## Particle Physics <br> Mark Scheme 2

| Level | International A Level |
| :--- | :--- |
| Subject | Physics |
| Exam Board | CIE |
| Topic | Particle \& Nuclear Physics |
| Sub Topic | Particle Physics |
| Paper Type | Theory |
| Booklet | Mark Scheme 2 |


| Time Allowed: | 78 minutes |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Score: | /65 |  |  |  |  |
| Percentage: | /100 |  |  |  |  |
| A* A | B | C | D | E | U |
| >85\% '77.5\% | 70\% | 62.5\% | 57.5\% | 45\% | <45\% |(a (i) 2 protons and 2 neutronsB1

(ii) e.g. positively charged $2 e$ mass $4 u$ constant energy
absorbed by thin paper or few cm of air ( $3 \mathrm{~cm} \rightarrow 8 \mathrm{~cm}$ )
(not low penetration)
highly ionizing
deflected in electric/magnetic fields
(One mark for each property, max 2) B2
(b) mass-energy is conserved B1
difference in mass 'changed' into a form of energy
energy in the form of kinetic energy of the products / $\gamma$-radiation photons / e.m. radiation

B1
(a) thin paper reduces count rate hence $\alpha$
addition of 1 cm of aluminium causes little more count rate reduction hence only other radiation is $\gamma$
(b) magnetic field perpendicular to direction of radiation
look for a count rate in expected direction / area if there were negatively charged radiation present. If no count rate recorded then $\beta$ not present.
(ii) $a=1$ and $b=0 \quad$ B1

$$
x=56
$$

B1

$$
y=92
$$

B1
[3]
(c) proton number $=90$ nucleon number $=235$ B1 B1
(a (i) the half life / count rate / rate of decay / activity is the same no matter what external factors / environmental factors or two named factors such as temperature and pressure changes are applied
(ii) the observations of the count rate / count rate / rate of decay / activity / radioactivity during decay shows variations / fluctuations
(b)

| property | $\alpha$-particle | $\beta$-particle | $\gamma$-radiation |
| :---: | :---: | :---: | :---: |
| charge | $\mathbf{( + ) 2 e}$ | $\mathbf{- e}$ | 0 |
| mass | $u$ | $\mathbf{9 . 1 1 \times \mathbf { 1 0 } ^ { \mathbf { - 3 1 } } \mathbf { k g }}$ | 0 |
| speed | $\mathbf{0 . 0 1}$ to $\mathbf{0 . 1} \boldsymbol{c}$ | up to $0.99 c$ | $\boldsymbol{c}$ |

## one mark for each correct line

(c) collision with molecules
causes ionisation (of the molecule) / electron is removed

5 (a (i) $\frac{\text { most } \alpha \text {-particles were deviated through small angles }}{\text { (allow } 1 \text { mark for 'straight through'/ undeviated) }}$
(ii) small fraction of $\alpha$-particles deviated through large angles

M1 greater than $90^{\circ}$ (allow rebound back)
(b) e.g. $\beta$-particles have a range of energies
$\beta$-particles deviated by (orbital) electrons
$\beta$-particle has (very) small mass
(any two sensible suggestions, 1 each, max 2)
Do not allow $\beta$-particles have negative charge or $\beta$-particles have high speed
6 (a) nuclei/atoms with same proton number/atomic number ..... B1
nuclei/atoms contain different numbers of neutrons/different atomic mass ..... B1
(b) (i) 92 ..... A1 [1]
(ii) 146 ..... A1 [1]
(c) (i) mass $=238 \times 1.66 \times 10^{-27}$ ..... C1
$=3.95 \times 10^{-25} \mathrm{~kg}$ ..... A1
(ii) volume $=\frac{4}{3} \pi \times\left(8.9 \times 10^{-15}\right)^{3} \quad\left(=2.95 \times 10^{-42}\right)$ ..... C1
density $=\left(3.95 \times 10^{-25}\right) /\left(2.95 \times 10^{-42}\right)$ $=1.3 \times 10^{17} \mathrm{~kg} \mathrm{~m}^{-3}$ ..... A1
[2]
(d) nucleus contains most of mass of atom ..... B1either nuclear diameter/volume very much less than that of atomor atom is mostly (empty) spaceB1
7 (a (i) either helium nucleusor contains 2 protons and 2 neutronsB1
(ii) e.g. range is a few cm in air/sheet of thin paper
speed up to 0.1 ccauses dense ionisation in airpositively charged or deflected in magnetic or electric fields(any two, 1 each to max 2)B2
(b) (i) ${ }_{2}^{4} \alpha$ ..... B1
either ${ }_{1}^{1} \mathrm{p}$ or ${ }_{1}^{1} \mathrm{H}$ ..... B1
$\qquad$
(ii) initially, $\alpha$-particle must have some kinetic energy ..... B1

(ii) $21.1 \mathrm{MeV}=1.1 \times 1.6 \times 10^{-13}=1.76 \times 10^{-13} \mathrm{~J}$

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(i) $E_{K}=1 / 2 m v^{2}$

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$1.76 \times \quad{ }^{-13}=1 / 2 \quad-27 \times v^{2}$

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$v=7.3 \times 10^{6} \mathrm{~m} \mathrm{~s}^{-1}$
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$v=7.3 \times 10^{6} \mathrm{~m} \mathrm{~s}^{-1}$ ..... A1 ..... A1 ..... A1 ..... A1 use of $1.67 \times 10^{-27} \mathrm{~kg}$ for mass is a maximum of $3 / 4$ use of $1.67 \times 10^{-27} \mathrm{~kg}$ for mass is a maximum of $3 / 4$ use of $1.67 \times 10^{-27} \mathrm{~kg}$ for mass is a maximum of $3 / 4$ use of $1.67 \times 10^{-27} \mathrm{~kg}$ for mass is a maximum of $3 / 4$[1]
(a (i) either helium nucleus or particle containing two protons and two neutrons B1
(ii) allow any value between 1 cm and 10 cm
(b) (i) $\begin{aligned} & \text { energy }=\left(8.5 \times 10^{-13}\right) /\left(1.6 \times 10^{-13}\right) \\ & \\ & =5.3 \mathrm{MeV}\end{aligned} \quad \mathrm{M}$
(ii) number $=\left(5.3 \times 10^{6}\right) / 31$
$=1.7 \times 10^{5}$ (allow 2 s.f. only) A
(iii) number per unit length $=\left(1.7 \times 10^{5}\right) /($ a)(ii) correct numerical value correct unit

A1
B1
(a) deviation shown correctly . B1
(b) smaller deviation (not zero deviation) ......................................................................M1
acceptable path wrt position of N
(c) the nucleus is (very) small .......................................................................................M1
in comparison to the atom A1
(special case: 'atom is mostly empty space' scores 1 mark)
(d) deviation depends on charge on the nucleus / $\mathrm{N} / \mathrm{electrostatic}$ repulsion ..........................................................................................
[Total: 7]

