National 5 Physics

Radiation

Problem Booklet

Contents

Properties of Radiation

1. Describe what the following radiations are made up of: Alpha, Beta, Gamma.

2. What is the meaning of the term 'ionisation'?

3. Describe how these types of radiation cause ionisation of an atom? (Alpha, Beta, Gamma)

4. Copy and complete this table to show the absorption of radiation as they travel through different materials. (Put a ✓if the radiation will pass through the material. Put a x if the radiation will be absorbed by the material).

Radiation	Absorbing material			
	3 cm of Air	Piece of Paper	3 cm of Aluminium	3 cm of Lead
Alpha				
Beta				
Gamma				

5. Give three safety precautions that should be followed when working with radioactive materials.

6. What is background radiation?

7. What are the main sources of background radiation?

8. Is background radiation mostly naturally occurring or man-made?

9. What effect does radiation have on living cells?

10. Smoke alarms are made with an alpha source (Americium-241). Describe how a smoke alarm uses ionisation to warn people of a possible fire.

11. A radioactive tracer is a gamma emitting chemical compound that can be injected in to a patient in hospital. Describe how this can be useful in diagnosis of medical problems.

12. Gamma rays can also be used to treat cancer in a method known as radiotherapy. Describe how a patient can have a cancer treated in this way, and how damage to surrounding healthy tissue is minimised.

13. Choose one piece of equipment and describe how it detects radiation: Geiger-Muller Tube, Film Badge, Scintillation Counter.

Activity

1. What is meant by the ‘activity’ of a source?

2. What is meant by the term ‘radioactive decay’?

3. What is the activity of a source that has 210 decays in a minute?

4. A source has an activity of 2.0 kBq. How many counts will be recorded from the source by a Geiger-Muller tube (and counter) in 30 seconds?

5. How long will it take a source with an activity of 1.8 MBq to have 8.1 x 10^8 radioactive decays?

6. Describe an experiment to find the activity of a radioactive source using the following equipment: Stopwatch, Geiger-Muller Tube, Counter.

7. In a laboratory, the background activity is measured as 1.5 Bq. A Geiger-Muller tube is used to measure the activity of a source in the laboratory. In three minutes, 1440 counts are recorded. What is the activity of the source?

8. Complete the table below:

Activity / Bq	Number of Decays	Time / s
	720	60
	4500	180
1000		100
12 500		500
40 000	3.0×10^7	
2.5×10^6	5.0×10^8	

9. In an experiment, the number of decays from a radioactive source is recorded. The background count is then taken away. The results of this are shown.

Time / minutes	Corrected Number of Decays
0	0
1	1800
2	3600
3	5400
4	7200
5	9000

Draw a line graph of these results, and use the gradient of the straight line to calculate the activity of the source.

Half Life

1. What happens to the activity of a source as it gets older?

2. What is the meaning of this statement? “The half-life of a radioactive source is 12 hours”

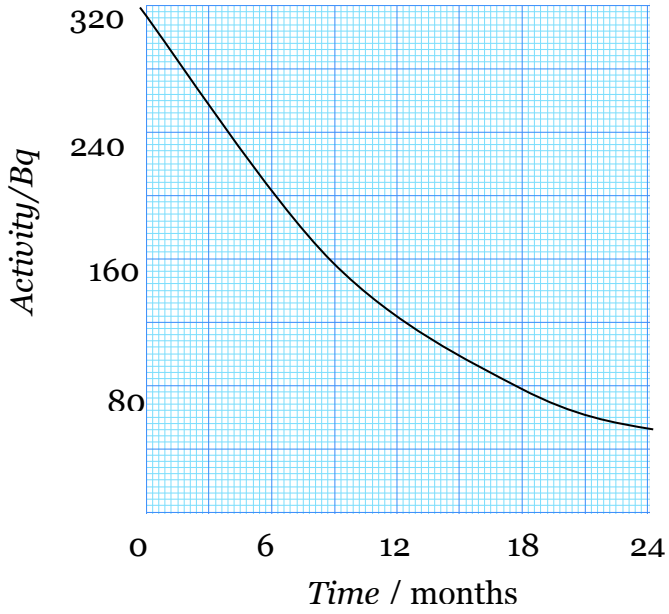
3. A radioactive material has a half life of 8 hours. If it has an original activity of 200 kBq, what is the activity of the source a day later?

