IJSO

14th INTERNATIONAL JUNIOR SCIENCE OLYMPIAD

THE NETHERLANDS 2017

Water and sustainability

Multiple Choice Test

December, 5th 2017

Carefully read the "EXAMINATION RULES" and "EXAM INSTRUCTIONS"

QUADRAAM

Radboud Universiteit

Hogeschool van Arnhem en Nijmegen

slo

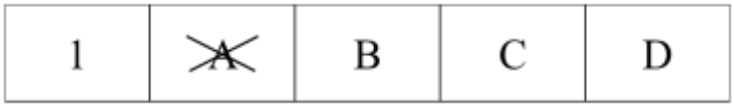
EXAMINATION RULES

1. You are NOT allowed to bring any personal items into the examination room, except for the water bottle, personal medicine or approved personal medical equipment.
2. You must sit at your designated desk.
3. Check the stationery items (pen, calculator, and scrap paper) provided by the organizers.
4. Do NOT start answering the questions before the **"START"** signal.
5. You are NOT allowed to leave the examination room during the examination except in an emergency in which case you will be accompanied by a supervisor/volunteer/invigilator.
6. If you need to visit the bathroom, please raise your hand.
7. Do NOT disturb other competitors. If you need any assistance, raise your hand and wait for a supervisor to come.
8. Do NOT discuss the examination questions. You must stay at your desk until the end of the examination time, even if you have finished the exam.
9. At the end of the examination time you will hear the **"STOP"** signal. Do NOT write anything more on the answer sheet after this stop signal. Arrange the exam, answer sheets, and the stationary items (pen, calculator, and scrap paper) neatly on your desk. Do NOT leave the room before all the answer sheets have been collected.

EXAM INSTRUCTIONS

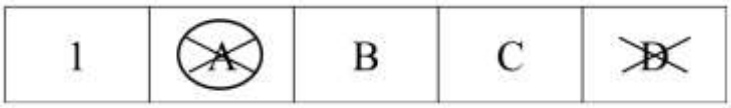
1. After the "START" signal, you will have 3 hours to complete the exam.
2. ONLY use the pen and pencil provided by the organizers.
3. Check that your name, code and country are on your answer sheet and sign your answer sheet. Raise your hand, if you do not have the answer sheet.
4. Read each problem carefully and indicate your answer on the answer sheet using a cross (as shown below). There is only one correct answer for each question.

   Example: (A) is your answer.



5. If you want to change your answer, circle your first answer and then indicate your new answer using a cross (as shown below). You can only make ONE correction per question.

   Example: (A) is your first answer and (D) is your final answer.



6. Only the answer sheet will be evaluated. Before writing your answers on the answer sheet, use the scrap paper provided.
7. Point rules

Correct answer	: + 1 point
Wrong answer	: − 0.25 point
No answer	: no point

8. The total number of questions is 30. Check that you have a complete set of the test questions (15 pages, page 5 – page 19) after the "START" signal is given. Raise your hand, if you find any missing sheets.
9. Useful information for answering the questions (atomic masses, constants and formulas) is provided on page 4.

GENERAL INFORMATION

The first twenty elements of the Periodic System with their standard atomic weights							
H 1.008							**He** 4.003
Li 6.941	**Be** 9.012	**B** 10.81	**C** 12.01	**N** 14.01	**O** 16.00	**F** 19.00	**Ne** 20.18
Na 22.99	**Mg** 24.31	**Al** 26.98	**Si** 28.09	**P** 30.97	**S** 32.06	**Cl** 35.45	**Ar** 39.95
K 39.10	**Ca** 40.08						

Constants

acceleration due to gravity: $g = 9.81\ \mathrm{m/s^2}$

gas constant $R = 8.3145\ \mathrm{J/(mol\ K)}$

Formulas

area of a circle: $A = \pi r^2$

circumference of a circle: $C = 2\pi r$

volume: $V = Ah$

density: $\rho = \frac{m}{V}$

pressure: $p = \frac{F}{A}$

heat: $Q = mc\Delta T$

power: $P = \frac{E}{t}$

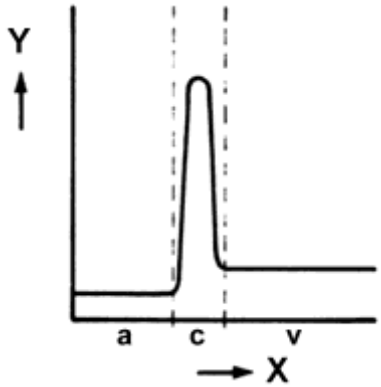
gravitational potential energy: $E_p = mgh$

