Name: _____

IB DP BIOLOGY · W01 (A1.1) · Weekly Homework

Surface tension and drop size on coins

_____ / 18 marks

Investigation: How does adding detergent change the maximum number of water drops a flat coin can hold before spilling?

Method: 1. Clean five flat coins of each diameter (16, 18, 20 and 22 mm) and dry thoroughly. 2. Dispense distilled water or 1% detergent drops from one vertical dropper held at fixed height. 3. Count drops added until each liquid dome spills over the coin rim. 4. Calculate the mean drop count across five replicate coins per diameter and liquid.

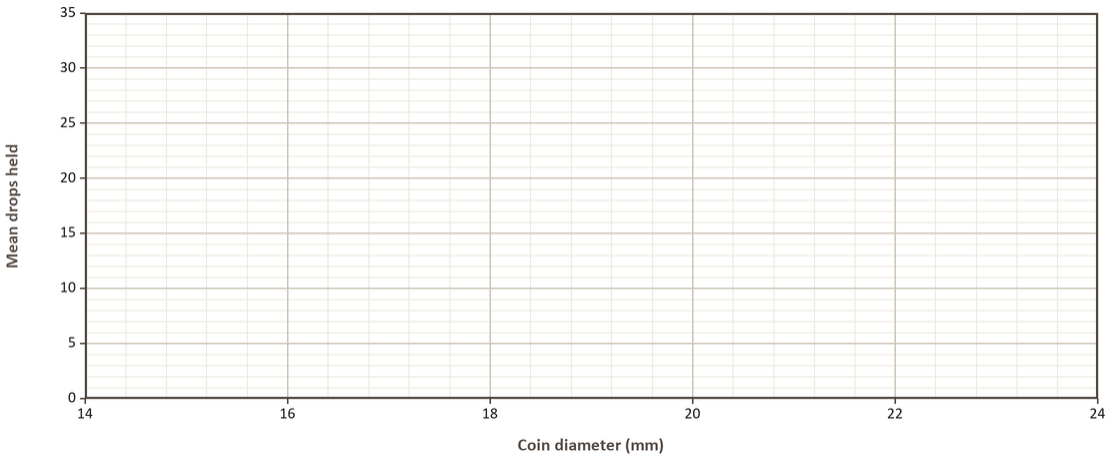
IV: Coin diameter (mm) and liquid type (plain water compared with 1% detergent) | **DV:** Mean number of drops held before spilling | **Controls:** Same dropper tip, drop release height, clean dry coin surface

Key Words & Units: **surface tension**: inward pull across a liquid surface caused by molecular cohesion · **cohesion**: hydrogen-bond attraction between neighbouring polar water molecules · **replicate**: independent repeat trial tested under identical conditions · **percentage decrease**: (reduction ÷ starting value) × 100

Method tip: For percentage decrease, divide the number of drops lost by the starting (plain-water) count, then multiply by 100.

Sentence frame: The claim is [supported / refuted] because on the [20 mm] coin drops fell by [X%], whereas on the [16 mm] coin drops fell by [Y%].

Coin diameter (mm)	Plain water (drops)	With detergent (drops)
16	18	11
18	22	13
20	28	16
22	32	18



Grid for plotting mean drops held against coin diameter for both liquids.

Part A · Read & Process Data

Q1. Calculate the percentage decrease in mean drops held on the 20 mm coin after adding detergent. **[3]**

(a) Show the drop difference and division using the plain-water starting value. [2]

(b) State the final percentage decrease to one decimal place. [1]

Q2. Plot both liquid series on the grid above. **[4]**

(a) Plot all four means cleanly for plain water and for detergent using distinct symbols. [2]

(b) Join each series with straight line segments and add a clear key. [2]

Part B · Interpret & Explain Biology

Q3. A student claims that adding detergent always reduces the drop count by exactly half (50%). **[5]**

(a) Evaluate this claim using calculated changes for two coin diameters from the table. [2]

(b) Explain how hydrogen bonds create surface tension across the water dome and how detergent changes this. [3]

Q4. Both trials hold 0.60 cm^3 total on the 20 mm coin before spilling, using Dropper Tip A (0.020 cm^3 $drop^{-1}$) or Tip B (0.030 cm^3 $drop^{-1}$). **[3]**

(a) Show how dividing total volume by drop volume predicts 30 drops for Tip A and 20 drops for Tip B. [1]

(b) Explain why comparing raw drop counts between two different droppers gives a misleading biological conclusion. [2]

Part C · Evaluate & Redesign the Investigation

Q5. Improve the measurement accuracy of the coin investigation. **[3]**

(a) Describe how to measure mean drop volume for Tip A and Tip B using a 0.01 g balance (1 cm^3 = 1.00 g). [2]

