

Chemistry

כימיה

Instructions for examinees

הוראות לנבחן

א. Duration of the exam: Two hours

א. משך הבחינה: שתיים.

ב. Exam structure and breakdown of points:

ב. מבנה השאלון ומפתח ההערכה:

This exam has two parts.

בשאלון זה שני פרקים.

Part I — (6×5) — 30 points

פרק ראשון — (5×6) — 30 נקודות

Part II — (2×35) — 70 points

פרק שני — (35×2) — 70 נקודות

Total — 100 points

סה"כ — 100 נקודות

ג. Material that may be used during the exam:

ג. חומר עזר מותר בשימוש:

(1) A calculator (graphing calculators are permitted)

(1) מחשבון (כולל מחשבון גרפי).

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

(2) מילון עברי-לועזי / לועזי-עברי.

ד. Special instructions:

ד. הוראות מיוחדות:

(1) **Note**: In Part I, there are six **required** questions.

(1) **שים לב**: בפרק הראשון יש שש שאלות **חובה**.

In each of Questions 1-6, four possible answers are given, and you must choose the correct answer.

בכל אחת מן השאלות 1-6 מוצגות ארבע תשובות, ומהן עליך לבחור בתשובה הנכונה.

Mark the correct answers on the answer sheet found at the end of the answer booklet (page 19).

את התשובות הנכונות עליך לסמן בתשובון שבסוף מחברת הבחינה (עמוד 19).

(2) **In Part II, you must answer two of the three questions.**

(2) **בפרק השני יש לענות על שתיים מבין שלוש השאלות.**

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

כתוב במחברת הבחינה בלבד, בעמודים נפרדים, כל מה שברצונך לכתוב כטיוטה (ראשי פרקים, חישובים וכדומה).

Write the word "טיוטה" at the top of each of these pages.

רשום "טיוטה" בראש כל עמוד טיוטה. רישום טיוטות כלשהן על דפים

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

שמחוץ למחברת הבחינה עלול לגרום לפסילת הבחינה!

Good Luck!

בהצלחה!

Questions

There are two parts in this exam.

Answer all the required questions from Part I and two questions from Part II.

Part I (30 points)

Questions 1-6 – Required

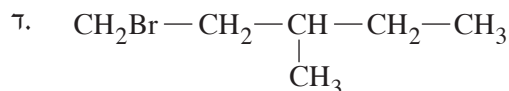
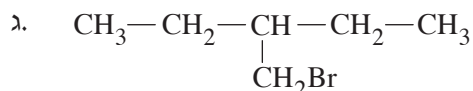
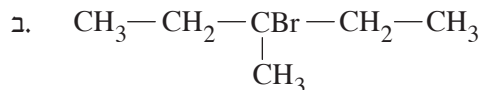
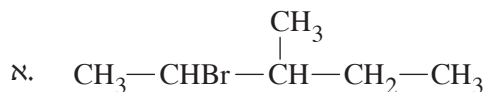
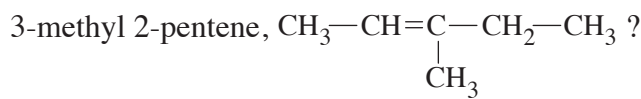
Answer all of the questions 1-6 (each question – 5 points).

Four possible answers, א-ד, are presented for each question.

Before you answer, read each of the possible answers, and choose the correct answer.

- * Mark your answer on the answer sheet printed on the back inside cover of the answer booklet (page 19).
- * For each question, mark an X, in pen, in the box below the letter (א-ד) that corresponds to the answer you chose.
- * Mark an X in only one box for each question.
- * If you want to erase your answer, fill in the whole box like this: ■.
- * Do **not** use White-Out to erase answers.
- * **Note: In order to limit the need to erase answers on the answer sheet, we recommend that you first mark the correct answers in the exam booklet and only later mark them on the answer sheet.**

1. What is the main product obtained by addition of hydrogen bromide, $\text{HBr}_{(g)}$, to



2. Three vessels, I-III, containing different solutions are given:

Vessel I contains a solution of $\text{KOH}_{(\text{aq})}$.

