1	(a)		Work = force x distance (moved in direction of force);	1	
			Power = work/time /AW	1	
			Power = force x distance/time = force x velocity	1	3
	(b)	(i)	$P = Fv = 2 \times 10^5 \times 10$	1	
			$= 2M/2 \times 10^6$ (W) *give 1 mark for 20(W)*	1	2
		(ii)	Graph shows F is proportional to 1/v **or** minimum of two more calculations of P to show same value	1	1
		(iii)	$F = 2 \times 10^6/5 = 4 \times 10^5$ (N) *ecf from b(i)*	1	1
	(c)	(i)	Resultant force = mass x acceleration;	1	
			$2 \times 10^5 - 5 \times 10^4 = 3 \times 10^5 a$;	1	
			$a = 0.5$ (m s^{-2}) *give max 1 mark for a = 0.67 (m s^{-2})*	1	3
		(ii)	max. speed when a = 0 / F = 5×10^4 N;	1	
			giving v = 40 (m s^{-1}) from fig 1.1 or by calculation	1	2
			Total		12
2	(a)	(i)	Line in direction NA	1	
		(ii)	Line passing perpendicular to the tangent at the point of closest approach to N *judged by eye*	1	2
	(b)	(i)	k.e. = ½ mv^2 (= 8×10^{-13})	1	
			$v^2 = 2 \times 8 \times 10^{-13}/6.7 \times 10^{-27} = 2.39 \times 10^{14}$	1	
			$v = 1.5(45) \times 10^7$ (m s^{-1})		2
		(ii)	$mv = 6.7 \times 10^{-27} \times 1.5 \times 10^7 = 1.0(35) \times 10^{-19}$ (kg m s^{-1})	1	1
	(c)	(i)	m/4, v x 2 so p/2 from b(ii) or use k.e = $p^2/2m$;correct substitution with $m = m_p$ to give $p = 5 \times 10^{-20}$ (kg m s^{-1})	2	2
		(ii)	(average) force smaller/recoil slower/momentum less/interaction time shorter/angle of recoil different/steeper/AW *allow smaller/shorter distance* *any 2*	2	2
	(d)		$F = (1/4\pi\varepsilon_0) Q_1Q_2/r^2$; $Q_1 = 1$ (e), $Q_2 = 97$ (e);	2	
			correct substitution of figures	1	
			giving $F = 3.97 \times 10^{-2}$ (N) accept 0.04 N *allow 79e giving 0.032 (N)*	1	4
			Total		13

3	(a)		p is the pressure, V the volume, n is the number of mole/amount of gas, R is (universal) gas constant, T is the absolute temperature /in K *for one error/omission give one mark, for two give zero*	2		2
	(b)	(i)	$pV = m/_M RT$; $1.0 \times 10^5 \times 0.1 = m/_{0.03} \times 8.31 \times 300$; **or** show n = 4.0 mol; m = nM; m = 0.12 (kg)	2 1		3
		(ii)	V/T = constant / ρT = constant; $x = \rho_1/\rho_2 = T_2/T_1$; = 300/500 = 0.6 [or calculate mass =0.072 kg at 500 K; using $pV = m/_M RT$; ratio with b(i)	1 2 3]		3
		(iii)				
		1	molecules have more k.e. / k.e.∝ T	1		
		2	$v \propto \sqrt{T}$ **or** ½ $mv^2 \propto T$; $f = \sqrt{(500/300)} = 1.29$ accept 1.3	2		3
				Total		**11**
4	(a)	(i)	acceleration ∝ displacement (from a fixed point); directed towards that point/AW *for symbols without explanation max 1 mark*	1 1		2
		(ii)	amplitude is decreasing; follows sine wave (of decreasing amplitude)/has constant period/frequency / period/frequency independent of amplitude	1 1		2
	(b)		reading T = 0.67 s / 6 oscillations in 4 s / AW; f = 1/T = 1.5 (Hz) [*alter* f = no. oscillations/s = 1.5 (Hz) *give 2 marks*]	1 1		2
	(c)	(i)	5 (mm)	1		1
		(ii)	e.g 0 to 3 in 0.5 steps *ecf from b*	1		1
		(iii)	approx. same (or slightly lower) resonance frequency; smaller amplitude/broader peak *but curves must not cross*; passes through (0, 5 mm)	1 1 1		3
				Total		**11**
5	(a)	(i)	at least 3 parallel lines perpendicular to plates; arrows down	2		2
		(ii)	$V = Ed = 3 \times 10^5 \times 1.5 \times 10^3 = 450$ M/4.5×10^8 (V)	1		1
	(b)		battery acts as the (thermal) source of energy/models wind/AW; resistor required to model slow rate of charging of cloud (to 25 s)/AW; capacitor is the plates/cloud which become(s) charged;	1 1 1		3
	(c)	(i)	I = Q/t; = 20/25 = 0.8 (A)	2		2
		(ii)	$R = V/I$; = $4.5 \times 10^8/4.0$ = 110M/1.1×10^8 Ω *ecf from c(i)*	2		2
		(iii)	$C = Q/V$; = $20/4.5 \times 10^8 = 4.4 \times 10^{-8}$/44 n(F)	2		2
		(iv)	T = RC; = 1.1 x 4.4 = 4.95 or 5.0(s) *ecf from c(ii) & (iii)*	2		2
				Total		**14**

