

RADIATION

Sc 10

Multiple choice questions – atomic structure and radioactivity

- 1 Proton number is another name for atomic number. Nucleon number is another name for mass number.

What are isotopes?

- A nuclei with different proton numbers and different nucleon numbers
- B nuclei with different proton numbers and the same nucleon number
- C nuclei with the same proton number and different nucleon numbers**
- D nuclei with the same proton number and the same nucleon number

- 2 Chlorine exists as two isotopes. One has a nucleon number (mass number) of 35 and the other has a nucleon number (mass number) of 37. ~~Use atomic mass~~

Which table shows the correct numbers of protons and neutrons in the isotopes?

A

	number of protons	number of neutrons
isotope 1	17	18
isotope 2	17	20

B

	number of protons	number of neutrons
isotope 1	18	17
isotope 2	20	17

C

	number of protons	number of neutrons
isotope 1	35	17
isotope 2	37	17

D

	number of protons	number of neutrons
isotope 1	17	35
isotope 2	17	37

- 3 The radioactive isotope radium-226 may be shown as $^{226}_{88}\text{Ra}$.

How many protons does an atom of radium contain?

- A 44
- B 88**
- C 138
- D 226

- 4 Which statement about a neutral atom of $^{226}_{88}\text{Ra}$ is correct? $p = e$

- A It has an equal number of neutrons and protons. $\times$
- B It has more electrons than neutrons. $\times$
- C It has more electrons than protons. $\times$
- D It has more neutrons than protons.**

$$226 - 88 = 138n.$$

p 88

e 88

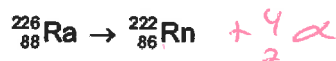
n 138

- 5 A nucleus X has 17 protons and 18 neutrons.

Which notation is correct for this nucleus?

- A ${}_{18}^{17}\text{X}$ B ${}_{35}^{17}\text{X}$ C ${}_{17}^{18}\text{X}$ **D** ${}_{17}^{35}\text{X}$

- 6 In one radioactive decay, radium (Ra) gives rise to radon (Rn) as shown.



What particle is also produced?

- A** an alpha-particle
 B a beta-particle
 C both an alpha-particle and a beta-particle
 D no particle but only gamma-rays
- 7 When a sample of a radioactive nuclide decays, the count rate falls from 1200 to 150 in three minutes.

What is the half-life of the radioactive nuclide?

- A 0.75 minutes
B 1.0 minutes
 C 3.0 minutes
 D 9.0 minutes

	Time
1200	0
600	1 min
300	2 min
150	3 min

- 8 Tritium is a radioactive isotope of hydrogen with a half-life of 12 years.

If a sample starts with 40 million atoms of tritium, how many atoms of tritium will be left after 12 years?

- A 40 million
B 20 million
 C 10 million
 D 5 million
- 9 A radioactive nuclide ${}_{92}^{238}\text{U}$ decays into thorium by emitting an alpha-particle.

The thorium then decays into protactinium by emitting a beta-particle.

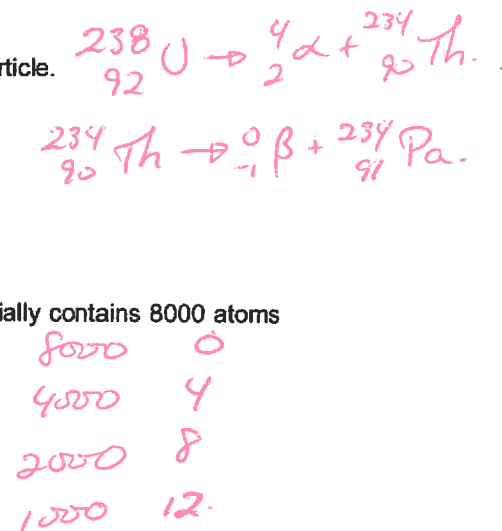
What is the symbol for protactinium?

