Scientific Report Writing – Assessment task solutions

1. ***C — Discussion.*** *(That sentence interprets the pattern and is placed in the discussion.)*
2. ***A — Predict the relationship between IV and DV.*** *(Hypothesis predicts between the IV and DV.)*
3. ***B — What is changed.*** *(Independent variable)*
4. ***B — The type of liquid.*** *(Type of liquid is the tested variable.)*
5. ***C — Method/Procedure.*** *(Figure of setup belongs in method.)*
6. ***B — state what was investigated.*** *(Aim states what is being investigated.)*
7. ***C — headings, units, ruled borders.*** *(Tables need headings, units etc.)*
8. ***C — The graph clearly represents the underlying trend.*** *(Best fit shows trend. Don't join all points.)*
9. ***A — describe the trend and errors.*** *(Discussion interprets trend and evaluates errors.)*
10. ***B — answer the aim.*** *(Conclusion must answer the aim.)*
11. ***A — Harvard style.*** *(Harvard is an acceptable referencing format.)*
12. ***E — None of the above.*** *(Random errors cannot be totally eliminated.)*
13. ***B — adjustments to the procedure and proper calibration of instruments.*** *(Reduces systematic error)*
14. ***B — contain personal beliefs.*** *(Hypotheses should not contain personal beliefs.)*
15. ***C — precise, numbered, clear.*** *(Procedure must be reproducible, ie. It must be able to be repeated by different groups of people in different laboratories.)*
16. ***B — The independent variable is the volume of water.*** *(x-axis = volume water = IV.)*
17. ***C — The data point at 4 litres is most likely indicative of a random error.*** *(Single outlier is likely a random error.)*
18. ***E — The procedure.*** *(Procedure is crucial for repeatability.)*
19. ***E — increase the validity of the investigation.*** *(Controlling variables other than the IV and DV increases validity.)*
20. ***B — All sources used.*** *(Bibliography should list all sources)*

Multiple choice answer sheet.

Circle one correct response

1.	A	B	**C**	D	E	11.	**A**	B	C	D	E
2.	**A**	B	C	D	E	12.	A	B	C	D	**E**
3.	A	**B**	C	D	E	13.	A	**B**	C	D	E
4.	A	**B**	C	D	E	14.	A	**B**	C	D	E
5.	A	B	**C**	D	E	15.	A	B	**C**	D	E
6.	A	**B**	C	D	E	16.	A	**B**	C	D	E
7.	A	B	**C**	D	E	17.	A	B	**C**	D	E
8.	A	B	**C**	D	E	18.	A	B	C	D	**E**
9.	**A**	B	C	D	E	19.	A	B	C	D	**E**
10.	A	**B**	C	D	E	20.	A	**B**	C	D	E

Part B – Short Answer Questions

A student sets up an investigation to determine the relationship between temperature of water and the rate of reaction, using an effervescent Panadol tablet. The setup is shown in figure 4, on the right.

Figure 4 – Panadol experimental setup.

1. Write an appropriate aim for the investigation.

To investigate how the temperature of water affects the time taken for an effervescent Panadol tablet to dissolve. *1 ---- mark*

2. Write an appropriate hypothesis for this investigation, identifying the IV and DV.

If water temperature is increased, then the tablet will dissolve faster (shorter time), because higher temperature increases molecular kinetic energy and collision frequency. 1 ----- mark
Temperature = IV, Rate or time taken to dissolve = DV. 2 ----- marks

3. Identify one random and one systematic error and explain the difference between the two types of errors.

Random errors any plausible random error such as the once mentioned below.
- Temperature differences of the water used to dissolve the tablet (slightly warmer or cooler each trial).
- Inconsistent stirring rate or duration affecting how completely the tablet dissolves.
- Tablet fragments sticking to the beaker walls, making dissolution uneven.
- Different particle sizes as tablets break apart inconsistently (finer pieces dissolve faster). *1 ---- mark*
Systematic error any plausible error, such as:
- *A thermometer that reads constantly 2°C above normal.*
- *Timer that is out by a given amount eg. 2 seconds*

1 -----mark

Random errors cause unpredictable scatter around the true value and reduce precision (affect individual trials unpredictably). *1-----mark*
Systematic errors shift all results consistently away from the true value (reduce accuracy but not precision) and are not removed by repeating trials. 1-----mark

