Baltic Chemistry Competition

BioSan
Medical - Biological Research and Technologies
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2011
Final round, Problems

Solve all problems provides. Fill answer sheets and till 13:00, March 20, 2011 send them to e-mail: kimijas_olimpiades@inbox.lv You will receive answer that your solutions are received and will be graded in few days.

This round consists from two parts. Part A – 60 multiple choice questions with one correct answer each. Maximum points for this round is 30 points. Part B – 6 short answer problems. Each problem is graded with maximum 5 points. Points for final round are added to points gained in first three rounds.

Part A – Multiple choice test

Choose one correct answer for each question and write corresponding letter in answer sheet provided.

Question 1

Which statement about solutions is correct?

A. When vitamin D dissolves in fat, vitamin D is the solvent and fat is the solute.

B. In a solution of NaCl in water, NaCl is the solute and water is the solvent.

C. An aqueous solution consists of water dissolved in a solute.

D. The concentration of a solution is the amount of solvent dissolved in 1 dm^3 of solution.

Question 2

Which is the best definition of *electronegativity*?

A. Electronegativity is the energy required for a gaseous atom to gain an electron.

B. Electronegativity is the attraction of an atom for a bonding pair of electrons.

C. Electronegativity is the attraction between the nucleus and the valence electrons of an atom.

D. Electronegativity is the ability of an atom to attract electrons from another atom.

Question 3

Which statements best describe the structure of sodium chloride, NaCl?

I. Each sodium ion is surrounded by six chloride ions.

II. The chloride ions are arranged octahedrally around each sodium ion.

III. The lattice forms a cubic structure.

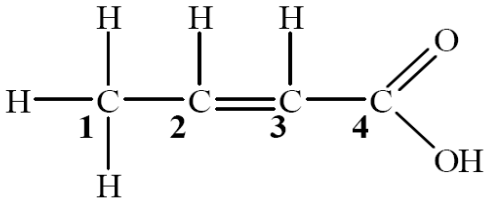
A. I and II only

B. I and III only

C. II and III only

Question 4

Identify the hybridization of carbon atoms in this molecule



	1	2	3	4
A.	sp^3	sp^2	sp^2	sp^2
B.	sp^2	sp^2	sp^2	sp
C.	sp^3	sp	sp^2	sp
D.	sp	sp^2	sp	sp^2

Question 5

Which structure has delocalized π electrons?

A. O_3

B. CO

C. HCN

D. CO_2

Question 6

Which process represents the C–Cl bond enthalpy in tetrachloromethane?

A. $CCl_4(g) \rightarrow C(g) + 4Cl(g)$

B. $CCl_4(g) \rightarrow CCl_3(g) + Cl(g)$

C. $CCl_4(l) \rightarrow C(g) + 4Cl(g)$

D. $CCl_4(l) \rightarrow C(s) + 2Cl_2(g)$

Question 7

Which reaction has the greatest increase in entropy?

A. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

B. $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

C. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

D. $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$

Question 8

What is the best definition of *rate of reaction*?

A. The time it takes to use up all the reactants

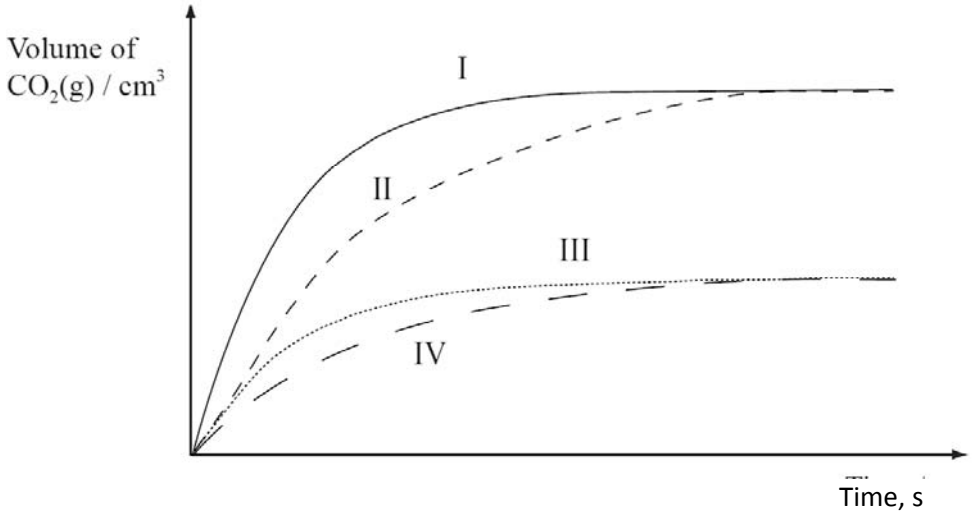
B. The rate at which all the reactants are used up

C. The time it takes for one of the reactants to be used up

D. The increase in concentration of a product per unit time

Question 9

Equal masses of powdered calcium carbonate were added to separate solutions of hydrochloric acid. The calcium carbonate was in excess. The volume of carbon dioxide produced was measured at regular intervals. Which curves best represent the evolution of carbon dioxide against time for the acid solutions shown in the table below.



	25 cm^3 of 2 mol dm^{-3} HCl	50 cm^3 of 1 mol dm^{-3} HCl	25 cm^3 of 1 mol dm^{-3} HCl
A.	I	III	IV
B.	I	IV	III
C.	I	II	III
D.	II	I	III

Question 10

Consider the following reversible reaction.

$$Cr_2O_7^{2-}(aq) + H_2O(l) \rightleftharpoons 2CrO_4^{2-}(aq) + 2H^+(aq)$$

What will happen to the position of equilibrium and the value of K_c when more H^+ ions are added at constant temperature?

	Position of equilibrium	Value of K_c
A.	shifts to the left	decreases
B.	shifts to the right	increases
C.	shifts to the right	does not change
D.	shifts to the left	does not change

Question 11

Consider this equilibrium reaction in a sealed container:

$$H_2O(g) \rightleftharpoons H_2O(l)$$

What will be the effect on the equilibrium of increasing the temperature from 20 °C to 30 °C?

A. More of the water will be in the gaseous state at equilibrium.

B. More of the water will be in the liquid state at equilibrium.

C. At equilibrium the rate of condensation will be greater than the rate of evaporation.

D. At equilibrium the rate of evaporation will be greater than the rate of condensation.

Question 12

When equal volumes of four 0.1 mol dm^{-3} solutions are arranged in order of increasing pH (lowest pH first), what is the correct order?

A. $CH_3COOH < HNO_3 < CH_3CH_2NH_2 < KOH$

B. $HNO_3 < CH_3COOH < CH_3CH_2NH_2 < KOH$

C. $CH_3CH_2NH_2 < HNO_3 < CH_3COOH < KOH$

D. $KOH < CH_3CH_2NH_2 < CH_3COOH < HNO_3$

Question 13

What happens at the negative electrode in a voltaic cell and in an electrolytic cell?

	Voltaic cell	Electrolytic cell
A.	oxidation	reduction
B.	reduction	oxidation
C.	oxidation	oxidation
D.	reduction	reduction

Question 14

Consider these standard electrode potentials.

$$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s) \qquad E^{\ominus} = -2.36\ V$$

$$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s) \qquad E^{\ominus} = -0.76\ V$$

What is the cell potential for the voltaic cell produced when the two half-cells are connected?

A. –1.60 V

B. +1.60 V

C. –3.12 V

D. +3.12 V

Question 15

What is the IUPAC name for $HCOOCH_2CH_2CH_3$?

A. Butanoic acid

B. Butanal

C. Methyl propanoate

D. Propyl methanoate

Question 16

Which conditions are required to obtain a good yield of a carboxylic acid when ethanol is oxidized using potassium dichromate(VI), $K_2Cr_2O_7(aq)$?

I. Add sulfuric acid

II. Heat the reaction mixture under reflux

III. Distil the product as the oxidizing agent is added

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Question 17

Which statements about substitution reactions are correct?

I. The reaction between sodium hydroxide and 1-chloropentane predominantly follows an S_N2 mechanism.

II. The reaction between sodium hydroxide and 2-chloro-2-methylbutane predominantly follows an S_N2 mechanism.

III. The reaction of sodium hydroxide with 1-chloropentane occurs at a slower rate than with 1-bromopentane.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Question 18

Which compound can exist as stereoisomers?

A. CH_3CH_2CHO

B. $CH_3CH_2COCH_3$

C. $CH_3CH(CH_3)_2$

D. $CH_3CH_2CHOHCH_3$

Question 19

What is the order of increasing energy of the orbitals within a single energy level?

A. d < s < f < p

B. s < p < d < f

C. p < s < f < d

D. f < d < p < s

Question 20

Which equation best represents the first ionization energy of magnesium?

A. $Mg(s) \rightarrow Mg^{+}(s) + e^{-}$

B. $Mg(g) \rightarrow Mg^{2+}(g) + 2e^{-}$

C. $Mg(g) \rightarrow Mg^{+}(g) + e^{-}$

D. $Mg(s) \rightarrow Mg^{+}(g) + e^{-}$

Question 21

What are the products of the reaction between chlorine and water?

A. O_2, H_2 and HCl

B. H_2 and OCl_2

C. HCl and HOCl

D. HOCl, H_2 and Cl_2

Question 22

Which statement best describes the **intramolecular** bonding in HCN(l)?

A. Electrostatic attractions between H^{+} and CN^{-} ions

B. Only van der Waals' forces

C. Van der Waals' forces and hydrogen bonding

D. Electrostatic attractions between pairs of electrons and positively charged nuclei

Question 23

Which of the following best describes the formation of π bonds?

A. They are formed by the sideways overlap of parallel orbitals.

B. They are formed by the axial overlap of orbitals.

C. They are formed by the sideways overlap of an s and p orbital.

D. They are formed by the axial overlap of either s or p orbitals.

Question 24

What is the standard entropy change, $\Delta S^{\ominus}$, for the following reaction?

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$$

	CO (g)	**O_2(g)**	**CO_2(g)**
$S^{\ominus}$ / J K^{-1} mol^{-1}	198	205	214

A. –189

B. –173

C. +173

D. +189

Question 25

Which step(s) is/are endothermic in the Born-Haber cycle for the formation of LiCl?

