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Water and sustainability

Practical Test

Marking scheme

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QUADRAAM GELDERSE ONDERWIJS GROEP

Radboud Universiteit

IN·DEI·NOMINE·FELICITER

Hogeschool van Arnhem en Nijmegen

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The contractile vacuole of *Paramecium*

1. **Maximum score 1.0**

· three correctly identified hypotheses (— 0.3 per incorrect hypothesis) 0.6
· all pairings correct (— 0.2 per incorrect pairing) 0.4

Table A1 – *Hypothesis and prediction*

	Hypothesis	**Prediction**
1	b	e
2	c	a
3	d	a

2. **Maximum score 2.1**

· micropipette set to 5 µL 0.4
· microscope set to 40x and droplet in focus 0.8
· on average nine or more living *Paramecia* in a droplet 0.9

Remarks:
- *If on average six, seven or eight living Paramecia in a droplet, assign 0.5 points instead of 0.9 points for the third dot.*
- *If on average fewer than six living Paramecia in a droplet, assign 0.0 points instead of 0.9 points for the third dot.*

3. **Maximum score 0.7**

· answer B 0.7

4. **Maximum score 3.9**

· per tabulated value 0.05
· per column: if the median falls within the expected range (see explanation below) 1.5

Explanation:
Scores per column (i.e. per Paramecium *environment) are calculated as follows:*
- *The contraction frequencies for 25* ***'P—'*** Paramecia *and 25* ***'P+'*** Paramecia *are determined by an expert microscopist on the day of the test. The frequencies are ordered from small to large per environment (*i.e. *for* ***'P—'*** *and* ***'P+'****). The* ***median*** *of the 25 contraction frequencies is determined per environment.*
- *The 95% confidence interval (CI)* ***of the median*** *runs from the expert's 7th frequency to the expert's 18th frequency. Student results (columns) that have medians falling within this interval receive full marks (1.5 points).*
- *The 99.9% CI* ***of the median*** *runs from the expert's 3rd frequency to the expert's 22nd frequency. Student results (columns) that have medians falling outside this interval receive no marks (0 points).*
- *Students results that have medians that fall outside the 95% CI, but within the 99.9% CI are graded 0.3 points lower for each consecutive expert's frequency below (for medians lower than the expert's median) or above (for medians higher than the expert's median) which the median value of their column lies.*

In summary, scores are awarded according to the table below:

range (expert's frequency no.'s)	*<3 or >22*	*[3,4] or [21, 22]*	*[4,5] or [20,21]*	*[5,6] or [19,20]*	*[6,7] or [18,19]*	*[7,18]*
Score	*0*	*0.3*	*0.6*	*0.9*	*1.2*	*1.5*

5. **Maximum score 0.9**

$f_{\text{contraction}} = 5/t_{6\ \text{contractions}}$

· calculation of the contraction frequency: division with numerator 5 0.2
· calculation of the contraction frequency: division with denominator $t_{6\ \text{contractions}}$ 0.2
· unit of $f_{\text{contraction}}$ is $[t]^{-1}$ (*i.e.* s^{-1} or min^{-1}), with corresponding numbers in table 0.1
· per correctly tabulated column (— 0.1 per mistake) 0.2

Remark
Correct values are calculated based on students' own observations

6. **Maximum score 0.8**

$$f_{\text{contraction, average, 'P—'}} = \frac{f_1 + f_2 + f_3 + f_4 + f_5 + f_6 + f_7 + f_8 + f_9}{9}$$

· insight that all frequencies for **'P—'** have to be summed 0.2
· dividing the sum by 9 (or the number of observations by the student) 0.2
· per correct result 0.2

Remark
Correct results are calculated based on students' own observations.

7. **Maximum score 0.2**

· for each correctly ordered column 0.1

8. **Maximum score 0.4**

· per correct result 0.2

Remark
Correct results are calculated based on students' own observations.

