DUTCH NATIONAL CHEMISTRY OLYMPIAD

SELECTION ROUND 1
PROBLEMS

(the week of)
Wednesday 4 February 2009

SCHEIKUNDE OLYMPIADE

Dutch Translation Services

Specialising in Chemical Translations

- **This selection round consists of 24 multiple choice questions divided over 5 subjects, 3 open questions consisting of a total of 13 sub questions and an answer sheet for the multiple choice questions.**
- **The maximum score for this test is 75 points.**
- **The selection round will take 2 hours (120 minutes) maximum.**
- **Resources needed: calculator and BINAS 5th edition.**
- **For each problem, the number of points that can be obtained for correct answers to the questions, is indicated.**

Problem 1 Multiple choice questions (36 points total)

1½ points per correct answer (For each question, write your answer (letter) on the answer sheet).
Please note: wrong answer –¼ point; no answer: 0 points

Separation methods

1 Which statement about separation in the Vigreux column (the inner wall has glass indentations) is true?
- **A** From the descending liquid, the component with the lowest boiling point is evaporated.
- **B** From the descending liquid, the least volatile component is evaporated.
- **C** From the ascending vapour, the component with the lowest boiling temperature is condensed.
- **D** None of the above.

2 Which separation technique should be applied in order to separate a homogenous mixture of two liquids?
- **A** chromatography
- **B** distillation
- **C** extraction
- **D** evaporation
- **E** ion exchange

3 Which statement is true? In chromatography, ...
- **A** the substance to be detected does not have to be present in large amounts.
- **B** the mobile phase is always a liquid.
- **C** the stationary phase is always a solid.
- **D** the sample to be examined must always contain coloured substances.

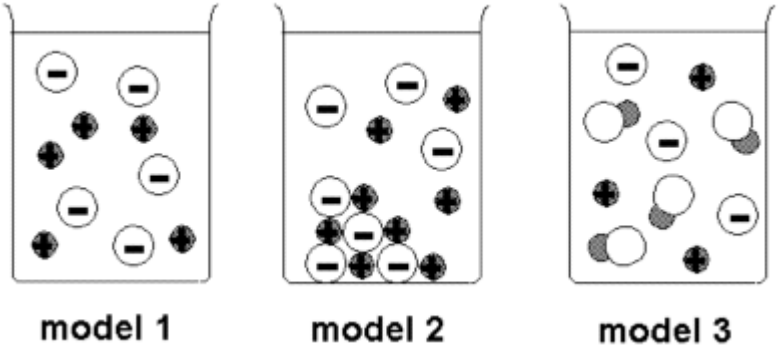
4 Which statement is FALSE? About chromatography can be said that:
- **A** the retention time/length of stay is always between 0 and 1
- **B** the technique can also be applied to dope testing.
- **C** very small amounts can be detected.
- **D** even complicated mixtures can be separated fast and accurately.

Aqueous solutions

5 Which solution is electroconductive? A solution in water of:
- **A** C_2H_5OH
- **B** $C_{12}H_{22}O_{11}$
- **C** Cl_2
- **D** H_3PO_4

6 A jet of water can be deflected by an electro statically charged rod. From this, we can conclude that:
- **A** water molecules are non-polar.
- **B** water molecules are dipolar.
- **C** water molecules are linear.
- **D** part of the water molecules have separated into ions.

7 Which of the models given below shows the dissolution of sugar?



A model 1
B model 2
C model 3
D none of the above models can be used to show the dissolution of sugar.

8 Which of the following equations describes the dissolution of calcium chloride?

A $CaCl_2(s) \rightarrow Ca^{2+}(aq) + Cl_2^{-}(aq)$
B $CaCl_2(s) \rightarrow Ca^{2+}(aq) + Cl_2^{2-}(aq)$
C $CaCl_2(s) \rightarrow Ca^{2+}(aq) + 2\ Cl^{-}(aq)$
D $CaCl_2(s) \rightarrow Ca^{2+}(aq) + 2\ Cl^{2-}(aq)$

