

Water and sustainability

Theoretical Test

Marking scheme

December, 7th 2017



Radboud Universiteit



Hogeschool



van Arnhem en Nijmegen

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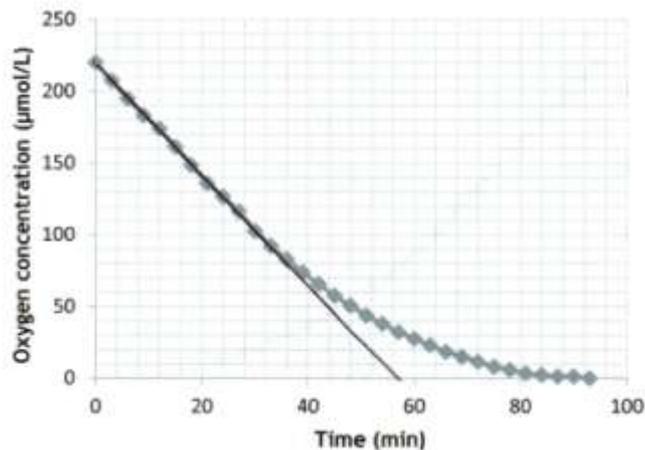
Biology questions

Plants in floodplains

1. Maximum score 1.2

An example of a correct calculation is:

The slope of the initial decline of the curve describes the maximum respiration rate per liter per minute. This slope is $\frac{220}{56}$ $\mu\text{mol}/(\text{L min})$ (see figure).



The volume of the box is 1.2 L, so the maximum respiration rate of the submerged plant is $\frac{220}{56} \times 1.2 = 4.7 \mu\text{mol}/\text{min}$ (range: $\pm 0.2 \mu\text{mol}/\text{min}$).

- notion that the slope of the initial decline of the curve describes the maximum respiration rate per liter per minute 0.4
- calculation of the slope 0.4
- multiplying the slope by 1.2 (L) 0.4

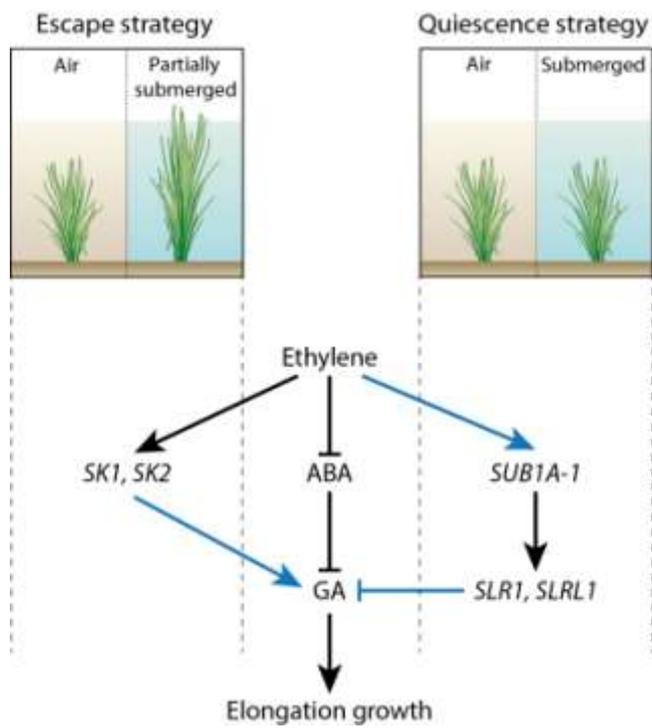
2. Maximum score 0.4

4.7 $\mu\text{mol}/\text{min}$

Remark

The answer should be the same as the result of the calculation of question 1.

