Nuclear Physics MS

M1. (a) repulsive then attractive **(1)**

short range (if distance quoted must be of order fm) **(1)**

correct distance for cross over (accept range 0.1 – 1.0 fm) **(1)**

3

(b) (i) a helium nucleus (accept 2p and 2n) **(1)**

1

(ii) (↓92↑238) *U* → (↓90↑234)*Th*(+↓2↑4)α **(1)**

2

(c) (i) same atomic number/proton number **(1)**

different number of neutrons/nucleons **(1)**

2

(ii) evidence of subtraction of mass number or atomic number **(1)**

(thus atomic number decreases to) **76** **(1)**

(atomic number of lead is 82 therefore) **6** (82 – 76) beta decays **(1)**

3

[11]

M2. (a) (i) nucleon number is the number of protons and neutrons OR mass number proton number is the number of protons OR atomic number ✓

1

(ii) 14 – 6 = 8 ✓

1

(iii) specific charge = $6 \times 1.6 \times 10^{-19}$ ✓ /($14 \times 1.66 \times 10^{-27}$ ✓)

specific charge = 4.1 × 107 (C kg^{-1}) ✓

3

(b) (i) isotopes are variations of an element that have same proton/atomic number ✓

but different nucleon number OR different number of neutrons ✓

2

(ii) $4.8 \times 10^{7} = 6 \times 1.6 \times 10^{-19}$ ✓ $/(A \times 1.66 \times 10^{-27})$

$A = 6 \times 1.6 \times 10^{-19}/(4.8 \times 10^{7} \times 1.66 \times 10^{-27})$

$A = 12$ ✓

Number of neutrons = 12-6 ✓

3

[10]

M3. (a) (atoms with) same number of protons/same atomic number **(1)**
different number of neutrons/mass number/ nucleons **(1)**

2

(b) (i) 7 protons **(1)**
8 neutrons **(1)**

(ii) $\left(\frac{\text{charge}}{\text{mass}}\right) = \frac{7 \times 1.6 \times 10^{-19}}{15 \times 1.67 \times 10^{-27}}$ **(1)**

$= 4.5 \times 10^{7}$ (C kg^{-1}) **(1)** (4.47×10^{7} (C kg^{-1}))

(allow C.E. for incorrect values in (b) (i))

4

(c) (i) (+) 1.6×10^{-19} (C) **(1)**

(ii) positive ion **(1)**

2

[8]

M4. (a) the ratio of charge to mass of nucleus ✓

C kg^{-1} ✓

2

(b) (i) number of protons and neutrons the same **or** number of neutrons less **or** mass the same ✓

but more protons therefore greater charge ✓

2

(ii) answers add up to 10 ✓

number of protons = 4 ✓

number of neutrons = 10 − 4 = 6 ✓

evidence of correct calculation ✓

eg 5q = 1.25 × ?q

? = 4

4

[8]

M5. (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)**

= 3.73×10^{7} (C kg^{-1}) **(1)**

(iv) X (= 236 – 137 – 4) = 95 **(1)**

6

[8]

M6. (a) (i) 94 (protons) **(1)**

(ii) 145 (neutrons) **(1)**

(iii) 93 (electrons) **(1)**

3

(b) same number of protons
[or same atomic number] **(1)**

different number of neutrons/nucleons
[or different mass number] **(1)**

2

[5]

M7. (i) same atomic number/number of protons ✓

different mass/nucleon number/different number of neutrons ✓

2

(ii) $^{A}_{Z}X \rightarrow {}^{A\ -4}_{Z\ -2}Y + {}^{4}_{2}\alpha$ ✓✓

2

(iii) $\frac{q}{m} = \frac{2 \times 1.6 \times 10^{-19}}{4 \times 1.67 \times 10^{-27}}$ ✓✓

$\frac{q}{m}$ = 4.8×10^{7} Ckg^{-1} ✓✓

4

(iv) strong nuclear force is short range ✓

no effect at distances larger 3 fm
(except any distance less than 10 fm) ✓

2

[10]

M8. (a) (i) (charge) = $92 \times 1.60 \times 10^{-19}$
= 1.47×10^{-17} (C) **(1)**

(ii) (magnitude of ion charge) = 3(*e*) **(1)**
number of electrons (= 92 – 3) = 89 **(1)**

4

(b) X: number of nucleons [or number of neutrons plus protons or mass number] **(1)**
239 **(1)**
Y: number of protons [or atomic number] **(1)**
94 **(1)**

4

[8]

M9. (a) (i) 88 protons **(1)**

140 neutrons **(1)**

88 electrons **(1)**

3

(ii) electron **(1)** 1

(iii) $^{228}_{88}Ra \rightarrow ^{228}_{89}Ac + ^{0}_{-1}e + \overline{\nu_e}$ **(1)(1)(1)(1)** 4

(b) 228 ± 10 **(1)**

88 **(1)** 2

[10]

M10. (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 + $\overline{p}$) **(1)** 1

[5]

M11. (a) (i) 9.11×10^{-31} (kg) **(1)**

(ii) (use of $E = hf$ and $c = f\lambda$ gives) $f = \frac{3.00 \times 10^{8}}{8.30 \times 10^{-13}}$ (= 3.61×10^{20}) **(1)**

$E = 6.63 \times 10^{-34} \times 3.61 \times 10^{20}$ **(1)**

$= 2.4 \times 10^{-13}$ J **(1)** (2.39×10^{-13} J)

(iii) $E = \frac{2.39 \times 10^{-13}}{1.60 \times 10^{-13}}$ **(1)**

= 1.5 (MeV) **(1)**

(allow C.E. for value of E from (ii) 6

(b) weak interaction/force **(1)**

1

(c) (i) A: neutron or n **(1)**

B: W^+ **(1)**

C: (electron) neutrino or $\nu_{(e)}$ **(1)**

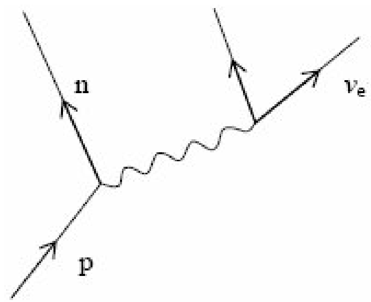
3

[10]

M12. (a) n **(1)**

p **(1)**

ν_e **(1)**



3

(b) (i) γ photon **(1)**

(ii) γ is massless

γ has infinite range

γ does not carry charge

(1)(1) any two

3

(c) (i) all properties/quantum numbers (e.g. charge, strangeness) are opposite **(1)**

but the masses are the same **(1)**

(ii) π° **(1)**

$\bar{K}^\circ$ **(1)**

γ **(1)**

5

[11]

M13. (a) $^{40}_{19}K \rightarrow {}^{40}_{18}Ar + {}^{0}_{1}e + \nu_e$ ✓✓✓✓

(accept + for 1 and e^+ or β^+)

4

(b) (i) electron/K capture ✓

1

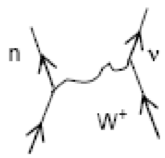
(ii) (inner) shell (of atom) ✓

1

(iii) conservation of **lepton number** ✓

1

(iv)

	*n* ✓ *v* ✓ W^+ ✓

3

[10]