Multiple choice questions – atomic structure and radioactivty

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.

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 $^{226}_{88}Ra$.

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 $^{226}_{88}Ra$ is correct?

A It has an equal number of neutrons and protons.

B It has more electrons than neutrons.

C It has more electrons than protons.

D It has more neutrons than protons.

5 A nucleus X has 17 protons and 18 neutrons.

Which notation is correct for this nucleus?

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

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

$$^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn$$

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

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 $^{238}_{92}U$ 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?

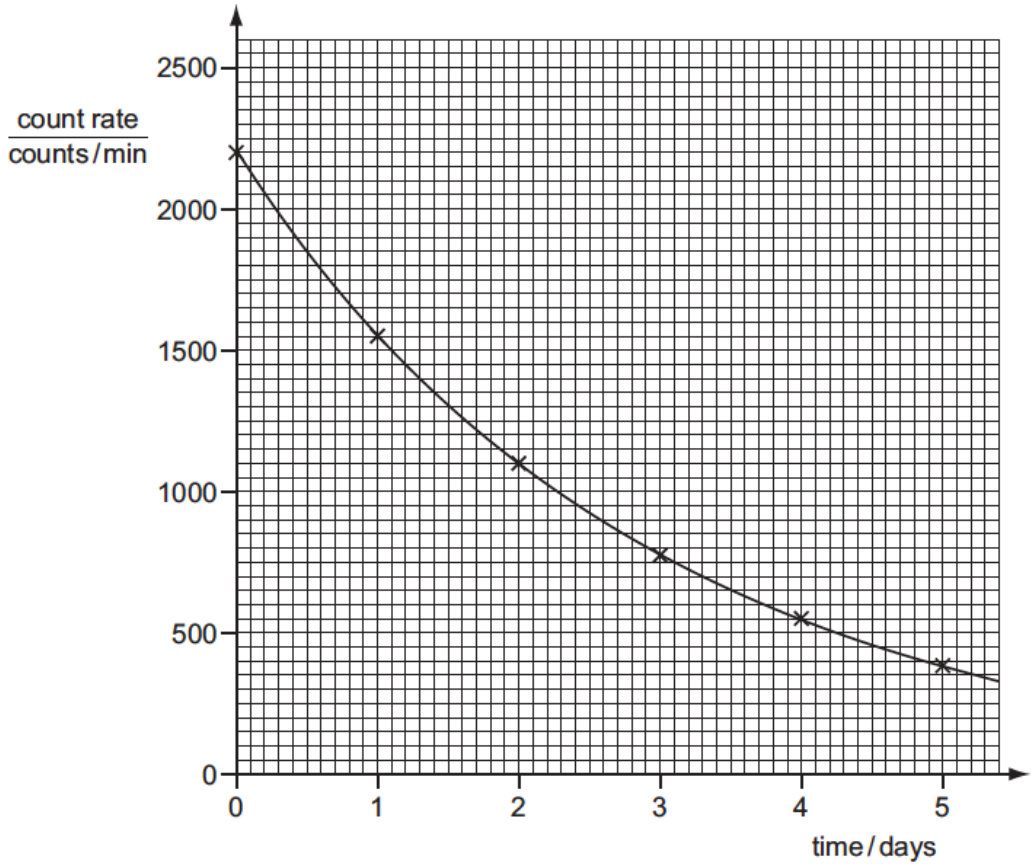
A $^{230}_{90}Pa$ **B** $^{234}_{89}Pa$ **C** $^{234}_{90}Pa$ **D** $^{234}_{91}Pa$

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.

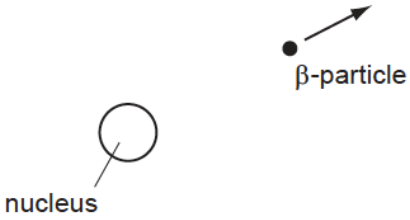
How many β-particles will it emit per minute after 6 weeks?