A. $\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$ **and** $Li(s) \rightarrow Li(g)$

B. $Cl(g) + e^- \rightarrow Cl^-(g)$ **and** $Li(g) \rightarrow Li^+(g) + e^-$

C. $Li^+(g) + Cl^-(g) \rightarrow LiCl(s)$

D. $\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$ **and** $Cl(g) + e^- \rightarrow Cl^-(g)$

Question 26

What is the function of iron in the Haber process?

A. It shifts the position of equilibrium towards the products.

B. It decreases the rate of the reaction.

C. It provides an alternative reaction pathway with a lower activation energy.

D. It reduces the enthalpy change of the reaction.

Question 27

Consider the following reaction.

$$5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(l)$$

The rate expression for the reaction is found to be:

$$\text{rate} = k[Br^-][BrO_3^-][H^+]^2$$

Which statement is correct?

A. The overall order is 12.

B. Doubling the concentration of all of the reactants at the same time would increase the rate of the reaction by a factor of 16.

C. The units of the rate constant, k, are $\text{mol dm}^{-3}\ \text{s}^{-1}$.

D. A change in concentration of Br^- or BrO_3^- does not affect the rate of the reaction.

Question 28

Consider the following reaction mechanism.

Step 1	$H_2O_2 + I^- \rightarrow H_2O + IO^-$	*slow*
Step 2	$H_2O_2 + IO^- \rightarrow H_2O + O_2 + I^-$	*fast*

Which statement correctly identifies the rate-determining step and the explanation?

A. Step 2 because it is the faster step

B. Step 1 because it is the slower step

C. Step 1 because it is the first step

D. Step 2 because it is the last step

Question 29

100 cm^3 of a NaOH solution of pH 12 is mixed with 900 cm^3 of water. What is the pH of the resulting solution?

A. 1

B. 3

C. 11

D. 13

Question 30

The indicator, HIn is used in a titration between an acid and base. Which statement about the dissociation of the indicator, HIn is correct?

$$\underset{\text{colour A}}{HIn\,(aq)} \rightleftharpoons \underset{}{H^+(aq)} + \underset{\text{colour B}}{In^-(aq)}$$

A. In a strongly alkaline solution, colour B would be observed.

B. In a strongly acidic solution, colour B would be observed.

C. $[In^-]$ is greater than [HIn] at the equivalence point.

D. In a weakly acidic solution colour B would be observed.

Question 31

Which list represents the halogens in **increasing** order of oxidizing strength (weakest oxidizing agent first)?

A. Cl_2 I_2 Br_2

B. I_2 Br_2 Cl_2

C. I_2 Cl_2 Br_2

D. Cl_2 Br_2 I_2

Question 32

What structural feature must a molecule have in order to undergo addition polymerization?

A. Two functional groups

B. A carbon–carbon double bond

C. Carbon atoms singly bonded together

D. A polar covalent bond

Question 33

Which statement is correct about the enantiomers of a chiral compound?

A. Their physical properties are different.

B. All their chemical reactions are identical.

C. A racemic mixture will rotate the plane of polarized light.

D. They will rotate the plane of polarized light in opposite directions.

Question 34

Which would be the best method to decrease the **random** uncertainty of a measurement in an acid-base titration?

A. Repeat the titration

B. Ensure your eye is at the same height as the meniscus when reading from the burette

C. Use a different burette

D. Use a different indicator for the titration

Question 35

What is the correct sequence for the processes occurring in a mass spectrometer?

A. vaporization, ionization, acceleration, deflection

B. vaporization, acceleration, ionization, deflection

C. ionization, vaporization, acceleration, deflection

D. ionization, vaporization, deflection, acceleration

Question 36

What type of solid materials are typically hard, have high melting points and poor electrical conductivities?

I. Ionic
II. Metallic
III. Covalent-network

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Question 37

Which reaction has the most negative $\Delta H^{\ominus}$ value?

A. $\mathrm{LiF(s) \rightarrow Li^+(g) + F^-(g)}$

B. $\mathrm{Li^+(g) + F^-(g) \rightarrow LiF\,(s)}$

C. $\mathrm{NaCl\,(s) \rightarrow Na^+(g) + Cl^-(g)}$

D. $\mathrm{Na^+(g) + Cl^-(g) \rightarrow NaCl\,(s)}$

Question 38

What is the order of reaction with respect to $NO_2(g)$ and $F_2(g)$ given the following rate data at a certain temperature?

$[NO_2(g)]$ / mol dm^{-3}	$[F_2(g)]$ / mol dm^{-3}	Rate / mol dm^{-3} min^{-1}
0.1	0.2	0.1
0.2	0.2	0.4
0.1	0.4	0.2

	Order with respect to $NO_2(g)$	Order with respect to $F_2(g)$
A.	first	first
B.	first	second
C.	second	first
D.	second	second

Question 39

For the reaction below:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

at a certain temperature, the equilibrium concentrations, in mol dm^{-3}, are

$$[H_2(g)] = 0.30,\ [I_2(g)] = 0.30,\ [HI(g)] = 3.0$$

What is the value of K_c?

A. 1.0×10^{-2}

B. 10

C. 33

D. 1.0×10^{2}

Question 40

Which methods will distinguish between equimolar solutions of a strong base and a strong acid?

I. Add magnesium to each solution and look for the formation of gas bubbles.

II. Add aqueous sodium hydroxide to each solution and measure the temperature change.

III. Use each solution in a circuit with a battery and lamp and see how bright the lamp glows.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Question 41

Which statement about indicators is **always** correct?

A. The mid-point of the pH range of an indicator is 7.

B. The pH range is greater for indicators with higher pK_a values.

C. The colour red indicates an acidic solution.

D. The pK_a value of the indicator is within its pH range.

Question 42

Consider the following reaction:

$$H_2SO_3(aq) + Sn^{4+}(aq) + H_2O(l) \rightarrow Sn^{2+}(aq) + HSO_4^-(aq) + 3H^+(aq)$$

Which statement is correct?

A. H_2SO_3 is the reducing agent because it undergoes reduction.

B. H_2SO_3 is the reducing agent because it undergoes oxidation.

C. Sn^{4+} is the oxidizing agent because it undergoes oxidation.

D. Sn^{4+} is the reducing agent because it undergoes oxidation.

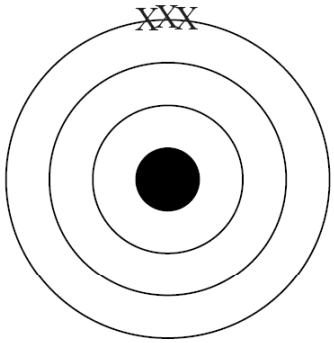
Question 43

Which combination is correct for the complex ion in $[Co(NH_3)_4(H_2O)Cl]Br$?

	Oxidation state of cobalt	**Shape of the complex ion**	**Overall charge of the complex ion**
A.	+2	Octahedral	+2
B.	+3	Octahedral	–1
C	+2	Octahedral	+1
D.	+2	Tetrahedral	+1

Question 44

The following diagram shows a set of experimental data points, X, determined when one experimental measurement was repeated three times. The centre of the diagram represents the ideal value calculated from theory. What statement is correct about these measurements?



A. The measurements involve low accuracy and low precision.

B. The measurements involve low accuracy and high precision.

C. The measurements involve high accuracy and low precision.

D. The measurements involve high accuracy and high precision.

Question 45

The geometry and bond angle of the sulfite ion (SO_3^{2-}) are best described as

A. pyramidal, 107°.

B. tetrahedral, 109°.

C. bent, 104°.

D. trigonal planar, 120°.

Question 46

As the size of the halogen molecules, X_2, increases down the group, their boiling points

A. decrease due to decreasing electronegativity.

B. decrease due to decreasing bond energies.

C. increase due to increasing permanent dipole–dipole attraction.

D. increase due to increasing van der Waals' forces.

Question 47

Which quantity will **not** change for a sample of gas in a sealed rigid container when it is cooled from 100 °C to 75 °C at constant volume?

A. The average energy of the molecules

B. The average speed of the molecules

C. The pressure of the gas

D. The density of the gas

Question 48

Which statement(s) is(are) correct about the effect of adding a catalyst to a system at equilibrium?

I. The rate of the forward reaction increases.

II. The rate of the reverse reaction increases.

III. The yield of the products increases.

A. I only

B. III only

C. I and II only

D. I, II and III

Question 49

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad K_c = 5.0\times10^{-3}$$

In an equilibrium mixture of these two gases, $[N_2O_4] = 5.0\times10^{-1}\ \text{mol dm}^{-3}$. What is the equilibrium concentration of NO_2 in mol dm^{-3}?

A. 5.0×10^{-1}

B. 5.0×10^{-2}

C. 5.0×10^{-3}

D. 2.5×10^{-4}

Question 50

Two moles of electrons are passed through an electrolytic cell containing molten sodium chloride. The same charge is passed through a second cell containing aqueous sodium chloride. In both cells the electrodes are made of platinum. Which statement is correct?

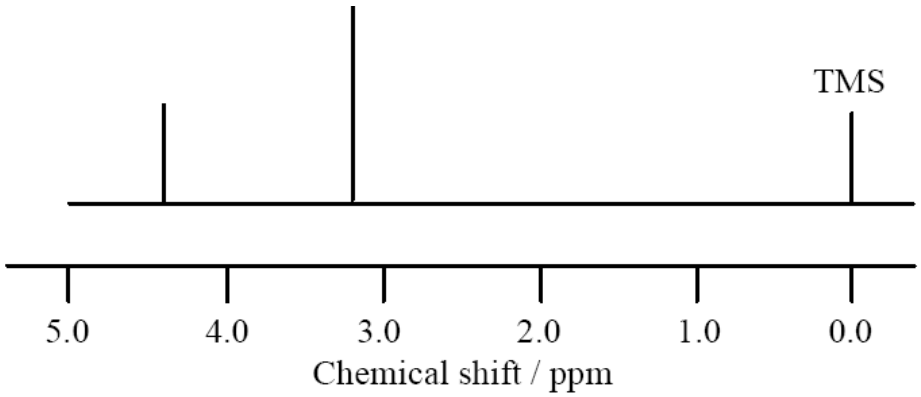
A. One mole of sodium metal will be formed in the first cell.

