

AQA GCSE PHYSICS (HIGHER) • 8463

PHYSICS



EXAM QUESTION PACK

4.4.3 HAZARDS AND USES OF RADIOACTIVE EMISSIONS AND OF BACKGROUND RADIATION (PACK 2)

SCORE

/119

PERCENTAGE

%

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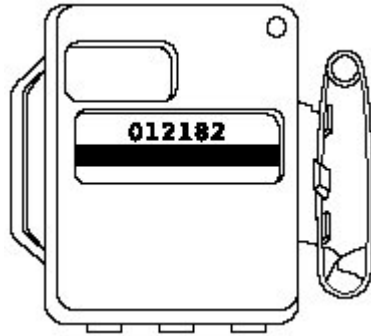
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Q1.

The diagram shows a badge used to monitor radiation. It measures the amount of radiation a worker has been exposed to in one month.



- (i) What is used inside the badge to detect radiation?

_____ (1)

- (ii) What would indicate that the worker has been exposed to a high level of radiation as opposed to a low level of radiation?

_____ (1)

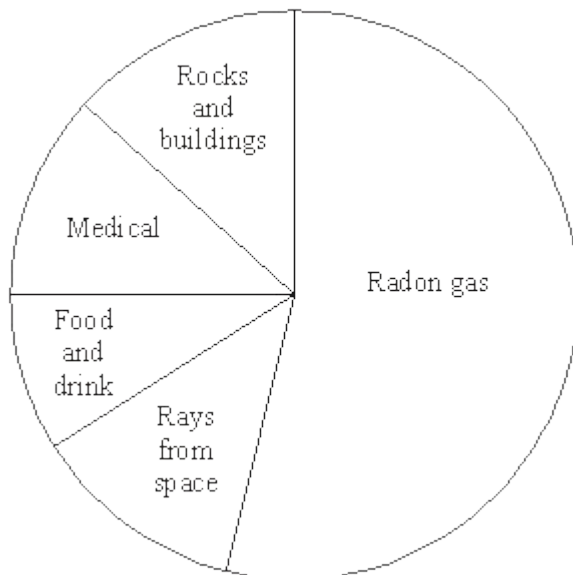
- (iii) Why is it important to monitor the amount of radiation the worker has been exposed to?

_____ (1)

(Total 3 marks)

Q2.

Radiation is around us all of the time. The pie chart shows the sources of this radiation.



- (i) What is the main source of this radiation?

(1)

- (ii) What name is given to the radiation that is around us all of the time?

(1)
(Total 2 marks)

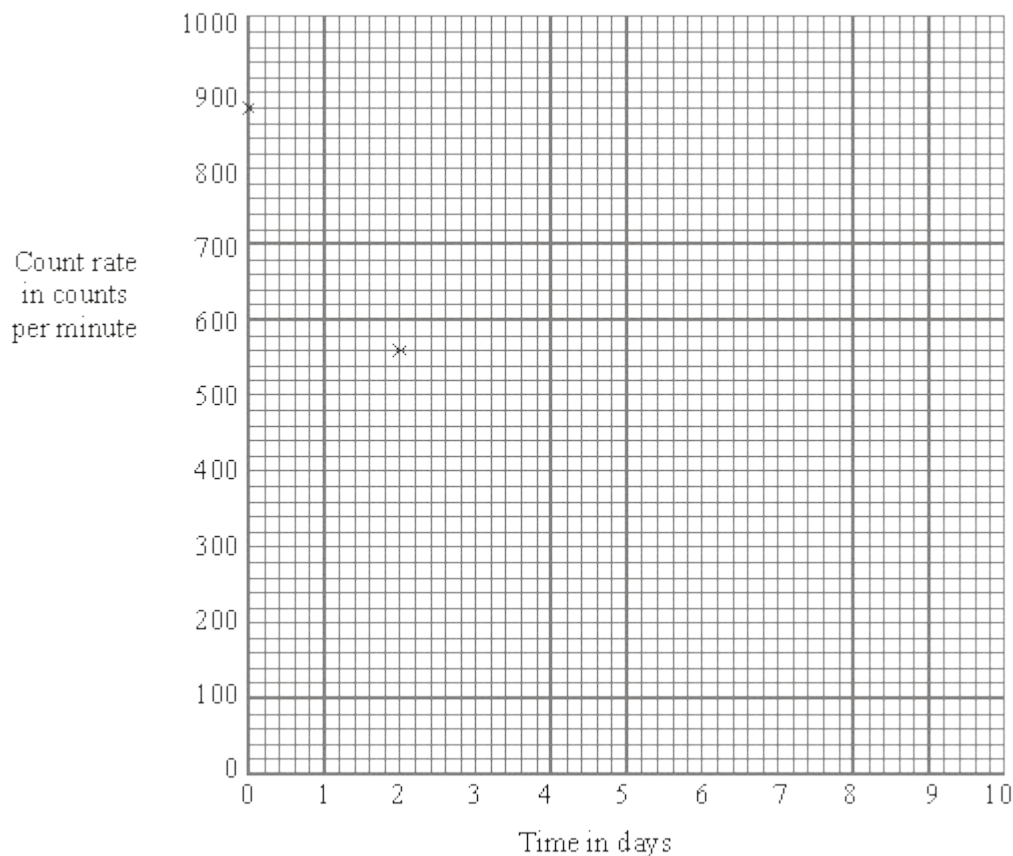
Q3.

The table shows how the count rate from a radioactive substance changes in 10 days.

Time in days	0	2	4	6	8	10
Count rate in counts per minute	880	555	350	220	140	90

- (a) Draw a graph of count rate against time.

The first two points have been plotted for you.



(3)

- (b) (i) Use your graph to find out how long it takes for the count rate to fall from 880 counts per minute to 440 counts per minute.

Time = _____ days

(1)

- (ii) What is the half-life of this substance?

Half-life = _____ days

(1)

- (c) The table gives the half-life and type of radiation given out by four different radioactive isotopes.

