## Particle Physics <br> Mark Scheme 1

| Level | International A Level |
| :--- | :--- |
| Subject | Physics |
| Exam Board | CIE |
| Topic | Particle \& Nuclear Physics |
| Sub Topic | Particle Physics |
| Paper Type | Theory |
| Booklet | Mark Scheme 1 |


(b)

|  | value |
| :---: | :---: |
| $a$ | 1 |
| $b$ | 0 |
| $c$ | 141 |
| $d$ | 55 |

( $a$ and $b$ both required)
B1
B1
B1
(c) kinetic energy (of products) or gamma/ $/$ (radiation or photon)

B1
(d) (total) mass on left-hand side/reactants is greater than (total) mass on right-hand side/products
difference in mass is (converted to) energy

2 (a (i) (rate of decay) not affected by any external factors or changes in temperature and pressure etc.

B1
(ii) two protons and two neutrons
(b) (i) (total) mass before decay/on left-hand side is greater than (total) mass

M1 on right-hand side/after the decay
the difference in mass is released as kinetic energy of the products
A1
(may also be some $\gamma$ radiation) (to conserve mass-energy)
(ii) $\left(6.2 \times 10^{6} \times 1.6 \times 10^{-19}=\right) 9.9(2) \times 10^{-13} \mathrm{~J} \quad \mathrm{~A} 1$
$\left.\begin{array}{l}\text { (a (i) } \mathrm{A}: 206 \text {, nucleon(s) or neutron(s) and proton(s) } \\ \mathrm{B}: 82, \text { proton(s) } \\ \text { (ii) kinetic } / E_{K} / \mathrm{KE} \\ \text { (b) energy }=5.3 \times 1.6 \times 10^{-13}(\mathrm{~J})\left[=8.48 \times 10^{-3}(\mathrm{~J})\right] \\ \text { power }\end{array}=\left(7.1 \times 10^{18} \times 5.3 \times 1.6 \times 10^{-13}\right) /(3600 \times 24)\right\}$
(ii) kinetic/ $E_{K} / \mathrm{KE}$
(b) energy $=5.3 \times 1.6 \times 10^{-13}(\mathrm{~J})\left[=8.48 \times 10^{-3}(\mathrm{~J})\right]$

C1

A1 [2]

4 (a) $\alpha$ : helium nucleus
$\beta$ : electron
$\gamma$ : electromagnetic radiation/wave/ray or photon
three correct 2/2, two correct 1/2
(b) (i) atomic number/proton number/Z-2, nucleon/mass number/A -4

B1 [1]
(ii) atomic number/proton number/Z +1 nucleon/mass number/ $A$ no change

B1
(iii) no change in proton or mass number or "no change"

B1

5 (a the majority/most went straight through or were deviated by small angles
a very small proportion/a few were deviated by large angles B1
small angles described as $<10^{\circ}$ and large angles described as $>90^{\circ}$
B1
(b) most of the atom is empty space/nucleus very small compared with atom B1 mass and charge concentrated in (very small) nucleus correct links made with statements in (a)
(ii) mass-energy is conserved ..... B1mass on rhs is less because energy is released
(b) not affected by external conditions/factors/environment ..... B1 or two examples temperature and pressure
7 (a) (i) nucleus contains 92 protons ..... B1
nucleus contains 143 neutrons (missing 'nucleus' 1/2) ..... B1
outside / around nucleus 92 electrons ..... (B1)
most of atom is empty space / mass concentrated in nucleus ..... (B1) total charge is zero ..... (B1)
diameter of atom $\sim 10^{-10} \mathrm{~m}$ or size of nucleus $\sim 10^{-15} \mathrm{~m}$ ..... (B1) any two of (B1) marks ..... B1 nuclei have 143 and 146 neutrons (missing 'nucleus' 1/2) ..... B1
(b) (i) $Y=35$A1$Z=85$A1
(ii) mass-energy is conserved in the reaction

(ii) mass-energy is conserved in the reactionB1mass on rhs of reaction is less so energy is releasedexplained in terms of $E=m c^{2}$B1

8 (a 92 protons in the nucleus and 92 electrons around nucleus 143 neutrons (in the nucleus) B1 B1
(b) (i) $\alpha$-particle travels short distance in air

B1 [1]
(ii) very small proportion in backwards direction / large angles B1 majority pass through with no /small deflections B1 either most of mass is in very small volume (nucleus) and is charged or most of atom is empty space
B1
(c) $I=Q / t$
$n / t=\left(1.5 \times 10^{-12}\right) /\left(2 \times 1.6 \times 10^{-19}\right)$
$n / t=4.7 \times 10^{6} \mathrm{~s}^{-1}$

C1
C
A1

9 (a (i) electron
(ii) any two:
can be deflected by electric and magnetic fields or negatively charged / absorbed by few $(1-4) \mathrm{mm}$ of aluminum / 0.5 to 2 m or metres for range in air / speed up to 0.99 c / range of speeds / energies
(iii) decay occurs and cannot be affected by external / environmental factors or two stated factors such as chemical / pressure / temperature / humidity
(b) 3 and 0 for superscript numbers

B1
2 and -1 for subscript numbers
B1

## [2]

C1
$v^{2}=\frac{2 \times 9.12 \times 10^{-16}}{9.11 \times 10^{-31}}$
$v=4.5 \times 10^{7} \mathrm{~m} \mathrm{~s}^{-1}$
(d) both have 1 proton and 1 electron

B1
1 neutron in hydrogen-2 and 2 neutrons in hydrogen-3 B1
(special case: for one mark 'same number of protons / atomic number different number of neutrons')

