

State of Israel
Ministry of Education

Exam Type:

א. *Bagrut* for high schools

ב. *Bagrut* for external examinees

Exam date: Summer 2013

Exam number: 037303, 27

Attachments: (1) Answer booklet

(2) Periodic table

(3) Electronegativity table

English translation (3)

מדינת ישראל

משרד החינוך

סוג הבחינה:

א. בגרות לבתי ספר על-יסודיים

ב. בגרות לנבחנים חיצוניים

מועד הבחינה: קיץ תשע"ג, 2013

מספר השאלון: 27, 037303

נספחים: (1) גיליון תשובות

(2) המערכה המחזורית

(3) טבלת אלקטרושליליות

תרגום לאנגלית (3)

Chemistry

3 points

כימיה

3 יחידות לימוד

Instructions for examinees

א. Duration of the exam: Three hours

ב. Exam structure and breakdown of points:

This exam has two parts.

Part I — Required — (2×20) — 40 points

Part II — (3×20) — 60 points

Total — 100 points

ג. Material that may be used during the exam:

(1) A calculator (graphing calculators are permitted).

(2) A Hebrew-foreign language/foreign language-Hebrew dictionary.

ד. Special instructions:

(1) **Note:** Question 1 in the first part of the exam includes eight items א-ח. Four possible answers are given for each item and you must choose the correct answer for each one. Mark the correct answers in your answer booklet.

(2) **Attach your answer booklet to the test booklet.**

(3) **In Part I, you must answer both questions. In Part II, you must answer three of the six questions.**

Write all of your rough work (calculations, notes, etc.) on separate pages of the answer booklet only.

Write the word "טייטה" on the top of each of these pages.

If you write any sort of work outside the answer booklet, your test may be disqualified!

Good Luck!

/continued on the next page/

הוראות לנבחן

א. משך הבחינה: שלוש שעות.

ב. מבנה השאלון ומפתח ההערכה:

בשאלון זה שני פרקים.

פרק ראשון — חובה —

40 נקודות (20×2)

פרק שני — (20×3) — 60 נקודות

סה"כ — 100 נקודות

ג. חומר עזר מותר בשימוש:

(1) מחשבון (כולל מחשבון גרפי).

(2) מילון עברי-לועזי / לועזי-עברי.

ד. הוראות מיוחדות:

(1) **שים לב:** בשאלה 1 שבפרק הראשון

שמונה סעיפים א-ח. לכל סעיף

מוצגות ארבע תשובות, ומהן

עליך לבחור בתשובה הנכונה.

סמן את התשובות הנכונות בגיליון

התשובות.

(2) **הדק את גיליון התשובות למחברת**

הבחינה.

(3) **בפרק הראשון יש לענות על שתי**

השאלות, ובפרק השני יש לענות על

שלוש מבין שש השאלות.

כתוב במחברת הבחינה בלבד, בעמודים נפרדים, כל מה שברצונך לכתוב כטייטה (ראשי פרקים, חישובים וכדומה). רשום "טייטה" בראש כל עמוד טייטה. רישום טייטות כלשהן על דפים שמחוץ למחברת הבחינה עלול לגרום לפסילת הבחינה!

בהצלחה!

/המשך מעבר לדף/

Questions

Part One (40 points)

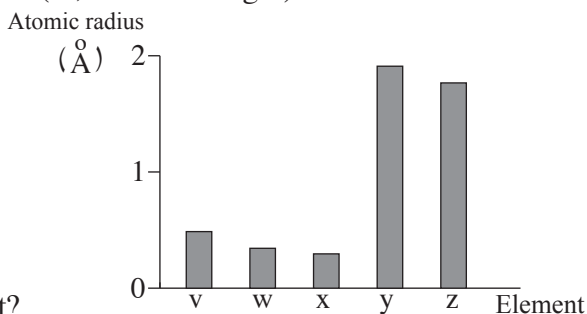
Answer **both** Question 1 **and** Question 2 (each question – 20 points).

