



Human Biology

HBI6T/P10/task

Unit 6T A2 Investigative Skills Assignment Task Sheet

The effect of temperature on the rate of photosynthesis

Introduction

Algae are single-celled organisms that photosynthesise. You are going to measure their rate of photosynthesis at different temperatures. You will be supplied with gel beads containing algae. This gel does not harm the algae.

You will put the gel beads in hydrogencarbonate indicator solution. As the algae photosynthesise, they take up carbon dioxide from the solution. This causes the indicator to change colour from yellow to red as the carbon dioxide concentration falls. You can use the colour change to measure the rate of photosynthesis.

You will find the mean rate of photosynthesis at two different temperatures.

You will do this by recording how long it takes yellow hydrogencarbonate indicator to change colour to red. Your teacher will supply you with yellow indicator to use in your experiments. You will also be given red indicator to use to determine when the colour change has taken place.

Materials

You are provided with

- gel beads containing algae
- a large beaker to use as a waterbath or access to an electric waterbath
- thermometers
- lamps
- hydrogencarbonate indicator solutions (yellow and red)
- small specimen tubes, or similar, which can be capped
- test tubes
- graduated pipettes
- marker pen
- 10 cm³ measuring cylinder or syringe
- timer
- distilled water.

You may ask your teacher for any other apparatus you require.

Outline Method

Read these instructions carefully before you start your investigation.

1. Rinse a test tube with 1 cm³ of the yellow indicator.
2. Put 5 cm³ of the yellow indicator solution into your rinsed tube. Label it tube A.
3. Rinse your algal beads in 1 cm³ yellow indicator solution. Put 10 algal beads into a specimen tube. Label it tube B.
4. Stand both tubes A and B in a water bath at 30 °C.
5. Leave the tubes in the water bath for 10 minutes.
6. Meanwhile, set up a lamp so that the light falls on the waterbath. Place the lamp between 20 cm and 30 cm from the tubes in the waterbath.
7. Take tube A with the indicator solution and add the contents to the specimen tube B containing the algal beads. Cap and shake the tube.
8. Immediately return tube B to the water bath and start the timer.
9. Leave the tube in the waterbath under the light, shaking the tube gently every few minutes.
10. You have been supplied with a tube containing red indicator. Compare the colour of the liquid in your tube with the red indicator.
11. Record the time it takes for the colour of your indicator in tube B to change to the colour of the red indicator.
12. Repeat steps 1–11 as many times as necessary to collect enough data to carry out a suitable statistical test.
13. Repeat steps 1–12 using a waterbath at 40 °C.

You will need to decide for yourself

- how to tell when the colour change of the hydrogencarbonate indicator solution is complete
- how many repeats to carry out
- which statistical test to carry out.

ISA HBI6T/P10 Candidate Results Sheet: Stage 1

The effect of temperature on the rate of photosynthesis

Centre Number

--	--	--	--	--

Candidate Number

--	--	--	--

Candidate Name

Record your data in a table in the space below.

(3 marks)