- A ${}_{90}^{230}\text{Pa}$ B ${}_{89}^{234}\text{Pa}$ C ${}_{90}^{234}\text{Pa}$ **D** ${}_{91}^{234}\text{Pa}$

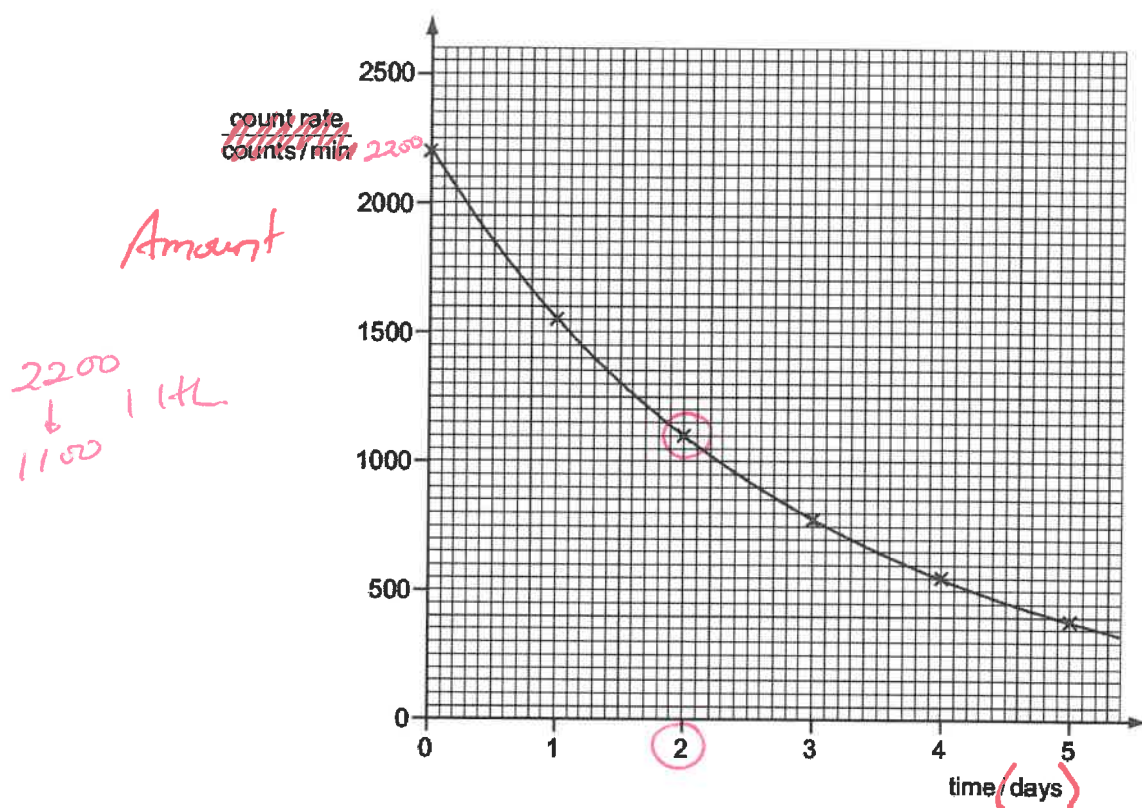
- 10 An isotope X is radioactive and has a half-life of 4 years. A sample initially contains 8000 atoms of X.

After how many years will the sample contain 1000 atoms of X?

- A 4 B 8 **C** 12 D 16



- 11 The graph shows the decay curve for one particular radioactive nuclide.



What is the half-life of this nuclide?

- A 1.0 day B 1.5 days **C 2.0 days** D 2.5 days
- 12 Which row describes the properties of α -particles?

	ionizing effect	radiation stopped by aluminium?
A	large	no
B	large	yes
C	small	no
D	small	yes

- 13 A radioactive substance has a half-life of 2 weeks. At the beginning of an investigation the substance emits 3000 β -particles per minute.

