Question	Answer	Marks
6(a)	it is zero when (plane of) probe is parallel to the (magnetic) field (lines)	**B1**
	it is maximum when (plane of) probe is perpendicular to (magnetic) field (lines)	**B1**
6(b)(i)	number density of charge carriers	**B1**
6(b)(ii)	smaller value of *n* so greater Hall voltage / V_H	**B1**
6(c)	(36 mV corresponds to) 48 mT	**C1**
	use of 1.4 s or (8.6 – 7.2) s	**C1**
	$E = \Delta BAN / \Delta t$	**C1**
	$= \dfrac{48 \times 10^{-3} \times 0.018^2 \times \pi \times 780}{1.4}$ = 0.027 V	**A1**

Question	Answer	Marks
7(a)	photon absorbed (by electron) and electron excited	B1
	photon energy equal to difference in (energy of two) energy levels	B1
	photon energy relates to a single wavelength / single frequency	B1
	electron de-excites and emits photon in any direction	B1
7(b)	$\frac{hc}{\lambda} = \Delta E$	C1
	uses 658 nm	C1
	$\frac{6.63\times10^{-34}\times3.00\times10^{8}}{658\times10^{-9}} = -E_1 - (-3.40\times1.60\times10^{-19})$ $E_1 = -2.42\times10^{-19}$ J	A1

Question	Answer	Marks
8(a)	234, 92 for the uranium nucleus	B1
	4, 2 for the alpha particle	B1
8(b)(i)	$N_0 = 0.874 / (238 \times 1.66 \times 10^{-27})$ $= 2.21 \times 10^{24}$	A1
8(b)(ii)	$A = \lambda N$	C1
	$= \dfrac{\ln 2}{87.7 \times 365 \times 24 \times 3600} \times 2.21 \times 10^{24}$ $= 5.54 \times 10^{14}$ Bq	A1
8(b)(iii)	power $= 5.54 \times 10^{14} \times 5.59 \times 10^{6} \times 1.60 \times 10^{-19}$	C1
	$= 496$ W	A1
8(b)(iv)	$65.3 = 100e^{-\frac{\ln 2}{87.7}t}$	C1
	$\ln 0.653 = -(\ln 2 / 87.7)\, t$ $t = 53.9$ years	A1
8(c)	advantage: less mass so less energy needed to launch probe	B1
	disadvantage: half-life shorter so will not provide power for as long	B1

Question	Answer	Marks
9(a)	piezo-electric crystal	B1
	(ultrasound) wave causes shape change / vibrations (of crystal)	B1
	shape change / vibrations causes e.m.f. (which is detected)	B1
9(b)(i)	93 V	A1
9(b)(ii)	2.7×10^7 rad s^{-1}	A1
9(c)(i)	kg m^{-2} s^{-1}	B1
9(c)(ii)	$\rho = Z / c = 1.7 \times 10^6 / 1600$ $= 1100$ kg m^{-3}	A1
9(c)(iii)	intensity reflection coefficient ≈ 1 **or** Z_1 and Z_2 are very different	B1
	almost no / no ultrasound transmitted (into air filled cavity)	B1

Question	Answer	Marks
10(a)	brighter star could be closer (to Earth)	B1
	brighter star could have a greater luminosity (in the visible wavelengths)	B1
10(b)	object with known luminosity	B1
10(c)(i)	$\frac{660.9 - 656.3}{656.3} \approx \frac{v}{3.0 \times 10^8}$ leading to 2.1×10^6 m s^{-1}	B1
10(c)(ii)	$v = H_0 d$	C1
	$d = 2.1 \times 10^6 / 2.3 \times 10^{-18}$ $= 9.1 \times 1023$ m	A1
10(c)(iii)	wavelength has increased / light is redshifted	B1
	star within galaxy is moving away / receding (from Earth)	B1
	Universe is expanding	B1