

UPDATED TO 2019-21 SYLLABUS

CAIE A2 LEVEL BIOLOGY

SUMMARIZED NOTES ON THE PRACTICAL SYLLABUS

Prepared for Pushpita Moulick for personal use only.

1. Data Analysis

1.1. Measures of Central Tendency, Location & Dispersion

- Mean is sum of data divided by no. of data.
- Mode is most common value.
- Median is middle quartile.
- Range is spread between smallest and largest value.
- It can be divided into 4 quarters by 3 quartiles.
- Interquartile range is spread between upper and lower quartile.
- Standard deviation (s) = $\sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$
- Standard deviation is spread of data around mean. Data with a narrow spread is more reliable than that with a wider spread.
- Standard error (s_m) = $\frac{s}{\sqrt{n}}$
- Standard error measures the reliability (of the estimate) of a mean. The larger the standard error the less reliable.
- Confidence limits are the ranges/intervals in which the true value of the mean lies with 95% probability. 95% confidence intervals (represented graphically by error bars) lie within 2 standard deviations/errors of the mean.

1.2. Statistical Tests & Calculation

- Statistically significant: it is an idea that the (observed) results are caused by an outside factor (not due to chance).
- $P < 0.05$: it is an idea that 0.05 means that there is less than 5% chance of obtaining the (observed) results by chance.
- Bar chart shows discontinuous/discrete/qualitative/categoric data.
- Chi square test is used for data which is categoric/discrete.
- Pearson's linear correlation test is suitable when (both sets of) data are continuous and (are approximately) normally distributed; a scatter graph or data suggests a linear correlation. 5 or more paired observations are required to carry out this test.

Statistics	Criteria	Formulae	Interpretation
t-test	2 sets of normal, continuous quantitative data (>5 readings)	$t = \frac{ \bar{x} - \bar{y} }{\sqrt{\frac{s_x^2}{n_x} + \frac{s_y^2}{n_y}}}$	$v = n_x + n_y - 2$
	null and alternate hypothesis →	$h_0 = t < CV$	$h_1 = t > CV$

Statistics	Criteria	Formulae	Interpretation
χ^2 - test	2 sets of discrete/nominal data	$\chi^2 = \sum \frac{(O - E)^2}{E}$	$*v * = (*n * - 1)^2$
	null and alternate hypothesis →	$h_0 = X^2 < CV$	$h_1 = X^2 > CV$
Pearson's linear correlation	2 sets of normal, discrete quantitative data (>5 readings)	$r = \frac{\sum xy - n(\bar{x})(\bar{y})}{n(s_x)(s_y)}$	-1 : (-) relation 0 : no relation +1 : (+) relation
Spearman's rank correlation	2 sets of discrete/ordinal, normal data (10-30 readings)	$r_0 = 1 - \left(\frac{6 - \sum D^2}{n^3 - n}\right)$	0 : no relation 1 : true relation
Simpson's index of diversity	Population data	$D = 1 - \sum \left(\frac{n}{N}\right)^2$	0 : not diverse 1 : very diverse
Mark-release-capture	Population data	$n = \frac{n_1 \times n_2}{n \text{ (marked)}}$	n = total population

2. Common Investigations

2.1. To investigate the effects of salt solution of different concentration on potato strips

- Make at least 5 new salt solutions (of 5 different concentrations) by diluting (serial or simples) the stock salt solution
- Keep volume of all the solution same
- Measure volume using graduated pipette/burette/measuring cylinder
- Repeat experiment at least three times with each solution and take mean
- Use same number/size/mass of strips in each solution
- Measure strips using callipers/ruler
- Measure mass with electronic balance
- Use strips from the same potato
- Keep strips in solution for the same amount of time
- Measure time using stopwatch

2.2. To investigate the effects of different concentrations of enzymes on the activity of enzymes

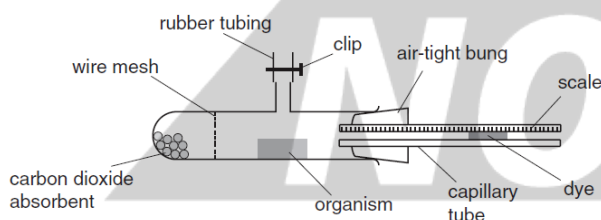
- Make at least 5 new enzyme solutions (of 5 different concentrations) by diluting (serial or simple) the stock enzyme solution
- Keep the volume of all the solutions the same

