OXFORD

INTERNATIONAL AQA EXAMINATIONS

Topic Test: OxfordAQA International GCSE Physics 9203

Nuclear physics

Name: _____

Class: _____

Date: _____

Time: **34 minutes**

Marks: **34 marks**

Comments:

1 (a) There are many isotopes of the element molybdenum (Mo).

What do the nuclei of different molybdenum isotopes have in common?

_____

(1)

(b) The isotope molybdenum-99 is produced inside some nuclear power stations from the nuclear fission of uranium-235.

(i) What happens during the process of nuclear fission?

_____

_____

(1)

(ii) Inside which part of a nuclear power station would molybdenum be produced?

_____

(1)

(c) When the nucleus of a molybdenum-99 atom decays, it emits radiation and changes into a nucleus of technetium-99.

$$^{99}_{42}\text{Mo} \longrightarrow {}^{99}_{43}\text{Tc} + \text{Radiation}$$

What type of radiation is emitted by molybdenum-99?

_____

Give a reason for your answer.

_____

_____

(2)

(d) Technetium-99 has a short half-life and emits gamma radiation.

What is meant by the term ‘half-life’?

_____

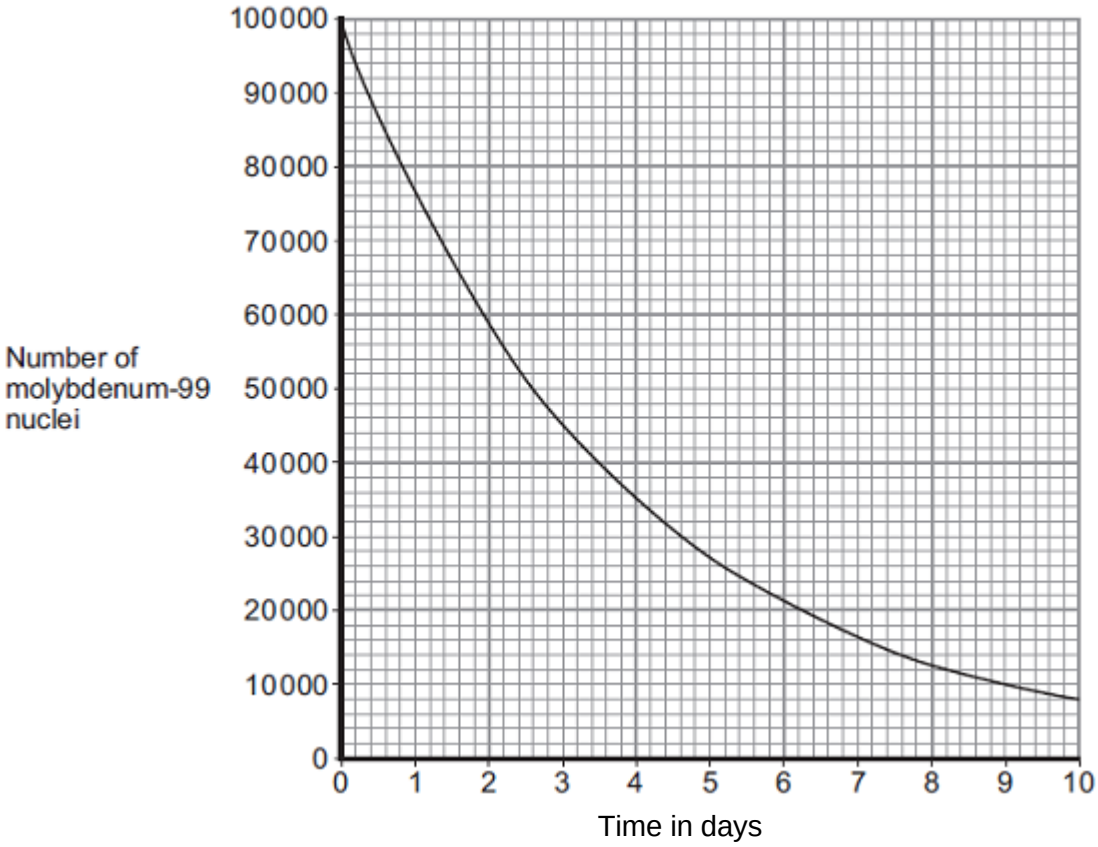
_____

_____

(1)

(e) Technetium-99 is used by doctors as a medical tracer. In hospitals it is produced inside a technetium generator by the decay of molybdenum-99 nuclei.

