State of Israel
Ministry of Education
Exam Type: *Bagrut*
Exam date: Summer 2023
Exam number: 37381
Attachments: (1) Periodic table
(2) Electronegativity table
(3) Formulas for calculations
(4) Functional groups
English translation (3)

מדינת ישראל
משרד החינוך
סוג הבחינה: בגרות
מועד הבחינה: קיץ תשפ"ג, 2023
מספר השאלון: 37381
נספחים: (1) הטבלה המחזורית
(2) טבלת אלקטרושליליות
(3) נוסחאות לחישובים
(4) קבוצות פונקציונליות
תרגום לאנגלית (3)

Chemistry

כימיה

Instructions

א. Duration of the exam: Three hours

ב. Exam structure and breakdown of points:
This exam has two parts.

Part One	–	40 points
Part Two	–	60 points
Total	–	100 points

ג. Material that may be used during the exam:
(1) A calculator (graphing calculators are permitted)
(2) Formula and data sheets (attached)
(3) A Hebrew–foreign language/ foreign language–Hebrew dictionary

ד. Special instructions:
(1) In Part One, there are nine questions.
For each of Questions 1–8, four possible answers are presented and you must choose the correct answer.
Mark the correct answers on the answer sheet at the end of the answer booklet (page 19).
Answer the items in Question 9 according to the instructions.
(2) In Part Two, there are five questions.
You must answer three of them.

Write in the answer booklet only. Write the word "טיוטה" at the top of each page you use as a draft page. If you write any draft material outside the answer booklet, your exam may be disqualified.

Good Luck!

הוראות

א. משך הבחינה: שלוש שעות.

ב. מבנה השאלון ומפתח ההערכה:
בשאלון זה שני פרקים.

פרק ראשון	–	40 נקודות
פרק שני	–	60 נקודות
סך הכול	–	100 נקודות

ג. חומר עזר מותר בשימוש:
(1) מחשבון (כולל מחשבון גרפי).
(2) דפי נוסחאות ונתונים (מצורפים).
(3) מילון עברי–לועזי / לועזי–עברי.

ד. הוראות מיוחדות:
(1) בפרק הראשון יש תשע שאלות.
בכל אחת מן השאלות 1–8 מוצגות ארבע תשובות, ומהן יש לבחור בתשובה הנכונה.
את התשובות הנכונות יש לסמן בתשובון שבסוף מחברת הבחינה (עמוד 19).
בשאלה 9 יש לענות על הסעיפים לפי ההנחיות.
(2) בפרק השני יש חמש שאלות. יש לענות על שלוש מהן.

יש לכתוב במחברת הבחינה בלבד. יש לרשום "טיוטה" בראש כל עמוד המשמש טיוטה. כתיבת טיוטה בדפים שאינם במחברת הבחינה עלולה לגרום לפסילת הבחינה.

בהצלחה!

Questions

Part One (40 points)

Answer all eight questions 1–8.

If you answer at least seven questions correctly, you will receive the full 20 points.

Before you answer a question, read all the suggested answers.

Four answers are suggested for each question. Choose the correct answer.

* Mark the answer you chose on the answer sheet on the inside cover at the end of the answer booklet (page 19).
* For each question, use a pen to mark an × in the box below the letter (א–ד) that represents the answer you chose.
* Mark an × 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 inside the exam booklet itself and only later mark them on the answer sheet.**

1. The following table shows data about the composition of three particles arbitrarily labeled X , Y , and Z .

Particle	Number of protons	Number of neutrons	Electron configuration
X	18	18	2,8,8
Y	17	18	2,8,8
Z	18	20	2,8,8

Which statement is correct?

א. Particles X and Y have the same nuclear charge.

ב. None of the particles X , Y , and Z have an electric charge.

ג. Particles X and Z are isotopes of the same element.

ד. The three particles X , Y , and Z are atoms of three different elements.

/continued on page 3/

2. Consider the molecular formulas of these four molecules: CS_2 , $C_2C\ell_2$, CO_2 , $C\ell CN$.

All four molecules are linear.

