12.2 Nuclear Physics

Question Paper

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

Time allowed: 20

Score: /10

Percentage: /100

Question 1

A radioactive source **X** consists of 10.4×10^{11} atoms of a nuclide of half-life 5 days. A second source **Y** consists of 5.2×10^{10} atoms of another nuclide of half-life 6 days.

After how many days will the number of radioactive atoms in **X** be equal to **Y**?

A. $\frac{30\ln(2)}{\ln(20)}$

B. $\frac{\ln(20)}{30\ln(2)}$

C. $\frac{30\ln(20)}{\ln(2)}$

D. $\frac{\ln(2)}{30\ln(20)}$

[1 mark]

Question 2

Two radioactive elements X and Y have half-lives T_X and T_Y respectively. Initially samples of S, N_X contains three times as many atoms of Y, N_Y .

After a certain time t, which of the expressions for $\frac{number\ of\ decayed\ atoms\ of\ X}{number\ of\ decayed\ atoms\ of\ Y}$ is correct?

A. $\frac{3\left(N_Y - N_Y\left(\frac{1}{2}\right)^{\frac{t}{T_X}}\right)}{N_Y - N_Y\left(\frac{1}{2}\right)^{\frac{t}{T_Y}}}$

B. $\frac{N_X\left(\frac{1}{2}\right)^{\frac{t}{T_X}} - N_X}{N_Y\left(\frac{1}{2}\right)^{\frac{t}{T_Y}} - N_Y}$

C. $\frac{N_X\left(\frac{1}{2}\right)^{\frac{t}{T_X}}}{N_Y\left(\frac{1}{2}\right)^{\frac{t}{T_Y}}}$

D. $\frac{3N_Y\left(\frac{1}{2}\right)^{\frac{t}{T_X}}}{N_Y\left(\frac{1}{2}\right)^{\frac{t}{T_Y}}}$

[1 mark]

Question 3

The initial activity of a radioactive source is 160 counts per second. After a time *T*, its activity becomes 5 counts per second.

If the half-life of the source is 18 hours, what is *T*?

A. $\frac{\ln(32)}{18\ln(2)}$ hours

B. $\frac{18\ln(32)}{\ln(2)}$ hours

C. $\frac{\ln(2)}{18\ln(32)}$ hours

D. $\frac{18\ln(2)}{\ln(32)}$ hours

[1 mark]

Question 4

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]

Question 5

Alpha particles with various energy *E* are directed at a nuclei with atomic number Z. Small deviations from the predictions of the Rutherford scattering model are observed.

Which value of E and Z is most likely to result in the greatest deviations from the Rutherford scattering model?

	E / MeV	Z
A.	39.0	350
B.	2.4	190
C.	39.0	190
D.	2.5	350

[1 mark]

Question 6

Two radioactive nuclides, P and Q, have half-lives of 70 s and 175 s respectively. At time *t* = 0, samples of P and Q contain the same number of nuclei.

What is $\frac{number\ of\ nuclei\ of\ P\ decayed}{number\ of\ nuclei\ of\ Q\ decayed}$ when *t* = 350 s?

A. 8

B. $\frac{24}{31}$

C. $\frac{31}{24}$

D. $\frac{1}{8}$

[1 mark]

Question 7

The diameter of Iridium-192 ($^{192}_{77}Ir$) nucleus is approximately four times that of the diameter of a nucleus of which other isotope?

A. $^{3}_{1}H$

B. $^{48}_{22}Ti$

C. $^{11}_{5}B$

D. $^{7}_{3}Li$

[1 mark]

Question 8

Two unstable isotopes are initially present in equal numbers. Isotope Y has a half life of 6 minutes and isotope Z has a half life of 3 minutes. Which expression correctly describes the ratio of the activity of Y to Z after 12 minutes?

A. $\frac{e^{-\frac{ln2}{2}\times 12}}{e^{-\frac{\ln 2}{2}\times 12}}$

B. $\frac{3}{6} \times \frac{e^{-\ln 2\times 12}}{e^{-ln2\times 12}}$

C. $\frac{1}{2} \times \frac{e^{-4\ln 2}}{e^{-3\ln 2}}$

D. $\frac{1}{2} \times \frac{e^{-2\ln 2}}{e^{-4\ln 2}}$

[1 mark]

Question 9

The ratio $\frac{radius\ of\ nucleus\ of\ Y}{radius\ of\ nucleus\ of\ X}$ is equal to 1.2 where the nucleus of X is ${}^{125}_{80}X$.

How many nucleons does nucleus Y have?

A. 36

B. 125

C. 6

D. 216

[1 mark]

Question 10

A pure sample of a known element has a very short half-life. What measurement(s), together with the initial activity of the sample, must be made in order to measure the half-life of the element?

A. The number of moles of the sample.

B. The activity and the number of moles of the sample after a given period of time.

C. The number of moles after a given period of time.

D. The activity after a given period of time.

[1 mark]