B. Chlorine gas will be formed at the cathodes of both cells.

C. One mole of hydrogen gas will be formed in the second cell.

D. One mole of oxygen gas will be formed at the anode of the second cell.

Question 51



The low resolution ^{1}H-NMR spectrum shown above could be given by

A. CH_3OH.

B. CH_3CH_2OH.

C. HCHO.

D. HCOOH.

Question 52

The electron transition between which two levels **releases** the most energy?

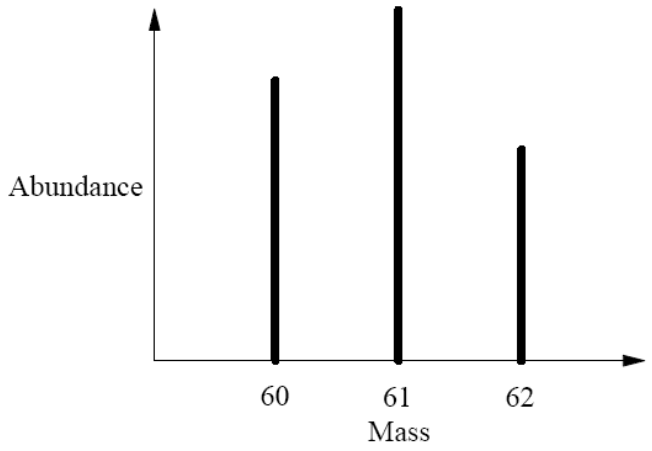
A. First to third

B. Fourth to ninth

C. Sixth to third

D. Second to first

Question 53



The mass spectrum of an element is shown above. Which statement about this element is correct?

A. The three isotopes are separated after being converted to negative ions

B. The isotope with mass 62 will be deflected more than the isotopes with masses 60 or 61

C. The most abundant isotope contains 61 neutrons

D. Its atomic mass will be between 60 and 61

Question 54

Which pair of species is listed in **increasing** order of the property given?

A. Ionisation energy: O, F

B. Radius: Mg, Mg^{2+}

C. Melting point: I_2, Br_2

D. Covalent character: HI, HBr

Question 55

Which species does **not** contain at least one 90° bond angle?

A. CF_4

B. PF_5

C. SF_6

D. SiF_6^{2-}

Question 56

$$C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g) \qquad \Delta H^{\circ} = -137\ \text{kJ}$$

Which statement about the information above is correct?

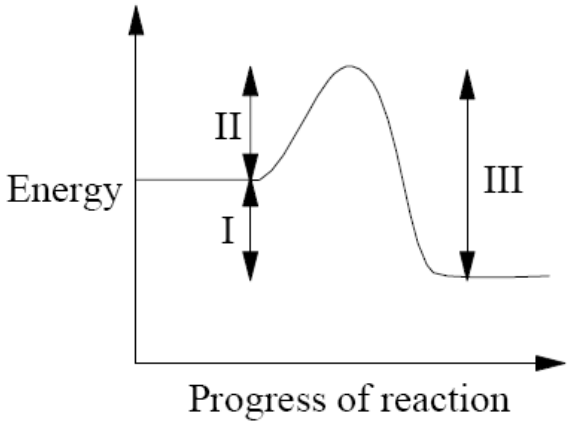
A. The total energy of the bonds broken in the reactants is **greater** than the total energy of the bonds formed in the product

B. The bonds broken and the bonds made are of the same strength

C. The total energy of the bonds broken in the reactants is **less** than the total energy of the bonds formed in the product

D. No conclusion can be made about the sums of the bond enthalpies in the product compared with the reactants.

Question 57



Which energy value(s) will change when a catalyst is added?

A. I only

B. II only

C. II and III only

D. I, II and III

Question 58

Which is the correct combination?

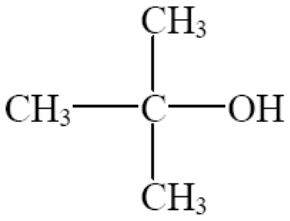
	Intermolecular forces	Boiling point	ΔH_{vap}
A.	weak	low	low
B.	weak	low	high
C.	strong	high	low
D.	strong	low	low

Question 59

Which compound gives **two** distinct peaks in its NMR spectrum?

A. C_6H_6

B. C_2H_5OH

C. 

D. CH_3OCH_3

Question 60

When the compounds below are listed in order of **decreasing** boiling point (highest to lowest) what is the correct order?

1. ethane 2. fluoroethane 3. ethanol 4. ethanoic acid

A. 4, 3, 1, 2

B. 4, 3, 2, 1

C. 3, 4, 1, 2

D. 2, 1, 3, 4

Part B – Short answer questions

Problem 1

Chemical crossword – inorganic chemistry (8 points)

Letters A, B, D ect. stands for unknown inorganic compounds, which react as shown in table. Formulas for all organic compounds are known.

- Compound A contains transition metal and transition metal content is approximately 72% (by mass)
- Solutions of compounds U, N, Ģ are strongly basic. There are no information about solutions of other compounds.
- Solutions of compounds O and N colors gas flame yellow, while compounds U un Ō colors flame purple red.
- Water solutions of compounds V, P and L are blue.
- Substances E, G, H, M, R, S, Ā contain only one chemical element.
- Three transition metals are mentioned in this crossword.
- Equations in crossword are not balanced.

Write chemical formulas for all compounds abbreviated with letters.

A	+	B	→	G	+	D				$C_2H_5NO_2$	+	F	←	C_2H_6	+	Y
+		↑		+		+								+		
E		I		J		H				U	+	C_2H_5Cl	→	Ō	+	C_2H_5OH
↓		+		↓		↓				+				↑		
F	+	H	←	E	+	B		D	+	F	→	Č		S		C_2H_6
+				+				+		+		+		+		+
G	+	L	→	K	+	M		R		Ā		Ģ		CH_3Cl		I
		+				+		↑		↓		↓				↓
		N				Q		B		Ē		Ķ	→	Ņ	+	D
		↓				↓		+		+		+		+		+
E		O		R	+	F	→	Ž	+	E		F		I		F
+		+		+		+								↓		
U		P	+	Q	→	V	+	F		Š	+	F	→	G	+	E
↑				↓		+		↓								+
F				Å		W		I	+	Z	+	F	→	Y		C_2H_4
+				+				+		+						↓
T	←	S	+	E		I	+	E	→	F						C_2H_6

Problem 2

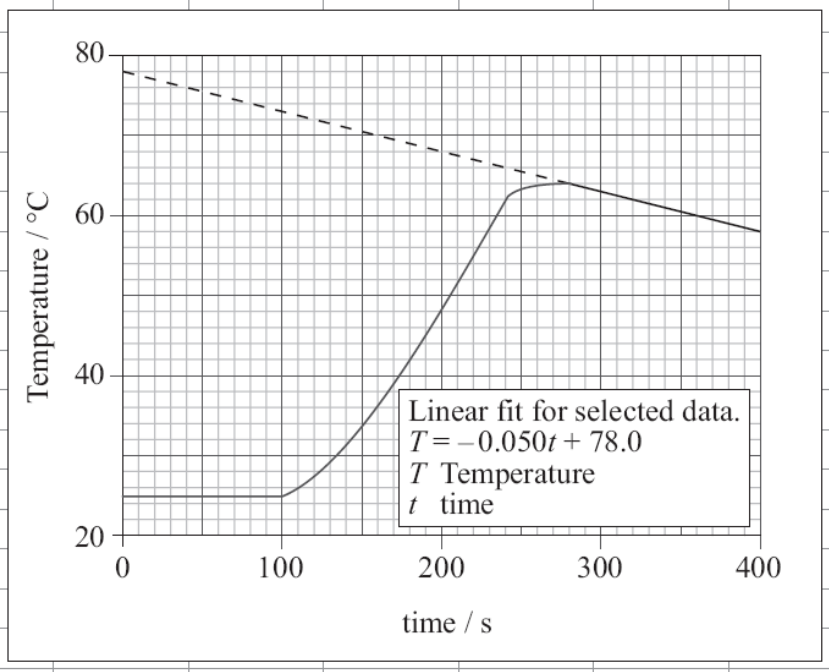
Use of math to describe chemical processes – physical chemistry (10 points)

The data below are from an experiment to measure the enthalpy change for the reaction of aqueous copper(II) sulfate, $CuSO_4(aq)$ and zinc, $Zn(s)$.

$$Cu^{2+}(aq) + Zn(s) \rightarrow Cu(s) + Zn^{2+}(aq)$$

50.0 cm^3 of 1.00 $mol\,dm^{-3}$ copper(II) sulfate solution was placed in a polystyrene cup and zinc powder was added after 100 seconds. The temperature-time data was taken from a data-logging software program. The table shows the initial 23 readings.

	A	B	C	D	E	F	G	H
1	**time / s**	**Temperature / °C**						
2	0.0	24.8						
3	1.0	24.8						
4	2.0	24.8						
5	3.0	24.8						
6	4.0	24.8						
7	5.0	24.8						
8	6.0	24.8						
9	7.0	24.8						
10	8.0	24.8						
11	9.0	24.8						
12	10.0	24.8						
13	11.0	24.8						
14	12.0	24.8						
15	13.0	24.8						
16	14.0	24.8						
17	15.0	24.8						
18	16.0	24.8						
19	17.0	24.8						
20	18.0	24.8						
21	19.0	24.8						
22	20.0	24.8						
23	21.0	24.8						
24	22.0	24.8						



A straight line has been drawn through some of the data points. The equation for this line is given by the data logging software as

$$T = -0.050\,t + 78.0$$

where T is the Temperature at time t.

(a) The heat produced by the reaction can be calculated from the temperature change, ΔT, using the expression below.

$$\text{Heat change} = \text{Volume of } CuSO_4(aq) \times \text{Specific heat capacity of } H_2O \times \Delta T$$

Describe **two** assumptions made in using this expression to calculate heat changes.

(b) (i) Use the data presented by the data logging software to deduce the temperature change, ΔT, which would have occurred if the reaction had taken place instantaneously with no heat loss.

(ii) Calculate the heat, in kJ, produced during the reaction using the expression given in part (a).