Read the four statements א–ד, below, about the covalent bonds in the molecules and the molecules' polarity.

Which statement is correct?

א. In all the molecules, <u>all</u> the covalent bonds are polar.

ב. The molecules $C_2C\ell_2$ and CO_2 are polar.

ג. The molecules CS_2 and CO_2 have single covalent bonds.

ד. The molecules $C\ell CN$ and $C_2C\ell_2$ have a triple covalent bond.

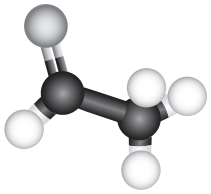
3. In a beaker, 200 ml of a 0.4M sodium chloride solution, $NaC\ell_{(aq)}$, were mixed with 200 ml of a 0.4M aluminum chloride solution, $A\ell C\ell_{3(aq)}$.

What is the molar concentration of each of the ions in the solution that was obtained after mixing?

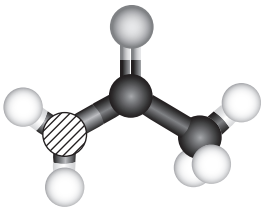
	$C\ell^-_{(aq)}$	$A\ell^{3+}_{(aq)}$	$Na^+_{(aq)}$
א.	0.8M	0.2M	0.2M
ב.	0.8M	0.4M	0.4M
ג.	0.4M	0.4M	0.4M
ד.	0.2M	0.2M	0.2M

/continued on page 4/

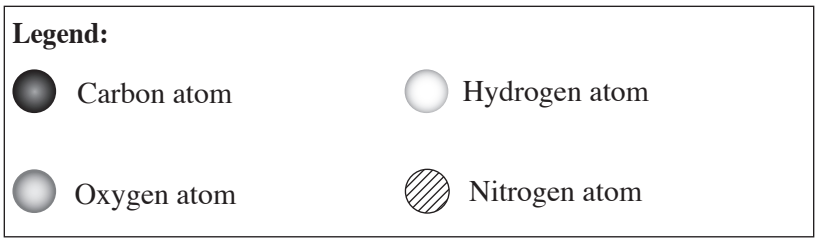
4. The models below represent the structural formulas of two molecules, arbitrarily labeled a and b .



Molecule a



Molecule b



Read statements I–IV below.

I In Molecule a , the functional group is a ketone.

II In Molecule b , the functional group is an amide.

III a molecules may form bonds with each other, including hydrogen bonds.

IV b molecules may form bonds with each other, including hydrogen bonds.

Which of the above statements are correct?

א. I and II

ב. II and III

ג. I and IV

ד. II and IV

5. Candle wax is made chiefly of a hydrocarbon whose molecular formula is $C_{25}H_{52}$ (molar mass: $352\ \frac{gram}{mol}$).

This is the complete combustion reaction of the hydrocarbon vapor as the candle burns:

$$C_{25}H_{52(g)} + 38O_{2(g)} \longrightarrow 25CO_{2(g)} + 26H_2O_{(g)}$$

The amount of energy emitted in the combustion reaction of 1.76 grams of $C_{25}H_{52(g)}$ was found to be 77.825 kJ .

What is the standard enthalpy of reaction (enthalpy change), ΔH^0 , in the combustion reaction of 1 mole of $C_{25}H_{52(g)}$?

א. $+15{,}565$ kJ

ב. $-15{,}565$ kJ

ג. $+77{,}825$ kJ

ד. $-77{,}825$ kJ

/continued on page 5/

6. Consider Reactions (1)–(3), below:

(1) $C_{(s)} + 2H_{2(g)} \longrightarrow CH_{4(g)}$ $\Delta H_1^0 = -74.8\ kJ$

(2) $C_{(s)} + 2H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow CH_3OH_{(\ell)}$ $\Delta H_2^0 = -238.9\ kJ$

(3) $CH_{4(g)} + \frac{1}{2}O_{2(g)} \longrightarrow CH_3OH_{(\ell)}$ $\Delta H_3^0 = ?$

What is the value of ΔH_3^0 for Reaction (3)?

