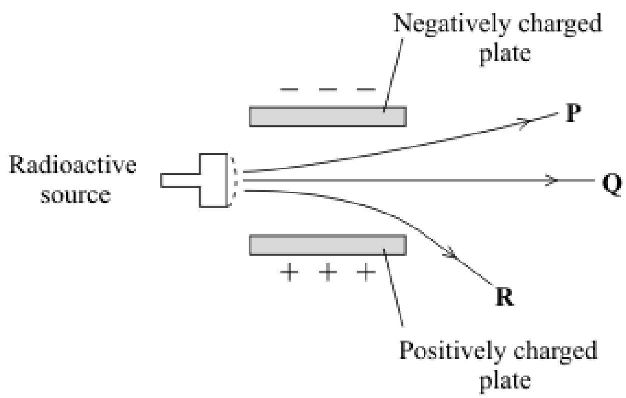
Q1. A radioactive source emits alpha (α), beta (β) and gamma (γ) radiation. The diagram shows what happens to the radiation as it passes between two charged metal plates.

Diagram 1

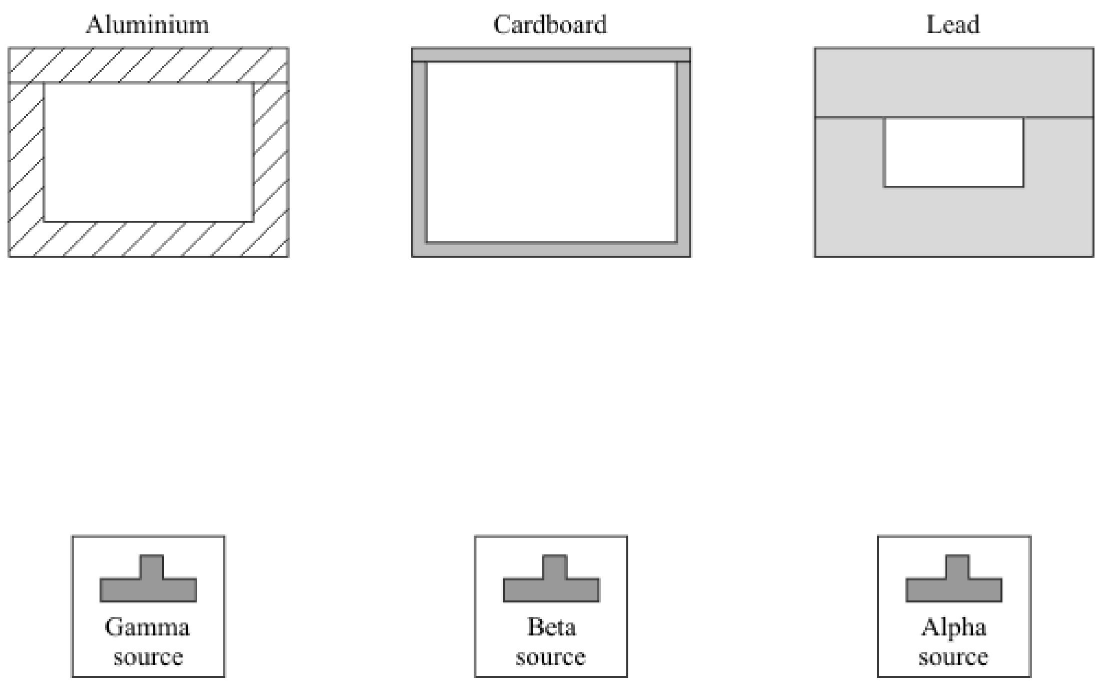


(a) Which line **P**, **Q** or **R** shows the path taken by:

(i) alpha radiation ....
(1)