Ohm's law: $V = IR$

Biology questions – Corrected version

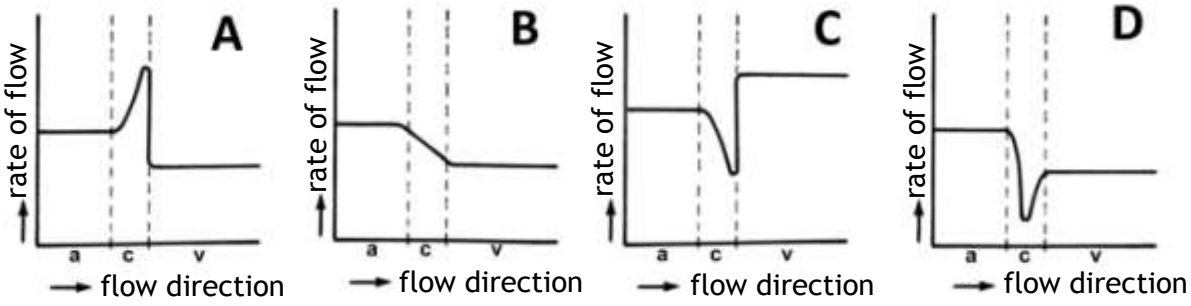
Rate of flow of blood

In a muscle in the upper arm of a human, blood runs through arteries, capillary vessels and veins. The picture shows the total area of a cross section of one of these arteries (a), the subsequent capillary vessels (c) and the corresponding returning veins (v).



X = direction of the blood flow
Y = total area of cross section

1. Which of the following pictures correctly shows the rate of flow (velocity) of the blood through an artery, a capillary vessel and a vein concerned?



Fermentation and Respiratory Quotient RQ

Floris investigates the conversion of glucose by yeast. The glucose is converted anaerobically as well as aerobically. Consider the reaction equations:

Aerobic: $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$
Anaerobic: $C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$

Floris starts off with a solution containing 0.50 mol of glucose and some yeast. By measuring the loss of mass he is able to determine the amount of CO_2 generated.

When all the glucose is converted, the total loss in mass due to the generation of CO_2 is 79.2 g (= 1.8 mol CO_2). Floris assumes that no carbon dioxide remains in the solution. Now Floris is able to calculate the Respiratory Quotient of the process.

The Respiratory Quotient is defined as:

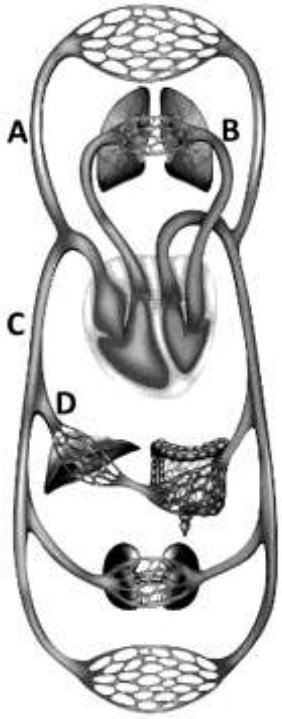
$$RQ = \frac{\text{moles of } CO_2 \text{ (produced)}}{\text{moles of } O_2 \text{ (used)}}$$

2. What is the correct Respiratory Quotient?

A $RQ = 0.67$
B $RQ = 1.2$
C $RQ = 1.5$
D $RQ = 1.8$

Glucose concentration in blood

The picture shows blood circulation in a mammal.
Four locations are indicated by A, B, C and D.

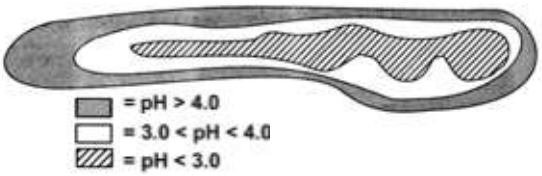


3. Which location has the lowest glucose concentration?

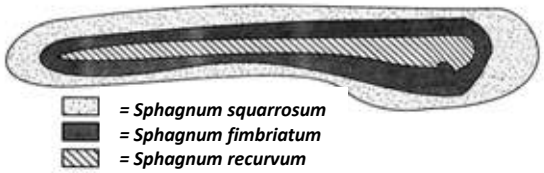
Sphagnum

The distribution of *Sphagnum* (moss) species is influenced by pH, but not by other abiotic factors.
After a long period of stable weather conditions Tom investigates the distribution of three different *Sphagnum* species on a small island surrounded by brackish water. The results are shown below.

pH distribution



moss distribution



Three conclusions are:

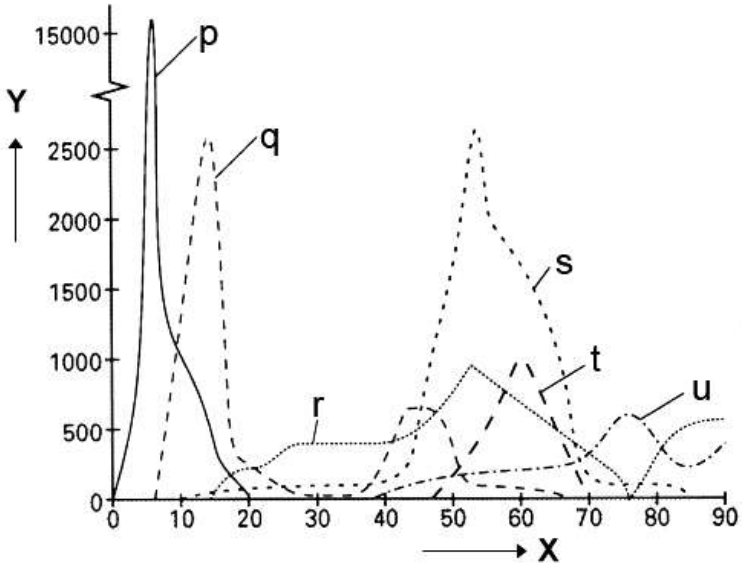
I *Sphagnum squarrosum* can only survive if pH > 4.0.
II Competition occurs between *Sphagnum recurvum* and *Sphagnum fimbriatum*.
III *Sphagnum recurvum* and *Sphagnum squarrosum* have overlapping habitats.

