

# Radioactivity

## Mark Scheme 1

|                   |                             |
|-------------------|-----------------------------|
| <b>Level</b>      | IGCSE(9-1)                  |
| <b>Subject</b>    | Physics                     |
| <b>Exam Board</b> | Edexcel IGCSE               |
| <b>Module</b>     | Double Award (Paper 1P)     |
| <b>Topic</b>      | Radioactivity and Particles |
| <b>Sub-Topic</b>  | Radioactivity               |
| <b>Booklet</b>    | Mark Scheme 1               |

**Time Allowed:** 69 minutes

**Score:** /57

**Percentage:** /100

**Grade Boundaries:**

| A*   | A    | B   | C   | D   | E   | U    |
|------|------|-----|-----|-----|-----|------|
| >85% | 775% | 70% | 60% | 55% | 50% | <50% |

| Question number | Answer  | Notes   | Marks |
|-----------------|---|---|-------|
| 1 (a) (i)       | number of protons = 1;<br>number of neutrons = 2;   |   | 2     |
|                 | (ii) any three of the following<br><b>comparisons:</b><br>MP1. beta particle is negatively charged <u>and</u> alpha is positively charged;<br>MP2. beta particle has lower/less mass ORA;<br>MP3. beta particle has 1 charge but alpha has 2 charges;<br>MP4. beta particle is an electron but alpha is 2p + 2n /eq;<br>MP5. beta is less ionising;<br>MP6. beta has higher speed;<br>MP7. beta particles have larger range;<br>MP8. beta has higher penetrating ability; | ignore descriptions of applications of types of radiation<br><br>allow 'beta is lighter' ORA<br><br>allow beta can pass through paper but alpha will be stopped | 3     |
|                 | (iii) any sensible suggestion;<br>e.g. <ul style="list-style-type: none"> <li>• alpha is 4 nucleons, tritium has (only) 3 / eq</li> <li>• tritium has only 1p, 2p are in alpha</li> <li>• tritium has not got enough mass / mass number too low</li> <li>• tritium has not got enough nucleons</li> <li>• tritium has not got enough p / atomic number too low</li> <li>• tritium has not got enough p+n</li> </ul>   | ignore tritium is too small   | 1     |

|     |  |   |   |
|-----|--|---|---|
| (b) | any two from:<br>MP1. energy explanation;<br>e.g. beta particles have given up all their KE on impact<br>MP2. absorption explanation;<br>e.g. beta particles have hit (and been absorbed by) phosphor<br>MP3. penetration explanation;<br>e.g. beta cannot penetrate (thick) glass / tube<br>MP4. range explanation;<br>e.g. signs are further away than the range of beta | ignore: <ul style="list-style-type: none"><li>• beta particles have low ionisation /OWTTE</li><li>• no gas can escape</li></ul> | 2 |
|-----|--|---|---|

| Question number | Answer   | Notes   | Marks |
|-----------------|--|---|-------|
| 1 (c) (i)       | time taken;<br><br>and either of <ul style="list-style-type: none"> <li>• for (radio)activity to <b>halve</b>;</li> <li>• for <b>half</b> of (radioactive) nuclei / atoms / isotope to decay;</li> </ul> | allow<br>how long it takes<br>reject 'half the time'<br><br>allow count rate for activity<br>reject: <ul style="list-style-type: none"> <li>• particles</li> <li>• molecules</li> <li>• substance</li> <li>• 'break down'</li> <li>• 'reactivity'</li> <li>• a nucleus / an atom</li> <li>• halve in mass</li> <li>• to completely/fully decay</li> </ul> | 2     |
| (ii)            | working seen/appropriate line(s) on graph seen;<br>13.5 years;   | tolerance $\pm 0.5$ years   | 2     |

|     |  |  |   |
|-----|--|--|---|
| (d) | <p>MP1. correct judgment re claim;</p> <p>MP2. (because) EITHER<br/>correct statement re time (at<br/>which the activity is 400);</p> <p>OR</p> <p>activity (at 20 years);</p> <p>e.g.<br/>the manufacturer is correct because<br/>the time would be 21.5 years (to reach<br/>an activity of 400)</p> <p>OR</p> <p>the manufacturer is correct because<br/>the activity is 420 (counts per minute)<br/>(at 20 years)</p> | <p>allow range of 21-22<br/>years</p> <p>allow range of 410 to<br/>440</p> <p>total marks = 14</p> | 2 |
|-----|--|--|---|

| Question number | Answer                             | Notes | Marks |
|-----------------|------------------------------------|-------|-------|
| 2 (a)           | A - fission                        |       | 1     |
| (b)             | A - absorbing some of the neutrons |       | 1     |