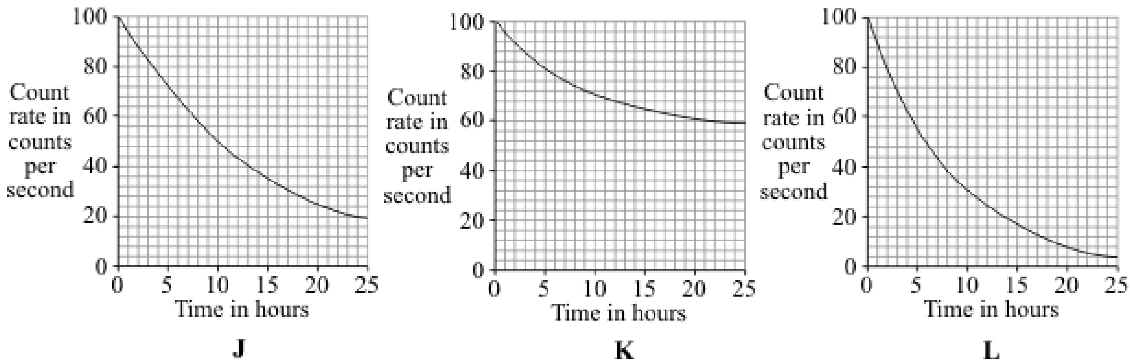
(ii) gamma radiation? ....
(1)

(b) The diagram shows three different boxes and three radioactive sources. Each source emits only one type of radiation and is stored in a different box. The box reduces the amount of radiation getting into the air.



Draw **three** lines to show which source should be stored in which box so that the minimum amount of radiation gets into the air.
(2)

(c) The graphs show how the count rates from three different radioactive sources, **J**, **K**, and **L**, change with time.



(i) Which source, **J, K**, or **L**, has the highest count rate after 24 hours? ....

(1)

(ii) For source **L**, what is the count rate after 5 hours?

.... counts per second

(1)

(iii) Which source, **J, K,** or **L**, has the longest half-life? ....

(1)

(iv) A radioactive source has a half-life of 6 hours.

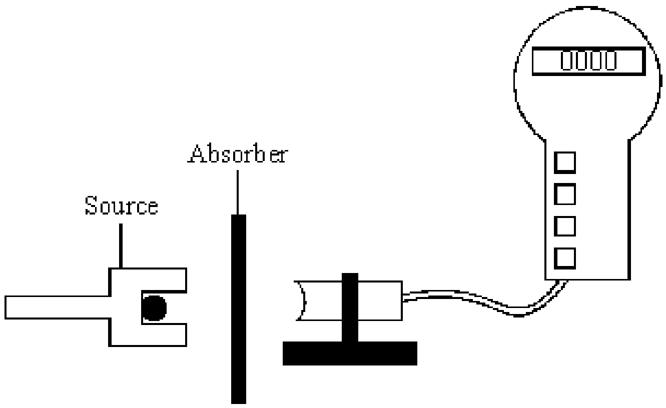
What might this source be used for?

Put a tick (✓) in the box next to your choice.

To monitor the thickness of paper as it is made in a factory	☐
To inject into a person as a medical tracer	☐
To make a smoke alarm work	☐

(1)
(Total 8 marks)

Q2. The detector and counter are used in an experiment to show that a radioactive source gives out alpha and beta radiation only.



Two different types of absorber are placed one at a time between the detector and the source. For each absorber, a count is taken over ten minutes and the average number of counts per second worked out. The results are shown in the table.

Absorber used	**Average counts per second**
No absorber	33
Card 1 mm thick	20
Metal 3 mm thick	2

Explain how these results show that alpha and beta radiation is being given out, but gamma radiation is **not** being given out.

....

....

....

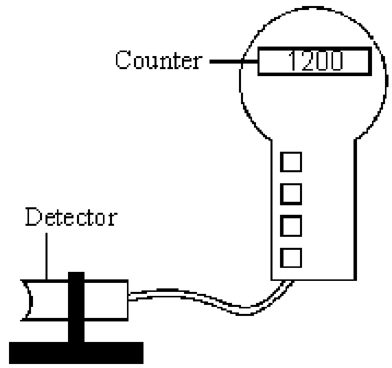
....

