State of Israel
Ministry of Education
Exam Type: *Bagrut*
Exam date: Summer 2026
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"ו, 2026
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.
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.
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 <u>all</u> eight questions 1–8 (20 points).

If you answer at least <u>six</u> 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 <u>correct</u> answer.

* Mark the answer you chose on the answer sheet at the end of the answer booklet.
* 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 <u>whole</u> box like this: ■ .
* Do **<u>not</u>** 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. Consider the molecular formulas of the following four molecules: CH_2O , BH_3 , $CSC\ell_2$, BF_3 .
All four molecules have a trigonal planar shape.
Read the statements א–ד below, relating to the covalent bonds in the molecules and to the molecules' polarity. Which statement is correct?

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

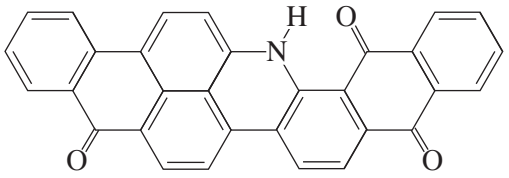
ב. The molecules BH_3 and BF_3 are not polar.

ג. <u>All</u> the covalent bonds in the molecules CH_2O and BF_3 are single covalent bonds.

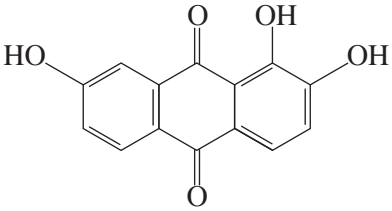
ד. <u>Only</u> the molecule $CSC\ell_2$ has a double covalent bond.

/continued on page 3/

2. The figure below shows the abbreviated structural formula of two pigments:



Green pigment



Red pigment

Consider two cups with an identical volume of hexane, $C_6H_{14(\ell)}$, which is a colorless, transparent, clear liquid.

The temperature of the hexane in both cups is the same. We add one of the pigments to each of the cups.

We obtain solution only, in just one of the cups.

What is the color of the obtained solution?

א. green

ב. red

ג. brown

ד. transparent

3. We heat up an equal number of moles of two substances: butanol and diethyl ether, in separate containers under identical conditions.

Both substances are in liquid state when we start heating.

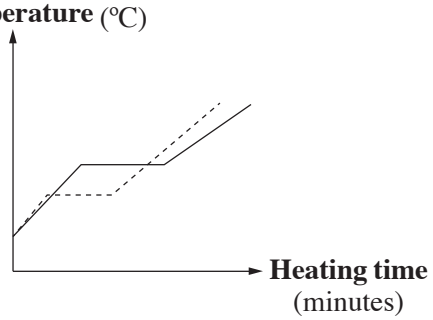
We measure the temperature of each of the substances while they are being heated.

The following table shows the structural formulas of the molecules of the two substances.

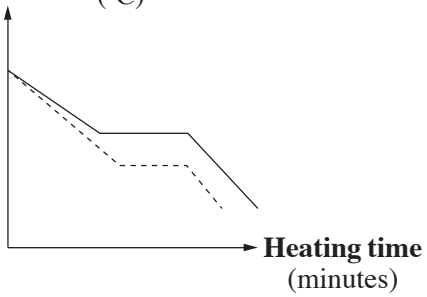
Substance	**Butanol**	**Diethyl ether**
Abbreviated structural formula	$CH_3CH_2CH_2CH_2OH$	$CH_3CH_2OCH_2CH_3$

Which of the graphs א–ד describes the two substances' measured temperature as they are heated?

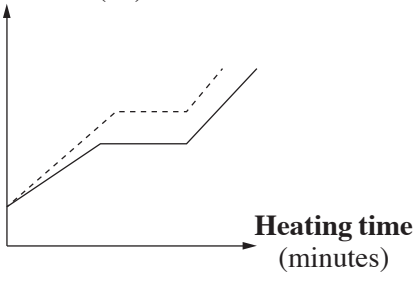
א. **Temperature** (°C)



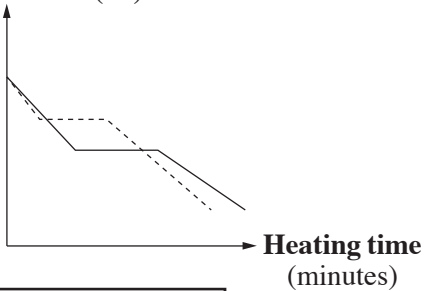
ב. **Temperature** (°C)



ג. **Temperature** (°C)



ד. **Temperature (°C)**



Legend: butanol ——— diethyl ether - - - - - - -

/continued on page 4/

4. Students conducted an experiment in which they placed a strip of magnesium, $Mg_{(s)}$, in a test tube that contained a solution of hydronium ions $H_3O^+_{(aq)}$.