Radioactive isotope	Half-life in days	Radiation given out
bismuth-210	5.0	beta
polonium-210	138.0	alpha and gamma
radon-222	3.8	alpha
thorium-234	24.1	beta and gamma

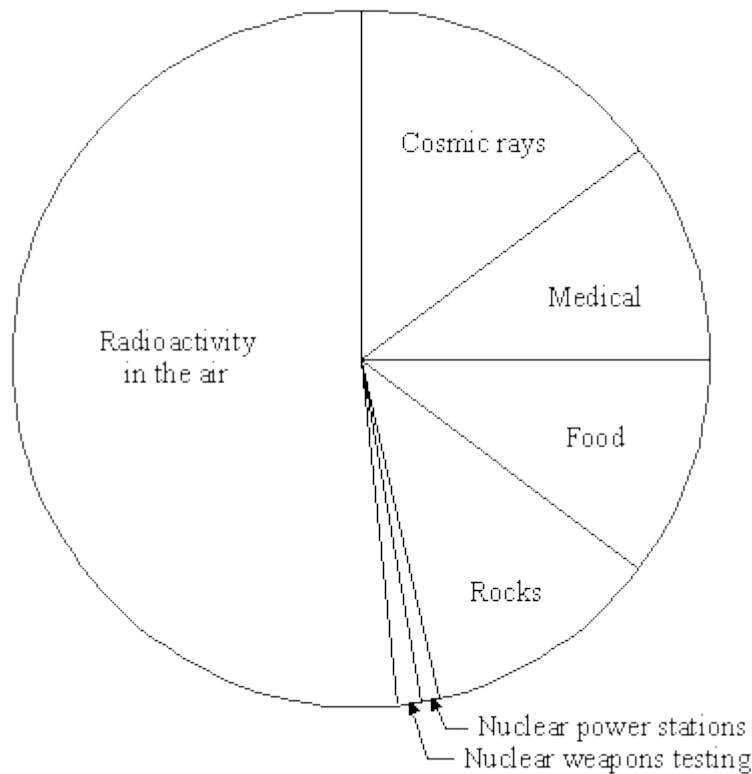
Some samples of each isotope have the same count rate today. Which sample will have the lowest count rate one month from today?

Give a reason for your answer.

(2)
(Total 7 marks)

Q4.

The different sources of radiation to which we are exposed are shown in the pie chart. Some sources are natural and some artificial.



- (i) Name **one** natural source of radiation shown in the pie chart.

(1)

- (ii) Name **one** artificial source of radiation shown in the pie chart.

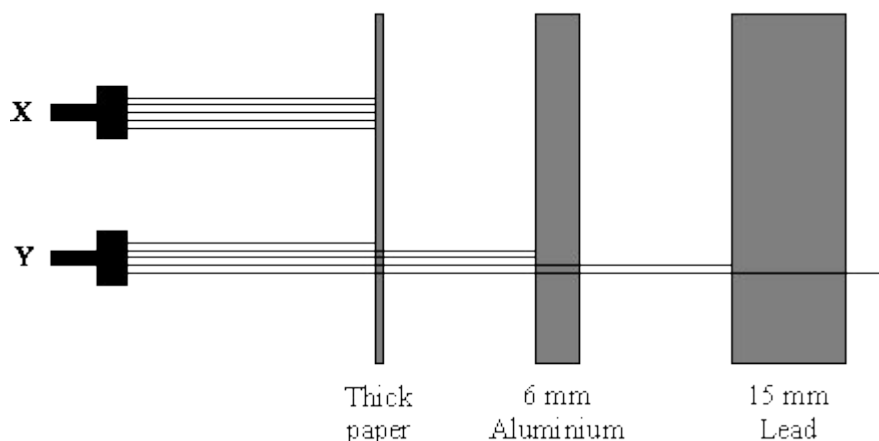
(1)
(Total 2 marks)

Q5.

- (a) A radioactive source can give out three types of emission:

alpha particles
beta particles
gamma radiation.

The diagram shows the paths taken by the radiation emitted by two sources, **X** and **Y**.



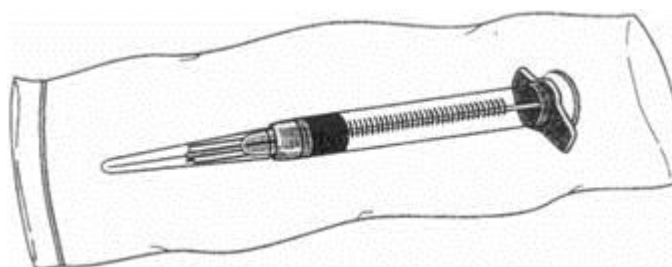
What types of radiation are emitted by each of the sources?

Source **X** emits _____

Source **Y** emits _____

(2)

- (b) The diagram shows a disposable syringe sealed inside a plastic bag. After the bag has been sealed the syringe is sterilised using radiation.



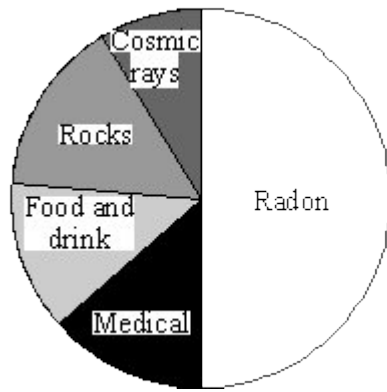
Explain why radiation can be used to sterilise the syringe.

(3)

(Total 5 marks)

Q6.

The pie chart shows the main sources of *background radiation*. Each source contributes to the average yearly radiation dose.



- (i) What is meant by the term *background radiation*?

(1)

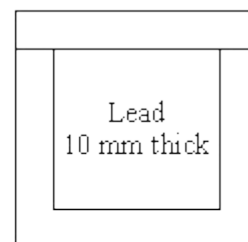
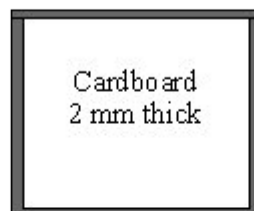
- (ii) Suggest why an airline pilot is likely to get a higher than average yearly radiation dose.

(2)

(Total 3 marks)

Q7.

- (a) The diagram shows three different boxes and three radioactive sources. Each source is stored in a different box.