How many β -particles will it emit per minute after 6 weeks?

- A 0 **B 375** C 500 D 1500

Time (week)

3000 0

1500 2

750 4

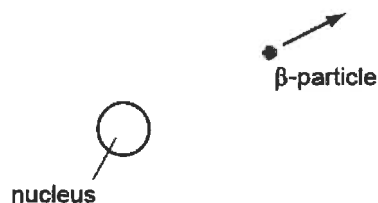
375 6

- 14 Which row shows the relative ionising effects and penetrating abilities of α -particles and β -particles?

	ionising effect	penetrating ability
A	α greater than β	α greater than β
B	α greater than β	α less than β
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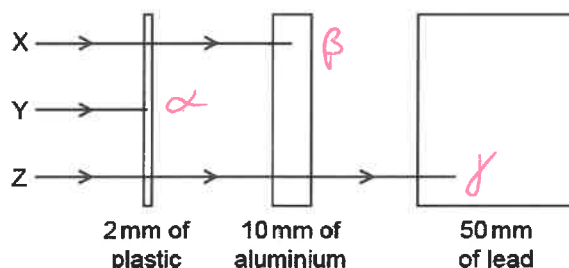
Don't Do.

- 15 A radioactive nucleus emits a β -particle.



What happens to the proton number (atomic number) of the nucleus?

- A** It stays the same.
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- 16 The diagram shows the paths of three different types of radiation, X, Y and Z.



Which row in the table correctly identifies X, Y and Z?

	X	Y	Z
A	α -particles	β -particles	γ -rays
B	β -particles	α -particles	γ -rays
C	β -particles	γ -rays	α -particles
D	γ -rays	α -particles	β -particles

- 17 A radioactive substance emits a particle from the nucleus of one of its atoms. The particle consists of two protons and two neutrons.

What is the name of this process?

- A** α -emission
B β -emission
C γ -emission
D nuclear fission

18 When dealing with radioactive materials there are possible dangers.

Which statement is correct?

- A** Beta-particles can pass through skin and damage body cells.
- B** Materials that emit only alpha-particles must be kept in thick lead containers.
- C** Radioactive materials are safe to handle after two half-lives.
- D** Sources of gamma radiation are dangerous because they have long half-lives.

19 Which row is correct for fission and for fusion?

	fission of a nucleus	fusion
A	produces larger nuclei ✓	is the energy source of a star ✓
B	produces larger nuclei	is used to release energy in a power station
C	produces smaller nuclei ✗	is the energy source of a star
D	produces smaller nuclei	is used to release energy in a power station

Longer answer questions – atomic structure and radioactivity

Question 1

substance	symbol	type of radiation emitted	half-life
barium-139	$^{139}_{56}\text{Ba}$	beta (β)	85 minutes
silver-110	$^{110}_{47}\text{Ag}$	beta (β)	24 seconds
technetium-99m	$^{99}_{43}\text{Tc}$	gamma (γ)	6.0 hours
thorium-232	$^{232}_{90}\text{Th}$	alpha (α)	1.4×10^{10} years

- (a) Which of these substances has the greatest number of particles in the nucleus of its atoms?

Thorium - 232 ($p+n=232$) [1]

- (b) Which of these substances has the least number of electrons in the orbits of a neutral atom?

Technetium - 99 ($43e^-$) [1]

- (c) Which of these substances are emitting particles?

Barium - 139 Silver - 110
Thorium - 232 (gamma is energy)* [2]

- (d) Samples of each of these substances are decaying. Each sample starts with the same number of atoms.

Which sample decays the most in one hour?

Silver - 110 (shortest HL) [1]

- (e) In the investigation of a blood circulation problem, a patient is given an injection containing one of these substances. The radiation needs to be detectable from outside the body.

Which of the substances might be suitable for this use?