1. Answer all of the Items κ through π in the attached answer booklet (each item – 2.5 points).

For each item, circle the number that corresponds to the correct answer.

Before you answer, read each of the possible answers.

- κ . Five elements with consecutive atomic numbers are represented by the letters v, w, x, y and z. The figure below shows the radii of the atoms of these elements in Angstroms ($\text{\AA}$, a unit of length).



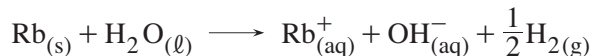
Which statement is correct?

- The elements v-z are located in the same row of the periodic table.
 - Element z is a member of the family of noble gases.
 - Element y is a member of the family of alkali metals.
 - The number of valence electrons in an atom of Element v is smaller than the number of valence electrons in an atom of Element z.
- π . In a liquid state, the forces of attraction between molecules of dichloromethane, $\text{CH}_2\text{Cl}_{2(l)}$, are stronger than the forces of attraction between molecules of 4-fluoromethane, $\text{CF}_4(l)$. The molecules of each of these substances have a tetrahedral shape. What causes the difference in the strength of the intermolecular forces in the two substances?
- The electron clouds in CH_2Cl_2 molecules are larger than the electron clouds in CF_4 molecules.
 - In molecules of CH_2Cl_2 there is a constant dipole; whereas in CF_4 molecules, there is only a temporary dipole.
 - The contact area between CH_2Cl_2 molecules is smaller than the contact area between CF_4 molecules.
 - There are hydrogen bonds between molecules of CH_2Cl_2 , whereas there are van der Waals forces between CF_4 molecules.

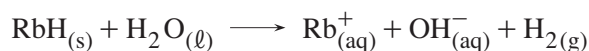
/continued on page 3/

- ג. Two containers, A and B, each contain 100 mL of water. A solid material was put into each container.

The following reaction occurred in Container A:



The following reaction occurred in Container B:



The reactions in the two containers proceeded at the same temperature and the same pressure.

During the course of each reaction, 0.25 mol of gas were emitted.

Which statement is correct?

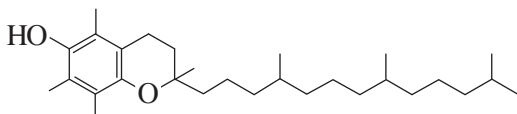
1. Equal masses of the reacting solid were put into each container.
 2. The same number of mols of the reacting solid were put into each container.
 3. Upon the completion of the reactions, the volume of gas in Container A was greater than the volume of gas in Container B.
 4. Upon the completion of the reactions, the number of mols of $\text{Rb}_{(\text{aq})}^+$ ions in Container A was greater than the number of mols of $\text{Rb}_{(\text{aq})}^+$ ions in Container B.
7. A solution containing iodate ions, $\text{IO}_3^-_{(\text{aq})}$, was mixed with a solution of hydrogen peroxide, $\text{H}_2\text{O}_{2(\text{aq})}$. A reaction occurred.
- What products might be obtained in this reaction?
1. $\text{O}_{2(\text{g})}$ and $\text{I}_{2(\text{aq})}$
 2. $\text{O}_{2(\text{g})}$ and $\text{IO}_4^-_{(\text{aq})}$
 3. $\text{OH}^-_{(\text{aq})}$ and $\text{I}_{2(\text{aq})}$
 4. $\text{OH}^-_{(\text{aq})}$ and $\text{IO}_4^-_{(\text{aq})}$

ה. Vitamin C and vitamin E are two vitamins that act as antioxidants.

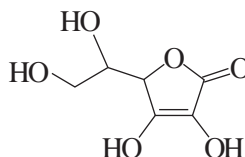
The molar mass of vitamin C is $176 \frac{\text{grams}}{\text{mol}}$.

The molar mass of vitamin E is $430 \frac{\text{grams}}{\text{mol}}$.

