4.1 Working Scientifically: Variables, Fair Tests and Planning: 30-minute Pack

Calculator allowed · about 30 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Erin tests how water temperature affects dissolving time. At 20°C she puts 2 g of sugar into 50 ml of water; at 40°C she puts 4 g of the same sugar into 50 ml of water. She uses identical beakers and the same stirring method and sugar grain size, and times until no grains are visible. Identify the confounding variable, explain why it prevents a clear conclusion about temperature, and suggest a specific improvement.

(3)

2 Oliwia investigates how daily water volume affects seedling growth. She gives one group 5 ml each day in a shaded cupboard and another group 15 ml each day on a bright windowsill. Each group has six similar seedlings of the same species, soil and pot size, and both locations are kept at the same temperature. She measures stem-height increase after seven days and repeats this whole arrangement three times. Explain why these repeats do not make the water comparison fair and propose an improvement.

(3)

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3 A pilot test releases a ball from heights of 10 cm, 30 cm and 50 cm onto the same firm surface. Rebound heights can be read clearly throughout this range. The teacher permits release heights from 10 cm to 50 cm inclusive. Suggest five equally spaced release heights for the main investigation, describe how to release the ball consistently and explain why testing intermediate heights is useful.

(3)

4 Noah tests whether adding a lid reduces water cooling. Identical cups each contain 100 ml of water starting at 60°C. After five minutes he records the temperature decrease. Three fresh trials give: no lid, 30°C, 32°C, 34°C; lid, 20°C, 22°C, 24°C. Room temperature, cup position and timing method are kept the same. Calculate the mean temperature decrease for each condition.

(4)

5 Amelia predicts that warmer water makes a fixed mass of sugar dissolve faster. She uses 2 g of the same sugar in 50 ml of water, identical beakers and the same stirring method. Three repeats at 20°C take 84 s, 88 s and 86 s; three at 40°C take 44 s, 48 s and 46 s. Evaluate the claim: "These results prove that sugar dissolves faster at every temperature." Use the results and suggest one next investigation step.

(3)

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6 In an investigation, a pupil writes: "The seeds given water will have a higher percentage germination after five days than the seeds given no water." Name the term for this statement of an expected result.

(1)

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7 Plan an investigation to test whether increasing the number of layers of felt around a cup reduces the temperature decrease of water over five minutes. Available apparatus includes identical cups, felt sheets, elastic bands, measuring cylinders, thermometers and stopwatches. A teacher supplies warm water at 50°C; pupils must not heat water themselves. Include a testable prediction, independent and dependent variables, a workable sequence with measurements and intervals, important controls, repeats and a relevant safety precaution. Explain how your choices make the comparison fair and the results useful.

(6)

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8 Priya investigates how water volume affects seedling growth. She gives identical seedlings 5 ml, 10 ml or 15 ml of water each day. After seven days she measures the increase in stem height. Identify the independent variable.

(1)

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9 Noah needs to measure 25 ml of water and the time for a sugar sample to dissolve. Choose an appropriate measuring instrument for each measurement. Available instruments are a ruler, a measuring cylinder, a balance and a stopwatch.

(2)

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Mark scheme · 4.1 Working Scientifically: Variables, Fair Tests and Planning: 30-minute Pack

Question 1

Sugar mass changes from 2 g to 4 g alongside temperature.	**B1**
Sugar mass can also affect dissolving time, so its effect cannot be separated from temperature here.	**B1**
Uses the same sugar mass at both temperatures, e.g. 2 g in each; allow 4 g in each. Repeats alone do not remove this confounder.	**B1**

Answer: **Sugar mass is a confounder. Both mass and temperature change, so dissolving-time differences cannot be attributed to temperature alone. Use 2 g of sugar at both temperatures.**

Question 2

Light exposure differs between water groups and can affect growth.	**B1**
Repeating the same arrangement retains the light difference and cannot separate its effect from water volume.	**B1**
Places both groups under equal light, e.g. next to each other under the same lamp with positions rotated. Accept a design testing each water volume under each light condition.	**B1**