3. Maximum score 1.2



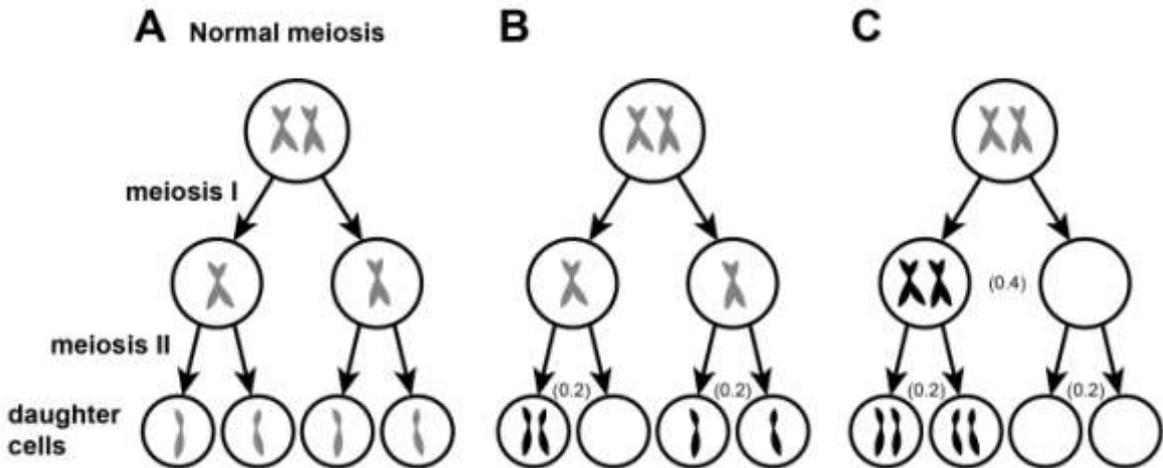
per correct interaction

0.4

Oysters

4. Maximum score 1.2

A correct answer may look as follows:



correct meiosis I step (from first to second row of C)
 per correct meiosis II step (second to third row of B and C)
 scores are also indicated in the figure above (in brackets).

0.4

0.2

Remark

Cells derived from the same cell can be permuted.

If in B the student gives a faulty meiosis II for all four daughter cells, he/she also receives full points.

If nothing is filled in on the second row of C, the student does not receive points for the empty cells on the third row.

5. Maximum score 0.8

Species	<i>O. edulis</i> (oyster)	<i>B. ostreae</i> (protist)
Role	III	IV

per correct answer

0.4

6. Maximum score 0.8

Parameter	p	q
Description	IV	VI

per correct answer

0.4

7. Maximum score 1.2

Parameter	a	b	c
Triploid vs. diploid	+	o	-

Explanation:

a : birth/growth rate of oyster: '[triploid oysters] grow and mature faster'.

b : death rate of oyster: no info provided

c : infection parameter: '[triploid oysters] are more resistant to infections'.

per correct cell

0.4

Remark

No points for empty cells.

Osmosis in fish

8. Maximum score 1.2

at location 1: → (arrow to the right)

at location 2: ← (arrow to the left)

at location 3: H (low % O₂)

at location 4: L (high % O₂)

- directions of both arrows at locations 1 and 2 are opposite 0.4
- if arrows are opposite and direction at locations 1 and 2 correct 0.4
- both indications at locations 3 and 4 correct 0.4

9. Maximum score 0.8

I swell up

II very little

III large

IV diluted

per correct answer

0.2

Anammox

10. Maximum score 1.2

Hypothesis	Experiment			Prediction	
I	A	(B)	C	(1)	2
II	(A)	B	C	(1)	2
III	A	B	(C)	(1)	OR (2)

- all pairings of I - III with A - C are correct 0.8
- if two pairing of I - III with A - C are correct 0.4
- if two pairing of I - III with A - C are correct 0.2
- all predictions correct 0.4
- if one or two pairing(s) of I - III with A - C is/are correct and the corresponding prediction correct 0.4
- if all pairings correct, but one prediction incorrect 0.2
- if no pairing is correct or no prediction is correct 0

Chemistry questions

Water and the fight against *Legionella*

11. Maximum score 1.2

An example of a correct answer is:

After x D-values the concentration is decreased to $0.10^x \times 1\,200$ cfu/L. So to reach a level of 100 cfu/L: $0.10^x \times 1\,200 = 100$. This gives $x = 1.08$.

So after heating during $1.08 \times 5 = 5.4$ min the concentration of *Legionella* in the water is below the level that is regarded as safe.

- after x D-values the concentration is decreased to $0.10^x \times 1\,200$ cfu/L 0.4
- calculation of x 0.4
- rest of the calculation 0.4

12. Maximum score 1.6

An example of a correct answer is:

The equilibrium is: $\text{HClO} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{ClO}^-$

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{ClO}^-]}{[\text{HClO}]} \text{ or } [\text{H}_3\text{O}^+] = K_a \frac{[\text{HClO}]}{[\text{ClO}^-]}$$

So when $[\text{H}_3\text{O}^+] > K_a$ then $[\text{HClO}] > [\text{ClO}^-]$ or $\text{pH} < \text{p}K_a$. $\text{p}K_a = -\log 4.0 \cdot 10^{-8} = 7.40$.

In the pH region below 7.40 $[\text{HClO}] > [\text{ClO}^-]$.

- correct expression for K_a 0.4
- when $[\text{H}_3\text{O}^+] > K_a$ then $[\text{HClO}] > [\text{ClO}^-]$ 0.4
- calculation of the pH value 0.4
- this is a maximum pH 0.4

Remark

If the student gives the wrong number of significant figures, no points will be subtracted.