....

....

(Total 3 marks)

Q3. The diagram shows a radiation detector and counter being used to measure background radiation. The number shows the count ten minutes after the counter was reset to zero.



(i) Name **one** source of background radiation.

....

(1)

(ii) Calculate the average background radiation level, in counts per second. Show clearly how you work out your answer.

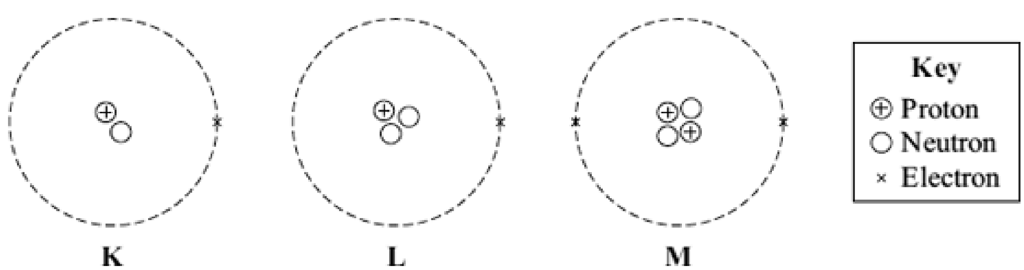
....

....

Background radiation level = ... counts per second

(2)
(Total 3 marks)

Q4. (a) The diagram represents 3 atoms, **K**, **L** and **M**.



(i) Which **two** of the atoms are isotopes of the same element?

.... and ....

(1)

(ii) Give a reason why the **two** atoms that you chose in part (a)(i) are:

(1) atoms of the same element ....

....

(2) different isotopes of the same element. ....

....

....

(2)

(b) The table gives some information about the radioactive isotope thorium-230.

mass number	230
atomic number	90

(i) How many electrons are there in an atom of thorium-230?

....

(1)

(ii) How many neutrons are there in an atom of thorium-230?

....

(1)

(c) When a thorium-230 nucleus decays, it emits radiation and changes into radium-226.

$$^{230}_{90}\text{Th} \longrightarrow {}^{226}_{88}\text{Ra} + \boxed{\text{Radiation}}$$

What type of radiation, alpha, beta or gamma, is emitted by thorium-230?

....

Explain the reason for your answer.

....

....

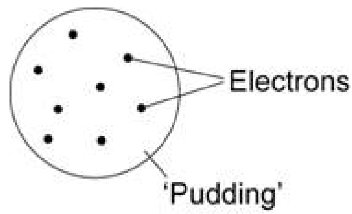
....

....

....

(3)
(Total 8 marks)

Q5. In the early part of the 20th century scientists used the 'plum pudding' model to explain the structure of the atom.

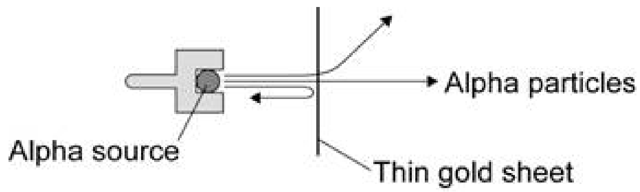


(a) What did scientists think that the 'pudding' part of the atom was?

....

(1)

(b) The scientists Geiger and Marsden devised an experiment to test the 'plum pudding' model. They fired positively charged alpha particles at a very thin sheet of gold foil. They then measured the different paths taken by the alpha particles.



List A gives some of the observations from the experiment. **List B** gives the conclusions reached from the observations.

Draw **one** line from each observation in **List A** to the conclusion reached in **List B**.

