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| Surname       | Centre Number | Candidate Number |
| First name(s) |               | 0                |



**GCSE**

3445U20-1



**TUESDAY, 13 JUNE 2023 – MORNING**

**APPLIED SCIENCE (Double Award)**

**UNIT 2: Space, Health and Life**

**FOUNDATION TIER**

1 hour 30 minutes

| For Examiner's use only |              |              |
|-------------------------|--------------|--------------|
| Question                | Maximum Mark | Mark Awarded |
| Section A               | 1.           | 6            |
|                         | 2.           | 11           |
|                         | 3.           | 4            |
|                         | 4.           | 10           |
|                         | 5.           | 12           |
|                         | 6.           | 7            |
| Section B               | 7.           | 6            |
|                         | 8.           | 11           |
|                         | 9.           | 8            |
| <b>Total</b>            | <b>75</b>    |              |

**ADDITIONAL MATERIALS**

In addition to this examination paper, you will require a separate Resource Folder, calculator, pencil and a ruler.

**INSTRUCTIONS TO CANDIDATES**

- Use black ink or black ball-point pen. Do not use gel pen or correction fluid.
- You may use a pencil for graphs and diagrams only.
- Write your name, centre number and candidate number in the spaces at the top of this page.
- Answer **all** questions.
- Write your answers in the spaces provided in this booklet.

**INFORMATION FOR CANDIDATES**

The number of marks is given in brackets at the end of each question or part-question. Question 4(a) is a quality of extended response (QER) question where your writing skills will be assessed. You are reminded to show all your workings. Credit is given for correct workings even when the final answer given is incorrect. You will need to refer to the separate resource folder to answer questions 7, 8 and 9. A Periodic Table is printed on page 20.



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**Section A**

Answer **all** questions.

1. Our solar system contains several planets and other objects that orbit the Sun.

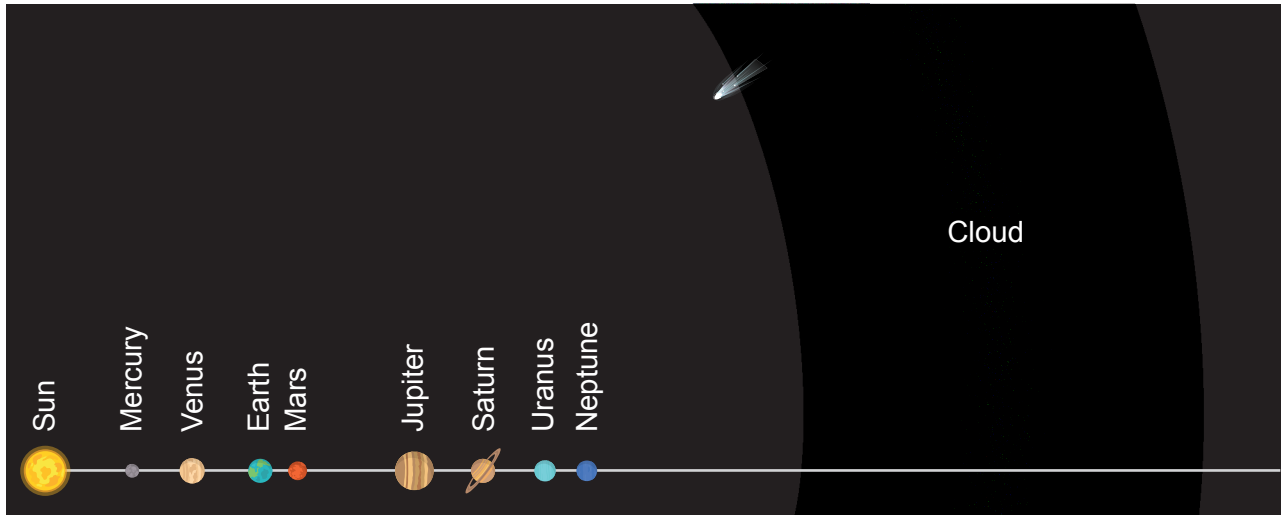


Diagram not drawn to scale

Answer the following questions using your knowledge, the diagram and the words in the box. Each word can be used once, more than once, or not at all.