9 On the labels of different types of mineral water the following information can be found:

Concentration in mg/L	
Vittel	Ca^{2+} : 202
	Mg^{2+}: 36
	Na^{+}: 3,8
	SO_4^{2-}: 306
	HCO_3^{-}: 402
Spa	Na^{+} : 3
	K^{+} : 0,5
	Ca^{2+} : 3,5
	Mg^{2+} : 1,3
	Cl^{-} : 5
	SO_4^{2-} : 6,5
	NO_3^{-} : 1,9
	HCO_3^{-} : 11
Evian	Na^{+} : 5
	K^{+} : 1
	Ca^{2+} : 78
	Mg^{2+} : 24
	SO_4^{2-} : 10
	HCO_3^{-} : 357
	Cl^{-} : 4,5
	NO_3^{-} : 3,8

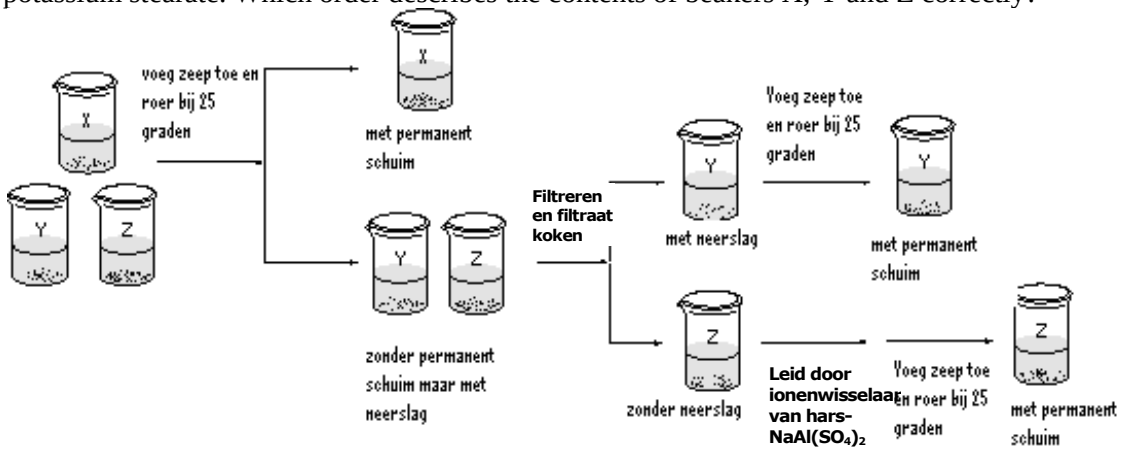
Which mineral water will show the highest electro conductivity?

A Vittel
B Spa
C Evian
D Impossible to tell from the information given above only.

10 Which statement is true?
A An electrically conducting liquid contains an electrolyte.
B Common salt is a weak electrolyte.
C Sugar dissolves in water, therefore it is an electrolyte.
D Iron conducts the electric current, therefore it is an electrolyte.

Chemical equilibria in water

11 Three randomly numbered beakers X, Y and Z have been mixed up. The beakers contain either temporary hard water (water with dissolved calcium and hydrogen carbonate), distilled water or permanent hard water (water with dissolved calcium and hydrogen sulphate). The content of the beakers is being tested according to the diagram given below. The soap used is a solution of potassium stearate. Which order describes the contents of beakers X, Y and Z correctly?



- Add soap and stir at 25 degrees
- with permanent foam
- without permanent foam, but with precipitate
- Filtering and boiling of filtrate
- with precipitate
- without precipitate
- Add soap and stir at 25 degrees
- with permanent foam
- Lead through ion-exchange resin $NaAl(SO_4)_2$.
- Add soap and stir at 25 degrees
- with permanent foam

	X	Y	Z
A	distilled water	temporary hard water	permanent hard water
B	distilled water	permanent hard water	temporary hard water
C	temporary hard water	distilled water	permanent hard water
D	distilled water	permanent hard water	temporary hard water

12 Which statement is correct? Pure water ...
A is not conductive, because water is a molecular substance.
B is only slightly conductive, because the ionisation factor is very small.
C is a little conductive, because water is polar.
D is highly conductive, because there are many free ions.

13 The calcium compound Iceland spar is hardly affected by normal rain, but is affected by acid rain. Which formula could Iceland spar possibly have?