Total 2 marks

| Question number | Answer   | Notes  | Marks |
|-----------------|--|--|-------|
| 3 (a) (i)       | A – electromagnetic waves  |  | 1     |
| (ii)            | time;<br><br>for amount of (radioactive) isotope to halve;<br><br>OR<br>for (radio)activity to halve;  | accept<br>how long it takes<br>do not accept 'half of the time'<br>accept for 'amount' (number of un-decayed) nuclei / atoms / molecules / (un-decayed) mass of isotope  | 2     |
| (b)             | Any two of -<br><br>MP1. ( $\alpha$ or $\beta$ ) would have insufficient <b>range</b> ;<br><br>MP2. ( $\alpha$ or $\beta$ ) would be absorbed by patient/air;<br><br>MP3. ( $\alpha$ or $\beta$ ) are more ionising (than gamma rays); | specific concepts and terminology are needed if the source is external<br>max mark is ONE<br>allow<br>ORA<br><b>penetration</b><br><br>ORA<br>stopped by skin / bone<br><br>Allow ( $\alpha$ or $\beta$ ) would be (more) likely to cause cancer/ damages cells (than gamma rays), ORA | 2     |

|         |   |   |   |
|---------|---|---|---|
| (c) (i) | <p>Any two of -</p> <p>MP1. Idea that activity is due to <b>nucleus</b> decaying;</p> <p>MP2. (after some time) fewer radioactive nuclei /atoms left;</p> <p>MP3. Number (of nuclei) decaying per second decreases;</p> | <p>specific concepts and terminology are needed<br/>do not credit repeat of stem<br/>Reject for 1 mark.<br/>(it/nucleus) breaks down<br/>allow</p> <ul style="list-style-type: none"> <li>• nucleus is unstable</li> <li>• nucleus emits gamma</li> <li>• nucleus changes into new isotope</li> </ul> <p>fewer atoms of the same isotope left</p> <p>decay rate decreases</p> | 2 |
|---------|---|---|---|



|      |   |   |   |
|------|---|---|---|
| (ii) | one halving calculated;<br>Idea of four half-lives / halvings;<br><br>Evaluation;<br>e.<br>(420/2=) 210 for 1 mark<br><br>24 ÷ 6 = 4 (half-lives)<br><br>26 MBq (26.25) | <ul style="list-style-type: none"><li>• 4 repeated halving seen</li><li>• fraction remaining is 1/16 of activity</li></ul> Allow <ul style="list-style-type: none"><li>• four divisions by 2 seen for 2<sup>nd</sup> mark</li><li>• remaining fraction = 1/16 = 0.0625</li></ul> Correct answer without working scores full marks | 3 |
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Total 10 marks