א. $-313.7\ kJ$

ב. $+313.7\ kJ$

ג. $-164.1\ kJ$

ד. $+164.1\ kJ$

7. Students conducted several experiments in which they dipped strips of 3 different metals into solutions that contained metal ions.

In each experiment they dipped a strip of one type of metal in an aqueous solution that contained ions of another metal (and negative ions too).

The following table shows whether a reaction occurred (+) or did not occur (–) in each experiment.

Metal ions / **Metals**	$Ba^{2+}_{(aq)}$	$Zn^{2+}_{(aq)}$	$Pb^{2+}_{(aq)}$
Barium $Ba_{(s)}$		+	+
Zinc $Zn_{(s)}$	–		+
Lead $Pb_{(s)}$	–	–	

Which of the following possibilities shows the metal ions in the correct order of their oxidation strength?

א. $Zn^{2+}_{(aq)} > Pb^{2+}_{(aq)} > Ba^{2+}_{(aq)}$

ב. $Ba^{2+}_{(aq)} > Zn^{2+}_{(aq)} > Pb^{2+}_{(aq)}$

ג. $Pb^{2+}_{(aq)} > Zn^{2+}_{(aq)} > Ba^{2+}_{(aq)}$

ד. $Pb^{2+}_{(aq)} > Ba^{2+}_{(aq)} > Zn^{2+}_{(aq)}$

/continued on page 6/

8. Some magnesium, $Mg_{(s)}$, is added to an open container that contains a solution of sulfuric acid, $H_2SO_{4(aq)}$.

The metal is fully immersed in the solution.

The net equation for the reaction is as follows:

$$Mg_{(s)} + 2H_3O^+_{(aq)} \longrightarrow Mg^{2+}_{(aq)} + H_{2(g)} + 2H_2O_{(\ell)}$$

Consider the following list of variables related to this experiment:

I mass of the gas hydrogen

II surface area of the magnesium

III concentration of the sulfuric acid solution

IV volume of the container in which the reaction takes place

Which variables in the list above might affect the rate of the reaction?

א. I and II

ב. II and III

ג. III and IV

ד. I and IV

Analysis of a passage from a scientific article – Required

9. **Read the passage below and on the following page and answer the items that follow, as directed** (required question – 20 points).

Global Warming – The Change Begins at the Poles

The polar regions of Earth are warming up faster than scientists predicted, which indicates the global change in climate. One result of this warming is that the Greenland ice sheet (Greenland is an island near the North Pole) and the Antarctic ice sheet (in the South Pole) are melting quickly. When ice sheets melt they cause sea level to rise, and also change the course of storms in parts of North America.

An ice sheet (also known as a continental glacier) is a large, ancient mass of ice that has formed over thousands of years from layers of snow that compressed and hardened. The ice sheets formed over land, continued to grow, and eventually started moving slowly toward the sea. Ice sheets are a main source of freshwater in many places on Earth.

Ice sheets are 99% ice, $H_2O_{(s)}$, and about 1% impurities from the sea and the air, including ions such as: sodium, Na^+, magnesium, Mg^{2+}, calcium, Ca^{2+}, chlorine, $C\ell^-$, and sulfate ions, SO_4^{2-}. These ions come from ionic compounds that dissolved in the water. The mass of sodium ions in 1 kg of glacier is 0.4×10^{-6} grams.

/continued on page 7/

Following the recent rise in the atmosphere's temperature, the oceans have been warming up at a faster rate. As a result, the base of the ice sheet, which is close to the warming ocean water, is melting and large parts of it are breaking off and falling into the ocean. These floating sections of terrestrial glacier, called icebergs, melt as they float on the ocean and in time cause sea level to rise.

As snow and ice are white substances, they reflect most of the solar radiation back into space. Ocean water is darker, so it absorbs solar radiation and this warms the water. This is the reason that, in some cases, glacier melting has a twofold effect:

– there is an increasing mass of water available to absorb radiation and warm up;
– there is a decreasing mass of ice available to reflect radiation back into space and prevent warming.

