Solutions to Nuclear, Particle and Medical Physics – Test B

1. (a) $^{234}_{90}\text{Th} \rightarrow {}^{234}_{91}\text{Pa} + {}^{0}_{-1}\beta + \bar{\nu}$
Accept e^- in place of beta; accept subscript e on antineutrino and A / Z values of 0 on antineutrino
Thorium written correctly **[1]**
Pa as a product **[1]**
234 and 91 correctly written with product symbol (even if not Pa) **[1]**
0 and -1 correctly written with other product **[1]**

(b) charge = $1.6 \times 9 = 1.44 \times 10^{-17}$ (C) **[1]**
mass = $1.[illegible] \times 234 = 3.91 \times 10^{-25}$ (kg) **[1]**
charge : mass ratio = $\dfrac{1.44\times10^{-17}}{3.91\times10^{-25}} = 3.68 \times 10^{7}$ **[1]**
Ckg^{-1} **[1]**

2. Up to 0.5 fm / 5×10^{-16} m **[1]**

3. A photon **[1]**
Incident on a nucleus **[1]**
Produces a particle **[1]**
and its equivalent antiparticle **[1]**

4. Momentum **[1]**
Energy **[1]**

5. gamma radiation is ionising **[1]**
gamma radiation has long range in air / is highly penetrating **[1]**
Then any two from:
- point the source away from people
- keep the source as far from [illegible] possible **[1]**
- stand behind a [illegible] **[1]**
- [illegible] inside a lead container when [illegible] **[1]**

6. (before Rutherford) plum pudding model / atoms were solid balls **[1]**
Rutherford model showed atoms were mostly empty space **[1]**
nucleus known to contain positive charge and be at the centre **[1]**
electrons in shells / different energy levels / orbitals **[1]**

7. intensity on the vertical axis **[1]**
1 / distance^2 on horizontal axis **[1]**
graph should be a straight line **[1]**
with positive gradient / gradient is k in $I = \dfrac{k}{x^2}$ **[1]**

8. background count rate is less significant / [illegible] to a small percentage of the count [illegible] accuracy not significantly affected **[1]**

9. (a) ln$A$ calcu[illegible]
all value[illegible]
and no u[illegible]

t / s
0
60
120
180
240
300
360
420

(b) graph wi[illegible]
horizonta[illegible]
scaled so[illegible]
the grid [illegible]
all points[illegible]
straight l[illegible]

(c) gradient [illegible]
the line [illegible]
all value[illegible]
calculati[illegible]
negative [illegible]
if all cor[illegible]

(d) numerica[illegible]
positive [illegible]
unit as s^{-1}

10. $\lambda = 0.693 / 1.9$[illegible]
3.59×10^{-4} ye[illegible]
$100 = 77 \times e^{-}$[illegible]
ln77 – ln100 =[illegible]
728 years **[1]**

11. charge on alp[illegible]
$= 3.2 \times 10^{-19}$ [illegible]
charge on nuc[illegible]
$= 1.26 \times 10^{-14}$
$\dfrac{8.99\times10^{9}\times3[illegible]}{(3[illegible]}$
296 N **[1]**

12. reactants 5.02[illegible]
products 5.01[illegible]
difference 0.0[illegible]
$0.019431 \times 1.[illegible]$
3.227×10^{-29} [illegible]
3.227×10^{-29}
2.90×10^{-12} (J[illegible]
$2.90 \times 10^{-12} \times$[illegible]
3.49×10^{12} J

13. (a) *Diagram/description to include:*
Collimator **[1]**
Scintillator **[1]**
Detector **[1]**
computer / software / circuitry / display **[1]**
Functions to include two from:
collimator selects gamma rays / photons from one direction only **[1]**
scintillator amplifies signal / converts one gamma photon to many visible photons **[1]**
detector detects visible photons **[1]**

14. (a) attenuation **[1]**
(b) photoelectric effect **[1]**
X-ray photon absorbed by electron/atom **[1]**
(photoelectron) emitted **[1]**

15. (a) acoustic impedance **[1]**
(b) (i) blood is denser / liquids are denser than gases **[1]**
particles/molecules packed more tightly **[1]**
vibrations/compressions in longitudinal wave more easily passed on **[1]**
(ii) λ in air = 3.3×10^{-5} m **[1]**
λ in blood 1.5×10^{-4} m **[1]**
difference = 1.17×10^{-4} **[1]**
$\left(\frac{1.17\times10^{-4}}{3.3\times10^{-5}}\times100=\right)$ = 355 % **[1]**

Preview of Answers Ends Here