9. **Maximum score 0.8**

· Advantage: answer A 0.4

· Disadvantage: answer C 0.4

10. **Maximum score 0.8**

I NO
II YES
III NO
Iv NO

· per correct choice 0.2

11. **Maximum score 0.7**

· answer C 0.7

12. **Maximum score 0.7**

· answer B 0.7

Determining the chloride concentration of a sodium chloride solution using the Fajans titration

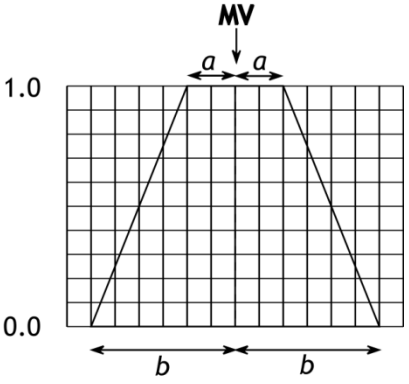
1. **Maximum score 1.9**

· mass(es) written down	0.1
· in g with three decimals	0.1
· volume(s) written down	0.1
· in mL with three decimals	0.1
· calculation of the density using the correct number of significant figures	0.2
· attention paid to an accurate determination, for example by performing the determination several (at least three) times and taking the average value (see also *Remarks*)	0.3
· result	1.0

Remarks:

- *If attention is paid to an accurate determination by performing the determination two times and taking the average value, then assign 0.2 points instead of 0.3 points for the sixth dot.*
- *If attention is paid to an accurate determination by pipetting multiple (at least three) times and using the combined volume and combined mass, then assign 0.2 points instead of 0.3 points for the sixth dot.*
- *If attention is paid to an accurate determination by pipetting two times and using the combined volume and combined mass, then assign 0.1 points instead of 0.3 points for the sixth dot.*
- *If the students did only 2 measurements and got the same result twice, full points are to be awarded for the sixth dot.*

The score for the result is calculated as follows:



If (MV – *a*) ≤ result ≤ (MV + *a*)	1.0
If (MV – *b*) ≤ result < (MV – *a*)	$\frac{result-(MV-b)}{b-a}$ × 1.0
If (MV + *a*) < result ≤ (MV + b)	$\frac{(MV+b)-result}{b-a}$ × 1.0
If result < (MV – *b*) or result > (MV + *b*)	0

Remarks:

- *The values for MV, a and b are determined by the organization.*
- *The result is calculated by the organization from the data given by the student.*

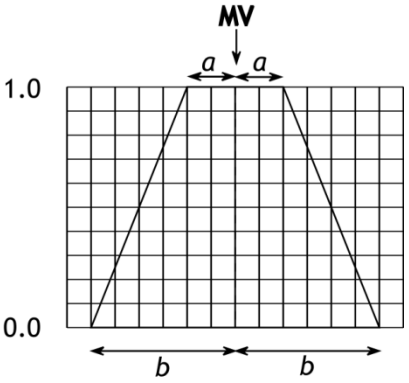
2. **Maximum score 1.9**

· mass(es) written down 0.1
· in g with three decimals 0.1
· volume(s) written down 0.1
· in mL with three decimals 0.1
· calculation of the density using the correct number of significant figures 0.2
· attention paid to an accurate determination, for example by performing the determination several (at least three) times and taking the average value or by pipetting multiple times and using the combined volume and combined mass (see also *Remarks*) 0.3
· result 1.0

Remarks:

- *If attention is paid to an accurate determination by performing the determination two times and taking the average value, then assign 0.2 points instead of 0.3 points for the sixth dot.*
- *If attention is paid to an accurate determination by pipetting multiple (at least three) times and using the combined volume and combined mass, then assign 0.2 points instead of 0.3 points for the sixth dot.*
- *If attention is paid to an accurate determination by pipetting two times and using the combined volume and combined mass, then assign 0.1 points instead of 0.3 points for the sixth dot.*
- *If the students did only 2 measurements and got the same result twice, full points are to be awarded for the sixth dot.*

The score for the result is calculated as follows:



If (MV – *a*) ≤ result ≤ (MV + *a*) 1.0

If (MV – *b*) ≤ result < (MV – *a*) $\frac{result-(MV-b)}{b-a}$ × 1.0

If (MV + *a*) < result ≤ (MV + *b*) $\frac{(MV+b)-result}{b-a}$ × 1.0

if result < (MV – *b*) or result > (MV + *b*) 0

Remarks:

- *The values for MV, a and b are determined by the organization.*
- *The result is calculated by the organization from the data given by the student.*

3. **Maximum score 0.4**

· all masses written down 0.3
· in g with three decimals 0.1

4. **Maximum score 0.85**

- calculation of the mass of sodium chloride solution used: subtracting the final mass from the initial mass 0.2
- calculation of the volume: dividing the mass of sodium chloride solution used by the calculated density 0.2
- three correctly calculated results 0.3
- correct dimension 0.15

Remark
If the volume is wrongly calculated, for example by dividing the density by the mass of the sodium chloride solution, the 0.3 points for the third dot are not assigned.

5. **Maximum score 0.85**

- calculation of the mass of silver nitrate solution used: subtracting the final mass from the initial mass 0.2
- calculation of the volume: dividing the mass of silver nitrate solution used by the calculated density 0.2
- three correctly calculated results 0.3
- correct dimension 0.15

Remark
If the volume is wrongly calculated, for example by dividing the density by the mass of the sodium chloride solution, the 0.3 points for the third dot are not assigned.

6. **Maximum score 0.4**

- calculation of the molar mass of $AgNO_3$ 0.2
- calculation of the molarity: dividing 20.00 g by the calculated molar mass of $AgNO_3$ 0.2

7. **Maximum score 2.9**

- calculation of the amount of mmol Ag^+ that has reacted: multiplying the volume of the silver nitrate solution calculated in question 5 by the calculated molarity 0.2
- calculation of the amount of mmol Cl^- that has reacted: is equal to the amount of mmol Ag^+ that has reacted (might be implicit) 0.2
- calculation of the molarity of Cl^-: dividing the amount of mmol Cl^- that has reacted by the calculated volume of the sodium chloride solution in question 4 0.2
- three correctly calculated results 0.3
- spreading 2.0

The score for the spreading is determined by calculating the standard deviation of the students' results (sd_{stud}) and comparing this with the 'ideal standard deviation' (sd_{id}).

If $sd_{stud} \leq 1.1 \times sd_{id}$ 2.0

If $1.1 \times sd_{id} < sd_{stud} \leq 2 \times sd_{id}$ $\frac{2 \times sd_{id} - sd_{stud}}{sd_{stud}} \times 2.0$

If $sd_{tud} > 2 \times sd_{id}$ 0

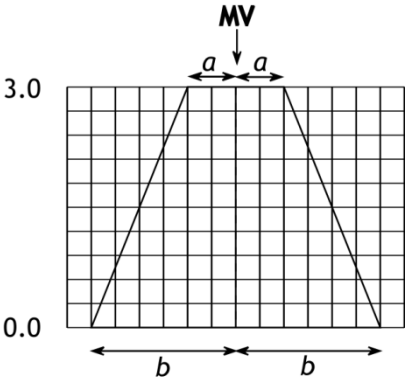
sd_{stud} is calculated by the organization from the students' results.

Remark
If the molarity of Cl^- is wrongly calculated, the 0.3 points for the fourth dot are not assigned.

8. **Maximum score 3.2**

· calculation of the average 0.2
· result 3.0

The score for the result is calculated as follows:



If (MV – *a*) ≤ result ≤ (MV + *a*) 3.0

If (MV – *b*) ≤ result < (MV – *a*) $\frac{result-(MV-a)}{b-a} \times 3.0$

If (MV + *a*) < result ≤ (MV + *b*) $\frac{(MV+b)-result}{b-a} \times 3.0$

If result < (MV – *b*) or result > (MV + *b*) 0

Remarks:

- *The values for MV, a and b are determined by the organization.*
- *The result is calculated by the organization from the data given by the student.*

9. **Maximum score 0. 6**

· calculation of the molar mass of sodium chloride 0.3
· calculation of the concentration in g/L 0.3

Blue energy

1. **Maximum score 1.2**

- concentrations written down in g/L 0.3
- log(*C*) correctly calculated 0.4
- measurements of *V* (in mV) are correct 0.5

The ranges for the measurements of *V* are as follows:

For **X0**: between — 3 and + 3 mV
For **X1**: between — 50 and — 20 mV
For **X2**: between — 20 and — 3 mV
For **X3**: between 0 and 12 mV
For **X4**: between 8 and 25 mV

For each value outside these ranges subtract 0.1 point.