- Measure volume using a graduated pipette/burette/measuring cylinder
- Repeat the experiment at least three times with each solution and take mean
- Keep the pH value most suitable for the enzyme to work (add acid/alkali/buffer to keep pH constant)
- Incubate enzyme at a suitable working temp of the enzyme (incubator, thermostatically controlled water bath)
- Use the same size/shape of sample/strips on which the enzyme is acting
- Continue experiments for the same period of time
- Immerse the sample/strip and start the stopwatch simultaneously

2.3. To investigate the effects of different concentration of solution on the number of cells being plasmolysed

- Cut strips of sample using tweezers/scalpel
- Standardize sizes of strips (measure length using callipers/ruler mass using electronic balance)
- Same number of strips in all different concentrations
- Leave for same period of time
- Mount on slide in sucrose solution (with coverslip); (see slide preparation technique)
- Count large number of cells, count more than once and in more than one field view, take mean
- Record number of plasmolysed and non-plasmolysed cells

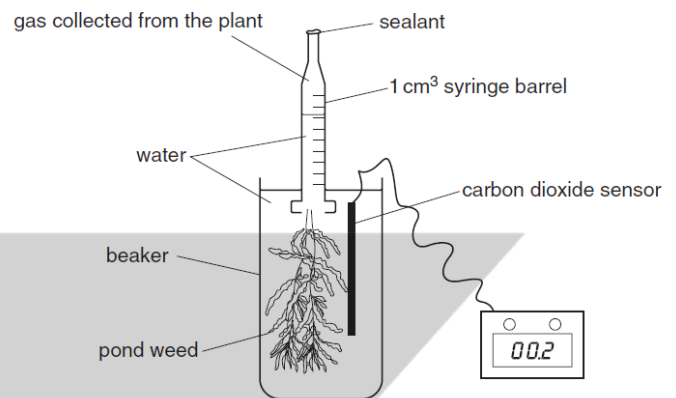
2.4. To investigate the respiration rates of small invertebrates and germinating seeds using respirometer



- Measure mass of invertebrates and germinating seedling
- Use seedlings before plumule emerged
- Dye at capillary tube farthest from tube
- Keep Airtight using the air-tight bung
- Keep temperature constant
- Allow organism to adjust for a given period of time
- Close clip before taking measurements
- Measure distance moved by dye for standard amount of time
- Repeat experiment at least 3 times
- Replace carbon dioxide absorbent (e.g. Soda lime) between measurements

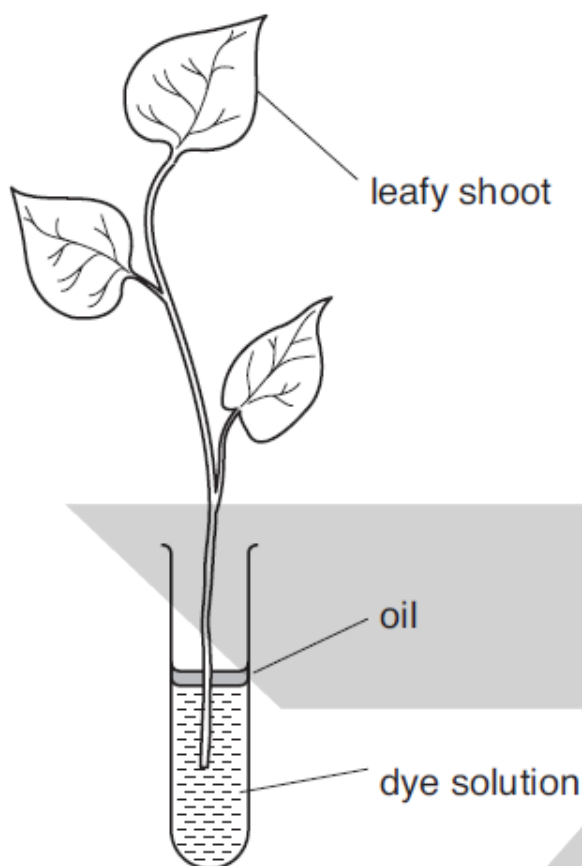
- Calculate volume by measuring diameter capillary and multiplying by the length/distance moved