Gamma source



Beta source

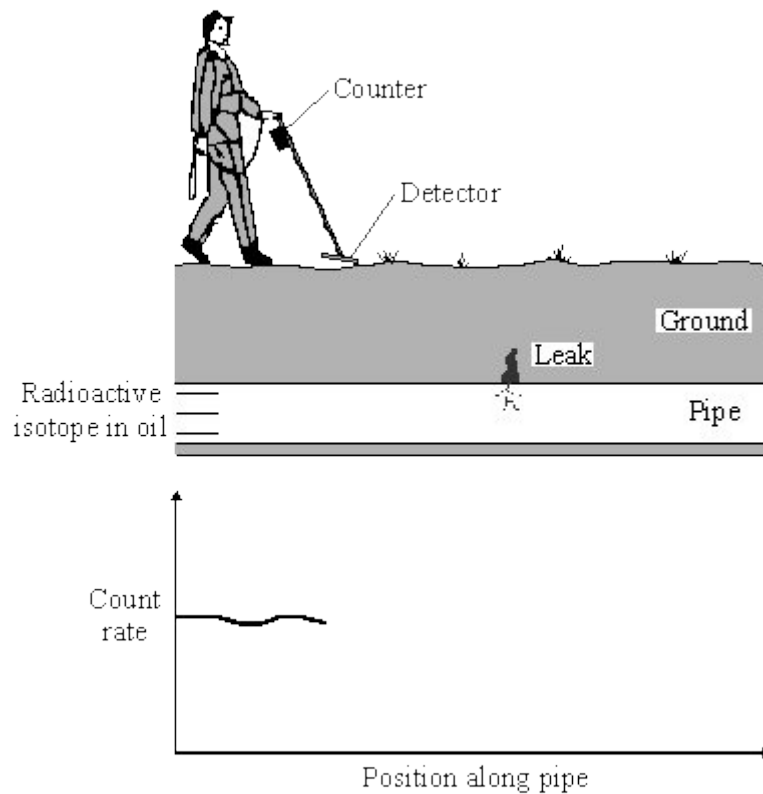


Alpha source

Draw lines to show which source should be stored in each box so that the risk of radiation leakage is a minimum.

(2)

- (b) A leak in an underground oil pipe can be found by injecting a radioactive isotope into the oil. The ground is then tested with a radiation detector and counter.



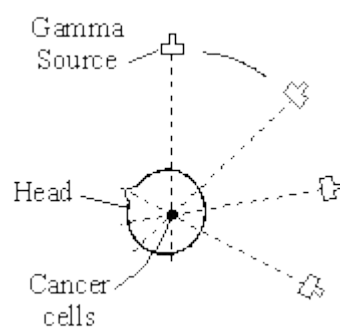
- (i) State the type of detector used.

(1)

- (ii) Complete the sketch graph to show how the reading on the detector will change as it passes along the ground above the pipe.

(1)

- (c) Gamma radiation can be used to kill cancer cells inside a person's head. During the treatment the patient is kept perfectly still while the source of gamma radiation moves in a circle.



- (i) Why is a source of gamma radiation the most suitable for this treatment?

(1)

- (ii) Suggest why a moving source of radiation is used rather than one which is kept stationary.

(2)

- (iii) Gamma radiation is an electromagnetic wave. Give **two** properties common to all electromagnetic waves.

1.

2.

(2)

(Total 9 marks)

Q8.

- (a) The table shows the half-life of some *radioactive* isotopes.

Radioactive isotope	Half-life
magnesium-27	10 minutes
sodium-24	15 hours
sulphur-35	87 days
cobalt-60	5 years

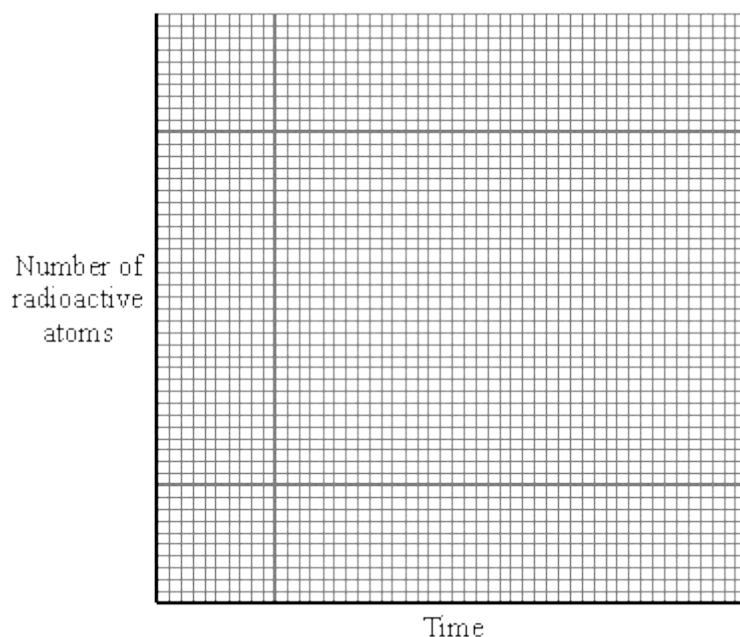
- (i) What is meant by the term *radioactive*?

(1)

- (ii) Which **one** of the isotopes in the table could form part of a compound to be used as a tracer in medicine? Explain the reason for your choice.

(3)

- (iii) Draw a graph to show how the number of radioactive atoms present in the isotope cobalt-60 will change with time.



(3)

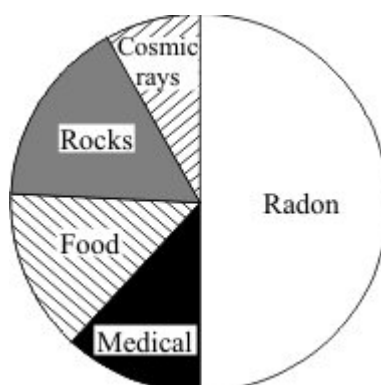
- (b) Nuclear power stations provide about 17% of the world's electricity. They add less than 1% to the total background levels of radiation. Some people are opposed to the use of nuclear fuels for the generation of electricity. Explain why.

(3)

(Total 10 marks)

Q9.

- (a) The pie-chart shows the main sources of background radiation.



- (i) Which source in the pie-chart adds the smallest amount of radiation to background levels?

(1)

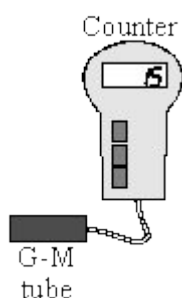
- (ii) Name **two** natural sources of background radiation in the pie-chart.

1. _____

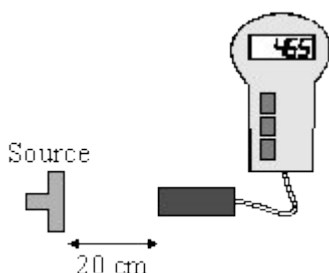
2. _____

(2)

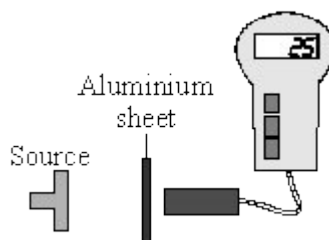
- (b) The diagrams show how a radiation detector and counter can be used to measure radiation levels. In each case the numbers show the count one minute after the counter is switched on.



- (i) How many counts are just from background radiation?



- (ii) How many counts are just from the source?



- (iii) What type of radiation did the source give out?