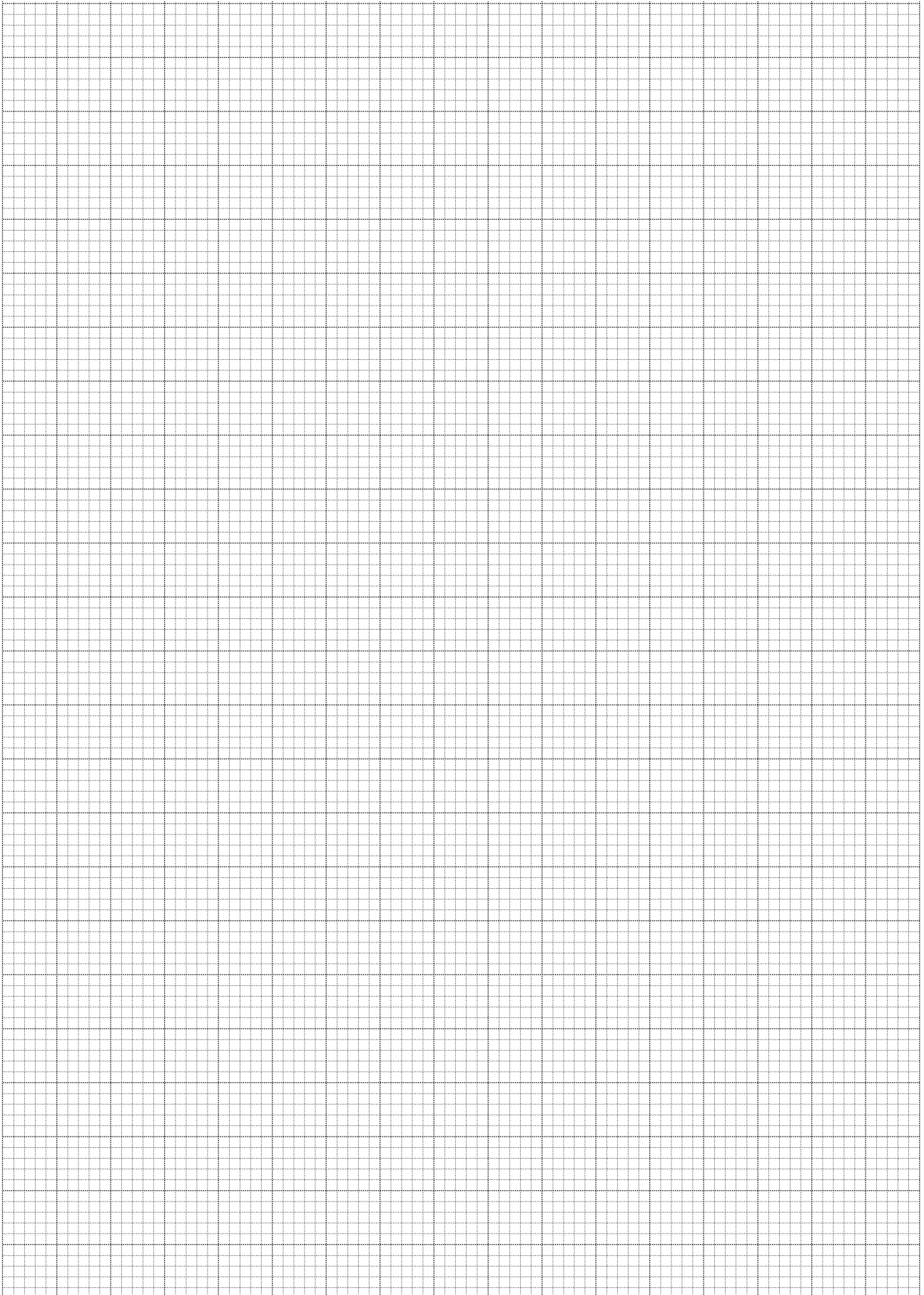
Hand in this sheet at the end of each practical session.

