10.3 Capacitors

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

KEY WORDS capacitor 电容器 • capacitance 电容 • series 串联 • parallel-plate capacitor 平行板电容器 • series and parallel 串联和并联

Objective

Build the skills to answer exam questions on **capacitors**.

You must be able to:

- define **capacitance** 电容 as $C = \dfrac{Q}{V}$
- use the parallel-plate result $C = \dfrac{\varepsilon_0 A}{d}$
- calculate the **energy stored**, $U = \frac{1}{2}CV^2 = \frac{1}{2}\dfrac{Q^2}{C}$
- combine capacitors in **series and parallel** 串联和并联

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Capacitance

$C = \dfrac{Q}{V}$ (farads). For parallel plates, $C = \dfrac{\varepsilon_0 A}{d}$ — larger area or smaller gap gives more capacitance.

■ Energy stored

$U = \frac{1}{2}CV^2 = \frac{1}{2}\dfrac{Q^2}{C}$, stored in the field (energy density $u = \frac{1}{2}\varepsilon_0 E^2$).

■ Combining capacitors

- **Parallel:** $C = C_1 + C_2 + \ldots$
- **Series:** $\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \ldots$ (less than the smallest).

2 Practice

2.1 A parallel-plate capacitor has area 0.020 m^2 and separation 1.0 mm ($\varepsilon_0 = 8.85 \times 10^{-12}$). Find its capacitance. [2]

2.2 Two 4.0 μF capacitors are connected in parallel. Find the total capacitance. [1]

2.3 Find the energy stored in a 10 μF capacitor at 12 V. [2]

3 Exam-style questions

3.1 The capacitance of a parallel-plate capacitor is [1]

- **A** $\dfrac{\varepsilon_0 d}{A}$
- **B** $\dfrac{\varepsilon_0 A}{d}$
- **C** $\varepsilon_0 A d$
- **D** $\dfrac{A}{\varepsilon_0 d}$

3.2 Two capacitors in series have a total capacitance that is [1]

- **A** the sum of the two
- **B** less than either one
- **C** the larger of the two
- **D** zero

3.3 A 5.0 μF capacitor is charged to 100 V.

(a) Find the charge stored. [2]

(b) Find the energy stored. [2]

Solutions

2.1 $C = \dfrac{\varepsilon_0 A}{d} = \dfrac{(8.85 \times 10^{-12})(0.020)}{1.0 \times 10^{-3}} = 1.8 \times 10^{-10}$ F.

2.2 $C = 4.0 + 4.0 = 8.0\ \mu$F.

2.3 $U = \frac{1}{2}CV^2 = \frac{1}{2}(10 \times 10^{-6})(12)^2 = 7.2 \times 10^{-4}$ J.

3.1 B.

3.2 B.

3.3 (a) $Q = CV = (5.0 \times 10^{-6})(100) = 5.0 \times 10^{-4}$ C. (b) $U = \frac{1}{2}CV^2 = \frac{1}{2}(5.0 \times 10^{-6})(100)^2 = 0.025$ J.