

4	<p>The only correct answer is A because impulse has the units of mass \times velocity B is not correct because this is not units of mass \times velocity C is not correct because N is not a base unit D is not correct because N is not a base unit</p>	1
5	<p>The only correct answer is D because this is a requirement for creating new particles rather than investigating structure A is not correct because this is a reason why particles with high energy are required B is not correct because this is a reason why particles with high energy are required C is not correct because this is a reason why particles with high energy are required</p>	1
4	<p>The only correct answer is C ($v \approx c$) A is not correct because the muons cannot travel faster than the speed of light B is not correct because muons cannot travel at the speed of light D is not correct because the muons would not experience relativistic effects with this speed</p>	1
6	<p>D is the only correct answer because $t = \frac{-r}{\ln\left(\frac{r}{r_0}\right)}$ A is not correct because it is not $\frac{-r}{\ln\left(\frac{r}{r_0}\right)}$ B is not correct because it is not $\frac{-r}{\ln\left(\frac{r}{r_0}\right)}$ C is not correct because it is not $\frac{-r}{\ln\left(\frac{r}{r_0}\right)}$</p>	1
8	<p>C is the only correct answer because the area under a force-time graph is the change in momentum A is not correct because the area under a force-time graph is not acceleration B is not correct because the area under a force-time graph is not force D is not correct because the area under a force-time graph is not distance</p>	1
6	<p>The only correct answer is D ($\sqrt{2 \times 9.11 \times 10^{-31} \times 3.5 \times 10^{-28}}$) A is not correct because this is not $\sqrt{2 \times m \times E_k}$ B is not correct because this is not $\sqrt{2 \times m \times E_k}$ C is not correct because this is not $\sqrt{2 \times m \times E_k}$</p>	1
7	<p>B is the only correct answer because neutrons were not demonstrated to exist until Chadwick's experiments A is not correct because this is a valid conclusion C is not correct because this is a valid conclusion D is not correct because this is a valid conclusion</p>	1
6	<p>The only correct answer is D (thermionic emission) A is not correct because the process is thermionic emission B is not correct because the process is thermionic emission C is not correct because the process is thermionic emission</p>	1
3	<p>The only correct answer is B ($\frac{8.99 \times 10^9 \times (8.0 \times 10^{-6})^2}{0.020^2}$) A is not correct because distance is not squared, and charge is not squared C is not correct because distance is not squared D is not correct because charge is not squared</p>	1

9	<p>The only correct answer is C ($\sqrt{2}$)</p> <p>A is not correct because $E = \frac{p^2}{2m}$</p> <p>B is not correct because this would be the ration of $\frac{\text{momentum of S}}{\text{momentum of T}}$</p> <p>D is not correct because $E = \frac{p^2}{2m}$</p>	1
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20(a)	<p>Use of $C = 4\pi\epsilon_0 r$ (1)</p> <p>Use of $Q = CV$ (1)</p> <p>Use of $E = \frac{V}{d}$ (1)</p> <p>Use of $F = EQ$ (1)</p> <p>$F = 1.6 \times 10^{-3} \text{ N}$ (1)</p> <p><u>Example of calculation</u></p> <p>$C = 4\pi \times 8.85 \times 10^{-12} \text{ F m}^{-1} \times 3.5 \times 10^{-2} \text{ m} = 3.89 \times 10^{-12} \text{ F}$</p> <p>$Q = 3.89 \times 10^{-12} \text{ F} \times 4500 \text{ V} = 1.75 \times 10^{-8} \text{ C}$</p> <p>$E = \frac{4500 \text{ V}}{5.0 \times 10^{-2} \text{ m}} = 9.0 \times 10^4 \text{ V m}^{-1}$</p> <p>$F = 9.0 \times 10^4 \text{ N C}^{-1} \times 1.75 \times 10^{-8} \text{ C} = 1.58 \times 10^{-3} \text{ N}$</p>	5
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20(b)	<p>When the sphere touches the plate it is charged with the same polarity The force on the sphere due to the electric field is away from that plate so it moves towards the opposite plate (1)</p> <p>Or the sphere is repelled from the plate with the charge of the same sign</p> <p>Or the sphere is attracted towards the plate with opposite charge When the sphere touches the charged plate opposite the first it becomes oppositely charged and is repelled from that charged plate (and so on) (1)</p> <p>Or When the sphere touches the oppositely charged plate it becomes oppositely charged and is attracted to the first plate (and so on) (1)</p>	3
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20(c)	<p>(The bell connected to the lightning conductor becomes positively charged so) <u>electrons</u> are attracted to the right-hand side of the sphere (1)</p> <p>The sphere is attracted to the positively charged bell (1)</p> <p>[MP2 dependent on award of MP1]</p>	2
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14(a)	<p>The (metal in the) filament is heated (by the current) (1)</p> <p>The electrons are released by <u>thermionic emission</u> (1)</p>	2
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14(b)	Use of $p = \frac{h}{\lambda}$	(1)	4
	Use of $E_k = \frac{p^2}{2m}$ Or $p=mv$ and $E_k = \frac{1}{2}mv^2$	(1)	
	Use of $V = \frac{w}{Q}$	(1)	
	$V = 2100 \text{ V}$	(1)	
	<u>Example of calculation</u> $p = \frac{6.63 \times 10^{-34} \text{ J s}}{2.65 \times 10^{-11} \text{ m}} = 2.50 \times 10^{-23} \text{ kg m s}^{-1}$ $E_k = \frac{(2.50 \times 10^{-23} \text{ kg m s}^{-1})^2}{2 \times 9.11 \times 10^{-31} \text{ kg}} = 3.44 \times 10^{-16} \text{ J}$ $V = \frac{3.44 \times 10^{-16} \text{ J}}{1.6 \times 10^{-19} \text{ C}} = 2147 \text{ V}$		

