ANSWERS

1

Subatomic Particle	Relative Charge
Proton	+1
Neutron	0
Electron	–1

Question 1A

A nucleus of the radioactive element uranium is represented as $^{235}_{92}\mathrm{U}$.

(a) How many protons are contained in this nucleus?

92 protons

(b) How many neutrons are contained in this nucleus?

235 – 92 = 143 neutrons

(c) How many electrons are contained in this nucleus? Why?

Zero. Electrons are not found in the nucleus.

Question 1B

Chlorine-35 and chlorine-37 are two isotopes of the same element. The nucleus of chlorine-35 is represented by $^{35}_{17}\mathrm{Cl}$

(a) State the nuclide notation for the nucleus of chlorine-37.

$$^{37}_{17}\mathrm{Cl}$$

(b) How many neutrons are contained in the nucleus of chlorine-37?

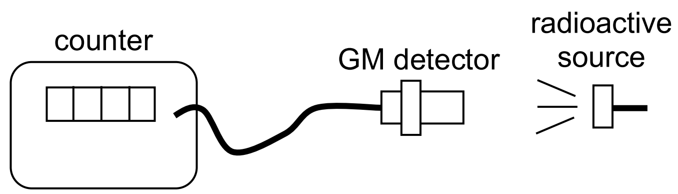
20 neutrons

(c) How many electrons would be found in a Cl^- ion?

18 electrons would be in a Cl^- ion

Question 2.4

A GM detector is placed near a radioactive source as shown below.



(a) The counter reads 1200 counts/min. Express this in counts/s.

1200 / 60 = 20 counts/s

(b) A 2 mm thick sheet of aluminium is placed between the source and the GM detector, the counter then reads 1150 counts/min. What type of radiation is being emitted from the source. Explain your reasoning.

γ-rays are being emitted. 2 mm of aluminium would stop all α and β particles. Thus only γ-rays can penetrate this material.

Question 2.5A

A student is given a sample of a radioactive element that has a half-life of 5 hours. She thinks the sample will be safe to handle after 10 hours as it will all have decayed. Is she correct?

No, she is not correct.
10 hours is two half-lives, meaning that the activity will have dropped to 25% of the original value.

Question 2.5B

The half-life of iodine-131 is 8 days.

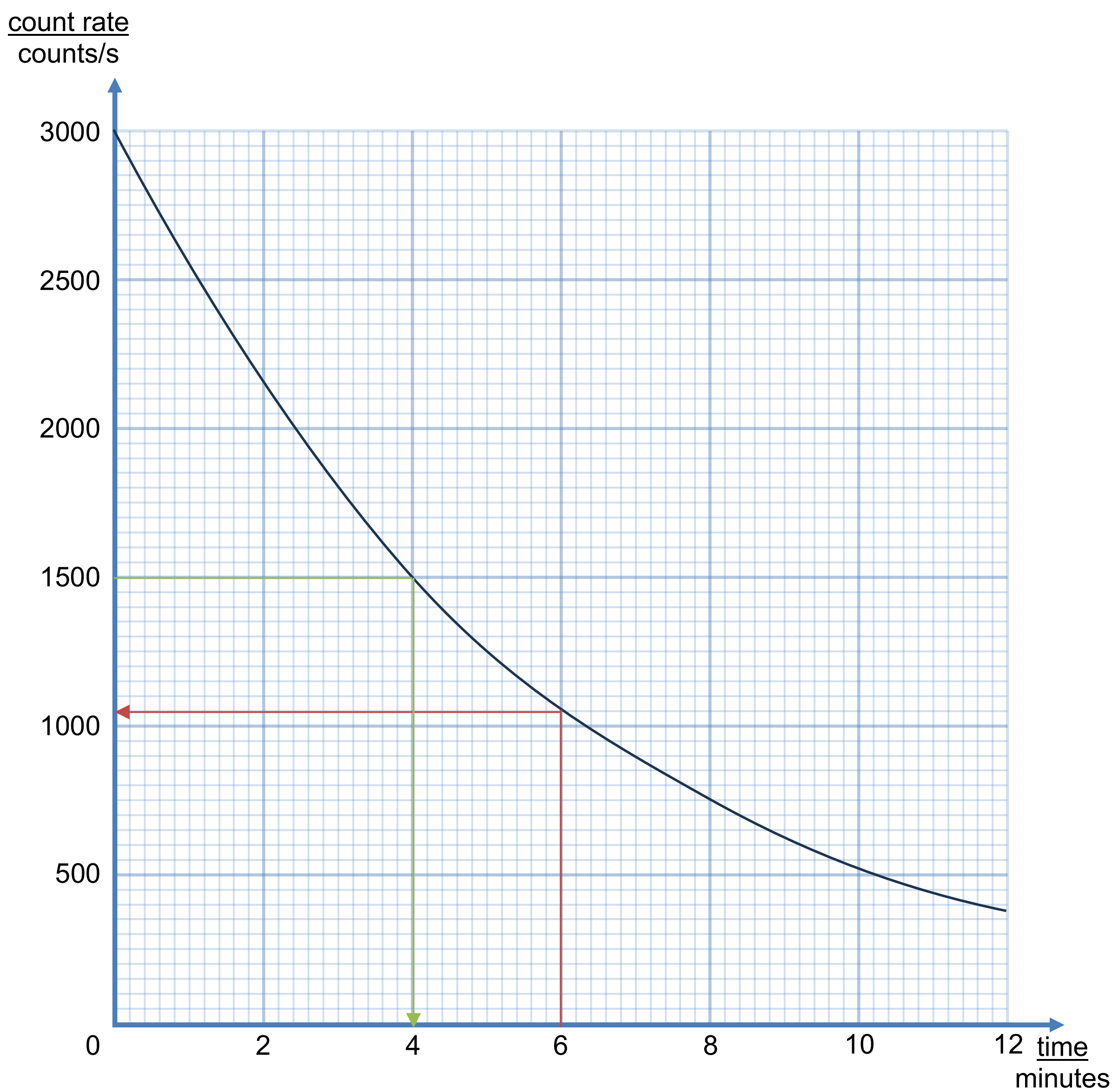
Given an initial 12 grams of this isotope, how much will be remaining after 24 days?