(i) The figure below shows how the number of nuclei in a sample of molybdenum-99 changes with time as the nuclei decay.



A technetium generator will continue to produce sufficient technetium-99 until 80% of the original molybdenum nuclei have decayed.

After how many days will a source of molybdenum-99 inside a technetium-99 generator need replacing?

Show clearly your calculation and how you use the graph to obtain your answer.

_____

_____

_____

Number of days = _____

(2)

(ii) Medical tracers are injected into a patient's body; this involves some risk to the patient's health.

Explain the risk to the patient of using a radioactive substance as a medical tracer.

_____

_____

_____

_____

(2)

(iii) Even though there may be a risk, doctors frequently use radioactive substances for medical diagnosis and treatments.

Suggest why.

_____

_____

(1)

(Total 11 marks)

2 Nuclear fission and nuclear fusion are two processes that release energy.

(a) (i) Use the correct answer from the box to complete each sentence.

Geiger counter	**nuclear reactor**	**star**

Nuclear fission takes place within a _____ .

Nuclear fusion takes place within a _____ .

(2)

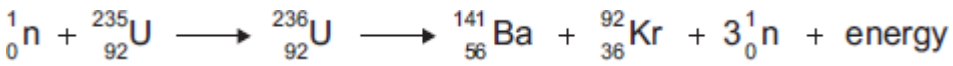
(ii) State **one** way in which the process of nuclear fusion differs from the process of nuclear fission.

_____

_____

(1)

(b) The following nuclear equation represents the fission of uranium-235 (U-235).



Chemical symbols:

Ba - barium

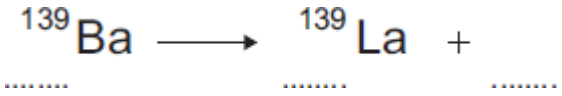
Kr - krypton

(i) Use the information in the equation to describe the process of nuclear fission.

(4)

(ii) An isotope of barium is Ba-139.
Ba-139 decays by beta decay to lanthanum-139 (La-139).

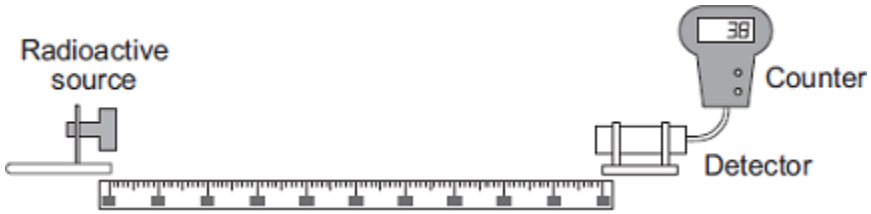
Complete the nuclear equation that represents the decay of Ba-139 to La-139.



(3)

(Total 10 marks)

3 A teacher used the equipment shown in the diagram to measure the count rate at different distances from a radioactive source.



(a) Her results are shown in **Table 1**.

Table 1

Distance in metres	Count rate in counts per minute	Corrected count rate in counts per minute
0.4	143	125
0.6	74	56
0.8	49	31
1.0	38	20
1.2	32	14
1.4	28	10
1.6	18	0
1.8	18	0
2.0	18	0

The background count rate has been used to calculate the corrected count rate.

(i) What is the value of the background count rate?

Background count rate = _____ counts per minute

(1)

(ii) What information does the corrected count rate give?

_____

_____

(1)

(iii) The radioactive source used in the demonstration emits only one type of radiation.

The radioactive source is **not** an alpha emitter.

How can you tell from the data in the table?

