

Storing charge and energy between two plates

AP Physics 2 (algebra-based) · Test answers (mark scheme)

Award marks as shown for the relation, the substitution and the final answer with unit. For explanations, accept any clear statement of the physical idea. Do not penalise the same unit mistake more than once.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 10

Question 1 Capacitance (2 marks)

(a) Capacitance is the charge stored per unit voltage, $C = Q/V$.

(b) $C = 12 / 3.0 = \mathbf{4.0 \mu F}$.

Marking: 1 mark for each part.

Question 2 Parallel plates (3 marks)

(a) $C = \epsilon_0 A/d = (8.85 \times 10^{-12})(0.030) / (5.0 \times 10^{-4}) = \mathbf{5.3 \times 10^{-10} F}$ (531 pF).

(b) C is inversely proportional to d, so it **halves**.

Marking: (a) 1 mark for the substitution, 1 mark for the answer; (b) 1 mark.

Question 3 Energy in a flash unit (3 marks)

$Q = CV = 220 \times 10^{-6} \times 24 = \mathbf{5.3 \times 10^{-3} C}$. $U = \frac{1}{2}CV^2 = 0.5 \times 220 \times 10^{-6} \times 24^2 = \mathbf{6.3 \times 10^{-2} J}$ (63 mJ).

Marking: 1 mark for Q; 1 mark for the energy relation; 1 mark for the energy value.

Question 4 Battery stays connected (3 marks)

New $C = 3.0 \times 2.0 = \mathbf{6.0 \mu F}$. Before: $Q = 2.0 \times 12 = 24 \mu C$. After: $Q = 6.0 \times 12 = \mathbf{72 \mu C}$.

Marking: 1 mark for the new C; 1 mark for stating that the voltage is fixed; 1 mark for the two charges.

Question 5 Isolated capacitor (3 marks)

The charge stays the same; C increases; V decreases ($V = Q/C$); and $U = Q^2/2C$ decreases. The lost energy is work done by the capacitor in pulling the dielectric in. **Q constant, V and U fall.**

Marking: 1 mark for Q constant and C up; 1 mark for V and U down; 1 mark for the

explanation.

Question 6 Voltage against charge (2 marks)

The gradient is **$1/C$** . The shaded area is the energy stored, **$\frac{1}{2}QV$** .

Marking: 1 mark for each.

Question 7 Breakdown (2 marks)

The field between the plates is $E = V/d$. If the field is too large, the insulator ionises and starts to conduct, causing a spark and damage. The rating keeps E below this limit.

Marking: 1 mark for $E = V/d$ rising with V ; 1 mark for breakdown of the dielectric.

Question 8 Doubling the voltage (2 marks)

The capacitance **stays the same** because it depends only on geometry and the dielectric. The energy is $\frac{1}{2}CV^2$, so it becomes **four times larger**.

Marking: 1 mark for each.