(b) Outline why weighing 20 pooled drops reduces percentage error compared with weighing 1 drop. [1]

Optional Challenge (+3 marks · Extension)

If the coin experiment is repeated using warm distilled water at 45 °C instead of 20 °C, predict how the drop-count line will shift and explain why in terms of molecular motion and hydrogen bonding. [3]

IB DP BIOLOGY · W01 (A1.1) · Mark Scheme & Teacher Notes

Matched 1:1 to Student Booklet pp. 1-2 · (Specimen Slide 6) · Surface tension and drop size on coins **18 + 3 marks**

Part A · Read & Process Data Mark Scheme [7 marks]

Q1: Percentage decrease on 20 mm coin [3]

- (a) Drop reduction = 28 − 16 = 12 drops. **[1]**
- (a) Percentage decrease = (12 ÷ 28) × 100. **[1]**
- (b) 42.9%. **[1]**

Q2: Plotting both coin-drop series [4]

- (a) All four plain-water points plotted accurately at (16,18), (18,22), (20,28), (22,32). **[1]**
- (a) All four detergent points plotted accurately at (16,11), (18,13), (20,16), (22,18) with a distinct symbol. **[1]**
- (b) Points joined cleanly point-to-point within each series (no cross-series join). **[1]**
- (b) Clear key distinguishes plain water from detergent. **[1]**

Accept: Q1: Carry-forward credit if divided by stated drop loss over 28. | Q2: Points plotted within half a small grid square, both axes labelled with IB SI units, and clear distinct series keys.

Do not accept: Q1: Bare final numbers without working, swapped numerator/denominator, or missing/incorrect IB SI units. | Q2: Unlabelled axes, mismatched scales, or points joined across separate data series.

Part B · Interpret & Explain Biology Mark Scheme [8 marks]

Q3: Evaluating the 50% claim & surface tension mechanism [5]

- (a) Data refutes exact halving: 16 mm falls 38.9% (18 → 11) and 18 mm falls 40.9% (22 → 13). **[1]**
- (a) 20 mm falls 42.9% (28 → 16) and 22 mm falls 43.8% (32 → 18): every diameter is well below 50%. **[1]**
- (b) Polar water molecules attract neighbours via hydrogen bonds (cohesion). **[1]**
- (b) Inward and sideways surface cohesion pulls the dome tightly over the coin rim. **[1]**
- (b) Detergent disrupts hydrogen-bonding between surface water molecules, lowering surface tension so it spills sooner. **[1]**

Q4: Drop volume vs. drop count [3]

- (a) Tip A: 0.60 ÷ 0.020 = 30 drops. Tip B: 0.60 ÷ 0.030 = 20 drops. **[1]**
- (b) Both liquids held the same total volume (0.60 cm^3), showing no real difference in dome capacity. **[1]**
- (b) Drop count confounds surface tension with dropper-tip bore size when different droppers are used. **[1]**

Accept: Q3: Any two diameters compared accurately against 50% of plain-water drop counts (half-counts: 9, 11, 14, or 16 drops across 16–22 mm). | Q4: Equivalent valid working showing substitution, intermediate figures, and IB SI units matching requested precision.

Do not accept: Q3: Restating drop counts without computing % loss or hydrogen-bond cohesion mechanism. | Q4: Bare final numbers without working, swapped numerator/denominator, or missing/incorrect IB SI units.

Part C · Evaluate & Redesign the Investigation Mark Scheme [3 marks]

Q5: Gravimetric dropper calibration [3]

- (a) Tare a dry beaker on a 0.01 g balance and dispense a fixed counted number (e.g., 20 drops) from Tip A. **[1]**
- (a) Divide total mass (g = cm^3) by drop count to find mean volume per drop, then repeat identically for Tip B. **[1]**
- (b) Weighing 20 pooled drops makes total mass ~20× larger than balance resolution (±0.01 g), lowering percentage error. **[1]**

Accept: Q5: Any valid controlled design specifying equal baseline treatments, independent replicates, and measurable DV.

Do not accept: Q5: Vague repeats ('repeat more times') without stating independent replicates, controls, or measured DV.

Optional Challenge (+3 marks · Extension) Mark Scheme

- [1] Drop counts at 45 °C sit lower than the 20 °C line at all coin diameters.
- [1] Higher temperature increases molecular kinetic energy so hydrogen bonds break more readily.
- [1] Weaker surface cohesion causes the water dome to spill at a smaller volume.

Accept: Equivalent causal chain linking molecular/ecological mechanism directly to the prediction. | **Do not accept:** Restating the prompt trend without biological mechanism.

Teacher Pacing, EAL & Safety Check: Stage 1 (Full EAL Scaffold · A1.1): Mark via Friday Deck (Specimen Slide 6). Model Key Words (surface tension, cohesion) aloud and verify IB SI units before marking Part B.