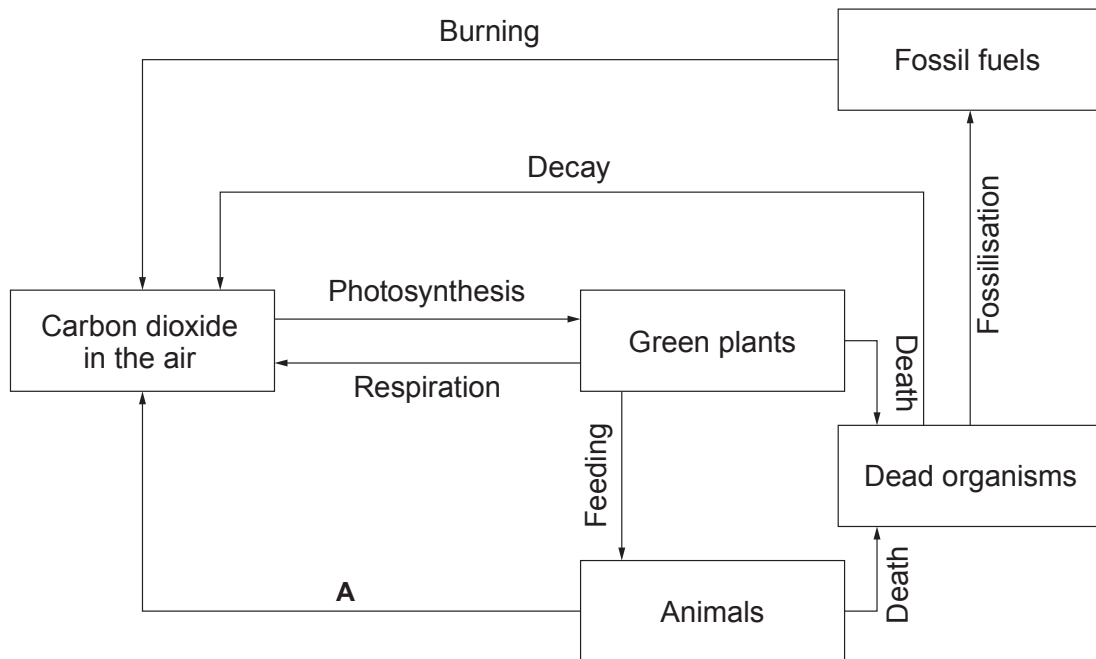
Comet                  Jupiter                  Mars                  Oort                  Venus                  Pluto

- (a) Name the second rocky planet from the Sun. .... [1]
- (b) Name the gas planet closest to the Sun. .... [1]
- (c) Name the type of object that orbits the Sun in a highly elliptical orbit. .... [1]
- (d) Between which **two** planets is the asteroid belt found? .... [2]
- (e) Name the cloud. .... [1]

6



2. The diagram shows the carbon cycle.



(a) Use the diagram and your knowledge to answer the following questions.

(i) Circle the name of the process shown by label **A**. [1]

feeding                  photosynthesis                  respiration

(ii) Tick (✓) the boxes next to the **three** correct statements. [3]

Photosynthesis uses carbon dioxide from the atmosphere.

Decomposing dead plants adds carbon dioxide to the atmosphere.

Fossilising dead plants adds carbon dioxide to the atmosphere.

Respiration adds carbon dioxide to the atmosphere.

Burning dead plants removes carbon dioxide from the atmosphere.

When green plants feed they add carbon dioxide to the atmosphere.

(iii) State **two** ways that human activity has caused carbon dioxide levels to increase. [2]

1. ....

2. ....



- (b) The table shown below is taken from a climate change website.

It gives the mass of carbon dioxide produced by a person travelling to work either by car or bus.

|   |      |
|---|------|
| Distance travelled (km)   | 20   |
| Mass of carbon dioxide produced per person travelling by car (kg) | 1.20 |
| Mass of carbon dioxide produced per person travelling by bus (kg) | 0.20 |

**Four** people each travel a total of 20 km per day.  
Use the information to answer the following questions.

- (i) Use the equation below to answer the following questions.

total mass of carbon dioxide produced (kg) = number of people  $\times$  mass of carbon dioxide produced per person

