

# 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 =  $4.1 \times 10^7$  (C kg<sup>-1</sup>) ✓ 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<sup>-1</sup>) **(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) 
$${}^A_Z X \rightarrow {}^A_{Z-2} Y + {}^4_2 \alpha \quad \checkmark \checkmark$$
 2

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

$$\frac{q}{m} = 4.8 \times 10^7 \text{ Ckg}^{-1} \quad \checkmark \checkmark$$
 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) =  $3(e) \text{ (1)}$   
 number of electrons (=  $92 - 3$ ) =  $89 \text{ (1)}$  4

(b) X: number of nucleons [or number of neutrons plus protons or mass number] **(1)**  
 $239 \text{ (1)}$   
 Y: number of protons [or atomic number] **(1)**  
 $94 \text{ (1)}$  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)  $228 \pm 10$  **(1)**

88 **(1)**

2

[10]

**M10.** (a) pair production **(1)**

1

(b) (i) the  $\gamma$  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)  $9.11 \times 10^{-31}$  (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)**

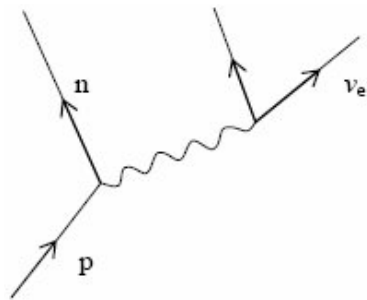
1

(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)**  
 $\nu_e$  **(1)**



3

(b) (i)  $\gamma$  photon **(1)**  
(ii)  $\gamma$  is massless  
 $\gamma$  has infinite range  
 $\gamma$  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)**

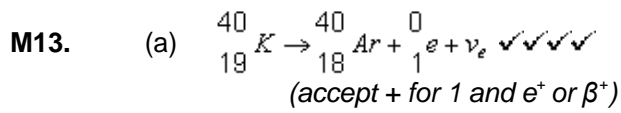
(ii)  $\pi^0$  **(1)**

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

$\gamma$  **(1)**

5

[11]



4

(b) (i) electron/K capture ✓

1

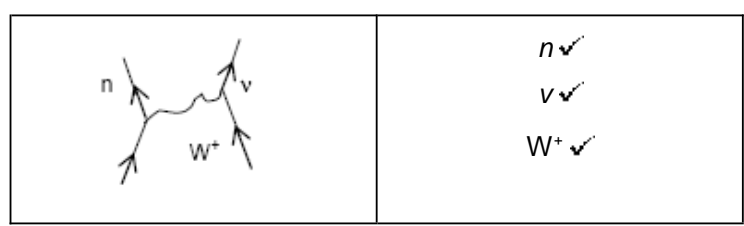
(ii) (inner) shell (of atom) ✓

1

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

1

(iv)



3

[10]