Topic 4 Atomic Structure H

Name: ____________________

Class: ____________________

Date: ____________________

Time: **42 minutes**

Marks: **42 marks**

Comments:

Q1.(a) Radioactive sources that emit alpha, beta or gamma radiation can be dangerous.

What is a possible risk to health caused by using a radioactive source?

....

....

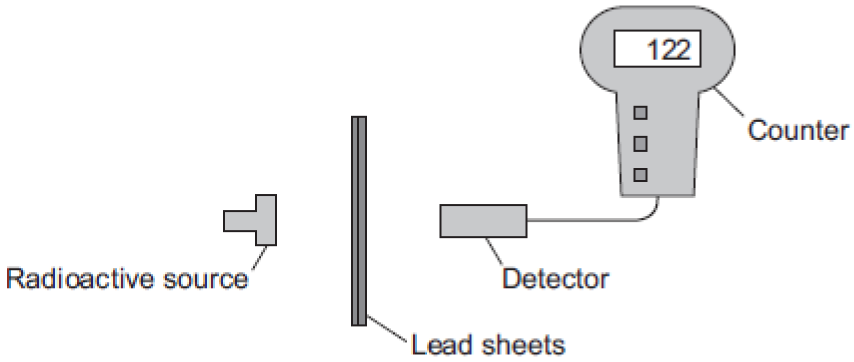
(1)

(b) In an experiment, a teacher put a 2 mm thick lead sheet in front of a radioactive source.
She used a detector and counter to measure the radiation passing through the lead sheet in one minute.

She then put different numbers of lead sheets, each 2 mm thick, in front of the radioactive source and measured the radiation passing through in one minute.

The apparatus the teacher used is shown in **Figure 1**.

Figure 1



(i) When using a radioactive source in an experiment, how could the teacher reduce the risk to her health?

Suggest **one** way.

....

....

(1)

(ii) The number recorded on the counter is actually higher than the amount of radiation detected from the source.

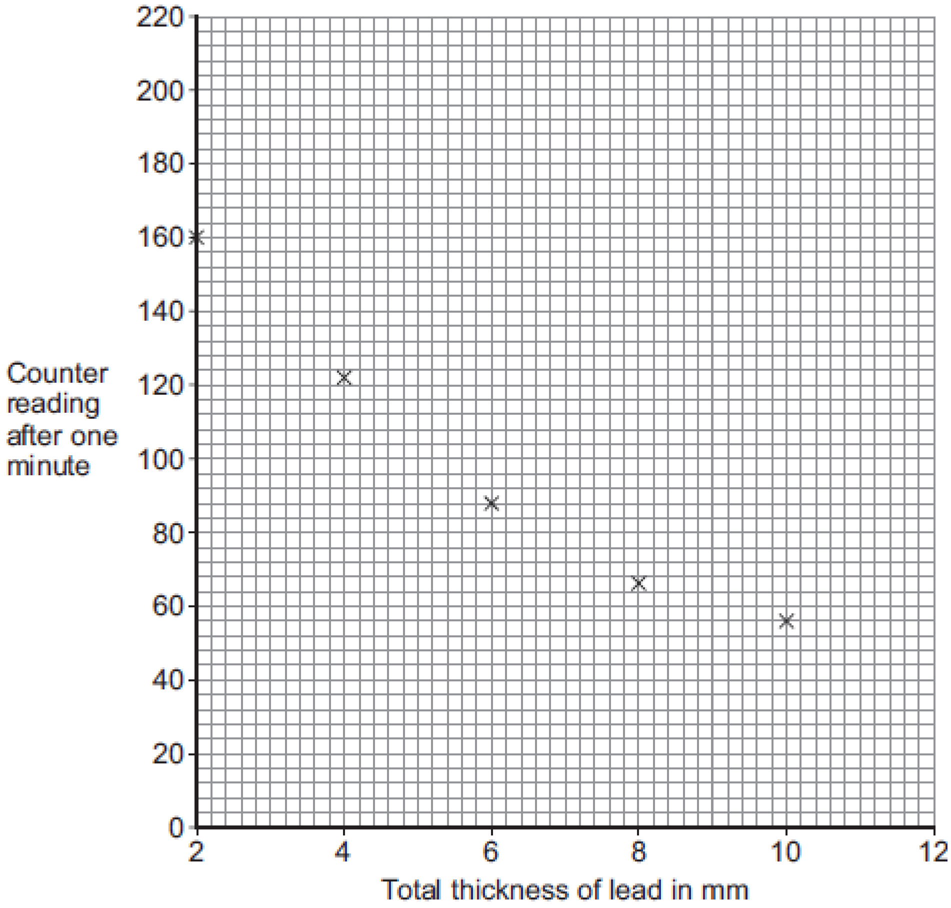
Complete the following word equation.