Vessel II contains a solution of $\text{KMnO}_{4(\text{aq})}$.

Vessel III contains a solution of $\text{HCl}_{(\text{aq})}$ / $\text{ZnCl}_{2(\text{aq})}$.

2-propanol, $\text{CH}_3-\overset{\text{OH}}{\underset{|}{\text{CH}}}-\text{CH}_3_{(\ell)}$, is added to each vessel.

In which of the three vessels does a reaction occur with the 2-propanol?

- א. in all of the vessels – I, II, and III
- ב. in Vessels I and II
- ג. in Vessels I and III
- ד. in Vessels II and III

3. Sodium iodide, $\text{NaI}_{(\text{s})}$, dissolves in acetone, $\text{CH}_3\text{COCH}_3_{(\ell)}$, and dissociates into ions.

Alkyl iodides are produced in an $\text{S}_{\text{N}}2$ reaction mechanism between alkyl bromides and a solution of sodium iodide in acetone.

Which of the following substances will react fastest with the nucleophile $\text{I}^-_{(\text{CH}_3\text{COCH}_3)}$?

א. CH_3Br

ב. $\text{CH}_3-\overset{\text{CH}_3}{\underset{|}{\text{CH}}}-\text{CH}_2\text{Br}$

ג. $\text{CH}_3-\text{CHBr}-\text{CH}_2-\text{CH}_3$

ד. $\text{CH}_3-\overset{\text{CH}_3}{\underset{|}{\text{C}}}\text{Br}-\text{CH}_3$

4. The tertiary structure of a protein is stabilized by interactions between the residues of the amino acids that comprise the protein.

Which of the following amino acids will form the strongest bond with lysine (Lys) at pH = 7?

- א. Arginine (Arg)
- ב. Serine (Ser)
- ג. Alanine (Ala)
- ד. Aspartic acid (Asp)

5. One way DNA can be damaged is when one of the strands is cut by the breakdown of some of the bonds between the nucleotides.

What type of bond breaks down when one of the DNA strands is cut?

- א. Hydrogen bond
- ב. N-glycosidic bond
- ג. Phosphoester bond
- ד. Peptide bond

6. In a study of DNA molecules in a certain strain of bacteria, researchers found that the two DNA strands together contain a total of 200,000 nitrogenous bases.

The total number of nitrogenous bases of cytosine (C) in the two strands is 70,000.

What is the total number of nitrogenous bases of adenine (A) in the two strands?

- א. 30,000
- ב. 60,000
- ג. 70,000
- ד. 200,000

Part II (70 points)

Answer two of the questions 7-9 (each question – 35 points).

7. In the past, diethyl ether served as an anesthetic in surgery. The American surgeon Crawford Williamson Long was the first to use it as a general anesthetic in 1842.

Diethyl ether can be produced from a suitable alkyl halide.

The abbreviated structural formula for diethyl ether is $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3(\ell)$.

- א. i Which alkyl halide should one choose for this reaction: alkyl chloride, alkyl bromide, or alkyl iodide? Explain.
- ii Write down the abbreviated structural formula for the alkyl halide you chose in Sub-item א i.
- iii Formulate a reaction in which the alkyl halide you chose in Sub-item א i can be obtained.
- ב. Diethyl ether can be obtained in a substitution reaction of the alkyl halide you chose in Sub-item א i, with the nucleophile $\text{CH}_3\text{CH}_2\text{O}^-(\text{CH}_3\text{CH}_2\text{OH})$.
- i Formulate the reaction mechanism for obtaining diethyl ether this way.
- ii Determine whether, at the end of the reaction, the vessel will contain a homogeneous mixture (solution) or a heterogeneous mixture. Explain.
Assume that the reaction goes to completion.
- ג. The following table shows data for the unbranched isomers of diethyl ether:

Isomer	Boiling point (°C)	Number of products obtained in a reaction with $\text{H}_2\text{SO}_4(\ell)$
A	117.7	1
B	99	3
C	38.8	Does not react

- i Write down the abbreviated structural formula for each of the unbranched isomers A, B, and C.
- ii Write down the full structural formula for each of the three products obtained in a reaction of isomer B with $\text{H}_2\text{SO}_4(\ell)$.