The structural formulas of the two vitamins are shown below:



Vitamin E



Vitamin C

Which statement is correct?

1. There are fewer molecules in 1 gram of vitamin C than there are in 1 gram of vitamin E.
 2. Both vitamins are members of the group of vitamins that are water-soluble.
 3. Both vitamins are members of the group of vitamins that are soluble in oil.
 4. In a reaction with free radicals, both vitamins will be oxidized.
- ו. Tea from the lavender plant can be used as an indicator for acids and bases.

The tea is pink at $\text{pH} < 7$, purple at $\text{pH} = 7$ and green at $\text{pH} > 7$.

Lavender tea was added to four different aqueous solutions.

Which of the rows, 1-4, in the table below correctly reports the color of each solution after the tea was added?

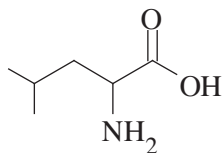
	$\text{HBr}_{(\text{aq})}$	$\text{KOH}_{(\text{aq})}$	$\text{CH}_3\text{OH}_{(\text{aq})}$	$\text{CH}_3\text{NH}_{2(\text{aq})}$
1	purple	pink	green	green
2	pink	green	green	green
3	pink	green	purple	green
4	pink	purple	purple	pink

- ז. 100 mL of a solution of barium hydroxide, $\text{Ba(OH)}_{2(\text{aq})}$, with a concentration of 0.01 M, were mixed with 100 mL of an aqueous solution of an acid. A reaction occurred. Upon the completion of the reaction, the pH of the solution was less than 7.

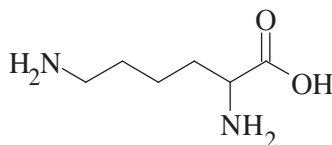
What was the aqueous acidic solution?

1. A $\text{HNO}_{3(\text{aq})}$ solution with a concentration of 0.01 M
2. A $\text{HNO}_{3(\text{aq})}$ solution with a concentration of 0.02 M
3. A $\text{H}_2\text{SO}_{4(\text{aq})}$ solution with a concentration of 0.01 M
4. A $\text{H}_2\text{SO}_{4(\text{aq})}$ solution with a concentration of 0.02 M

- ח. The structural formulas of two amino acids are presented below:



Leucine



Lysine

Four statements (I-IV) are presented below.

- I. Each of the two amino acids has a side-group, R, that includes a dipole.
- II. Both amino acids are solids at room temperature.
- III. In an aqueous solution with a pH = 7, the overall electrical charge for each of the two amino acids is equal to 0.
- IV. A condensation [דחיסה] reaction could occur between the two amino acids.

Which statements are correct?

1. I and III only
2. II and IV only
3. I and IV only
4. II and III only

Analysis of a Passage from a Scientific Article - Required

2. Read the passage below and respond to all of the items ה-א that follow.

Sugar and Bacteria Clean the Environment

Drycleaning is a method of cleaning clothes with a solvent other than water. In the past, the solvent perchlorethane (PCE), whose formula is $C_2Cl_{4(l)}$ was commonly used. Recently, this solvent has been found to be harmful to human health.

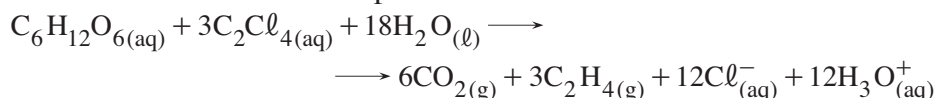
In areas in which drycleaning plants were located, the wastewater from those plants, which included high concentrations of PCE, contaminated the soil and sources of drinking water.

In Israel, the maximum permissible level of PCE in drinking water is 5 molecules of PCE per 10^9 molecules of water. Drinking water that contains higher concentrations of PCE is a health hazard.