Because the air temperature is rising and the glaciers are melting, the air at the poles contains more water vapor. This has resulted in more rain clouds and more frequent rain storms with lightning.

Rain clouds contain an enormous number of water molecules. The motions of these molecules cause a current of electrons to pass through the air between clouds or between the cloud and Earth's surface. This current turns the molecules in the air into charged particles and individual atoms. A great deal of energy is emitted as the electrons travel, heating the air in their vicinity up to 30,000°C.

The passage of energy is seen as a bright white flash, which we call lightning, and is heard as thunder, which is caused by the rapid expansion of heated air.

Chemists discovered that when lighting is created, individual atoms of oxygen and hydrogen originating from the water molecules in the clouds are detectable in the air.

Sometimes lightning strikes flammable materials on the ground and this often causes fires.

Knowledge and understanding of the changes our world is undergoing will allow scientists to predict the effects of climate change, so that we can prepare in advance, prevent harm to life, and minimize damage.

Adapted from: https://climate.nasa.gov/news/3062/warming-seas-are-accelerating-greenlands-glacier-retreat/

/continued on page 8/

Answer the items א, ב, ד, ה, ו, ז and one of the items ג **or** ח.

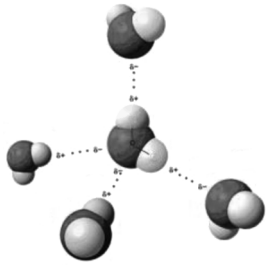
א. Write the formulas of 4 ionic compounds that could be the source of the ions found in glaciers.

In the northern part of the globe, the concentration of sodium ions in sea water is 0.46 mole/liter.

ב. By what factor is the mass of sodium ions in 1 liter of sea water greater than the mass of sodium ions in 1 kg of glacier? Show detailed calculations.

Item **ג** is an optional item. If you choose to answer it, do not answer Item **ח**.

ג. The model in the following diagram represents a certain part of the arrangement of water molecules in ice.



Legend:
Oxygen atom
Hydrogen atom

i Look at the model, and determine how many hydrogen atoms are bound to each oxygen atom, and what types of bonds are involved.

ii Write the equation for the process of ice melting.

ד. Read Statements I and II . Determine whether each statement is true or false.

I The motions of the atoms of water molecules in **ice** are only vibrational.

II The motions of molecules of water in **ice** are only translational.

ה. Determine whether the process of ice melting in an ice sheet is an endothermic or exothermic process.

Explain your answer and base it on the types of forces that operate between the molecules.

ו. A glacier whose mass is 2 metric tons fell into the water, and melted completely. How many water molecules were added to the ocean? Show detailed calculations.

Given: 1 metric ton = 1×10^6 grams.

ז. Read Statements I , II , and III below. Use the information in the scientific article to determine whether each statement is true or false.

I In a bolt of lightning, covalent bonds between atoms in water molecules in the clouds break.

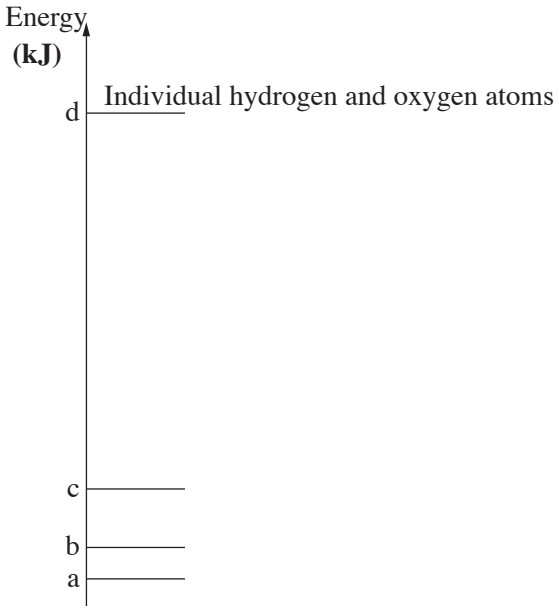
II In a bolt of lightning, covalent bonds between atoms in molecules in the air break.

