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Water and sustainability

Multiple Choice Test

Answer key

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Answer key

Biology questions

Rate of flow of blood

1. **D**
   On average the total amount of blood running should stay the same (in fact slightly less in capillary vessels and vein due to run off of lymph through lymph vessels, but this influence can be neglected). So roughly the rate of flow will be a flipped version of the cross section area ⇒ D is correct.

Fermentation and Respiratory Quotient RQ

2. **C**
   Assume *a* mol is converted aerobically, so (0.5 – *a*) mol glucose is converted anaerobically.
   This means that 6*a* mol CO_2 (aerobically) plus 2×(0.5 - *a*) mol CO_2 (anaerobically) is generated while 6*a* mol O_2 is used.
   Total amount generated mol CO_2 = 6*a* + 2×(0.5 - *a*) = 4*a* + 1 and this equals 1.8, so *a* = 0.2.
   In other words: 1.8 mol CO_2 is generated and 6×0.2=1.2 mol O_2 is used.
   $$RQ = \frac{\text{moles of CO2 (produced)}}{\text{moles of O2 (used)}} = \frac{1.8}{1.2} = 1.5$$

Glucose concentration in blood

3. **A**
   Liver is essential as it releases glucose. So D is highest.
   From liver vein the blood flows into posterior (inferior) vena cava (C). There it is mixed with lower glucose containing blood stream coming from lower body parts. After right atrium and ventricle of the heart blood flows to lungs where some glucose is consumed. After that it flows back through pulmonary artery (B) to the heart. Next blood leaves the heart by aorta and flows partly to the brains (again some glucose consumption) and other body parts. From upper body finally blood returns to the heart by anterior (superior) vena cava (A).

Sphagnum

4. **C**
   At some places (especially East part) *Sphagnum squarrosum* exist while pH<4.0, so conclusion I is wrong. *Sphagnum recurvum* and *Sphagnum fibriatum* are neighbors and do not mix. The boundary is sharp, but does not overlap with the pH boundaries. So competition must exist. Conclusion II is correct.
   The picture shows that *S. squarrosum* and *S. recurvum* exist in different pH ranges: *S. squarrosum* doesn't occur where pH<3, while *S. recurvum* doesn't exist where pH>4. So III is correct.

Hay water

5. **A**

I The beaker only contains heterotrophic organisms which are dissimilating and consuming organic materials. No organic compounds are produced by something like photosynthesis. So mass must decrease.

II The heterotrophic organisms are continuously using organic compounds, which will run out. Their number will gradually decrease to zero. A climax stadium will not be established.

Determination of Caminalcules

6. **D**

See table. Features present are indicated with √ for I up to VIII.
With focusing only on long arms, long body and belly spots it is possible to identify all eight creatures. Fingers, only present in II and VII, are not needed.

Feature	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**
Long arms				√	√	√	√	
Long body	√		√	√			√	
Belly spots		√	√		√		√	
Fingers		√					√	

Water loss

7. **B**

Diffusion of water through skin (do not mix up with sweating) is not influenced by body activity and must be constant. So this is II → A and C are incorrect. Strenuous activity will result in extra air inhalation (breathing), causing extra water loss by lung ventilation. This must be process I. Meanwhile this extra water loss will result in reduction of urine production (process III).

Temperature-sensitive alleles

8. **A**

Genotype F1 is: ¼ EE + ½ Ee + ¼ ee, but EE will not develop at 19 °C, so F1 offspring is ⅔ Ee and ⅓ ee.
The combination EE again will not develop. The fraction of genotype EE in F2 will be: ½ × ⅔ (Ee) × ½ × ⅔ (Ee) = 1/9.

DNA and evolutionary relationship

9. **C**

A & D and C & E are most related (short distance) and must be close together in the dendogram.
D & E and D & C must be far from each other in the dendogram as they are least related (i.e. largest distance). The only dendogram matching with these statements is C.

Legionella

10. **A**

(670 – 199)/3 = 157, an integer result, so the T at position 671 is the first base of a new codon. This codon is T T C on the coding strand, which is transcribed into RNA as U U C, which is translated into Phe. The next codon is A G T, which is transcribed into A G U and translated into Ser, so answer A is correct.

Chemistry questions

Photosynthesis by algae

11. **B**
In photosynthesis carbon dioxide and water are converted and oxygen is formed.

12. **D**
On the right side only neutral molecules are written.
1 HPO_4^{2-} and 16 NO_3^- are needed to supply the P and N atoms in $C_{106}H_{263}O_{110}N_{16}P$.
1 HPO_4^{2-} and 16 NO_3^- have 18 negative charges, so 18 positive charges at the left side are needed to obtain neutrality.

Green chemistry

13. **B**
The atom economy represents how much of the starting materials gets into the products. The higher the better.
The *E*-factor represents how much waste is obtained. The lower the better.

Determination of oxygen

14. **C**
If the burette is not rinsed with the solution of sodium thiosulfate, this solution is diluted with the water from the inside of the burette. Because of this V_{thio} will be too high and consequently the result.
If there is air in the tap aperture of the burette, in the beginning of the titration the level of the solution in the burette goes down while no solution leaves the burette. Because of this V_{thio} will be too high and consequently the result.

