1 Which one of the following **cannot** be used as a unit for electric field strength?

A $J\ m^{-1}\ C^{-1}$

B $J\ A^{-1}\ s^{-1} m^{-1}$

C $N\ A^{-1}\ s^{-1}$

D $J\ C\ m^{-1}$

(Total 1 mark)

2 An electron and a proton are 1.0×10^{-10} m apart. In the absence of any other charges, what is the electric potential energy of the electron?

A $+2.3 \times 10^{-18}$J

B -2.3×10^{-18}J

C $+2.3 \times 10^{-8}$J

D -2.3×10^{-8}J

(Total 1 mark)

3 The electric potential at a distance *r* from a positive point charge is 45 V. The potential increases to 50 V when the distance from the charge decreases by 1.5 m. What is the value of *r*?

A 1.3 m

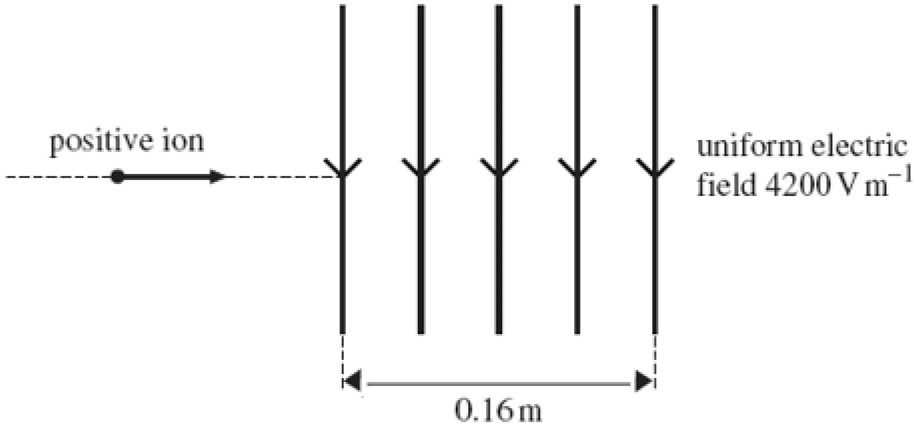
B 1.5 m

C 7.9 m

D 15 m

(Total 1 mark)

4



An ion carrying a charge of $+4.8 \times 10^{-19}$C travels horizontally at a speed of 8.0×10^{5}ms^{-1}. It enters a uniform vertical electric field of strength 4200 V m^{-1}, which is directed downwards and acts over a horizontal distance of 0.16m. Which one of the following statements is **not** correct?

A The ion passes through the field in 2.0×10^{-7}s.

B The force on the ion acts vertically downwards at all points in the field.

C The magnitude of the force exerted on the ion by the field is 1.6×10^{-9} N.

D The horizontal component of the velocity of the ion is unaffected by the electric field.

(Total 1 mark)

5

The repulsive force between two small negative charges separated by a distance *r* is *F*.

What is the force between the charges when the separation is reduced to $\frac{r}{3}$?

A $\frac{F}{9}$

B $\frac{F}{3}$

C $3F$

D $9F$

(Total 1 mark)

6

What is the acceleration of an electron at a point in an electric field where the field strength is 1.5×10^{5} V m^{-1}?

A 1.2×10^{6} m s^{-2}

B 1.4×10^{13} m s^{-2}

C 2.7×10^{15} m s^{-2}

D 2.6×10^{16} m s^{-2}

(Total 1 mark)

7

Two protons are 1.0×10^{-14} m apart. Approximately how many times is the electrostatic force between them greater than the gravitational force between them?
(Use the Data and Formulae booklet)

A 10^{23}

B 10^{30}

C 10^{36}

D 10^{42}

(Total 1 mark)

8

The diagram shows two charges, +4 μC and –16 μC, 120 mm apart. What is the distance from the +4 μC charge to the point between the two charges where the resultant electric potential is zero?

