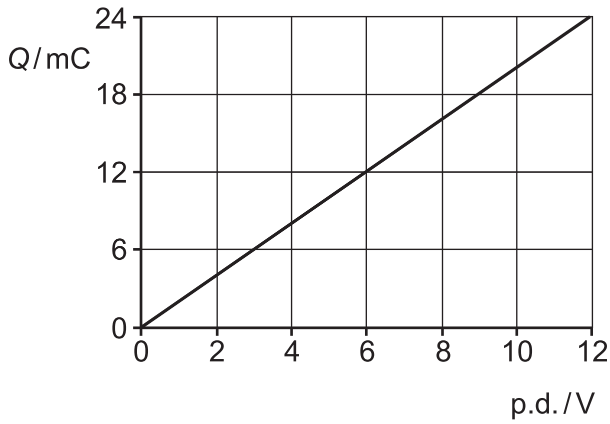
The following information is for use in questions **7** and **8**.

The diagram shows the $Q - V$ graph for a capacitor charged to 12 V.



7 What is the capacitance?

A 2×10^{-3} F

B 144×10^{-3} F

C 288×10^{-3} F

D 500 F

Your answer ☐ **[1]**

8 Which of the following is the energy stored?

A 2×10^{-3} J

B 144×10^{-3} J

C 288×10^{-3} J

D 500 J

Your answer ☐ **[1]**

34 A student makes an iterative model for the decay of charge on a capacitor. The time constant of the circuit is $RC = 10$ s.

time lapsed / s t	**charge Q on capacitor / C** Q	**charge ΔQ leaving capacitor in time interval $\Delta t = 1$ s / C** $\Delta Q \approx \frac{Q\Delta t}{RC}$	**charge Q remaining after time interval Δt / C** $Q = (Q - \Delta Q)$
0	5	$\frac{5 \times 1}{10} = 0.5$	$5 - 0.5 = 4.5$
1	4.5	$\frac{4.5 \times 1}{10} = 0.45$	$4.5 - 0.45 = 4.05$

(a) Complete the numerical values in the two blank cells in the table. **[2]**

(b) (i) Explain the physics behind the approximation in the third column of the table $\Delta Q \approx \frac{Q\Delta t}{RC}$.

Change in ΔQ in time t (or Δt) = I × Δt

$V = IR$ so $\Delta Q = \frac{V}{R} \Delta t$. $Q = CV$ so $V = Q/C$

∴ $\Delta Q = \frac{Q \Delta t}{CR}$.

It's approx ∴ I changes during Δt **[2]**

(ii) State the assumption made in using this approximation and explain how its effect can be made insignificant.

that I is constant (or V, or Q on cap) during Δt ... which it isn't. Reduce Δt to smaller value **[2]**

2 This question is about charging a capacitor in a circuit with two resistors in series.

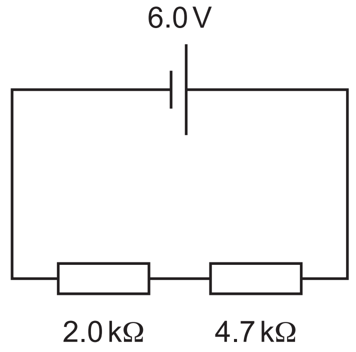


Fig. 2.1

(a) Show that the p.d. across the 4.7 kΩ resistor in the circuit in Fig. 2.1 is about 4 V, assuming that the cell has zero internal resistance.

$\left(\frac{4.7}{2+4.7}\right) \times 6 = 4.20$

[2]

(b) A student changes the circuit as shown in Fig. 2.2

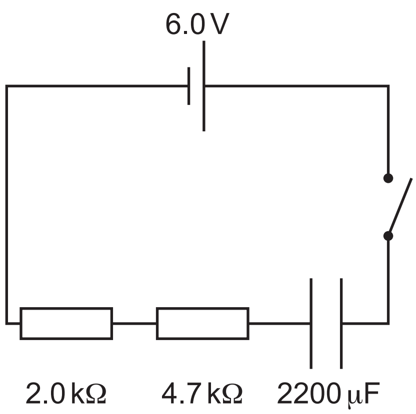


Fig. 2.2

Show that the time constant of the circuit is about 15 s.

$t = RC = 2200 \times 10^{-6} \times 2000 \times 4700$

$= 14.7 s$

[2]

(c) The graph in Fig. 2.3 shows how the p.d. across the capacitor varies with time up to 5*RC*. Add a line to the graph that shows how the p.d. across the **4.7 kΩ resistor** varies with time.

