Cambridge Assessment International Education

Interactive

Interactive Example Candidate Responses
Paper 4 (May/June 2016), Question 6
Cambridge International AS & A Level Physics 9702

Version 1.0

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HIGH | MIDDLE | LOW

6 **(a)** By reference to electric field lines, explain why, for points outside an isolated spherical conductor, the charge on the sphere may be considered to act as a point charge at its centre.

The electric field lines spread outwards radially and would meet at a point in the centre of the sphere. The electric field lines show the strength of the electric field, which is ~~zero~~ concentrated in the centre. Thus all the charge is considered to act at its centre. [2]

(b) Two isolated protons are separated in a vacuum by a distance x.

(i) Calculate the ratio

$$\frac{\text{electric force between the two protons}}{\text{gravitational force between the two protons}}$$

$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2} = \frac{(1.60\times10^{-19})^2}{4\pi\varepsilon_0 x^2}$

$F = \frac{GMm}{r^2} = \frac{6.67\times10^{-11}\times(1.67\times10^{-27})^2}{x^2}$

$\frac{(1.60\times10^{-19})^2}{4\pi\varepsilon_0 x^2} \div \frac{6.67\times10^{-11}\times(1.67\times10^{-27})^2}{x^2}$

$\frac{2.56\times10^{-38}}{1.11\times10^{-11}} \times \frac{1}{1.86\times10^{-64}}$

$\frac{2.56\times10^{-38}}{2.08\times10^{-74}} = \frac{1.24\times10^{36}}{1}$ ratio = 1.24 × 10 36 [3]

(ii) By reference to your answer in **(i)**, suggest why gravitational forces are not considered when calculating the force between charged particles.

The gravitational forces are negligable compared to the forces between charges. $\left(\frac{1.24\times10^{36}}{F_E} : \frac{1}{F_G}\right)$ [1]

[Total: 6]

	Your Mark
6(a)	
6(b)(i)	
6(b)(ii)	

Q6	Mark scheme		
(a)	lines perpendicular to surface **or** lines are radial	M1	
	lines appear to come from centre	A1	**[2]**
(b)(i)	$F_E = (1.6 \times 10^{-19})^2 / 4\pi\varepsilon_0 x^2$	C1	
	$F_G = G \times (1.67 \times 10^{-27})^2 / x^2$	C1	
	$F_E / F_G = (1.6 \times 10^{-19})^2 \times (8.99 \times 10^9) / [(1.67\times10^{-27})^2 \times (6.67\times10^{-11})]$ $= 1.2\ (1.24) \times 1036$	A1	**[3]**
(b) (ii)	$F_E >> F_G$	B1	**[1]**
			[Total: 6]

EXAMINER COMMENTS | MARK SCHEME

Select page

HIGH | MIDDLE | LOW

6 (a) By reference to electric field lines, explain why, for points outside an isolated spherical conductor, the charge on the sphere may be considered to act as a point charge at its centre.

Outside spherical conductor, charges can move and hence there is a resultant force on charge. With resultant force, there is field acting on the charge.

[2]

(b) Two isolated protons are separated in a vacuum by a distance x.

(i) Calculate the ratio

$$\frac{\text{electric force between the two protons}}{\text{gravitational force between the two protons}} = \frac{\frac{Q_1Q_2}{4\pi\varepsilon_0 x^2}}{\frac{GM_1M_2}{x^2}}$$

$$= \frac{(1.6\times10^{-19})^2}{4\pi(8.85\times10^{-12})x^2} \div \frac{6.67\times10^{-11}(1.67\times10^{-27})^2}{x^2}$$

$$= \frac{(1.6\times10^{-19})^2}{4\pi(8.85\times10^{-12})} \times \frac{1}{6.67\times10^{-11}(1.67\times10^{-27})^2}$$

$$= 1.24\times10^{36} \text{ (no unit)}$$

ratio = 1.24×10^{36} [3]

(ii) By reference to your answer in (i), suggest why gravitational forces are not considered when calculating the force between charged particles.

It is too small compared to electric force since ratio is big.

[1]

[Total: 6]

Your Mark

6(a) ☐

6(b)(i) ☐

6(b)(ii) ☐

Q6	Mark scheme		
(a)	lines perpendicular to surface **or** lines are radial	M1	
	lines appear to come from centre	A1	**[2]**
(b)(i)	$F_E = (1.6 \times 10^{-19})^2 / 4\pi\varepsilon_0 x^2$	C1	
	$F_G = G \times (1.67 \times 10^{-27})^2 / x^2$	C1	
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(b) (ii)	$F_E >> F_G$	B1	**[1]**
			[Total: 6]

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH | MIDDLE | LOW

6 (a) By reference to electric field lines, explain why, for points outside an isolated spherical conductor, the charge on the sphere may be considered to act as a point charge at its centre.

Electric field lines show the path and direction of an isolated positive charge. Since the isolated spherical conductor has a charge and is in the electric field it can be considered as a point charge. [2]

(b) Two isolated protons are separated in a vacuum by a distance x.

(i) Calculate the ratio

$$\frac{\text{electric force between the two protons}}{\text{gravitational force between the two protons}}$$

$= \frac{kQQ_2}{x^2} \div \frac{GM_1M_2}{x^2}$

$= \frac{kQQ_2}{x^2} \times \frac{x^2}{GM_1M_2}$

$= \frac{\frac{1}{4\pi\varepsilon_0} \times (1.6\times10^{-19})^2}{6.67\times10^{-11}\times2(1.67\times10^{-27})} = \frac{2.3\times10^{48}}{2.2\times10^{-37}}$

ratio = 1.03 [3]

(ii) By reference to your answer in (i), suggest why gravitational forces are not considered when calculating the force between charged particles.

It's always the same, since the ratio between the two forces is one. [1]

[Total: 6]

Your Mark

6(a) ☐

6(b)(i) ☐

6(b)(ii) ☐

Q6	Mark scheme		
(a)	lines perpendicular to surface **or** lines are radial	M1	
	lines appear to come from centre	A1	**[2]**
(b)(i)	$F_E = (1.6 \times 10^{-19})^2 / 4\pi\varepsilon_0 x^2$	C1	
	$F_G = G \times (1.67 \times 10^{-27})^2 / x^2$	C1	
	$F_E / F_G = (1.6 \times 10^{-19})^2 \times (8.99 \times 10^9) / [(1.67\times10^{-27})^2 \times (6.67\times10^{-11})]$ $= 1.2\ (1.24) \times 1036$	A1	**[3]**
(b) (ii)	$F_E >> F_G$	B1	**[1]**
			[Total: 6]

EXAMINER COMMENTS | MARK SCHEME

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