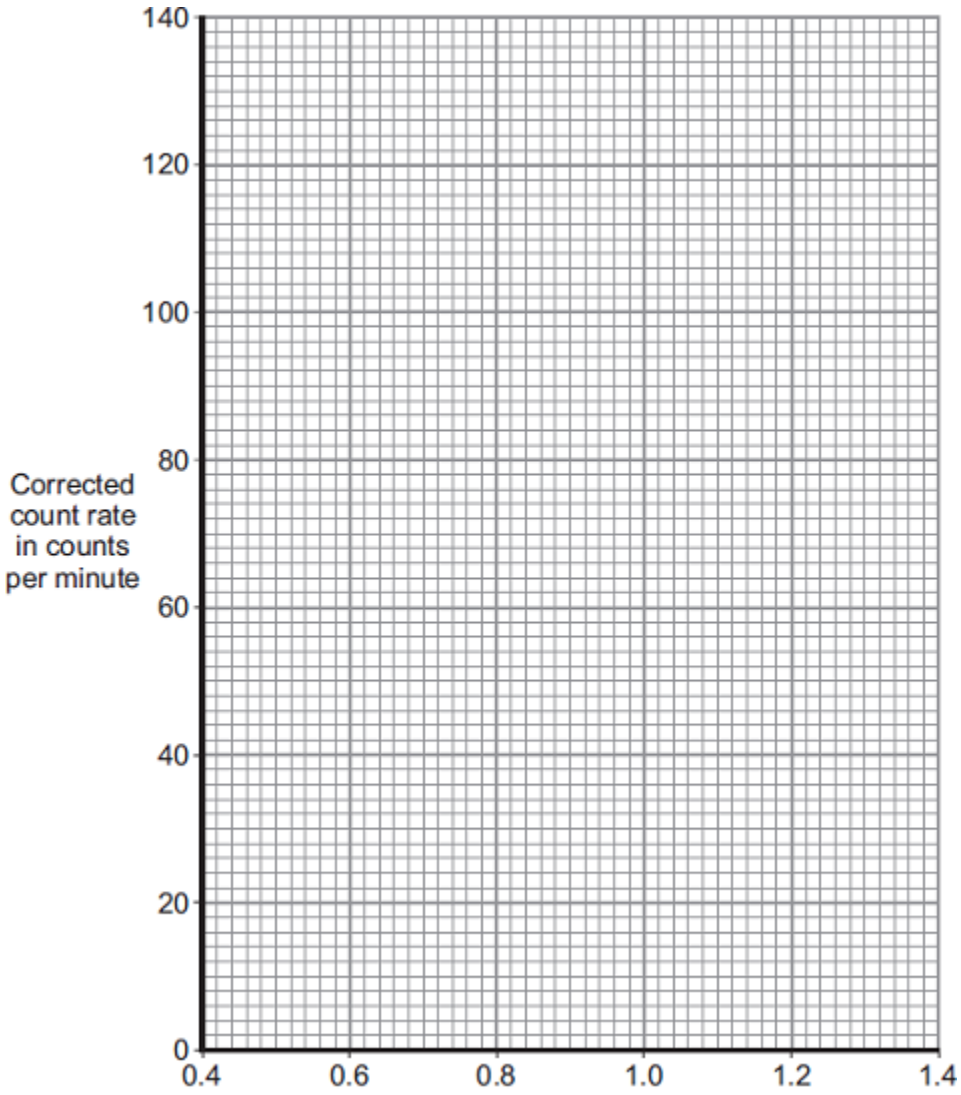
_____

_____

(1)

(iv) Plot a graph of corrected count rate against distance for distances between 0.4 m and 1.4 m.

Draw a line of best fit to complete the graph.



(3)

(v) The ‘half-distance’ is the distance a detector has to be moved away from a radioactive source for the corrected count rate to halve.

A student has the hypothesis:
A radioactive source has a constant ‘half-distance’.

Table 1 has been repeated for your information.

Table 1

Distance in metres	Count rate in counts per minute	Corrected count rate in counts per minute
0.4	143	125
0.6	74	56
0.8	49	31
1.0	38	20
1.2	32	14
1.4	28	10
1.6	18	0
1.8	18	0
2.0	18	0

Use **Table 1** to determine if the hypothesis is correct for this radioactive source.

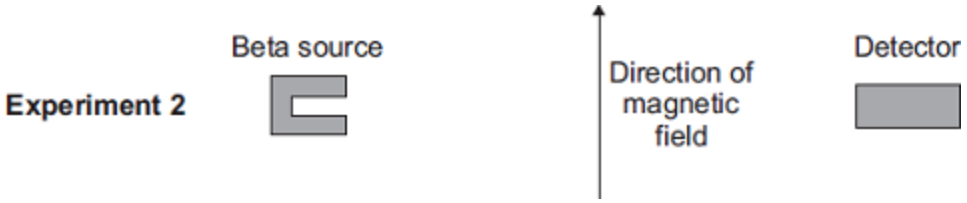
You should use calculations in your answer.

