**3** A student investigated the effect of temperature on the heart rate of *Daphnia*.
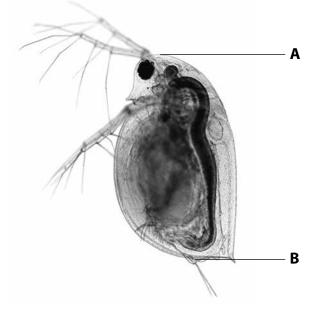


Magnification ×60

(Source: http://www.nature-education.org/water-life.html)

(a) Use the lines A to B to calculate the actual length of this *Daphnia*.

**(2)**

Answer ........................................................

(b) The student used five *Daphnia* in the investigation.

The *Daphnia's* heartbeats were counted over a 20-second period.

A stopwatch was used and a pencil mark made on a piece of paper while observing the *Daphnia* through a low powered microscope.

The number of heartbeats was counted three times for each *Daphnia*.

This was repeated at five different temperatures using the same *Daphnia* each time.

This was then repeated using the four other *Daphnia*.

The results obtained are shown in the table below.

| Daphnia | Heart rate / beats in 20 seconds | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5°C | | | 10°C | | | 15°C | | | 20°C | | | 25°C | | |
| 1 | 20 | 18 | 19 | 30 | 26 | 29 | 36 | 35 | 36 | 42 | 45 | 44 | 53 | 47 | 53 |
| 2 | 22 | 23 | 19 | 36 | 32 | 29 | 36 | 39 | 34 | 42 | 46 | 42 | 50 | 51 | 63 |
| 3 | 16 | 18 | 20 | 26 | 30 | 27 | 35 | 33 | 36 | 39 | 41 | 40 | 58 | 52 | 50 |
| 4 | 19 | 22 | 21 | 30 | 32 | 35 | 38 | 36 | 37 | 45 | 46 | 42 | 62 | 62 | 58 |
| 5 | 20 | 25 | 21 | 35 | 32 | 34 | 36 | 39 | 38 | 44 | 48 | 42 | 52 | 55 | 59 |

(i)  Explain why the number of heartbeats was measured in 20 seconds rather than in one minute.

**(2)**

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

(ii) The mean heart rate at 5°C is 20.2 beats in 20 seconds. Calculate how many times faster the mean heart rate is at 25°C than at 5°C.

(2)

Answer .........................................................

(iii) The student concluded that temperature increased the heart rate of *Daphnia*.

Analyse the data to explain how this investigation could be modified to improve the validity of this conclusion.

(3)

........................................................................................................................................................................................................................

........................................................................................................................................................................................................................

........................................................................................................................................................................................................................

........................................................................................................................................................................................................................

........................................................................................................................................................................................................................

........................................................................................................................................................................................................................

(c) Discuss the ethical issues that might arise from the use of invertebrates in investigations.

(4)

.......................................................................................................................................................................................................

.......................................................................................................................................................................................................

.......................................................................................................................................................................................................

.......................................................................................................................................................................................................

.......................................................................................................................................................................................................

.......................................................................................................................................................................................................

.......................................................................................................................................................................................................

.......................................................................................................................................................................................................

.......................................................................................................................................................................................................

**(Total for Question 3 = 13 marks)**

| Question Number | Acceptable Answer | Additional guidance | Mark |
|---|---|---|---|
| **3(a)** | Measurement in 5.1 cm / 51 mm correct (1)<br><br>51 ÷ 60 = 0.85 mm (1) | need to measure on paper | **(2)** |

| Question Number | Acceptable Answer | Additional guidance | Mark |
|---|---|---|---|
| **3(b)(i)** | An explanation that makes reference to the following:<br><br>• very high heart rate makes it difficult to count (1)<br>• so greater chance of error (1) | | **(2)** |

| Question Number | Acceptable Answer | Additional guidance | Mark |
|---|---|---|---|
| **3(b)(ii)** | Calculation of mean = 55 (1)<br>Answer = 55 ÷ 20.2 = 2.72 (1) | | **(2)** |

| Question Number | Acceptable Answer | Additional guidance | Mark |
|---|---|---|---|
| **3(b)(iii)** | An explanation that makes reference to three of the following:<br><br>• control of variables (1)<br><br>• returning fleas to ambient temperature for specified time (1)<br><br>• acclimatisation (1)<br><br>• use smaller intervals (1) | | **(3)** |

| Question Number | Acceptable Answer | Additional guidance | Mark |
|---|---|---|---|
| **3(c)** | An answer that makes reference to the following:<br><br>• undeveloped nervous system  so don't feel pain and there aren't ethical issues (1)<br><br>• unethical to use any living organism in an experimental procedure (1)<br><br>• relativism would state that it is acceptable under certain circumstances to use invertebrates (i.e. if there is potential benefit to human health) (1)<br><br>• absolutism promotes use of invertebrates under any circumstance or under no circumstance (1) | | **(4)** |

(Total for Question 3 = 13 marks)