We know that:

$$Mg_{(s)} + 2H_3O^+_{(aq)} \longrightarrow H_{2(g)} + Mg^{2+}_{(aq)} + 2H_2O_{(\ell)} \qquad \Delta H^0 < 0$$

Which of these statements does <u>not</u> describe an observation made during this experiment?

א. Bubbles are emitted where the strip is in contact with the solution.

ב. We can feel that the test tube in which the reaction is taking place is getting warmer.

ג. The strip of magnesium gets smaller.

ד. Electrons pass from the magnesium atoms to the $H_3O^+_{(aq)}$ ions.

5. We have two closed flasks, A and B, of <u>identical</u> volume.

Flask A contains the gas methane, $CH_{4(g)}$.

Flask B contains the gas oxygen, $O_{2(g)}$.

The temperature and pressure in both containers are the same.

Which statement is correct?

א. The mass of the gas in Flask A is the same as the mass of the gas in Flask B.

ב. The number of moles of gas in Flask B is twice the number of moles of gas in Flask A.

ג. The number of molecules of gas in Flask A is the same as the number of molecules of gas in Flask B.

ד. The mass of the gas in Flask A is twice the mass of the gas in Flask B.

6. The following statements are about oxidation-reduction processes.

Which statement is correct?

א. The atoms in a fluorine molecule, F_2, can only undergo reduction.

ב. The atoms in an oxygen molecule, O_2, can only undergo reduction.

ג. The hydrogen atoms in a water molecule, H_2O, can undergo either oxidation or reduction.

ד. The sulfur atoms in a sulfite ion, SO_3^{2-}, can only undergo reduction.

/continued on page 5/

7. We have a solution of calcium chloride, $CaC\ell_{2(aq)}$, whose volume is 200 ml and concentration is 0.2M .

We add 800 ml of distilled water to the solution and stir.

We check the ion concentrations in the obtained solution.

Which row in the following table (א-ד) shows the correct ion concentrations in the obtained solution?

	Calcium ion $Ca^{2+}_{(aq)}$ concentration (M)	Chlorine ion $C\ell^{-}_{(aq)}$ concentration (M)
א.	0.10	0.20
ב.	0.04	0.08
ג.	0.05	0.10
ד.	0.20	0.20

8. Consider the equations א–ד. Which equation is correct?

א. $NH_{3(g)} + H_2O_{(\ell)} \longrightarrow H_3O^{+}_{(aq)} + NH^{-}_{2(aq)}$

ב. $HI_{(g)} + H_2O_{(\ell)} \longrightarrow H_2I^{+}_{(aq)} + OH^{-}_{(aq)}$

ג. $HNO_{3(\ell)} + H_2O_{(\ell)} \longrightarrow H_3O^{+}_{(aq)} + NO^{-}_{3(aq)}$

ד. $H_2SO_{4(\ell)} + H_2O_{(\ell)} \longrightarrow H_3O^{+}_{(aq)} + SO^{-}_{4(aq)}$

/continued on page 6/

Analysis of a passage from a scientific article — Required

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

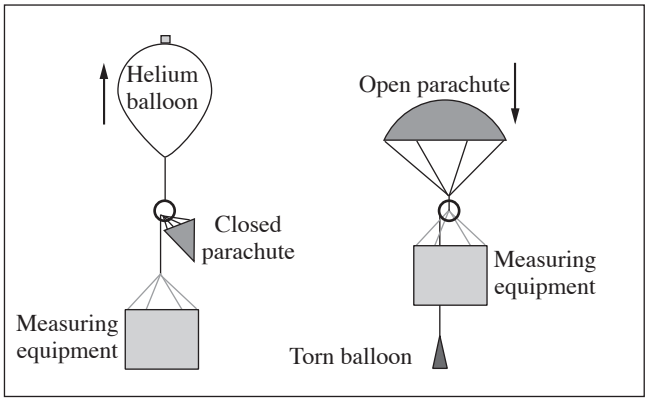
Essential substances — Do we have enough?

