Name of the Student:_____
Max. Marks : 17 Marks **Time : 17 Minutes**

Mark Schemes

Q1.

(a) γ radiation because it is very / the most penetrating

OR

γ radiation because it is penetrating enough to irradiate all sides of the instruments

OR

γ radiation is penetrating so instruments can be sterilised without removing the packaging

✔ OWTTE

The quoted radiation must be gamma only and not a mixture
It is not sufficient to just state 'gamma'. The mark is based on the reason for the choice

1

(b) To become radioactive the nucleus has to be affected which (ionising) radiation does not do

OR

(Ionising) radiation only affects the outer electrons and not the nucleus

OR

The energy of the radiation is insufficient to induce radioactivity. (For this mark high energy is not the same as highly ionizing)

OR

(Ionising) radiation does not affect the nucleus ✔ owtte

1

(c) (Conclusion using the inverse square law $I = k/d^2$)

Make the point that $I \times d^2$ should be constant if the inverse square law is operating ✔ owtte

Show calculations using data from 3 rows

The column may be completed in the following ways ✔

Corrected count rate count s^{-1}	$I \times d^2$ Using I as count rate		$I \times d^2$ Using $I \propto$ count in 1.0 minute
150	6.00	Or	361
23.3	5.83		349
4.03	4.03		242

Accept 2 sig figs and 1 sig fig in the case of the 4 and 6 in the second column shown here.

The mark is mainly based on the technique used.

The written answer must be enough to indicate a conclusion.

This mark can be gained even if there is a slip in the table.

The conclusion mark can be gained even if the second mark is lost because only two data points are taken.

Look out for different approaches. E.g. use the CCR at one distance to predict the CCR at other distances if the inverse function is followed. E.g. CCR might be in order 9013,1440 and 360.

2

(d) **Mark given for any of these ideas (max 2)**

The random nature of the radiation count (although small in this case)

Dead-time in the G-M detector

d is not the real distance between source and detector **OR** source is not a point source

The source may not be a pure gamma emitter

(Gamma and beta is acceptable but not gamma and alpha together)

A reference to short half-life provided that an explanation of how this has an effect on separate measurements eg activity changes during the measurements

Assumes no absorption between source and detector(although small in this case) ✔✔

*No credit for unexplained bland statements such as 'because of systematic errors' **OR** 'more data needs to be taken to be certain' etc.*

Note: reference to background count does not gain a mark because the corrected count-rate is supplied in the question.

2

[6]

Q2.

(a) (moderator) - the neutron undergoes an elastic collision / bounces off with less speed / kinetic energy ✔ (Any reference to absorption loses the mark)

Must have the idea that the neutron slow because of collisions

1

(b) (control rod) – the neutron is absorbed ✔

'stopped' will not get the mark.

If alternatives are given all must be correct to gain mark.

1

(c) the neutron is absorbed/U-236 is formed ✔
(causing) the nucleus (of fuel / uranium) to split into (two smaller) daughter nuclei / nuclei / fragments ✔

releasing (several fast-moving) neutrons ✔

1st mark can use words like absorbed / takes in /

*2nd mark: alternative words for nuclei are **not** acceptable (eg daughter ~~products~~)*

3rd mark 'neutrons' must be plural.

3

(d)

Descriptor	**(Bullet point headings are detailed at the bottom end of the table)**	**Mark**
High Level – Good to Excellent All three bullet points must be addressed. The source must be identified and two stages in the treatment sequence must be given. Finally three problems encountered in the treatment of waste and how the problems are overcome should be stated. (Note discussion of a problem will often cover a stage of the treatment). *The information presented as a whole should be well organised using appropriate specialist vocabulary. There should only be one or two spelling or grammatical errors for this mark.*	6 marks = At least 6 points made coming from all three of the bullet point headings. (note some written points may count as answers to bullet point headings 2 and 3) 5 marks = 5 points made coming from all three of the bullet point headings. To be in this top band communication skills must be good and the ideas easy to follow.	5-6
Intermediate Level – Modest to Adequate All three bullet points must be addressed. The source must be identified as well a stage in the treatment along with a problem encountered in the treatment of waste and how it is dealt with. One additional piece of information must be made from any of the bullet points listed below to be at the top of this band. *The grammar and spelling may have a few shortcomings but the ideas must be clear.*	4 marks = 4 points made coming from at least 2 bullet point headings. 3 marks = 3 points made coming from at least 2 bullet point headings. To be in this moderate band communication skills must be good enough to understand the ideas easily even if the order is a little unclear.	3-4
Low Level – Poor to Limited To be at the top of this band two bullet points must be addressed which must include a problem encountered in the treatment of waste and how it is dealt with. A single mark is awarded if any of the information given in the bullet points listed below is given.	2 marks = Two points made from any bullet point heading. 1 mark = any point made coming from any bullet point heading. Or the script as a whole shows some basic understanding of the issues.	1-2

There may be many grammatical and spelling errors and the information may be poorly organised.		
The description expected in a competent answer should include: **1st bullet point** The (highly radioactive/ most dangerous) waste are the fission fragments from the fission of uranium-235 or from (spent) fuel rods. **2nd bullet point** The waste is initially placed in cooling ponds/water (close to the reactor for a number of years) plutonium/uranium is separated to be recycled high level waste is vitrified/made solid into (pyrex) glass then placed in (stainless) steel/lead/concrete cylinders/containers/bunkers to be stored **deep** underground (simply stating buried/underground is not enough) **3rd bullet point** (the problem and its solution must both be given, some examples are given below) the waste is (initially) is very hot/generates heat so has to be placed in water/cooling ponds (to remove the heat) the waste (initially) is highly radioactive and needs to be screened in water/cooling ponds (to absorb the radiation) the waste (initially) is highly radioactive and needs to be remotely handled (to avoid human contact with the waste). In liquid form the (high level) waste may leak hence the need to vitrify (and barrel in steel) The waste will be radioactive for hundreds/thousands of years so storage needs to be stable in a container hence the need to vitrify (and barrel in stainless steel) The waste will be radioactive for hundreds/thousands of years so		

long term storage needs to be in geologically stable areas (deep underground). Transporting waste presents a potential danger to the public so waste is transported enclosed in impact/crash resistant/extra thick and strong casings Or processed onsite or nearby.		

[11]