List A Observation	**List B Conclusion**
Most of the alpha particles go straight through the gold foil	Most of the atom is empty space
Some alpha particles are deflected through a big angle	The nucleus of the atom is very small
Only a very small number of alpha particles rebound backwards	The nucleus has a large positive charge

(2)

(c) Following the work of Geiger and Marsden, the 'plum pudding' model of the atom was replaced by the 'nuclear model' of the atom.

Explain why it is sometimes necessary for scientists to replace a scientific model.

....

....

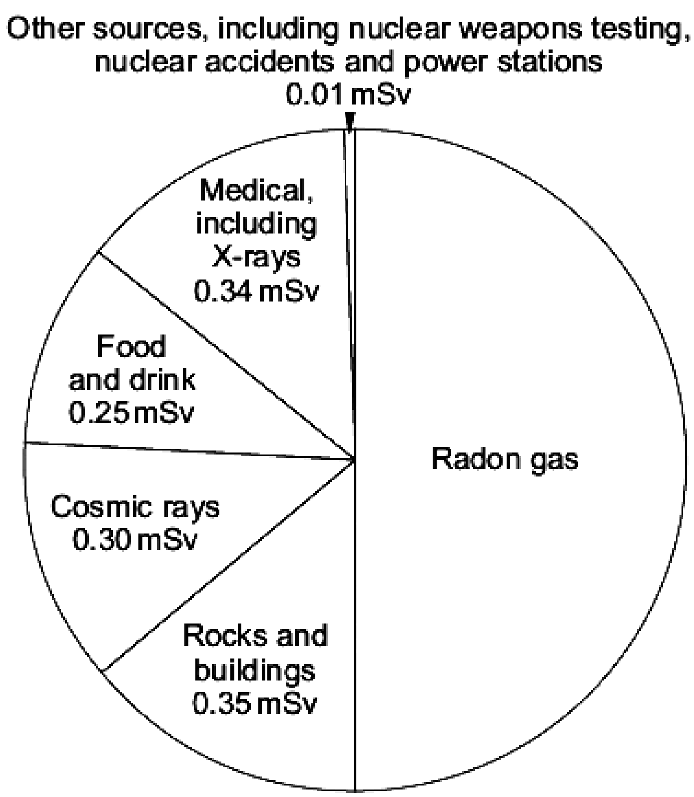
....

....

(2)
(Total 5 marks)

Q6. The pie chart shows the sources of the background radiation and the radiation doses that the average person in the UK is exposed to in one year.

Radiation dose is measured in millisieverts (mSv).



(a) (i) What is the radiation dose that the average person in the UK receives from radon gas?

....

....

Radiation dose from radon gas = ... mSv

(1)

(ii) A person may receive a higher than average dose of radiation from background sources.

Suggest **two** reasons why.

1 ....

....

2 ....

....

(2)

(b) Exposure to radon gas can cause lung cancer.
A recent study has compared the risk of getting lung cancer, by the age of 75 years, for cigarette smokers and non-smokers.
The people in the study had been exposed throughout their lives to different levels of radon gas.
A summary of the data produced from the study is given in the table.

Exposure to radon gas	**Risk of lung cancer by age of 75**	
	Non-smoker	**Smoker**
No exposure	0.4 %	10 %
Moderate exposure	1.0 %	14 %
Very high exposure	1.5 %	32 %

(i) Why were people that have had **no exposure** to radon gas included in the study?

....

....

(1)

(ii) Using information from the table, what conclusions can be made about exposure to radon gas and the risk of getting lung cancer?

....

....

....

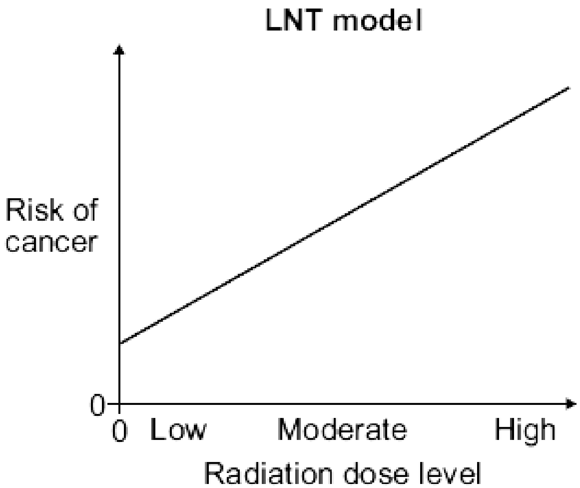
....