A $CaCO_3$
B $Ca(CH_3COO)_2$
C $CaCl_2$
D $CaSO_4$

14 Which statement is FALSE?

A Acetate is a weak base.
B Ammonia is a strong base.
C Acetic acid is a weak acid.
D Hydrogen chloride is a strong acid.

15 The conjugated base of a strong acid

A has a high K_b.
B has a high pK_b.
C has a low pK_b.
D is a strong base.

Calculations

16 How many moles of bonded O-atoms does 100 g aluminium phosphate contain?

A 0.820
B 3.09
C 3.28
D 3.54
E $1.98 \cdot 10^{24}$

17 Calculate how much substance (g, mole or molecules) is present in $1.0 \cdot 10^2$ litre CO_2(g) (T = 273 K and $p = p_0$).

A 4.1 mole
B 50 g
C $2.0 \cdot 10^2$ g
D $2.2 \cdot 10^3$ mole
E $2.5 \cdot 10^{24}$ molecules

18 How many water molecules does 15.0 g water contain?

A 0.833
B 7.44
C $5.02 \cdot 10^{23}$
D $10.0 \cdot 10^{23}$

19 The density of an unknown substance in the gas phase (298 K and $p = p_0$) is 1.63 g L^{-1}. Which molecular formula could the unknown substance possibly have?

A Ar
B CO_2
C Ne
D O_2

20 How many moles of ethanol does 1.0 litre of ethanol contain (T = 293 K and $p = p_0$). The formula of ethanol is C_2H_5OH.

A 0.041
B 0.045
C 0.058
D 17

Redox reactions

21 Which of the following reactions is a redox reaction?

A $2\ Al^{3+}(aq) + 3\ SO_4^{2-}(aq) \rightarrow Al_2(SO_4)_3(s)$
B $Fe_2O_3(s) + 3\ CO(g) \rightarrow 2\ Fe(l) + 3\ CO_2(g)$
C $Na_2O(s) + H_2O(l) \rightarrow 2\ Na^+(aq) + 2\ OH^-(aq)$
D $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(l)$

22 What is the charge of the iron particles in a rust free nail?

A 0
B 2+
C 3+
D Impossible to tell without a reaction equation

23 In the following reaction: $N_2 + 3\ H_2 \rightarrow 2\ NH_3$

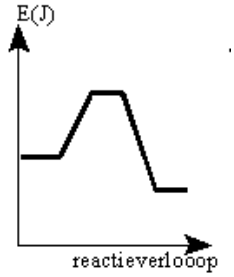
A H_2 is the reducing agent
B N_2 is the reducing agent
C H_2 is reduced
D N_2 is oxidised

24 Which energy diagram matches the combustion of ether?

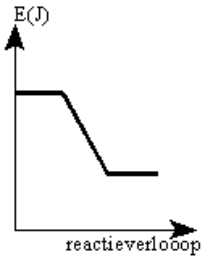
On a bottle of ether, this pictogram can be found

reactieverloop means reaction path

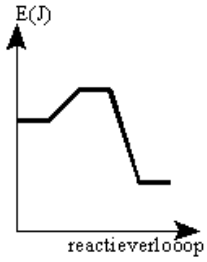
A



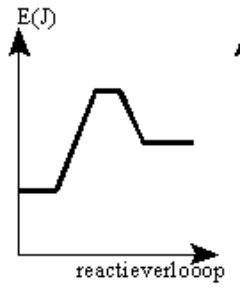
B



C



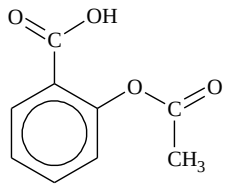
D



Open questions (39 points total)

Problem 2 Effervescent tablets (17 points)

When one's getting a headache, or suffering from an infection, one can take aspirin. Aspirin tablets contain the substance acetylsalicylic acid. The structural formula of acetylsalicylic acid is given below:



Acetylsalicylic acid is an ester. In the gastrointestinal tract, the ester is partly hydrolysed.

3p 1 ❑ Give the reaction equation for this hydrolysis, writing the organic particles as structural formulas.