The number recorded on the counter	=	The amount of radiation detected from the source	+	.... radiation

(1)

(c) The readings taken by the teacher are plotted in **Figure 2**.

Figure 2



(i) Draw a line of best fit to complete **Figure 2**.

(1)

(ii) How does the amount of radiation **absorbed** by the lead change as the total thickness of the lead is increased?

....

....

(1)

(iii) Use **Figure 2** to estimate the reading on the counter when the total thickness of the lead is increased to 12 mm.

Estimated counter reading = ...

(1)

(d) What type of radiation was emitted from the radioactive source?

Draw a ring around the correct answer.

alpha **beta** **gamma**

Give a reason for your answer.

....

....

(2)
(Total 8 marks)

Q2. Different radioactive isotopes have different values of half-life.

(a) What is meant by the 'half-life' of a radioactive isotope?

....

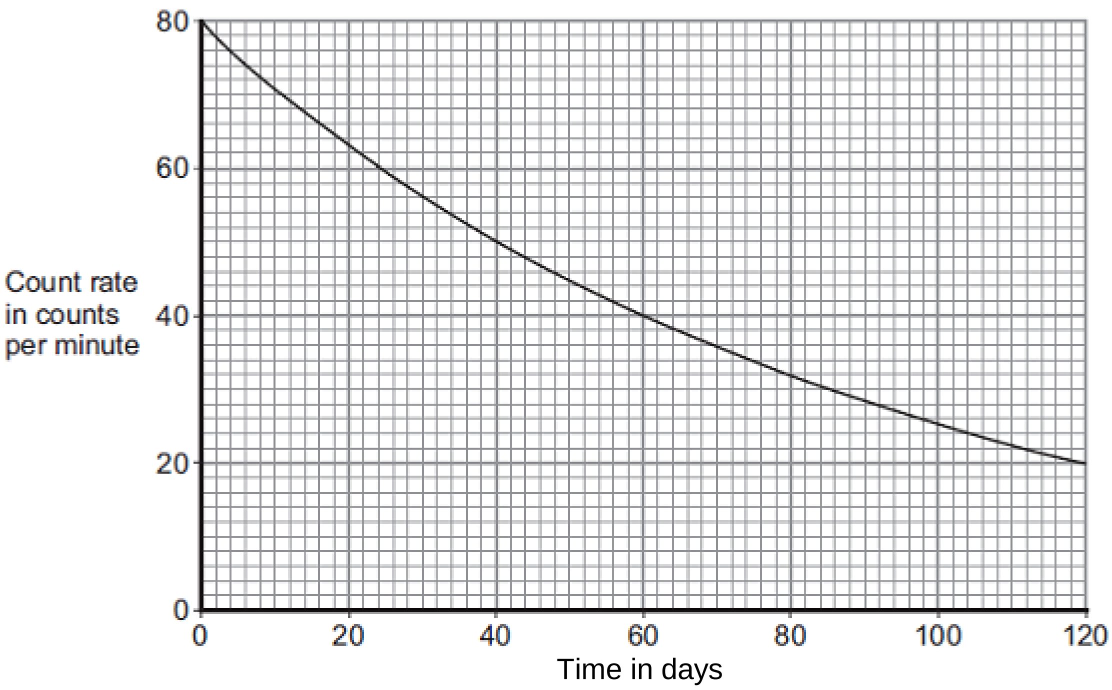
....