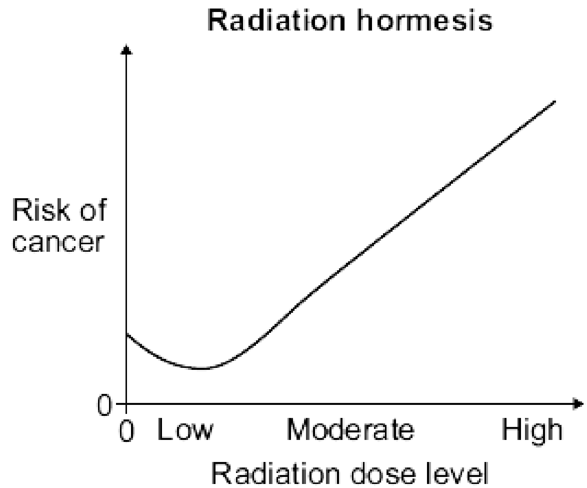
....

(2)

(c) At the moment, the regulations designed to protect people from over-exposure to radiation are based on a model called the 'linear no-threshold' (LNT) model.
Some scientists believe that the LNT model is too simple.These scientists believe that at low radiation levels a process called 'radiation hormesis' happens.

The graphs show that each model suggests a link between the risk of developing a cancer and exposure to low levels of radiation.





The link between the risk of developing cancer and exposure to low levels of radiation suggested by each of the models is different.

Describe how.

....

....

....

....

....

(2)

(d) Scientists have conducted experiments in which mice have been exposed to different levels of radiation. The number of mice developing a cancer has then been measured.

Discuss whether it is ethical to use animals in scientific experiments.

....

....

....

....

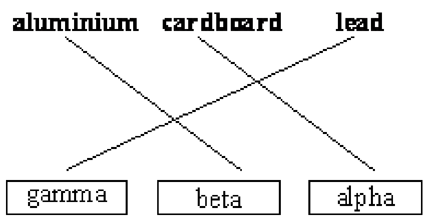
....

(2)
(Total 10 marks)

M1. (a) (i) **P** 1

(ii) **Q** 1

(b) 3 lines correct



*allow **1** mark for 1 correct line*

two lines drawn from any source or box – both incorrect 2

(c) (i) **K** 1

(ii) 56

accept 50 – 60 inclusive 1

(iii) **K** 1

(iv) to inject... tracer 1

[8]

M2. *answers must be comparative*

accept converse answers throughout

alpha: the count rate is (greatly) reduced by the card **or** the card absorbs alphas <u>but not betas</u>

accept paper for the card 1

beta: the count rate is (greatly) reduced by the metal **or** the thin metal absorbs alphas <u>and</u> betas **or** the thin metal absorbs all of the radiation (from the source)

accept aluminium for the metal

1

gamma: would pass through the thin

accept aluminium for the metal

metal but count rate is background **or** no radiation passing through **or** a higher reading would be recorded **or** to reduce the count to 2 would require <u>much more</u> than 3 mm of metal

accept lead / aluminium for the metal

1

[3]

M3. (i) any **one** from:

the ground
the air
radon (gas)
building materials
buildings
rocks / granite
food
cosmic <u>rays</u> or solar <u>rays</u>

*do **not** accept mobile phones*

X-rays
nuclear weapons testing
nuclear power stations / accidents

accept from outer space
*accept sun but **not** sunlight*
accept medical uses

1

(ii) 2

allow $\frac{1200}{60 \times 10}$ ***or*** $\frac{120}{600}$ ***or*** 120

2

[3]