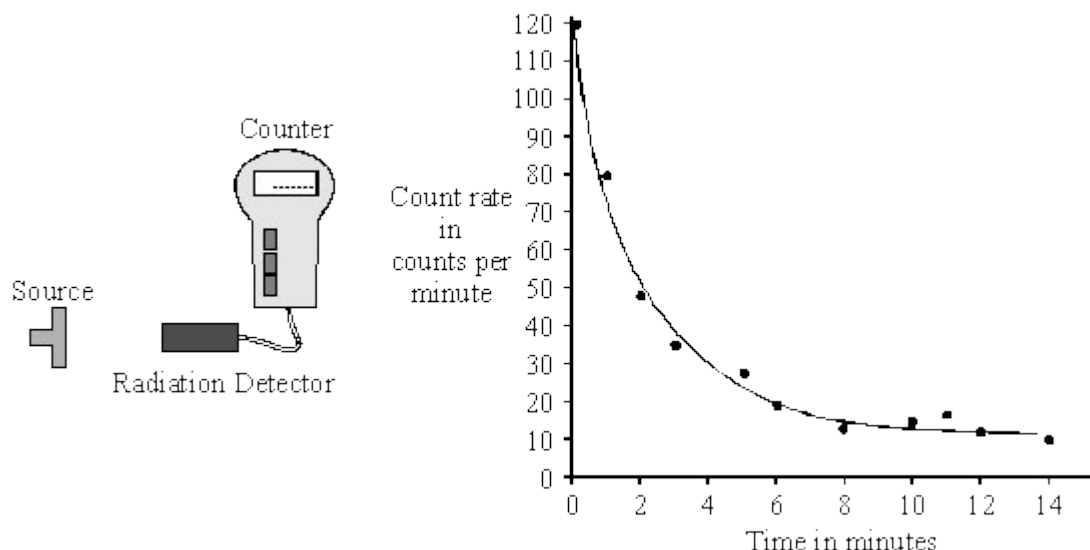
Give a reason for your answer.

(4)

(Total 7 marks)

Q10.

- (a) A radiation detector and counter were used to detect and measure the radiation emitted from a weak source. The graph shows how the number of counts recorded in one minute changed with time.



- (i) Even though the readings from the counter were accurately recorded, not all the points fit the smooth curve. What does this tell us about the process of radioactive decay?

(1)

- (ii) After ten minutes the number of counts recorded each minute is almost constant. Explain why.

(2)

- (b) The radioactive isotope sodium-24 injected into the bloodstream can be used to trace blood flow to the heart. Sodium-24 emits both *beta particles* and *gamma rays*.

- (i) What is a *beta particle*?

(1)

- (ii) What is a *gamma ray*?

(1)

- (iii) The count rate from a solution containing sodium-24 decreases from 584 counts per minute to 73 counts per minute in 45 hours. Calculate the half-life of sodium-24. Show clearly how you work out your answer.

Half-life = _____ hours

(3)

- (iv) Give **one** advantage of using sodium-24 to trace blood flow compared to using an isotope with a half-life of:

[A] ten years; _____

(1)

[B] ten seconds. _____

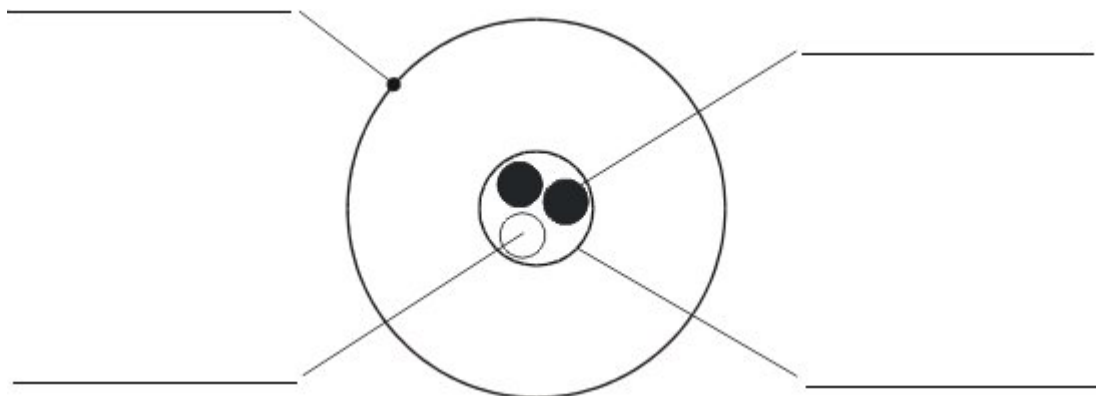
(1)

(Total 10 marks)

Q11.

- (a) Tritium (${}^3_1\text{H}$) is an isotope of hydrogen. Tritium has a proton number of 1 and a mass number of 3.

- (i) The diagram below shows a simple model of a tritium atom. Complete the diagram by adding the names of the particles indicated by the labels.



(4)

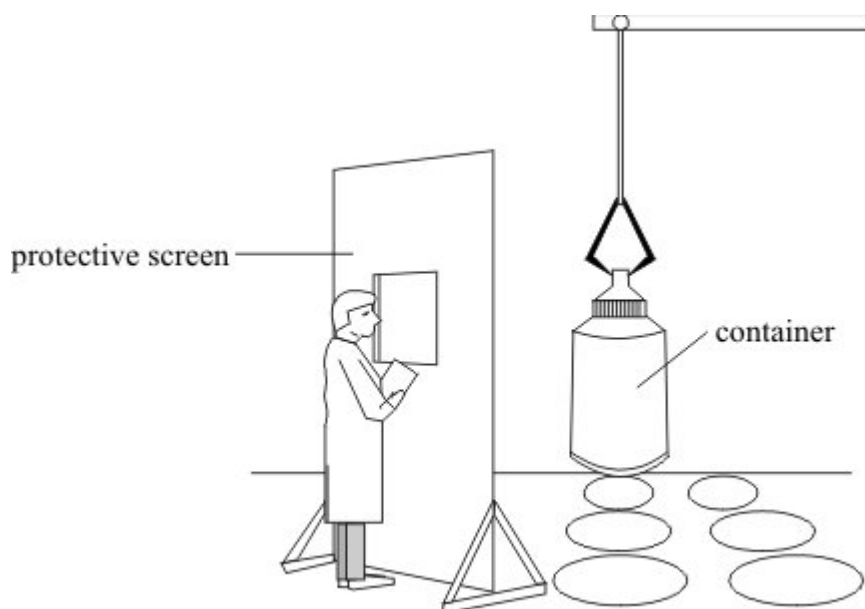
- (ii) Explain how the nucleus of an ordinary hydrogen atom is different from the nucleus of a tritium atom. Ordinary hydrogen atoms (${}^1_1\text{H}$) have a mass number of 1.