- I. Calculate the total mass of carbon dioxide produced when four people drive 20 km by car. [2]

mass of carbon dioxide produced = ..... kg

- II. Calculate the mass of carbon dioxide produced if four people travelled 20 km by bus. [1]

mass of carbon dioxide produced = ..... kg

- (ii) Calculate the savings in carbon dioxide production per week if they travel by bus on the same 20 km journey from Monday to Friday instead of using their cars. [2]

savings in carbon dioxide production = ..... kg

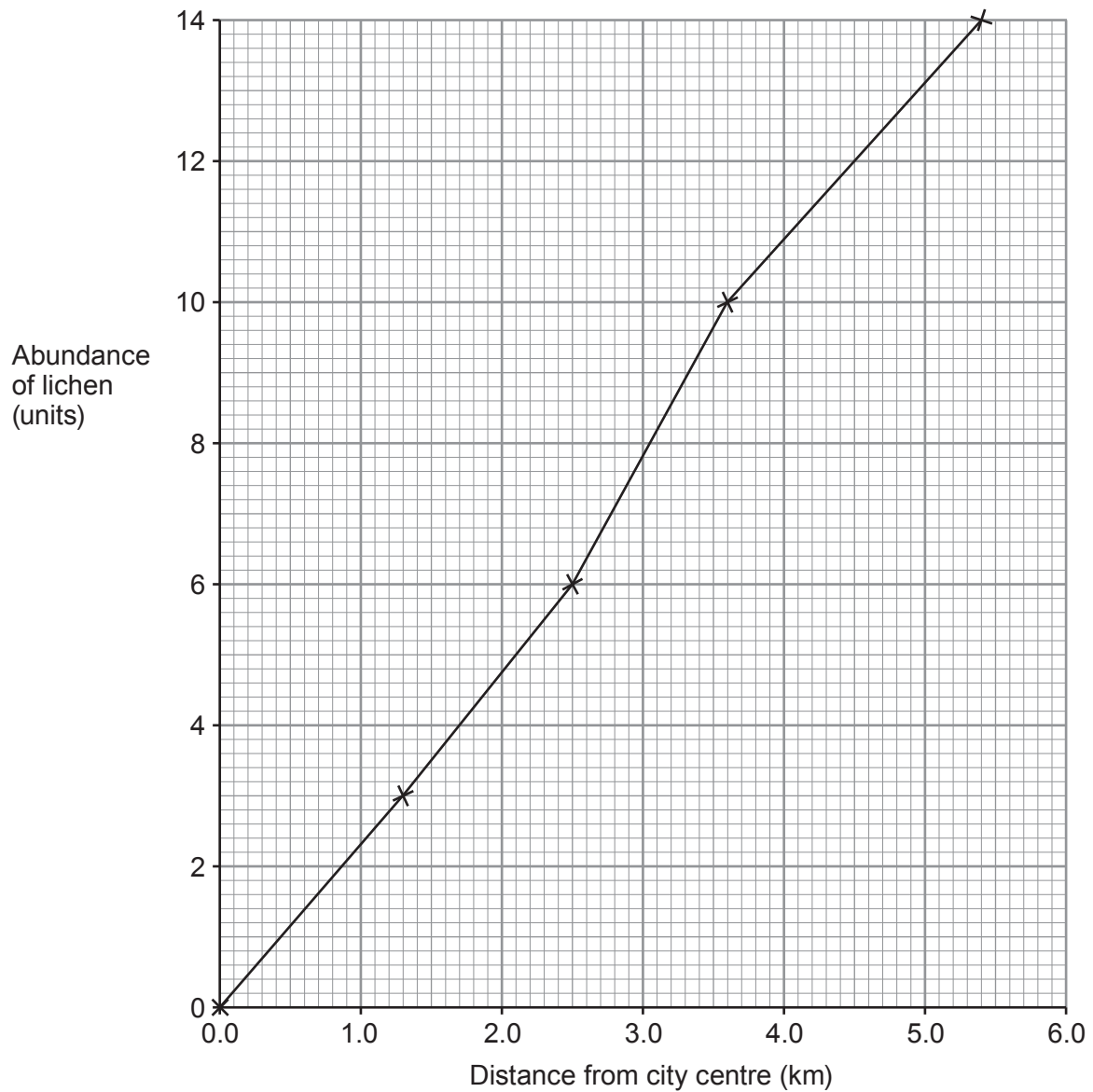
11



3. Lichen is an indicator species for air pollution.

Students measured the abundance of lichen at various distances from the city centre.

Their results are shown on the graph below.



(a) Use the graph to answer the following questions.

(i) Estimate the abundance of lichen 4.0 km from the city centre. [1]

abundance = ..... units

(ii) Describe the trend shown by the graph. [1]

.....  
.....