2. **Maximum score 1.4**

- log(*C*) along *x*-axis 0.2
- *V* along *y*-axis 0.2
- no unit along *x*-axis, unit mV along *y*-axis 0.2
- grid optimally used 0.2
- data points clearly indicated 0.3
- best fit straight line drawn 0.3

3. **Maximum score 1.0**

- determination of *b* as the slope of the graph 0.5
- determination of *a* either by reading the intercept of the graph or by calculating from one point of the graph 0.5

4. **Maximum score 0.5**

- point (*x*,*y*) correctly indicated in Figure A1 0.2
- correct values for *x* ($\log C_0$) and *y* (*V*) 0.3

5. **Maximum score 0.9**

- correct method used for the calculation of C_0 (different methods are possible) 0.5
- correct result of the calculation 0.4

6. **Maximum score 0.4**

- Mistake in circuit is reduction of 0.4 points
- Incorrect AC/DC setting on multimeter is reduction of 0.2 points
- Minimum score for this question is 0 points

7. **Maximum score 1.0**

· concentrations correctly written down 0.1
· V_1 and V_2 correct 0.5
· all units in table are correct 0.4

The ranges for V1 and V2 are as follows:

For **X0**: V1 = 130 — 250 mV; V2 = 45 — 65 mV 0.1
For **X1**: V1 = 40 — 52 mV; V2 = 64 — 70 mV 0.1
For **X2**: V1 = 110 — 168 mV; V2 = 52 — 66 mV 0.1
For **X3**: V1 = 145 — 290 mV; V2 = 17 — 46 mV 0.1
For **X4**: V1 = 170 — 400 mV; V2 = 24 — 40 mV 0.1

For each value outside these ranges subtract 0.05 point.

8. **Maximum score 0.8**

· calculation of I: dividing V_1 by 100 0.4
· calculation of G: dividing I by V_2 0.4

9. **Maximum score 1.4**

· C along x-axis 0.2
· G along y-axis 0.2
· correct units along x-axis and along y-axis 0.2
· grid optimally used 0.2
· data points clearly indicated 0.3
· best fit smooth curve drawn 0.3

10. **Maximum score 0.8**

· C_0 correctly read from graph 0.4
· correct value for C_0 0.4

The score for the second dot is determined as follows:

If C_0 correct within 1 g/L 0.4
If C_0 correct within 2 g/L 0.3
If C_0 correct within 3 g/L 0.2
If C_0 correct within 4 g/L 0.1
If C_0 correct within 5 g/L 0.0

11. **Maximum score 0.8**

· correct value for I 0.2
· correct value for the diameter of the gold plate 0.2
· use of $A = \pi r^2$ for the calculation of A 0.2
· A correctly calculated 0.2

12. **Maximum score 0.4**

· using values for I and A from question 11 0.2
· rest of the calculation for σ of X0 0.2

13. **Maximum score 0.9**

· **X4** for salt water 0.2
· **X1** for fresh water 0.2
· ΔV correctly read from graph 0.5

14. **Maximum score 0.5**

· $G_{\text{salt}} = \frac{A}{l} \cdot \sigma_4 = 50000\ \sigma_4$ 0.2
· $G_{\text{fresh}} = \frac{A}{l} \cdot \sigma_1 = 50000\ \sigma_4$ 0.2
· unit S 0.1

15. **Maximum score 0.5**

· correct calculation of R_{int} 0.4
· unit Ω 0.1

16. **Maximum score 0.8**

· use of $I = \frac{\Delta V}{R_{\text{ext}} + R_{\text{int}}}$ 0.4
· rest of the calculation 0.4

17. **Maximum score 0.4**

· insight that (since the voltage across R_{ext} is $\frac{1}{2} \cdot \Delta V$) $P = \frac{1}{2} \cdot \Delta V \cdot I$ 0.2
· rest of the calculation 0.2

18. **Maximum score 0.3**

· the number of cells is $\frac{1 \cdot 10^6}{P}$ 0.2
· rest of the calculation 0.1