Barium - 139 (β). [1]

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C It has more electrons than protons. *x*
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$$226 - 88 = 138n.$$

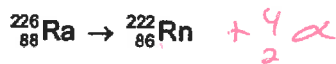
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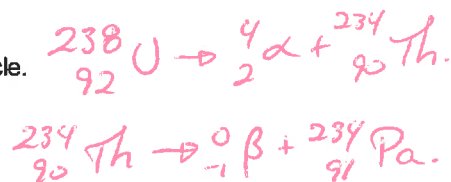
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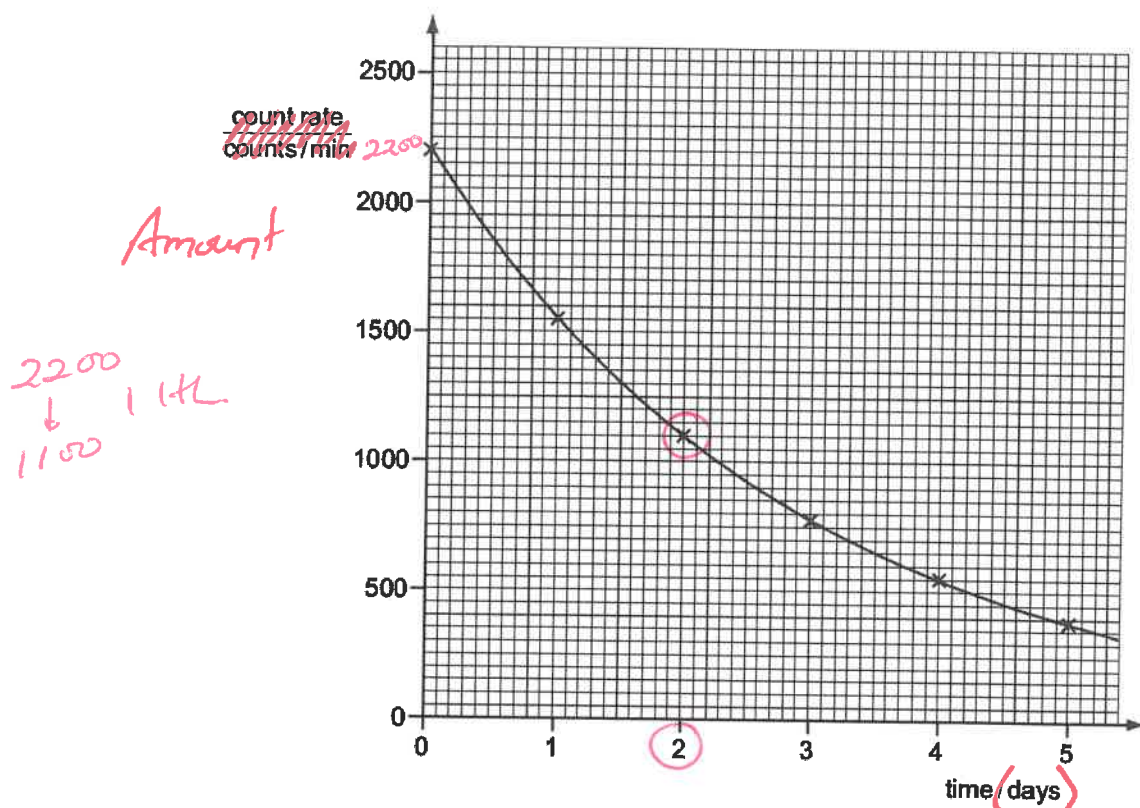
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8000	0
4000	4
2000	8
1000	12

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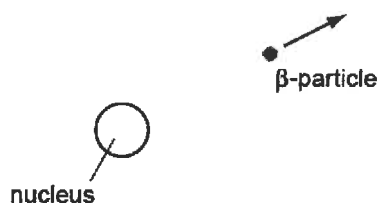
Time (week)
0
2
4
6

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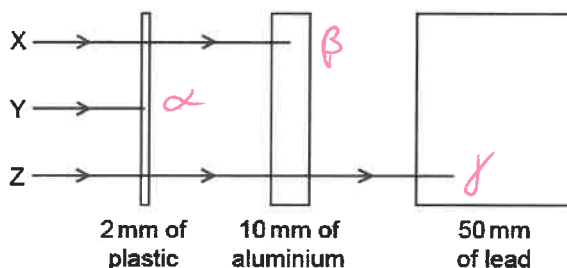
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Barium - 139 (β). [1]

*Silver - 110 wouldn't last long enough.