13. Maximum score 1.2

- half-reaction of the reducing agent: $\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$ 0.4
- half-reaction of the oxidizing agent: $2\text{HClO} + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{Cl}_2(\text{aq}) + 2\text{H}_2\text{O}$ 0.4
- overall reaction equation: $\text{Cu(s)} + 2\text{HClO(aq)} + 2\text{H}^+(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{H}_2\text{O(l)} + \text{Cl}_2(\text{aq})$ 0.4

If the following answer is given: 0.8

half-reaction of the reducing agent: $2\text{HClO} + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{Cl}_2(\text{aq}) + 2\text{H}_2\text{O}$

half-reaction of the oxidizing agent: $\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$

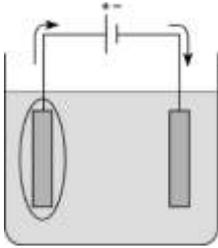
overall reaction equation: $\text{Cu(s)} + 2\text{HClO(aq)} + 2\text{H}^+(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{H}_2\text{O(l)} + \text{Cl}_2(\text{aq})$

Remarks:

- *When the student gives an equation like $\text{Cu(s)} - 2\text{e}^- \rightarrow \text{Cu}^{2+}(\text{aq})$ no points will be subtracted.*
- *No points will be subtracted for missing or incorrect state indications.*

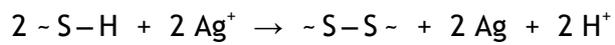
14. Maximum score 0.8

A correct answer may look as follows:



- correct electrode indicated 0.4
- flow of the electrons correct in relation to indicated electrode 0.4

15. Maximum score 0.8



- 2 $\sim S-H$ left and 2 H^+ right 0.4
- 2 Ag^+ left and 2 Ag right 0.4

16. Maximum score 0.4

The reaction of silver ions with $\sim S-H$ groups in one protein chain results in a change of the tertiary structure of the protein.

Wastewater treatment

17. Maximum score 1.2

An example of a correct answer is:

$$0.632 \times 2 \times 32.00 \times 10^{-3} \times 175\,000 \times 365 \times 3 \times 0.19 = 1.5 \cdot 10^6 \text{ euros}$$

- calculating the number of moles of oxygen needed per inhabitant per day: multiplying 0.632 (moles) by 2 0.4
- converting the number of moles of oxygen needed into kg oxygen needed per inhabitant per day: multiplying by the molar mass of oxygen (= 32.00 g/mol) and by 10^{-3} (kg/g) 0.4
- converting the amount of kg oxygen needed per inhabitant per day into kg oxygen per year for the population of Nijmegen: multiplying by 175 000 (inhabitants) and by 365 (days per year) 0.2
- converting the amount of kg oxygen per year for the population of Nijmegen into the costs per year: multiplying by 3 (kWh per kg oxygen) and by 0.19 (€ per kWh) and the answer lies in between $1.47 \cdot 10^6$ euros and $1.5 \cdot 10^6$ euros 0.2

Remark

If the answer is given as 1 470 000 euros or 1 500 000 euros no points are subtracted.

18. Maximum score 1.6

An example of a correct answer is:

$$\frac{2-0.75}{2} \times 100\% = 63\%.$$

- oxidizing one mole of NH_4^+ to NO_3^- in the conventional process requires 2 moles of oxygen 0.4
- oxidizing one mole of NH_4^+ to NO_2^- in the anammox process requires 1.5 moles of oxygen 0.4
- only half of the amount of NH_4^+ has to be oxidized 0.4
- calculation of the percentage reduction 0.4

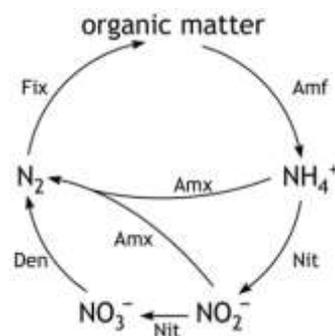
If the answer $\frac{2-1.5}{2} \times 100\% = 25\%$ is given: 1.2

If the answer $\frac{3-1}{3} \times 100\% = 67\%$ is given 0.8

If the answer $\frac{3-2}{3} \times 100\% = 33\%$ is given 0.4

19. Maximum score 1.2

A correct answer may look as follows:



- NH_4^+ connected with N_2 via NO_2^- and NO_3^- 0.4
- 'Nit' and 'Den' in the right place 0.4
- shortcut 'Amx' from NH_4^+ to N_2 and shortcut 'Amx' from NO_2^- to N_2 0.4

Physics questions

Wind energy

20. Maximum score 0.4

$$P = 8P_0 \text{ (W)}$$

21. Maximum score 1.6

An example of a correct answer is:

$$P = \frac{1}{2} \times \pi \times \left(\frac{80}{2}\right)^2 \times 1.2 \times \left(\frac{36 \times 10^3}{3600}\right)^3 \times 0.70 \times 0.59 = 1.2 \cdot 10^6 \text{ W}$$