(2)

- (iii) Tritium is a radioactive substance which emits beta (β) radiation. Why do the atoms of some substances give out radiation?

(2)

- (b) Tritium is one of the elements found in the waste material of the nuclear power industry. The diagram below shows a worker behind a protective screen. The container holds a mixture of different waste materials which emit alpha (α), beta (β) and gamma (γ) radiation.



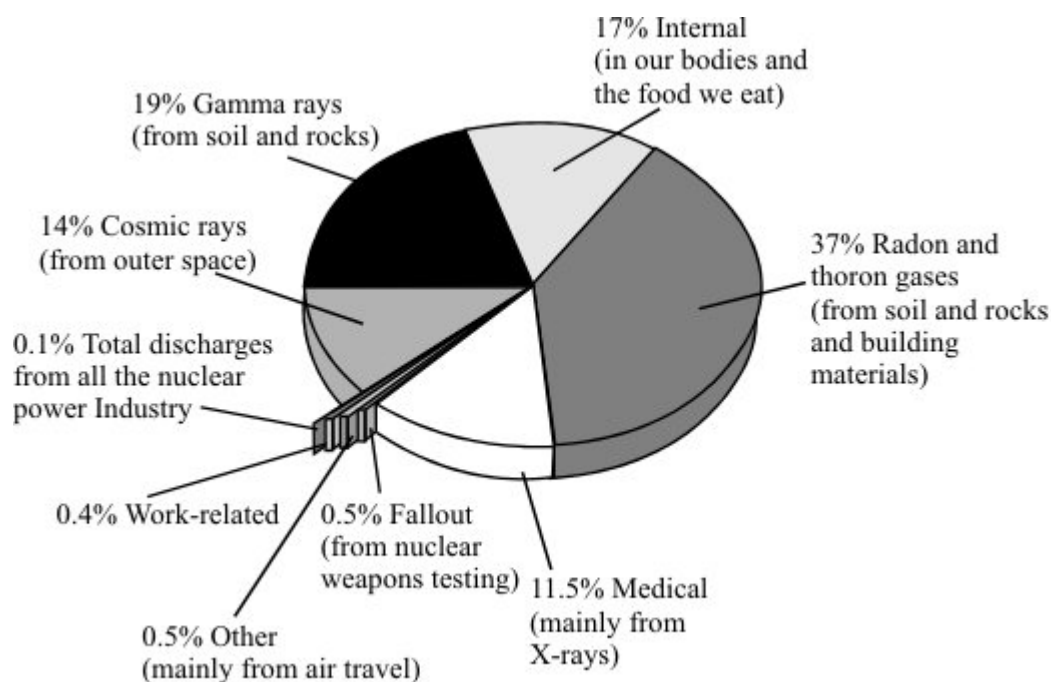
Suggest a suitable material for the protective screen. The material should prevent radiation from the container reaching the worker. Explain your answer.

(2)

(Total 10 marks)

Q12.

The chart below shows the sources of radiation in Britain.



- (a) Give **two** sources of natural radioactivity from the chart.

(2)

- (b) How might the chart be used to reassure people that nuclear power is safe?

(1)

- (c) Some material is spilled on a bench. How could you find out if this material is radioactive?

(2)

- (d) The table shows the proton number and mass number of two isotopes of iodine.

Iodine is found naturally in the world as the isotope I-127. Iodine-127 is not radioactive and is essential to life.

Other isotopes of iodine are formed in nuclear reactors. In the Chernobyl nuclear power station disaster in Ukraine an explosion caused a large quantity of the isotope iodine-131 to be released into the atmosphere. Iodine-131 is radioactive.

	proton number	mass number
iodine-127	53	127
iodine-131	53	131

Explain, in terms of particles found in the nucleus, how an iodine-131 nucleus is different from an iodine-127 nucleus.

(2)

- (e) (i) Explain, as fully as you can, why iodine-131 could be harmful to our bodies.

(4)

- (ii) Iodine-131 and iodine-127 have the same chemical properties. Explain why this would be a problem if iodine-131 was taken into our bodies.

(1)

- (iii) The Chernobyl disaster took place in 1986. Do you think that iodine-131 from the disaster is still a threat to us today? Explain your answer.

(3)

(Total 15 marks)

Q13.

In some areas of the U.K. people are worried because their houses are built on rocks that release radon.

Read the information about radon.

- It is a gas.

- It is formed by the breakdown of radium.
- It emits alpha radiation.
- Each radon atom has 86 protons.
- Each radon atom has 136 neutrons.

Explain why it may be dangerous to live near rocks that release radon.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

(Total 3 marks)

Q14.

The picture shows a man at work in a factory that uses radioactive materials.



The radioactive material is kept behind glass shields. The man wears gloves so that he cannot touch the radioactive material directly.

Explain, as fully as you can, why these precautions are taken.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

Q15.

The table gives the properties of some radionuclides (radioactive isotopes).

Radionuclide	Half life	Main type of radiation emitted
Radon-220	54.5 seconds	Alpha
Americium-241	433 years	Alpha
Phosphorus-32	14 days	Beta
Strontium-90	28 years	Beta
Technetium-99	6 hours	Gamma
Cobalt-60	5 years	Gamma

- (i) Which radionuclide would be best for monitoring the thickness of aluminium foil?

Explain the reason for your answer.

(2)

- (ii) Which radionuclide would be best for acting as a tracer inside the human body?

Explain the reason for your answer.

