Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*		Mass can be converted to energy (or vice versa or $E = mc^2$) (1) So mass-energy cons used if change of mass (1) i.e. short concluding comment stating briefly mass-energy conservation (rather than simple energy conservation) also accept $m_0c^2 + E$ conserved (or similar)	2			2		
	(b)		Baryon number OK [1+1 = 5-3+1-1+0+0+0] or 2=2 (1) Accept U and D conservation : 4U + 2D = 4U + 2D Or Quark number: 6 = 6 Lepton number not OK [0+0 ≠ 0+0+0+0+0+0+4] or 0≠4 (1) Charge conservation OK [1+1 = 5-3+0+0+2-2+0] or 2=2] (1) Mass energy not OK not enough energy to produce products (1) If not 4 correct conclusions 3max.			4	4		
			Question 7 total	**2**	**0**	**4**	**6**	**0**	**0**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			Indicative content: 1. Names - electron, positron (anti-electron), neutron, anti-proton, pion/pi meson 2. Fundamental/composite - electron&positron fundamental others not 3. Leptons - electron & positron (anti-lepton) OR lepton numbers 4. Hadrons - neutron, anti-proton & pion 5. Baryons & mesons - neutron (B), anti-proton (anti-baryon), pion - meson OR baryon numbers 6. Quarks - neutron - 3 quarks, anti-proton - 3 anti-quarks, pion - quark + anti-quark 7. Strong force - felt by hadrons or quarks only 8. Weak force - felt by all particles OR accept leptons 9. E-M force - felt by all charged particles 10. Make-up - udd, $\overline{\mathbf{uud}}$, $\overline{\mathbf{ud}}$ 11. Charge - -1, +1, 0, -1, -1 12. Anti-particles - positron for electron and anti-proton mentioned	6			6		
			5-6 marks 7-12 points – all particles considered There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. **3-4 marks** 3-6 points – majority of particles considered There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. **1-2 marks** 1-2 points – a few particles considered 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 total	**6**	**0**	**0**	**6**	**0**	**0**

#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)		$-\frac{2}{3}-\frac{2}{3}-\frac{2}{3}=-2$ seen or statement that this is the only way to get a charge of -2(e)		1		1		
	(b)		$\overline{uuu} \rightarrow \overline{uu}\overline{d} + \overline{u}d$ or $\overline{uuu}+u\overline{u}$ or $\overline{uuu}+d\overline{d}$ [1] [any order of quarks in the baryon and meson] Anti-proton or anti- Δ^+ and π^- OR anti- Δ^{++} and π^0 [1]			2	2		
	(c)		Strong force [1] no ecf Short time or conservation of u and d and no photon or accept ONLY quarks / hadrons involved or no neutrinos and no photons or no flavour change and no photons [1]			2	2		
	(d)		**Any 3 x (1) valid points:** -contradicts current theories (relativity) or can't travel faster than the speed of light ✓ -current theories well established ✓ -further experiments ✓ -by other groups / scientists / peer review ✓ -due to instrument problems (timing delay) / systematic errors ✓			3	3		
			Question 6 total	**0**	**1**	**7**	**8**	**0**	**0**

#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		0 +0 = 0 -1 [+1] [Lepton conservation] (1) +1 +1 = +1 +1 [+0] [Charge conservation] (1) Neutrino (1)		1 1	1	3		
	(b)		Weak (1) Presence of neutrino / change of quark flavour (1)	2			2		
	(c)	(i)	Proton / p / ^2_1H	1			1		
		(ii)	Positron / e^+ Allow anti-electron	1			1		
	(d)		Any 2 ×(1) from: • Economic argument given e.g. money better spent on welfare / health etc • Scientific consequence discussed e.g. need to know origin of universe • Benefits to mankind from advanced research / new technologies • Scientific investment generates money			2	2		
			Question total	**4**	**2**	**3**	**9**	**0**	**0**