Answer: **Light exposure changes with water volume and can affect growth, so either could explain a growth difference. Repeating the same arrangement retains that confounder. Give both water-volume groups the same light exposure.**

Question 3

10, 20, 30, 40 and 50 cm, equally spaced across the permitted range.	**B1**
Uses a consistent release without pushing, measuring height from the same point on the ball each time.	**B1**
Intermediate heights give more detail about the relationship or reveal changes in the pattern.	**B1**

Answer: **10, 20, 30, 40 and 50 cm. Release the same ball without pushing from a consistent reference point. Intermediate heights show whether the pattern continues between the pilot values.**

Question 4

Adds 30 + 32 + 34 and divides by 3.	**M1**
32°C for no lid, dependent on the first method.	**A1**
Adds 20 + 22 + 24 and divides by 3.	**M1**
22°C for lid, dependent on the second method.	**A1**

Answer: **No lid: 32°C; lid: 22°C.**

Question 5

Uses the shorter times at 40°C as evidence supporting faster dissolving for the tested conditions.	**B1**
Rejects proof at every temperature because only 20°C and 40°C were tested; allow recognition that evidence supports rather than proves a universal claim.	**B1**
Tests additional temperatures with the other conditions controlled and repeated measurements.	**B1**

Answer: **All three times at 40°C are shorter than those at 20°C, supporting the prediction for these conditions. Two temperatures cannot establish a pattern at every temperature. Test additional water temperatures with the same controls and repeats.**

Question 6

Prediction; allow a testable prediction.	**B1**

Answer: **Prediction.**

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Question 7

Level 1 Gives isolated relevant planning points, such as a variable or apparatus, but the method has major gaps. Award 0 if nothing is creditworthy. **1-2**

Level 2 Describes a partly workable comparison of felt layers and temperature decrease, with measurements and some controls. Includes some detail about repeats or safety, with limited explanation of how the choices help. **3-4**

Level 3 Gives a coherent, workable plan with a testable prediction, correct variables, a range of layers, timed temperature measurements, relevant controls, repeats and safety. Explains how controls isolate the effect of layers and repeats help assess consistency. Use the upper mark for a complete, clearly linked plan. **5-6**

Indicative content:

- Predict that more felt layers will give a smaller temperature decrease over five minutes, because the insulation reduces energy transfer to the surroundings. Accept a different testable prediction if scientifically reasoned.
- Change only the number of felt layers, e.g. 0, 1, 2 and 3. Measure temperature decrease over five minutes as the dependent variable.
- Use the same cup or identical cups; use a measuring cylinder to put 100 ml of water into each cup and a thermometer to check each starts at 50°C.
- Wrap equal-sized felt sheets around the same area of each cup and secure them with elastic bands. Leave the top equally open for every condition.
- Start the stopwatch at the initial reading. Record temperature at 0, 1, 2, 3, 4 and 5 minutes, keeping the thermometer bulb in the water at the same depth without touching the cup. Accept initial and final readings alone if the five-minute interval is clear.
- Subtract the five-minute reading from the initial reading to find the temperature decrease. Compare decreases for different layer numbers.
- Keep water volume, starting temperature, cup type, room conditions, exposed area and cooling duration constant, so they do not provide alternative explanations for a difference.
- Repeat each layer condition with fresh water at the same starting temperature, ideally three times; compare the spread and calculate a mean decrease. Check an unusual result rather than automatically removing it.
- Keep cups stable on a tray away from the bench edge, handle warm water carefully and report spills promptly. The teacher supplies the warm water; do not heat it.

Question 8

Volume of water given each day; allow daily water volume. **B1**

Answer: **Volume of water given each day, in ml.**

Question 9

Measuring cylinder for the volume. **B1**

Stopwatch for the time. **B1**

Answer: **Measuring cylinder for water volume; stopwatch for dissolving time.**

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