15. **B**
V_{thio} mL 0,0100 M sodium thiosulphate solution contains $V_{thio} \times 0.0100$ mmol $S_2O_3^{2-}$; this has reacted with $\frac{1}{2} \times V_{thio} \times 0.0100$ mmol I_2 and to form this amount of I_2, in the first reaction $\frac{1}{2} \times \frac{1}{2} \times V_{thio} \times 0.0100$ mmol O_2 has reacted with iodide.
$\frac{1}{2} \times \frac{1}{2} \times V_{thio} \times 0.0100$ mmol O_2 is $\frac{1}{2} \times \frac{1}{2} \times V_{thio} \times 0.0100 \times 32.00$ mg.
This was dissolved in 10.00 mL surface water. So the O_2 concentration in the surface water is $\frac{1}{2} \times \frac{1}{2} \times V_{thio} \times 0.0100 \times 32.00 \times \frac{10^3}{10.00} = 8.00 \times V_{thio}$ mg/L.

Fertilizer from urine

16. **D**
From figure 1 it can be seen that at pH = 8 the predominant phosphate species is HPO_4^{2-} and from figure 2 it can be seen that at pH = 8 the predominant ammonium species is NH_4^+.

Hydrogen fuel cell

17. **C**

In an electrochemical cell, the electrode where the oxidator, in this case oxygen, reacts is the positive electrode . The other electrode is the negative electrode.

No CO_2

18. **C**

$\Delta_r H = -\Delta_f H_{CO_2} + \Delta_f H_{CO} + \Delta_f H_{H_2O}$ = –(–394) + (–111) + (–242) = +41 kJ/mol.

The reaction enthalpy is positive, so the reaction is endothermic.

19. **A**

According to Le Chatelier's principle an increase in pressure leads to a decrease in the number of gas molecules.
And an increase in temperature favors the endothermic reaction.

Fertilizers

20. **C**

All three fertilizers have the same amount of N atoms per mol. So the one with the least molar mass has the highest mass percentage of N.
The molar masses are:
$(NH_4)_2SO_4$: 132.14 g/mol
$CaCN_2$: 66.02 g/mol
$CO(NH_2)_2$: 60.06 g/mol.

Physics

Solar Shower

21. **C**

The amount of heat the water takes up is:
$Q = mc\Delta T = 15 \times 4.2 \cdot 10^3 \times (35 - 18) = 1.07 \cdot 10^6$ J.

The heating time can be calculated as: $t = \frac{Q}{P} = \frac{1.07 \cdot 10^6}{200} = 5.33 \cdot 10^3$ s and that is $\frac{5.33 \cdot 10^3}{3600} = 1.5$ h.

Liquid and vapor

22. **C**

Because $\rho = m/V$, the density of the vapor becomes 1000 times lower than the density of the liquid. It is easy to see that statement II is also correct.

Hydro pneumatic suspension

23. **B**

$p = 1.0 \cdot 10^5 + \frac{4000}{200 \cdot 10^{-4}} = 3.0 \cdot 10^5$ Pa

Heating paraffin

24. **B**

The specific heat capacity of the solid and liquid paraffin is indicated by the *slopes* of the first and the last part of the graph, respectively. If the slope is steeper, the heat capacity is lower, so the heat capacity of liquid paraffin is higher than the heat capacity of solid paraffin, so statement I is false.
During melting, the temperature is constant, so the kinetic energy of the molecules is constant, so only the potential energy of the molecules increases. N.B. The work done on the environment is neglected here.

A little boat and a bottle in the river

25. **B**

Because we are considering relative motions here, we can omit the motion of the river for the time being. In that case, the boat travels for 10 minutes in one direction followed by 10 minutes in the opposite direction after which it overtakes the bottle. In truth, the bottle has covered a distance of 3 km in 20 minutes, so the speed of the river is 3 km per 1/3 hour, so 9 km/h.

Electric circuit

26. **B**

When the slide is displaced towards X, the total resistance in the circuit increases. As a result, both the current in, and the voltage over Q decrease. The voltage across P must increase, because the sum of the voltages is equal to the voltage of the source. This means that the current in P will also increase.

Super tanker

27. **A**

The density of salt water is higher than the density of fresh water, so the buoyancy of a volume of salt water is higher than the buoyancy of the same volume of fresh water. Hence, the tanker will displace a larger volume of fresh water and will have a deeper draft in the river, which contains fresh water.

Electricity storage

28. **C**

$E_{rot} = \frac{1}{2} I\omega^2$, with $I = \frac{1}{2} mR^2$

Thus $E = \frac{1}{4} mR^2\omega^2 = \frac{1}{4} \times 1\,350 \times 0.45^2 \times \left(\frac{20\,000 \times 2\pi}{60}\right)^2 = 3.0 \cdot 10^8$ J.

Sky crane

29. **D**

The thrust force is pointed diagonally upwards and is larger than its vertical component. Together, the vertical components must equal the gravitational force F_g. So $F_{thrust} > \frac{1}{4} F_g$

Properties of water

30. **C**

Because of its high heat capacity, a lot of heat is needed to increase the temperature of a volume of water and, the other way round, a lot of heat is emitted when it cools down. Thus, water limits temperature changes in its surroundings: statement I is correct.

Because the density of water of + 4 ^{0}C is greater than the density of water between 0 ^{0}C and 4 ^{0}C, the bottom of the ditch will contain water of + 4 ^{0}C: statement 2 is also correct.