Apart from acetylsalicylic acid, an effervescent tablet also contains, amongst other things, sodium hydrogen carbonate ($NaHCO_3$). When an effervescent tablet is put into water, a reaction takes place between the acetylsalicylic acid and the hydrogen carbonate. Among the products formed, are the acid radical of acetylsalicylic acid and carbon dioxide. The tablet's effervescing is caused by carbon dioxide escaping from the solution as a gas.
An example of an effervescent tablet is Aspro-Clear. When an Aspro-Clear tablet is put into water, a solution with pH = 5.00 is obtained when the gas production has finished. In this solution, just about all acetylsalicylic acid molecules have been converted into the acid radical ions. This follows from the ratio of the concentrations of acetylsalicylic acid molecules and the acid radical ions.

3p 2 ❑ Calculate the ratio between the concentrations of the acetylsalicylic acid molecules and the acid radical ions in this solution. Write the ratio as $\frac{[\text{Haz}]}{[\text{Az}-]}$. Use a K_z value of $3.0 \cdot 10^{-4}$.

Acetylsalicylic acid is not the only acid present in effervescent tablets. Apart from acetylsalicylic acid, Aspro-Clear tablets contain also citric acid ($C_6H_8O_7$, molecular mass 192.1 u), which reacts with hydrogen carbonate producing carbon dioxide. Acetylsalicylic acid is a monovalent acid and citric acid is a trivalent acid. However, when the gas production, occurring after an Aspro-Clear tablet is put into water, has finished, not all citric acid molecules have parted with their three available H^+ ions.
An Aspro-Clear tablet contains 500 mg acetylsalicylic acid, 865 mg citric acid and 851 mg hydrogen carbonate.

6p 3 ❑ Calculate on average how many H^+ ions a citric acid molecule has parted with when the gas production, occurring after the Aspro-Clear tablet is put into water, has finished. Assume for the calculation that all of the acetylsalicylic acid and all of the hydrogen carbonate have reacted.

Often the information leaflet of effervescent tablets does not state the amount of $NaHCO_3$ in milligrams per tablet. Ellen has been given the task to determine how much $NaHCO_3$ is in an Aspro-Clear tablet. For her study, apart from Aspro-Clear tablets, she *only* used a beaker, water and a set of scales. To start off with, she assumed the amount of CO_2 remaining in the solution to be negligible for her study. Furthermore, she assumed all $NaHCO_3$ to be reacting and $NaHCO_3$ to be the only substance in effervescent tablets from which CO_2 can be formed.
In her study, Ellen first determined the amount $NaHCO_3$ in an effervescent tablet (experiment 1). Upon discussing the results of her experiment, her teacher indicated that she should also check whether the assumption of the amount of CO_2 remaining in solution being negligible, is correct.
For this reason, using once again only a beaker, water, Aspro-Clear tablets and a set of scales, she carried out a control study (experiment 2), to determine whether the amount of CO_2 which dissolves, is indeed negligible. This showed the assumption to be wrong.

3p 4 ❑ Show how Ellen carried out experiment 1 and which measurements she did at the time.

2p 5 ❑ Describe a way how Ellen could have carried out experiment 2 and also indicate how, in the experiment described by you, the assumption mentioned is shown to be wrong.

Problem 3 No NO (14 points)

In a diesel motor, diesel is combusted. In the cylinders of the motor, this fuel is added to an excess amount of air. In the cylinders, at the prevailing temperature, the diesel oil is combusted , producing mostly carbon dioxide and water.
At this temperature, nitrogen monoxide is also formed.
The formation of nitrogen monoxide in the cylinders of a diesel motor is an equilibrium reaction:

$N_2 + O_2 \rightleftarrows 2\ NO$

When the gas mixture with the above mentioned equilibrium is cooled down slowly, the amount of NO decreases.

3p 6 ❑ Explain by using information from Binas Table 57A that the amount of NO decreases when the gas mixture is cooled down. Mention the numerical value of this information in your explanation. Assume that this information also applies in the conditions present in diesel motors.

The temperature of the gas mixture leaving the exhaust of a diesel motor, is much lower than the temperature prevailing in the motor. Consequently, the gas mixture leaving the cylinders is cooled down significantly over a short period of time. During this rapid cooling, the amount of NO in the gas mixture does not change noticeably. As a result, more NO escapes from the exhaust, than would be the case if the gas mixture from the cylinders would be cooled down slowly to the temperature prevailing outside the cylinders. Even if the gas mixture, which has left the cylinders, is kept at this lower temperature for a longer period of time, the amount of NO remains the same.

