

Potential from fields and equipotentials

AP Physics C (Mechanics and E&M, calculus-based) · Test answers (mark scheme)

Award marks as shown. Accept answers within rounding, and give full credit for a correct method with a transcription slip carried through. Penalise a missing unit once only.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:E&M Unit 9

Question 1 Meaning of potential (2 marks)

Potential is the electric potential energy per unit charge at a point ($V = U/q$). A 12 V difference means 12 J of work per coulomb to move charge between the points.

Marking: 1 mark for energy per unit charge; 1 mark for 12 J/C interpretation.

Question 2 Point charge (2 marks)

$$V = kq/r = (8.99 \times 10^9)(-6.0 \times 10^{-9})/0.20 = -2.7 \times 10^2 \text{ V}.$$

Marking: 1 mark for substitution with the negative sign; 1 mark for the answer with unit.

Question 3 Reading the graph (3 marks)

- a. $|E| = \Delta V/\Delta x = 6/0.30 = 20 \text{ V/m}$, in the +x direction because V falls.
b. The slope is zero, so $E = 0$ there.

Marking: (a) 1 mark for the magnitude, 1 for the direction; (b) 1 mark for zero slope hence zero field.

Question 4 Integrating a field (3 marks)

$$\Delta V = -\int \text{from } 0 \text{ to } 0.10 \text{ of } 4.0 \times 10^3 \times dx = -2.0 \times 10^3 (0.10)^2 = -20 \text{ V}.$$

Marking: 1 mark for the integral set-up, 1 for evaluation, 1 for the sign and unit.

Question 5 Equipotentials (2 marks)

No work is done moving a charge along an equipotential, so the field has no component along it. The field is therefore perpendicular to the surface.

Marking: 1 mark for zero work along the surface; 1 mark for no tangential component.

Question 6 Conducting sphere (3 marks)

(a) $V = kQ/R = (8.99 \times 10^9)(2.0 \times 10^{-8})/0.10 = \mathbf{1.8 \times 10^3 \text{ V}}$.

(b) Same as the surface, $\mathbf{1.8 \times 10^3 \text{ V}}$.

(c) $\mathbf{E = 0}$ in the interior of the conductor.

Marking: 1 mark each part.

Question 7 Ring on its axis (3 marks)

$s = \sqrt{(0.30^2 + 0.40^2)} = 0.50 \text{ m}$, so $V = kQ/s = \mathbf{36 \text{ V}}$. Every piece of charge is at distance s and potential adds as a scalar.

Marking: 1 mark for s ; 1 mark for the value with unit; 1 mark for the scalar explanation.

Question 8 Energy of a charge (2 marks)

$\frac{1}{2}mv^2 = e\Delta V$, so $v = \sqrt{(2 \times 1.60 \times 10^{-19} \times 500)/1.67 \times 10^{-27}} = \mathbf{3.1 \times 10^5 \text{ m/s}}$.

Marking: 1 mark for the energy equation; 1 mark for the answer.