(b) Explain why the abundance of lichen is not the same at all the distances shown. [2]

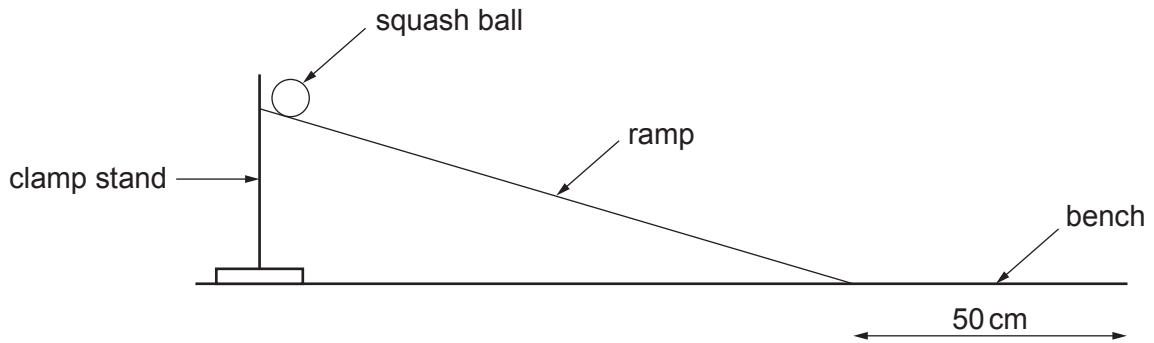
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4. The diagram shows the apparatus used to find the acceleration of a squash ball as it rolls down a ramp. A stopwatch is also required.



- (a) Describe the method used in this investigation.  
Include in your answer:

[6 QER]

- How you would carry out the experiment
- How to reduce the uncertainty in your results.

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(b) The following readings were taken during the investigation.

Time to travel 50 cm along the bench = 2.0 s  
Time to reach the bottom of the ramp = 2.5 s

(i) Use the equation:

$$\text{velocity} = \frac{0.5}{\text{time to travel 50 cm along the bench}}$$

to calculate the velocity of the ball travelling along the bench. [2]

velocity = ..... m/s

(ii) Use the equation:

$$\text{acceleration} = \frac{\text{velocity along the bench}}{\text{time to reach the bottom of the ramp}}$$

to calculate the acceleration of the ball down the ramp. [2]

acceleration = ..... m/s<sup>2</sup>



5. Cystic fibrosis is an example of an inherited disease. A carrier of cystic fibrosis has one unaffected allele (F) and one affected allele (f).

(a) Two parents are planning to have a child. The father is a carrier of cystic fibrosis (Ff), the mother is unaffected.

(i) Circle the genotype of the unaffected mother. [1]

FF          ff          Ff

(ii) Complete the Punnett square to show the possible genotypes of the children. [2]

|  |   |   |
|--|---|---|
|  | F | f |
|  |   |   |
|  |   |   |

(iii) State the chance of a child from these parents being born with cystic fibrosis. [1]

.....

(iv) The possible genotypes of children from two carrier parents are shown below.

|   |    |    |
|---|----|----|
|   | F  | f  |
| F | FF | Ff |
| f | Ff | ff |

These carrier parents thought they would have the same chance of having a child with cystic fibrosis as the parents in (a)(ii). Explain whether you agree. [1]

.....  
.....



- (b) Cystic fibrosis causes a build-up of thick mucus in the lungs. Mucus in the lungs helps bacteria to grow.

Underline two statements below which show ways white blood cells help to defend the body against bacterial infection. [2]

Carry oxygen to the bacteria

Ingest bacteria

Produce antibodies

Make glucose

- (c) (i) Complete the table below to show how the number of bacteria doubles every 15 minutes. [2]

|                    |   |    |       |    |       |
|--------------------|---|----|-------|----|-------|
| Time (minutes)     | 0 | 15 | 30    | 45 | 60    |
| Number of bacteria | 1 | 2  | ..... | 8  | ..... |

- (ii) Antibiotic resistance is a concern. The list below describes the stages involved in the development of bacteria with antibiotic resistance. It is not in the correct order.

1. Many more bacteria survive antibiotic treatment.
2. There was a mutation to a gene in a few bacteria.
3. The survivors reproduce, passing on the mutated gene.
4. Bacteria with the mutation survive antibiotics.

Arrange the stages in the correct order starting with stage 2. [2]

2 → ..... → ..... → .....