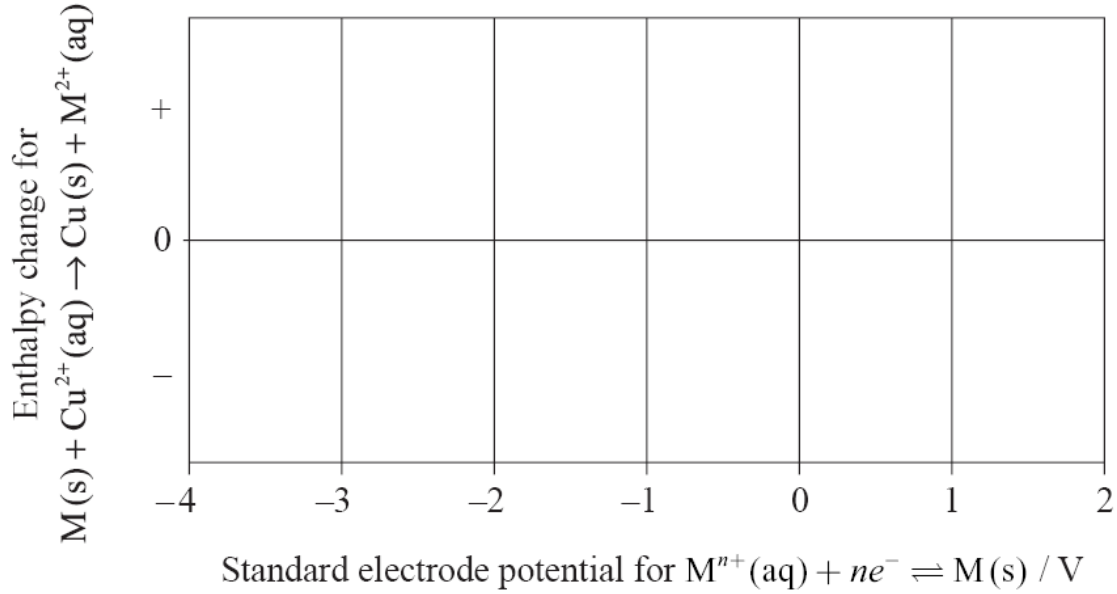
(c) The colour of the solution changed from blue to colourless. Deduce the amount, in moles, of zinc which reacted in the polystyrene cup.

(d) Calculate the enthalpy change, in $kJ\,mol^{-1}$, for this reaction.

(e) An experiment was designed to investigate how the enthalpy change for a displacement reaction relates to standard electrode potentials. The standard electrode potentials of some half reactions, $M^{n+}(aq) + ne^- \rightleftharpoons M(s)$, are listed in wikipedia
The following metals were available: copper, iron, magnesium, silver and zinc. Excess amounts of each metal were added to 1.00 $mol\,dm^{-3}$ copper(II) sulfate solution. The temperature change was measured and the enthalpy change calculated.

(i) Suggest a possible hypothesis for the relationship between the enthalpy change that occurs when the metal, M, is added to copper(II) sulfate(aq) and the standard electrode potential for the half reaction $M^{n+}(aq) + ne^- \rightleftharpoons M(s)$.

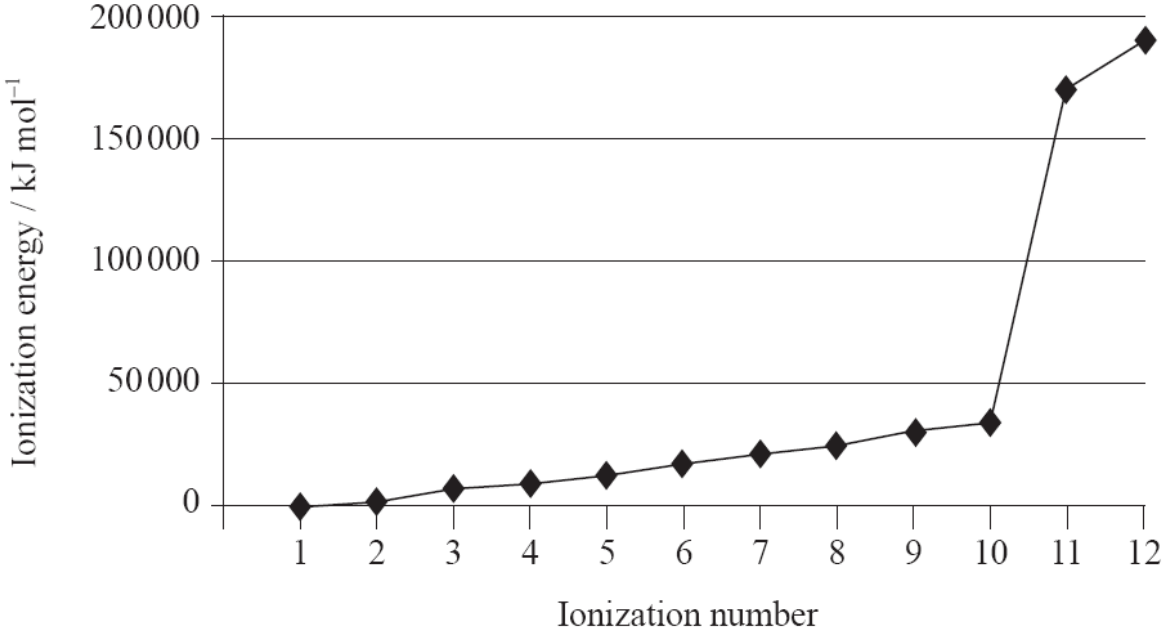
(ii) Sketch a graph on the diagram below to illustrate your hypothesis.



(f) Explain the origin of colour in transition metal complexes and use your explanation to suggest why copper(II) sulfate, $CuSO_4(aq)$, is blue, but zinc sulfate, $ZnSO_4(aq)$, is colourless.

(g) $Cu^{2+}(aq)$ reacts with ammonia to form the complex ion $[Cu(NH_3)_4]^{2+}$. Explain this reaction in terms of an acid-base theory, and outline how the bond is formed between Cu^{2+} and NH_3.

Magnesium is the eighth most abundant element in the earth's crust. The successive ionization energies of the element are shown below.



(h) (i) Define the term *first ionization energy* and state the equation for the first ionization of magnesium.

(ii) Explain the general increase in successive ionization energies of the element.

(iii) Explain the large increase between the tenth and eleventh ionization energies.

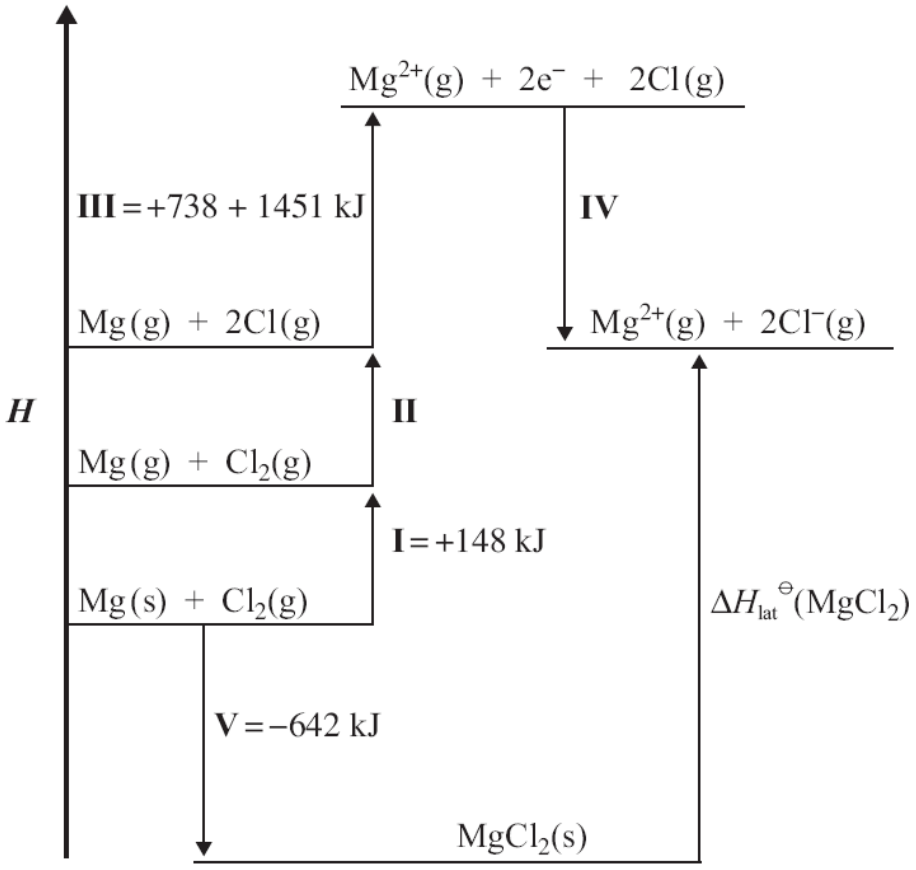
(i) Magnesium can be produced from the electrolysis of molten magnesium chloride, $MgCl_2$.

(i) Explain how molten magnesium chloride conducts an electric current.

(ii) Identify the electrode where oxidation occurs during electrolysis of molten magnesium chloride and state an equation for the half-reaction.

(iii) Explain why magnesium is not formed during the electrolysis of aqueous magnesium chloride solution.

(j) The lattice enthalpy of magnesium chloride can be calculated from the Born-Haber cycle shown below.



(i) Identify the enthalpy changes labelled by **I** and **V** in the cycle.

(ii) Use the ionization energies given in the cycle above and further data from wikipedia or other source to calculate a value for the lattice enthalpy of magnesium chloride.

Problem 3

Some organic chemistry (6 points)

Consider the following sequence of reactions.

$$RCH_3 \xrightarrow{reaction\ 1} RCH_2Br \xrightarrow{reaction\ 2} RCH_2OH$$

RCH_3 is an unknown alkane in which R represents an alkyl group.

(a) The alkane contains 82.6 % by mass of carbon. Determine its empirical formula, showing your working.

(b) A 1.00 g gaseous sample of the alkane has a volume of 385 cm^3 at standard temperature and pressure. Deduce its molecular formula.

(c) State the reagent and conditions needed for *reaction 1*.

(d) *Reaction 1* involves a free-radical mechanism. Describe the stepwise mechanism, by giving equations to represent the initiation, propagation and termination steps.

(e) The mechanism in *reaction 2* is described as S_N2. Explain the mechanism of this reaction using curly arrows to show the movement of electron pairs, and draw the structure of the transition state.

(f) There are four structural isomers with the molecular formula C_4H_9Br. One of these structural isomers exists as two optical isomers. Draw diagrams to represent the three-dimensional structures of the two optical isomers.

