Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*		Mass defect = $((235.01+1.01)-(91.90+140.89+3(1.01)))$ u [or $(235.01-(91.90+140.89+2\times1.01))$] = 0.20 u (1) Energy released = 0.20×931 = 186 MeV [190 MeV] (1) (Accept 3.0×10^{-11} J) **UNIT**		2		2	2	
	(b)		**General (G)** G1:General shape of curve [correct asymmetry] & axes labelled G2:Maximum around nucleon number 60 / iron / nickel G3:Stability linked to BE/nuc to stability G4:Nucleons react to move towards maximum (on curve) G5:In doing so there is a loss / reduction in mass G6: Mass loss linked to energy released = $\Delta m\ c^2$ **Fusion (Fu)** Fu1: Smaller nucleon number nuclei combine Fu3: Larger nucleons of larger nucleon number formed: energy released, BE/nuc increases, stability increases, lower mass **Fission (Fi)** Fi1: Larger nucleon number split Fi3: Smaller nucleons of smaller nucleon number formed energy released, BE/nuc increases, stability increases, lower mass Additional point: gradient of curve larger in fusion region than fission resulting in more energy release (per nucleon) **5-6 marks** At least 6 G points (6-8 G) 8 – 11 points *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.*	6			6		
			3-4 marks 5 – 7 points *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** 1 – 4 points *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* **0 marks** *No attempt made or no response worthy of credit.*						
			Question 4 total	6	2	0	8	2	0

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		The most stable nuclei (or reference to elements near to peak i.e. Fe, Ni Ca) are therefore where the curve (or binding energy per nucleon) reaches its maximum. (1) Nuclei of small atomic mass number (lhs of graph) can combine to produce species of larger atomic mass number, [hence larger binding energy per nucleon. Energy is released]. Fusion. (1) Nuclei of large atomic mass number (on rhs of graph) break down to produce species of smaller atomic mass number, [hence larger binding energy per nucleon. Energy is released]. Fission. (1) Reference anywhere to there being energy released, when a <u>reduction in mass</u> occurs i.e. mass converted to energy. (1)	4			4		
	(b)		Mass defect = 4 (1.00728) + 2(0.00055) (1) – 4.00151 = [0.02871 u] (1) Energy: 0.02871 × 931= 26.7 [MeV] (1)		3		3	3	
	(c)		**Benefit:** routine supply of energy (i.e. does not depend on weather) or jobs or no CO_2 emission (1) **Issue:** needs secure storage of radioactive waste (products) over a extended time period or reference to long half-lives or long build time or building extra transmission power lines (1) **Reasoned conclusion** (1)			3	3		
			Question total	**4**	**3**	**3**	**10**	**3**	**0**

#3

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*			$^{228}_{90}\text{Th} \rightarrow {}^{224}_{88}\text{Ra} + {}^{4}_{2}\alpha$ (1) $^{90}_{38}\text{Co} \rightarrow {}^{90}_{39}\text{Y} + {}^{0}_{-1}\beta$ (1)		2		2		
	(b)			Nucleon mass = 90.727 u **or** nucleon mass +38 e (90.747u) (1) Mass defect attempted with or without electrons 0.84 u or 0.82 u (1) × 931 and division by 90 (1) Answer = 8.69 [MeV per nucleon] (1) If electrons not taken into account answer = 8.47 [MeV per nucleon] award 3 marks 782 or 762 [MeV per nucleon] award 2 marks	1	1 1 1		4	3	
	(c)	(i)		Probability of landing on black face = ¼ **or** 0.25 **or** 25 %		1		1	1	1
		(ii)	I.	Probability of not decaying (i.e. of remaining) after 1 throw = 1 – 0.25 = 0.75 (1) Probability of remaining after 2 throws = 0.75^2 **or** probability of remaining after n throws = $(0.75)^n$ (1)		2		2	2	2
			II.	Number predicted = $N_0 \times (0.75)^n$ = 31.76 = 32 Accept 31 or 31.76		1		1	1	1
			III.	Close to 0.75 for many throws **or** mean close to 0.75 or 32 is close to 35 or fits quite well with $(0.75)^n$ (1) Some further out e.g. 0.90 (1) Random process [these results are to be expected] (1)			3	3		3
				Question 6 total	**1**	**9**	**3**	**13**	**7**	**7**

#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*		Use of $F = Ap$ **and** $A = \pi r^2$ **or** accept $A = 4\pi r^2$ (1) Correct answer = 3 173 [N] (1) [no **ecf** from use of $A = 4\pi r^2$]	1	1		2	2	
	(b)		Fewer collisions …. (1) …because greater distances between molecules (or smaller density or more free space) (1)		2		2		
	(c)	(i)	Application of conservation of energy i.e. $E_k = \frac{Qq}{4\pi\varepsilon_0 r}$ (1) Conversion of 4.7 MeV → J i.e. $4.7 \times 10^6 \times 1.6 \times 10^{-19} = 7.52 \times 10^{-13}$ J (1) Answer = 4.8×10^{-14} [m] (1)		3		3	3	
		(ii)	Smaller than atomic radius or inside plum pudding (1) So force / PE never great enough (for rebound) or scattering angle too large in experiment (1)			2	2		
	(d)		Use of conservation of energy to get speed or momentum e.g. $p^2 = 2mE_k$ etc. $v = 3.75 \times 10^7$ [m s^{-1}] or $p = 3.41 \times 10^{-22}$ [N s] (1) Calculation of a wavelength using $\lambda = \frac{h}{p}$ (even if incorrect, 1.94×10^{-11} m is the correct value) (1) Comparison of the calculated wavelength with atomic separation (or 10^{-9} to 10^{-11} m) (1) Correct final conclusion **and** correct wavelength (1.94×10^{-11} m) (1)			4	4	3	
	(e)		Proton repulsion or like charges repel etc.	1			1		
	(f)		Photon mom calculated $\left(p = \frac{h}{\lambda}\right)$ = 2.73×10^{-22} [kg m s^{-1}] (1) Electron momentum calculated = 9.11×10^{-26} [kg m s^{-1}] (1) [Initial momentum negligible] so final momenta must cancel (1)			3	3	2	
	(g)		Charge of $\bar{\mathrm{u}}\mathrm{d} = -\frac{2}{3} - \frac{1}{3}$	1			1		
	(h)		**Either:** Mass = $\frac{172\ \mathrm{G[eV]}}{931\ \mathrm{M[eV\ u^{-1}]}}$ = 185 [u] (1) ∴ Mass = 185 [u] × 1.66×10^{-27} [kg u^{-1}] = 3.07×10^{-25} [kg] (1) **Or:** Mass energy = 172 GeV × 1.60×10^{-19} J eV^{-1} = 2.75×10^{-8} [J] (1) ∴ Mass = $\frac{2.75 \times 10^{-8}\ \mathrm{[J]}}{(3.00 \times 10^8\ \mathrm{[m\ s^{-1}]})^2}$ = 3.06×10^{-25} [kg] (1)		2		2	2	
			Question 7 total	**3**	**8**	**9**	**20**	**12**	**0**