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

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
C	α less than β	α greater than β
D	α less than β	α less than β

15 A radioactive nucleus emits a β-particle.



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

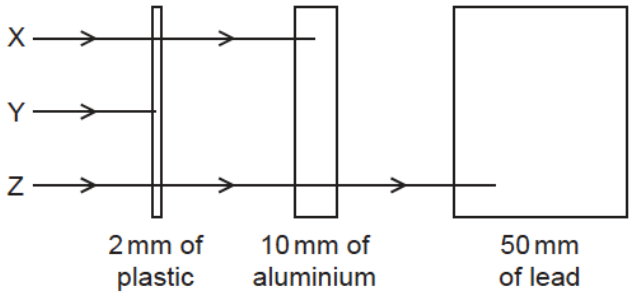
A It stays the same.

B It increases by 1.

C It decreases by 2.

D It decreases by 4.

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	$^{139}_{56}Ba$	beta (β)	85 minutes
silver-110	$^{110}_{47}Ag$	beta (β)	24 seconds
technetium-99m	$^{99}_{43}Tc$	gamma (γ)	6.0 hours
thorium-232	$^{232}_{90}Th$	alpha (α)	1.4×10^{10} years

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

..... [1]

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

..... [1]

(c) Which of these substances are emitting particles?

.....

..... [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?

..... [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?

..... [1]

Question 2

In Geiger and Marsden's α-particle scattering experiment, α-particles were directed at a very thin gold foil.

Fig. 11.1 shows five of the nuclei of the atoms in one layer in the gold foil. Also shown are the paths of three α-particles directed at the foil.

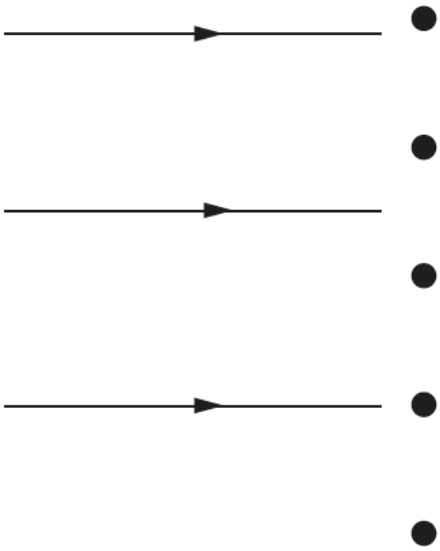


Fig. 11.1

(a) On Fig.11.1, complete the paths of the three α-particles. [3]

(b) **(i)** State the result of the experiment that shows that an atom consists of a very tiny, charged core, containing almost all the mass of the atom.

.....

..... [1]

(ii) State the sign of the charge on this core. ..... [1]

(iii) State what occupies the space between these charged cores.

..... [1]

(c) The nuclide notation for an α-particle is ${}^{4}_{2}\alpha$.

State the number of protons and neutrons in an α-particle

protons = ...

neutrons = ... [1]

Question 3

(a) What is meant by *radioactive decay*?

.....

.....

..... [2]

(b) Fig. 12.1 shows two samples of the same radioactive substance. The substance emits β-particles.

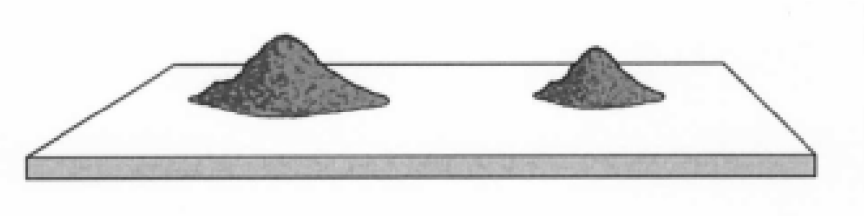


Fig. 12.1

Put a tick alongside any of the following quantities which is the same for both samples.

