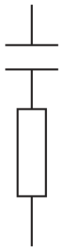
17 A student investigated the properties of capacitors.

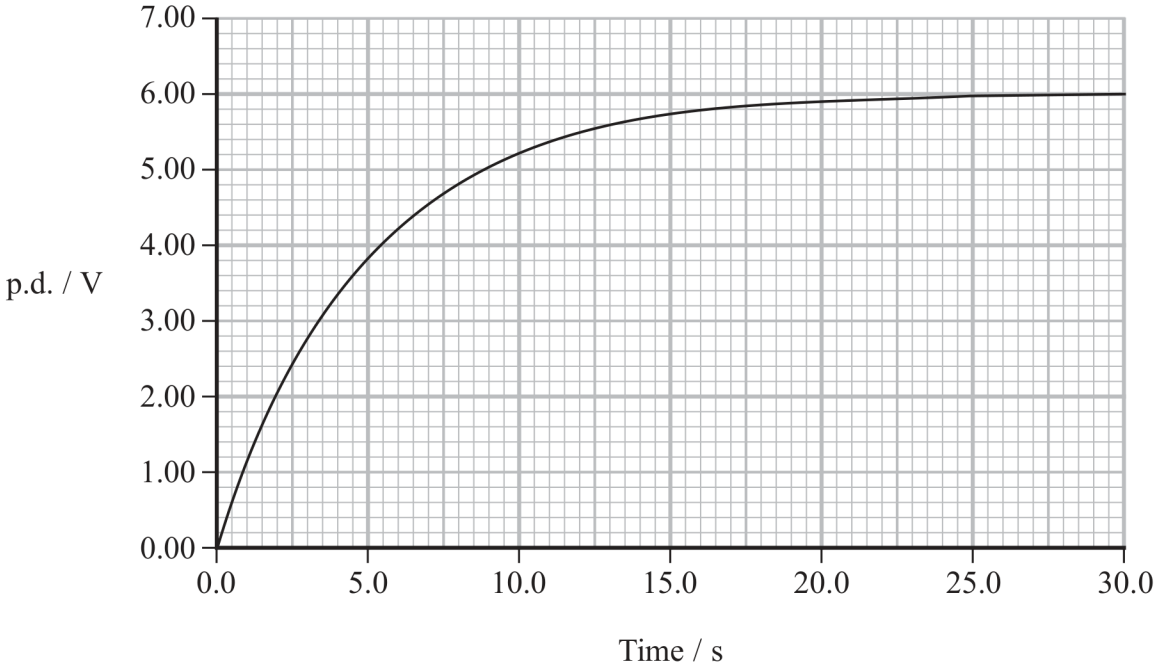
The student connected a capacitor in series with a resistor. The capacitor was charged through the resistor by applying a potential difference (p.d.) using a battery of e.m.f. 6.0 V and negligible internal resistance. The capacitor was then discharged through the resistor. The p.d. across the capacitor was measured during the charging and discharging processes.

(a) Add to the diagram to show a suitable circuit for charging and discharging the capacitor while measuring the p.d. across it.

(3)



(b) The graph shows how the p.d. across the capacitor varies with time as it is being charged by the 6.0 V battery.



(i) Sketch, on the same axes, a graph to show how the p.d. across the resistor varies with time.

(2)

(ii) Show that the p.d V across the capacitor when it is charging is given by

$$V = V_0 - V_0 e^{-t/RC}$$

where V_0 is the e.m.f. of the battery
t is the time
R is the resistance of the resistor
and C is the capacitance of the capacitor.

(3)

(iii) During the charging process, the student recorded the p.d. across the capacitor and the resistance of the resistor.

The capacitors available had the following values:

10 μF 15 μF 47 μF 100 μF 150 μF

Deduce the value of capacitance for the capacitor that was used.

$R = 330\,\text{k}\Omega$

(4)

(iv) Calculate the charge on the fully charged capacitor.

(2)

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Charge = ...

(v) Calculate the energy stored by the fully charged capacitor.

(2)

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Energy stored = ...

(Total for Question 17 = 16 marks)