Name……………………………

# Nuclear Physics and radioactivity – Data analysis

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## Part A

**Question 1-3 are all based around the data in the table below**

The table below shows results of the number of 'clicks' on a Geiger counter taken in one minute intervals when placed next to a number of unknown samples

| Sample | Geiger counter count (counts per minute) when sample and Geiger counter are separated by: | | | | |
|---|---|---|---|---|---|
| | 1 mm air only | 0.1mm paper | 0.02mm Aluminium | 2mm Aluminium | 10 mm Lead |
| A | 475 | 449 | 397 | 199 | 150 |
| B | 1037 | 998 | 901 | 415 | 325 |
| C | 1163 | 94 | 17 | 13 | 16 |
| D | 584 | 573 | 523 | 312 | 17 |
| E | 604 | 612 | 590 | 588 | 540 |
| F | 591 | 279 | 282 | 302 | 262 |

A Geiger counter normally picks up a background count.

**Question 1.**

a) What causes this background count?

…………………………………………………………………………………………………………………………………………….

…………………………………………………………………………………………………………………………………… (1 mark)

b) Using the data in the table above, suggest a possible range of values for the background count in this experiment.

…………………………………………………………………………………………………………………………………… (1 mark)

c) Explain how you decided on this value?

…………………………………………………………………………………………………………………………………………….

…………………………………………………………………………………………………………………………………… (1 mark)

**Question 2.**

a) Which sample has the greatest activity? ……………………………………………………………… (1 mark)

b) Calculate the activity of this sample. ………………………………………………………… Bq (1 mark)

**Question 3.**

Look carefully at the data and try to determine what sort of radioactive decay is occurring for the samples below. The samples may be emitting alpha, beta, gamma radiation or a combination of two of these (but not all three). For each sample below, state what type radiation the samples are emitting and how you worked this out.

| Sample | Type of decay | Explanation (explain clearly how you know) |
|---|---|---|
| **C** | | |
| **D** | | |
| **F** | | |

(6 marks)

**Part B**

Let $N_o$ = the original number of atoms of radioactive material.

Let $N$ = the number of atoms of radioactive material present after $n$ half-lives have passed.

Therefore, $N = \frac{N_0}{2^n}$

**Question 4**

The following table shows measurements taken to determine the fraction of parent nuclei remaining as a function of time elapsed for a sample of lead-214 ( $^{214}Pb$).

| Time (hours) | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 |
|---|---|---|---|---|---|---|---|---|---|
| Activity (Bq) | 398.0 | 242.0 | 154.0 | 104.0 | 66.0 | 39.0 | 21.5 | 16.0 | 9.5 |

a) Plot a graph of these results **(4 marks)**

b) Estimate the half-life for $^{214}Pb$ from the graph (show your working on the graph).

**(2 mark)**

c) What percentage is left after 4 half lives?

**(1 mark)**

d) With reference to your graph, or otherwise, determine how much of a sample of 800g of $^{214}Pb$ would be left after

i) 45 hours

ii) 1350 minutes

**(2+ 2 = 4 marks)**

**Question 5**

The table below provides the name of the elements, the atomic number and the mass number of common isotopes relating to this question. It also give the decay modes (in brackets) for each isotope.

| Titanium | Lead | Bismuth | Polonium | Astatine | Radon |
|---|---|---|---|---|---|
| Ti-203<br>Ti-205 | Pb-210 ($\beta$)<br>Pb-214 ($\beta$) | Bi 209 ($\alpha$)<br>Bi 214 ($\beta$) | Po 214 ($\alpha$)<br>Po 218 ($\alpha$) | At 218 ($\alpha$) | Rn 220 ($\alpha$)<br>Rn 222 ($\alpha$) |
| 81 | 82 | 83 | 84 | 85 | 86 |

Radon-222 undergoes alpha decay to form Polonium-218. The decay equation is shown below and also represented on the grid below.

$${}^{222}_{86}\mathrm{Rn} \longrightarrow {}^{218}_{84}\mathrm{Po} + {}^{4}_{2}\mathrm{He}$$

a) Write two equations to show the next two stages of the decay series by referring to the data on the table at the beginning of this question.

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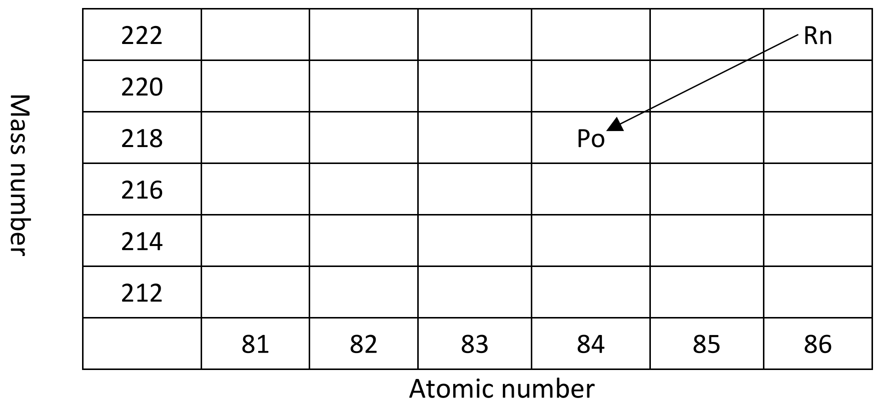
(2 marks)

**Radon-222 Decay Series Grid**




b) Draw the same two stages of this decay series on the grid (above). Label each entry with the element's symbol and an arrow indicating the decay step.

(2 marks)