An innovative method known as bioremediation is being used to decontaminate both soil and water sources that have been polluted with PCE. In this method, bacteria are used to treat pollutants in the environment. In this method, molasses is added to the soil or water source. Molasses is a thick liquid rich in glucose, $C_6H_{12}O_{6(aq)}$, which is produced in the process by which sugar is produced from sugarcane.

Glucose provides optimal conditions for the culturing of certain bacteria that are found in soil or water sources. With the help of glucose, these bacteria can transform molecules of PCE into ethene, C_2H_4 , molecules in a multi-stage oxidation-reduction reaction.

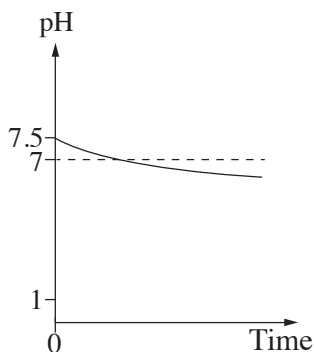
The overall reaction for this process is shown below:



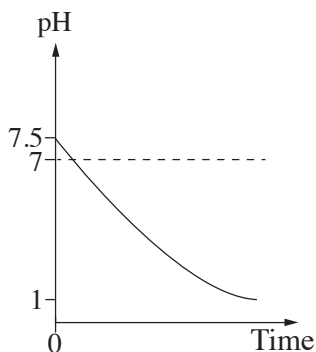
This process is repeated several times until the concentration of PCE reaches the permitted level. In recent years, the use of this method has spread.

(Adapted from: Argentine, C. "Microbes and Molasses: A Successful Partnership" ChemMatters, April 2012)

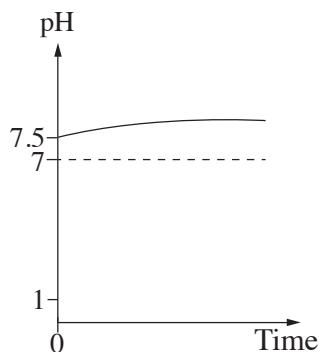
- א. i Draw the structural formulas of a molecule of PCE and a molecule of ethene.
- ii Explain why, under room conditions, PCE is a liquid, while ethene is a gas.
- ב. Calculate the maximum number of PCE molecules permitted in a cup that contains 180 grams of water. In one mol of particles, there are $6.02 \cdot 10^{23}$ particles. Show detailed calculations.
- ג. Name two functions of glucose in the decontamination process described in the passage.
- ד. i Determine the oxidation level of the carbon atoms in each of the following molecules:
 C_2Cl_4 , CO_2 , C_2H_4
- ii Determine whether, in the reaction shown in the passage, $C_2H_{4(g)}$ is a product of the oxidation or the reduction of $C_2Cl_{4(aq)}$.
Explain.
- ה. i The decontamination of a source of drinking water was monitored by measuring the pH.
 Which of the graphs below (I-III) correctly describes the change in the pH of the water over time? Explain.



I



II



III

- ii It is recommended that chalk, $CaCO_{3(s)}$, be added to soils treated as described in the passage. Explain why.

Part Two (60 points)

Answer three of the questions 3-8 (each question – 20 points).

Atomic Structure, Bonding and Characteristics of Materials

3. In the table below, you will find data concerning five atoms that have been randomly labeled with the letters a, b, c, f and g.

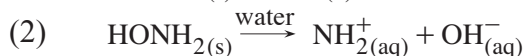
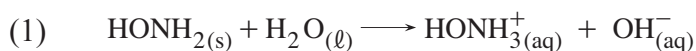
Atom	a	b	c	f	g
Mass number	14	14	15	17	18
Number of neutrons	7	8	8	9	9

- א. i Determine which of the atoms in the table has the smallest nuclear charge. Explain.
- ii Determine which (two or more) of the atoms in the table are isotopes of nitrogen, N. Explain.
- iii Draw the arrangement of the electrons at the different energy levels of atoms c, f and g.