8. Asparagine (Asn) was the first amino acid to be discovered, in 1806. It was obtained by extraction [מיצוי] from the asparagus plant (the source of its name). It is not an essential amino acid, and can be obtained from a reaction between another amino acid and ammonia, $\text{NH}_3(\text{g})$.

- א. i Extraction is the process of separating a substance from a mixture by using a suitable solvent.

Which solvent extracts (dissolves) asparagine better: water, $\text{H}_2\text{O}(\ell)$, or hexane, $\text{C}_6\text{H}_{14}(\ell)$? Explain.

- ii Which of the following amino acids is the precursor [חומר מוצא] of asparagine: tyrosine (Tyr), phenylalanine (Phe), or aspartic acid (Asp)?

Explain, and formulate the reaction for obtaining asparagine.

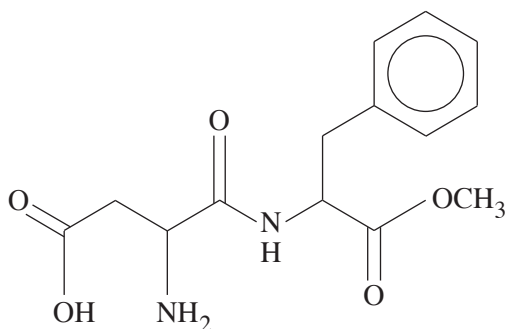
- ב. Aspartic acid (Asp) can be obtained in an oxidation reaction of compound A.

- i Determine whether compound A is a primary, secondary, or tertiary diol [דו-כוהל] (in addition to an amino group).

Write down an abbreviated structural formula for compound A, and explain.

- ii What reactant is needed for the reaction, in addition to compound A, and what is its role? Explain.

- ג. The abbreviated structural formula below is the formula of aspartame, an artificial sweetener.



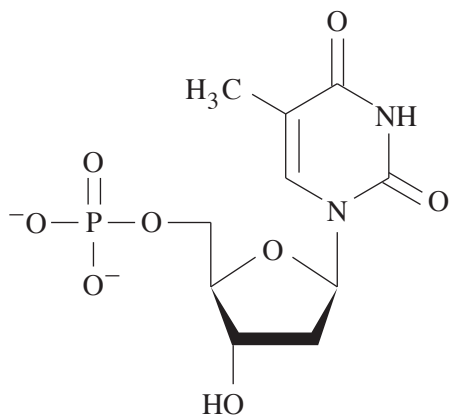
(Note: The question continues on the next page.)

The following table shows pKa values for the acidic groups of four amino acids:

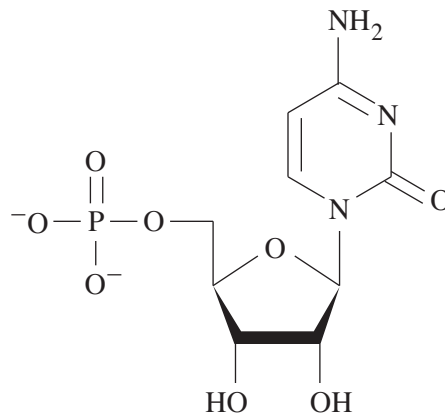
Amino acid symbol	pKa ₁ (COOH)	pKa ₂ (NH ₃ ⁺)	pK _R
Asn	2.14	8.72	
Tyr	2.20	9.21	
Asp	1.99	9.90	3.90
Phe	2.20	9.31	

- i List the two amino acids used to produce aspartame.
 - ii The pH of gastric (stomach) juice is in the range 1.5-3.5. Under these conditions, aspartame reacts and is completely hydrolyzed. Write down the abbreviated structural formula of each of the three products of the complete hydrolysis at pH = 1.5.
 - iii Determine the total charge of each of the products that you listed in Sub-item a ii.
7. The genetic disease phenylketonuria (PKU) is caused by a deficiency of the enzyme phenylalanine hydroxylase, whose function is to catalyze the transformation of phenylalanine in the body to the amino acid tyrosine (Tyr). The enzyme deficiency causes phenylalanine to accumulate in the body, and this is liable to cause intellectual developmental disability.
- Explain why PKU sufferers are advised to avoid beverages that are sweetened with aspartame.