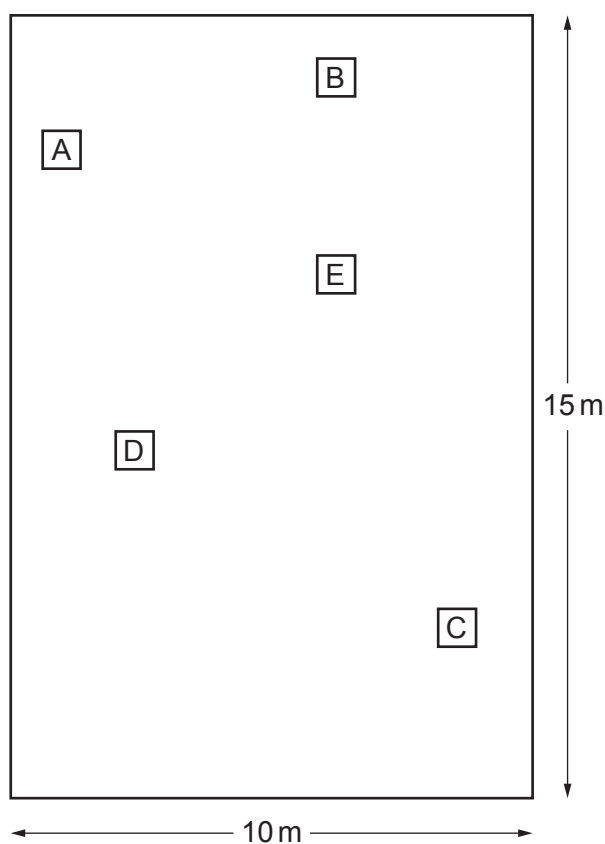
- (iii) Complete the following sentence by underlining the correct word in brackets. [1]

The development of antibiotic resistant bacteria is an example of ( **evolution** / **vaccination** / **digestion** ).

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| 12 |



6. Some students investigated the number of dandelion plants on a lawn. The diagram shows the lawn and the location of 5 quadrats (**A to E**) which the students had placed at random.



The students counted the number of dandelions in each quadrat and recorded their results in the table below.

| Quadrat | Number of dandelions |
|---------|----------------------|
| A       | 6                    |
| B       | 3                    |
| C       | 4                    |
| D       | 8                    |
| E       | 4                    |

- (a) Calculate the mean number of dandelions per quadrat. [1]

mean number of dandelions = .....

- (b) Calculate the area of the lawn. [1]

area of lawn = ..... m<sup>2</sup>



- (c) Each quadrat has an area of  $1 \text{ m}^2$ . Calculate how many quadrats will fit in the area of the lawn. [1]

number of quadrats = .....

- (d) Use your answers to (a) and (c) to calculate the total number of dandelions on the lawn. [1]

number of dandelions = .....

- (e) The actual number of dandelions on the lawn is 600. Use the formula below, and your answer to (d), to calculate the percentage error of your answer above. [2]

$$\text{percentage error} = \frac{\text{number of dandelions} - 600}{600} \times 100$$

percentage error = ..... %

- (f) State **one** improvement to the method used by the students which would give more confidence in their answer for the number of dandelions. [1]

.....



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**Section B**

Refer to the separate Resource Folder to answer questions **7, 8** and **9**.

**7.** X-rays are commonly used to diagnose illness.

(a) Refer to **Figure 2** to answer the following questions.

(i) State the range of wavelength for X-rays. .... m [1]

(ii) Estimate the highest frequency of X-rays. .... Hz [1]

(b) Refer to **Figure 3** to answer the following questions.

(i) A patient has received a total radiation dose of 70 units from X-rays during the year.  
Calculate how many chest X-rays this dose is equivalent to. [2]

number of chest X-rays = .....

(ii) A patient has an X-ray taken of their spine. Calculate the fraction of the yearly background radiation this dose is equivalent to.  
(1 year = 365 days). [2]

fraction = .....



8. (a) Use the information under **Figure 1** to answer the following question.  
The wave speed of ultrasound in body tissue is 1540 m/s.

Use the equation:

$$\text{wavelength} = \frac{\text{wave speed}}{\text{frequency}}$$

to calculate the wavelength of the ultrasound used in a 2 MHz scan.

[3]

wavelength = ..... m

- (b) Use the information in **Figure 4** to answer the following questions.

- (i) Select the most suitable radioisotope of iodine from the table in **Figure 4** that would be used as a tracer. Explain your choice.

[2]

.....

.....

.....



- (ii) The photograph shows a patient undergoing external beam radiation therapy for a brain tumour.



Select the most suitable radioisotope from the table in **Figure 4** that would be used for this treatment. Explain your choice. [3]

.....

.....

.....

.....

.....

- (c) Refer to **Figures 4 and 6** in the Resource Folder to answer the following question.

State which of the radioisotopes **R1, R2, R3, R4, R5** or **R6**, is lutetium-177. Explain your reasoning. [3]

Radioisotope ..... is lutetium-177.