III Lightning affects the temperature of its surroundings only when it strikes the ground.

/continued on page 9/

Item **ח** is an optional item. If you choose to answer it, do not answer Item **ג**.

ח. Consider the following energy diagram for 1 mole of water.



i What is the physical state of water in each of the positions: a , b , and c ?

ii Explain why the energy transition c–d is greater than the energy transition a–b .

/continued on page 10/

Part Two (60 points)

Answer three of the questions 10–14 (each question – 20 points).

Atomic Structure, Structure and Bonding, Stoichiometry (calculations)

10. Batteries supply energy to many devices. They contain ionic compounds, solutions that contain mobile ions, and other substances.

Lithium, $Li_{(s)}$, was an essential component in early lithium batteries.

א. Describe the structure of lithium, $Li_{(s)}$, and explain why the substance conducts electricity at room temperature.

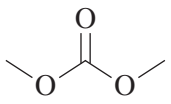
In batteries that are not lithium-based, water is the solvent, but in lithium batteries, the solvents are non-aqueous.

Consider the following reaction: $Li_{(s)} + H_2O_{(\ell)} \longrightarrow \frac{1}{2}H_{2(g)} + Li^+_{(aq)} + OH^-_{(aq)} \qquad \Delta H^0 < 0$

ב. Explain why water is not used as the solvent in lithium batteries.

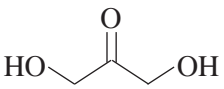
One of the solvents in lithium batteries is dimethyl carbonate (DMC).

The abbreviated structural formula of a molecule of DMC is:

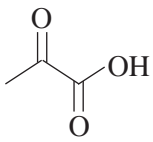


ג. Write the molecular formula of DMC .

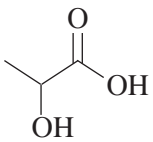
Consider the following abbreviated structural formulas of three additional molecules:



3



2



1

ד. Which molecule or molecules are isomers of DMC ? Explain your choice.

ה. The boiling point of DMC is lower than the boiling point of water under the same conditions. Explain this fact.

ו. 139 grams of DMC were dissolved in water, and a 1 liter solution was prepared.

i Explain why DMC dissolves in water.

ii Calculate the molar concentration of the prepared solution.

Rechargeable lithium batteries are called lithium-ion batteries. They are used to power electric cars, among other things. Some lithium-ion batteries are based on lithium compounds such as lithium cobalt oxide, $LiCoO_{2(s)}$.

The ionic compound $LiCoO_{2(s)}$, is composed of lithium ions, cobalt ions, Co^{3+} , and oxygen ions , O^{2-} .

ז. Write the electron dot diagrams [נוסחאות ייצוג אלקטרונים] for lithium ions and for oxygen ions.

/continued on page 11/

Fatty Acids, Structure and Bonding, Stoichiometry (calculations)

11. Cocoa beans contain cocoa butter and cocoa solids. Cocoa butter contains fat. Cocoa solids contain substances that are not fats.

After suitable processing, cocoa beans are used to make chocolate.

Chocolate is a mixture of cocoa butter and cocoa solids, and varying quantities of other substances like sugar and flavorings.

Cocoa butter contains triglycerides that are mainly composed of the three fatty acids shown in Table 1 below:

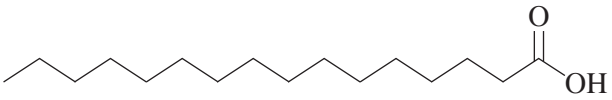
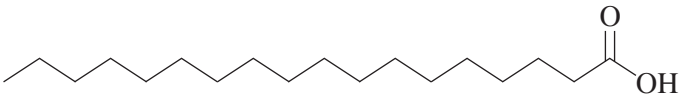
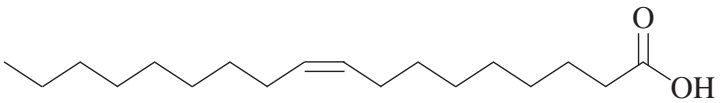
Fatty acid	Symbol	Abbreviated structural formula
Palmitic acid	P	
Stearic acid	S	
Oleic acid	O	

Table 1

א. Give the abbreviated notation [רישום מקוצר] for <u>each</u> of the fatty acids shown in Table 1.