....

(1)

(b) **Figure 1** shows how the count rate from a sample of a radioactive isotope varies with time.

Figure 1



Use information from **Figure 1** to calculate the half-life of the radioactive isotope.

Show clearly on **Figure 1** how you obtain your answer.

Half-life = ... days

(2)

(c) The table below shows data for some radioactive isotopes that are used in schools.

Radioactive isotope	**Type of radiation emitted**	**Half-life in years**
Americium-241	Alpha and gamma	460
Cobalt-60	Gamma	5
Radium-226	Alpha, beta and gamma	1600
Strontium-90	Beta	28
Thorium-232	Alpha and beta	1.4×10^{10}

(i) State which radioactive isotope in the table above emits only radiation that is **not** deflected by a magnetic field.

Give a reason for your choice.

....

....

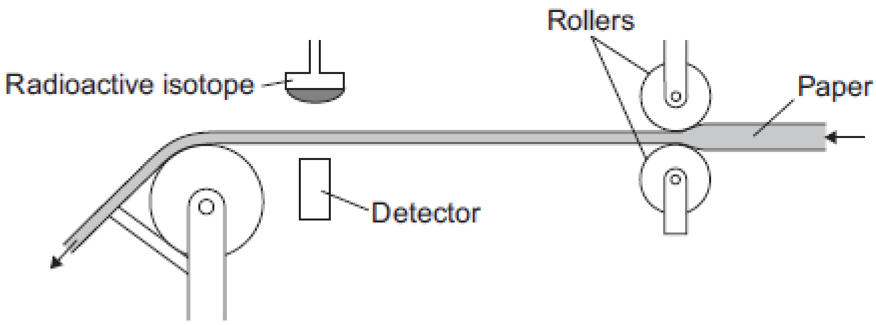
....

....

(2)

(ii) **Figure 2** shows a radioactive isotope being used to monitor the thickness of paper during production.

Figure 2



State which radioactive isotope in the table should be used to monitor the thickness of the paper.

Explain your choice.

....

....

....

....

....
(3)

All the radioactive isotopes in the table have practical uses.

State which source in the table would need replacing most often.

Explain your choice.

....

....

....

....

....
(3)

(iii) When the radioactive isotopes are not in use, they are stored in lead-lined wooden boxes.

The boxes reduce the level of radiation that reaches the surroundings.

Figure 3 shows two of these boxes.

Figure 3

State **one** source from the table which emits radiation that could penetrate the box.

Explain your answer.

(3)
(Total 14 marks)

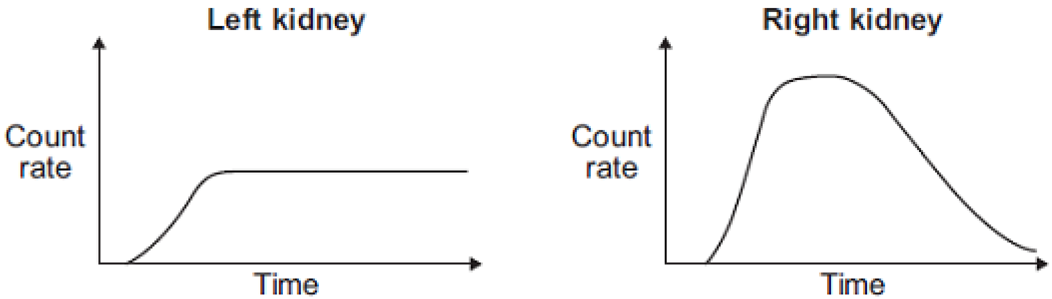
Q3. A doctor uses the radioactive isotope technetium-99 to find out if a patient’s kidneys are working correctly.

