12.2 Nuclear Physics

Question Paper

Course	DP IB Physics
Section	12. Quantum & Nuclear Physics (HL only)
Topic	12.2 Nuclear Physics
Difficulty	Medium

Time allowed: 20

Score: /10

Percentage: /100

Question 1

Two elements are compared where the nucleus of the first element, N_1 has radius r and nucleon number Z, and the nucleus of the second element N_2 has radius $3r$ and nucleon number $\frac{5}{3} Z$. What is the ratio of $\frac{density\ N_1}{density\ N_2}$?

A. $\dfrac{1}{5}$

B. $\dfrac{4}{9}$

C. 1

D. $\dfrac{5}{2}$

[1 mark]

Question 2

The Physicists Geiger and Marsden bombarded a thin gold foil with alpha particles. They observed that

I.
most alpha particles passed through without deflection

II.
a very small number of alpha particles were deflected by a large angle

Select the row which explains these effects.

	I.	II.
A.	most α-particles miss the gold atoms	a small number of α-particles are deflected by the gold atoms
B.	the nucleus of the gold atom is very small so that most α-particles do not interact with it	the ratio of deflected particles is small because it reflects the ratio of the size of the nucleus compared to the atom
C.	the charge on the nucleus is insufficient to deflect the α-particle	the ratio of deflected particles is small because it reflects the ratio of the size of the nucleus compared to the atom
D.	α-particles are high energy and able to pass through the nucleus	the charges on the α-particle and the nucleus are such that large angle deflection cannot occur

[1 mark]

Question 3

Two samples P and Q of different radioactive isotopes have the same initial activity. Sample P has a third of the number of atoms as sample Q. The half-life of P is T seconds.

What is the half-life of sample Q?

A. $\dfrac{T}{3}$

B. $\dfrac{T}{3\sqrt{2}}$

C. $3T$

D. $3\sqrt{2}\,T$

[1 mark]

Question 4

The half-life of a radioactive isotope is 10 days. What is the approximate percentage of the sample remaining after 25 days?

A. 20

B. 19

C. 16

D. 15

[1 mark]

Question 5

A pure sample of a radioactive nuclide undergoes a decay resulting in a stable daughter nuclide. What fraction of the sample is made up of the daughter nuclide after five half-lives?

A. $\dfrac{1}{16}$

B. $\dfrac{1}{32}$

C. $\dfrac{15}{16}$

D. $\dfrac{31}{32}$

Question 6

A series of radioactive decays produce both alpha particles and anti-neutrinos. Which answer option describes the nature of the energy spectrum of these two particles?

	Anti-neutrino	Alpha-particle
A.	discrete	discrete
B.	discrete	continuous
C.	continuous	discrete
D.	continuous	continuous

Question 7

The decay of several unstable nuclei are observed in a radiation chamber. The following identifications are made:

   I. Alpha-particles have discrete kinetic energy levels
   II. Beta-particles have a continuous range of kinetic energies
   III. Gamma-ray photons have discrete kinetic energy levels

These observations directly relate to two important discoveries; the use of emission spectra to identify elements and the existence of the neutrino.

Which row correctly identifies the observations that lead researchers to the discovery of emission spectra and the existence of the neutrino?

	Emission spectra	Existence of the neutrino
A.	II only	II only
B.	I and III only	II only
C.	II only	I and III only
D.	I and III only	I and II

Question 8

The best estimate of the radii of nuclei is determined from experiments involving

    A. The scattering of charged particles.

    B. The emission of photoelectrons due to UV light incident on a metal surface.

    C. Diffraction of high energy electron beams.

    D. Ionisation due to alpha-particle radiation.

[1 mark]

Question 9

A radioactive sample of initial activity 10.0 Bq has a half-life of 1.0 day. Which value represents the most likely activity after 2.5 days?

    A. 0.8 Bq

    B. 1.2 Bq

    C. 1.6 Bq

    D. 2.2 Bq

[1 mark]

Question 10

A pure sample of a radioactive nuclide has mass m, half-life $T_{1/2}$ and initial activity A_0.

Identify the half-life and initial activity of another sample which is otherwise identical but has mass 3m.

	Half-life	Initial activity
A.	$T_{1/2}$	A_0
B.	$3T_{1/2}$	$\frac{1}{3}A_0$
C.	$T_{1/2}$	$3A_0$
D.	$3T_{1/2}$	$3A_0$

[1 mark]