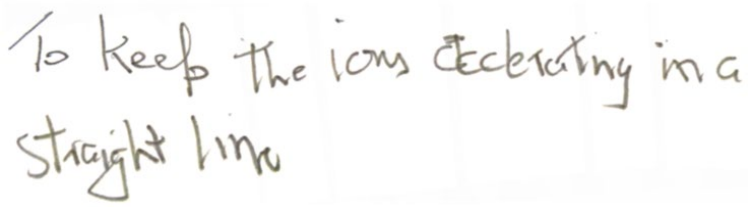
Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	To ensure the (accelerating) force on the hydrogen ion is in the same direction. **OR** To ensure the hydrogen ions accelerate in the same direction. **OR** To ensure that the direction of the electric field is correct when the hydrogen ions pass across the gaps.	**1**	Response must make some implication of 'same direction'.
		(ii)	As the speed of hydrogen ions increases, they travel further in the same time.	**1**	Accept: So that the hydrogen ions are at the ends of the tubes when the field changes polarity. **OR** So that a constant frequency AC supply can be used.
	(b)		$l' = l\sqrt{1-\left(\frac{v}{c}\right)^2}$ **(1)** $l' = 13\sqrt{1-\left(\frac{0{\cdot}50c}{c}\right)^2}$ **(1)** $l' = 11$ m **(1)**	**3**	Accept: 10, 11·3, 11·26 Alternative substitutions: $l' = 13\sqrt{1-(0{\cdot}50)^2}$ $l' = 13\sqrt{1-\left(\frac{0{\cdot}50\times 3{\cdot}00\times 10^8}{3{\cdot}00\times 10^8}\right)^2}$
	(c)	(i)	A (composite) particle made of a quark-antiquark pair.	**1**	Do not accept: made of two quarks
		(ii)	Into the page	**1**	
	(d)	(i)	W boson **OR** Z boson	**1**	
		(ii)	$4{\cdot}20$ GeV = $4{\cdot}20 \times 10^9 \times 1{\cdot}60 \times 10^{-19}$ **(1)** $E = mc^2$ **(1)** $(4{\cdot}20\times10^9\times 1{\cdot}60\times10^{-19}) = m\times(3{\cdot}00\times10^8)^2$ **(1)** $m = 7{\cdot}47\times10^{-27}$ kg **(1)**	**4**	Accept: 7·5, 7·467, 7·4667 Relationship anywhere 1 mark.

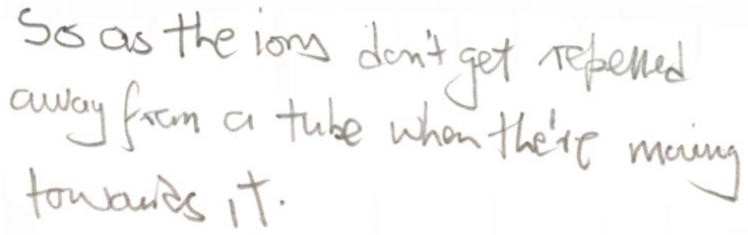
Q7(a)(i) Maximum mark: 1

Response A

Marks



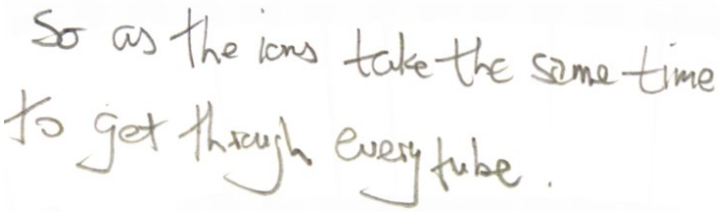
Response B



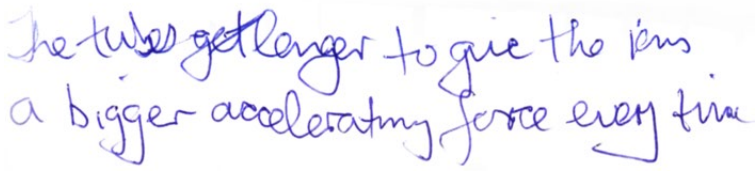
Q7(a)(ii) Maximum mark: 1

Response A

Marks



Response B



Q7(b) **Maximum mark: 3**

Response A

Marks

$$l' = l\sqrt{\left(1-\frac{v^2}{c^2}\right)}$$

$$l' = 13\sqrt{1-\frac{0.5c^2}{c^2}}$$

$$l' = 9.2\ m$$

Response B

$$l' = l\sqrt{1-v^2/c^2}$$

$$l' = 13\sqrt{1-\frac{c^2}{4c^2}}$$

$$l' = 11.258\ m$$

7(a)(i)	A	1	0	The candidate's explanation is insufficient for the mark to be awarded. The statement 'in a straight line' is not an acceptable alternative for 'in the same direction'.
	B	1	1	The use of 'repelled' in the candidate's explanation implies that, without an alternating supply voltage, the force on the hydrogen ion would not be in the same direction.
7(a)(ii)	A	1	1	The candidate's suggestion is an acceptable alternative to 'they travel further in the same time'.
	B	1	0	The candidate's suggestion is incorrect.

Question	Candidate response	Max mark	Mark awarded	Commentary
7(b)	A	3	1	The candidate has selected an appropriate relationship but has not correctly substituted values ($0.5c^2$ rather than $(0.5c)^2$).
	B	3	2	The candidate has selected appropriate relationships and has correctly substituted values. The candidate has given the final answer to an unacceptable number of significant figures (sig figs), (correct final answer to 2 sig figs, acceptable final answers to 1, 3 or 4 sig figs).