(g) All the isomers can by hydrolysed with aqueous sodium hydroxide solution. When the reaction of one of these isomers, **X**, was investigated the following kinetic data were obtained.

Experiment	Initial [X] / mol dm^{-3}	Initial [OH^-] / mol dm^{-3}	Initial rate of reaction / mol dm^{-3} min^{-1}
1	2.0×10^{-2}	2.0×10^{-2}	4.0×10^{-3}
2	2.0×10^{-2}	4.0×10^{-2}	4.0×10^{-3}
3	4.0×10^{-2}	4.0×10^{-2}	8.0×10^{-3}

(i) Deduce the rate expression for the reaction.

(ii) Determine the value of the rate constant for the reaction and state its units.

(iii) State the name of isomer **X** and explain your choice.

(iv) State equations for the steps that take place in the mechanism of this reaction and state which of the steps is slow and which is fast.

Problem 4

Complex formation and red-ox properties (6 points)

You have to investigate 1st type electrode using software MS Excel (or analogue). The first type electrode consists from metal (M(s)) and it's ions in solution ($M^{x+}(aq)$). This time solution also contain protolytic pair from which conjugated base acts as ligands and form complex ions with M^{x+}.

Draw graph to show how reduction standard potential is dependent on pH if free ligand concentration in solution is a) 0.1 M, b) 1.0 M and 5.0 M.

Given electrode:	$Cu^{2+}(aq) + 2e \rightarrow Cu(s)$	$E^o = + 0.345$ V
Ligands:	NH_3 / NH_4^+	$pKa(NH_4^+) = 9.25$

Summary complex formation constants:

$\lg \beta_1 = 3.99$
$\lg \beta_{1,2} = 7.33$
$\lg \beta_{1,2,3} = 10.06$
$\lg \beta_{1,2,3,4} = 12.03$
$\lg \beta_{1,2,3,4,5} = 11.43$
$\lg \beta_{1,2,3,4,5,6} = 8.9$

Hints:

1. Assume that concentration sum for conjugate acid and base and acid are constant (if base are used for complex formation it is added to solution to maintain constant concentration or concentration of base is huge enough and stays almost constant).

2. Write mathematical equations for calculation real reduction standard potentials depending from molar fraction of metal ions in solution.
   Example:
   $E(o,r) = E(o) + 0.059 * \lg x\ (Me)/z$

   $x(Me) = 1 / (1+ \beta1[L] + b2[L]^2 + ...+ b6[L]^6) = 1 / (1 + 10^(lgb1-pL) + 10^(lgb2-2pL) + ...+ 10^(lgb6 - 6pL))$

   $[L] = c_L * x_B = c_L * (1 / (1 + 10^(pKa-pH)))$

3. Using MS Excel program calculate real standard potential values, if pH changes from 0 to 14 (step 0.5). Made calculation in three cases: a) conjugate acid and base concentration sum is CL = 0.1 M, b) CL = 1 M and c) CL = 5 M. All calculation results collect in table.

Baltic Chemistry Competition

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2011
FINAL ROUND, SOLUTIONS

Part A – Multiple choice test

Q. number	Answer
1 .	B
2 .	B
3 .	D
4 .	A
5 .	A
6 .	B
7 .	A
8 .	D
9 .	C
10 .	D
11 .	A
12 .	B
13 .	A
14 .	B
15 .	D
16 .	A
17 .	B
18 .	B
19 .	B
20 .	C
21 .	C
22 .	D
23 .	A
24 .	B
25 .	A
26 .	C
27 .	B
28 .	B
29 .	C
30 .	A
31 .	B
33 .	D

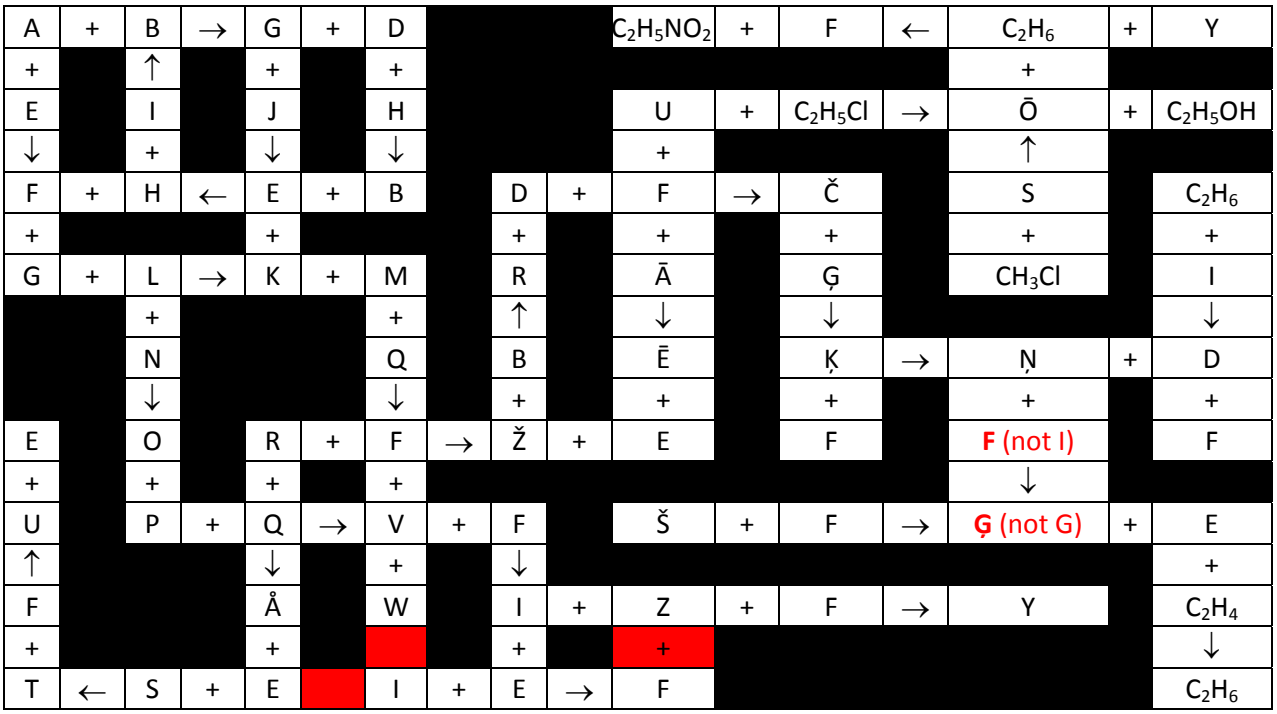
No correct answer, D , all statements are true

32 .	B
33 .	D
34 .	A
35 .	A
36 .	B
37 .	B
38 .	C
39 .	D
40 .	A
41 .	D
42 .	B
43 .	C
44 .	B
45 .	A
46 .	D
47 .	A
48 .	A
49 .	B
50 .	B
51 .	B
52 .	D
53 .	D
54 .	A
55 .	A
56 .	C
57 .	C
58 .	A
59 .	C
60.	B

Part B – Short answer questions

Problem 1

Chemical crossword – corrections (made with red color)



Answers:

A – Fe_3O_4 or other oxide which contains 72% metal, Mn_3O_4, Rh_2O_5, CaO – is not accepted wrong chemistry
B – CO
D – CO_2
E – H_2
F – H_2O
G – Fe
H – C
I – O_2
J – HCl
K – $FeCl_2$
L – $CuCl_2$
M – Cu
N - NaOH
O – NaCl
P – $Cu(OH)_2$
Q – H_2SO_4
R – Zn or other metal
S – Li or other alkali metal
T – LiH or other alkali metal
U – LiOH or other alkali metal

V – $CuSO_4$
W – SO_2
Z – NO_2
Y – HNO_3
Š – CaH_2, Ca accepted
Ž – ZnO
Ā – Al
Č – H_2CO_3
Ē – $Li[Al(OH)_4]$
Ģ – $Ca(OH)_2$
Ķ – $CaCO_3$
Ņ – CaO
Ō – LiCl or other metal
Å – $ZnSO_4$

Problem 2

(a) all heat is transferred to water/copper sulfate solution / no heat loss;
specific heat capacity of zinc is zero/negligible / no heat is absorbed by the zinc;
density of water/solution = 1.0 / density of solution = density of water;
heat capacity of cup is zero / no heat is absorbed by the cup;
specific heat capacity of solution = specific heat capacity of water;
temperature uniform throughout solution; ***[2 max]***
*Award **[1]** each for any two.*
Accept energy instead of heat.

(b) (i) $T_{final} = 73.0\ (^{\circ}C)$;
Allow in the range 72 to 74 (°C).

$\Delta T = 48.2\ (^{\circ}C)$; ***[2]***
Allow in the range 47 to 49 (°C).
*Award **[2]** for correct final answer*
Allow ECF if T_{final} or $T_{initial}$ correct.

(ii) 10.1 (kJ); ***[1]***
Allow in the range 9.9 to 10.2 (kJ).

(c) $\left(n_{Zn} = n_{CuSO_4} = \frac{1.00 \times 50.0}{1000}\right) = 0.0500\,(\text{mol})$; ***[1]***

(d) $-201\,(\text{kJ mol}^{-1})$; ***[1]***

Allow in the range -197 to -206 (kJ mol^{-1}).
Value must be negative to award mark.

(e) (i) the more negative the electrode potential the more negative the enthalpy change / the more exothermic the reaction / *OWTTE*; ***[1]***
Accept electrode potential proportional to the enthalpy change.
Do not accept greater enthalpy change.

(ii) any line (straight or curve) with positive gradient;
Accept if curve becomes flat for electrode potentials above 0.25.

which passes through $\Delta H = 0$ at standard electrode potentials between 0.25 and 0.50; ***[2]***
Accept either positive or zero enthalpy change for electrode potentials greater than value of copper (in range 0.25 to 0.50).

(f) d orbitals are split (into two sets of different energies);
frequencies of (visible) light absorbed by electrons moving from lower to higher d levels;
colour due to remaining frequencies/complementary colour transmitted;
Cu^{2+} has unpaired electrons/partially filled d sub-level;
Zn^{2+} has filled d sub-shell;
electronic transitions/d-d transitions possible for Cu^{2+} / no electronic/d-d transitions possible for Zn^{2+}; ***[4 max]***
Allow wavelength as well as frequency.