(2)

(Total 4 marks)

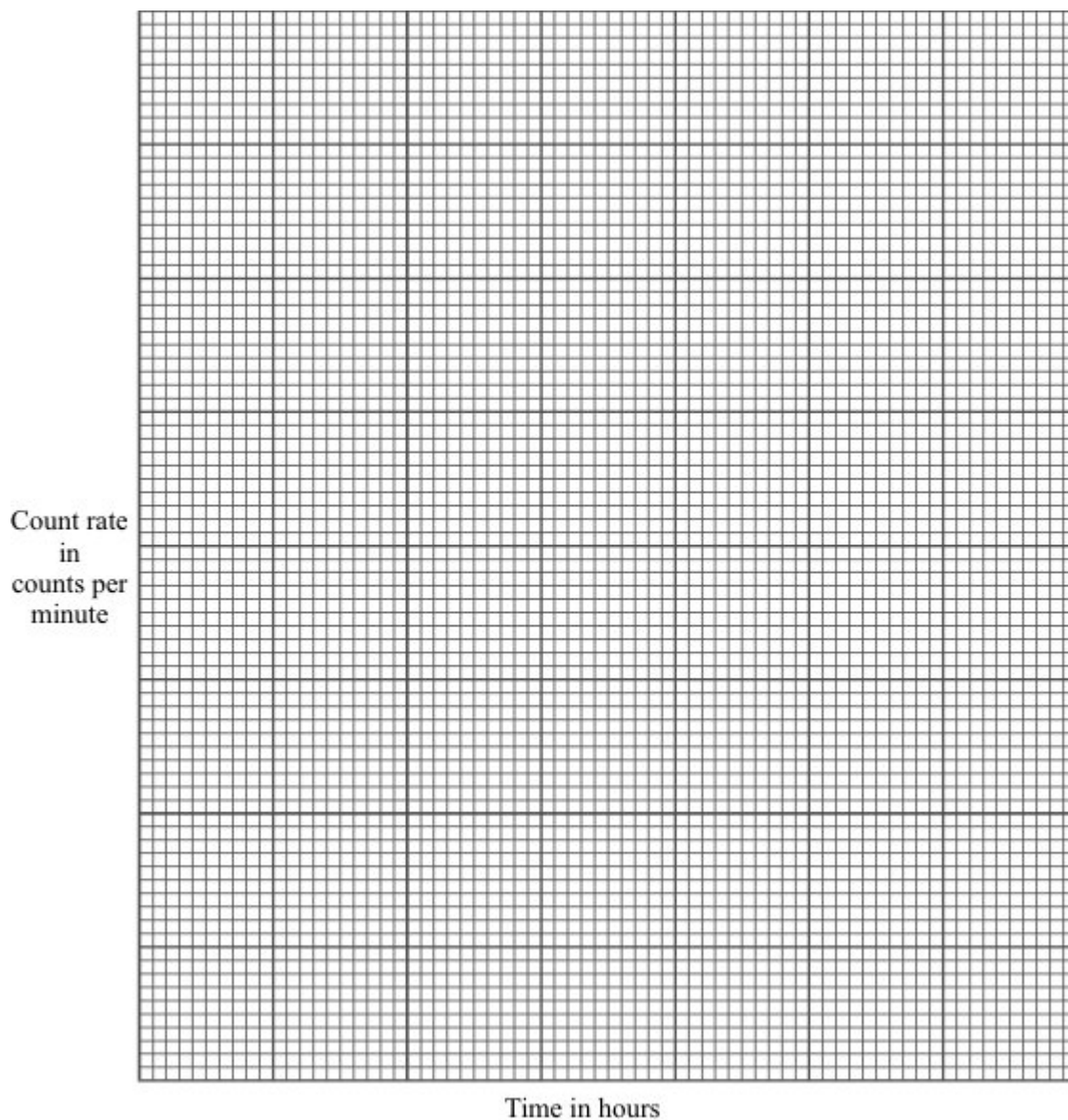
Q16.

The isotope of sodium with a mass number of 24 is radioactive. The following data were obtained in an experiment to find the half-life of sodium-24.

Time in hours	Count rate in counts per minute
---------------	---------------------------------

0	1600
10	1000
20	600
30	400
40	300
50	150
60	100

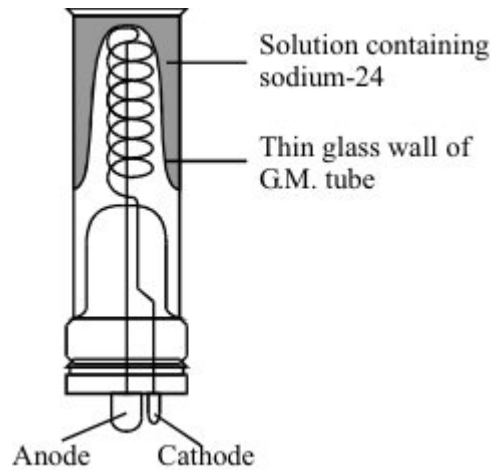
- (a) Draw a graph of the results and find the half-life for the isotope. On the graph show how you obtain the half-life.



Half-life = _____ hours

(4)

- (b) Sodium-24 decays by beta emission. The G.M. tube used in the experiment is shown in the diagram. Each beta particle which gets through the glass causes a tiny electric current to pass in the circuit connected to the counter.



- (i) Why must the glass wall of the G.M. tube be very thin?

(1)

- (ii) Why is this type of arrangement of no use if the radioactive decay is by alpha emission?

(1)

- (c) Sodium chloride solution is known as saline. It is the liquid used in 'drips' for seriously-ill patients. Radioactive sodium chloride, containing the isotope sodium-24, can be used as a tracer to follow the movement of sodium ions through living organisms.

Give **one** advantage of using a sodium isotope with a half-life of a few hours compared to using an isotope with a half-life of:

- (i) five years; _____

(1)

- (ii) five seconds. _____

(1)

(Total 8 marks)

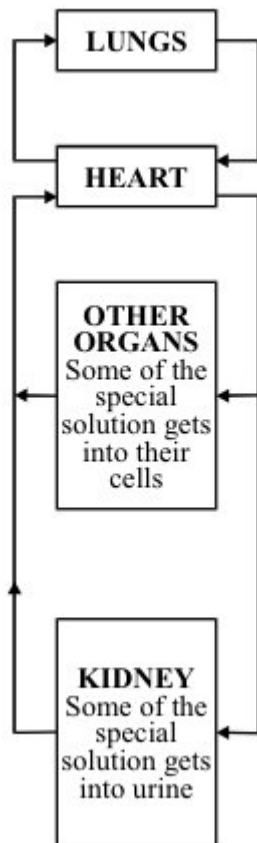
Q17.

Doctors sometimes need to know how much blood a patient has.

They can find out by using a radioactive solution.

After measuring how radioactive a small syringe-full of the solution is they inject it into the patient's blood.

YOUR BLOOD CIRCULATION



They then wait for 30 minutes so that the solution has time to become completely mixed into the blood.

Finally, they take a syringe-full of blood and measure how radioactive it is.