#5

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	(a)		Protons and neutrons are each made up of 3 quarks (1) Quarks and neutrinos are not made up of other particles (1)	2			2		
	(b)	(i)	No strong force / no electromagnetic force /only interact by weak force (1) They are uncharged (1)	2			2		
		(ii)	Conservation of charge 0 + 1 → 1 + 1 –**1** (1) Conservation of lepton 1 + 0 → 0 + 0 + **1** (1) x is an electron (1)		1 1	1	3		
	(c)		Electromagnetic (1) Presence of photons / gamma rays (1)		1	1	2		
			Question 7 total	**4**	**3**	**2**	**9**	**0**	**0**

#6

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*		**Differences** **Hadrons** H1 Made up of quarks H2 Affected by strong interaction H3 e.g. protons / neutrons / mesons **Leptons** L1 Fundamental particles L2 Not affected by strong interaction L3 e.g. electron / electron neutrino **Similarities** S1 Both have a rest mass / gravitational attraction S2 Both can be affected by the weak interaction S3 Both can be affected by the electromagnetic interaction **Sub group** G1 Hadrons can be split into Baryons and mesons G2 Baryons contain 3 quarks G3 Mesons contain a quark antiquark pair **5 – 6 marks** 2 points from each of H L S and G *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3 – 4 marks** 1 point from each of H L S and G *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1 – 2 marks** 3 points from any group *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.*	6			6		
	(b)	(i)	Charge +1 -1 = 0 + 0 (1) Lepton number 0 +1 = 0 +1 (1) Hence, x is an uncharged lepton, … … Hence Particle identified as an electro neutrino (1)		3		3		
		(ii)	u changes to d / uud to udd		1		1		
		(iii)	Weak interaction because of the presence of a neutrino / change in quark flavour	1			1		
			Question 5 total	**7**	**4**	**0**	**11**	**0**	**0**

#7

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	Charge: 6 = 7 -1 + 0 **or** 0 = 1 - 1 + 0 **or** $-\frac{1}{3} = \frac{2}{3} - 1 + 0$ (1) Baryon number: 14 = 14 + 0 + 0 **or** 1 = 1 + 0 + 0 **or** $\frac{1}{3} = \frac{1}{3} + 0 + 0$ **or** 42 = 42 + 0 + 0 (1) Lepton number: 0 = 0 + 1 – 1 **or** 6 = 6 + 1 – 1 (1)		3		3		
		(ii)	Change of quark flavour [from d to u] (1) Neutrino involved accept symbol (1) Accept long half-life		2		2		
	(b)	(i)	Use of the equation $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ (1) $T_{\frac{1}{2}} = 1.81 \times 10^{11}$ [s] (1) 5 730 [year] (1)	1	1 1		3	3	
		(ii)	Use of the equation $A = \lambda N$ (1) Method for obtaining N correct ($6.02 \times 10^{23} \times 1 \times 10^{-12}$) (1) Answer = 2.30 Bq **unit mark** (1)	1	1 1		3	3	
		(iii)	$0.34 \times 10^{-12} = 1 \times 10^{-12} e^{-\lambda t}$ i.e. substitution or into $\frac{1}{2^n}$ (1) Taking logs correctly e.g. $\log A = \log A_0 - \lambda t$ (1) 2.82×10^{11} [s] or 8 900 [year] (1)	1	1 1		3	3	
	(c)		11, 5 for boron (1) Positron symbol correct e.g. e+ or beta + (1) Neutrino symbol correct (ν_e) but accept ν (1) Any fourth particle added lose 1 mark		1	1 1	3		
	(d)		**Any 3 × (1) from:** • cannot tell who is correct or words to that effect • further experiments or research must be carried out • experiments at higher (collision) energies (to find other particles) / bigger or better colliders • time/history will (probably) show who was correct • further theory / theoretical research • reference to the Higgs behaving as expected or not as expected • those who claim not should suggest an alternative • Higgs thought to be detected with 5σ [confidence] **Don't accept** any reference to charge or baryon number or lepton number conservation			3	3		
			Question total	**3**	**12**	**5**	**20**	**9**	**0**