(c) Fig. 12.2 shows the decay curve for a particular radioactive substance.

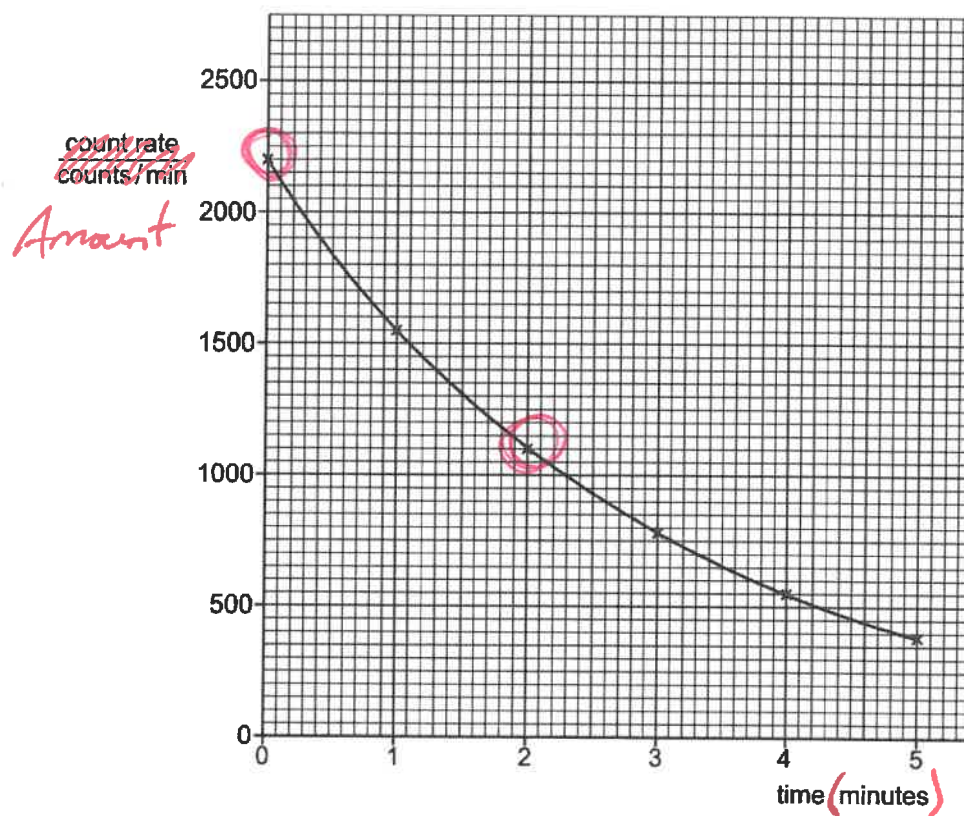


Fig. 12.2

- (i) Select and use numbers from the graph to deduce the half-life of the radioactive substance.

$$\begin{array}{r} 2200 \\ \div 2 \leftarrow 1 \text{ half life} \\ \hline 1100 \end{array}$$

half-life = 2 minutes minutes [3]

- (ii) Predict the value of the count rate at a time of 6 minutes from the start of the measurements. Show your working.

T	Count
0	2200
2	1100
4	550
6	275

count rate = 275 counts/min [2]

Question 4

Iodine-131 is a radioactive isotope of iodine. Iodine-131 decays by the emission of a β -particle and a γ -ray.