| Question number                       | Answer   |            |  | Notes             | Marks  |            |                                      |     |  |           |   |  |             |  |     |              |  |   |                                       |   |  |                   |  |   |                            |   |  |  |   |
|---------------------------------------|--|------------|--|-------------------|--------|------------|--------------------------------------|-----|--|-----------|---|--|-------------|--|-----|--------------|--|---|---------------------------------------|---|--|-------------------|--|---|----------------------------|---|--|--|---|
| 4 (a) (i)                             | <table border="1"> <thead> <tr> <th data-bbox="596 467 907 545">safety precaution</th> <th data-bbox="907 467 1083 545">needed</th> <th data-bbox="1083 467 1230 545">not needed</th> </tr> </thead> <tbody> <tr> <td data-bbox="596 545 907 636">not touch the source with bare hands</td> <td data-bbox="907 545 1083 636">(✓)</td> <td data-bbox="1083 545 1230 636"></td> </tr> <tr> <td data-bbox="596 636 907 714">use tongs</td> <td data-bbox="907 636 1083 714">✓</td> <td data-bbox="1083 636 1230 714"></td> </tr> <tr> <td data-bbox="596 714 907 792">wear gloves</td> <td data-bbox="907 714 1083 792"></td> <td data-bbox="1083 714 1230 792">(✓)</td> </tr> <tr> <td data-bbox="596 792 907 870">wear goggles</td> <td data-bbox="907 792 1083 870"></td> <td data-bbox="1083 792 1230 870">✓</td> </tr> <tr> <td data-bbox="596 870 907 961">students sit at least two metres away</td> <td data-bbox="907 870 1083 961">✓</td> <td data-bbox="1083 870 1230 961"></td> </tr> <tr> <td data-bbox="596 961 907 1039">wear a lead apron</td> <td data-bbox="907 961 1083 1039"></td> <td data-bbox="1083 961 1230 1039">✓</td> </tr> <tr> <td data-bbox="596 1039 907 1130">store source in a lead box</td> <td data-bbox="907 1039 1083 1130">✓</td> <td data-bbox="1083 1039 1230 1130"></td> </tr> </tbody> </table> <p data-bbox="596 1159 991 1253">3 ticks correct in first column;<br/>2 ticks correct in second column;</p> |            |  | safety precaution | needed | not needed | not touch the source with bare hands | (✓) |  | use tongs | ✓ |  | wear gloves |  | (✓) | wear goggles |  | ✓ | students sit at least two metres away | ✓ |  | wear a lead apron |  | ✓ | store source in a lead box | ✓ |  | <p data-bbox="1260 1117 1566 1253">Ignore incorrect ticks in first column (award 1 mark as long as the three correct boxes are ticked)</p> | 2 |
| safety precaution                     | needed   | not needed |  |                   |        |            |                                      |     |  |           |   |  |             |  |     |              |  |   |                                       |   |  |                   |  |   |                            |   |  |  |   |
| not touch the source with bare hands  | (✓)  |            |  |                   |        |            |                                      |     |  |           |   |  |             |  |     |              |  |   |                                       |   |  |                   |  |   |                            |   |  |  |   |
| use tongs                             | ✓  |            |  |                   |        |            |                                      |     |  |           |   |  |             |  |     |              |  |   |                                       |   |  |                   |  |   |                            |   |  |  |   |
| wear gloves                           |  | (✓)        |  |                   |        |            |                                      |     |  |           |   |  |             |  |     |              |  |   |                                       |   |  |                   |  |   |                            |   |  |  |   |
| wear goggles                          |  | ✓          |  |                   |        |            |                                      |     |  |           |   |  |             |  |     |              |  |   |                                       |   |  |                   |  |   |                            |   |  |  |   |
| students sit at least two metres away | ✓  |            |  |                   |        |            |                                      |     |  |           |   |  |             |  |     |              |  |   |                                       |   |  |                   |  |   |                            |   |  |  |   |
| wear a lead apron                     |  | ✓          |  |                   |        |            |                                      |     |  |           |   |  |             |  |     |              |  |   |                                       |   |  |                   |  |   |                            |   |  |  |   |
| store source in a lead box            | ✓  |            |  |                   |        |            |                                      |     |  |           |   |  |             |  |     |              |  |   |                                       |   |  |                   |  |   |                            |   |  |  |   |

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|         |  |  |   |
| (b) (i) | (because distance is a) controlled variable;   | allow idea of fair test/affecting results<br><br>ignore comments relating to accuracy, reliability | 1 |
|         |  |  |   |
| (ii)    | MP1. idea of background radiation;<br><br>MP2. any ONE sensible source;<br>e.g.<br>cosmic rays<br>rocks/Earth/buildings<br>some foodstuffs (coffee)<br>radon | allow 'sources of radiation all around us'<br>allow nuclear weapons testing/disasters              | 2 |
|         |  |  |   |

|       |   |   |   |
|-------|---|---|---|
| (iii) | <p>MP1. lead;</p> <p>MP2. idea of best absorber giving lowest count rate;</p> <p>MP3. for Ba-133/can't evaluate using Sr-90 data;</p>   | <p>dependent on MP1</p> <p>dependent on MP1</p>   | 3 |
| (iv)  | <p>any 3 of:</p> <p>MP1. stone absorbs better than {plastic / wood / paper} for Sr-90/beta;</p> <p>MP2. stone worst absorber for Ba-133/gamma;</p> <p>MP3. use of data to justify MP1 or MP2;</p> <p>MP4. may not be worse absorber than paper as paper much thinner/not tested for Ba-133;</p> | <p>no mark for 'I agree with this conclusion /OWTTE'</p> <p>allow stone best absorber for Sr-90</p> <p>e.g. the count rate for plastic is about half that of stone for Ba-133</p> | 3 |