A 24 mm

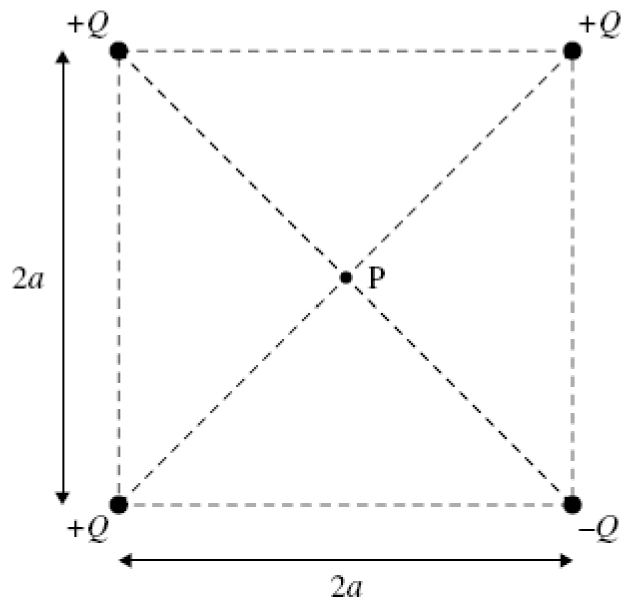
B 40 mm

C 80 mm

D 96 mm

(Total 1 mark)

9 The diagram shows four point charges at the corners of a square of side 2*a*. What is the electric potential at P, the centre of the square?



A $\dfrac{Q}{2\sqrt{2}\pi\varepsilon_0 a}$

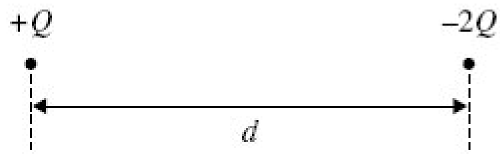
B $\dfrac{Q}{\sqrt{2}\pi\varepsilon_0 a}$

C $\dfrac{Q}{2\pi\varepsilon_0 a}$

D $\dfrac{Q}{4\pi\varepsilon_0 a}$

(Total 1 mark)

10



The diagram shows two particles at a distance *d* apart. One particle has charge +*Q* and the other –2*Q*. The two particles exert an electrostatic force of attraction, *F*, on each other. Each particle is then given an additional charge +*Q* and their separation is increased to a distance 2*d*.
Which one of the following gives the force that now acts between the two particles?

A an attractive force of $\frac{F}{4}$

B a repulsive force of $\frac{F}{4}$

C an attractive force of $\frac{F}{2}$

D a repulsive force of $\frac{F}{2}$

(Total 1 mark)

11 Which one of the following statements about a charged particle in an electric field is correct?

A No work is done when a charged particle moves along a field line.

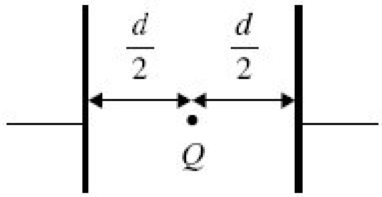
B No force acts on a charged particle when it moves along a field line.

C No work is done when a charged particle moves along a line of constant potential.

D No force acts on a charged particle when it moves along a line of constant potential.

(Total 1 mark)

12 Two parallel metal plates separated by a distance *d* have a potential difference *V* across them. What is the magnitude of the electrostatic force acting on a charge *Q* placed midway between the plates?



A $\frac{2VQ}{d}$

B $\frac{VQ}{d}$

C $\frac{VQ}{2d}$

D $\frac{Qd}{V}$

(Total 1 mark)

13 Which one of the following statements about *electric field strength* and *electric potential* is **incorrect**?

A Electric potential is a scalar quantity.

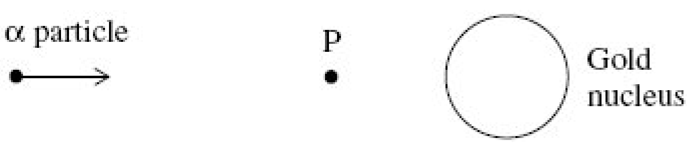
B Electric field strength is a vector quantity.

C Electric potential is zero whenever the electric field strength is zero.

D The potential gradient is proportional to the electric field strength.

(Total 1 mark)

14



An α particle travels towards a gold nucleus and at P reverses its direction.
Which one of the following statements is **incorrect**?

A The electric potential energy of the α particle is a maximum at P.

B The kinetic energy of the α particle is a minimum at P.

C The total energy of the α particle is zero.