4. Which conclusion(s) are correct?

A only II
B only I and III
C only II and III
D I, II and III

Hay water

Mary boiled water and dried grass in a beaker for some time, and left it uncovered for several days. During that period only heterotrophic bacteria were found in the beaker. After ten days, she added a few drops of water from a ditch and covered it with a lid. The water from the ditch only contained heterotrophic unicellular organisms, but no bacteria or fungi. Mary regularly determined the population size of the different species present in the beaker over three months. Alltogether six different species (p - u) were found. The diagram shows the number of individuals per mL in the beaker.



X = Time (days); Y = number of individuals per mL

Looking at the results Mary considers two conclusions.

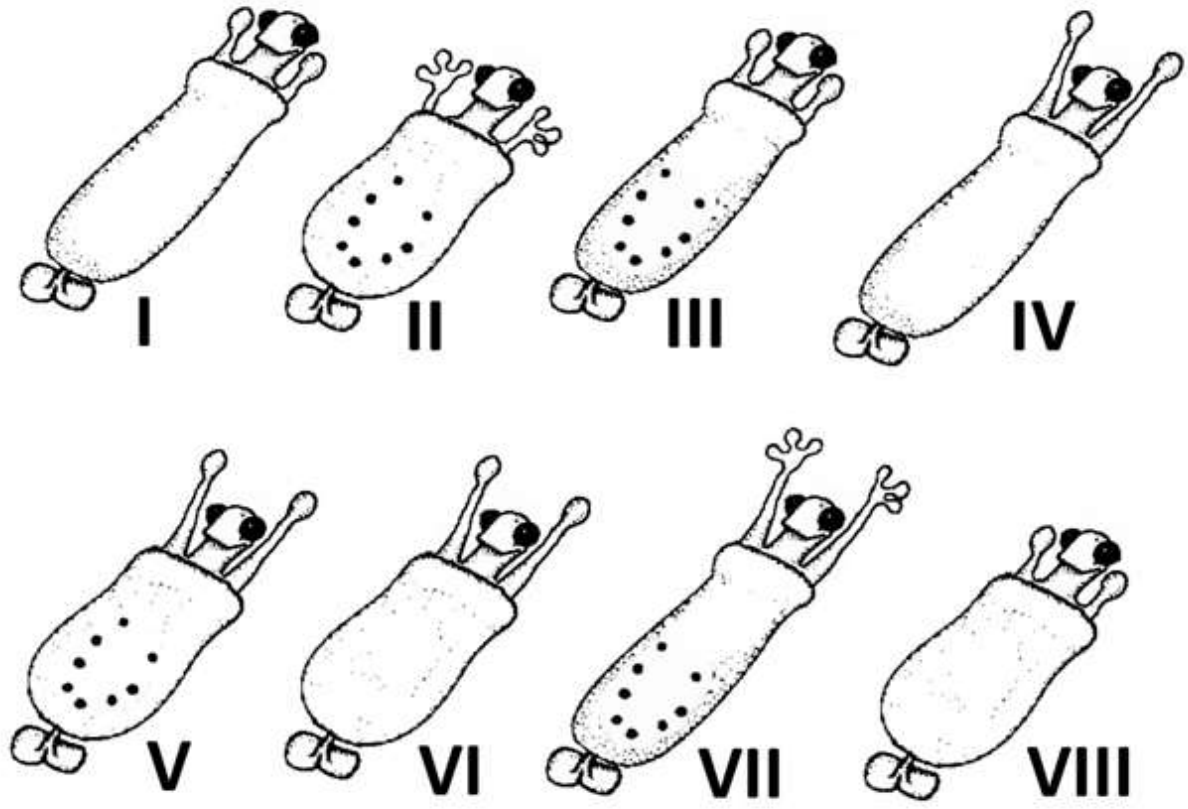
I Eventually the number of dividing bacteria will decrease to zero.
II Eventually a climax stage will develop, comprising bacteria and other heterotrophic unicellular organisms, in a stable natural equilibrium.

5. Which conclusion(s) is/are correct?

A only I
B only II
C both I and II
D neither I nor II

Identification of Caminalcules

In modern biology DNA plays an important role in distinguishing different species. In the past this was done primarily by considering external characteristics. The picture below shows *Caminalcules*: non-existent creatures invented by Joseph Camin to demonstrate to his students how to distinguish species and set up evolutionary trees.



The eight *Caminalcules* shown can be distinguised with just three of the following four features:
Long arms, long body, presence of belly spots, and presence of fingers.