6	(a)		Circular; motion caused by a force in plane perpendicular to the B-field; and at right angles to the motion of the charged particle at all points/AW *any 2*	2	2
	(b)	(i)	$F = mv^2/r$; $= 9.1 \times 10^{-31} \times 10^{16}/0.04$;	2	
			$= 2.3 \times 10^{-13}$ (N)	1	3
		(ii)	Perpendicular to path towards centre of circle	1	1
	(c)		$F = BQv$; $= 2.3 \times 10^{-13}$ *ecf b(i)*	1	
			$B = 2.3 \times 10^{-13}/1.6 \times 10^{-19} \times 10^{8}$; $= 1.4(4) \times 10^{-2}$; T/tesla/Wb m^{-2}	3	4
	(d)		Use of $E = mc^2$;	1	
			$E = 2m_ec^2 = 2 \times 9.1 \times 10^{-31} \times 9.0 \times 10^{16}$;$= 1.6(3) \times 10^{-13}$ (J)	2	3
			allow E + k.e. of particles = 1.7(3) x 10^{-13} (J)		
			Total		13
7	(a)		*Activity*:The number of atoms/nuclei which decay/decays per second from/within the sample	1	
			factors affecting activity:the decay constant/the half-life/the nature of the nuclide;	1	
			the number of undecayed nuclei present; which determines how many will decay in the next second as the probability of decay is fixed/AW time factor/how old the sample is/the shorter the half-life the more decays per second/other sensible similar statements	2	
			factors not affecting activity: maximum of two sensible suggestions such as pressure, temperature, chemical reaction, etc.	1	
			maximum 6 marks	2	6
	(b)		*similarities*: both release energy in process;	1	
			(rest) mass of fragments less than original;	1	
			conservation of charge/mass-energy, etc. *maximum 2 marks*	1	
			differences:decay into two particles; fission into more particles/4 or 5;	2	
			decay energy release is small compared to fission;	2	
			decay cannot be initiated by any known process/random/spontaneous/ obeys laws of probability/AW; fission can be initiated by incident neutron/fission rate can be varied/controlled/AW;	2	
			energies and masses in decay always the same; fission can be into many different combinations with different energies;	2	
			most of energy in decay carried away by small particle; in fission by massive particles/fragments;	2	
			any other sensible difference with 1 mark for description of each process in comparison (marks must be awarded in pairs) maximum mark 4	2	6
			Quality of Written Communication (see separate sheet)		4
			Total		16

Criteria for assessment of written communication

4 marks

- The candidate expresses ideas extremely clearly and fluently. Sentences and paragraphs follow on from one another smoothly and logically.
- Arguments are consistently relevant, based on sound knowledge of Physics, and are well structured.
- There are few, if any, errors in grammar, punctuation and spelling.

3 marks

- The candidate expresses moderately complex ideas clearly and reasonable fluently through well-linked sentences and paragraphs.
- Arguments are generally relevant being based on a good knowledge of physics, and are well structured.
- There are occasional errors in grammar, punctuation and spelling.

2 marks

- The candidate expresses straightforward ideas clearly and accurately, if not always fluently. Sentences and paragraphs are not always well connected.
- Arguments may sometimes stray from the point or be weakly presented.
- There are some errors in grammar, punctuation and spelling, but not to suggest a serious weakness in these areas.

1 mark

- The candidate expresses simple ideas clearly, but is imprecise and awkward in dealing with complex or subtle concepts.
- Arguments are of doubtful relevance or obscurely presented.
- Errors in grammar, punctuation and spelling and noticeable and intrusive, suggesting weaknesses in these areas.

0 marks

- Even simple ideas are not expressed clearly.
- Arguments are irrelevant or poorly stated.
- There are gross errors in grammar, punctuation and spelling.