(g) NH_3: Lewis base / Cu^{2+}: Lewis acid;
each NH_3/ligand donates an electron pair (to Cu^{2+});
NH_3 replace H_2O ligands around Cu^{2+} ion/around central ion;
forming coordinate (covalent)/dative covalent bond; ***[3 max]***

(h) (i) energy (per mole) needed to remove one/first/most loosely bound electron from a (neutral) atom;
in the gaseous state;
$Mg(g) \rightarrow Mg^{+}(g) + e^{-}$; ***[3]***
Gaseous state symbols needed.
Accept e instead of e^{-}.
Only penalize omission of gas phase once in either the second marking point or the third marking point.

(ii) successive electrons (are more difficult to remove because each is) taken from more positively charged ion/ *OWTTE*;
increased electrostatic attraction; ***[2]***

(iii) 10^{th} electron comes from 2^{nd} energy level/$n = 2$ **and** 11^{th} electron comes from 1^{st} first energy level/$n = 1$ / *OWTTE*;
electron in 1^{st} energy level closer to nucleus;
electron in 1^{st} energy level not shielded by inner electrons / exposed to greater effective nuclear charge; ***[3]***

(i) (i) contains ions which are free to move (only) in molten state;
Mg^{2+} move to cathode/negative electrode and Cl^{-} move to anode/positive electrode / *OWTTE*; ***[2]***

(ii) anode/positive electrode;
$2Cl^{-} \rightarrow Cl_2 + 2e^{-}$ / $Cl^{-} \rightarrow \frac{1}{2}Cl_2 + e^{-}$; ***[2]***
Accept e instead of e^{-}.
Do not accept $Cl^{-} \rightarrow Cl + e^{-}$.
Ignore state symbols.

(iii) magnesium has large negative electrode potential / $E^{\ominus}$;
reduction of H_2O/H^{+} to H_2 has less negative electrode potential;
Mg^{2+} not readily reduced (in comparison to H_2O);
if formed, magnesium would (immediately) react with water to form Mg^{2+};
magnesium more reactive than hydrogen; ***[1 max]***
Do not accept Mg too reactive.

(j) (i) *I*:

atomization/sublimation (of Mg) / $\Delta H^{\ominus}_{\text{atomization}}(\text{Mg})$ / $\Delta H^{\ominus}_{\text{sublimation}}(\text{Mg})$;

V:

enthalpy change of formation of $(MgCl_2)$ / $\Delta H^{\ominus}_{\text{formation}}(MgCl_2)$; ***[2]***

(ii) *Energy value for II*:

+243;

Energy value for III:

$738 + 1451 = 2189$;

Energy value for IV:

$2(-349)$;

$\Delta H^{\ominus}_{\text{lat}}(MgCl_2) = 642 + 148 + 243 + 2189 = (+)2252(KJ)$; ***[4]***

Problem 3

(a) $n_C = \frac{82.6}{12.01} = 6.88$ **and** $n_H = \frac{17.4}{1.01} = 17.2$;

ratio is 1:2.5;

C_2H_5; ***[3]***

No penalty for using 12 and 1.

(b) $\left(M = \frac{22400}{385}\right) = 58.2$ / $\left(M = \frac{mRT}{PV}\right) = 58.3$;

C_4H_{10}; ***[2]***

(c) Br_2/bromine;

UV/ultraviolet light; ***[2]***

Accept hf/hv/sunlight.

(d) *Initiation:*

$Br_2 \rightarrow 2Br\bullet$;

Propagation:

$Br\bullet + RCH_3 \rightarrow HBr + RCH_2\bullet$;

$RCH_2\bullet + Br_2 \rightarrow RCH_2Br + Br\bullet$;

Termination: ***[1 max]***

$Br\bullet + Br\bullet \rightarrow Br_2$;

$RCH_2\bullet + Br\bullet \rightarrow RCH_2Br$;

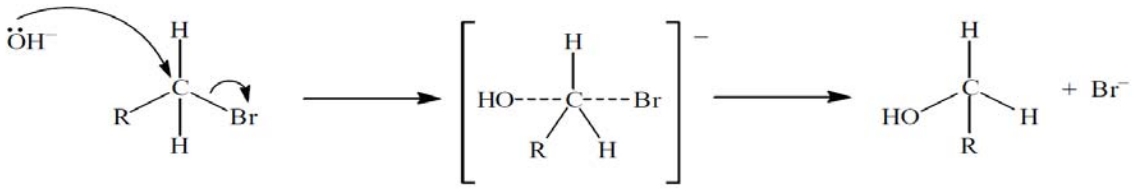
$RCH_2\bullet + RCH_2\bullet \rightarrow RCH_2CH_2R$; ***[4 max]***

Award ***[1]*** *for any termination step.*

Accept radical with or without • throughout.

Do not penalise the use of an incorrect alkane in the mechanism.

(e)



curly arrow going from lone pair/negative charge on O in OH^- to C;

Do not allow curly arrow originating on H in OH^-.

curly arrow showing Br leaving;

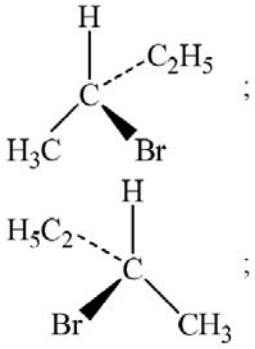
Accept curly arrow either going from bond between C and Br to Br in bromoethane or in the transition state.

representation of transition state showing negative charge, square brackets and partial bonds; ***[3]***

Do not penalize if HO and Br are not at 180° to each other.

Do not award M3 if OH ---- C bond is represented unless already penalised in M1.

Do not penalise the use of an incorrect alkyl chain in the mechanism

(f) 

;
;

[2]

First and second structures should be mirror images. Tetrahedral arrangement around carbon must be shown.

(g) (i) order with respect to OH^- = 0 ;
order with respect to X = 1;
rate = k[X] ; *[3]*
*Award **[3]** for final correct answer.*

(ii) 0.2(0);
min^{-1}; *[2]*

(iii) 2-bromo-2-methyl-propane;
Do not penalize missing hyphens or added spaces.
Accept 2-bromomethylpropane.

tertiary (structure); *[2]*

(iv) $C_4H_9Br \rightarrow C_4H_9^+ + Br^-$ / in equation with curly arrows **and** slow;
$C_4H_9^+ + OH^- \rightarrow C_4H_9OH$ / in equation with curly arrows **and** fast; *[2]*
No penalty if primary structure is shown.
No credit for S_N2 mechanism, except by ECF.

Problems for part A and part B exercises 2 and 3 taken from International baccalaureate organization chemistry exam papers.

Problem 4

$Cu^{2+} + 2\ e^- \rightarrow Cu$ $\qquad \varepsilon^0_{red} = -0{,}764\ V$

$Cu^{2+} + NH_3 \rightleftharpoons [Cu(NH_3)]^{2+}$ $\qquad \lg\beta_1 = 3{,}99$

$Cu^{2+} + 2NH_3 \rightleftharpoons [Cu(NH_3)_2]^{2+}$ $\qquad \lg\beta_2 = 7{,}33$

$Cu^{2+} + 3NH_3 \rightleftharpoons [Cu(NH_3)_3]^{2+}$ $\qquad \lg\beta_3 = 10{,}06$

$Cu^{2+} + 4NH_3 \rightleftharpoons [Cu(NH_3)_4]^{2+}$ $\qquad \lg\beta_4 = 12{,}03$

$Cu^{2+} + 5NH_3 \rightleftharpoons [Cu(NH_3)_5]^{2+}$ $\qquad \lg\beta_5 = 11{,}43$

$Cu^{2+} + 6NH_3 \rightleftharpoons [Cu(NH_3)_6]^{2+}$ $\qquad \lg\beta_6 = 8{,}9$

$NH_4^+ + H_2O \rightleftharpoons H_3O^+ + NH_3$ $\qquad pK_A = 9{,}25$

$$\varepsilon = \varepsilon^0_{red} - \frac{RT}{2\cdot F}\ln\frac{1}{[Cu^{2+}]} = \varepsilon^0_{red} + \frac{RT}{2\cdot F}\ln[Cu^{2+}]$$

$$\begin{cases} K_A = \dfrac{[H_3O^+]\cdot[NH_3]}{[NH_4^+]} \\ C_L = [NH_4^+] + [NH_3] + [\{Cu(NH_3)_1\}^{2+}] + 2\cdot[\{Cu(NH_3)_2\}^{2+}] + 3\cdot[\{Cu(NH_3)_3\}^{2+}] + \\ + 4\cdot[\{Cu(NH_3)_4\}^{2+}] + 5\cdot[\{Cu(NH_3)_5\}^{2+}] + 6\cdot[\{Cu(NH_3)_6\}^{2+}] \\ K_1 = \dfrac{[\{Cu(NH_3)\}^{2+}]}{[Cu^{2+}]\cdot[NH_3]} \\ K_2 = \dfrac{[\{Cu(NH_3)_2\}^{2+}]}{[Cu^{2+}]\cdot[NH_3]^2} \\ K_3 = \dfrac{[\{Cu(NH_3)_3\}^{2+}]}{[Cu^{2+}]\cdot[NH_3]^3} \\ K_4 = \dfrac{[\{Cu(NH_3)_4\}^{2+}]}{[Cu^{2+}]\cdot[NH_3]^4} \\ K_5 = \dfrac{[\{Cu(NH_3)_5\}^{2+}]}{[Cu^{2+}]\cdot[NH_3]^5} \\ K_6 = \dfrac{[\{Cu(NH_3)_6\}^{2+}]}{[Cu^{2+}]\cdot[NH_3]^6} \\ C_{Cu} = [Cu^{2+}] + [\{Cu(NH_3)_1\}^{2+}] + [\{Cu(NH_3)_2\}^{2+}] + [\{Cu(NH_3)_3\}^{2+}] + [\{Cu(NH_3)_4\}^{2+}] + \\ + [\{Cu(NH_3)_5\}^{2+}] + [\{Cu(NH_3)_6\}^{2+}] \end{cases}$$