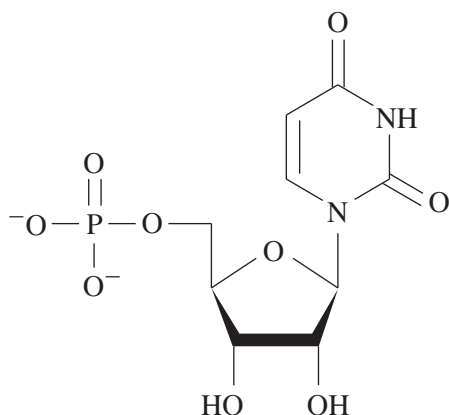
9. The structural formulas of four nucleotides, I-IV, are shown below.



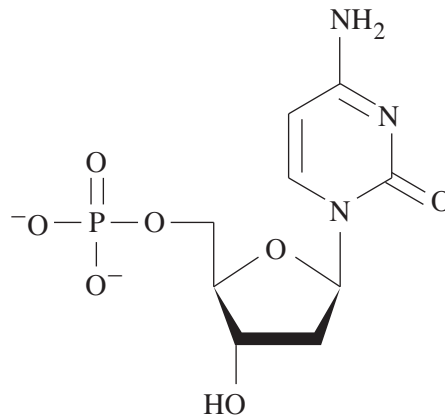
II



I



IV



III

8. i For each of the nucleotides I-IV, determine whether it is a DNA nucleotide or an RNA nucleotide. Explain how you decided.
- ii Copy the formula of nucleotide III to your answer booklet. Mark a phosphoester bond and an N-glycosidic bond in the formula.

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

- ב. A segment of DNA from an *E. coli* bacterium was transcribed [עבר תעתוק].

The nucleotide sequence below is a segment of the mRNA obtained in the transcription:

5' CUA CCG UCC AAA GUG 3'

- i Write down the nucleotide sequence of the DNA segment that was transcribed.
Mark the 3' end and the 5' end.
- ii Write down the amino acid sequence in the protein segment produced by translation of the nucleotide sequence in the given mRNA segment.
- ג. One of the methods for comparing DNA from different sources is to track the process of separation of complementary strands. When DNA is heated, the hydrogen bonds between the strands break down, and single-strand molecules are formed.
Given: There are two hydrogen bonds between the complementary bases adenine (A) and thymine (T), and there are three hydrogen bonds between the complementary bases cytosine (C) and guanine (G).

Given: two double-stranded DNA segments:

	Segment (1)	Segment (2)
First strand	3' TCA TGC 5'	3' CCA TGC 5'
Second strand	5' AGT ACG 3'	5' GGT ACG 3'

The two segments were heated separately.

In one of the segments, the separation between the strands completed at 75°C, whereas in the other segment, the separation completed only at 85°C.

In which of the two segments, (1) or (2), did the separation complete at 75°C ? Explain.

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

7. Three segments of the DNA strand are shown below: a normal segment and two segments that underwent a point mutation.

Normal segment: 3' ATG GCC TGC AAA CGC TGG 5'

Segment with one exchanged nucleotide: 3' ATG GGC TGC AAA CGC TGG 5'

Segment with one added nucleotide: 3' ATG GCC C TGC AAA CGC TGG 5'

Each of these segments codes for protein.

- i Explain what structural changes may occur in the protein obtained from the DNA segment in which one nucleotide was exchanged, compared to the protein obtained from the normal DNA segment. In your answer, discuss the primary structure and the tertiary structure.
- ii In the protein obtained from the segment to which one nucleotide was added, changes in many amino acids may occur. Explain why.

Good Luck!

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בהצלחה!

זכות היוצרים שמורה למדינת ישראל
אין להעתיק או לפרסם אלא ברשות משרד החינוך