- ☐ the half-life
- ☐ the mass
- ☐ the number of atoms decaying each second
- ☐ the number of β-particles emitted each second

[1]

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

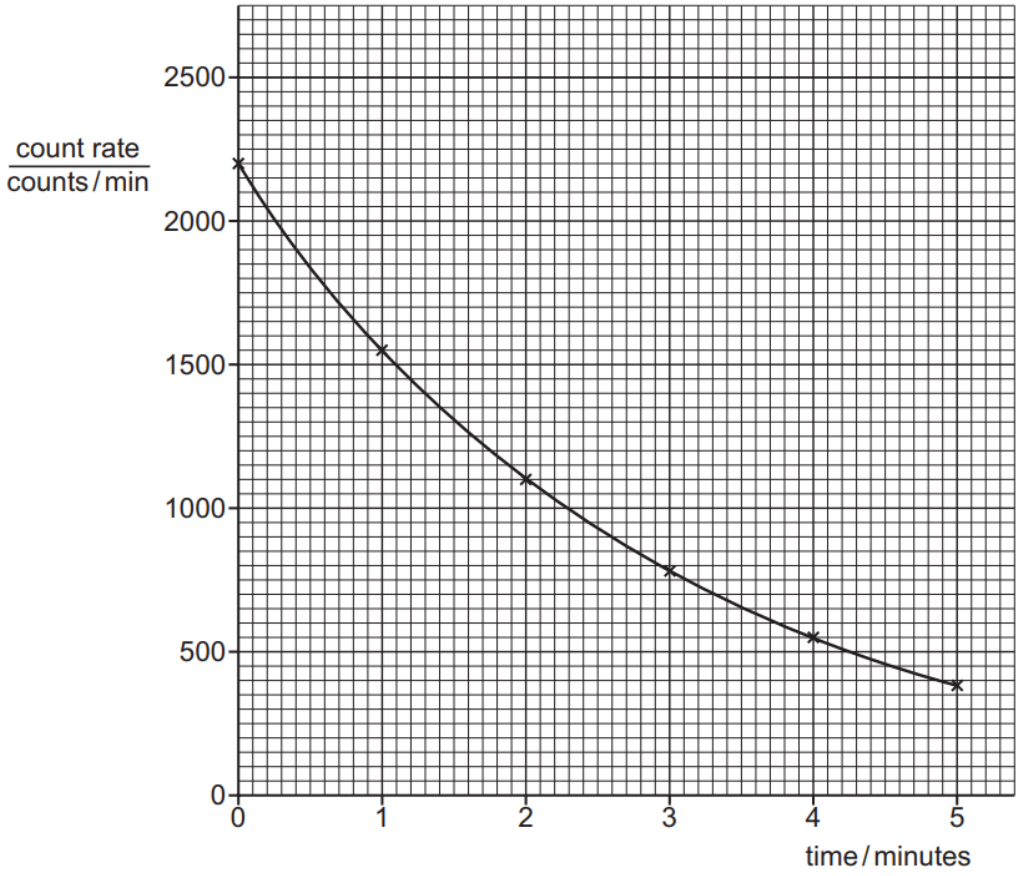


Fig. 12.2

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

half-life = ... 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.

count rate = ... counts / min [2]

(d) People handling radioactive substances need to take certain safety precautions.

(i) Explain why safety precautions are necessary.

.....

..... [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

$$^{131}_{53}\mathrm{I}$$

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

number of neutrons ..... [1]

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

Explain the meaning of *ionising* radiations.

.....