- (a) A nucleus of iodine-131 can be represented as



$$131 - 53 = 78$$

Determine the number of neutrons in a nucleus of iodine-131.

number of neutrons 78 [1]

- (b) β -particles and γ -rays are ionising radiations.

Explain the meaning of ionising radiations.

Don't Do.

- (c) Fig. 8.1 shows a decay curve for iodine-131.

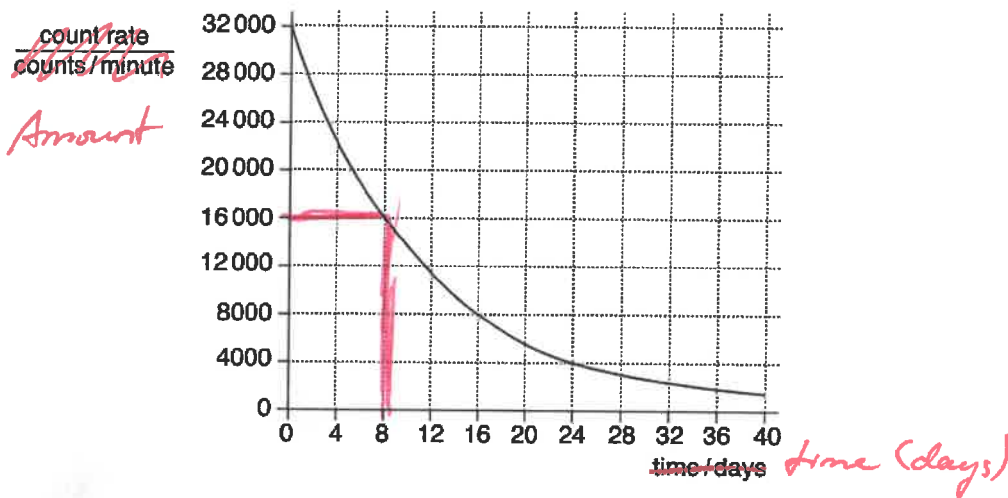


Fig. 8.1

Use information from Fig. 8.1 to determine the half-life of iodine-131. Show clearly how you used the graph.

$$32\ 000 \div 2 = 16\ 000$$

↑
1 HL.

half-life = ... 8 days days [3]

(d) A different radioactive substance has a half-life of 120 hours.

Calculate the time for it to decay to 25% of its original amount.

%	Time
100	0
50	120
25	240

time = ... *240 hours* hours [2]

[Total: 7]

Question 5

- 11 Strontium-90 is a radioactive isotope that emits β -particles as it decays. The nuclear equation below shows this decay.



(a) Calculate

- (i) the value of a ,

$$90 = a + 0$$

$$a = 90$$

$$a = 90$$

- (ii) the value of b .

$$38 = b + (-1)$$

$$b = 39$$

$$b = 39$$

[2]

- (b) (i) Tick the element from the list below that is produced by this decay.

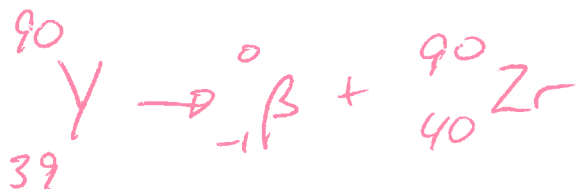
element	proton number	place one tick in this column
selenium	34	
bromine	35	
krypton	36	
rubidium	37	
strontium	38	
yttrium	39	✓
zirconium	40	
niobium	41	
molybdenum	42	

[1]

- (ii) The isotope ${}_b^a\text{X}$ is also radioactive and undergoes β -decay.

State the name of the element that is produced by this decay.

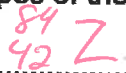
${}_{40}^{90}\text{Zr}$ or Zirconium-90 [1]



(c) Three nuclei are represented as



State and explain which nuclei are isotopes of the same element.



both have the same

number of protons (42)

[2]

[Total: 6]

Question 6

In a research laboratory, a radioactive sample is placed close to a radiation detector. The graph in Fig. 11.1 shows the decay of the sample.