24 days is 4 half-lives.

Amount of iodine-131 present after 4 half-lives have passed will be 12 ÷ 2 ÷ 2 ÷ 2 ÷ 2 = 0.75 g

Question 2.5C

A radioactive sample has an initial count rate of 3000 counts/s. The count rate drops as the sample decays as shown below.



(a) What is the count rate after 6 minutes?

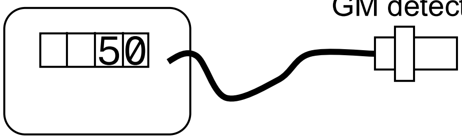
1050 counts/s

(b) What is the half-life of this particular nuclide?

Time taken to drop from a count rate of 3000 counts/s to 1500 counts/s is 4 minutes.

Question 2.6

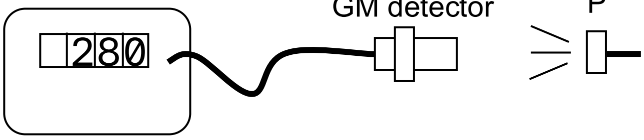
When a GM detector is placed far away from any known source of radiation it shows a reading of 50 counts/min.



(a) Explain why there is a reading on the GM counter.

It is detecting background radiation.

A source of radiation, P, with a half-life of 2 hours, is brought close to the GM detector. The counter initially reads 280 counts/min.



(b) What is the initial activity (count rate) of source P alone?

280 – 50 = 230 counts/min

(c) What reading will be shown on the counter after 4 hours have passed?

4 hours is two half-lives, thus the activity would be reduced to 25% of the original activity. i.e. activity of P alone would now be 230 ÷ 4 = 58 counts/min (2 s.f.)

Including the background radiation, we would see a reading of 58 + 50 = 108 counts/min on the counter.

Question 3.1

A uranium-238 nuclei spontaneously undergoes fission to create daughter nuclides of strontium-95 (atomic number 38) and an isotope of xenon (atomic number 54) as well as three neutrons.

(a) Name the isotope of xenon that is formed in this nuclear fission process.

238 – 95 – 3 = 140

Isotope formed is xenon-140

(b) Complete the nuclear reaction equation for this nuclear fission process

$$^{238}_{92}\text{U} \rightarrow {}^{95}_{38}\text{Sr} + {}^{140}_{54}\text{Xe} + 3\ {}^{1}_{0}\text{n}$$

Question 3.2A

Write a nuclear equation to show the nuclear fusion reaction shown in the diagram above.

$$^{3}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$$

Question 3.2B

Explain why nuclear fusion can only occur at very high temperatures and pressures.

This is to ensure that the nuclei are close together and moving at very high speeds so as to overcome the very strong repulsive force between the 2 nuclei (which are both positively charged).

Question 4.1

(a) Why are isotopes with short half-lives (eg 2 hours) usually used for medical imaging?

So that the level of activity will decay to nothing within a short period of time. This will minimise unwanted effects due to radioactivity taking place within the body.

(b) Why it is safe to eat strawberries that have been irradiated with γ-rays?

The γ-rays will kill all the bacteria present on the strawberries. But, being just electromagnetic waves, they will not leave the strawberries radioactive.

(c) Why can carbon-dating not be used to determine the age of dinosaur bones?

Dinosaur bones are millions of years old. With carbon-14 having a half-life of just 5700 years, so many half-lives will have passed since the dinosaurs died that there will not be any measurable carbon-14 left in the dinosaur bones.

Question 4.2

Give **two** reasons why long tongs used to pick up and handle a radioactive source in the laboratory?

So that the radioactive material is not touched with our hands, thus contaminating us.

The long tongs keep the distance from our hands to the source larger and thus reduce the level of exposure that we would receive compared to using shorter tongs.

Summary of The Three Nuclear Emissions:

	α	β	γ
Nature of radiation	The fast moving nucleus of a helium atom. (i.e. composed of 2 protons and 2 neutrons)	A fast moving electron emitted from the nucleus of a radioactive atom.	High energy electromagnetic wave emitted from the nucleus of a radioactive atom.
Penetrating power	Least penetrating		Most penetrating
Ionising power	Most ionising		Least ionising
Distance travelled in air	A few cm	A few metres	Very far
Deflected by electric fields	Yes (has +ve charge)	Yes (has –ve charge)	No. Has no charge.
Deflected by magnetic fields	Yes (has +ve charge)	Yes (has –ve charge)	No. Has no charge.
Absorbed by	Can be stopped by paper	Can be stopped by 2 mm of aluminium	Many cm of lead to be stopped