Example:

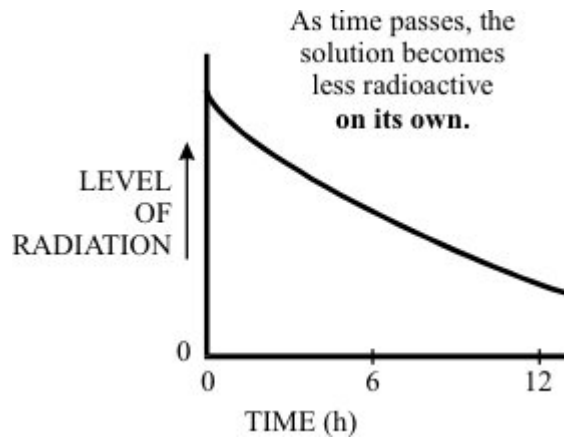
If the doctor injects 10 cm^3 of the radioactive solution and this is diluted 500 times by the blood there must be $10 \times 500 = 5000 \text{ cm}^3$ of blood.

(a) After allowing for background radiation:

- 10 cm^3 of the radioactive solution gives a reading of 7350 counts per minute;
- a 10 cm^3 sample of blood gives a reading of 15 counts per minute.

Calculate the volume of the patient's blood.
(Show your working.)

(4)



Radiation from radioactive substances can harm your body cells.

- (b) The doctor's method of estimating blood volume will not be completely accurate. Write down **three** reasons for this.

1. _____
2. _____
3. _____

(3)

- (c) The doctors use a radioactive substance which loses half of its radioactivity every six hours. Explain why this is a suitable radioactive substance to use.

(2)

(Total 9 marks)

Q18.

- (a) Sam and Kris are arguing about alpha and gamma radiation.

Sam says that alpha radiation is more dangerous.

Kris disagrees. He thinks that gamma radiation is more dangerous. What do you think?

Explain your answer as fully as you can.

(4)

- (b) Cancer cells in a particular organ of the body can be killed by injecting a radioactive substance which is absorbed by that organ.

What other features must the radioactive substance have to make it suitable for this job?

(2)

- (c) Radon is a radioactive gas with a half-life of 3.6 days.
It often seeps into buildings from the ground.

Estimate how long it takes for 99% of a sample of radon gas to decay.
(Show your working.)

(2)

(Total 8 marks)

Mark schemes

Q1.

- (i) photographic film / paper
accept X-ray film 1
- (ii) (when developed) the film is darker
must have a comparison 1
- (iii) to prevent them receiving / being exposed to too much radiation **or**
so they know how much radiation they have been exposed to
accept if he gets too much radiation there may be something wrong with the plant
any statement making reference to a need for preventive or corrective action gains 1 mark
an isolated statement of fact of the effect of radiation gains 0 marks 1

[3]

Q2.

- (i) radon (gas)
do not accept gas 1
- (ii) background 1

[2]

Q3.

- (a) all points correctly plotted
tolerance $\pm \frac{1}{2}$ square on y axis only
allow 1 mark for 3 correctly plotted points 2
- attempt made to draw a smooth curve
do not accept dot-to-dot line 1
- (b) (i) 3 days ± 0.2
or any value correctly obtained using their graph line
if no line drawn in (a), answer must be exactly 3 1
- (ii) 3 days or their (b)(i) 1

- (c) radon-222
accept radon or 222
accept alpha or 3.8
correct isotope required for reason to score 1
- has the shortest half-life
accept the others have longer half-lives 1

[7]

Q4.

- (i) any **one** from
 cosmic rays
 rocks
 food
 air 1
- (ii) any **one** from
 medical
 nuclear power stations
 nuclear weapons testing
 food
but do not accept food in both (i) and (ii) 1

[2]

Q5.

- (a) X emits beta
accept β 1
- Y emits alpha, beta, gamma
must have all three accept α , β , γ 1
- (b) gamma
accept beta and gamma
any mention of alpha loses first mark 1
- radiation can penetrate (the plastic) 1
- kills bacteria **or** microbes **or** micro-organisms **or** viruses
not germs

Q6.

- (i) radiation (received by the body) due to our environment

not naturally occurring radiation

accept radiation all around us

accept radiation that is always there

1

- (ii) larger than average dose of cosmic rays

must have idea of comparison

1

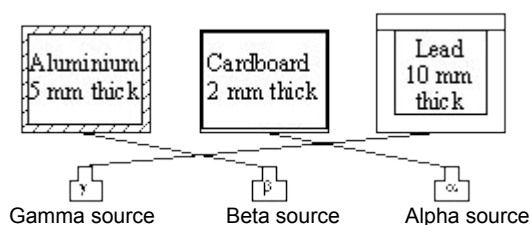
when flying less air to absorb **or** shield from radiation

1

[3]

Q7.

- (a) all 3 correct



allow 1 mark for one or two possible links

no marks for more than one line from a source or to a box

2

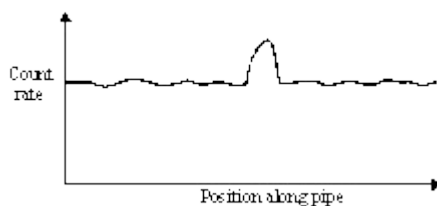
- (b) (i) geiger-müller (tube)

accept G-M (tube)

accept geiger tube or geiger counter

1

- (ii) steady line rising then falling at leak



must be one peak only

1

- (c) (i) can penetrate (skull **or** head)

accept goes through body

accept most penetrating

do not accept strongest

do not accept can penetrate skin

1

- (ii) cancer cells receive full dose **or** more radiation
accept healthy cells not damaged 1
- healthy **or** other cells receive low dose only
*do **not** accept it is safer* 1
- (iii) any **two** properties from:
- travel through a vacuum
*do **not** accept they are an energy form*
 - travel at same speed in air **or** vacuum
 - can be diffracted
treat as a list ignoring 1 and 2
 - can be reflected
 - can be refracted
 - travel in straight lines
 - all transverse
 - can be polarised
 - transfer energy
- 2

[9]

Q8.

- (a) (i) an unstable nucleus **or** atom **or** isotope
accept nucleus has too much energy
 an atom **or** nucleus **or** isotope which decays 1
- (ii) sodium – 24
if Mg-27 chosen can get third mark if explained
 sufficiently long to allow circulation and take readings
 short enough that levels of radiation in the body will become insignificant quickly 3
- (iii) each axis is given a linear scale 1
- curve concave to axes drawn 1
- (curve) shows correct half-life of five years

must show two half lives check first two plotted points correct to $\pm$ half square

1

(b) any **three** points from the following:

- waste remains radioactive for a long time **or** waste has to be disposed of
- waste may leak from its storage point
- possibility of accident at power station **or** in transport of fuel
- contamination of the local environment
- people living close to a power station may have a greater risk of developing cancer **or** leukaemia
accept harmful to people
- high cost to decommission power station
*do **not** accept expensive*

3

[10]

Q9.