6. Which of the following four features is **NOT** needed?

   A long arms
   B long body
   C presence of belly spots
   D presence of fingers

Water loss

In a pilot study the daily water loss of a group of subjects is monitored under different conditions. Three processes are monitored: diffusion (not sweating) of water through skin, lung ventilation, and urine production.
The table shows the results in a random order.

	Average daily loss of water in mL/day		
	mild exercise at 20 °C	mild exercise at 30 °C	strenuous exercise at 20 °C
Process I	350	250	650
Process II	50	50	50
Process III	1400	1300	600

7. Which processes correspond to lung ventilation and urine production?

	lung ventilation	urine production
A	process I	process II
B	process I	process III
C	process II	process III
D	process III	process I

Temperature-sensitive alleles

Some fly species have alleles that are temperature sensitive. Fertilized eggs only develop below a specific temperature, see the table below.

Genotype	Temperature necessary for development
EE	< 18 °C
Ee	< 20 °C
ee	< 28 °C

Two flies, both with genotype Ee, mate. Their fertilized eggs (F1) are allowed to develop at 19 °C. The F1 flies mate randomly and the eggs produced are again allowed to develop at 19 °C.

8. What fraction of eggs produced in the F1 crossing will **not** develop?

A 1/9
B 2/9
C 4/9
D 6/9

DNA and evolutionary relation

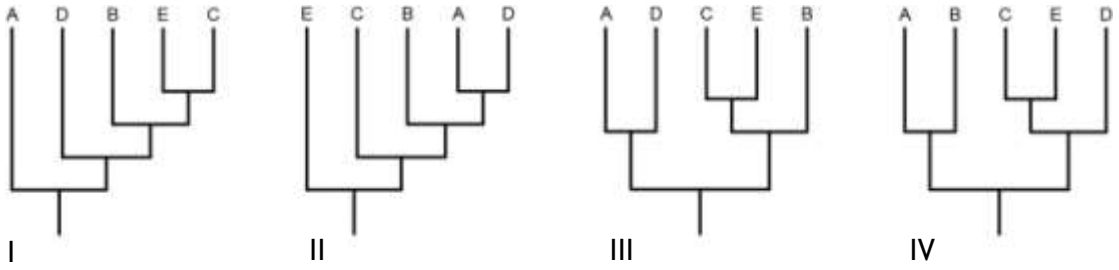
Several people (A - E) in the same city contract Legionnaires' disease. It is important to identify how many sources are causing this outbreak, and what those sources are, to prevent the disease from spreading. The pathogens' DNA is extracted, and the alleles of seven of its genes are determined to identify the number of sources. Then, for each pair of patients, we count how often the alleles for those seven genes are different, known as the 'distance' between the patient's pathogens. If the two pathogens of two patients are identical on all seven genes, then the distance is 0, whereas if the pathogens have different alleles for all seven genes, the distance is 7. The distances for all pairs of patients A - E are given below in the 'Distance matrix'.

Distance matrix

Patient A	Patient B	Patient C	Patient D	Patient E	
	5	5	1	4	Patient A
		2	5	2	Patient B
			6	1	Patient C
				6	Patient D
					Patient E

The data in the table can be used to depict the relation of the pathogens in patients A - E as a dendrogram (tree structure).

9. Which of the dendrograms below corresponds to the distance matrix?



I II III IV

A I
B II
C III
D IV

Legionella

Strains of *Legionella* (the bacterium responsible for Legionnaires' disease) can be identified by means of the allele for the gene *flaA*. This gene codes for a protein that is part of the bacterium's flagellum.

The bases 670 to 700 of the coding strand (the complement of the template strand) of the DNA of an allele of *Legionella*'s *flaA* gene are represented below. Bases 197 to 199 make up the start codon.

	670----------700	
5'	T T T C A G T A T C G G C A G C A C A A A A G C T T C T T C T	3'

10. What is the correct order of the amino acids in the part of the protein that is coded for by the DNA fragment above? Use the table below, in which the genetic code is depicted.

standard genetic code									
1st base (5'-end)	**2nd base**								**3rd base (3'-end)**
	U		**C**		**A**		**G**		
U	UUU	Phe (F)	UCU	Ser (S)	UAU	Tyr (Y)	UGU	Cys (C)	**U**
	UUC		UCC		UAC		UGC		**C**
	UUA	Leu (L)	UCA		UAA	Stop	UGA	Stop	**A**
	UUG		UCG		UAG	Stop	UGG	Trp (W)	**G**
C	CUU		CCU	Pro (P)	CAU	His (H)	CGU	Arg (R)	**U**
	CUC		CCC		CAC		CGC		**C**
	CUA		CCA		CAA	Gln (Q)	CGA		**A**
	CUG		CCG		CAG		CGG		**G**
A	AUU	Ile (I)	ACU	Thr (T)	AAU	Asn (N)	AGU	Ser (S)	**U**
	AUC		ACC		AAC		AGC		**C**
	AUA		ACA		AAA	Lys (K)	AGA	Arg (R)	**A**
	AUG	Met (M)	ACG		AAG		AGG		**G**
G	GUU	Val (V)	GCU	Ala (A)	GAU	Asp (D)	GGU	Gly (G)	**U**
	GUC		GCC		GAC		GGC		**C**
	GUA		GCA		GAA	Glu (E)	GGA		**A**
	GUG		GCG		GAG		GGG		**G**