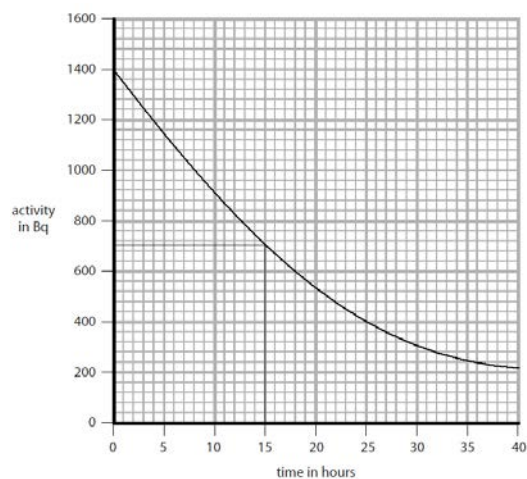
|       |   |  |   |
|-------|---|--|---|
| (v)   | <p>MP1. beta;</p> <p>MP2. it's not alpha <i>because</i> {alpha would not reach the detector at this distance/ alpha would not go through paper};</p> <p>MP3. it's not gamma <i>because</i> gamma is not stopped by metals ;</p> | <p>allow 'beta and gamma'</p> <p>allow 'it goes through paper'</p> <p>allow 'it doesn't go through metals'</p> <p>MP2 and MP3 dependent on MP1</p>                                     | 3 |
| (vi)  | reading would be too high/eq;   |  | 1 |
| (vii) | idea that count rate needs to be constant during the investigation/ORa;   | <p>allow either</p> <p>idea that would not need to replace the source often/ORa;</p> <p>or</p> <p>idea that shorter half-life has higher activity and therefore is more hazardous;</p> | 1 |

Total 16 marks

| Question number | Answer  | Notes  | Marks  |
|-----------------|---|--|--------|
| 5 a             | (Atoms / nuclei with the) same number of protons;<br>Different numbers of neutrons;   | ALLOW relevant correct alternatives e.g.<br><ul style="list-style-type: none"> <li>• atomic number, proton number</li> <li>• nucleon number, atomic mass</li> </ul> ignore comments about electrons  | 1<br>1 |
| b i             | Electron;   | ignore comments about properties of electrons<br>e.g. speed<br>ALLOW<br><ul style="list-style-type: none"> <li>• <math>e^-</math> or <math>e^+</math></li> <li>• positron</li> </ul>   | 1      |
| ii              | any suitable detector<br>e.g.<br>Geiger(-Muller) tube/detector/counter;<br>photographic film;<br>zinc sulfide;<br>gold leaf electroscope; | ALLOW<br><ul style="list-style-type: none"> <li>• phonetic/incorrect spelling</li> </ul>   | 1      |
| iii             | beta penetrates paper;<br>beta absorbed/stopped by lead +/-or aluminium ;   | IGNORE<br><ul style="list-style-type: none"> <li>• all details of experimental setup</li> <li>• beta goes through aluminium/eq</li> </ul> DO NOT ALLOW<br><ul style="list-style-type: none"> <li>• bounced back for absorbed</li> <li>• contradictions in answers e.g. re aluminium</li> </ul> | 1<br>1 |

- MP1. line goes through 0, 1400 and (first half-life plotted at) 15, 700;  
 MP2. line goes through/second half-life plotted at 30, 350;  
 MP3. a correctly **curved line** between 15 and 30 hours AND the line extends beyond 35 hours;

i.e.



ALLOW for MP2  
 an ecf from incorrect first half-life to 'correct'  
 second half-life e.g. 800---400

IGNORE

- a *slight* upcurve at 35 to 40 hours
- Bar charts

- **Since this is a sketch then allow tolerance of +/- 1 square on the points**

1

1

1

| Question number | Answer   | Notes  | Marks                               |
|-----------------|--|--|-------------------------------------|
| d i             | <p>any FOUR from:</p> <p>MP1. there is a known proportion / composition / activity when rocks formed;</p> <p>MP2. measure/determine the proportion of uranium or the activity now;</p> <p>MP3. compare activity now to original activity/eq;</p> <p>MP4. (hence) determine the time / number of half-lives elapsed;</p> <p>MP5. (hence) calculate age from reference to half-life;</p> | <p>allow as a numerical example<br/>ignore work out the proportion when rocks were formed</p> <p>ALLOW</p> <ul style="list-style-type: none"> <li>• Bq for activity</li> <li>• radioactivity for activity</li> <li>• amount for proportion</li> </ul> <p>IGNORE</p> <ul style="list-style-type: none"> <li>• measure half-life of uranium</li> <li>• they know its activity</li> </ul> <p>ALLOW colloquial expressions such as 'see how long it took to decay this much'</p> | <p>1</p> <p>1</p> <p>1</p> <p>1</p> |



