

# Marking Scheme

#1

Question		Marking details	Marks available				Maths	Prac
			AO1	AO2	AO3	Total		
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 [ $0+0 \neq 0+0+0+0+0+4$ ] or $0 \neq 4$ (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		
<b>Question 7 total</b>			<b>2</b>	<b>0</b>	<b>4</b>	<b>6</b>	<b>0</b>	<b>0</b>

#2

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
		<b>Indicative content:</b> 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 - $udd$ , $uud$ , $\bar{u}\bar{d}$ 11. Charge - $-1$ , $+1$ , $0$ , $-1$ , $-1$ 12. Anti-particles - positron for electron and anti-proton mentioned	6			6		
		<b>5-6 marks</b> 7-12 points – all particles considered There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.  <b>3-4 marks</b> 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.  <b>1-2 marks</b> 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.  <b>0 marks</b> No attempt made or no response worthy of credit						
<b>Question total</b>			<b>6</b>	<b>0</b>	<b>0</b>	<b>6</b>	<b>0</b>	<b>0</b>

#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)	$\overline{uuu} \rightarrow \overline{uud} + \overline{ud}$ or $\overline{uuu} + \overline{uu}$ or $\overline{uuu} + \overline{dd}$ [1] [any order of quarks in the baryon and meson] Anti-proton or anti- $\Delta^+$ and $\pi^-$ OR anti- $\Delta^{++}$ and $\pi^0$ [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 $\times$ (1) valid points: -contradicts current theories (relativity) or can't travel faster than the speed of light $\checkmark$ -current theories well established $\checkmark$ -further experiments $\checkmark$ -by other groups / scientists / peer review $\checkmark$ -due to instrument problems (timing delay) / systematic errors $\checkmark$			3	3		
		<b>Question 6 total</b>	<b>0</b>	<b>1</b>	<b>7</b>	<b>8</b>	<b>0</b>	<b>0</b>

#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 / $p$ / ${}^1_1\text{H}$	1			1		
		(ii) Positron / $e^+$ Allow anti-electron	1			1		
	(d)	Any 2 $\times$ (1) from: <ul style="list-style-type: none"> <li>Economic argument given e.g. money better spent on welfare / health etc</li> <li>Scientific consequence discussed e.g. need to know origin of universe</li> <li>Benefits to mankind from advanced research / new technologies</li> <li>Scientific investment generates money</li> </ul>			2	2		
		<b>Question total</b>	<b>4</b>	<b>2</b>	<b>3</b>	<b>9</b>	<b>0</b>	<b>0</b>

#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 $0 + 1 \rightarrow 1 + 1 - 1$ (1) Conservation of lepton $1 + 0 \rightarrow 0 + 0 + 1$ (1) $x$ is an electron (1)		1 1	1	3		
	(c)	Electromagnetic (1) Presence of photons / gamma rays (1)		1	1	2		
		<b>Question 7 total</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>9</b>	<b>0</b>	<b>0</b>

#6

Question		Marking details	Marks available				Maths	Prac	
			A01	A02	A03	Total			
5	(a)	<p><b>Differences</b></p> <p><b>Hadrons</b>                      H1 Made up of quarks                      H2 Affected by strong interaction                      H3 e.g. protons / neutrons / mesons</p> <p><b>Leptons</b>                      L1 Fundamental particles                      L2 Not affected by strong interaction                      L3 e.g. electron / electron neutrino</p> <p><b>Similarities</b>                      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</p> <p><b>Sub group</b>                      G1 Hadrons can be split into Baryons and mesons                      G2 Baryons contain 3 quarks                      G3 Mesons contain a quark antiquark pair</p> <p><b>5 – 6 marks</b>                      2 points from each of H L S and G  <i>There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.</i></p> <p><b>3 – 4 marks</b>                      1 point from each of H L S and G  <i>There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.</i></p> <p><b>1 – 2 marks</b>                      3 points from any group  <i>There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.</i></p> <p><b>0 marks</b>                      No attempt made or no response worthy of credit.</p>	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		
			<b>Question 5 total</b>	7	4	0	11	0	0

#7

Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
(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 $\frac{1}{3} = \frac{1}{3} + 0 + 0$ (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		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 <b>unit mark</b> (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) $2.82 \times 10^{11}$ [s] or 8900 [year] (1)	1	1		3	3		
(c)	11, 5 for boron (1) Positron symbol correct e.g. e+ or beta + (1) Neutrino symbol correct ( $\nu_e$ ) but accept $\nu$ (1) Any fourth particle added lose 1 mark		1	1	3				
(d)	<b>Any 3 × (1) from:</b> <ul style="list-style-type: none"> <li>cannot tell who is correct or words to that effect</li> <li>further experiments or research must be carried out</li> <li>experiments at higher (collision) energies (to find other particles) / bigger or better colliders</li> <li>time/history will (probably) show who was correct</li> <li>further theory / theoretical research</li> <li>reference to the Higgs behaving as expected or not as expected</li> <li>those who claim not should suggest an alternative</li> <li>Higgs thought to be detected with <math>5\sigma</math> [confidence]</li> </ul> <b>Don't accept</b> any reference to charge or baryon number or lepton number conservation			3	3				
<b>Question total</b>			<b>3</b>	<b>12</b>	<b>5</b>	<b>20</b>	<b>9</b>	<b>0</b>	