Formulas of four molecules that contain nitrogen are shown below:



- ב. i Write out the Lewis electron-dot structure [נוסחת ייצוג אלקטרונית] of each of the given molecules.
- ii Indicate whether the partial charge on the nitrogen atom in each of the molecules is a positive partial charge or a negative partial charge.
- ג. i In a molecule of HONH_2 , the O–H bond is shorter than the N–H bond. State one cause for this and explain its effect on the length of the bond.
- ii Which bond is shorter: N–O or N=O? Explain.
- ד. i Hydroxyl amine, $\text{HONH}_{2(s)}$, is put into water. The solution that is obtained has a $\text{pH} > 7$.
 Determine which of the two equations below, (1)-(2), correctly represents the reaction that took place. Explain why you rejected the other equation.



- ii The boiling point of ammonia, $\text{NH}_{3(\ell)}$, is higher than the boiling point of nitrogen trifluoride, $\text{NF}_{3(\ell)}$. Explain why.

Characteristics of Materials and Stoichiometry

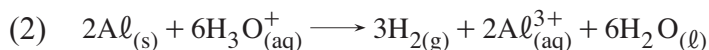
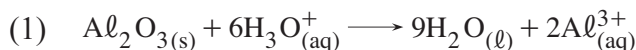
4. Linnet is an alloy [סגסוגת] of aluminum, $\text{Al}_{(s)}$, and copper, $\text{Cu}_{(s)}$.

A layer of aluminum oxide, $\text{Al}_2\text{O}_{3(s)}$, is formed on the surface of this alloy and that layer helps to protect the alloy against corrosion.

- א. How does the structure of $\text{Al}_2\text{O}_{3(s)}$ differ from the structure of linnet?
In your answer, refer to the type of particles present and the forces that act between those particles.

An experiment was conducted to determine the composition of the alloy linnet. A sample of 6 grams of linnet was taken and put into a solution of hydrochloric acid, $\text{HCl}_{(aq)}$.

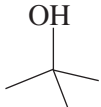
Only two reactions, (1) and (2), occurred.



- ב. i Determine whether each of the two reactions, (1) and (2), is an oxidation-reduction reaction or an acid-base reaction. Explain.
- ii What is the function of the hydronium ions, $\text{H}_3\text{O}_{(aq)}^+$, in each of the reactions, (1) and (2)? Explain.
- ג. In the reaction of 6 grams of linnet with a sufficient amount of $\text{HCl}_{(aq)}$ solution, 7.875 liters of $\text{H}_{2(g)}$ were emitted and 0.3 grams of unreacted solid remained.
- The volume of 1 mol of gas under the reaction conditions is 25 liters.
- i How many mols of gas were emitted? Show detailed calculations.
- ii How many mols of $\text{Al}_{(s)}$ reacted? Explain.
- iii Calculate the percentage of $\text{Al}_{(s)}$ in the sample.
Show detailed calculations.
- iv Calculate the mass of $\text{Al}_2\text{O}_{3(s)}$ in the sample.
Show detailed calculations.
- ד. Which substance is a better conductor of electricity, $\text{Al}_{(s)}$ or $\text{Al}_2\text{O}_{3(s)}$? Explain.

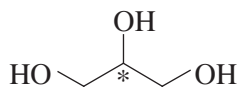
Structure and Bonding, Oxidation-Reduction

5. The table below contains information about the boiling points of three substances, A, B and C, that all have the molecular formula $C_4H_{10}O$.

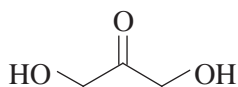
Substance	Abbrev. structural formula	Boiling point ($^{\circ}C$)
A	 OH	118
B		83
C	?	below 40

- א. i Explain why the boiling point of Substance A is higher than the boiling point of Substance B.
- ii Explain why Substance A does not dissolve very well in water.
- iii Water and Substance A were put into a test tube and mixed. Describe, at the macroscopic level, the mixture that was obtained.
- ב. i Suggest a structural formula for the molecules of Substance C.
- ii Explain why the boiling point of Substance C is lower than the boiling point of Substance B.

