7.1 Discrete Energy & Radioactivity

Question Paper

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

Time allowed: 90

Score: /75

Percentage: /100

Question 1a

(a)

Match, by drawing a line, the words with their correct definitions.

Ionisation	Fundamental particles that make up all forms of electromagnetic radiation
Photon	A group of atoms containing the same number of protons and neutrons
Nuclide	The electron has gained enough energy to be removed from the atom entirely
Isotope	An atom of the same element that has an equal number of protons but a different number of neutrons

[4]

[4 marks]

Question 1b

The energy of a photon can be calculated using the equation

$$E = \frac{hc}{\lambda}$$

(b)
Define the following terms and give the unit:

(i)
h

[2]

(ii)
c

[2]

(iii)
λ

[2]

[6 marks]

Question 1c

(c)
Calculate the wavelength of a photon with an energy of 1.44×10^{-19} J.

[2]

[2 marks]

Question 1d

(d)

(i)

Complete the gaps in the following paragraph by writing the correct words on the line.

Electrons in an atom can only have specific energies. These energies are called _____ _____ _____ .

Normally, electrons occupy the _____ energy level available. This is known as the _____ _____.

Electrons can gain energy and move up the energy levels by _____ energy.

[4]

(ii)

Underline the processes that allow an electron to move up an energy level.

Collisions with other atoms or electrons Releasing a photon Radioactive decay Absorbing a photon Changing colour Emitting a neutrino

A physical source, such as heat

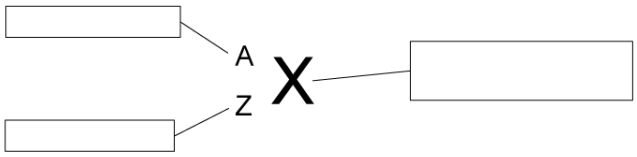
[3]

[7 marks]

Question 2a

Nuclides can be written in symbol form.

(a)
Complete the labels on the general nuclide symbol using the words below:



- Chemical symbol for the element
- Proton number
- Nucleon number

[3]

[3 marks]

Question 2b

(b)
Define radioactive decay.

[4]

[4 marks]

Question 2c

(c)
Draw lines to match the phrases with the correct definitions.

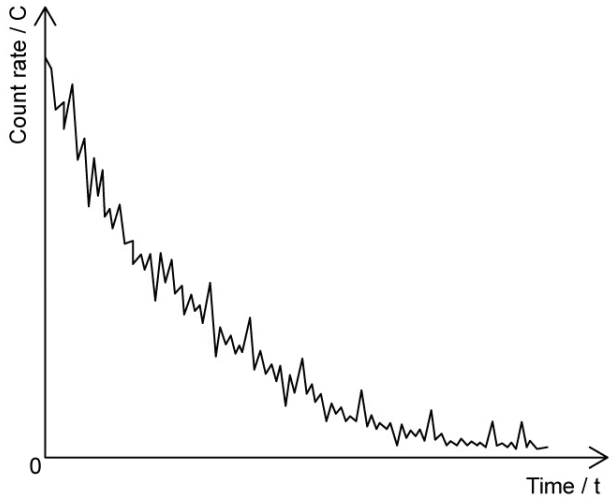
A spontaneous process	A process in which the exact time of decay of a nucleus cannot be predicted
A random process	The relative amounts of different isotopes of an element found within a substance
Isotopic data	A process which cannot be influenced by environmental factors

[3]

[3 marks]

Question 2d

The graph shows the count rate of a radioactive substance measured by a Geiger-Müller tube.



(d)

State what the fluctuations in the count rate provide evidence for.

[1]

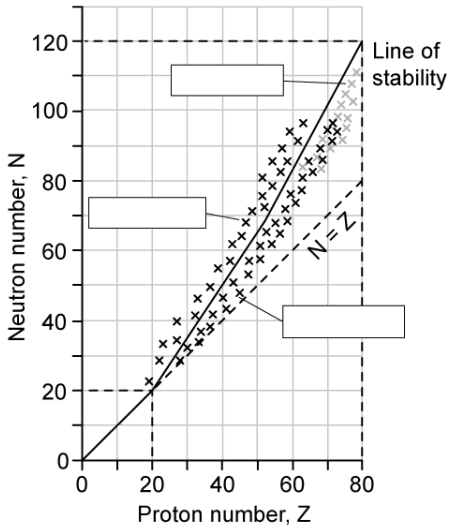
[1 mark]

Question 3a

The number of neutrons and number of protons for different isotopes can be plotted on a graph called a nuclear stability curve. Different regions on the graph represent the type of decay which is expected.