ב. Palmitic acid has a lower melting point than stearic acid. What is the reason for this?

Cocoa butter contains small amounts of other fatty acids, including the fatty acids listed in Table 2:

Fatty acid	Abbreviated notation
Myristic acid	C14:0
Linoleic acid	C18: 2ω6 cis, cis
Linolenic acid	C18: 3ω3 cis, cis, cis
Arachidic acid	C20:0

Table 2

ג. Write the abbreviated structural formulas [ייצוג מקוצר של נוסחאות מבנה] of the <u>unsaturated</u> fatty acids listed in Table 2.

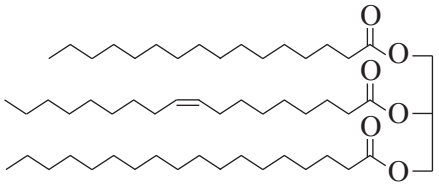
ד. Oleic acid has a higher melting point than linoleic acid. What is the reason for this?

/continued on page 12/

Palmitoleic acid is another fatty acid found in cocoa butter. The abbreviated notation for this acid is C16: 1ω7 cis .

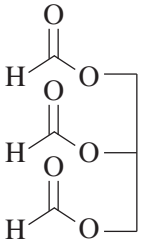
ה. Write the complete structural formula for a molecule of palmitoleic acid.

The symbols of the triglycerides in cocoa butter are: POS , SOS , POP .
The abbreviated structural formula of a triglyceride molecule is:

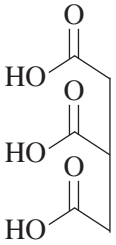


ו. Select the symbol that correctly represents the abbreviated structural formula above.

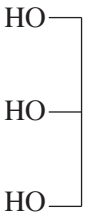
Consider the abbreviated structural formulas of three molecules below:



3



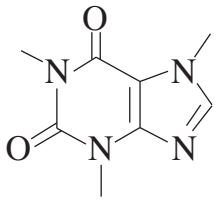
2



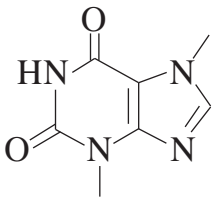
1

ז. Which of these three abbreviated structural formulas is the abbreviated structural formula of the glycerol molecule?

The cocoa solids in chocolate contain several substances, including the stimulants theobromine and caffeine.
Consider the abbreviated structural formulas of a molecule of theobromine, $C_7H_8N_4O_2$, and a molecule of caffeine, $C_8H_{10}N_4O_2$.



Caffeine

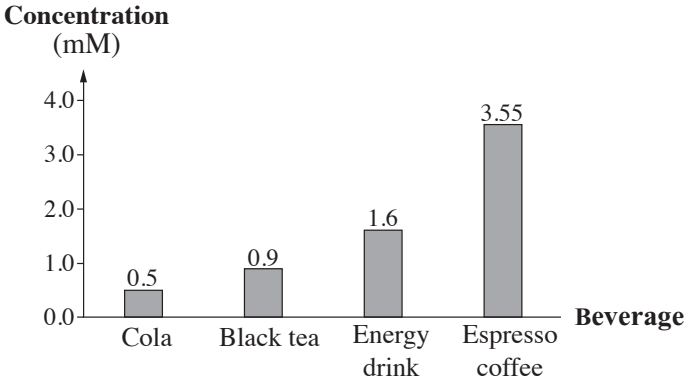


Theobromine

ח. Explain why the substances theobromine and caffeine dissolve in cocoa butter.

/continued on page 13/

ט. Consider the following data about the concentration of caffeine in several beverages.



It is better to keep consumption of caffeine below 400 milligrams per day. A student drank 4 cans of an energy drink in one day.

i What is the mass of caffeine in one can of energy drink? Provide detailed calculations.

ii Determine whether the student exceeded the recommended daily allowance of caffeine (assuming the energy drink was his only source of caffeine).
Provide detailed calculations.