2.5. To investigate the effects of carbon dioxide concentration on the rate of photosynthesis



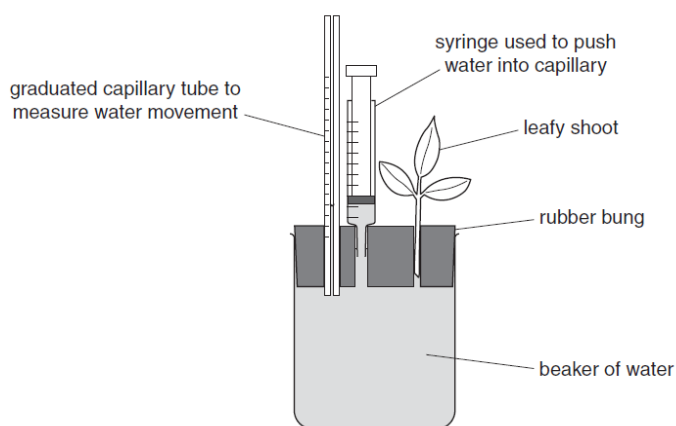
- Use hydrogen carbonate to provide carbon dioxide
- Make at least 5 different concentration of carbon dioxide
- Measure concentration of carbon dioxide with a probe
- Measure the time taken to collect a known volume of gas
- Use same mass/length/same piece/same number of leaves/same species of pondweed
- Keep light at a fixed distance from plant (light intensity)
- Use thermostatically controlled water bath
- Use same volume of water (measuring cylinder, burette)
- Carry out experiment in a dark room (eliminate any other light source)
- Use 3 sets of measurements per experiment and take mean
- Low risk experiment (electric shocks faulty equipment/wet wiring)

2.6. To investigate transpiration in plants



- Observe dye through stem, at known time interval and known distance; record time for dye to reach it
- Use Vernier callipers to measure stem and ruler in cm/mm
- Use several shoots/sequential measurements on the same shoot
- Cut under water/dye to avoid air from entering
- Keep temperature constant e.g., temperature-controlled room
- Carry out experiment in a dark room with light at fixed illumination
- Keep light at a fixed distance
- Provide steady air flow using a fan set at constant speed
- Repeat experiment for at least 3 times and take mean
- Low risk experiment: dye can be toxic, wear gloves

2.7. To investigate the transpiration rates of two different plants using a potometer



- Use shoots/leaves of different types of plant used
- Keep surface area of shoots/leaves same
- Measure/record the movement (of water) along the capillary
- Measure time of water movement for a fixed amount of distance using stopwatch
- Keep light intensity, temperature, and humidity same
- Carry out experiment in a dark room with light of fixed illumination
- Keep temperature constant e.g. temperature-controlled room
- Insert shoot under water/cut shoot at an angle
- Dry the leaves before measuring mass
- Keep airtight using an airtight apparatus/rubber bung
- Use a syringe to set water level in capillary
- Leave until equilibrium reached
- Repeat experiment for at least 3 times and take mean

2.8. To investigate the concentration of enzymes in a given extract (e.g. starch agar well)

- Dilute the stock enzyme solution using serial dilution to make at least 5 solutions of different concentrations
- Use denatured enzyme as control
- Use ruler / callipers / string and ruler to measure diameter of the well
- Plot a calibration curve of known concentrations and use it to determine extract concentration
- Use the same volume of enzyme
- Leave all plates for the same period of time
- Use a thermostatically controlled water bath to keep temperature constant
- Use a buffer to keep the pH of the agar same
- Use same concentration of starch in the agar plates
- Keep same depth/volume of agar in Petri dish
- Cover to prevent contamination / evaporation
- Repeat experiment at least 3 times and calculate mean
- Low risk investigation: agar is irritant and wearing gloves

2.9. To investigate the change in distribution and abundance of the plant species as the distance from the edge of a pond is increased using systemic sampling method