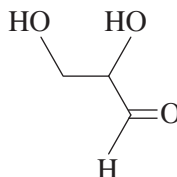
Abbreviated structural formulas of molecules of several substances, I-IV, are presented below.



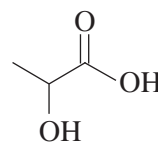
I



II



III



IV

- א. i Write out the full structural formulas of molecules of the substances I-IV.
- ii Which (two or more) of the substances I-IV are isomers?
- ב. Determine the level of oxidation of the carbon atom marked with the * in the molecules of Substance I. Explain.

Gasous State and Stoichiometry

6. This question concerns hydrogen sulfide gas, $\text{H}_2\text{S}_{(\text{g})}$.

א. The gas is stored in a closed container.

What are two microscopic characteristics of the gas in the closed container?

ב. In the closed container A, there are 6.8 grams of $\text{H}_2\text{S}_{(\text{g})}$.

In the closed container B, there are 12.8 grams of sulfur dioxide, $\text{SO}_{2(\text{g})}$.

The pressure of the gas in Container A is less than the pressure of the gas in Container B. The two containers are at the same temperature.

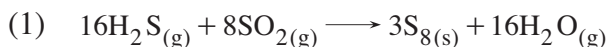
Determine whether each of the statements below, i and ii, is true or false. Explain each of your conclusions.

i The total number of atoms in Container A is equal to the total number of atoms in Container B.

ii The volume of Container A is smaller than the volume of Container B.

ג. The gases $\text{H}_2\text{S}_{(\text{g})}$ and $\text{SO}_{2(\text{g})}$ are emitted in volcanic eruptions and react with each other as described in Reaction (1).

This reaction yields sulfur, $\text{S}_{8(\text{s})}$, the yellow solid found scattered around the craters of volcanos.



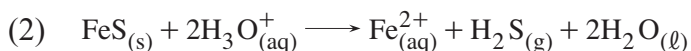
Reaction (1) was carried out in a laboratory and 64 grams of $\text{S}_{8(\text{s})}$ were obtained.

Under the reaction conditions, the volume of 1 mol of gas is 60 liters.

i Calculate the volume of $\text{H}_2\text{S}_{(\text{g})}$ that reacted with a sufficient amount of $\text{SO}_{2(\text{g})}$. Show detailed calculations.

ii What volume of $\text{SO}_{2(\text{g})}$ reacted? Explain.

7. In a laboratory, $\text{H}_2\text{S}_{(\text{g})}$ is produced in a reaction between iron sulfide, $\text{FeS}_{(\text{s})}$, and an aqueous solution of hydrochloric acid, $\text{HCl}_{(\text{aq})}$, as described in Reaction (2):



Calculate the volume of $\text{HCl}_{(\text{aq})}$ solution with a concentration of 0.2 M needed to produce 4.25 liters of $\text{H}_2\text{S}_{(\text{g})}$. Under the reaction conditions, the volume of 1 mol of gas is 25 liters. Show detailed calculations.

- ה. $\text{H}_2\text{S}_{(\text{g})}$ is a poisonous gas.

The maximum concentration of $\text{H}_2\text{S}_{(\text{g})}$ permitted in the air is $1.47 \cdot 10^{-5}$ mols of $\text{H}_2\text{S}_{(\text{g})}$ per liter of air.

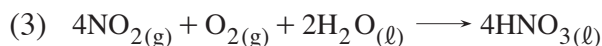
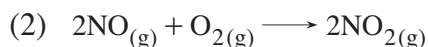
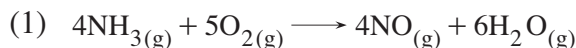
A certain amount of $\text{H}_2\text{S}_{(\text{g})}$ is produced in a laboratory chamber that has a volume of 120,000 liters and that gas is used immediately.