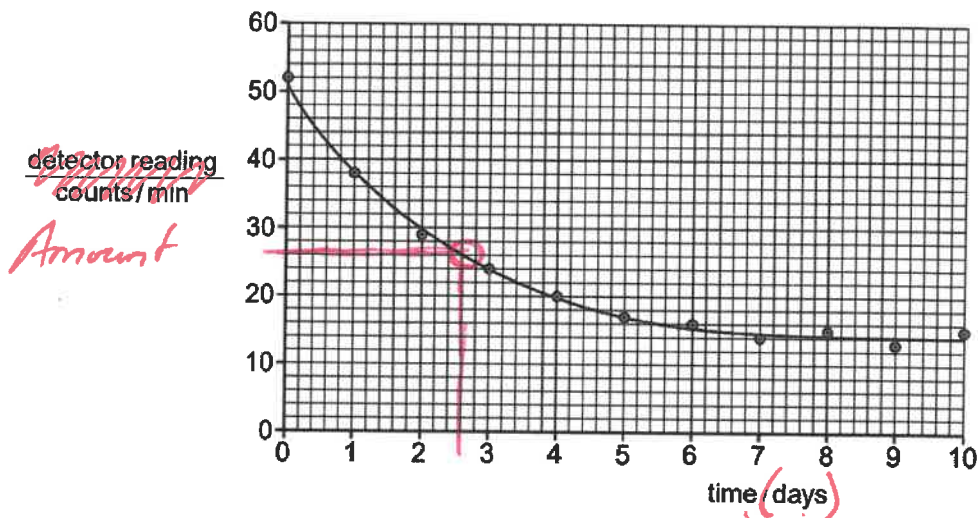


Fig. 11.1

- (a) After 6 days the count rate hardly decreases and, in fact, increases a little at times. Explain these observations.

.....

 [2]

*Don't
Do*

- (b) Use the graph to determine the half-life of the sample. Explain your working carefully.

$$52 \div 2 = 26$$

half-life = *2.6 days* [4]

- (c) Another radioactive sample is a strong emitter of α -particles and γ -rays. A junior researcher suggests that a sufficient safety precaution, when working with this sample, would be to hold the sample with long forceps. Explain why this suggestion, although helpful, may be insufficient.

.....

 [2]

*Don't
Do*

[Total: 8]

REFER TO
DATA PAGES

For this section of the examination, refer to:

- Periodic Table of the Elements on Data Page 3
- The Electromagnetic Spectrum on Data Page 6
- Common Isotope Pairs Chart on Data Page 6

54. True or false? Electromagnetic waves that have lower frequencies are less hazardous than electromagnetic waves with higher frequencies.

radiowaves

gamma rays

- ☒ A. True
B. False

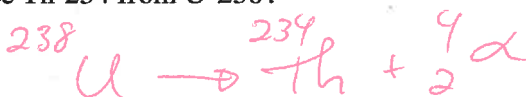
55. Mammoths are a group of elephants that became extinct about 9000 years ago during the Holocene Epoch. An entire baby mammoth was found frozen in the Siberian ice fields. Which of the following isotope pairs would be best for calculating the age of this specimen?

- ☒ A. carbon-14/nitrogen-14
B. uranium-238/lead-206
C. potassium-40/argon-40
D. all three isotope pairs

HL = 5730 years ✓
4.5 billion x
1.3 billion x

56. Which process will produce Th-234 from U-238?

- A. fission
B. beta decay
☒ C. alpha decay
D. gamma decay



57. Which of the following can pass through a human body?

I	X-ray	✓
II	gamma ray	✓
III	alpha particle	x

- A. I only
☒ B. I and II only
C. II and III only
D. I, II and III