Question	Answer	Marks
1	D	1
2	Activity = (–)5.0 × 10^{-11} s^{-1} × $\left(\frac{8.0\times10^{-11}\text{kg}}{4.0\times10^{-25}\text{kg}}\right)$ = 1 × 10^4 Bq	1 1
3 a	The chance of a given (or single) nucleus decaying in one second.	1 1
3 b	$T_{1/2} = \frac{\ln 2}{3.8\times10^{-12}\text{s}^{-1}}$ = 1.8 × 10^{11} s (or 5700 years)	1 1
3 c	$\frac{N}{N_0} = e^{-3.8\times10^{-12}\times14\,000\times3.2\times10^7}$ = 0.18 (18%)	1 1
4 a	The equation of the line is of the form $y = mx + c$. The decay constant is the negative of the gradient.	1 1
4 b	Suitable pairs of points taken from graph Leading to value of decay constant in range 0.009 to 0.011 s^{-1}	1 1
4 c	$T_{1/2} = \frac{\ln 2}{(\text{answer from part b})}$ Answers in range 63 s to 77 s	1 1
5	0.1 = $e^{-\lambda t}$ ln 0.1 = –7.6 × 10^{-10} s^{-1} × t t = 3(.03) × 10^9 s = 95 years	1 1 1
6 a	Third row: 810, 7290 Fourth row: 7290, 729, 6561	1 1
6 b	Substitution in equation; evaluation to 6700. Note that the time interval is 30 s. The iterative model keeps the rate of decay constant during each ten second interval. This exaggerates the rate of decay. Reducing the time interval between iterations will give a result closer to that obtained using the solution to the differential equation.	1 1 1 1 1
7	Energy = $\frac{1}{2}CV^2$ $C = \frac{2\times1\times10^6}{(10\times10^3)^2}$ = 0.02 F	 1 1
8 a	$V_{\text{voltmeter}} = V_0 e^{-t/RC}$ 1.9 = 3.0 × $e^{-100/RC}$ ln 1.9 = ln 3.0 – $\frac{100}{RC}$ $R = \frac{100}{220\times10^{-6}\times(\ln 3-\ln 1.9)}$ = 1.0 MΩ	 1 1 1
8 b	220 s	1

8 c	$0.5 = 3.0 \times e^{-t/220}$ T = (ln 3.0 – ln 0.5) × 220 = 400 s (1 s.f.)	 1 1
9 a	time constant = 2.2 kW × 4700 mF = 10.3 s	1 1
9 b	If exponential, the results will show the constant ratio property. 0.92/1.50 = 0.61 0.58/0.92 = 0.63 0.35/0.58 = 0.61 (one mark for two calculations, two marks for three calculations) Within the precision of the voltmeter and allowing for experimental errors, this seems reasonable as the ratios are constant. (Third mark only available if three correct calculations are made.)	2 1
10	$R = 5\ \text{M}\Omega$ $\ln\left(\frac{V}{V_0}\right) = -t/RC$ $C = 1.7 \times 10^{-3}$ F	1 1 1
11 a	$Q = 10^{-2}$ F × 6 V $= 6 \times 10^{-2}$ C	1 1
11 b	$I = \frac{V}{R} = \frac{6\ \text{V}}{6000\Omega}$ = 1 mA	1 1
11 c	Assuming constant current: charge leaving capacitor in 10 s = 1×10^{-2} C which is roughly 17% of the original charge.	1 1
11 d	$RC = 6 \times 10^{3}\ \Omega \times 10^{-2}$ F = 60 s The time constant is the time taken for the charge on the capacitor to fall to e^{-1} or about 37% of its original value.	1 1 1 1
11 e	$E = \frac{1}{2} \times 0.01\ \text{F} \times (6\ \text{V})^2$ = 0.18 J (or use $E = \frac{1}{2}CV^2$)	1 1
11 f	36 Ω	1
11 g	Assume complete discharge in five time periods (5τ) $= 5 \times 36\ \text{W} \times 10^{-2}$ F = 1.8 s Limitations: not fully discharged and the resistance of the filament will not be constant throughout the time interval/not as high as the working resistance calculated.	1 1 1 1