4. Describe one improvement that would reduce the impact of random errors.

Repeat each temperature condition several times, such as four trials and take the average. This reduces the influence of random variation as the same random error is unlikely to occur in successive trials. Any other acceptable response. 1----- mark

5. Describe one improvement that would reduce systematic error.

Calibrate the thermometer and electronic balance before the experiment (compare the thermometer and balance with known quantities and adjust if needed). 1-----mark

6. Write a procedure for the investigation using the experimental setup shown in figure 4.

1. *Place an electronic balance on a stable bench and close the draft shield.*
2. *Measure **100.0 mL** of distilled water using a 100mL graduated cylinder and pour it into a **250 mL beaker**.*
3. *Adjust the water to the required temperature by using a hot plate or ice bath. Record the **actual water temperature** using a calibrated thermometer.*
4. *Dry the outside of the beaker and place the beaker on the balance. Record the **initial mass (m_0)***
5. *At **$t = 0$ s**, drop one effervescent Panadol tablet into the beaker and immediately start the stopwatch.*
6. *With the balance draft shield closed, record the mass **every 5 seconds** until the mass becomes constant. Do **not** cover the beaker, as CO_2 gas must escape freely.*
7. *Remove the beaker, rinse it, and dry it thoroughly.*
8. *Repeat steps 2 – 7 three more times.*
9. *Repeat steps 2-8 for temperature 10 °C, 20 °C, 40 °C, 60 °C, Safety – use PPE (goggles, glove labcoat), hot water can cause burns only do not exceed the 60°C temperature mark.*

1 ---- mark - for numbered steps
1-----mark - clear, sequential logical steps
1-----mark - repeat statements
1-----mark safety considerations

7. Consider the graph shown in figure 5 representing the data collected during the investigation.
   a. In what section of the report should the analysis of this data be included?

      Discussion 1-----mark

   b. In the space provided write the section of the report specified part a. using the data in figure 5 and the procedure in question 6

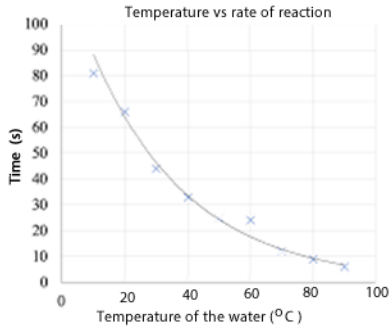

Figure 5 – Graphed data from the temperature vs rate of reaction investigation.

The graph (Figure 5) shows that as water temperature increased, the time taken for the tablet to dissolve decreased exponentially. Between 10 °C (80 s)and 30 °C (45s) there is a steep decrease in dissolution time, indicating a strong temperature dependence in this range. Above 40 °C (30s) the rate of change becomes smaller, suggesting the effect of temperature on rate levels off. The plotted points are close to the best-fit line, indicating consistent results. A minor outlier at 60 °C deviates from the mean by approximately 5 s. This is likely due to an unspecified random error. Overall, the data support the hypothesis that increasing temperature increases reaction rate because higher temperature increases molecular collision frequency.

1-----mark for analysis of trend (exponential decay)

1-----mark for using data to support the trend

1-----mark for recognising the outlier and ignoring it in the discussion of the trend.

Uncertainties & limitations: *Human timing introduces an uncertainty. Temperature control could be improved by using a preset, temperature water bath. Systematic error could arise if the thermometer is not properly calibrated or the precision of the balance fails to record small changes in mass hence the experimenter determines a consistent lower time to reach constant mass. 1-----mark for mentioning a plausible limitation*

Improvements: *Calibrate thermometers and ensure the tablet is dropped from the same height each trial and any agitation of the beaker whilst on the balance is controlled and consistent each trial. As this will introduce a new source of kinetic energy into the system and impact the rate of dissolving and hence the rate of reaction. Thus making the results less valid. 1-----mark any plausible improvement with an explanation as to how it will improve results.*

The five marks can be allocated as the teacher agrees that the student has met all the criteria applicable to a good discussion.

c. In the space provided below, draw a properly formatted table of the data presented in figure 5 and indicate in what section of the report the table should be placed in. Only include the **mean** data from temperatures, 10, 20, 30, 40 and 60.

Section of report ___*Results*_____

Temperature of water vs average time for a Panadol tablet to fully dissolve.

Temp (°C)	Mean (s)
10	80
20	65
30	45
40	32
60	24

1-----mark – heading (using IV and DV)

1-----mark – carefully ruled appropriate number of columns and rows.