(a) (i) cosmic rays

1

(ii) any **two from**:
rocks
cosmic rays
food
radon

2

(b) (i) 15

1

(ii) 450

*e.c.f. 465 – (d)(i)
do **not** accept negative number*

1

(iii) beta

*count (greatly) reduced by aluminium
or alpha not reach GM tube and gamma would pass (unaffected) through the aluminium
accept aluminium stops beta*

2

[7]

Q10.

(a) (i) it is random

*do **not** accept unpredictable*

	<i>do not accept irregular</i>	1
(ii)	source adds nothing or little to the count	1
	continues to record background level <i>accept a clear explanation of background</i>	1
(b) (i)	an electron $\overset{0}{-1}e$ <i>accept $\overset{0}{-1}e$</i>	1
(ii)	<u>electromagnetic</u> wave with high frequency or short wavelength <i>must have high frequency or short wavelength</i>	1
(iii)	15 <i>allow 1 mark for 3 iterative steps 584/2 292/2 146/2</i> <i>allow 1 mark for 45/3</i>	3
(iv)	[A] a safe level of radiation reached much quicker <i>could answer in terms of isotope but answer must be clear whether it refers to isotope or sodium-24</i>	1
	[B] long enough to obtain measurements	1
		[10]

Q11.

(a) (i)	electron neutron proton nucleus <i>1 mark for each correct label</i>	4
(ii)	H-1 has no neutrons H-3 has 2 neutrons <i>more neutrons gets 1 mark</i>	2
(iii)	nucleus unstable	2
(b)	lead/concrete lead/concrete needed to stop gamma rays	2

[10]

Q12.

- (a) two from:
internal/bodies
thoron
building materials
soil
food
rocks
radon
gamma rays
cosmic rays/outer space
any 2 for 1 mark each 2
- (b) only a very small amount of the background radioactivity comes from nuclear power owtte.
accept any sensible response for 1 mark 1
- (c) use G.M. tube/meter/counter or film
'count' higher than or compare with background/normal/control or film is blacker
for 1 mark each 2
- (d) more neutrons/different number
gains 1 mark
- but** I-131 has 4 extra neutrons = 2
or I-131 has 78 neutrons I-127 has 74 (2)
gains 2 marks 2
- (e) (i) emits radiation
ionises
molecules
in cells
radiation damages cells/mutation/kills cells
may cause cancer
 β / γ / radiation is penetrating
half-life is long enough for damage to be caused
any 4 for 1 mark each (4 from above) 4
- (ii) e.g. replace I-127 in body/body cannot tell the difference/causes thyroid cancer/causes cancer (but not if already given in (i))
for 1 mark 1
- (iii) **Either** No
half-life = 8 days many half lives have passed/attempts to calculate number of half-lives **or** explains meaning of half-life so very little left/become harmless
for 1 mark each
- or** Yes half-life = 8 days such a large quantity was released although little left it is still harmful

Q13.**Quality of written communication**

The answer to this question requires ideas in good English in a sensible order with correct use of scientific terms. Quality of written communication should be considered in crediting points in the mark scheme

Any **three** from

radon releases (alpha) radiation

accept radon is radioactive

1

(radon **or** radiation causes) harm **or** damage to body or cells

*accept cause cancer / mutations /
radiation sickness*

1

idea that living near radiation over long period will lead to large 'dose' of radiation

radon (is a gas) that can be breathed in

1

[3]

Q14.**Quality of written communication**

correct use of **three scientific** terms e.g. radiation / α **or** β **or** γ / cells /
ionisation / mutation (not cells or body) / chromosomes / DNA /
genes / cancer

1

any **three** from:

(materials emit) radiation

named type of radiation (α **or** β **or** γ)

damage / harm / kill

dangerous is neutral

cells / chromosomes / DNA / genes

cancer

mutations

ionisation

gloves or glass absorb radiation / prevent radiation reaching body or cells

3

[4]

Q15.

- (i) (strontium-90)
beta rays partly absorbed by aluminium
*accept gamma rays not absorbed **and** alpha all absorbed*
if phosphorus -32 then one mark max for beta ray
explanation
1
- long half life means it can be used for a long time
1
- (ii) (technetium-99)
(gamma) rays will pass out of body / less likely to be absorbed
accept (gamma) less damaging or alpha / beta will damage
cells if cobalt -60 then one mark max for gamma ray
explanation
1
- short half life means it will not affect body over a long period
1

[4]

Q16.

- (a) sensible scales
full use of y axis
1
- completely accurate plotting
1
- a smooth curve going through all bar one of the points
do not accept a dot-to-dot graph if two parts shown for
curves accept the more correct
1
- at least one line or a clear mark showing how to obtain the half life
from the graph and obtaining between 13 and 15
at the bottom of the page cross or ticks in the order of the
mark scheme
1
- (b) (i) to let the beta particles get through
*accept must be there to let the radiation through **or** if thick*
they may be stopped
1
- (ii) alpha particles would be stopped by the glass **or** cannot penetrate glass
do not accept alphas are weak
1
- (c) (i) it will give more counts per minute for a small quantity **or** it does not last
so long so may not be as dangerous
accept answers in terms of 5 years assume it refers
appropriately
1

- (ii) it will not be there long enough to act as a tracer **or** it could cause radiation damage as all its activity will be in the first place it enters the system
accept answer in terms of 5 seconds
accept not there long enough to work assume it refers appropriately

1

[8]

Q17.

- (a) evidence of $\frac{7350}{15}$
gains 1 mark

but

490
gains 2 marks

but

4900
gains 3 marks

units cm³
for 1 further mark

4

- (b) some of radioactive solution gets into cells/body organs
 some of radioactive solution gets into urine (in the kidney)
 the radioactive solution becomes less radioactive during the test
 variability in readings
in any order for 1 mark each

3

- (c) *ideas that*

- won't lose (too) much radioactivity during the test
- won't stay radioactive/harm cells for too long after test is over
for 1 mark each

2

[9]

Q18.

- (a) γ /gamma

- because more penetrating
- so can reach/damage cells from outside body/through skin

but

α /alpha

- does more damage/more likely to cause cancer
- can only do this if inside the body/cells
each • for 1 mark
[credit same ideas expressed conversely]

4

- (b)
- must emit alpha / α radiation
 - *idea that* half-life must be just long enough to kill cancer cells
each for 1 mark
[do not credit simply short half-life]
(allow 'must be liquid / in solution)

2

- (c) *evidence of repeated halving then*
 n $\times 3.6$
gains 1 mark

but

answer in range
22 – 25.2 days
(ie >6 and up to 7 half lives)
gains 2 marks

2

[8]