GCE Physics, Specification A, PHYA5/1, Nuclear and Thermal Physics

1	a		$\Delta T = (\frac{\Delta Q}{mc} =)\ \frac{8.5\times10^3}{4200\times0.12}$ ✓ 17 K ✓	2
1	b		$\left(\frac{\Delta T}{\Delta t} = \frac{\frac{\Delta Q}{\Delta t}}{mc}\right) = \frac{100-26}{\Delta t} = \frac{8.5\times10^3}{0.41\times4200}$ ✓ t = 15 s ✓	2
2	a		$({}^{206}_{76}\text{X} \rightarrow {}^{206}_{82}\text{Pb} + \beta\times {}^{0}_{-1}\beta + \beta\times\overline{\nu_e})$ β = 6 ✓	1
2	b	i	the energy **required** to split up the nucleus ✓ into its individual neutrons and protons/nucleons ✓ (or the energy **released** to form/hold the nucleus ✓ from its individual neutrons and protons/nucleons ✓)	2
2	b	ii	7.88 × 206 = 1620 MeV ✓ (allow 1600-1640 MeV)	1
2	c	i	U, a graph starting at 3×10^{22} showing exponential fall passing through 0.75×10^{22} near 9×10^9 years ✓ Pb, inverted graph of the above so that the graphs cross at 1.5×10^{22} near 4.5×10^9 years ✓	2
2	c	ii	(*u* represents the number of uranium atoms then) $\frac{u}{3\times10^{22}-u} = 2$ $u = 6\times10^{22} - 2u$ ✓ $u = 2\times10^{22}$ atoms	1
2	c	iii	(use of $N = N_o e^{-\lambda t}$) $2\times10^{22} = 3\times10^{22}\times e^{-\lambda t}$ ✓ $t = \ln 1.5 / \lambda$ (use of $\lambda = \ln 2 / t_{1/2}$) $\lambda = \ln 2 / 4.5\times10^9 = 1.54\times10^{-10}$ ✓ $t = 2.6\times10^9$ years ✓(or 2.7×10^9 years)	3
3	a		any 2 from: the sun, cosmic rays, radon (in atmosphere), nuclear fallout (from previous weapon testing) , any radioactive leak(may be given by name of incident) nuclear waste, carbon-14 ✓	1

3	b	i	(ratio of area of detector to surface area of sphere) ratio = $\frac{0.0015}{4\pi(0.18)^2}$ ✓ 0.0037 ✓ (0.00368)	2
3	b	ii	activity = 0.62/(0.00368 × 1/400) give first mark if either factor is used. 67000 ✓ Bq accept s^{-1} or decay/photons/disintegrations s^{-1} but not counts s^{-1}✓ (67400 Bq)	3
3	c		(use of the inverse square law) $\frac{I_1}{I_2} = \left(\frac{r_2}{r_1}\right)^2$ or calculating k = 0.020 from I = k/x^2 ✓ $I_2 = 0.62 \times \left(\frac{0.18}{0.28}\right)^2$ ✓ 0.26 counts s^{-1} ✓(allow 0.24-0.26)	3
4	a	i	$n = PV/RT = 3.2 \times 10^5 \times 1.9 \times 10^{-3}/8.31 \times 285$ n = 0.26 mol ✓ (0.257 mol)	1
4	a	ii	$P_2 = \frac{T_2}{T_1} \times P_1 = \frac{295}{285} \times 3.20 \times 10^5$ ✓ 3.31 × 10^5 Pa ✓(allow 3.30-3.35 × 10^5 Pa) 3 sig figs ✓sig fig mark stands alone even with incorrect answer	3
4	b		similar -(rapid) **random** motion - range of speeds different - **mean** kinetic energy - root **mean** square speed - **frequency** of collisions	2
5	a		graph starting (steeply) near/at the origin and decreasing in gradient ✓	1
5	b	i	(use of density = mass/volume) $\frac{197 \times 1.67 \times 10^{-27}}{\frac{4}{3}\pi\,(6.87 \times 10^{-15})^3}$ ✓✓mark for top line and mark for bottom line (allow use of 1.66 x 10^{-27}) Lose mass line mark if reference is made to mass of electrons = 2.4(2) × 10^{17} kg m^{-3}	2

5	b	ii	$R_{\text{A1}} = R_{\text{Au}} \left(\frac{A_{\text{A1}}}{A_{\text{Au}}}\right)^{\frac{1}{3}} = 6.87 \times 10^{-15} \left(\frac{27}{197}\right)^{\frac{1}{3}}$ ✓ = 3.54×10^{-15} m ✓ or $r_0 = \frac{R}{A^{\frac{1}{3}}} = \frac{6.87 \times 10^{-15}}{197^{\frac{1}{3}}} = 1.18 \times 10^{-15}$ m ✓ $R = 1.18 \times 10^{-15} \times 27^{\frac{1}{3}} = 3.54 \times 10^{-15}$ m ✓ or volume = mass/density = $\frac{27 \times 1.67 \times 10^{-27}}{2.42 \times 10^{17}} = \frac{4}{3}\pi \times R^3$ ✓ = 3.54×10^{-15} m ✓	2

5	c		**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. *The candidate makes 5 to 6 points concerning the principles of the method, the limitations to the accuracy and the advantages and disadvantages of a particular method* **Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. *The candidate makes 3 to 4 points concerning the principles of the method, the limitations to the accuracy and the advantages and disadvantages of a particular method* **Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. *The candidate makes 1 to 2 points concerning the principles of the method, the limitations to the accuracy and the advantages and disadvantages of a particular method*	max 6

			The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences. **principles** • α scattering involves coulomb or electrostatic repulsion • electron diffraction treats the electron as a wave having a de Broglie wavelength • some reference to an equation, for example $\lambda = h/mv$; $eV = mv^2/2$; $Qq/4\pi\varepsilon_o r = E_\alpha$; $\sin\theta = 0.61\lambda/R$ • reference to first minimum for electron diffraction **accuracy** • α's only measure the least distance of approach, not the radius • α's have a finite size which must be taken into account • electrons need to have high speed/kinetic energy • to have a small wavelength or wavelength comparable to nuclear diameter, the wavelength determines the resolution • the wavelength needs to be of the same order as the nuclear diameter for significant diffraction • requirement to have a small collision region in order to measure the scattering angle accurately • importance in obtaining monoenergetic beams • cannot detect alpha particles with exactly 180^o scattering • need for a thin sample to prevent multiple scattering **advantages and disadvantages** • α-particle measurements are disturbed by the nuclear recoil • Mark for α-particle measurements are disturbed by the SNF when coming close to the nucleus or electrons are not subject to the strong nuclear force. • A second mark can be given for reference to SNF if they add electrons are leptons or alpha particles are hadrons. • α's are scattered only by the protons and not all the nucleons that make up the nucleus • visibility – the first minimum of the electron diffraction is often difficult to determine as it superposes on other scattering events	