$$C_L = [NH_4^+] + [NH_3] + [\{Cu(NH_3)_1\}^{2+}] + 2\cdot[\{Cu(NH_3)_2\}^{2+}] + 3\cdot[\{Cu(NH_3)_3\}^{2+}] + \\ + 4\cdot[\{Cu(NH_3)_4\}^{2+}] + 5\cdot[\{Cu(NH_3)_5\}^{2+}] + 6\cdot[\{Cu(NH_3)_6\}^{2+}]$$

$$C_L = [NH_4^+] + [NH_3]$$

$$
\begin{cases}
K_A = \dfrac{[H_3O^+]\cdot[NH_3]}{[NH_4^+]} \\
C_L = [NH_4^+] + [NH_3] \;\Rightarrow\; [NH_4^+] = C_L - [NH_3] \;\Rightarrow\; K_A = \dfrac{10^{-pH}\cdot[NH_3]}{C_L - [NH_3]} \;\Rightarrow \\
\Rightarrow\; 10^{-pH}\cdot[NH_3] = K_A\cdot C_L - [NH_3]\cdot K_A \;\Rightarrow\; (10^{-pH}+K_A)\cdot[NH_3] = K_A\cdot C_L \;\Rightarrow \\
\Rightarrow\; [NH_3] = \dfrac{K_A\cdot C_L}{10^{-pH}+K_A} \\
\beta_1 = \dfrac{[\{Cu(NH_3)\ \}^{2+}]}{[Cu^{2+}]\cdot[NH_3]} \;\Rightarrow\; \beta_1 = \dfrac{[\{Cu(NH_3)\ \}^{2+}]}{[Cu^{2+}]\cdot\left(\dfrac{K_A\cdot C_L}{10^{-pH}+K_A}\right)} \;\Rightarrow\; [\{Cu(NH_3)\ \}^{2+}] = \beta_1\cdot[Cu^{2+}]\cdot\left(\dfrac{K_A\cdot C_L}{10^{-pH}+K_A}\right) \\
\beta_2 = \dfrac{[\{Cu(NH_3)_2\}^{2+}]}{[Cu^{2+}]\cdot[NH_3]^2} \;\Rightarrow\; \beta_2 = \dfrac{[\{Cu(NH_3)_2\}^{2+}]}{[Cu^{2+}]\cdot\left(\dfrac{K_A\cdot C_L}{10^{-pH}+K_A}\right)^2} \;\Rightarrow\; [\{Cu(NH_3)_2\}^{2+}] = \beta_2\cdot[Cu^{2+}]\cdot\left(\dfrac{K_A\cdot C_L}{10^{-pH}+K_A}\right)^2 \\
\beta_3 = \dfrac{[\{Cu(NH_3)_3\}^{2+}]}{[Cu^{2+}]\cdot[NH_3]^3} \;\Rightarrow\; \ldots \;\Rightarrow\; [\{Cu(NH_3)_3\}^{2+}] = \beta_3\cdot[Cu^{2+}]\cdot\left(\dfrac{K_A\cdot C_L}{10^{-pH}+K_A}\right)^3 \\
\beta_4 = \dfrac{[\{Cu(NH_3)_4\}^{2+}]}{[Cu^{2+}]\cdot[NH_3]^4} \;\Rightarrow\; \ldots \;\Rightarrow\; [\{Cu(NH_3)_4\}^{2+}] = \beta_4\cdot[Cu^{2+}]\cdot\left(\dfrac{K_A\cdot C_L}{10^{-pH}+K_A}\right)^4 \\
\beta_5 = \dfrac{[\{Cu(NH_3)_5\}^{2+}]}{[Cu^{2+}]\cdot[NH_3]^5} \;\Rightarrow\; \ldots \;\Rightarrow\; [\{Cu(NH_3)_5\}^{2+}] = \beta_5\cdot[Cu^{2+}]\cdot\left(\dfrac{K_A\cdot C_L}{10^{-pH}+K_A}\right)^5 \\
\beta_6 = \dfrac{[\{Cu(NH_3)_6\}^{2+}]}{[Cu^{2+}]\cdot[NH_3]^6} \;\Rightarrow\; \ldots \;\Rightarrow\; [\{Cu(NH_3)_6\}^{2+}] = \beta_6\cdot[Cu^{2+}]\cdot\left(\dfrac{K_A\cdot C_L}{10^{-pH}+K_A}\right)^6 \\
C_{Cu} = [Cu^{2+}] + [\{Cu(NH_3)\}^{2+}] + [\{Cu(NH_3)_2\}^{2+}] + [\{Cu(NH_3)_3\}^{2+}] + [\{Cu(NH_3)_4\}^{2+}] + \\
+ [\{Cu(NH_3)_5\}^{2+}] + [\{Cu(NH_3)_6\}^{2+}]
\end{cases}
$$

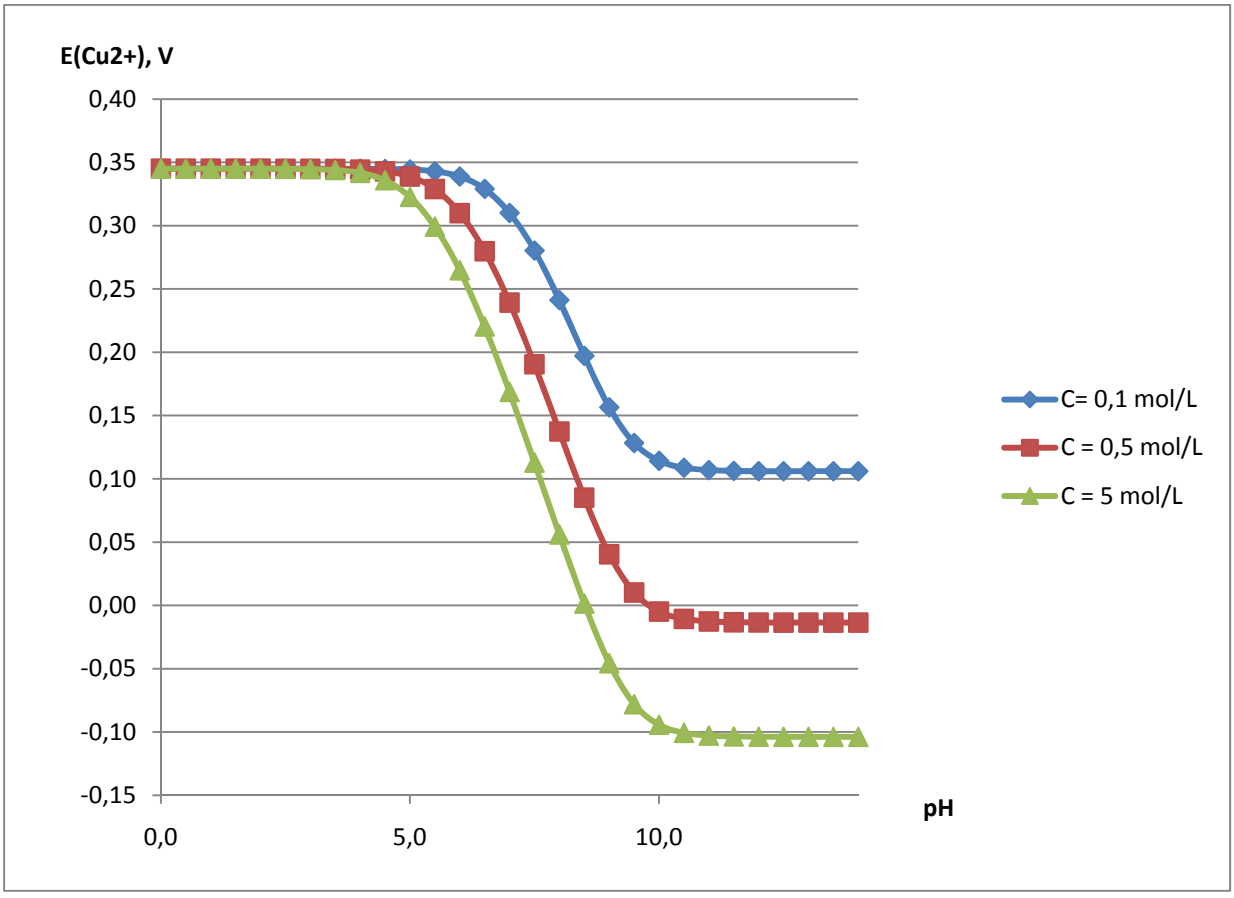
$$
\begin{aligned}
C_{Cu} &= [Cu^{2+}] + [\{Cu(NH_3)\}^{2+}] + [\{Cu(NH_3)_2\}^{2+}] + [\{Cu(NH_3)_3\}^{2+}] + [\{Cu(NH_3)_4\}^{2+}] + \\
&+ [\{Cu(NH_3)_5\}^{2+}] + [\{Cu(NH_3)_6\}^{2+}] = \\
&= [Cu^{2+}]\cdot\left(\begin{array}{l} 1 + \beta_1\cdot\left(\dfrac{K_a\cdot C_L}{10^{-pH}+K_a}\right) + \beta_2\cdot\left(\dfrac{K_a\cdot C_L}{10^{-pH}+K_a}\right)^2 + \beta_3\cdot\left(\dfrac{K_a\cdot C_L}{10^{-pH}+K_a}\right)^3 + \beta_4\cdot\left(\dfrac{K_a\cdot C_L}{10^{-pH}+K_a}\right)^4 + \\ + \beta_5\cdot\left(\dfrac{K_a\cdot C_L}{10^{-pH}+K_a}\right)^5 + \beta_6\cdot\left(\dfrac{K_a\cdot C_L}{10^{-pH}+K_a}\right)^6 \end{array}\right)
\end{aligned}
$$

$$
[Cu^{2+}] = \frac{1}{\begin{array}{l} 1 + \beta_1\cdot\left(\dfrac{K_a\cdot C_L}{10^{-pH}+K_a}\right) + \beta_2\cdot\left(\dfrac{K_a\cdot C_L}{10^{-pH}+K_a}\right)^2 + \beta_3\cdot\left(\dfrac{K_a\cdot C_L}{10^{-pH}+K_a}\right)^3 + \beta_4\cdot\left(\dfrac{K_a\cdot C_L}{10^{-pH}+K_a}\right)^4 + \\ + \beta_5\cdot\left(\dfrac{K_a\cdot C_L}{10^{-pH}+K_a}\right)^5 + \beta_6\cdot\left(\dfrac{K_a\cdot C_L}{10^{-pH}+K_a}\right)^6 \end{array}}
$$

