Nuclear Physics
Mark Scheme 1

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

Time Allowed: **72 minutes**

Score: **/60**

Percentage: **/100**

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

1 (a $^{3}_{2}\text{He} + ^{3}_{2}\text{He} \rightarrow ^{4}_{2}\text{He} + ^{1}_{1}\text{p} + Q$
       A numbers correct   (**4** and **1**)   B1
       Z numbers correct   (**2** and **1**)   B1   [2]

   (b) both <u>nuclei</u> have 2 protons   B1
        the two isotopes have 1 neutron and two neutrons   B1   [2]
        [allow 1 for 'same number of protons but different number of neutrons']

   (c) proton number and neutron number   B1
        energy – mass   B1
        momentum   B1   [2]

   (d) (i) γ radiation   B1   [1]

        (ii) <u>product</u>(s) must have kinetic energy   B1   [1]

   (e) $13.8\,\text{MeV} = 13.8 \times 1.6 \times 10^{-19} \times 10^{6}\ (= 2.208 \times 10^{-12})$ C
        $60 = n \times 13.8 \times 1.6 \times 10^{-13}$
        $n = 2.7(2) \times 10^{13}\ \text{s}^{-1}$ A1   [

2 (a W = 1 and X = 0   A1   [1]
       Y = 2   A1   [1]
       Z = 55   A1   [1]

   (b) explanation in terms of mass – energy conservation   B1
        energy released as gamma or photons or kinetic energy of products or
        em radiation   B1   [2]

3 (a *either*   different forms of same element
       or   <u>nuclei</u> have same number of protons   M1
       different numbers of neutrons (in the nucleus)   A1   [2]

   (b) (i) proton number conserved   B1
            nucleon number conserved   B1
            mass-energy conserved   B1   [3]

        (ii) **1.** *Z* = 36   A1   [1]
              2. *x* = 3   A1   [1]

4 **(a** <u>nucleus</u> emits α-particles or β-particles and/or γ-radiation
to form a different / more stable nucleus   B1   [2]

(b) (i) fluctuations in count rate   (not 'count rate is not constant')   B1   [1]

   (ii) no effect   B1   [1]

   (iii) if the source is an α-emitter
   either   α-particles stopped within source (and gain electrons)
   or   α-particles are helium <u>nuclei</u>   B1   [2]

   allow 1/2 for 'parent nucleus gives off radiation to form daughter nucleus'

5 **(a** *either* forms of same element
   or   atoms / nuclei with same number of protons M1
   atoms / nuclei contain different numbers of neutrons   .... A1   [2]
   (*use of 'element' rather than atoms / nuclei scores max 1 mark*)

   (b) (decay is not affected by environmental factors   .... B1   [1]
   (*allow two named factors*)

   (ii) *either*   time of decay (of a nucleus) cannot be predicted
   or   nucleus has constant probability in a given time   .... B1   [1]

   (c) $^{185}_{75}\text{Re}$ B1
   either $^{0}_{-1}\text{e}$ *or* $^{0}_{-1}\beta$ .... B1   [2]

                                                                            [Total: 6]

6 **(a** rate of decay / activity / decay (of nucleus) is not affected by external factors / environment / surroundings .... B2 [2]
(If states specific factor(s), rather than giving general statement above, then give 2 marks for two stated factors, but 1 mark only if one factor stated)

(b) (gamma / γ .... B1 [1]

(ii) alpha / α .... B1 [1]

(iii) gamma / γ .... B1 [1]

(iv) beta / β .... B1 [1]

7 **(a** <u>nucleus</u> has constant probability of decay   M1
per unit time / in a given time   A1 [2]
(allow 1 mark for 'cannot predict which <u>nucleus</u> will decay next')

(b) count rate / activity decreases   B1 [1]

(ii) count rate fluctuates / is not smooth   B1 [1]

(c) *either* the (decay) curves are similar / same
or curves indicate same half-life   B1 [1]

8 **(a)** nucleus emits   M1
α- or β- particles and/or γ-rays   A1 **[2]**

(b) decay unaffected by environmental changes   M1
such as temperature, pressure etc. (*one e.g. is sufficient*)   A1 **[2]**

(c) constant probability of decay (per unit time) of a nucleus   B1
cannot predict which particular nucleus will decay next   B1 **[2]**

9 (a position shown as $A = 227$, $Z = 91$ B1   **[1]**

   (b) Pu shown as $A = 243$, $Z = 94$ B1
            D shown with $A = A_{Pu}$ and with $Z = (Z_{Pu} + 1)$ B1   **[2]**

10 **(a)** **(i)** curve is not smooth, fluctuations, etc B1

          (ii) curve is same shape or same half-life, not affected by temperature,
                    etc........... .... B1   [2]

    (b) **(i)** 134........... .... B1   [1]

          (ii) α-particle shown as $^{4}_{2}\text{He}$ or as $^{4}_{2}\alpha$ B1
                    nucleon number of Po shown as 216 .... B1
                    proton number of Po shown as 84... B1
                                                                                                          [3]