17(a)(i)	Calculates area swept out	(1)	5
	Use of $s = vt$	(1)	
	Calculates volume of air	(1)	
	Use of $m = \rho V$	(1)	
	$m = 3.3 \times 10^{-3} \text{ (kg)}$	(1)	
	<u>Example of calculation</u> $A = \pi \times (0.041 \text{ m})^2$ $= 5.28 \times 10^{-3} \text{ m}^2$ $s = 2.4 \text{ m s}^{-1} \times 0.2 \text{ s} = 0.48 \text{ m}$ $V = 5.28 \times 10^{-3} \text{ m}^2 \times 0.48 \text{ m} = 2.53 \times 10^{-3} \text{ m}^3$ $m = 1.3 \text{ kg m}^{-3} \times 2.53 \times 10^{-3} \text{ m}^3$ $m = 3.29 \times 10^{-3} \text{ kg}$		

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17(a)(ii)	Use of $p = mv$	(1)	2
	$p = 7.91 \times 10^{-3} \text{ kg m s}^{-1}$ (ecf from (i))	(1)	
	<u>Example of calculation</u> $p = 3.29 \times 10^{-3} \text{ kg} \times 2.4 \text{ m s}^{-1}$ $p = 7.91 \times 10^{-3} \text{ kg m s}^{-1}$		

17(a)(ii)	Use of $p = mv$ (1) $p = 7.91 \times 10^{-3} \text{ kg m s}^{-1}$ (ecf from (i)) (1) <u>Example of calculation</u> $p = 3.29 \times 10^{-3} \text{ kg} \times 2.4 \text{ m s}^{-1}$ $p = 7.91 \times 10^{-3} \text{ kg m s}^{-1}$	2
17(a)(iii)	Use of $F = \Delta mv / \Delta t$ (1) $F = 0.039 \text{ N}$ (ecf from (ii)) (1) <u>Example of calculation</u> $F = 7.91 \times 10^{-3} \text{ kg m s}^{-1} / 0.2 \text{ s}$ $F = 0.039 \text{ N}$	2
17(b)(i)	Vertically downward arrow from plane labelled weight/ W/mg (1) Arrow along thread away from plane labelled tension/ T (1)	2
17(b)(ii)	States $mg = T \cos \theta$ (1) States $mv^2 / r = T \sin \theta$ (1) Suitable algebra to arrive at $\tan \theta = v^2 / rg$ (1) OR $\tan \theta = F_C / W$ substitute $F_C = mv^2 / r$ and $W = mg$ Suitable algebra to arrive at $\tan \theta = v^2 / rg$ <u>Example derivation</u> $mg = T \cos \theta$ $mv^2 / r = T \sin \theta$ $\sin \theta / \cos \theta = mv^2 / rmg$ $\tan \theta = v^2 / rg$	3
17(b)(iii)	Use of $\tan \theta = v^2 / rg$ (1) Use of $\omega = \frac{2\pi}{T}$ and use of $v = \omega r$ Or Use of $v = \frac{2\pi r}{T}$ (1) $t = 1.4 \text{ s}$ (1) <u>Example of calculation</u> $\tan 22^\circ = v^2 / 0.21 \text{ m} \times 9.81 \text{ N kg}^{-1}$ $v = 0.91 \text{ m s}^{-1}$ $0.91 \text{ m s}^{-1} = 2 \times \pi \times 0.21 \text{ m} / T$ $t = 1.446 \text{ s}$	3