- calculation of the area that is covered by the sails: $\pi \times \left(\frac{80}{2}\right)^2$ 0.4
- calculation of the wind speed in m/s: multiplying 36 (km/h) by 10^3 (m/km) and dividing by 3600 (s/h) 0.4
- applying the factor 0.70×0.59 0.4
- completion of the calculation 0.2
- answer in 2 or 3 significant figures 0.2

22. Maximum score 1.2

An example of a correct answer is:

The volume of water that has to be pumped is $V = \frac{m}{\rho} = \frac{3.3 \cdot 10^{11}}{1.03 \cdot 10^3} = 3.2 \cdot 10^8 \text{ m}^3$.

The height difference is $h = 40.0 - 32.0 = 8.0 \text{ m}$.

So the area of the reservoir is $A = \frac{V}{h} = \frac{3.2 \cdot 10^8}{8.0} = 4.0 \cdot 10^7 \text{ m}^2$.

- use of $A = \frac{V}{h}$ 0.4
- use of $V = \frac{m}{\rho}$ 0.4
- completion of the calculation 0.2
- answer in 2 or 3 significant figures 0.2

23. Maximum score 2.0

An example of a correct answer is:

The increase in potential energy is: $\Delta E_p = mg\Delta h = 3.3 \cdot 10^{11} \times 9.81 \times \frac{1}{2} \times (40.0 + 32.0) = 1.17 \cdot 10^{14} \text{ J}$.

The total average power of the wind turbines is $75 \times 5.0 \cdot 10^6 = 375 \cdot 10^6 \text{ W}$.

Since $E = Pt$, and $E = \Delta E_p$, it follows that $t = \frac{\Delta E_p}{P} = \frac{1.17 \cdot 10^{14}}{375 \cdot 10^6} = 3.11 \cdot 10^5 \text{ s}$ or $\frac{3.11 \cdot 10^5}{3600} = 86 \text{ h}$.

- insight that $\Delta E_p = mg\Delta h$ 0.4
- insight that $\Delta h = \frac{1}{2} \times (40.0 + 32.0) \text{ m}$ 0.4
- calculation of ΔE_p 0.4
- use of $E = Pt$ 0.4
- completion of the calculation 0.2
- answer in 2 or 3 significant figures 0.2

24. Maximum score 1.2

Yes	No	Question
	√	Because of its location at sea, nobody is annoyed by this plant.
√		In this plant, energy can be stored and subsequently be used in the absence of wind.
√		In this plant, energy can be stored and subsequently be used whenever necessary.
	√	This plant is a cheap way of generating electricity.
√		This plant can supply a constant power.
√		The power supply of this plant can be adapted to the demand.
	√	This plant can replace a number of coal-fired power stations.
	√	This plant does not expel CO ₂ .

Per correct answer

0.15

Remark:

For every wrong argument 0.15 points deduction. The total score for this question cannot be less than 0 points.

Room for the river

25. Maximum score 0.8

An example of a correct derivation is:

$$\text{For } n \text{ holds: } n = \frac{A}{Q} D^{2/3} S^{1/2}$$

So the unit of n is: $\frac{\text{m}^2}{\text{m}^3/\text{s}} \text{m}^{2/3}$ or $\text{s}/\text{m}^{1/3}$.

- all units correctly used 0.4
- rest of the derivation 0.4

26. Maximum score 1.2

An example of a correct calculation is:

$$D = \left(\frac{0.10 \times 1.4 \cdot 10^4 \times 0.018}{200 \times (5.0 \cdot 10^{-4})^{1/2}} \right)^{3/5} = 2.8 \text{ m.}$$

- multiplying $1.4 \cdot 10^4$ (m^3/s) by 0.10 0.4
- use of the correct values of D , W and S 0.4
- completion of the calculation 0.2
- answer in 2 or 3 significant figures 0.2

27. Maximum score 1.6

An example of a correct calculation is:

$$0.99 \times 0.99^{2/3} \times \frac{0.018}{0.022} \times 10\% = 8.0\%.$$

- insight that A decreases by 1% 0.4
- insight that because of the decrease in D of 1%, the drain decreases by a factor $0.99 \times 0.99^{2/3}$ 0.4
- insight that when n increases by a factor $\frac{0.022}{0.018}$, the drain decreases by a factor $\frac{0.018}{0.022}$ 0.4
- completion of the calculation 0.2
- answer in 2 or 3 significant figures 0.2

Remark

If D of previous question is used, correct calculation gives the same answer and same amount of marks.