..... [1]

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

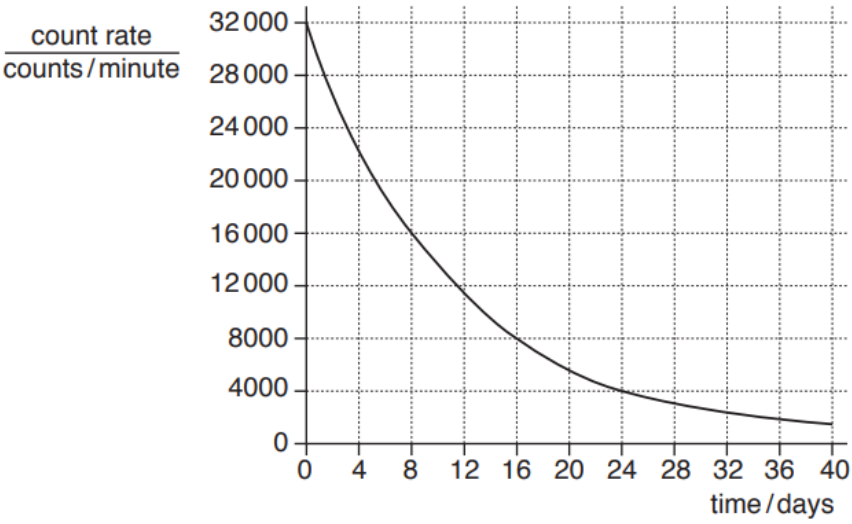


Fig. 8.1

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

half-life = ... 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 = ... 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.

$$^{90}_{38}\text{Sr} \longrightarrow {}^{a}_{b}\text{X} + {}^{0}_{-1}\text{e}$$

(a) Calculate

(i) the value of *a*,

a = ...

(ii) the value of *b*.

b = ...

[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 $^{a}_{b}\text{X}$ is also radioactive and undergoes β-decay.

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

.....[1]

(c) Three nuclei are represented as

$$^{83}_{42}X \qquad ^{209}_{83}Y \qquad ^{84}_{42}Z$$

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

.....

.....

.....

.....[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.

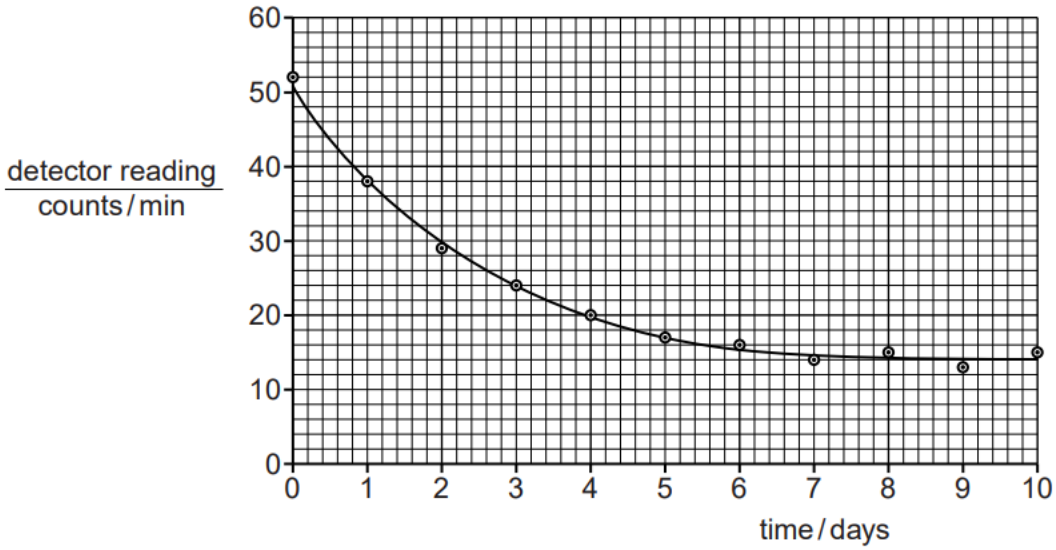


Fig. 11.1

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

.....

.....

.....

