Abbreviations, annotations and conventions used in the Mark Scheme	/	= alternative and acceptable answers for the same marking point
	;	= separates marking points
	()	= words which are not essential to gain credit
	ecf	= error carried forward
	AW	= alternative wording

Question			Expected Answers	Marks	
1	a	i	acceleration ∝ displacement; indication of restoring force by negative sign/acc. in opp. direction to displacement/acc. towards origin/AW	1	
		ii	linear graph through origin; negative gradient	1	
	b	i	0.05 (m)	2	4
		ii	$4\pi^2f^2 = a/A$; = 12.5/0.05 = 250 so f = 2.5(1) Hz; T = 1/f (= 0.4 s)	1 3	4
	c	i	cosine wave; correct period of 0.4 s; correct amplitude of 0.05 m	3	3
		ii	0; 0.1/0.3/0.5/0.7/0.9 (s)	2	2
			Total		13
2	a	i	$\rho = m/V = m/Av$; $m = A\rho v = 7.5 \times 10^{-5} \times 1000 \times v = 0.09$ giving $v = 1.2$ m s^{-1}	2	
		ii	2.4 (m s^{-1})	1	
		iii	F = d (mv)/dt /AW; F = 0.09 x (2.4 – 1.2) ;= 0.11 (N) ; *ecf (a)ii*	3	
		iv	towards or into shower head/backwards *ecf (a)iii*	1	7
	b	i	P = (m/s)cθ ; = 0.09 x 4200 x (27 – 15); = 4536 or 4500; W or 4.5 kW	4	
		ii	energy losses in pipe from heater to shower head/ less than 100% energy transfer from heater to water/AW	1	
		iii	15 + 24 = 39(°C)	1	6
			Total		13
3	a		equally spaced horizontal parallel lines from plate to plate; arrows towards B; quality mark	1	
	b		E = V/d ; = 600/0.04 ;(= 1.5 x 10^4 V m^{-1})	2	3
	c		F = QE / 1.6 x 10^{-19} x 1.5 x 10^4 ;= 2.4 x 10^{-15} (N)	2	2
	d		$1/2mv^2 = Fd$ **or** QV ; = 1.6 x 10^{-19} x 600 or = 2.4 x 10^{-15} x 0.04 *ecf (c)* **or** alternative method by constant acceleration formulae; (either method giving $v^2 = 2.1 \times 10^{14}$ and v = 1.45 x 10^7 m s^{-1})	2	2
	e		$\sqrt{2}v = 2.05 \times 10^7$ (m s^{-1})	1	1
	f		fewer electrons will reach grid B **or** C (as higher initial speed required); so current will fall (to zero if beam is taken to be monoenergetic)	1 1	2
			Total		12

Question			Expected Answers	Marks	
4	a	i	C = Q/V or gradient of graph / = 24 μC/3V ; = 8.0 (μF)	2	
		ii	$E = ½ CV^2$ / = $^1/_2$ x 8 x 3^2 ; = 36 (μJ) *ecf a(i)* or ½ QV / = ½ x 24 x 3 ; = 36 (μJ)	2	
		iii	T = RC = (0.04) ; R = 0.04/8.0μ = 5.0 x 10^3 (Ω) *ecf a(i)*	2	
		iv	idea of exponential/constant ratio in equal times; which is independent of initial value/AW or argued mathematically in terms of $Q/Q_o = e^{-t/RC}$ *give 1 mark for statement that time depends only on time constant/RC*	2	8
	b	i	$C_p = C + C = 6$ μF; $1/C_s = 1/2C + 1/C$; = 3/2C giving $C_s = 2C/3 = (2$ μF)	3	
		ii	2 sets of (3 in series) in parallel/ 3 sets of (2 in parallel) in series	2	5
			Total		13
5	a	i	number of decays/atoms/nuclei decaying per second/unit time in the source/AW	1	
			count (rate) without source present/AW	1	
		ii	distance of detector from source/dimensions of source or detector window/efficiency of detector/rate of emission v detection, e.g dead time correction/other sensible suggestion;	1	
			reason/effect on count rate	1	4
	b	i	(take lns of both sides) appreciate $\ln e^{-\lambda t} = -\lambda t$; and $\ln C/C_o = \ln C - \ln C_o$ **or** when multipyling logs add	2	
		ii	gradient = 0.056 h^{-1} *allow ± 0.002 h*$^{-1}$;T = ln2/λ =ln2/gradient = ln2/0.056 h; T = 12.4 h *allow ± 0.4 h*	3	5
	c		mass change/charge change/range/speed of emission/monoenergetic v range of speed/alpha emitted from only high mass nuclei/number of particles in the decay/other sensible suggestion **or** further detail *any three*	3	3
			Total		12
6	a	i	BA / = 0.05 x 0.05 x 0.026 ; = 6.5 x 10^{-5}; Wb/T m^2	3	
		ii	BA sin 45°/BAcos 45° = 4.6 x 10^{-5} Wb *ecf (a)i*	1	
		iii	0	1	5
	b	i	a point where curve crosses t-axis	1	
		ii	voltage is proportional to the rate of change of flux linking the coil; rate of flux change is zero/very small when the flux linking the coil is a maximum	1 1	
		iii	sinusoidal curve; of double the amplitude; and half the period	3	6
			Total		11

Question		Expected Answers		Marks	
7	a	proves existence of a nucleus to the atom;		1	
		containing most of the atomic mass; because of bouncing back;		2	
		of very small size; because of few scattered through any angles at all;		2	
		containing charged particles; because the scattering is consistent with the pattern predicted by Coulomb/electrostatic repulsion;		1 1	
		electrons have opposite/smaller charge; and a much smaller mass;		1	
		a diffraction pattern is observed (superimposed on the Rutherford scattering curve);		2	
		as the electrons behave like waves; with a λ of the order of d for significant scattering/having a de Broglie wavelength;		1 1	
		pattern/size of ring enables radius of the nucleus to be found	*max 7*	1	7
	b	Diagram showing **or** description of incident beam scattered by or diffracted through crystal at only certain angles;		1	
		moveable detector to measure angles;		1	
		electrons are scattered from crystal planes like a diffraction grating/because of the regular array of atoms;		1	
		constructive interference only occurs at certain angles ; depending on λ and d;		1	
		pattern of maximum signals can be very complex depending on structure/AW;		1	
		must achieve λ of the order of d for significant scattering;		1	
		size of pattern depends on ratio of λ/d **or** maxima occur at angles of about nλ/d;		1	
		de Broglie's relation p = h/λ for electrons shows why different energies are needed	*with this detail worth 2 marks*;	2	
		further detail, e.g. electrons accelerated to MeV for nuclei or a few keV for atomic spacing		1	
		as λ is known d can be found	*max 5*	1	5
		Quality of Written Communication			4
			Total		16