- Use belt (interrupted or continuous) or line transect
- Use measuring tapes with marks to measure distance / length, of transect Select where around pond/river to place the
- transect
- Use frame quadrat/point frame/point quadrat
- Sample continuously at regular intervals
- Use same/stated size, quadrat/frame/point
- frame/sample area
- Identify different species using a guidebook/photograph
- Estimate distribution by counting/calculating percentage/density)
- Replicate transect at least once
- Sample at different times of year/seasons
- Safety: injury/getting lost and staying with a group; allergy to plants and wearing gloves/protective clothing; allergy to pollen/hay fever and wearing mask or taking medication; dangerous environment; hazardous plants/hazardous animals; wearing suitable shoes

2.10. To investigate a random (unbiased) method to collect data needed to calculate the biodiversity of plant species

- Mark out the area to be sampled using tape measures/string and marker pole/
- Generate random number (for coordinates) using a mobile application
- Use a frame or point quadrat for individual samples
- Place quadrat at the coordinates
- Identify different species using a guidebook/photograph
- Count the number of individuals or the population of/ each type of species present in quadrat
- Count the total number of all the plants present in quadrat
- Calculate percentage cover if species of concern is grass.sta
- Use quadrat of the same size
- Use same size plot in each area
- Use the same number of different quadrats/samples per plot
- Replicate the procedure with a different plot in each area
- Carry out sampling at different times of year/seasons
- Safety: injury/getting lost and staying with a group; allergy to plants and wearing gloves/protective clothing; allergy to pollen/hay fever and wearing mask or taking

medication; dangerous environment; hazardous plants/hazardous animals; wearing suitable shoes

2.11. To investigate the effect of caffeine/addictive substances heart rate/pulse rate/reaction time in animal's (e.g. Daphnia) body

- Use a large number of test subjects
- Provide groups with drinks with and without caffeine/addictive substance
- Allow animals to acclimatize after adding substance
- Use a clicker/tally counter to count the number of heart beats
- Count for the same period of time
- Use same volume/same number of drops of substance solution added to each drink
- Making drinks indistinguishable
- Make sure test subjects do not take in any substance for at least 5 hours before the test
- Test each subject in isolation/away from others throughout the experiment
- Make sure subject is at rest whilst having measurements (reaction time/heart rate)
- Take measurements (of reaction time/heart rate) before giving the drink
- Wait a minimum of 45 minutes after giving the drink before measuring the reaction time and heart rate
- Give the same volume of drink to all subjects
- Use subjects of same age/mass/weight/fitness level/ethnicity/race
- Standardize sex balance (equal number of one sex)
- Calculate mean for the measurements
- Make sure that subjects have no pre-existing medical conditions that may affect the experiment
- Allow test-subjects to stop if they feel unwell
- Make a minimum of three replicates and calculate mean

2.12. To investigate how the rate of photosynthesis is related to changes in light intensity

- Vary light intensity by altering the distance between lamp and the plant (seaweed) container
- Use different strengths of neutral density filters
- *OR* change the number of lamps with same power ratings
- State values of distances in the range 10 to 200 cm
- Use sodium hydrogen carbonate for carbon dioxide supply
- Record changes in colour/pH (using pH probe) after a set amount of time
- Use a control (dead plant/seaweed)
- *OR cover tubes with light proof foil to act as control*
- Use same volume of hydrogen carbonate solution

- Use same mass of plant/seaweed
- Make a minimum of two replicates and calculate mean
- Safety: sodium hydrogen carbonate indicator solution is harmful/irritant and wear gloves

2.13. To investigate how noise affects reaction time of human

- Carry out experiment in silence (soundproof room)
- Ensure consistent/known volume/decibels of noise
- Carry out experiment on a large number of volunteers
- Do not warn when an action is needed to be taken (e.g. catching an object which is dropped suddenly/needed to make a click on computer keyboard)
- Use same object/weight of object
- Volunteers should be of same or similar age/ same sex
- Use same/dominant hand to catch/make clicks
- Make sure subjects do not take any (named) drugs/medications/stimulants/depressants
- Do not recruit people with conditions affecting reaction time (e.g. poor hearing/poor sight/neurological disorders) for experiments
- Carry out experiments on same time of day
- Make a minimum of three repeats and calculate mean
- low/medium risk

