7.1 Discrete Energy & Radioactivity

Question Paper

Course	DP IB Physics
Section	7. Atomic, Nuclear & Particle Physics
Topic	7.1 Discrete Energy & Radioactivity
Difficulty	Hard

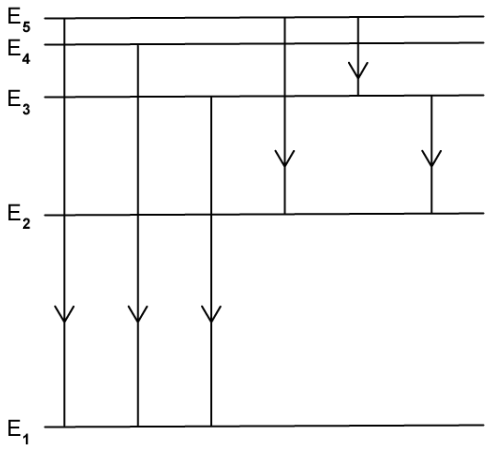
Time allowed: 20

Score: /10

Percentage: /100

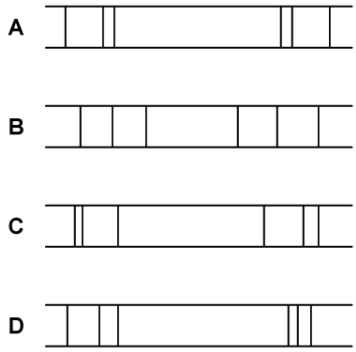
Question 1

The energy level diagram below shows six possible transitions between the energy levels of an atom. Each transition between levels creates a photon of definite energy and frequency.



The increase in frequency is from left to right.

Which of the following spectrum corresponds most closely to the transitions?



[1 mark]

Question 2

A particular nucleus, ${}^{A}_{Z}X$ decays to form ${}^{a}_{z}Y$, which then has two possible decay paths, resulting in either an isotope of Thallium (Tl) or Polonium (Po), as shown.

Which isotope could **not** be ${}^{A}_{Z}X$?

A. ${}^{215}_{82}Pb$

B. ${}^{214}_{84}Po$

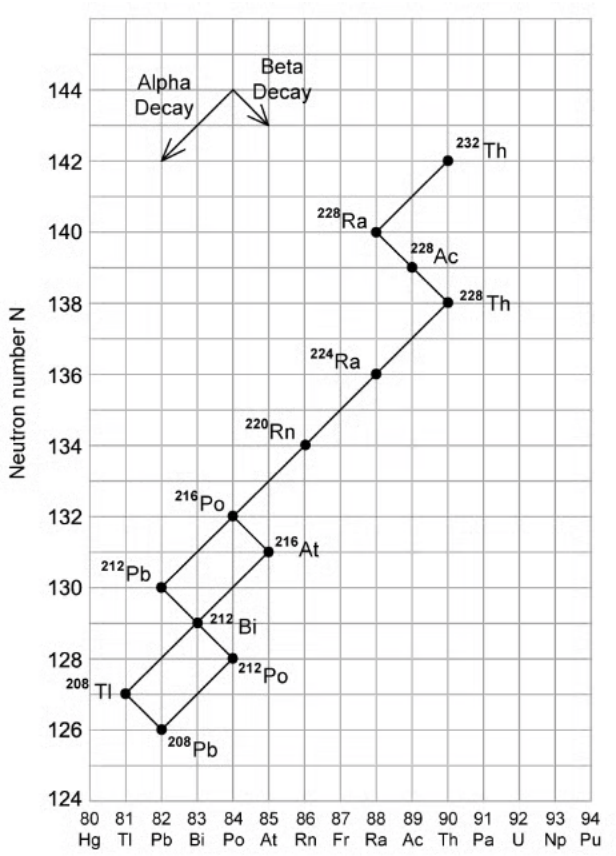
C. ${}^{218}_{85}At$

D. ${}^{214}_{82}Pb$

[1 mark]

Question 3

The decay series for Thorium-232 can be plotted as shown.



According to the diagram, how many possible routes are available for Thorium-232 to decay to a stable nucleus of lead-208?

A. 2

B. 4

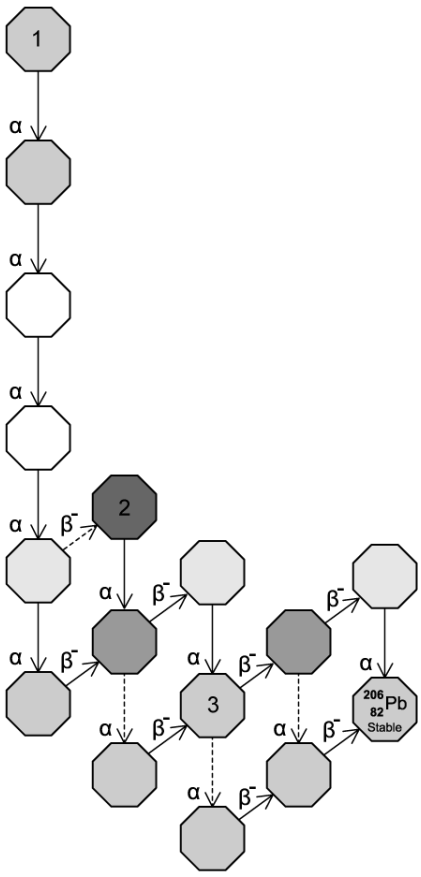
C. 10

D. 12

[1 mark]

Question 4

The diagram shows the decay chain for a particular isotope.