Data for calculations: 1×10^{-3} M = 1 mM

1 milligram = 1×10^{-3} gram

$194 \frac{\text{gram}}{\text{mo}\ell} = \text{Mw}_{\text{caffeine}}$

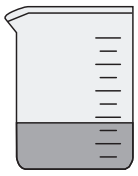
Volume of one can = 330 ml

/continued on page 14/

Acids and Bases

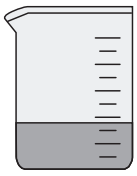
12. Consider the 3 beakers below, each containing a different solution.

Beaker 1



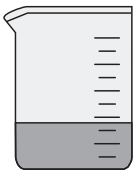
100 ml
0.01M $HC\ell_{(aq)}$

Beaker 2



100 ml
0.01M $HNO_{3\,(aq)}$

Beaker 3



100 ml
0.01M $HBr_{(aq)}$

A strip of pink litmus paper and a strip of blue litmus paper were dipped in each of the solutions.

Each of the solutions was also tested for pH and electrical conductivity.

In all three beakers:

- both litmus papers were pink when in the solution;
- the pH of the solution was 2 ;
- the solution was electrically conductive.

Given: The following table specifies the color of litmus paper dipped in different solutions.

	In an acid solution	**In a neutral solution**	**In a basic solution**
Pink litmus paper	unchanged	unchanged	color changes to blue
Blue litmus paper	color changes to pink	unchanged	unchanged

א. i List all the types of particles present in the solutions in each of the beakers **1–3**.

ii Why is each solution electrically conductive?

iii Why do all the beakers have the same pH?

/continued on page 15/

Different volumes of sodium hydroxide solution, $NaOH_{(aq)}$, at several concentrations, were added to the beakers, as follows:

To Beaker 1 – 50 ml of a 0.02M $NaOH_{(aq)}$ solution

To Beaker 2 – 50 ml of a 0.01M $NaOH_{(aq)}$ solution

To Beaker 3 – 100 ml of a 0.02M $NaOH_{(aq)}$ solution

After adding solution to the beakers, the solution in each beaker was clear.

A piece of pink litmus paper was dipped in each of the beakers.

ב. i Formulate the net equation for the reaction that occurred in each of the beakers.

ii In which beaker did the color of the litmus paper change? Show detailed calculations.

iii Determine whether the pH was lower than, equal to, or higher than 7 in each of the beakers after the addition of sodium hydroxide solution.

ג. Two experiments were conducted:

Experiment 1

The experimenter measured the pH of 100 ml of a 0.2M solution of $H_2SO_{4(aq)}$.

Next, the experimenter added 100 ml of a 0.2M solution of $HC\ell_{(aq)}$ and mixed the two solutions.

After mixing, the experimenter measured the pH again.

i Determine whether, after mixing, the pH was higher than, lower than, or equal to the initial pH. Explain your answer **or** show detailed calculations.

Experiment 2

The experimenter measured the pH of 100 ml of a 0.1M solution of $HC\ell_{(aq)}$.

Next, the experimenter added 100 ml of a 0.1M solution of $NaC\ell_{(aq)}$, and mixed the two solutions.

After mixing, the experimenter measured the pH again.

ii Determine whether, after mixing, the pH was higher than, lower than, or equal to the initial pH. Explain your answer **or** show detailed calculations.

/continued on page 16/

Oxidation-Reduction, Structure and Bonding, Stoichiometry (Calculations)

13. This question discusses the metal titanium, $Ti_{(s)}$, and its alloys [סגסוגות]. Titanium and its alloys have many uses in the aerospace industry and other industries.

Titanium is extracted from ores that contain titanium oxide, $TiO_{2(s)}$.

The metal titanium is extracted in two steps:

Step 1

In this step, titanium oxide, $TiO_{2(s)}$, reacts with carbon, $C_{(s)}$, and with the gas chlorine, $C\ell_{2(g)}$. One of the products is the liquid $TiC\ell_{4(\ell)}$, according to Reaction (1).