Turn over ►

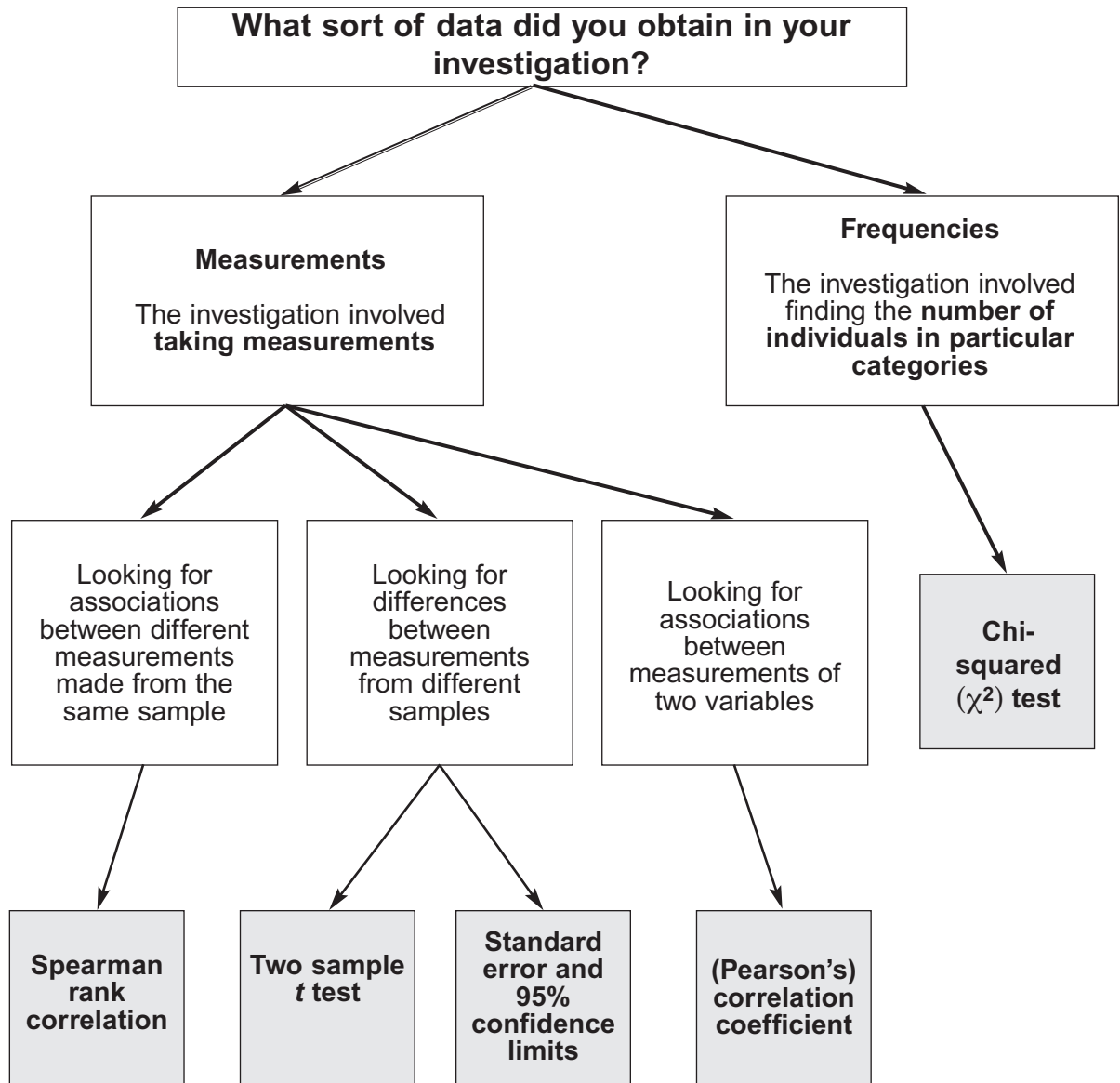
- WMP/Jun10/HBI6T/P10/task

This graph paper is provided for use if you need it.

Hand in this sheet at the end of the practical session.



Students' Statistics Sheet



For use in the A2 ISA and EMPA assessment

Turn over ►

Statistical tests and tables of critical values

Tables of critical values

A table of critical values is provided with each statistical test. If your calculated test statistic is less than, or equal to, the critical value, then the result of your statistical test is significant. This means that your null hypothesis should be rejected.

Spearman rank correlation test

Use this test when

- you wish to find out if there is a significant association between two sets of measurements from the same sample
- and you have between 5 and 30 pairs of measurements.

Record the data as values of X and Y.

Convert these values to rank orders, 1 for largest, 2 for second largest, etc.

Now calculate the value of the Spearman rank correlation, r_s , from the equation

$$r_s = 1 - \left[\frac{6 \times \sum D^2}{N^3 - N} \right]$$

Where N is the number of pairs of items in the sample.