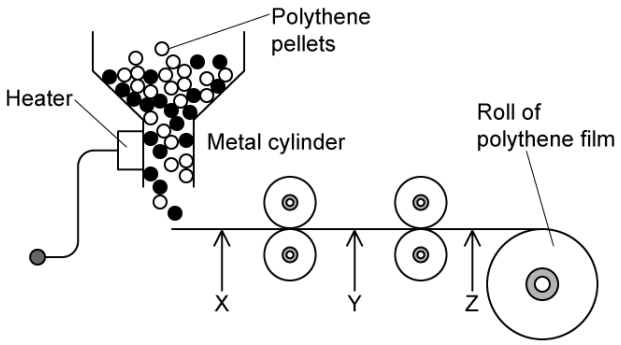
What are the isotopes labelled 1, 2 and 3?

	1	2	3
A	$^{230}_{90}Th$	$^{218}_{85}At$	$^{210}_{82}Pb$
B	$^{234}_{92}U$	$^{218}_{85}At$	$^{210}_{82}Pb$
C	$^{234}_{92}U$	$^{218}_{84}Po$	$^{210}_{81}Tl$
D	$^{230}_{90}Th$	$^{218}_{84}Po$	$^{210}_{82}Pb$

[1 mark]

Question 5

Polythene film is made by extruding polythene and drawing it into a long sheet which is wound onto a roll, as shown in the diagram below.



The manufacturer has to carefully choose a radioactive isotope which will effectively remove any electrostatic charge that has built up on the film. The manufacturer also has to consider the point X, Y or Z at which the radioactive isotope should be placed along the assembly line.

At which point should the radioactive isotope be placed, and which type of radiation should the manufacturer choose to remove excess electrostatic charge?

	Point	Type of radiation
A	X	alpha
B	X	gamma
C	Y	beta
D	Z	alpha

[1 mark]

Question 6

Transitions between three energy levels in a particular atom give rise to the three spectral lines of frequencies, in decreasing magnitude f_1, f_2 and f_3 with wavelengths λ_1, λ_2 and λ_3.

Which of the following correctly relates f_1, f_2 and f_3 and λ_1, λ_2 and λ_3.

	Frequency	Wavelength
A.	$f_3 = f_1 + f_2$	$\frac{1}{\lambda_1} = \frac{1}{\lambda_2} + \frac{1}{\lambda_3}$
B.	$f_3 = f_1 - f_2$	$\frac{1}{\lambda_1} = \frac{1}{\lambda_2} + \frac{1}{\lambda_3}$
C.	$\frac{1}{f_1} = \frac{1}{f_2} - \frac{1}{f_3}$	$\lambda_1 = \lambda_2 + \lambda_3$
D.	$\frac{1}{f_1} = \frac{1}{f_2} + \frac{1}{f_3}$	$\frac{1}{\lambda_3} = \frac{1}{\lambda_1} - \frac{1}{\lambda_2}$

[1 mark]

Question 7

Radioactive isotopes are used in medical imaging.

For example, two isotopes of iodine, 123–*I* and 131–*I* are both used by radiographers, who give them to patients in the form of iodide before taking scans.

The possible decay equations for these isotopes are:

1. ${}^{123}_{53}I \rightarrow {}^{123}_{52}Te + \_\_\_\_\_$
2. ${}^{131}_{53}I \rightarrow {}^{131}_{54}Xe + \_\_\_\_\_$

Which is a correct difference between these two decays?

A. In decay 1, an electron neutrino is emitted, but in decay 2 an anti-electron neutrino is emitted

B. In decay 1, an electron has been absorbed but in decay 2 a neutron has been absorbed

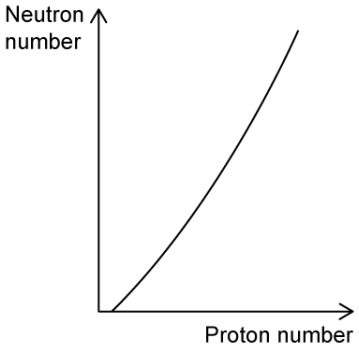
C. In decay 1, an anti-electron neutrino is emitted, but in decay 2 an electron neutrino is emitted

D. In decay 1, a neutron became a proton but in decay 2 a proton became a neutron

[1 mark]

Question 8

The graph shows the how the neutron-proton ratio of stable nuclei changes as proton number increases.



What other changes with increasing proton number are suggested by the graph?

1. The charge-mass ratio increases
2. The charge-mass ratio decreases
3. The likelihood of α-decay increases
4. The likelihood of β-positive decay increases
5. Protons outnumber neutrons in large nuclei, with a rapidly increasing ratio

A. 1 and 3

B. 2 and 3

C. 2, 4 and 5

D. 2, 3 and 5

[1 mark]

Question 9

The charge to mass ratio, $\frac{Q}{m}$, is also known as the specific charge.

What is the ratio of $\frac{specific\ charge\ of\ {}^{7}_{3}\mathrm{Li}}{specific\ charge\ of\ {}^{16}_{8}\mathrm{O}^{2+}}$?

A. $\frac{6}{7}$

B. $\frac{7}{6}$

C. $\frac{24}{7}$

D. $\frac{7}{24}$

[1 mark]

Question 10

The number of undecayed atoms, *N*, of a radioactive substance after time, *t*, can be calculated by the equation:

$$N = N_0\left(\frac{1}{2}\right)^{\frac{t}{T_{\frac{1}{2}}}}$$

Where:

- $T_{\frac{1}{2}}$ = the half-life
- N_0 = the original number of atoms

Two radioactive elements X and Y have half-lives T_X and T_Y respectively. An initial sample contains three times as many atoms of X, N_X than 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. $\frac{3N_Y\left(\frac{1}{2}\right)^{\frac{t}{T_Y}}}{N_Y\left(\frac{1}{2}\right)^{\frac{t}{T_Y}}}$

[1 mark]