.....

.....

.....

.....



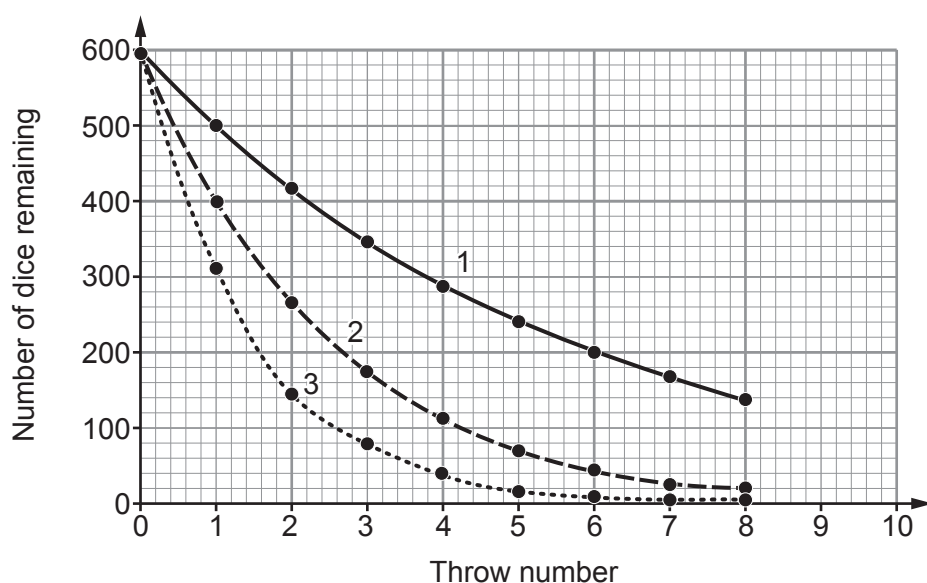
9. The following questions are based on the information on pages 6 and 7 of the Resource Folder about using dice to model half-life.

(a) Each group's results were added together to give class results. Give **one** reason why this makes the data more repeatable. [1]

.....

.....

(b) The results in **Figures 7 and 8** are used to plot graphs on the grid below.



(i) Add lines to the graph to determine the half-life represented by line 3. [2]

half-life = ..... throws



- (ii) Use the information in the graph to tick (✓) the boxes next to the **three** correct statements. [3]

Line 1 represents the data from Model 2.

Line 2 shows decay of the quickest rate.

Line 2 shows the equivalent of three half-lives after 5 throws.

Line 1 represents the longest half-life.

Line 3 would have been produced if 600 coins had been used instead of dice and the number of 'heads' counted after each throw.

Line 3 has an activity that is  $\frac{1}{8}$  of the original after 8 throws.

- (c) The teacher suggests to the class that they add 5 red wooden cubes to the 50 dice they start with. The red cubes would not be removed after each throw but would be counted every time to improve the modelling of radioactive decay.

- (i) State what the red cubes represent. [1]

.....

- (ii) State how the presence of the red cubes would affect line 1 on the graph. [1]

.....