(1) $TiO_{2(s)} + C_{(s)} + 2C\ell_{2(g)} \longrightarrow TiC\ell_{4(\ell)} + CO_{2(g)}$

Step 2

The liquid compound titanium tetrachloride, $TiC\ell_{4(\ell)}$, which is formed in Reaction (1), reacts with the magnesium metal, $Mg_{(s)}$, according to Reaction (2).

(2) $TiC\ell_{4(\ell)} + 2Mg_{(s)} \longrightarrow Ti_{(s)} + 2MgC\ell_{2(s)}$

Given: the electronegativity of titanium, Ti, is 1.54.

א. Determine which substance is the oxidizer and which substance is the reducer in each of the reactions (1) and (2). Explain your answers.

ב. Which metal is a better reducer, magnesium or titanium? Explain your answer.

ג. How many metric tons of titanium oxide, $TiO_{2(s)}$, are needed to produce one metric ton of the metal titanium, $Ti_{(s)}$? Show detailed calculations.

Given: 1 metric ton = 1×10^6 gram

ד. One useful alloy used in the aerospace industry is made by processing the metals titanium, $Ti_{(s)}$, vanadium, $V_{(s)}$, and aluminum, $A\ell_{(s)}$.

Every 100 grams of this alloy contains 90 grams of titanium, 4 grams of vanadium, and the rest is aluminum.

i Consider the following list of particle types: atoms, molecules, ions, mobile ions, mobile electrons. Which of these particle types is the alloy composed of (more than one type)?

ii How many moles of aluminum are in 1 kg of this alloy? Show detailed calculations.

To make titanium alloys, the titanium must be melted. Melted titanium can react with gases in the air.

ה. The compound titanium nitride, $TiN_{(s)}$, is produced when melted titanium reacts with the gas nitrogen, $N_{2(g)}$, in the air.

Formulate and balance the reaction.

ו. Melted titanium is processed in an argon gas, $Ar_{(g)}$, environment. Explain why.

ז. This question discusses the substances: $Ti_{(s)}$, $TiO_{2(s)}$, $TiC\ell_{4(\ell)}$, $TiN_{(s)}$.

Determine with which of these substances titanium can react only as a reducer.

/continued on page 17/

Structure and Bonding, Oxidation and Reduction, Acids and Bases

14. The following table presents data about three elements arbitrarily labeled a , b , and c .

Element (arbitrary symbol)	Melting point (^{o}C)	Boiling point (^{o}C)	Electrical conductivity at room temperature
a	98	883	Conductive
b	−259	−253	Non-conductive
c	−7	59	Non-conductive

א. Match the elements: hydrogen, $H_{2(g)}$, bromine, $Br_{2(\ell)}$, sodium, $Na_{(s)}$, with the letters a , b , and c .

ב. i Determine what type of bonds exists between the atoms of the element labeled b .

ii Explain why the boiling point of the element labeled c is higher than the boiling point of the element labeled b .

Under suitable conditions, the elements react with one another.

ג. A reaction between the element labeled a and the element labeled b produces a single product that is solid at room temperature.

What is the oxidation level of <u>each</u> of the particles in the obtained product?

ד. A reaction between the element labeled a and the element labeled c produces a single product that is solid at room temperature.

This product is water soluble.

i Formulate the dissolution reaction of the product in water.

ii Is the resulting solution conductive? <u>Explain your answer</u>.

ה. A reaction between the element labeled b and the element labeled c produces a single product that is a gas at room temperature.

This product reacts with water and a solution is formed.

i What is the formula of this product?

ii Formulate the product's reaction with water.

iii Is the resulting solution acidic, basic, or neutral? <u>Explain your answer</u>.

ו. The element nitrogen, $N_{2(g)}$, reacts with the element labeled b , and a single product that is a gas is obtained. This product reacts with water and a basic solution is formed.

i Formulate the reaction that produces this product.

ii Formulate the reaction between the obtained product and water.

ז. The element nitrogen, $N_{2(g)}$, reacts with the element labeled a , and a single product is obtained.

Write the formula of the product at room temperature.

Good Luck!