A Phe - Ser - Ile - Gly - Ser - Thr - Lys - Ala - Ser - Ser
B Phe - Gln - Tyr - Trp - Gln - His - Lys - Ser - Phe - Phe
C Ser - Val - Ser - Ala - Ala - Gln - Lys - Leu - Leu
D Lys - Ser - *Stop*

Chemistry questions

Photosynthesis by algae

Surface water can contain organic and inorganic matter. In many surface water most of the organic matter is formed by photosynthesis. Phytoplankton, such as algae, are one of the major producers of organic matter. In this organic matter carbon atoms, nitrogen atoms and phosphorous atoms often occur in the following ratio: C : N : P = 106 : 16 : 1. Organic matter produced during photosynthesis by algae can be described by the formula $C_{106}H_{263}O_{110}N_{16}P$.

The following incomplete equation summarizes phytoplankton photosynthesis:

$$\_\ NO_3^- + \_\ HPO_4^{2-} + \_\ H^+ + \ldots \rightarrow C_{106}H_{263}O_{110}N_{16}P + \ldots \qquad \text{(equation 1)}$$

In this equation some coefficients are missing as well as the formulas of some molecules.

11. Which molecules are missing in this incomplete equation?

	on the left	on the right
A	CO_2	H_2O and O_2
B	CO_2 and H_2O	O_2
C	CO_2 and O_2	H_2O
D	O_2	CO_2 and H_2O

12. What should the coefficient of H^+ be when equation 1 is balanced?

A 3
B 16
C 17
D 18

Green chemistry

Green chemistry is an area of chemistry and chemical engineering that deals with the development of sustainable production processes.
Two important concepts in green chemistry are atom economy and the *E* – factor. The formulas for these concepts are:

$$\text{atom economy} = \frac{\text{mass of the desired product}}{\text{mass of the starting materials}} \times 100\%$$

and

$$E - \text{factor} = \frac{\text{mass of the starting materials} - \text{mass of the obtained product}}{\text{mass of the obtained product}}$$

13. Which words have to be filled in for I and for II in the sentence below?

A green process has a ..I.. atom economy and a ..II.. *E* – factor.

	I	II
A	high	high
B	high	low
C	low	high
D	low	low

Determination of oxygen

Dissolved oxygen (O_2) is important for underwater life. The concentration of oxygen in polluted surface water can decrease dangerously. Therefore this concentration is determined regularly.
The concentration of dissolved oxygen can be determined with a titration. A sample of 10.00 mL is taken from the surface water. The sample is treated with an acidic solution of potassium iodide after which the following reaction takes place:

$O_2 + 4\ H^+ + 4\ I^- \rightarrow 2\ I_2 + 2\ H_2O$

An excess of an acidic solution of potassium iodide is added to make sure that all oxygen reacts.
Next the iodine is titrated with a 0.0100 M solution of sodium thiosulfate ($Na_2S_2O_3$). The following reaction takes place:

$I_2 + 2\ S_2O_3^{2-} \rightarrow 2\ I^- + S_4O_6^{2-}$

Starch is used to indicate the endpoint of the titration.

A student performed the determination. At the end of the titration the solution turned colorless when the last drop of the solution of sodium thiosulfate was added, as it should. Nevertheless it turned out that the calculated concentration of dissolved oxygen higher than expected.

14. Which of the following errors could be responsible for this result?

I After rinsing the burette with distilled water the burette was immediately filled with the solution of sodium thiosulfate.
II At the start of the titration the nozzle through which the titrant should leave the burette was filled with air, not with the solution of sodium thiosulfate.

A only I
B only II
C both I and II
D neither I nor II

The numerical value of the concentration of dissolved oxygen in mg per liter is given by the relation $K \times V_{thio}$.

In which V_{thio} is the volume, in mL, of the sodium thiosulfate solution that was used in the titration.

15. What is the value of K?

A 4.00
B 8.00
C 16.0
D 32.0

Fertilizer from urine

In some open air rock festivals in The Netherlands, the urine that those attending produce is collected. This urine is first treated in such a way that the urea in it is converted into ammonium salts. Then the pH of the solution is adjusted and a solution of magnesium chloride is added, to give an insoluble compound called struvite. The formula of struvite is $MgNH_4PO_4.6H_2O$. In this way phosphate is recovered, which contributes to slowing the depletion of natural sources of phosphorous. Also a useful fertilizer is obtained.

The pH of the solution is important, as both phosphate and ammonium are involved in pH dependent equilibria. In Figure 1 the percentage occurrence of H_3PO_4, $H_2PO_4^-$, HPO_4^{2-} and PO_4^{3-} as a function of pH is given. In Figure 2 the percentage occurrence of NH_4^+ and NH_3 as a function of pH is given.