Calculate the mass of $\text{H}_2\text{S}_{(\text{g})}$ that can be produced in this chamber, so that if the gas were to escape and spread in the chamber, the concentration in the air would be equal to the maximum permissible amount. Show detailed calculations.

Oxidation-Reduction and Acids and Bases

7. Nitric acid, $\text{HNO}_{3(\ell)}$, is used in the production of fertilizers and explosives.

In the chemical industry, $\text{HNO}_{3(\ell)}$ is produced from ammonia, $\text{NH}_{3(\text{g})}$. The process by which $\text{HNO}_{3(\ell)}$ is produced has three steps. Each step involves one of the reactions (1)-(3).



א. i Copy the table below into your answer booklet.

$\ominus 3$	$\oplus 2$	$\oplus 4$	$\oplus 5$	Oxidation level of N atoms [דרגת החמצון של אטומי N]
				Nitrogen compound [תרכובת החנקן]

Determine the oxidation level of the N atoms in each of the nitrogen compounds involved in Reactions (1)-(3) and complete the table accordingly.

ii Which (two or more) of the nitrogen compounds that appear in Reactions (1), (2), (3), can serve as oxidants [מחמצנים]? Explain.

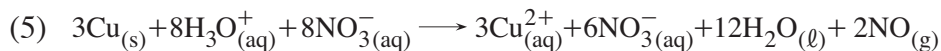
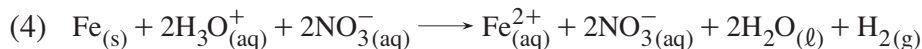
ב. Determine whether each of the statements below, i, ii and iii, is true or false. Explain each of your answers.

i In Reaction (1), the gas $\text{NH}_{3(\text{g})}$ acts as a reductant [מחזר].

ii In Reaction (2), 2 mols of electrons are transferred.

iii In Reaction (3), the acid $\text{HNO}_{3(\ell)}$ acts as an oxidant [מחמצן].

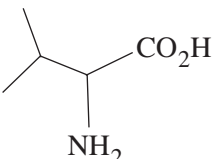
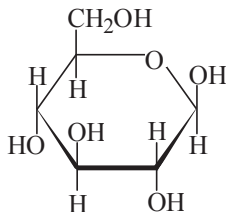
- ג. A $\text{HNO}_{3(\text{aq})}$ solution reacts with iron, $\text{Fe}_{(\text{s})}$, and with copper, $\text{Cu}_{(\text{s})}$, as described in Reactions (4)-(5).



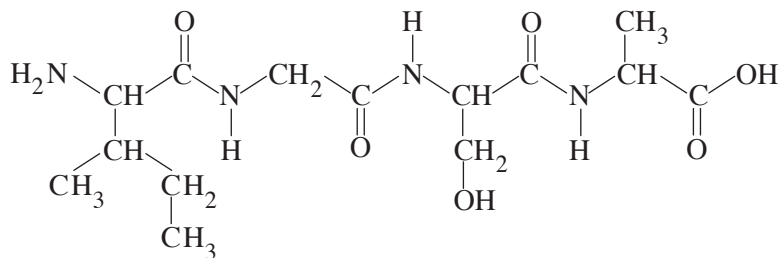
- i In each of the reactions (4) and (5), determine what acts as the reductant [מחזר] and what acts as the oxidant [מחמצן]. Explain.
 - ii Determine whether during the course of each of the reactions, (4) and (5), the pH of the solution increases, decreases or remains unchanged. Explain.
- ד. 10 grams of potassium hydrogen carbonate, $\text{KHCO}_{3(\text{s})}$, were put into 120 mL of a 1 M $\text{HNO}_{3(\text{aq})}$ solution. A reaction occurred.
- i Write out and balance the equation of the reaction that occurred.
 - ii Determine whether, upon the completion of the reaction, the pH of the obtained solution was higher than 7, lower than 7 or equal to 7. Show detailed calculations and explain.