The doctor injects a small amount of technetium-99 into the patient's bloodstream. Technetium-99 emits gamma radiation.

If the patient's kidneys are working correctly, the technetium-99 will pass from the bloodstream into the kidneys and then into the patient's urine.

Detectors are used to measure the radiation emitted from the kidneys.

The level of radiation emitted from each kidney is recorded on a graph.



(a) How do the graphs show that technetium-99 is passing from the bloodstream into each kidney?

....

....

(1)

(b) By looking at the graphs, the doctor is able to tell if there is a problem with the patient's kidneys.

Which **one** of the following statements is correct?

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

Only the right kidney is working correctly. ☐

Only the left kidney is working correctly. ☐

Both kidneys are working correctly. ☐

Explain the reason for your answer.

....

....

....

....

(3)
(Total 4 marks)

Q4.(a) Nuclear fission is used in nuclear power stations to generate electricity. Nuclear fusion happens naturally in stars.

(i) Explain briefly the difference between *nuclear fission* and *nuclear fusion*.

....

....

....

....

....

(2)

(ii) What is released during both nuclear fission and nuclear fusion?

....

(1)

(b) Plutonium-239 is used as a fuel in some nuclear reactors.

(i) Name another substance used as a fuel in some nuclear reactors.

....

(1)

(ii) There are many isotopes of plutonium.

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

....

(1)
(Total 5 marks)

Q5.(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.

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

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’?

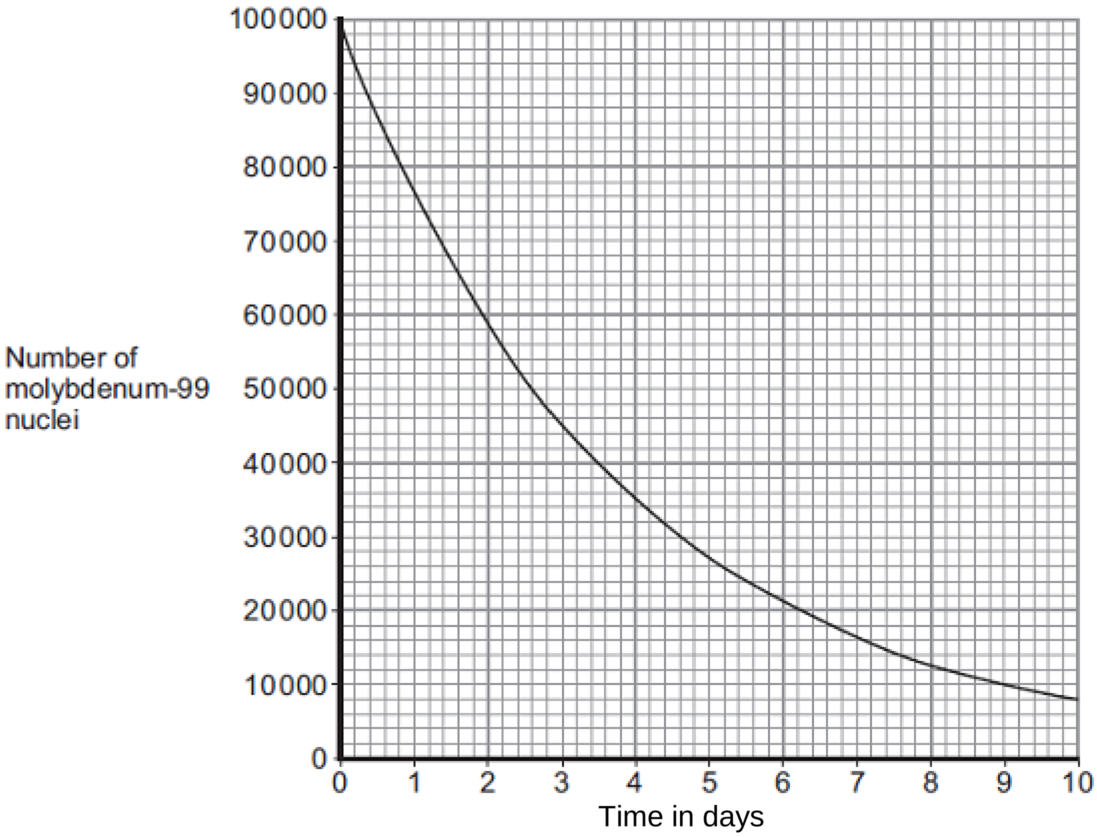
....