1-----mark – clearly labelled columns with units

1-----mark - faithfully replicated the data from the graph

8. Name five variables that should be tightly controlled in this investigation.

i. _____*Volume of water*_____*1-----mark*

ii. _____*Size of beaker*_____*1-----mark*

iii. _____*Source of water*_____*1-----mark*

iv. _____*Brand of tablet*_____*1-----mark*

v. _____*Method of placing the tablet in the water 1-----mark*

Any other plausible controlled variables

9. Write a conclusion to this investigation.

The investigation showed that the Panadol tablet dissolved faster at higher temperatures, supporting the hypothesis. The repeated measurements at each temperature were consistent, indicating high precision and repeatability. However, the overall validity of the results may be lower, because the method relies on mass loss as an indirect measure of reaction rate, and any CO_2 bubbles sticking to the tablet or glassware could affect the mass readings. Additionally, temperature may not have been perfectly controlled at the moment the tablet was added. Therefore, while the results strongly support the trend predicted, some aspects of the procedure limit the validity of the conclusions.

Conclusion should directly answer aim and reference hypothesis (1-----mark), summarise trend (1-----mark) and note main limitation(s) (1-----mark)

10. Describe the difference between repeatable and reproducible data and explain what is required for a high degree of reproducibility.

Repeatable => *Same person repeats the experiment, using the same equipment and conditions, and gets similar results (high precision). 1-----mark*
Reproducible: *Different persons or different labs repeat the experiment procedure (possibly with different equipment) and obtain comparable results.. 1-----mark*

High reproducibility 1-----mark – any one plausible factor. Such as:

- *A detailed, unambiguous procedure that others can follow precisely (exact volumes, times, type of equipment or precise brands).*
- *Calibrated instruments.*
- *Standardised materials and clear environmental controls.*
- *Good training so different operators follow the same method.*

11. Consider the two hypotheses written below by two different students. Discuss why the cannot be excepted as valid hypotheses.
i. "If a plant is happy, then it will grow faster, because happy plants grow faster."

The variable "happy" is not defined or measurable. Because it cannot be quantified, the statement cannot be tested and therefore cannot be supported or falsified. A hypothesis is falsifiable only if there is a possible observation that could prove it false. Since no objective measurement of "happiness" in a plant can be designed, the hypothesis fails this requirement.
1----- mark - If the student recognises that "happy" is not measurable and therefore the hypothesis cannot be tested, supported, or falsified.

ii. "If more stuff is added to the water used to nourish the plants then they will grow faster because the more stuff that is in the water the more chance plants have of getting the appropriate nutrients with which to photosynthesise"

The phrase "more stuff" is vague and undefined.
A valid hypothesis must be specific, testable, measurable, and falsifiable. Because "stuff" does not refer to a clearly identified chemical or nutrient, the independent variable cannot be measured or controlled. Without a defined IV, no proper experiment can be designed, and no observation could reliably prove the statement true or false.
1-----mark – for stating that the term "Stuff" is unclear and ambiguous, hence no test can be designed to support or falsify the hypothesis.

12. Below are the results of three groups measuring the time taken for an effervescent tablet of a specific brand of Panadol to dissolve at 60 ^{o}C. The literature value indicates it takes 100 seconds to dissolve completely.

Data table 1— three groups, four trials each at 60 ^{o}C.

Group	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trial 4 (s)	Mean (s)
Group A	92.1	92.0	92.2	91.9	**92.05**
Group B	99.8	100.1	99.9	100.0	**99.95**
Group C	107.9	108.0	107.8	108.1	**107.95**

a. Which group has obtained precise and accurate results? ***Group B 1-----mark***
Explain
Group B's mean (99.95 s) is very close to the literature value (100 s) therefore we can say it is accurate. Its trial values are tightly clustered (small spread) so the data has high precision. 1-----mark

b. Which groups show precise, repeatable, but, inaccurate results? *Groups A and C 1-----mark*
Explain
Both groups A and C have very small variation among their trials (high precision/repeatability), but their means (92.05 s and 107.95 s) are far from the literature value (100 s) hence inaccurate. May be due to a possible systematic error. 1-----mark

c. Which group has results with very low precision? *None 1-----mark*
Explain

All three groups show high precision (the trials within each group are tightly clustered). Low precision would show widely scattered trial values; that is not the case here. 1-----mark