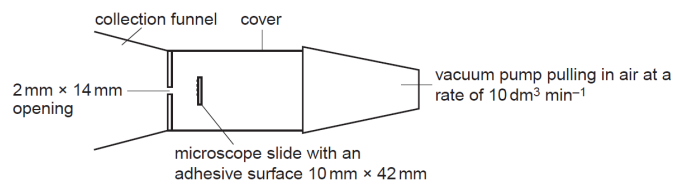
2.14. To investigate if lower epidermis of leaves has more stomata than upper epidermis

- Use strips from upper and lower epidermis
- Use strips from 5 different leaves of same type of plant
- Use microscope and eyepiece graticule
- Count the number of stomata visible (e.g. in field of view)
- Mount epidermis in water/glycerol/(suitable) stain
- Measure the diameter of field of view using graticule
- Calculate the area field of view using formula πr^2
- Convert area measured to mm^2

2.15. To investigate how electrophoresis can be used to obtain genetic fingerprinting

- Keep samples in wells of agarose gel/support medium
- Place wells near the cathode
- Add buffer solution to keep pH constant
- Apply potential difference to buffer
- DNA fragments that move to positive electrode/anode/DNA is negatively charged
- Fragments of different sizes move different distances
- Smaller fragments move further in given time/faster

2.16. To investigate if there are more pollen grains in the atmosphere during the day or night



- Expose slide/apparatus for a known period of time in different light
- Use intensities ranging from dark (zero intensity) to light and dark conditions
- Count pollen in the field of view
- Count at least 3 areas of the slide
- Measure the diameter of field of view using the eyepiece graticule
- Calculate area of field of view using formula πr^2
- Take all readings from the same location
- Remove any pollen on opening between each slide
- Carry out experiment in an outside location
- Make sure there are no walls/hedges/trees in the way
- Repeat the whole investigation on 3 different days and taking mean
- safety: use mask in case of pollen allergy
- Low risk investigation

2.17. To investigate the optimum temperature for respiration of yeast

- Use water-baths at different temperatures (at least 5 different temperatures)
- Carry out retesting within the approximate optimum zone
- Use methylene blue as indicator
- Keep volume of methylene blue constant
- Use graduated pipette to measure volume of methylene blue
- The fastest time until blue disappears is optimum temperature
- Use a control without methylene/same volume of a solution
- Use a standard volume of yeast/suspension in tube
- Stir to mix indicator and yeast
- Repeats at least 3 times and find mean value/remove anomalies
- safety: Toxicity of methylene blue/allergic to yeast
- Low risk experiment

2.18. To investigate a method to extract photosynthetic pigments from algae and obtain chromatograms

- Use a sample from each type of alga
- Use same number and mass of algae
- Extract pigments from the algae by grinding/crushing
- Crush algae with a solvent, e.g. ethanol
- Concentrate the extract by evaporating or heating
- Filter/centrifuge to remove debris/obtain pigments
- Run the sample in a solvent for a set distance
- Cover the container to prevent evaporation
- Dry before using second solvent; before solvent front reaches the end/pre-marked line
- Run in second solvent at 90° to first run
- Find/measure the position of the pigments/colours on the chromatogram and calculate R_f value
- Repeat to compare chromatograms/to find anomalies
- Safety: solvents (toxic/flammable) gloves and goggles

2.19. To investigate the activity of free enzymes and immobilized enzymes

- Use same volume/stated volume of enzyme for making beads and free enzyme
- Use methylene blue as indicator
- Use same volume/concentration of methylene blue
- Use substrate of same type/volume/surface area
- Measure time using a stopwatch to measure time taken for colour change
- Use thermostatically controlled water bath to keep temperature constant
- Use a buffer to maintain pH
- Allow temperature to equilibrate before mixing enzyme and substrate
- Repeat at least 3 times and find mean/identify anomalies
- safety: suitable hazard and precaution/low risk experiment

