Mark schemes

1 **B**

[1]

2 B

[1]

3 **B**

[1]

4 B

[1]

5 **C**

[1]

6 C

[1]

7 B

[1]

8 **C**

[1]

9 B

[1]

10 D

[1]

11 (a) 18 (protons) **(1)**
(37 – 18 gives) 19 (neutrons **(1)**

2

(b) (charge) = 2^+ or 2^- **(1)**
$Q = 2 \times 1.60 \times 10^{-19} = 3.2 \times 10^{-19}$ (C) **(1)**

2

(c) (i) neutron **(1)**

(ii) electron **(1)**

2

(d) $(\%) = \dfrac{16 \times 9.11 \times 10^{-31}}{1.67 \times 10^{-27} \times 37}$ **(2)** (for correct nuclear mass and substitution)

$(= 2.36 \times 10^{-4}) = 2.36 \times 10^{-2}$ (%) **(1)**

3

[9]

12 (a) pair production **(1)**

1

(b) (i) the γ ray must provide enough energy to provide for the (rest) mass **(1)**
any extra energy will provide the particle(s) with **kinetic** energy **(1)**

(ii) (0.511 + 0.511) = 1.022 (MeV) **(1)**

3

(c) any pairing of a particle with its corresponding antiparticle (e.g. p + $\bar{p}$) **(1)**

1

[5]

13 (a) (i) moves between one object and another/carrier acting on two particles

B1

gives rise to the force between the particles

B1

gluon(s) (accept pions)

B1

(ii) gluons light**er**/(w) bosons more massive

B1

(iii) gluons have long**er** range/(w) bosons have shorter range
not distance

B1

5

(b) $^{1}_{1}p$

B1

$^{0}_{0}\bar{\nu}$ in either order

B1

2

(c) baryon 0 → 0 + 0 + 0

B1

lepton 1 → 1 + (–1) + 1

B1

charge –1 → (–1) + 0 + 0

B1

3

[10]

14 (a) any two hadrons e.g. proton, neutron, pion, kaon, etc. **(1)**

(b) any two antiparticle leptons e.g. e^+, μ^+, anti-(electronic) neutrino etc **(1)**

(c) $d\bar{d}$ (or $u\bar{u}$ or $\frac{1}{\sqrt{2}}(d\bar{d}+u\bar{u})$)

(d) usually created in pairs (*)
normally decays into combinations of π, p and n (*)
contains at least one strange quark (*)
usually decays via the weak interaction (*)
half - life is relatively long compared with half -life of typical particle decaying via strong interaction (*)
(*) any one **(1)**

[4]

15 (a) number of protons = number of electrons (e.g.14) **(1)**

number of protons + number of neutrons = 28 **(1)**

2

(b) (i) nuclei with the same number of protons **(1)**
but different number of neutrons/nucleons **(1)**

(ii) (137 – 55) = 82 **(1)**

(iii) $\frac{Q}{m} = \frac{92 \times 1.60 \times 10^{-19}}{236 \times 1.67 \times 10^{-27}}$ **(1)**

$= 3.73 \times 10^7$ (C kg^{-1}) **(1)**

(iv) X (= 236 – 137 – 4) = 95 **(1)**

6

[8]

16 (a) (i) hadrons (are not fundamental) are composed of quarks
[or hadrons may interact through the strong nuclear force
(as well as all the other interactions)] **(1)**

(ii) (neutron) udd **(1)**
(neutral pion) $u\bar{u}$ or $d\bar{d}$ **(1)**

(iii) (kaon) meson **(1)**
(muon) lepton **(1)**

5

(b) proton **(1)**

1

(c) (i) (X) baryon **(1)**

(ii) (a) not possible **(1)**
charge not conserved **(1)**
(allow C.E. from previous line)

(b) not possible **(1)**
baryon number not conserved **(1)**
(allow C.E. from previous line)

5

[11]

17 (a) charge – yes*

baryon number – yes*

strangeness – no*

* all correct **(1) (1)**

deduct one for each incorrect answer

(max 2)

(b) (i) no **(1)**

strangeness [or baryon number] not conserved **(1)**

(ii) yes **(1)**

charge and baryon number conserved **(1)**

(4)

[6]

18 (a) baryon qqq

antibaryon $\bar{q}\bar{q}\bar{q}$

meson $q\bar{q}$

two names **(1)**
composition of each sub-group **(1) (1)**

3

(b) (i) $n \rightarrow p$ **(1)** + $^{0}_{-1}\beta^{-}$ **(1)** + $\bar{\nu}_{(e)}$ **(1)**

(ii) a down (d) quark changes to an up (u) quark
[or udd changes to uud] **(1)**

4

[7]