2p 7 ❑ Explain why, even after a longer period of time, the amount of NO remains the same in the gas mixture which has left the cylinders.

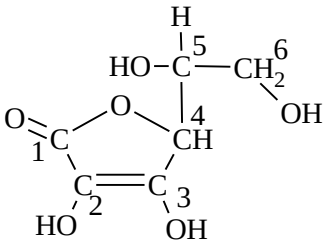
One of the effects of NO is its contribution to the formation of smog and acid rain. For this reason, a maximum limit has been set for the exhaust of NO.
The exhaust of NO from diesel motors can be reduced by injecting a solution of urea (CH_4ON_2) into the gas mixture leaving the cylinders.
A catalysts in the exhaust system enables reactions to take place between urea, NO and another substance, which is present in the gas mixture coming into the exhaust from the cylinders. These reactions can be described in a reaction equation. The only reaction products in this equation are CO_2, N_2 and H_2O.
In the equation, the molar ratio of urea and NO is CH_4ON_2 : NO = 1 : 2.

4p 8 ❑ Give this reaction equation.
The diesel motor of a large ship without a provision to reduce the amount of NO exhaust, produces 53 kg NO per hour.
The ship's motor is fitted with the described facility. Per second, 150 mL of urea solution (80 g urea per L) is injected.

5p 9 ❑ Calculate the decrease in NO exhaust as a percentage. Assume that all urea reacts according to the reaction described above question 8.

Problem 4 Vitamin C (8 points)

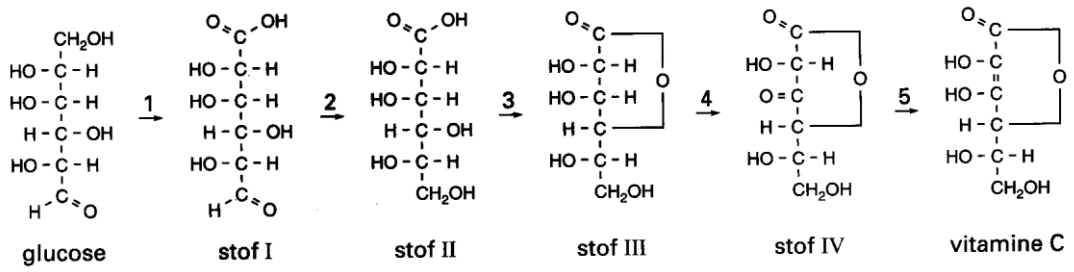
Vitamin C has the molecular formula $C_6H_8O_6$. The structural formula is given below:



Vitamin C is one of the optical isomers which can be described by this structural formula.

2p 10 ❑ Give the number of each asymmetric carbon atom in the structural formula shown above.

Many live organisms – plants as well as animals – are capable of producing vitamin C themselves. The most important reactions occurring during this so-called biosynthesis of vitamin C, can be described schematically as in figure 1:



glucose substance I substance II substance III substance IV vitamin C
figuur 1

Reactions 1 up to (and including) 4 take place under influence of enzymes.
Humans need to take in vitamin C with their food, because the enzyme necessary for the conversion of substance III into substance IV via reaction 4, is absent in the human body.
In reaction 4 of the biosynthesis of vitamin C, only the OH group on carbon atom 3 is converted.

2p 11 ❑ Explain how it is possible that only this OH group is converted.

Reaction 4 is a redox reaction.

2p 12 ❑ Explain whether substance III reacts with an oxidising or reducing agent in reaction 4.

Apart from reaction 4, there are more redox reactions in figure 1. A reaction which can be interpreted as esterification, is also shown.

2p 13 ❑ Give the reaction number of a redox reaction other than reaction 4 and the reaction number of the esterification.
Formulate your answer as follows:
Redox reaction: number ...
Esterification: number ...