Sugars and Proteins

8. The table below contains data concerning two substances: valine and β -glucose.

Substance	Structural formula	Molar mass <u>grams</u> mol	Melting point (°C)
Valine		117	315
β -glucose		180	149

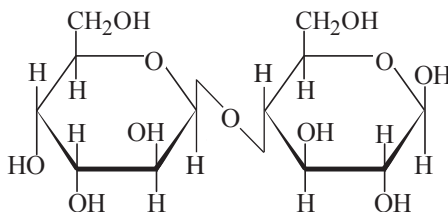
- א. Explain why the melting point of valine is higher than the melting point of β -glucose.
- ב. The structural formula of a tetrapeptide, a peptide made up of four amino-acid units, is shown below.



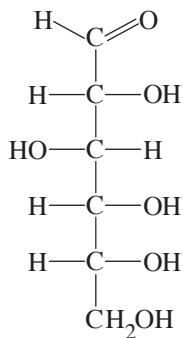
- What type of bond is found between the amino-acid units in the tetrapeptide?
- Draw the structural formulas of the amino acids from which the tetrapeptide was produced.

- ג. Altrose is an isomer of glucose.

The Haworth formula of a disaccharide composed of altrose and β -glucose is shown below.



- i How does the structure of a molecule of altrose differ from the structure of a molecule of β -glucose?
- ii The Fischer projection of glucose is shown below.

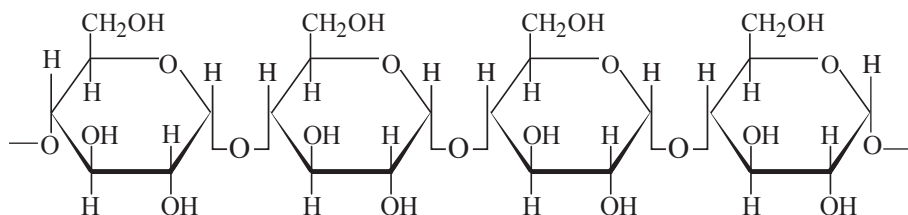


Draw the Fischer projection of altrose.

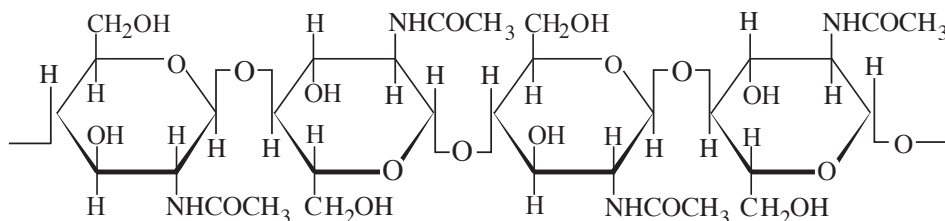
(Note: This question continues on the next page.)

7. Amylose is a polysaccharide found in plants. Chitin is a polysaccharide found in the exoskeletons of scorpions.

Haworth formulas of a segment of an amylose molecule and a segment of a chitin molecule are shown below.



Amylose



Chitin

Five structural characteristics, a-e, of polysaccharide molecules are presented below.

- The molecules are made up of identical repeating units.
 - The repeating units in the molecules are units of glucose.
 - The number of repeated units in the molecules is not fixed.
 - The bonds between the repeating units have the α pattern.
 - Every repeated unit is the inverse of the one before it.
- Which (one or more) of the characteristics listed above is/are true only for molecules of amylose?
 - Which (one or more) of the characteristics above is/are true only for molecules of chitin?
 - Which (one or more) of the characteristics listed above is/are true for both molecules of amylose and molecules of chitin?

Good Luck!

All rights reserved by the State of Israel.

No part of this document may be copied or disseminated without the permission of the Ministry of Education.

בהצלחה!

זכות היוצרים שמורה למדינת ישראל

אין להעתיק או לפרסם אלא ברשות משרד החינוך