2.20. To investigate the rate of movements of pigments with varying masses in a chromatogram

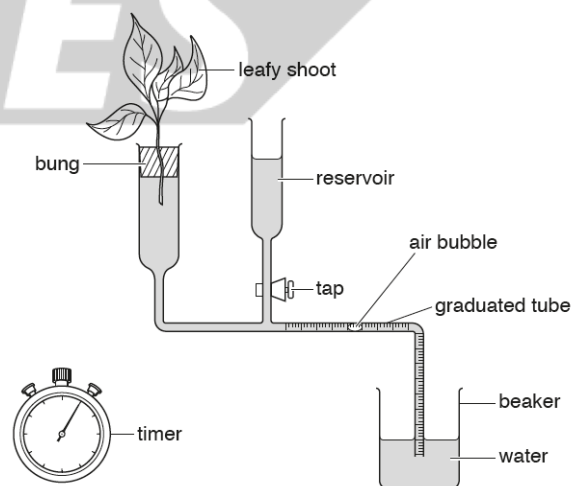
- Count the number of spots
- Run the pigment to the same distance moved by solvent front
- Apply the same number of pigments in the origin
- Use a capillary tube to give a spot on the chromatography paper
- Draw a base line using a pencil
- Concentrate the extract either by drying between adding spots or evaporating the extract before using
- Place the solvent so that the level of solvent is below the origin line
- Cover to prevent evaporation
- Dry before spraying with dye
- Run at least 3 chromatograms for both enzymes
- Calculate R_f value for each experiment
- Take mean of distances travelled by each spot or taking mean R_f values

- Safety: toxic/irritant/corrosive solvent or dye; wear gloves and goggles

2.21. To investigate the K_m value of enzymes at different temperatures¹/pH²

- Use a suitable range of at least 5 temperatures (10-70 degrees Celsius)¹
- Use a thermostatically controlled water bath to incubate enzyme and substrate solutions at constant temperature(s)²
- Use same concentration of enzyme each time
- Use same volume of enzyme each time
- Measure volume using graduated pipette
- Use same volume of buffer to maintain a constant pH¹
- Add acid/alkali to change pH and measure pH using a probe²
- incubating enzyme and substrate concentrations separately
- Mix enzyme and substrate on the magnetic stirrer and immerse a conductivity probe
- Take readings from meter at same time for each temperature
- Carry out experiments at different concentration of enzymes for the same range of temperature/pH to gather more data
- Take a minimum of 3 replicates and find mean
- Safety: enzyme is allergen or irritant; wear gloves and goggles

2.22. To investigate the rate of transpiration at different light intensities using a potometer



- Cut/insert stem of plant under water
- Use petroleum jelly/silicone to make joints air-tight
- Remove tube from water to introduce an air bubble

- Obtain a minimum of 5 different light intensities; keep lamp at a fixed distance and use filters of different strengths/thickness
- Allow apparatus/plant to equilibrate before starting measurements
- Reset air bubble to start position between measurements
- Measure distance moved by bubble over a set time using the graduated pipette OR Measure time taken for bubble to move a set distance using a stopwatch
- Take a minimum of 2 repeats at each light intensity and calculate mean/identify anomalies
- Low/medium risk investigation: Cut stem and cut away from your hand with scalpel
- Keep temperature constant by carrying out experiment in a temperature-controlled room
- Carry out experiment in a dark room, no external light source should be present
- Use same lamp to ensure same wavelength/brightness/colour of light
- Keep airflow constant by turning fan off or on at the same speed
- Use same species if plant's leaves/shoot
- Use a humidifier to keep humidity the same

2.23. To investigate the effect of temperature on carbon dioxide production during respiration of photosynthetic protocist