M4. (a) (i) **K** and **L**

both answers required either order

1

(ii) (1) same number of protons

accept same number of electrons
accept same atomic number

1

(2) different numbers of neutrons

1

(b) (i) 90

1

(ii) 140

1

(c) alpha (particle)

reason may score even if beta or gamma is chosen

1

mass number goes down by 4
or
number of protons and neutrons goes down by 4
or
number of neutrons goes down by 2

*candidates that answer correctly in terms of why gamma **and** beta decay are not possible gain full credit*

1

atomic / proton number goes down by 2
or
number of protons goes down by 2

*accept an alpha particle consists of 2 neutrons and 2 protons for **1** mark*

*accept alpha equals $^{4}_{2}He$ or $^{4}_{2}\alpha$ for **1** mark*

an alpha particle is a helium nucleus is insufficient for this mark

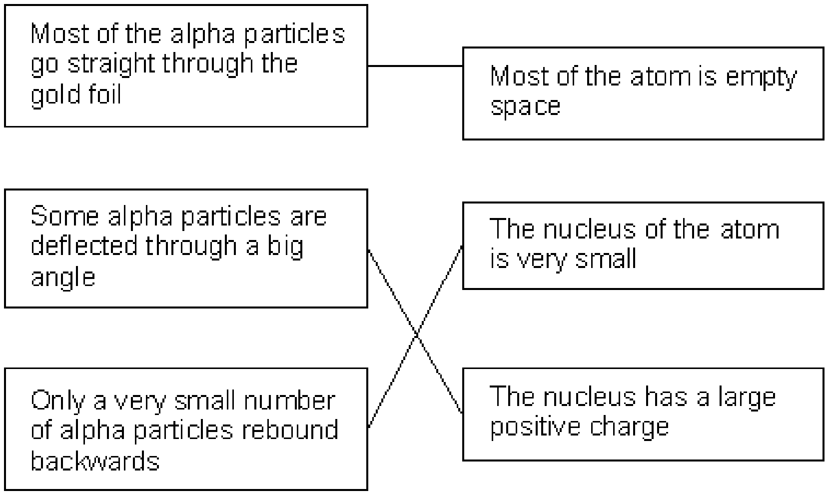
1

[8]

M5. (a) (mass of) positive charge

1

(b) three lines correct



*allow **1** mark for 1 correct line*

*if more than 1 line is drawn from a box in **List A** then all those lines are incorrect*

2

(c) new scientific evidence / data is obtained

1

which cannot be explained by the model

1

[5]

M6. (a) (i) 1.25 (mSv)

1

(ii) any **two** from:

- (frequent) flying
  accept stated occupation that involves flying
- living at altitude
- living in areas with high radon concentrations
  accept a specific area, eg Cornwall
- living in a building made from granite (blocks)
- having more than the average number of X-rays
  or
  having a CT scan
  accept more medical treatments
- working in a nuclear power station
  accept any suggestion that could reasonably increase the level from a specific source

2

(b) (i) to be able to see the effect of exposure (to radon gas)
or
as a control
accept to compare (the effect of) exposure (with no exposure)
1

(ii) increased levels of exposure increases the risk (of developing cancer)
accept exposure (to radon gas) increases the risk
1

smoking increases the (harmful) effect of radon
answers that simply reproduce statistics are insufficient
1

(c) LNT model – risk increases with increasing radiation (dose) level
accept in (direct) proportion
accept low doses increase the risk
1

Radiation hormesis - low radiation (dose) levels reduce the risk
1

(d) two valid points made – examples:

- animals have no choice and so should not be used
- should not make animals suffer
- better to experiment on animals than humans
- experiments lead to a better understanding / new knowledge
- experiments may lead to health improvement / cures for humans

results for animals may not apply to humans is insufficient
2

[10]