D is the difference between each pair (X-Y) of measurements.

A table showing the critical values of r_s for different numbers of paired values.

Number of pairs of measurements	Critical value
5	1.00
6	0.89
7	0.79
8	0.74
9	0.68
10	0.65
12	0.59
14	0.54
16	0.51
18	0.48

Correlation coefficient (Pearson's correlation coefficient)

Use this test when

- you wish to find out if there is a significant association between two sets of measurements measured on interval or ratio scales
- the data are normally distributed.

Record the data as values of variables X and Y.

Now calculate the value of the (Pearson) correlation coefficient, r , from the equation

$$r = \frac{\Sigma XY - [(\Sigma X)(\Sigma Y)]/n}{\sqrt{\{\Sigma X^2 - [(\Sigma X)^2/n]\} \{\Sigma Y^2 - [(\Sigma Y)^2/n]\}}}$$

Where n is the number of values of X and Y.

A table showing the critical values of r for different degrees of freedom.

Degrees of freedom	Critical value	Degrees of freedom	Critical value
1	1.00	12	0.53
2	0.95	14	0.50
3	0.88	16	0.47
4	0.81	18	0.44
5	0.75	20	0.52
6	0.71	22	0.40
7	0.67	24	0.39
8	0.63	26	0.37
9	0.60	28	0.36
10	0.58	30	0.35

For most cases, the number of degrees of freedom is $= n - 2$

The t test

Use this test when

- you wish to find out if there is a significant difference between two means
- the data are normally distributed
- the sample size is less than 25.

t can be calculated from the formula

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{(s_1^2/n_1) + (s_2^2/n_2)}}$$

Where \bar{x}_1 = mean of first sample

\bar{x}_2 = mean of second sample

s_1 = standard deviation of first sample

s_2 = standard deviation of second sample

n_1 = number of measurements in first sample

n_2 = number of measurements in second sample

A table showing the critical values of t for different degrees of freedom.

Degrees of freedom	Critical value	Degrees of freedom	Critical value
4	2.78		
5	2.57	15	2.13
6	2.48	16	2.12
7	2.37	18	2.10
8	2.31	20	2.09
9	2.26	22	2.07
10	2.23	24	2.06
11	2.20	26	2.06
12	2.18	28	2.05
13	2.16	30	2.04
14	2.15	40	2.02

The number of degrees of freedom = $(n_1 + n_2) - 2$

Standard error and 95% confidence limits

Use this when

- you wish to find out if the difference between two means is significant
- the data are normally distributed
- the sizes of the samples are at least 30. For assessment purposes, five samples are acceptable providing that this is acknowledged either at a convenient place in the statistical analysis or in the conclusions.

Standard error

Calculate the standard error of the mean, SE , for each sample from the following formula:

$$SE = \frac{SD}{\sqrt{n}}$$

Where SD = the standard deviation
 n = sample size

95% confidence limits

In a normal distribution, 95% of datapoints fall within ± 2 standard deviations of the mean.

Usually, you are dealing with a sample of a larger population. In this case the 95% confidence limits for the sample mean is calculated using the following formula

$$95\% \text{ confidence limits} = \bar{x} \pm 2 \times \frac{SD}{\sqrt{n}} \quad \text{OR} \quad \bar{x} \pm 2 \times SE$$

Turn over ►

The chi-squared test

Use this test when

- the measurements relate to the number of individuals in particular categories
- the observed number can be compared with an expected number which is calculated from a theory, as in the case of genetics experiments.

The chi-square (χ^2) test is based on calculating the value of χ^2 from the equation

$$\chi^2 = \frac{\sum (O - E)^2}{E}$$

Where O represents the observed results

E represents the results we expect.

A table showing the critical values of χ^2 for different degrees of freedom.

Degrees of freedom	Critical value
1	3.84
2	5.99
3	7.82
4	9.49
5	11.07
6	12.59
7	14.07
8	15.51
9	16.92
10	18.31

The number of degrees of freedom = number of categories – 1