

Field maps, voltage and energy per unit charge

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 wording that states the right physical idea. Do not penalise a repeated unit error more than once.

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

Question 1 Force from a field (2 marks)

(a) The force per unit positive charge, $E = F/q$.

(b) $F = qE = 5.0 \times 10^{-9} \times 4.0 \times 10^3 = \mathbf{2.0 \times 10^{-5} \text{ N}}$.

Marking: 1 mark for each part.

Question 2 Field and potential (3 marks)

$E = kQ/r^2 = (8.99 \times 10^9)(2.0 \times 10^{-9}) / (0.50)^2 = \mathbf{72 \text{ N/C}}$, directed away from the charge. $V = kQ/r = 17.98 / 0.50 = \mathbf{36 \text{ V}}$.

Marking: 1 mark for E; 1 mark for V; 1 mark for the direction.

Question 3 Parallel plates (2 marks)

$E = V/d = 250 / 0.0050 = \mathbf{5.0 \times 10^4 \text{ V/m}}$.

Marking: 1 mark for the relation and conversion to metres; 1 mark for the value with unit.

Question 4 Accelerated electron (3 marks)

$K = e\Delta V = 1.60 \times 10^{-19} \times 800 = \mathbf{1.28 \times 10^{-16} \text{ J}}$. $v = \sqrt{(2K/m)} = \sqrt{(2 \times 1.28 \times 10^{-16} / 9.11 \times 10^{-31})} = \mathbf{1.7 \times 10^7 \text{ m/s}}$.

Marking: 1 mark for $K = e\Delta V$; 1 mark for the value; 1 mark for the speed.

Question 5 Moving along an equipotential (3 marks)

(a) The work is **zero** because A and B have the same potential, so $\Delta V = 0$ and $W = q\Delta V = 0$. The field is perpendicular to the path.

(b) **Positive**: the field pushes a positive charge outward, to lower potential.

Marking: (a) 1 mark for zero, 1 mark for the reason; (b) 1 mark.

Question 6 Inside a conductor (3 marks)

If there were a field, free electrons would move. They keep moving until their own field cancels the applied one, so no field remains inside. Excess charge repels itself to the outer surface. **$E = 0$ inside.**

Marking: 1 mark for free charges moving; 1 mark for $E = 0$ at equilibrium; 1 mark for the charge on the surface.

Question 7 Proton energy change (2 marks)

$$\Delta U = q\Delta V = 1.60 \times 10^{-19} \times 100 = +1.6 \times 10^{-17} \text{ J, an increase.}$$

Marking: 1 mark for the value; 1 mark for stating an increase.

Question 8 Force on an electron (2 marks)

The force is to the **left**, opposite to the field, because the charge is negative. It moves towards higher potential.

Marking: 1 mark for the direction of force; 1 mark for the higher potential.