Name:

Answer sheet multiple choice questions of selection round 1 of the Dutch National Chemistry Olympiad 2009

nr.	Answer	
1		
2		
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	total	

DUTCH NATIONAL CHEMISTRY OLYMPIAD

SELECTION ROUND 1

CORRECTION MODEL

(the week of)

Wednesday 4 February 2009

SCHEIKUNDE OLYMPIADE

Dutch Translation Services

Specialising in Chemical Translations

- This selection round consists of 24 multiple choice questions divided over 5 subjects and 3 open questions consisting of 13 sub questions
- The maximum score for this test is 75 points (no extra points)
- For each problem the number of points, obtained for correct answers, is indicated
- For correction of the work, the enclosed correction model must be used. Furthermore, the general rules, as provided by the correction regulations of the CSE[1], apply.

[1] CSE = National Final Exam for High School

Opgave 1 Multiple choice questions (36 points total)

Per correct answer: 1½ points
Please note: wrong answer –¼ point; no answer: 0 points

Separation methods:

1	A	The lowest boiling component in the reflux column will evaporate first.
2	B	One uses the difference in boiling temperature between the components. Please note: **D: ¾ points**
3	A	Mobile phase can be liquid or gas; solid phase can be solid or adsorbed liquid; non-coloured components can be made visible by reagents or UV-light.
4	A	The retention time can take any value > 0.

Aqueous solutions

5	D	Aqueous solutions of molecular substances are not conductive, except for acids.
6	B	The electrostatically charged rod attracts the dipoles, because these molecules will align themselves with their opposite charge towards the rod.
7	D	Sugar is a molecular substance and as a consequence it won't form any charged particles.
8	C	
9	D	Important information is missing: molar conductivity and molar mass.

Chemical equilibria in water

10	A	An electrolyte contains charged particles which can undergo transformation under the influence of an electric current.
11	A	Distilled water is soft. Temporary hardness (Ca^{2+} with HCO_3^-) will disappear upon boiling. Permanent hardness (Ca^{2+} with HSO_4^-) will not disappear upon boiling, but Ca^{2+} can be removed by ion exchange.
12	B	The ionisation equilibrium lies far to the left, as such little ionisation will occur.
13	A	The acetate dissolves well in normal rain, just like the chloride; the sulphate has medium solubility in normal rain and this solubility does not change for acid rain (sulphate does not have base properties); acid particles in acid rain are CO_2(aq), SO_2(aq) and HNO_2(aq); $CaCO_3$ can react with these acid particles to give the acid carbonate with has good solubility.
14	B	Ammonia is a weak base (ammonia has pH ≈ 11)
15	B	Is a weak base with low K_b and therefore with a high pK_b.

Calculations

16	C	$\frac{100\ \text{g}}{122\frac{\text{g}}{\text{mole}}} \times 4 = 3.28$ mole O-atoms
17	C	$\frac{1.0\cdot10^2\text{L}}{22.4\frac{\text{L}}{\text{mole}}} = 4.46$ mole CO_2; 4.46 mole × 44.01 g mole^{-1} = $2.0\cdot10^2$ g or $1.0\cdot10^2$ L × 1.986 g L^{-1} = $2.0\cdot10^2$ g
18	C	$\frac{15\ \text{g}}{18\frac{\text{g}}{\text{mole}}} \times \frac{6.02\cdot10^{23}}{\text{mole}} = 5.02\cdot10^{23}$ molecules
19	A	24.5 L × 1.63 g L^{-1} = 39.9 g; this matches with M(Ar)
20	D	Density of ethanol is $8.0\cdot10^2$ g L^{-1}; 1.0 L alcohol contains $\frac{8.0\cdot10^2\ \text{g}}{46.07\frac{\text{g}}{\text{mole}}} = 17$ mole ethanol.