..... [2]

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

half-life = ... [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]

[Total: 8]

Multiple choice answers

1	C	6	A	11	C	16	B
2	A	7	B	12	B	17	A
3	B	8	B	13	B	18	A
4	D	9	D	14	B	19	C
5	D	10	C	15	B	20	--

Question 1

a) Thorium-232 (highest mass number)
b) Technetium – 99m (lowest proton number therefore lowest number of electrons)
c) Barium, silver and thorium (technetium is emitting gamma which is a wave)
d) Silver – 110 (shortest half life)
e) Technetium. Gamma rays will pass outside of body and half life is short. (Silver and barium cannot be used as though the beta would penetrate the body the half life is too short to be usable. Thorium cannot be used as half life is too long and alpha particles could not pass out of the bod

Question 2

a)

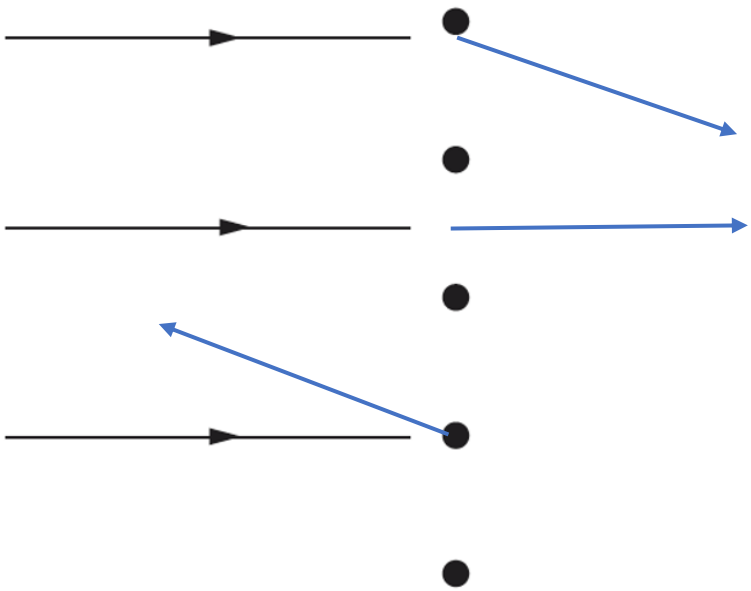


Fig. 11.1

b) (i) deflection greater than 90 /the bottom one [1]
(ii) positive ignore numbers [1]
(iii) nothing/vacuum/space/electrons [1]
(c) 2 AND 2 [1]

Question 3

a) break up of unstable nuclei [1]
emission of ionising radiation / alpha / beta / gamma [1]
b) only half-life ticked [1]
c) (i) clear statement of start point (can be inferred from markings on graph) [1]
clear halving [1]
2 minutes [1]

(ii) 550/2 OR 1100/4 OR 2200/8 e.c.f. [1]
275 (counts / min) e.c.f.

d) (i) any two from: emissions (from radioactive substances) are ionising (ionising) radiation can damage cells / body tissue / burns risk of cancer risk of radiation sickness risk of mutations / damage to offspring [max 2]

Question 4

a) 78
b) (radiation that) removes electrons or breaks molecules
c) Pair of count rate values used
Clear indication of use of graph, expect two vertical lines or indicators on axes using their values
8 days (+ 1 day)
d) 2 half lives
240 hours

Question 5

a) (i) 90
(ii) 39 [2]
b) (i) tick corresponds to candidate's (a)(ii) [1]
c) (ii) zirconium c.a.o. [1]
d) c) X (and) Z (are isotopes of same element)
same proton number [2]
[Total: 6]

Question 6

a) any mention background radiation
background/radiation varies randomly o.w.t.t.e. OR rate of decay very small OR sample nearly all decayed [2]
b) correctly deducts correct background (13 – 15 /s)
takes 2 detector readings, one twice the other
correct working, with/without background subtraction, i.e. use of graph
half life = 1.2 – 1.8 days OR follows from working [4]
c) α (very) short range in air OR will not reach researcher
γ long range/very penetrating/heavy shielding needed OR will reach researcher [2] [Total: 8]