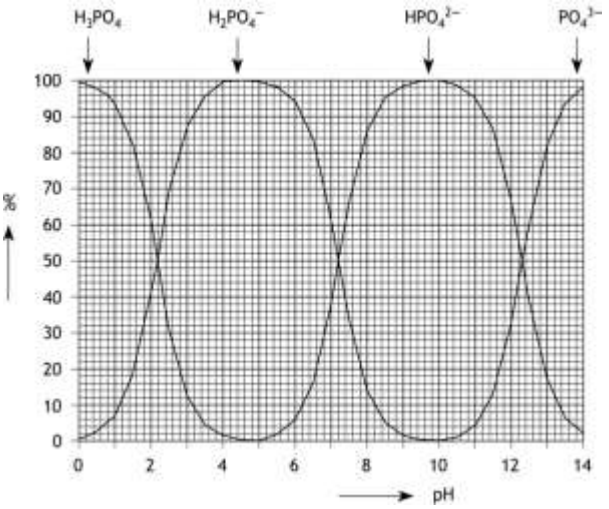


Figure 1

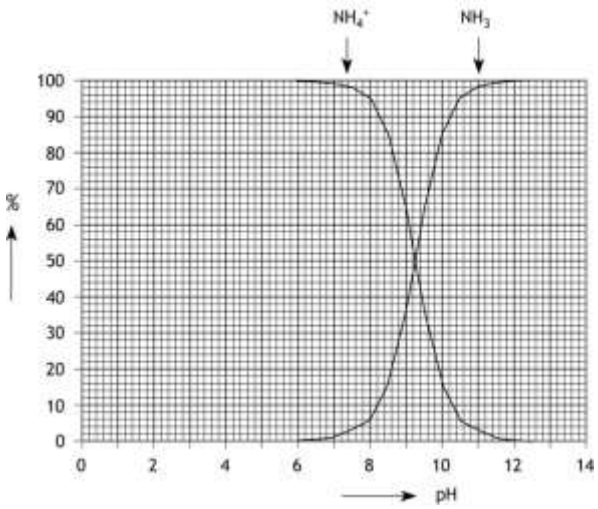


Figure 2

The reaction wherein struvite is formed, is carried out at a pH of about 8.
The reaction equation shows the main species that are present in the solution.

16. Which equation describes the formation of struvite at pH = 8?

A $Mg^{2+} + NH_3 + 7\ H_2O + PO_4^{3-} \rightarrow MgNH_4PO_4.6H_2O + OH^-$
B $Mg^{2+} + NH_4^+ + PO_4^{3-} + 6\ H_2O \rightarrow MgNH_4PO_4.6H_2O$
C $Mg^{2+} + NH_3 + HPO_4^{2-} + 6\ H_2O \rightarrow MgNH_4PO_4.6H_2O$
D $Mg^{2+} + NH_4^+ + HPO_4^{2-} + 5\ H_2O + OH^- \rightarrow MgNH_4PO_4.6H_2O$

Hydrogen fuel cell

Hydrogen is regarded as a fuel of the future, because there is no emission of CO_2.
Hydrogen can be used in fuel cells.

17. Which reaction takes place at which electrode in a hydrogen powered fuel cell during use?

	positive electrode	negative electrode
A	$H_2 \rightarrow 2\ H^+ + 2\ e^-$	$O_2 + 4\ H^+ + 4\ e^- \rightarrow 2\ H_2O$
B	$H_2 + 2\ e^- \rightarrow 2\ H^+$	$O_2 + 4\ H^+ \rightarrow 2\ H_2O + 4\ e^-$
C	$O_2 + 4\ H^+ + 4\ e^- \rightarrow 2\ H_2O$	$H_2 \rightarrow 2\ H^+ + 2\ e^-$
D	$O_2 + 4\ H^+ \rightarrow 2\ H_2O + 4\ e^-$	$H_2 + 2\ e^- \rightarrow 2\ H^+$

Elimination of CO_2

Carbon dioxide is a greenhouse gas. During the combustion of fossil fuels, large amounts of carbon dioxide are formed. To prevent this from entering the atmosphere, one might consider to remove it using the so called water-gas shift reaction. In this reaction carbon dioxide reacts with hydrogen to form carbon monoxide and water:

$CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g)$

The enthalpy of formation of CO_2, CO, and H_2O are as follows:
$CO_2(g)$: – 394 kJ/mol, CO(g): – 111 kJ/mol and $H_2O(g)$: – 242 kJ/mol.

18. What is the reaction enthalpy ($\Delta_r H$) of the forward reaction; is this reaction endothermic or exothermic?

	$\Delta_r H$	endothermic/exothermic
A	– 41 kJ/mol	endothermic
B	– 41 kJ/mol	exothermic
C	+ 41 kJ/mol	endothermic
D	+ 41 kJ/mol	exothermic

Using the water-gas shift reaction to prevent carbon dioxide from entering the atmosphere has the drawback that the highly toxic gas carbon monoxide is formed. Carbon monoxide can be converted into methanol by adding extra hydrogen gas. The formation of methanol from carbon monoxide and hydrogen is an equilibrium reaction:

$CO(g) + 2\ H_2(g) \rightleftharpoons CH_3OH(g)$

The forward reaction is exothermic.