4. The activity of a radioactive substance drops from 100 MBq to 6.25 MBq in 12 years. What is the half life of the substance?

5. A material with a half life of 4 hours has an activity of 15 Bq at this moment. What was its activity 24 hours ago?

6. A patient in a hospital is being given a radioactive tracer to find a blockage in his kidneys. The tracer is prepared in a laboratory with an initial activity of 16 kBq. It can’t be safely given to the patient until the activity drops to 0.25 kBq. The half life of the tracer is 6 hours, and the patient is due to be treated at 9am on Saturday. When should the tracer be prepared?

7. The activity of a radioactive source is shown on this graph. What is the half-life of the source?



8. A radiotherapist in a hospital has to decide which of five materials is to be used as a radioactive tracer. The materials and some of their properties are listed.

Material	Radiation Emitted	Half Life
A	Alpha	4 hours
B	Gamma	3 hours
C	Beta	10 hours
D	Gamma	63 years
E	Alpha	5 minutes

Which material should the radiotherapist use? Give two reasons for your answer.

Absorbed Dose

1. What is the meaning of the term ‘absorbed dose’?

2. Copy and complete this table.

Absorbed Dose / Gy	Energy/ J	Mass / kg
	6×10^{-6}	0.5
	3.5×10^{-5}	0.25
8.8×10^{-5}		0.05
6.5×10^{-5}		0.26
1.1×10^{-5}	3.3×10^{-6}	
1.2×10^{-5}	1.8×10^{-6}	

3. What is the absorbed dose of a 400 g hand that absorbs 7 µJ of alpha particles?

4. What is the mass of skin exposed to radiation with 4.2 µJ of energy if the absorbed dose is 10 µGy?

5. A tumour of mass 150 g is exposed to gamma rays. The absorbed dose from this exposure is 5.1 x 10^{-5} µGy. What is the energy of the gamma rays absorbed by the tumour?

Equivalent Dose

1. What is the meaning of the term ‘equivalent dose’?

2. What is the equivalent dose of a patient’s tissue, if it is exposed to 1.5 µGy of slow neutrons?

3. What is the absorbed dose of a patient’s foot, if it’s equivalent dose is 0.4 mSv of gamma rays?

4. A piece of skin is exposed to 15 µGy of a radiation. The equivalent dose of the skin is 0.3 mSv.

5. What is the weighting factor of the radiation?

6. What kind of radiation has the skin likely been exposed to?

7. A piece of tissue has a mass of 100 g and is exposed to 10 µJ of fast neutrons.

8. What is the absorbed dose of the tissue?

9. What is the equivalent dose of the tissue?

10. As a part of his job, an airport security guard has to expose his hand to x-rays ($W_R = 1$) as he removes blockages from a baggage scanner. On average, each time he does this, the absorbed dose of his hand is 0.03 µGy. What is the equivalent dose of his hand each time he removes a blockage?

11. The safety rules in the airport state that the maximum equivalent dose for his hand in one hour is 0.6 µSv. How many times can the airport security guard safely put his hand in the scanner in an hour?

13. The average person in the UK receives an background equivalent dose of 2.5 mSv per year. Why would you expect a person in Dalbeattie to have a slightly higher (yet still safe) equivalent dose?

14. Radioactive substances have many uses in society, such as in medicine. However, there are also some disadvantages of using radioactivity, such as the altering and killing of living cells. List some risks and benefits of using radioactivity in society.

15. The average annual equivalent dose of the most common sources of background radiation in the UK are shown.

Background Source	Equivalent Dose / mSv
Radon Gas (from rocks)	1.25
Buildings	0.35
Medical	0.35
Food & Drink	0.30
Cosmic Rays	0.25
Nuclear Power & Weapons	0.0075

Construct a bar graph or pie chart to show this information. Make sure that it is clear which sources are man-made and which are naturally occurring.

16. Complete the table below

Equivalent Dose /Sv	Absorbed Dose / Gy	Radiation Weighting Factor
	4.2×10^{-6}	1
	1.7×10^{-5}	3
6.8×10^{-5}		10
3.5×10^{-5}		20
1.1×10^{-5}	1.1×10^{-4}	
4.5×10^{-5}	1.5×10^{-5}	

Nuclear Fission and Fusion

1. What is nuclear fission?
2. What is a chain reaction in nuclear fission?
3. How does a fission reaction create heat energy?
4. What is nuclear fusion?
5. How does nuclear fusion create heat energy?