$$\varepsilon'_{red} = \varepsilon^0_{red} + \frac{RT}{2 \cdot F} \ln \left(\frac{1}{1 + \beta_1 \cdot \left(\frac{K_a \cdot C_L}{10^{-pH} + K_a} \right) + \beta_2 \cdot \left(\frac{K_a \cdot C_L}{10^{-pH} + K_a} \right)^2 + \beta_3 \cdot \left(\frac{K_a \cdot C_L}{10^{-pH} + K_a} \right)^3 + \beta_4 \cdot \left(\frac{K_a \cdot C_L}{10^{-pH} + K_a} \right)^4 + \right.$$
$$\left. + \beta_5 \cdot \left(\frac{K_a \cdot C_L}{10^{-pH} + K_a} \right)^5 + \beta_6 \cdot \left(\frac{K_a \cdot C_L}{10^{-pH} + K_a} \right)^6 \right)$$

$$K_a = 10^{-pK_a}$$

$$K_n = 10^{\lg K_n}$$



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Final results of BCC 2011

Nr.p.k.	Name	State	School	Form	TOTAL	Prize	Round 1					Round 2						Round 3					FINAL ROUND					
							1.	2.	3.	4.	Sum	1.	2.	3.	4.	5.	Sum	1.	2.	3.	4.	Sum	Part A	Part B1	Part B2	Part B3	Part B4	Sum
max					150,00		8	10	4	8	30	5	5	10	5	5	30	5	8	8	9	30,00	30,00	8,00	10,00	6,00	6,00	60,00
1	**Sigitas Mikutis**	**LT**			107,71	**1st place**	3,28	9,25	4	7,724	24,25	4,1	2,32	7,5	5	4,6	23,52	3,5	4,83	8	5,499	21,83	23,50	2,35	6,25	6,00	0,00	38,10
2	**Emilis Bruzas**	**LT**	**Klaipeda "Azuolynas" gymnasium**	12	105,83	**2nd place**	6,24	9,25	4	8	27,49	3,8	3	7	4,5	3,9	22,2	3,5	7,17		7,002	17,67	24,50	4,47	7,50	6,00	-4,00	38,47
3	**Jurgis Kuliesius**	**LT**	**Vilniaus Žirmūnu gimnazija**	12	102,56	**3rd place**	4,64	7,75	1	7,724	21,11	4,5	4,5	8,9	4,5	4,8	27,2	4	3,54	3,2	6,201	16,94	22,50	2,59	7,78	4,44	0,00	37,31
4	Kristina Smokrovich	CR	V. gimnazija	12	97,99	Honorary mention	4,04	6,25	4	6,345	20,63	3,65	4,16	9,3	4,5	2,5	24,11	3,5	7,17	8	6,804	25,47	23,00	1,41	0,00	3,36	0,00	27,77
5	Taivo Pungas	EE	Tallinn Secondary Science School	11	95,53	Honorary mention	5,56	9	0	8	22,56	5	3,83	9,2	5	2	25,03	4	2,33	0	1,602	7,93	23,50	3,53	7,22	5,76		40,01
6	Rene Lomp	EE	Liivalaia Secondary school		94,19	Honorary mention	4	7	4	8	23	6	3,205	8,9	5	1,5	24,605		0,375	8		8,38	25,00	3,76	4,17	5,28	0,00	38,21
7	Jana Volaric	CR	V. gimnazija	4th	93,91	Honorary mention	3,12	6	4	8	21,12	4,25	3,85	9,4	5	2,8	25,3	3,5	4,08	8	4,302	19,88	24,00	0,00	3,61	0,00	0,00	27,61
8	Julia Tseglakova	EE	Tallinn High School of Humanities	11	91,05	Honorary mention	1,28	8	0	7,72	17	2,8	4	4	5	3,8	19,6	4,5	6,5	3,2	2,196	16,40	24,00	3,29	5,00	5,76	0,00	38,05
9	Mirna Mustapić	CR	V. gimnazija	4th	86,75		2,84	4,5	4	6,621	17,96	3,75	3,33	8,8	5	3,7	24,58	3,5	5,21	8	4,725	21,44	22,50	0,00	0,28	0,00	0,00	22,78
10	Aurimas Narkevicius	LT	KTUG	11	82,51		2,44	6	4	6,345	18,78	4,3	3,285	7,5	5	1,2	21,285	3,5	3,17	0	1,305	7,98	19,50	5,88	5,00	4,08	0,00	34,46
11	Kaur Aare Saar	EE	Tallinn English College	10	80,82		0	0	0	7,034	7,034	4	3,58	8,5	5	1	22,08	3	1,5	0	0,801	5,30	24,50	7,29	8,33	5,28	1,00	46,41
12	Mindaugas Siauciulis	LT	Mykolas Birziska gymnasium	11	67,49		0	4	0	7,448	11,45	4,15	3,75	6,5	3,5	1,1	19	3,5	1,5	0	0,504	5,50	22,00	0,71	4,03	4,80	0,00	31,53
13	Eva-Lotta Kasper	EE	Hugo Treffner Gymnasium	11	64,54		3,72	8,5	0	7,172	19,39	4,38	2,5	3	0	1,2	11,08	2,5	0	0	0	2,50	21,50	6,82	0,00	3,24	0,00	31,56
14	Katrina Sepp	EE	Miina Harma Gumnaasium	12	59,94		3,68	7,75	0	8	19,43	4,13	0,83	4,5	3	0,7	13,16					0,00	21,50	2,59	2,78	0,48	0,00	27,35
15	Lona-Liisa Sutt	EE	Miina Harma Gumnaasium	10	55,46		3,16	0,75	0	6,621	10,53	4,45	3,375	5,4	5	2	20,225					0,00	20,00	4,71	0,00	0,00	0,00	24,71
16	Jānis Briška	LV	Salas secondary school	11	53,45		0,8	6,25	0	7,72	14,77	0					0					0,00	21,00	8,00	5,83	3,84	0,00	38,67
17	Valdis Dakuļs	LV	Viļānu secondary school	11	50,30		0	0	0	5,793	5,793	3,5	3,17	2	3,5	0,4	12,57	1	0	0	0,594	1,59	21,50	7,29	0,83	0,72	0,00	30,35
18	Jaan Toots	EE	Tallinna Reaalkool	10	48,88		1,08	0	0	8	9,08	0					0	5	0,833	0	0,594	6,43	23,00	3,29	7,08	0,00	0,00	33,38
19	Kristers Ozols	LV	Riga State Gymnasium No.3	11	43,02		0	8	4	7,172	19,17	0					0					0,00	19,00	3,06	0,83	0,96	0,00	23,85
20	Kert Pütsepp	EE	Tallinn Secondary Science School		35,08		0,12	9,25	0	7,034	16,4	4,5	1,875	4,3	2,5	1	14,175	2	1,5	0	0,999	4,50	0,00		0,00	0,00		0,00
21	Mantas Vasiliauskas	LT	Kuršėnu Lauryno Ivinskio gymnasium	12	33,86		0,2	5,25	0	4,966	10,42	2,6	1	0	1	0,9	5,5					0,00	17,00	0,94	0,00	0,00	0,00	17,94
22	George Trenin	LV	Riga 95th Secondary school	10	27,61						0						0					0,00	21,50	0,00	6,11	0,00	0,00	27,61
23	Ralf Ahi	EE			23,10		0	4,5	0	7,172	11,67	4	2,125	0,4	4	0,9	11,425					0,00	0,00		0,00	0,00		0,00
24	Māris Seržāns	LV	Riga State Gymnasium No.1	10	19,25		0	0	0	0	0	3,65	3	8,9	3	0,7	19,25					0,00	0,00		0,00	0,00		0,00
25	Vytaute Maciulsyte	LT			18,75		0	6,75	4	8	18,75	0					0					0,00	0,00		0,00	0,00		0,00
26	Elza Liniņa	LV	Riga State Gymnasium No.3		17,20		0	0	0	0	0	4,15	2,045	6	3,5	1,5	17,195					0,00	0,00		0,00	0,00		0,00
27	Kaur Karus	EE			13,25		1,6	0	0	0	1,6	2,5	0,25	3,9	4	1	11,65					0,00	0,00		0,00	0,00		0,00
28	Greta Macileviciute	LT			11,01		0,24	0,75	0	5,517	6,507	3,25	1,25	0	0	0	4,5					0,00	0,00		0,00	0,00		0,00
29	Ernestas Blazevic	LT			10,81		3,64	0	0	7,172	10,81	0					0					0,00	0,00		0,00	0,00		0,00
30	Erik Tamre	EE			8,50		0	0	0	0	0	0		7,5	0	1	8,5					0,00	0,00		0,00	0,00		0,00
31	Gediminas Aucina	LT			7,40		0	0	0	0	0	4,23	2,17	0	1	0	7,4					0,00	0,00		0,00	0,00		0,00
33	Katrīna Krieviņa	LV	Riga State Gymnasium No.1	11	6,08		0,84	0	0	5,241	6,081	0					0					0,00	0,00		0,00	0,00		0,00
34	Augustinas Juskauskas	LT			6,05		0,12	0	0	5,931	6,051	0					0					0,00	0,00		0,00	0,00		0,00
35	Madis Ollikainen	EE			5,52		0	0	0	5,517	5,517	0					0					0,00	0,00		0,00	0,00		0,00
36	Tatjana Gerasimova	LV	Riga Secondary school No. 72	12	5,29		0,6	0	0	4,69	5,29	0					0					0,00	0,00		0,00	0,00		0,00
37	Pijus Savickas	LT			5,24		0	0	0	5,241	5,241	0					0					0,00	0,00		0,00	0,00		0,00
38	Simonas Balkaitis	LT			4,26		0,12	0	0	4,138	4,258	0					0					0,00	0,00		0,00	0,00		0,00
39	Silvija Svambaryte	LT			4,14		0	0	0	4,138	4,138	0					0					0,00	0,00		0,00	0,00		0,00
40	Dovile Meliauskaite	LT			3,00		0,52	0	0	2,483	3,003	0					0					0,00	0,00		0,00	0,00		0,00

International jury:
Egle Maksimaviciute LT
Vladislav Ivaništšev EE
Kaspars Veldre LV
Filip Topić CRO

Students will be awarded during Chemistry Olympiad of Baltic states, 2011, April 15-17, Vilnius, Lithuania