....

.... **(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)

M1.(a) cell damage or cancer

accept kills / mutates cells

radiation poisoning is insufficient
ionising is insufficient

1

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

- use tongs to pick up source
- wear gloves
- use (lead) shielding
- minimise time (of exposure)
- maximise distance (between source and teacher).

accept any other sensible and practical suggestion

ignore reference to increasing / decreasing the number / thickness of lead sheets

1

(ii) background

1

(c) (i) curve drawn *from point 2,160*

*do **not** accept straight lines drawn from dot to dot*

1

(ii) (also) increases

less radiation passes through is insufficient

1

(iii) 50

accept any value from 40 to 56 inclusive

1

(d) gamma

1

only gamma (radiation) can pass through lead

*accept alpha **and** beta cannot pass through lead*
a general property of gamma radiation is insufficient

1

[8]

M2.(a) (average) time taken for the amount / number of nuclei / atoms (of the isotope in a sample) to halve
or
time taken for the count rate (from a sample containing the isotope) to fall to half

accept (radio)activity for count rate

1

(b) *60* ±*3* (days)

1

indication on graph how value was obtained

1

(c) (i) cobalt(-60)

1

gamma not deflected by a magnetic field
or
gamma have no charge

dependent on first marking point

accept (only) emits gamma

gamma has no mass is insufficient

do ***not*** *accept any reference to half-life*

1

(ii) strontium(-90)

1

any **two** from:

- *only* has beta
- alpha would be absorbed
- gamma unaffected
- *beta penetration / absorption depends on thickness of paper*

if thorium(-232) or radium(-226) given, max ***2*** *marks can be awarded*

2

(iii) cobalt(-60)

1

shortest half-life

accept half-life is 5 years

dependent on first marking point

1

so activity / count rate will decrease quickest

1

(iv) *americium(-241) / cobalt(-60) / radium(-226)*

1

gamma emitter

1

(only gamma) can penetrate lead *(of this box)*

do not allow lead fully absorbs gamma

1

[14]

M3.(a) (both graphs show an initial) increase in count rate

accept both show an increase

1

(b) only the right kidney is working correctly

1

any **two** from:

if incorrect box chosen maximum of ***1*** *mark can be awarded*

reference to named kidney can be inferred from the tick box

- count-rate / level / line for <u>right</u> kidney decreases (rapidly)

  it decreases is insufficient

- count-rate / level / line for <u>left</u> kidney does not change *it does not change is insufficient*

- radiation is being passed out into urine – if referring to right kidney
- radiation is not being passed out – if referring to the left kidney
- <u>left</u> kidney does not initially absorb as much technetium-99

2

[4]

M4.(a) (i) (nuclear) fission is the splitting of a (large atomic) nucleus

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

1

(nuclear) fusion is the joining of (two atomic) nuclei (to form a larger one)

do not accept particles/atoms for nuclei

1

(ii) energy

accept heat/radiation/nuclear energy

accept gamma (radiation)

do not accept neutrons/neutrinos

1

(b) (i) uranium (–235)

accept U (–235)

ignore any numbers given with uranium

accept thorium

accept MOX (mixed oxide)

*do **not** accept hydrogen*

1

(ii) (same) number of protons

accept (same) atomic number

accept (same) positive charge

ignore reference to number of electrons

1

[5]

M5.(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]