PRACTICAL NOTES

1. SKELETAL MARK-SCHEME

SKILL	BREAKDOWN
MANIPULATION OF APPARATUS, MEASUREMENT, AND OBSERVATION [16]	• Making decisions about measurements or observations [8] • Successfully collecting data & observations [8]
PRESENTATION OF DATA AND OBSERVATIONS [12]	• Recording data and observations [4] • Displaying calculations and reasoning [2] • Data or observations layout [6]
ANALYSIS, CONCLUSIONS, AND EVALUATION [12]	• Interpreting data or observations and identifying sources of error [6] • Drawing conclusions [3] • Suggesting improvements to procedure, modifications to extend investigation [3]

2. MANIPULATION OF APPARATUS, MEASUREMENT & OBSERVATION

2.1 Variables

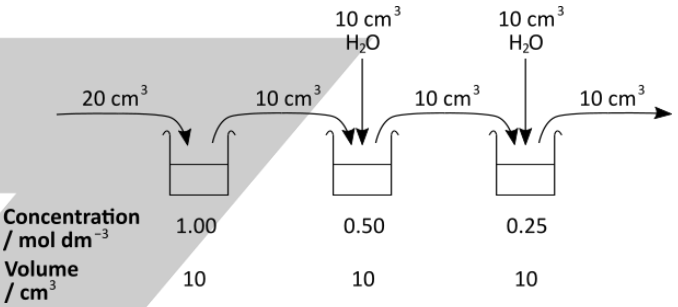
- Independent variable is the factor that changes in an investigation and dependent variable is the factor that changes as a result.
- Other variables that may affect the dependent variable must be identified and kept constant, i.e. standardized.
- Control samples are standardized ones with effect of independent variable also removed.
- Qualitative (non-numerically observable) variables can be nominal (categorisable) or ordinal (rank-able).
- Quantitative (numerically representable) variables can be continuous or discrete.

2.2 Experimental Skills

- Range (spread between highest and lowest value) and intervals (difference between values) of independent variable must be decided.
- Concentration of a sample is a common independent variable, thus dilution becomes an important skill.
- **Dilution is of 2 types:**
  - Simple, where a mother solution is diluted by different ratios:

Mother solution		Volume of H_2O added / cm^{-3}	Final solution	
Conc. / $mol\ dm^{-3}$	Volume / cm^{-3}		Conc. / $mol\ dm^{-3}$	Volume / cm^{-3}
1.0	80	2.0	0.8	10.0
1.0	6.0	4.0	0.6	10.0
1.0	4.0	6.0	0.4	10.0
1.0	2.0	8.0	0.2	10.0

  - Serial, where previously diluted solution is diluted by same ratio:



- Other variables must be identified and standardized:

VARIABLE	STANDARDISING METHOD
TEMPERATURE	Thermo-statically controlled water bath
PH	Buffer solution of known concentration
LIGHT INTENSITY	Heat-shielded lamp set at constant distance/power
WIND SPEED	Fan set at constant distance & power
HUMIDITY	Solid anhydrous Calcium Chloride

  - Other standardised variables include: mass, concentration, volume, source, age, storage, conditions, genotype of sample.
- Dependent variables must be measured by proper instrument:
  - Temperature – Thermometer.
  - Colour – Colorimeter.
  - pH – Indicator/pH meter.
  - No. of cells – Haemocytometer.
  - Power – Voltmeter & ammeter.
  - Mass – Balance.
  - Time – Clock/Stopwatch.
  - Length – Microscope with calibrated eyepiece graticule/Ruler.
  - Volume – Beaker/Measuring cylinder/Burette/Pipette.
- **Note:** Read from bottom of meniscus and estimate to half of smallest division in analogue scales, e.g. burette.

2.3 Quality of Measurements

TERM	EXPLANATION	IMPROVEMENT
Accuracy	Closeness to true value	Better instruments
Precision	Closeness to repeated readings	Control all variables
Reliability	Confidence in results	Repeat readings and take mean
Validity	Agreement between hypothesis and investigation	Check relation between key and derived variables

3. Presentation of Data & Observations

3.1 Tabulating Results

- Draw table with neat, ruled pencil lines.
- Give each column suitable heading (Quantity/SI unit)
- Arrange columns in order: independent, dependent & derived variable.
- Round data to some no. of decimal places to maintain consistency.

3.2 Plotting Graphs

- Decide type of graph:
  - Line graph (Both variables are continuous)
  - Histogram (Independent variable is continuous)
  - Bar chart (Dependent variable is continuous)
  - Bars touch in histograms only, not in bar charts.
- Independent variable at x-axis and dependent at y-axis.
- Use linear scale with sensible (1s, 2s, 5s, 10s, …) intervals.
- Axes don't have to stand out. If they do, a break should be indicated.
- Use as much of graph paper as possible.
- Label each axis fully, according to variable's column heading.
- For line graphs:
  - Plot points with ✕ or ⊙ marks.
  - Join successive points with straight lines.
  - If there is clear relation, draw smooth wave, or line of best fit.
- Don't extrapolate line.

3.3 Making Biological Drawings

- Drawings can be low-power plan (showing distribution of tissue without outlining cells), or high-power detail (showing details of small group of individual cells).
- Use most space available to make drawing large enough to show essential features.
- Draw clear, single lines with sharp HB pencil (keep a clean eraser).
- Show overall shape and ensure proportions are correct.
- Don't shade or colour.
- Label using accurate, straight, horizontal, non-intersecting ruled lines.

3.4 Mathematical Skills

- $\%\ \text{error} = \frac{\text{No. of readings} \times \text{Half of smallest scale division}}{\text{Total reading}} \times 100\%$
- $\text{Mean} = \frac{\text{Sum of data}}{\text{No. of data}}$
  - Useful for replicated readings.
- $\text{Gradient} = \frac{\Delta y}{\Delta x}$, where Δy & Δx are height and width of triangle.
- Draw right-angled triangle from 2 points on straight line graph or tangent of curve; Ensure that triangle exceeds half of graph.
- $\%\ \text{change} = \frac{\text{Final} - \text{Initial}}{\text{Initial}} \times 100\%$
- It makes comparing easier by negating effects of differences in initial readings between samples.
- Magnification is no. of times image is larger than actual:

$$\text{Magnification} = \frac{\text{Image}}{\text{Actual}}$$

  - Resolution indicates amount of detail.
  - It is shortest distance between 2 points that can be distinguished or separable.
  - It is equal to half of wavelength of light used.

4. Analysis, Conclusion & Evaluation

4.1 Describing & Interpreting Data

- Describe overall trend.
- Comment on changes in gradient.
- Quote figures to support claim.
- Avoid phrases that suggest something is happening over time, unless it is the independent variable.
- Draw a conclusion by connecting it to description using theoretical reasoning.
- Conclusion should be simple, clean, focused and scientifically explainable statement describing deduction regarding the hypothesis from results.

4.2 Identifying Errors

- Systematic errors are equal throughout investigation, as they result from uncertainties in measurements.
- Random errors differ across investigation as they arise owing to difficulties in controlling standardised variables and measuring dependent variable.
- Common error sources include:
  - Anomalous readings (owing to inadequate technique/replicates)
  - Inadequate range and intervals.
  - Uncontrolled variables.