The three types of radioactive particles shown are alpha emitters, beta–minus emitters and beta–positive emitters.

(a)
Label the regions of the graph to indicate which type of radioactive particle is expected to be emitted.



[3]

[3 marks]

Question 3b

Background radiation comes from a variety of sources, some are natural and some are man-made.

(b)
Place ticks (✔) in the correct column to indicate whether the source is man-made or natural:

	Mad-made source	Natural source
Fallout from nuclear weapons		
Cosmic rays		
Nuclear waste		
Nuclear accidents		
Carbon–14 in biological material		
Radon gas		
Medical sources		
Radioactive material in food and drink		

[8]

[8 marks]

Question 3c

Radiation is emitted as various different types of particle.

(c)
State 4 types of radioactive particle.

[4]

[4 marks]

Question 3d

When a beta emission occurs, a particle called a neutrino is also emitted.

(d)
Complete the gaps in the following sentences. Choose from the words below:

A neutrino has no _____ and negligable _____. Electron anti-neutrinos are produced during _____ decay. Electron neutrinos are produced during _____ decay.

mass gravity age charge beta-minus beta-positive alpha

[4]

[4 marks]

Question 4a

(a)

Complete the table with the correct properties of alpha, beta–minus, beta–positive and gamma radiation.

Particle	Composition	Mass / u	Charge / e
Alpha	2 protons and 2 neutrons		
Beta-minus		0.0005	-1
Beta-plus	Positron (e^+)	0.0005	
Gamma			0

[6]

[6 marks]

Question 4b

Plutonium–239 decays to Uranium–235 through the emission of an alpha particle.

(b)

Determine the missing values in the decay equation:

$$^{239}_{94}\text{Pu} \rightarrow ^{\text{(i)}}_{92}\text{U} + ^{4}_{\text{(ii)}}\alpha$$

[2]

[2 marks]

Question 4c

Strontium-90 decays through beta-minus decay to form Yttrium-90.

(c)
Determine the missing values in the decay equation.

$$^{90}_{38}\mathrm{Sr} \rightarrow ^{90}_{(\mathrm{i})}\mathrm{Y} + ^{0}_{-1}\beta + (\mathrm{ii})$$

[2]

[2 marks]

Question 4d

Fluorine-18 decays through beta-plus decay to form oxygen-18.

(d)
Determine the missing values in the decay equation.

$$^{18}_{9}\mathrm{F} \rightarrow ^{(\mathrm{i})}_{8}\mathrm{O} + ^{0}_{(\mathrm{ii})}\beta + \nu_e$$

[2]

[2 marks]

Question 5a

(a)
Define half-life.

[2]

[2 marks]

Question 5b

A student investigates the half–life of technetium with time. This list shows the variables in the experiment.

time size of sample distance from detector to sample

same material for the sample radioactive activity

(b)
Using variables from the list:

(i)
State the independent variable

[1]

(ii)
State the dependent variable

[1]

(iii)
State the control variables for the experiment

[3]

[5 marks]

Question 5c

The experiment uses a variety of apparatus.

(c)
Draw a line to match the apparatus with its correct use.

Apparatus
Long tongs
Geiger-Müller tube
Secure holder for radioactive source
Stopwatch

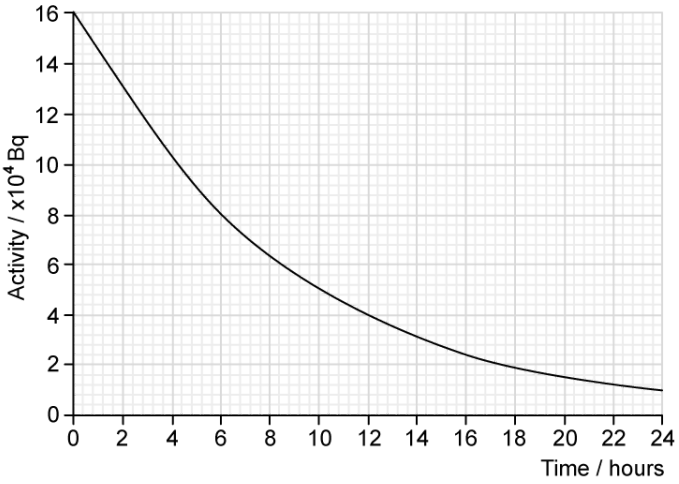
Purpose
To detect the count rate of the radioactive source
To measure the same interval of time for each reading
To handle the radioactive source at a distance
To ensure the radioactive source remains in place. It is lined with lead to reduce unnecessary exposure

[4]

[4 marks]

Question 5d

The student plots the following graph of their results.



(d)

Determine the half–life of the sample.

[3]

[3 marks]