(3)

(b) A teacher places a beta source and a detector in a magnetic field.

The arrangement of the magnetic field is shown.

.....The teacher repeated the experiment with the magnetic field in a different direction.



A set of results is shown in **Table 2**.

Table 2

Distance between source and detector in metres	Count rate in counts per minute without magnetic field	Count rate in counts per minute in Experiment 1	Count rate in counts per minute in Experiment 2
0.8	48	48	32

(i) Describe **and** explain the effect of the magnetic field on the count rate detected by the detector.

_____

_____

_____

_____

_____

_____

(2)

(ii) The experiment is repeated with a different distance between the source and the detector.

Table 3 shows the repeated results.

Table 3

Distance between source and detector in metres	Count rate in counts per minute without magnetic field	Count rate in counts per minute in Experiment 1	Count rate in counts per minute in Experiment 2
1.8	19	18	20

Explain these results.

_____

_____

_____

_____

_____

_____

(2)

(Total 13 marks)

1

(a) (same) number of protons

same atomic number is insufficient

1

(b) (i) nuclei split

*do **not** accept atom for nuclei / nucleus*

1

(ii) (nuclear) reactor

1

(c) beta

1

any **one** from:

- atomic / proton number increases (by 1)

  accept atomic / proton number changes by 1
- number of neutrons decreases / changes by 1
- mass number does not change

  (total) number of protons and neutrons does not change
- a neutron becomes a proton

1

(d) (average) time taken for number of nuclei to halve
or
(average) time taken for count-rate / activity to halve

1

(e) (i) 6.2 (days)

Accept 6.2 to 6.3 inclusive
*allow **1** mark for correctly calculating number remaining as 20 000*
or
*allow **1** mark for number of*
80 000 plus correct use of the graph (gives an answer of 0.8 days)

2

(ii) radiation causes ionisation

allow radiation can be ionising

1

that may then harm / kill healthy cells

accept specific examples of harm, eg alter DNA / cause cancer

1

(iii) benefit (of diagnosis / treatment) greater than risk (of radiation)

accept may be the only procedure available

1

[11]

2

(a) (i) nuclear reactor

1

star

1

(ii) nuclei are joined (not split)

accept converse in reference to nuclear fission

*do **not** accept atoms are joined*

1

(b) (i) any **four** from:

- neutron
- (neutron) absorbed by U (nucleus)

ignore atom

*do **not** accept reacts*

*do **not** accept added to*

- forms a larger nucleus
- (this larger nucleus is) unstable
- (larger nucleus) splits into two (smaller) nuclei / into Ba and Kr
- releasing three neutrons and energy

accept fast-moving for energy

4

(ii) 56 (Ba)

1

57 (La)

*if proton number of Ba is incorrect allow **1** mark if that of La is 1 greater*

1

$^{0}_{-1}\beta$

accept e for β

$^{139}_{56}Ba \longrightarrow {}^{139}_{57}La + {}^{0}_{-1}\beta$

*scores **3** marks*

1

[10]

3 (a) (i) 18

1

(ii) the count rate for the source

1

(iii) the alpha radiation would not cover such a distance

1

(iv) plots correct to within ½ small square

*allow **1** mark for 4 correct points plotted*

2

correct curve through points as judged by eye

1

(v) two attempts at finding 'half-distance' using the table

20 to 10 cpm d = 0.4 m
125 to 56 cpm d = 0.2 m
31 to 14 cpm d = 0.4 m

*allow **1** mark for one attempted comparison*

2

obeyed or not obeyed

dependent on previous two marks

1

(b) (i) there is no effect on the count rate in experiment 1 because the field is parallel **or** beta particles are not deflected **or** there is no force

1

count rate is reduced in experiment 2 because field is perpendicular **or** beta particles are deflected **or** there is a force

1

(ii) only background radiation (as beta do not travel as far)

1

slightly different values show the random nature of radioactive decay

1

[13]