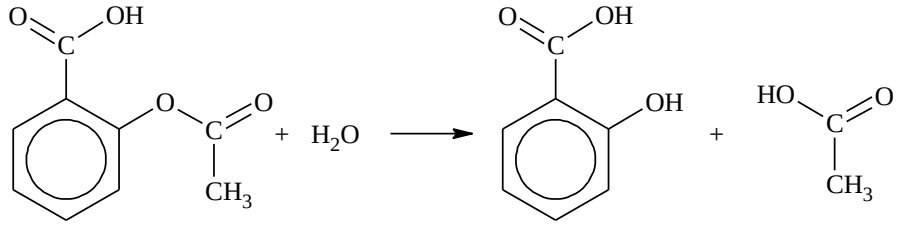
Redox reactions

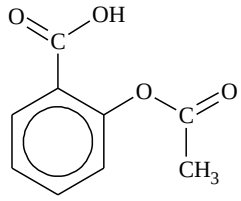
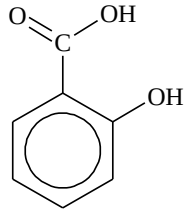
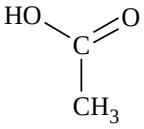
21	B	The charge of atom type Fe (and C) changes.
22	A	A rust free nail consists of an alloy with the metal Fe (an element) as main component.
23	A	H changes from element to compound (oxidation number changes from 0 to 1+).
24	C	Exothermic path with low activation energy (flammable)

Open questions (39 points total)

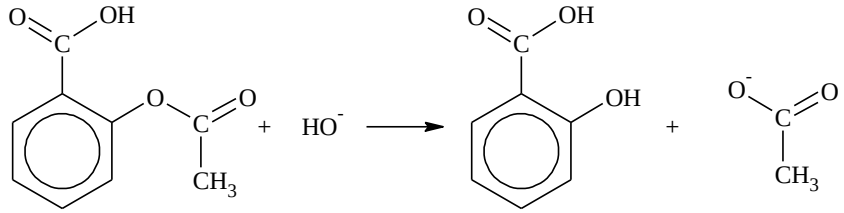
Opgave 2 Effervescent tablets (17 points)

1 Maximum score 3



-  and H_2O before the arrow 1
-  after the arrow 1
-  after the arrow 1

If an equation of the saponification reaction is given, e.g.:

 2

Notes:
- Subtract one point if a reaction equation was given with incorrect tally.
- If equilibrium arrows were used, this is to be marked as correct.
- If the carboxyl group was indicated as COOH, this is to be marked as correct.

2 Maximum score 3

A correct calculation will give the answer $3.3 \cdot 10^{-2}$.

- calculation $[H_3O^+]$: $10^{-5.00}$ 1
- correct equilibrium condition, e.g. given as $\frac{[H_3O^+][Az^-]}{[HAz]} = K_z$
  (possibly already partly substituted) 1
- (further) completion of the equilibrium condition and calculation of the ratio $\frac{[HAz]}{[Az^-]}$ 1

Note:
If a calculation is provided in which was assumed $[H_3O^+] = [Az^-]$, and this was used correctly in further calculations, this is to be marked as correct.

□ 3 Maximum score 6

A correct calculation will lead to the answer 1.6.

- calculation of molar mass salicylic acid: 180.154 g $mole^{-1}$ 1
- conversion of 500 mg salicylic acid into mole: 2.78 1
- calculation of the number of moles of citric acid: 4.50 1
- calculation of number of moles of sodium hydrogen carbonate: 10.12 1
- calculation of the number of mmole hydrogen carbonate which has reacted with citric acid: 10.12 (mmole hydrogen carbonate) minus 2.78 (mmole acetylsalicylic acid) 1
- calculation of the average number of H^+ ions per citric acid molecule which have reacted: divide the number of mmole hydrogen carbonate which have reacted with citric acid by 4.50 (mmole citric acid) 1

□ 4 Maximum score 3

- she has measured the mass of the beaker filled with water and the mass of an effervescent tablet 1
- she has put the effervescent tablet in the water filled beaker and waited for the gas production to finish 1
- after that, she has measured the mass of the beaker, filled with the solution generated 1

If an answer is provided like: 'She puts the water filled beaker on the scales, adds the effervescent tablet and measures the mass reduction.', this is to be marked as correct. 2

□ 5 Maximum score 2.

Examples of correct answers are:
- *let a second effervescent tablet react in less water; the mass reduction will be larger in that case.*
- *let a second effervescent tablet react in more water; the mass reduction will be smaller in that case.*
- *let a second effervescent tablet react in the solution which was formed after the reaction of the first tablet; the mass reduction will be larger.*

- correct approach with the materials provided 1
- correct conclusion in regard to the change in mass 1

Note
If an answer like "Let a second effervescent tablet react in a saturated solution of carbondioxide (obtained by dissolving previous tablets), the mass reduction will be larger in that case "is given, this is to be marked as correct.