D The total energy of the α particle has a constant positive value.

(Total 1 mark)

Mark schemes

1 D **[1]**

2 B **[1]**

3 D **[1]**

4 C **[1]**

5 D **[1]**

6 D **[1]**

7 C **[1]**

8 A **[1]**

9 A **[1]**

10 A **[1]**

11 C **[1]**

12 B **[1]**

13 C **[1]**

14 C **[1]**

Examiner reports

1 This question was the most demanding question on the paper, with only 39% of the students giving the correct answer. In order to identify the correct combinations of units to give V m^{-1}, it was necessary to remember that 1 V = 1 J C^{-1} and that 1 C = 1 A s. Distractor C was the choice of over a quarter of the students.

2 Failure to realise that a negatively charged electron has an associated negative value of electric potential caused many candidates to go wrong in this question. As in gravitation, the force between an electron and a proton is attractive and so the potential is negative. 40% of the candidates made the correct selection, B. 26% selected distractor A; the only difference between A and B is the – sign in B.

3 This question tested the relationship $V \propto 1/r$ for a point charge, but made appreciable mathematical demands because it required candidates to deal with a change in *V*. Rather fewer than half of the responses were correct, with distractor C as the most popular incorrect answer.

4 This question tested candidates' understanding of the mechanics of the motion of a positive ion as it passes through a uniform electric field. Quite a lot of calculation was needed to arrive at the correct response, but 57% were successful. Incorrect answers were evenly distributed amongst the other distractors.

5 Almost three quarters of the candidates chose the correct answer in this question, which was a fairly direct test of Coulomb's inverse square law.

6 This question, requiring a combination of $F = EQ$ and $F = ma$, was the most discriminating question in the test; its facility was 67%.

7 Another reused question combined Coulomb's law with Newton's law of gravitation and needed candidates to take data from the *Data and Formulae Booklet*. The incorrect responses were distributed fairly evenly across the three remaining distractors.

8 This question required candidates to appreciate that, for the total potential to be zero at the chosen point, the magnitude of *V* due to the +4 μC charge should be the same as the magnitude of V due to the –16 μC charge. This required (Q/r) to be the same and should give a distance ratio of 1:4. 58% of the candidates were able to work this out correctly, which is 5% lower than when this question was last used in an examination. Almost one in four of the candidates chose distractor B, suggesting that the distance ratio would be 1:2. This question was the worst discriminator in this examination.

9 There is no doubt that this question made appreciable mathematical demands, but it is surprising that the facility declined from 38% when pre-tested to 28% in this examination. This made it the most demanding question on the paper. Candidates should have seen that the contributions to V from the charges at top left and bottom right would effectively cancel. This then meant that the total potential would be double that due to one of the remaining charges. Application of Pythagoras leads to the distance r being $\sqrt{2}\,a$. Guesswork is probably the explanation for as many as 32% of the responses being for distractor D, which was no more than the simple potential equation $V = Q / 4\pi\varepsilon_0 r$ with $r = a$.

10 Coulomb's law had to be applied in this question. 66% of the candidates realised that doubling the separation would have the effect of reducing the force by a factor of four, whilst the changes to the charges would mean that they would become $+2Q$ and $-Q$, so that the force would remain one of attraction. Distractor C was selected by 22% of candidates; this could be because they thought that $F \propto 1/r$ instead of $F \propto 1/r^2$.

11 This question, about a charged particle moving in an electric field, had a facility of 66% and was a good discriminator. Incorrect responses were almost equally distributed between the incorrect distractors.

12 This question required candidates to apply $F = EQ$ in a charged parallel plate situation. 58% of them appreciated that the separation of the plates was d and that the field strength E would be V/d. However, 29% chose distractor A, for which the field strength must have been interpreted as $V \div (d/2)$.

13 This question on electrostatics, was concerned with field strength and potential. This was the worst discriminator in the test, and only 43% of candidates selected the correct response. A principal reason for as many as 24% of them choosing distractor A (potential is a scalar) must be that they had failed to notice that the question asked for the *incorrect* statement.

14 The statement that is incorrect was to be chosen in this question, about the energy of an α particle during a head-on encounter with a gold nucleus. The facility of this question was 62%, the most common incorrect choice being distractor D (19%).