|   |
|---|
|   |
| 8 |

**END OF PAPER**



# THE PERIODIC TABLE

Group      1      2      3      4      5      6      7      0

|                                    |                                    |                                    |                                    |  |                                     |                                     |                                     |                                     |                                     |                                     |                                       |                                       |                                    |                                   |                                    |                                       |  |                                    |                                       |                                    |                                    |                                       |   |  |  |                                     |                                      |                                      |  |                                       |                                      |
|------------------------------------|------------------------------------|------------------------------------|------------------------------------|--|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|---------------------------------------|---------------------------------------|------------------------------------|-----------------------------------|------------------------------------|---------------------------------------|--|------------------------------------|---------------------------------------|------------------------------------|------------------------------------|---------------------------------------|---|--|--|-------------------------------------|--------------------------------------|--------------------------------------|--|---------------------------------------|--------------------------------------|
| 7<br><b>Li</b><br>Lithium<br>3     | 9<br><b>Be</b><br>Beryllium<br>4   | 11<br><b>Na</b><br>Sodium<br>11    | 12<br><b>C</b><br>Carbon<br>6      | 13<br><b>Al</b><br>Aluminium<br>13     | 14<br><b>N</b><br>Nitrogen<br>7     | 15<br><b>P</b><br>Phosphorus<br>15  | 16<br><b>O</b><br>Oxygen<br>8       | 17<br><b>F</b><br>Fluorine<br>9     | 18<br><b>Ne</b><br>Neon<br>10       |                                     |                                       |                                       |                                    |                                   |                                    |                                       |  |                                    |                                       |                                    |                                    |                                       |   |  |  |                                     |                                      |                                      |  |                                       |                                      |
| 19<br><b>K</b><br>Potassium<br>19  | 20<br><b>Ca</b><br>Calcium<br>20   | 23<br><b>Na</b><br>Sodium<br>11    | 24<br><b>Mg</b><br>Magnesium<br>12 | 27<br><b>Co</b><br>Cobalt<br>27        | 28<br><b>Ni</b><br>Nickel<br>28     | 29<br><b>Cu</b><br>Copper<br>29     | 30<br><b>Zn</b><br>Zinc<br>30       | 31<br><b>Ga</b><br>Gallium<br>31    | 32<br><b>Ge</b><br>Germanium<br>32  | 33<br><b>As</b><br>Arsenic<br>33    | 34<br><b>Se</b><br>Selenium<br>34     | 35<br><b>Br</b><br>Bromine<br>35      | 36<br><b>Kr</b><br>Krypton<br>36   |                                   |                                    |                                       |  |                                    |                                       |                                    |                                    |                                       |   |  |  |                                     |                                      |                                      |  |                                       |                                      |
| 37<br><b>Rb</b><br>Rubidium<br>37  | 38<br><b>Sr</b><br>Strontium<br>38 | 39<br><b>K</b><br>Potassium<br>19  | 40<br><b>Ca</b><br>Calcium<br>20   | 41<br><b>Nb</b><br>Niobium<br>41       | 42<br><b>Mo</b><br>Molybdenum<br>42 | 43<br><b>Tc</b><br>Technetium<br>43 | 44<br><b>Ru</b><br>Ruthenium<br>44  | 45<br><b>Rh</b><br>Rhodium<br>45    | 46<br><b>Pd</b><br>Palladium<br>46  | 47<br><b>Ag</b><br>Silver<br>47     | 48<br><b>Cd</b><br>Cadmium<br>48      | 49<br><b>In</b><br>Indium<br>49       | 50<br><b>Tl</b><br>Thallium<br>81  | 51<br><b>Sb</b><br>Antimony<br>51 | 52<br><b>Te</b><br>Tellurium<br>52 | 53<br><b>I</b><br>Iodine<br>53        | 54<br><b>Xe</b><br>Xenon<br>54           |                                    |                                       |                                    |                                    |                                       |   |  |  |                                     |                                      |                                      |  |                                       |                                      |