Opgave 3 No NO (14 points)

□ 6 Maximum score 3

The heat of formation of NO is + 0.904 ($\cdot 10^5$ J $mole^{-1}$), therefore the formation of NO is an endothermic reaction / the decomposition of NO is an exothermic reaction. Therefore, upon decrease of the temperature, the equilibrium shifts to the left (towards the exothermic side).

- Mention of the heat of formation of NO: + 0.904 ($\cdot 10^5$ J $mole^{-1}$) 1
- (Therefore) the formation of NO is an endothermic reaction/ the decomposition of NO is an exothermic reaction 1
- Therefore, upon decrease of the temperature, the equilibrium shifts to the left (towards the exothermic side). 1

Note:
When, in answer to this question, one or more data from Binas Table 51 have been used in a correct way, this is to be marked as correct. *1*

7 Maximum score 2

At the low temperature, the reaction no longer takes place / the reaction velocity has become zero / the activation energy can no longer be met (therefore the composition of the gas mixture no longer changes).

Note
If an answer like "the equilibrium is 'frozen' by the rapid cooling" is given, this is to be marked as correct.

8 Maximum score 4

$2\ CH_4ON_2 + 4\ NO + O_2 \rightarrow 2\ CO_2 + 4\ N_2 + 4\ H_2O$

- CH_4ON_2 and NO before the arrow and CO_2, N_2 and H_2O after the arrow 1
- O_2 before the arrow 1
- ratio 1 : 2 for CH_4ON_2 and NO correct and the carbon/nitrogen/hydrogen balances correct 1
- oxygen balance correct 1

If the following equation is given:
$6\ NO + 2\ CH_4ON_2 \rightarrow 5\ N_2 + 2\ CO_2 + 4\ H_2O$ 3

9 Maximum score 5

Depending on the calculation method, a correct calculation will give the answer 80, 81 or 82 (%).

- calculation of the number of grams urea per second: $150 \cdot 10^{-3}$ (L) multiplied by 80 g L^{-1} 1
- conversion of the number of grams urea per second into the number of moles urea per second: divide by the mass of a mole of urea (e.g. using Binas table 104: 60.06 g) 1
- conversion of the number of moles urea per second into the decrease of the number of moles NO per hour: multiply by 2 and by 3600 (seconds per hour) 1
- conversion of the decrease of the number of moles NO per hour into the decrease of the number of kg NO per hour: multiply by the mass of a mole of NO (e.g. using Binas table 41: 30.01 g) and divide by 10^3 1
- conversion of the decrease of the number of kg NO per hour into the decrease in percentages: divide by 53 and multiply by 10^2 1

Note:
If an incorrect reaction equation was given at question 8, with a molar ratio between CH_4ON_2 and NO other than 1:2, and this is used consistently for the calculations in answer to question 9, the answer for question 9 should be marked as correct.

Opgave 4 Vitamin C (8 points)

10 Maximum score 2

The carbon atoms with numbers 4 and 5 are asymmetrical.

- one asymmetrical carbon atom indicated 1
- the second asymmetrical carbon atom indicated 1

If, apart from numbers 4 and 5, the number of another carbon atom is given 1
If, apart from numbers 4 and 5, the numbers of two more carbon atoms are given 0

11 Maximum score 2

The enzyme works specifically for exactly this conversion

- the reaction takes place under influence of an enzyme 1
- enzymes work specifically 1

12 Maximum score 2

A correct answer could for instance be phrased like:
In reaction 4, a C–OH group is converted into a C=O group / a secondary alcohol is converted into an alkanone. In order for this to happen, substance III must react with an oxidising agent.

- a C–OH group is converted into a C=O group / a secondary alcohol is converted into an alkanone 1
- therefore substance III should react with an oxidising agent 1

If the answer provided states that reaction should take place with an oxidising agent without explanation or with a wrong explanation 0

Note
If a correct half reaction has been given for the conversion of substance III into substance IV, with a correct conclusion, this is to be marked as correct.

13 Maximum score 2

- redox reaction: number 1 or redox reaction: number 2 1
- esterification: number 3 1