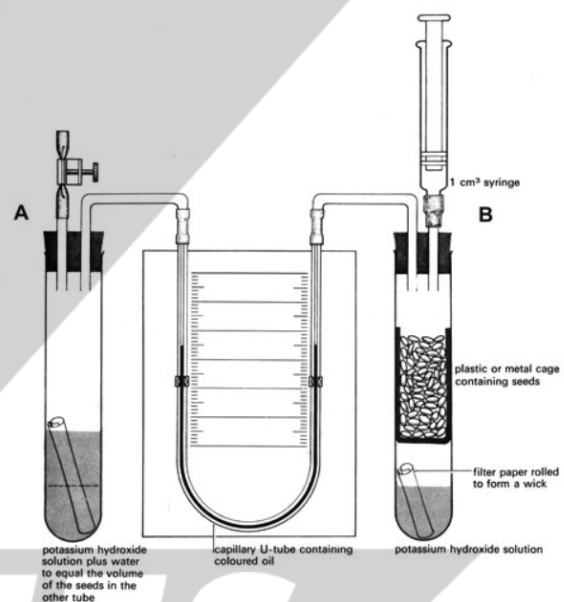
- Set up at least 5 water-baths at different temperatures (state temperature values with units)
- Use same volume/concentration of hydrogen carbonate/indicator to each test-tube
- Add oxygen into indicator solution
- Ensure same colour/pH of indicator at each test tube before starting experiment.
- Use colorimeter/pH probe to judge colour/measure pH
- Use same volume and species of photosynthetic protocist
- Put indicator and the photosynthetic protocist in separate tubes in a water-bath to reach desired temperature
- Mix protocist and indicator until endpoint is reached.
- Keep pH value/colour of endpoint constant
- Use boiled protocist of the same volume to act as control
- Make at least three replicates and finding mean (of time or pH) and identify anomalies
- Low risk experiment

2.24. To investigate the respiration rates of yeast of different varieties

- Use same/known/stated volume of each yeast
- Add them to separate flasks
- Use same/known/stated volume and concentration of nutrient solution/glucose

- Use thermostatically controlled water bath to keep temperature constant
- Use at least 5 different temperature values between (15 degrees Celsius – 80 degrees Celsius)
- Allow temperature equilibration of glucose and yeast suspension
- Add a known indicator
- Measure time taken for permanent colour change
- Use a computer-controlled gas flow train to maintain oxygen concentration
- Use at least 3 replicates and find mean
- Identify and eliminate anomalies
- Low risk experiment
- Safety: yeast allergenic/indicator irritant, wear mask, gloves, and goggles

2.25. To calculate respiratory quotient by conducting an experiment



- Pour known volumes of potassium hydroxide to each respirometer vessel
- Add filter paper to act as wicks
- Add known volume of seeds in one of the vessels, make sure the seeds/invertebrates do not meet potassium hydroxide, keep seeds in a box
- Add same volume of water in the other vessel
- Fit bungs in both vessels
- Attach two connecting tubes to vessel with water, one with a clip on a flexible hose
- Attach a syringe of known volume and a connecting tube to vessel with seeds/invertebrates
- Add dye/coloured liquid to U-shaped manometer
- Connect manometer to the connecting tubes
- Make sure that the apparatus is airtight
- Use the syringe (by pressurizing and releasing pressure) to adjust the manometer so that the fluid levels is same on both side

- Record position of syringe, position of both sides of meniscus and the time
- Record new positions of manometer fluid at regular intervals. When it reaches the end of one side of the tube, restore original position and record readings on syringe
- Find volume of oxygen absorbed by seeds/invertebrates in a known period. This is Vol₁
- Remove potassium hydroxide from both vessels and wash them out with water
- Replace seeds/invertebrates with equal volume of water and record changes in gas volume for known period. This is Vol₂
- Calculate volume of CO₂ produced
- Calculate respiratory quotient using formula

$$\text{Respiration Quotient} = \frac{\text{Volume of carbon dioxide produced}}{\text{Volume of oxygen absorbed}}$$

$$RQ = \frac{Vol1 + Vol2}{Vol1}$$

3. Measurements and counting

3.1. Measuring sections of specimen (e.g. tubules/lumen) with eyepiece graticule

- Set magnification at x40 – x400
- Use stage micrometre and eyepiece graticule
- Calculate the number of eyepiece graticule units per stage micrometre unit/calibrate the eyepiece graticule with the stage micrometre
- Convert from eyepiece units/mm to micrometre
- Use the formula:

$$\frac{\text{number of stage micrometer divisions}}{\text{number of eyepiece graticule units}} \times \text{value of 1 mm}$$

3.2. Counting cells using a hemocytometer

- Dilute the sample and use a coverslip
- Count squares where cells are fully inside and touching the lines.
- Calculate the volume of the sample
- Count cells in a sample of known volume
- Use microscopes and suitable magnification
- Calculate the actual number of cells
- (Divide the number of cells by the volume) — optional

NOTES

CAIE A2 LEVEL

Biology

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