19. Which of the following conditions favors the formation of methanol in this equilibrium reaction?

I high pressure
II high temperature

A only I
B only II
C both I and II
D neither I nor II

Fertilizers

The quality of surface water in the Netherlands is influenced by the use of fertilizers in agriculture. Many fertilizers contain nitrogen (N). It is important to reduce the use of nitrogen in fertilizer to minimize the nitrogen load of surface water.
Three nitrogen containing fertilizers are:
$(NH_4)_2SO_4$ (ammonium sulfate), $CaCN_2$ (calcium cyanamide), and $CO(NH_2)_2$ (urea).

20. Which of these fertilizers has the highest mass percentage of nitrogen?

A ammonium sulfate
B calcium cyanamide
C urea
D all three have the same mass percentage of nitrogen

Physics questions

Solar shower

You can use solar power to have a warm shower while camping. The Solar Camp Shower bag (see Figure 1), contains 15 kg of water with a temperature of 18 °C. On a sunny day, the water absorbs 200 W of solar power.

Figure 1: Solar Camp Shower.

21. How long does it take for the water to reach a temperature of 35 °C? (The specific heat of water is $c = 4.2 \times 10^3$ J/(kg K).)

A 0.4 h
B 0.8 h
C 1.5 h
D 3.0 h

Liquid and vapor

Boiling transforms 1 liter of liquid into 1000 liters of vapor at a certain pressure.

Consider the following statements.

I The density of the vapor is 1/1000th times the density of the liquid.
II The average distance between the molecules in the vapor phase is 10 times the average distance between the molecules in the liquid phase.

22. Which of these statements is true?

A only I
B only II
C both I and II
D neither I nor II

Hydro pneumatic suspension

The hydro pneumatic suspension of some cars is equipped with spring bulbs. Such a metal bulb is filled with nitrogen gas. The purpose of the gas is to lift about ¼ of the weight of the car that rests on the suspensions, via a piston, oil and a rubber membrane (see Figure 2). The area of the rubber membrane is 200 cm^2. The weight of the car that rests on the suspensions is 16 000 N. Neglect the weight of the oil and the piston. The whole system is in rest. The pressure of the outer air is $1.0 \cdot 10^5$ Pa.

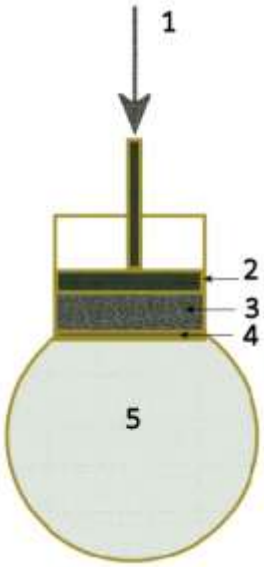


Figure 2: Spring bulb.
1 = ¼ weight of the car
2 = piston
3 = oil
4 = rubber membrane
5 = nitrogen gas

23. What is the pressure of the enclosed nitrogen gas?

A $2.0 \cdot 10^5$ Pa
B $3.0 \cdot 10^5$ Pa
C $8.0 \cdot 10^5$ Pa
D $12 \cdot 10^5$ Pa

Heating paraffin

A constant amount of heat is added per second to a certain amount of solid paraffin (see Figure 3).

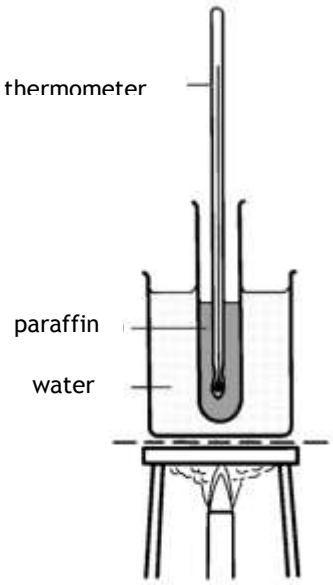


Figure 3: Experimental setup

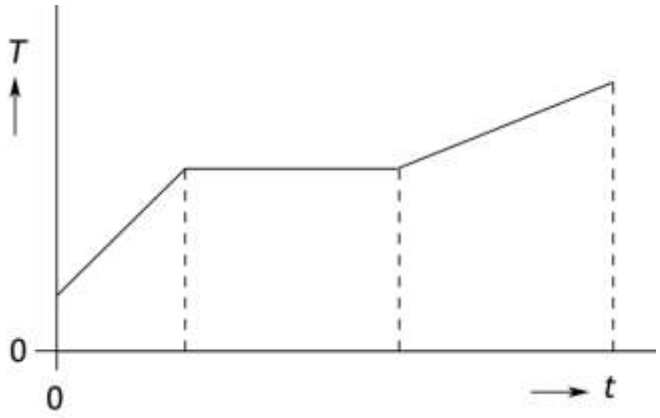


Figure 4: *T* - *t* diagram

The graph in Figure 4 displays the temperature (*T*) of the paraffin as a function of time (*t*).

Consider the following two statements regarding the change in the temperature of the paraffin.

I The specific heat capacity of liquid paraffin is smaller than that of solid paraffin.
II During melting, the potential energy of the molecules increases.

