Particle Physics

Mark Scheme 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Particle & Nuclear Physics
Sub Topic	Particle Physics
Paper Type	Theory
Booklet	Mark Scheme 3

Time Allowed: **75 minutes**

Score: **/62**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a** α-particle: *either* helium nucleus *or* contains 2 protons + 2 neutrons
or $^{4}_{2}He$ B1

β-particle: *either* electron *or* $^{0}_{-1}e$ B1

α speed < β speed (1)
α discrete values of speed/energy, β continuous spectrum (1)
either α ionising power >> β ionising power
or α range << β range (1)
α positive, β negative *(only if first two B marks not scored)* (1)
α mass > β mass *(only if first two B marks not scored)* (1)
(any two sensible pairs of statements relevant to differences,
– do not allow statements relevant to only α or β, 1 each, max 2) B2 [4]

(b) **(i)** $^{236}_{92}U \rightarrow {}^{232}_{90}Th$ M1
$+ {}^{4}_{2}He$ A1 [2]

(ii) **1.** correct position for U at Z = 92, N = 145 B1
2. correct position for Np relative to U i.e. Z + 1 and N – 1 B1 [2]

2 **(a** most α-particles deviated through small angles B1
(*accept 'undeviated'*)
few α-particles deviated through angles greater than 90° B1 [2]

(b) allow 10^{-9} m $\rightarrow$ 10^{-11} m B1 [1]

(ii) allow 10^{-13} m $\rightarrow$ 10^{-15} m B1 [1]
(*if **(i)** and **(ii)** out of range but **(ii)** = 10^{-4}**(i)**, then allow 1 mark*)
(*if no units or wrong units but **(ii)** = 10^{-4}**(i)**, then allow 1 mark*)

3 **(a** β(-decay) [1]

(b) γ(-decay)
either any two of Z, N and A do not change
or it is loss of energy only
or it is an electromagnetic wave B1 [2]
Allow 'α(-decay) as change of 4 in the nucleon number cannot be shown on the diagram'
Do not give credit for a 'bald' α(-decay)

4 **(a) (i)** nucleus is small **M1**

in comparison to size of atom **A1** **[2]**

(ii) nucleus is massive/heavy/dense **B1**

and charged (allow to be scored in **(i)** or **(ii)**) **B1** **[2]**

(b) (i) symmetrical path and deviation correct w.r.t. position of nucleus **B1**

deviation less than in path AB **B1**

(ii) deviation > 90° and in correct direction **B1** **[3]**

5 **(a)** **(i)** 26 protons B1

(ii) 30 neutrons ..... B1 [2]

(b) **(i)** mass = $56 \times 1.66 \times 10^{-27}$ C1
(allow 1.67×10^{-27} but 0/2 for use of 26 or 30)
= 9.3×10^{-26} kg A1

(ii) density = mass/volume where volume = $4/3 \times \pi \times r^3$ C1
= $(9.3 \times 10^{-26})/(4/3 \times \pi \times \{5.7 \times 10^{-15}\}^3)$
= 1.2×10^{17} kg m^{-3} ..... A1 [4]

(c) nucleus occupies only very small fraction of <u>volume of atom</u>
or 'lot of empty space inside atom' B1
(do not allow spacing between atoms)
any further good physics e.g. nuclear material is very dense ..... B1 [2]

6 (a) shows nucleon number as 220 ..... B1
shows proton number as 87 ..... B1 [2]

(b) shows products as He OR \a. B1
and ²!: At ....(allowe.c.f.from(a)) ..... B1 [2]

7	**(a**	a region/space/area where a (stationary) charge experiences an (electric) force	B1	[1]
	(b) (i)	at least four parallel equally spaced straight lines perpendicular to plates	B1	
		consistent direction of an arrow on line(s) from left to right	B1	[2]
	(ii)	electric field strength $E = V / d$	C1	
		$E = (450 / 16 \times 10^{-3})$ $= 28 \times 10^{3}$ (28 125) V m^{-1}	A1	[2]
	(iii)	$W = Eqd$ or Vq	C1	
		$q = 3.2 \times 10^{-19}$ (C)		
		$W = 28\,125 \times 3.2 \times 10^{-19} \times 16 \times 10^{-3}$ or $450 \times 3.2 \times 10^{-19}$		
		$= 1.4(4) \times 10^{-16}$ J	A1	[3]
	(iv)	ratio $= \dfrac{450 \times 3.2 \times 10^{-19}}{450 \times -1.6 \times 10^{-19}}$ *(evidence of working required)*		
		= (–) 2	A1	[1]

8	**(a) (i)**	the direction of the fields is the same OR fields are uniform OR constant electric field strength OR $E = V / d$ with symbols explained	B1	[1]
	(ii)	reduce p.d. across plates	B1	
		increase separation of plates	B1	[2]
	(iii)	α opposite charge to β (as deflection in opposite direction)	B1	
		β has a range of velocities OR energies (as different deflections) and α all have same velocity OR energy (as constant deflection)	B1	
		α are more massive (as deflection is less for greater field strength)	B1	[3]
	(b)	$W = 234$ and $X = 90$	B1	
		$Y = 4$ and $Z = 2$	B1	[2]
	(c)	$A = 32$ and $B = 16$ and $C = 0$ and $D = -1$	B1	[1]

9	**(a**	**(i)** greater deflection	M0	
		greater electric field / force on α-particle	A1	[1]
		(ii) greater deflection	M0	
		greater electric field / force on α-particle	A1	[1]
	(b)	(*either* deflections in opposite directions	M1	
		because oppositely charged	A1	
		or β less deflection	(M1)	
		β has smaller charge	(A1)	[2]
		(ii) α smaller deflection	M1	
		because larger mass	A1	[2]
		(iii) β less deflection because higher speed	B1	[1]
	(c)	*either* $F = ma$ and $F = Eq$ *or* $a = Eq / m$	C1	
		ratio = *either* $\frac{(2 \times 1.6 \times 10^{-19}) \times (9.11 \times 10^{-31})}{(1.6 \times 10^{-19}) \times 4 \times (1.67 \times 10^{-27})}$		
		or [2*e* × 1 / 2000 u] / [*e* × 4u]	C1	
		ratio = *or* 2.5 $^{-4}$ *or* 2.7 $^{-4}$	A1	[3]