| 55<br><b>Cs</b><br>Caesium<br>55   | 56<br><b>Ba</b><br>Barium<br>56    | 57<br><b>La</b><br>Lanthanum<br>57 | 58<br><b>Ce</b><br>Cerium<br>58    | 59<br><b>Pr</b><br>Praseodymium<br>59  | 60<br><b>Nd</b><br>Neodymium<br>60  | 61<br><b>Pm</b><br>Promethium<br>61 | 62<br><b>Sm</b><br>Samarium<br>62   | 63<br><b>Eu</b><br>Europium<br>63   | 64<br><b>Gd</b><br>Gadolinium<br>64 | 65<br><b>Tb</b><br>Terbium<br>65    | 66<br><b>Dy</b><br>Dysprosium<br>66   | 67<br><b>Ho</b><br>Holmium<br>67      | 68<br><b>Er</b><br>Erbium<br>68    | 69<br><b>Tm</b><br>Thulium<br>69  | 70<br><b>Yb</b><br>Ytterbium<br>70 | 71<br><b>Lu</b><br>Lutetium<br>71     | 72<br><b>Hf</b><br>Hafnium<br>72         | 73<br><b>Ta</b><br>Tantalum<br>73  | 74<br><b>W</b><br>Tungsten<br>74      | 75<br><b>Re</b><br>Rhenium<br>75   | 76<br><b>Os</b><br>Osmium<br>76    | 77<br><b>Ir</b><br>Iridium<br>77      | 78<br><b>Pt</b><br>Platinum<br>78       | 79<br><b>Au</b><br>Gold<br>79          | 80<br><b>Hg</b><br>Mercury<br>80       | 81<br><b>Tl</b><br>Thallium<br>81   | 82<br><b>Pb</b><br>Lead<br>82        | 83<br><b>Bi</b><br>Bismuth<br>83     | 84<br><b>Po</b><br>Polonium<br>84      | 85<br><b>At</b><br>Astatine<br>85     | 86<br><b>Rn</b><br>Radon<br>86       |
| 87<br><b>Fr</b><br>Francium<br>87  | 88<br><b>Ra</b><br>Radium<br>88    | 89<br><b>Ac</b><br>Actinium<br>89  | 90<br><b>Th</b><br>Thorium<br>90   | 91<br><b>Pa</b><br>Protactinium<br>91  | 92<br><b>U</b><br>Uranium<br>92     | 93<br><b>Np</b><br>Neptunium<br>93  | 94<br><b>Pu</b><br>Plutonium<br>94  | 95<br><b>Am</b><br>Americium<br>95  | 96<br><b>Cm</b><br>Curium<br>96     | 97<br><b>Bk</b><br>Berkelium<br>97  | 98<br><b>Cf</b><br>Californium<br>98  | 99<br><b>Es</b><br>Einsteinium<br>99  | 100<br><b>Fm</b><br>Fermium<br>100 | 101<br><b>Mendelevium</b><br>101  | 102<br><b>Nobelium</b><br>102      | 103<br><b>Lr</b><br>Lawrencium<br>103 | 104<br><b>Rf</b><br>Rutherfordium<br>104 | 105<br><b>Db</b><br>Dubnium<br>105 | 106<br><b>Sg</b><br>Seaborgium<br>106 | 107<br><b>Bh</b><br>Bohrium<br>107 | 108<br><b>Hs</b><br>Hassium<br>108 | 109<br><b>Mt</b><br>Meitnerium<br>109 | 110<br><b>Ds</b><br>Darmstadtium<br>110 | 111<br><b>Rg</b><br>Roentgenium<br>111 | 112<br><b>Cn</b><br>Copernicium<br>112 | 113<br><b>Nh</b><br>Nihonium<br>113 | 114<br><b>Fl</b><br>Flerovium<br>114 | 115<br><b>Mc</b><br>Moscovium<br>115 | 116<br><b>Lv</b><br>Livermorium<br>116 | 117<br><b>Ts</b><br>Tennessine<br>117 | 118<br><b>Og</b><br>Oganesson<br>118 |
| 119<br><b>Fr</b><br>Francium<br>87 | 120<br><b>Ra</b><br>Radium<br>88   | 121<br><b>Ac</b><br>Actinium<br>89 | 122<br><b>Th</b><br>Thorium<br>90  | 123<br><b>Pa</b><br>Protactinium<br>91 | 124<br><b>U</b><br>Uranium<br>92    | 125<br><b>Np</b><br>Neptunium<br>93 | 126<br><b>Pu</b><br>Plutonium<br>94 | 127<br><b>Am</b><br>Americium<br>95 | 128<br><b>Cm</b><br>Curium<br>96    | 129<br><b>Bk</b><br>Berkelium<br>97 | 130<br><b>Cf</b><br>Californium<br>98 | 131<br><b>Es</b><br>Einsteinium<br>99 | 132<br><b>Fm</b><br>Fermium<br>100 | 133<br><b>Mendelevium</b><br>101  | 134<br><b>Nobelium</b><br>102      | 135<br><b>Lr</b><br>Lawrencium<br>103 | 136<br><b>Rf</b><br>Rutherfordium<br>104 | 137<br><b>Db</b><br>Dubnium<br>105 | 138<br><b>Sg</b><br>Seaborgium<br>106 | 139<br><b>Bh</b><br>Bohrium<br>107 | 140<br><b>Hs</b><br>Hassium<br>108 | 141<br><b>Mt</b><br>Meitnerium<br>109 | 142<br><b>Ds</b><br>Darmstadtium<br>110 | 143<br><b>Rg</b><br>Roentgenium<br>111 | 144<br><b>Cn</b><br>Copernicium<br>112 | 145<br><b>Nh</b><br>Nihonium<br>113 | 146<br><b>Fl</b><br>Flerovium<br>114 | 147<br><b>Mc</b><br>Moscovium<br>115 | 148<br><b>Lv</b><br>Livermorium<br>116 | 149<br><b>Ts</b><br>Tennessine<br>117 | 150<br><b>Og</b><br>Oganesson<br>118 |

|                                |
|--------------------------------|
| 1<br><b>H</b><br>Hydrogen<br>1 |
|--------------------------------|

|                               |
|-------------------------------|
| 4<br><b>He</b><br>Helium<br>2 |
|-------------------------------|

## Key

|        |                      |
|--------|----------------------|
| $A_r$  | relative atomic mass |
| Symbol |                      |
| Name   |                      |
| $Z$    | atomic number        |

