Questions on Particle Physics MS

1.	Charge on strange quark = – 1/3 **(1)**	1	
	Conservation law:		
	Charge – (–1) + (+1) → (0) + X/by charge conservation **(1)**		
	X is neutral **(1)**	2	
	Particle X is a meson **(1)**		
	Baryon number conservation (0) + (+1) → (+1) + (0) **(1)**	2	
	OR discussion in terms of total number of q + $\bar{q}$ = 5 OR Σq – $\bar{q}$ = 3		
	Composition of X is s$\bar{d}$ [0/3 if not q$\bar{q}$]**(1)**		
	Justify S quark:		
	This is not a weak interaction/only a weak interaction can change quark type/this is a strong interaction/strangeness is conserved/ quark flavour cannot change **(1)**		
	Justify $\bar{d}$ quark:		
	X neutral; s – 1/3; $\bar{d}$ + 1/3. [e.c.f. if s = – 1/3 in first line.]		
	For the third mark accept any q$\bar{q}$ pair that creates a meson of the charge deduced for X above. **(1)**	3	
	[The justification for both q and $\bar{q}$ can be done also by tracking individual quarks]		
			[8]

2.	Gluon Weak Electromagnetic Gravitational Gravitational circled		
			[5]

3.	Ω^- is a baryon [no mark] p is a baryon/need to conserve baryon number Strangeness – 3 needs three quarks	2	
	p is uud Ω^- is sss All Ks quark-antiquark pairs		
	K^- is $\bar{u}s$ K^+ is $u\bar{s}$ K^0 is $d\bar{s}$ [all right]	4	
			[6]

4.	(a)	Lots of energy needed to produce the extra mass	2
	(b)	Conservation laws: charge lepton number baryon number	3
	(c)	They annihilate one another giving rise to γ ray/γ photon	

Energy of γ ray
= 2(0.00055) (930 MeV)
= 1.0/1.02/1.023 MeV 4

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5. How properties of particles and antiparticles compare

Same mass/properties, opposite charge **(1)** 1

Energy

$E = mc^2 = 1.67 \times 10^{-27} \times (3 \times 10^8)^2$ J [m or c subbed correctly] **(1)**

$= 1.503 \times 10^{-10}$ J [u.e. if comparison made here]

$= 1.503 \times 10^{-10}/10^9 \times 1.6 \times 10^{-19}$ GeV **(1)**

= 0.94 GeV **(1)** 3

[jump to "≈ 1 GeV" omitting last line scores **(1)(1)×**]

Survival of anti-atom

Anti–proton meets proton OR positron meets electron OR (anti-atom) meets atom **(1)**

(leads to) annihilation **(1)** 2

Table 2

	Meson	Baryon	Lepton	
proton		✓		**(1)**
antiproton		✓		
electron			✓	**(1)**
positron			✓	

Quark structure

Antiproton: 2 × –2/3 (anti u) + 1 × + 1/3 (anti d) **(1)**

= –1 (e not needed) **(1)**

[3 × d ⇒ –1 scores ××] 2

[10]

6. Explanation

energy gained by electron accelerated through 1 V/$W = QV$ **(1)**

$W = 1.6 \times 10^{-19}$ C × 1 V $= 1.6 \times 10^{-19}$ J **(1)** 2

Unit of mass

$\Delta E = c^2 \Delta m$ so $\Delta m = \Delta E/c^2$ **(1)**

GeV is energy ⇒ GeV/c^2 is mass **(1)** 2

Mass of Higgs boson

$m = 115 \times [10^9] \times 1.6 \times 10^{-19}/(3 \times 10^8)^2$ **(1)**

$= 2.04 \times 10^{-25}$ kg **(1)** 2

Antiparticle

Same mass and opposite charge **(1)**
[Accept Particle and its antiparticle annihilate (→ photons)] 1

Explanation of need for a magnetic field and why it can be small

Force deflects particles/force produces circular motion **(1)**

Force is perpendicular to motion/force provides centripetal force **(1)**

r is large or curvature is small/gentle **(1)**

reference to $B = p/rQ$ to show why small B is needed **(1)** 4

[11]

7. "The standard model"

Everyday matter/atoms: p,n, e [maybe in two places] **(1)**

Protons / neutrons are made from quarks **(1)**

p: uud and n:udd **(1)**

show charge of either [p: u(+2/3) u(+2/3) d(–1/3) ⇒ + 1 OR n: u (+2/3) d(–1/3) d(–1/3) ⇒ 0] **(1)**

All baryons have three quarks **(1)**

Hadrons contain quarks **(1)**

Electron is fundamental/leptons are fundamental **(1)**

Electron-neutrino created during β-decay **(1)** Max 6

[6]

8. Description of production of a beam of electrons

Hot filament / cathode /plate **(1)**

Thermionic emission **(1)**

Anode/other electrode positive wrt source (can be dia) **(1)**

Collimator/hole/focusing detail **(1)**

Control of beam (e.g. with *E* or *B* **(1)**)

Vacuum **(1)**

Cyclotron:

Magnetic field →circles **(1)**

Acceleration across gap **(1)**

Repeated accelerations / details of voltage variation **(1)**

LINAC:

At least 2 sections connected to a.c. **(1)**

Details of variation of voltage with time / synchronisation **(1)**

Acceleration across each gap / attraction to + section **(1)**

Detail of lengths of tubes **(1)** Max 6

High energy needed to break particles into constituents and/or create new particles **(1)**

High energy linked to short wavelength, e.g. $\lambda = h/p$ **(1)**

Short wavelength comparable to dimensions of structures / mention of diffraction **(1)**

Electrons easily detected because charged **(1)**

High energy needed to get close to nuclei **(1)** Max 3

[Max 7]