24. Which of these statement(s) is true?

A only I
B only II
C both I and II
D neither I nor II

A little boat and a bottle in a river

On a windless day, someone throws an empty sealed bottle in the river Waal, and the bottle floats downstream. At the same time, and at the same place, a powerboat sails upstream. After 10 minutes, the boat turns quickly around and travels downstream with the same power as before. After a while, the boat overtakes the bottle. At that time, the bottle and the boat are 3 km downstream from the initial starting point.

25. How fast does the river Waal flow on a windless day?

A 3 km/h
B 9 km/h
C 12 km/h
D 15 km/h

Electric circuit

In the circuit depicted in Figure 5, slide S is displaced along variable resistor R towards point X.

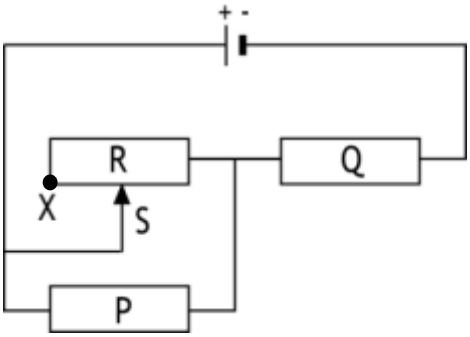


Figure 5: Electric circuit

26. How does the current passing resistors P and Q change?

	in P	in Q
A	increases	increases
B	increases	decreases
C	decreases	increases
D	decreases	decreases

Supertanker

A supertanker sails from the North Sea, via a river, to the port of Rotterdam.

Figure 6: Supertanker

27. Which statement about the draft (i.e. how deep a ship lies in the water) is true when the ship sails from the sea into the river?

A The tanker will have a deeper draft in the river.
B The tanker will have a shallower draft in the river.
C The draft will remain the same.
D The draft depends on the air pressure.

Electricity storage

In California, storage systems will be installed to improve regulation of the production of electricity by wind turbines. When there is an energy surplus, the wind turbine drives a flywheel. The cylindrical flywheel has a diameter of 0.90 m, a length of 1.5 m and a mass of 1 350 kg. The maximum frequency of the flywheel is 20 000 revolutions per minute. When the storage system has to supply electricity, the flywheel drives the generator. The rotational energy of a spinning object equals $E_{rot} = \frac{1}{2} I\omega^2$, with the moment of inertia $I = \frac{1}{2} mR^2$ for a cylinder with mass m and radius R that turns with angular velocity ω (in rad/s).

28. Taking these data into account, how much energy can maximally be stored by the flywheel?

A $7.6 \cdot 10^6$ J
B $1.5 \cdot 10^8$ J
C $3.0 \cdot 10^8$ J
D $1.2 \cdot 10^9$ J

Sky crane

A sky crane was used for the landing of the Mars explorer 'Curiosity'.
The four exhausts expel combustion gases that hold the crane at a constant height before landing. The four exhausts are arranged in an oblique arrangement. In Figure 7 you can see the thrust exerted on the crane by the gas from exhaust A. The thrust of the gas ejected from the other exhausts have the same magnitude and operate at the same angle.

Compare the thrust (F_{thrust}) at A to the gravitational force (F_g) on the whole system.

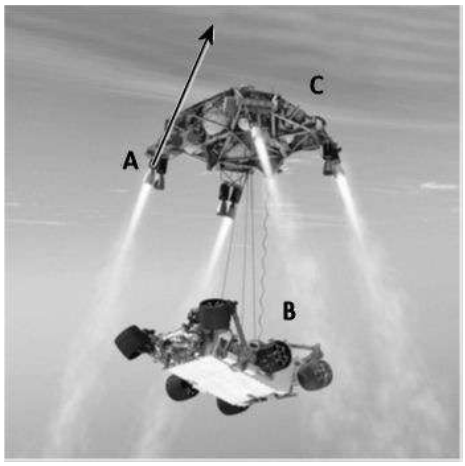


Figure 7: The landing system
A = One of the four exhausts
B = Mars explorer 'Curiosity'
C = Flying crane

29. Which statement is true?

A $F_{thrust} = F_g$
B $F_{thrust} = ¼F_g$
C $F_{thrust} < ¼F_g$
D $F_{thrust} > ¼F_g$

Properties of water

Two specific properties of water are highlighted below.

Property 1
The heat capacity of water is large compared to other common substances.

Property 2
The density of water behaves differently between 0 °C and 4 °C compared to other substances (see Figure 8).

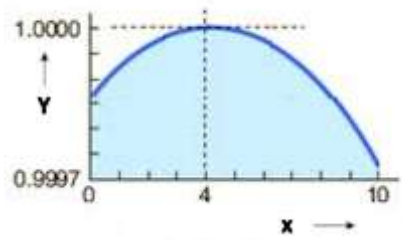


Figure 8:
Y = density of water in kg/dm^3
X = temperature in °C

Consider the following statements:

I Property 1 has a stabilizing effect on the average temperature on earth.
II Property 2 causes that liquid water with a temperature of + 4 °C will be located on the bottom of a ditch, when there is a thin layer of ice on top of the water.

30. Which of these statements is true?

A only I
B only II
C both I and II
D neither I nor II