Add another line to show how the p.d. across the **2.0 kΩ resistor** varies with time. Label the lines.

both exp → 0 at 5RC

max V over 4.7K = 4.2

max V across 2kΩ will be ≈ 1.8

had to draw on pc

Your lines must be better than mine!

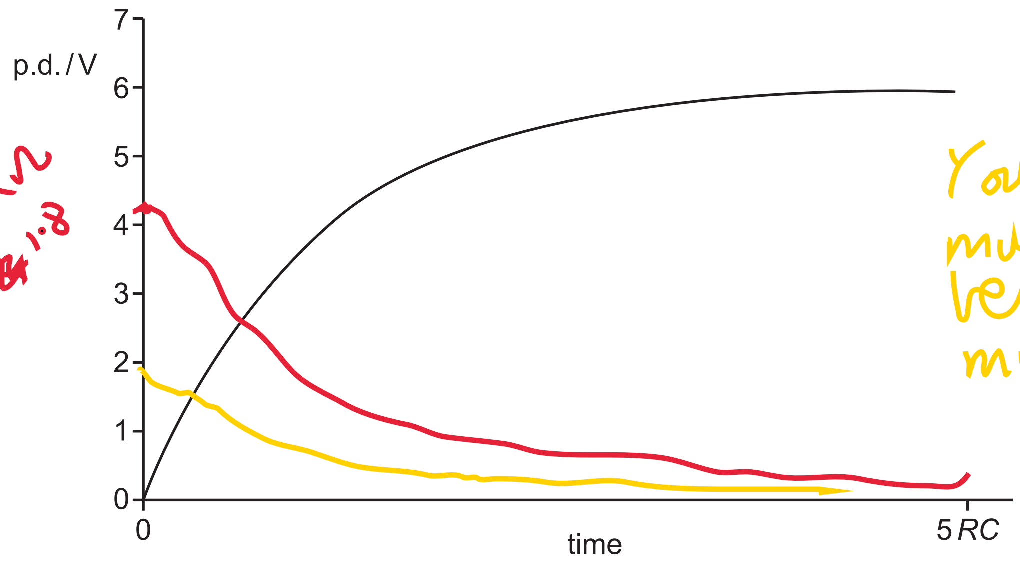


Fig. 2.3

[2]

(d) Calculate the time it takes from the start of the charging for the p.d across the capacitor to reach 5.0 V.

$V = V_0(1 - e^{-t/RC}) \Rightarrow \frac{V}{V_0} = 1 - e^{-t/RC}$ 　 $\ln 1 = 0$

$\frac{V}{V_0} - 1 = -e^{-t/RC} \Rightarrow 1 - \frac{V}{V_0} = e^{-t/RC}$

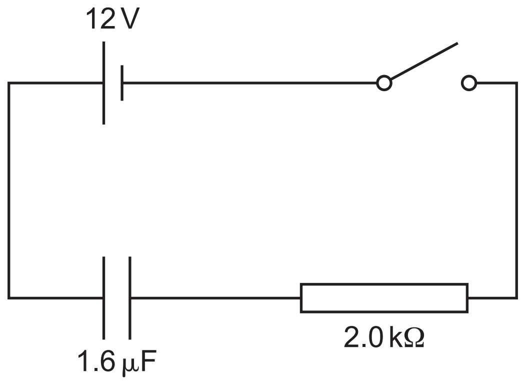
$\Rightarrow \ln\left(1 - \frac{V}{V_0}\right) = -\frac{t}{RC} \Rightarrow -1.79 \times RC = -t$

26.3 sec

time = ... s **[4]**

The following information is for use in questions **13** and **14**.

An uncharged capacitor and a resistor are connected in this circuit.



	current / mA	p.d. across the capacitor / V	p.d. across the resistor / V
A	0	12	0
B	2	8	4
C	3	6	6
D	6	0	12

13 Which set of values **A** to **D** above, most closely represents the situation immediately after the switch is closed?

no p.d. over C

Your answer D **[1]**

14 Which set of values **A** to **D** above, most closely represents the situation 3 seconds after the switch is closed?

Your answer A **[1]**

$RC = 1.6 \times 10^{-6} \times 2 \times 10^{3}$
$= 3.2 \times 10^{-3}$ s

so its a fully charge capacitor

so $I \approx 0$ amps
& $V_c \approx 12$ V