19.2 Energy stored in a capacitor

Name: ____________ Class: ________ Date: __________ **Total: 10 marks**

Objective

Build the skills to answer exam questions on the **energy stored in a capacitor**.

You must be able to:

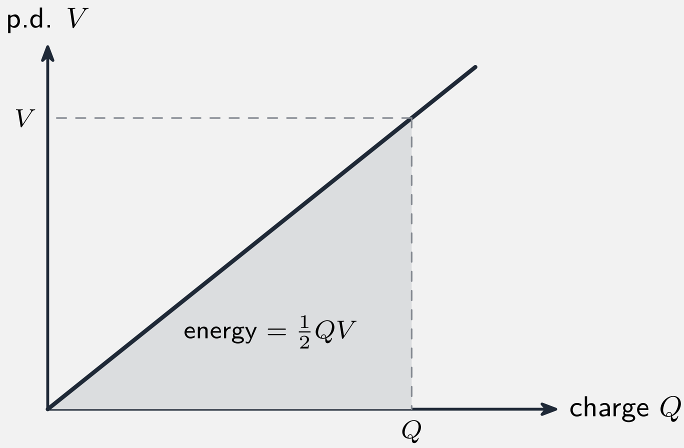
- find energy from the **area under the potential–charge graph**
- use $W = \frac{1}{2}QV = \frac{1}{2}CV^2 = \dfrac{Q^2}{2C}$

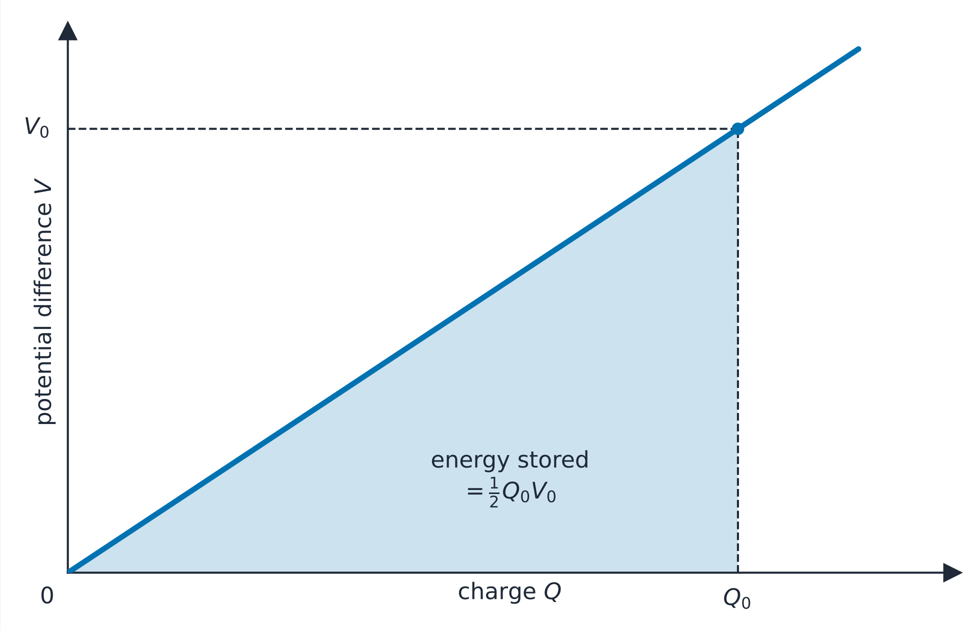
1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

■ Energy stored

The energy is the **area under the V–Q graph** —a triangle:





Energy stored is the area under the Q-V graph

$$W = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2 = \frac{Q^2}{2C}.$$

The factor $\frac{1}{2}$ appears because the **average** p.d. during charging is $V/2$ (it grows from 0 to V).

Worked example. 100 μF at 12 V: $W = \frac{1}{2}CV^2 = \frac{1}{2}(100\times10^{-6})(12)^2 = 7.2\times10^{-3}$ J.

2 Practice

Now apply the methods above.

2.1 Write the **three** forms of the capacitor energy formula. [1]

2.2 Find the energy stored in a 100 μF capacitor charged to 12 V. [2]

2.3 State what the **area** under a potential–charge graph represents. [1]

3 Exam-style questions

3.1 The energy stored in a capacitor is: [1]

- **A** QV
- **B** $\frac{1}{2}QV$
- **C** CV
- **D** Q^2C

3.2 A 220 μF capacitor stores 4.0 mJ of energy. Calculate the **voltage** across it. [3]

3.3 Explain why the energy stored is $\frac{1}{2}QV$ and **not** QV. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **19.2 Energy stored in a capacitor** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/41 N25 —Q6 (energy stored in a capacitor)
- 9702/43 N25 —Q6 (capacitor energy, structured)

Solutions

2.1 $W = \frac{1}{2}QV = \frac{1}{2}CV^2 = \dfrac{Q^2}{2C}$.

2.2 $W = \frac{1}{2}CV^2 = \frac{1}{2}(100 \times 10^{-6})(12)^2 = 7.2 \times 10^{-3}$ J.

2.3 The **energy stored** in the capacitor.

3.1 **B** —$\frac{1}{2}QV$.

3.2 $W = \frac{1}{2}CV^2 \Rightarrow V = \sqrt{\dfrac{2W}{C}} = \sqrt{\dfrac{2(4.0 \times 10^{-3})}{220 \times 10^{-6}}} = 6.0$ V.

3.3 As the capacitor charges, the p.d. rises from 0 to V; the **average** p.d. is $V/2$, so the work done is $Q \times (V/2) = \frac{1}{2}QV$, not QV.