

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) $(\downarrow 92 \uparrow 238) U \rightarrow (\downarrow 90 \uparrow 234) Th + (\downarrow 2 \uparrow 4) \alpha$ **(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 = $6 \times 1.6 \times 10^{-19} \checkmark / (14 \times 1.66 \times 10^{-27} \checkmark)$
specific charge = 4.1×10^7 (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) $4.8 \times 10^7 = 6 \times 1.6 \times 10^{-19} \checkmark / (A \times 1.66 \times 10^{-27})$

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

$A = 12 \checkmark$

Number of neutrons = $12 - 6 \checkmark$

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

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

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

4

- (c) (i) (+) $1.6 \times 10^{-19} \text{ (C) (1)}$
(ii) positive ion **(1)**

2

[8]

- M4.** (a) the ratio of charge to mass of nucleus \checkmark

$\text{C kg}^{-1} \checkmark$

2

- (b) (i) number of protons and neutrons the same **or** number of neutrons less **or**
mass the same \checkmark

but more protons therefore greater charge \checkmark

2

- (ii) answers add up to 10 ✓
 number of protons = 4 ✓
 number of neutrons = 10 - 4 = 6 ✓
 evidence of correct calculation ✓
 eg $5q = 1.25 \times ?q$
 $? = 4$

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)**
 $= 3.73 \times 10^7$ (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) ${}^A_Z X \rightarrow {}^A_{Z-2} Y + {}^4_2 \alpha$ ✓✓

2

(iii) $\frac{q}{m} = \frac{2 \times 1.6 \times 10^{-19}}{4 \times 1.67 \times 10^{-27}}$ ✓✓
 $\frac{q}{m} = 4.8 \times 10^7 \text{ Ckg}^{-1}$ ✓✓

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) = $92 \times 1.60 \times 10^{-19}$
 $= 1.47 \times 10^{-17} \text{ (C)}$ (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) ${}^{228}_{88}\text{Ra} \rightarrow {}^{228}_{89}\text{Ac} + {}^0_{-1}\text{e} + \bar{\nu}_e$ **(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. $p + \bar{p}$) **(1)**

1

[5]

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

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

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

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

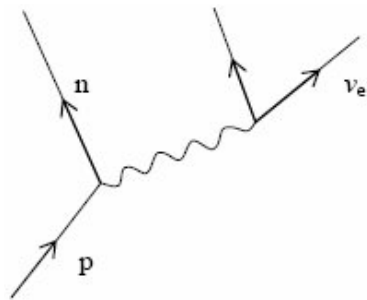
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(c) (i) A: neutron or n **(1)**
B: W^+ **(1)**
C: (electron) neutrino or $\nu_{(e)}$ **(1)**

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)**

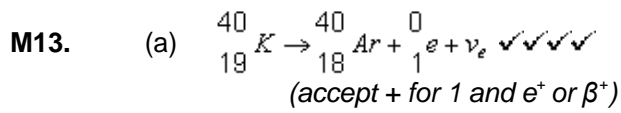
(ii) π^0 **(1)**

\bar{K}^0 **(1)**

γ **(1)**

5

[11]



4

(b) (i) electron/K capture ✓

1

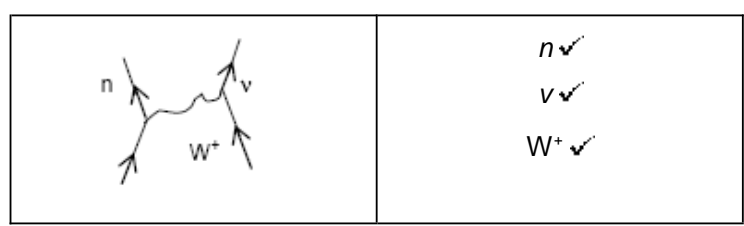
(ii) (inner) shell (of atom) ✓

1

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

1

(iv)



3

[10]