As technology advances, our use of 'smart' devices like mobile phones, televisions, medical diagnostic devices, and electric vehicles is expanding. The growing demand for smart devices means we consume more of the elements (and their compounds) used to produce these devices. It is a mistake to assume that the natural resources on Earth that supply these essential substances will never run out. In this article we discuss three elements of importance to modern industry: aluminum, $A\ell_{(s)}$, lithium, $Li_{(s)}$, and helium, $He_{(g)}$, and their availability to man.

Aluminum and lithium occur naturally only as compounds, not as free elements. Aluminum is the most common metallic element in the crust of Earth, making up 8% of the crust's weight. Lithium is a less common element than aluminum, making up 0.005% of the crust's weight. Given its many applications in industries like construction, food, and electronics, aluminum production must be increased. Aluminum is extracted in several steps: first, a mixture of metal oxides called bauxite is mined, then aluminum oxide, $A\ell_2O_{3(s)}$, is extracted from the mined bauxite. Next, liquid aluminum, $A\ell_{(\ell)}$, is produced from the aluminum oxide in a decomposition process, using an electric current that requires an enormous amount of electrical energy.

Certain regions in the world have naturally occurring brines—aqueous mixtures that are rich in compounds of lithium and of other metals. Lithium carbonate, $Li_2CO_{3(s)}$, which is used to produce electric car batteries, is extracted from the original brine in multiple steps of evaporation, separation, and filtration until the desired compound is obtained.

Helium is the second most abundant element in the universe, but it is <u>very rare</u> on Earth. Helium is used to cool large magnets in scientific and medical devices. It is also used in weather balloons and other aircraft. In weather balloons, sensors are placed in a box that is attached to a parachute and to a helium-filled balloon about two meters in diameter.



The balloon is set free from its anchor on the ground, floats up to an elevation of several dozen kilometers (where the temperature is about -50^oC), and starts collecting data. Eventually, the helium balloon tears, and the parachute brings the box of sensors to the ground. The helium gas leaves the atmosphere and disperses in space, beyond retrieval (see figure).

/continued on page 7/

Helium is formed by nuclear decay of uranium or thorium in the core of the Earth. The gas rises through the planet's layers until it reaches rock that blocks its route out to the air. Some places in the world have natural reservoirs of natural gas mixed with helium. Natural gas is a mixture containing mostly methane, $CH_{4(g)}$, nitrogen, $N_{2(g)}$, and some other hydrocarbons. The amount of helium in the mixture is about 0.01% . Helium has many specialized uses, so it is extracted from this mixture, despite the high energy cost of the process. One method of extracting the helium from this mixture is based on cooling and liquefying the natural gas mixture by lowering the temperature and increasing the pressure.

Alternatives and recycling options must be developed because extracting these important substances is difficult, costs a lot of energy, and causes pollution. This is why recycling aluminum foil, aluminum cans and depleted lithium batteries is so important. It is also advisable to limit use of helium-filled balloons, which although a delightful addition to parties, fly away in the wind and disappear forever.

Adapted chiefly from:

visualcapitalist.com/cp/the-periodic-table-of-endangered-elements/
thyssenkrupp-materials.co.uk/how-is-aluminum-made
systems.carmeuse.com/en/knowledge-center/blog/guide-use-of-lime-in-lithium-extraction-and-processing/
bbc.com/future/article/20250331-why-helium-shortages-are-worrying-the-world
stratoflights.com/en/weather-balloon-burst/

Answer all the items א–ה, and one of the items ו or ז.

In the final step of aluminum extraction, an electrolytic reaction is used to decompose the aluminum oxide extracted from bauxite.

א. **(1)** Write the formula of aluminum oxide extracted from the bauxite. You must also include its state of matter.

(2) Explain why aluminum oxide must be melted in order to perform the electrolytic decomposition.

(3) Formulate and balance the equation for electrolytic decomposition of **melted** aluminum oxide down to its elements. Base your answer on the passage and always include the state of matter.

ב. **(1)** Name one shared macroscopic property in each of the following pairs of substances.

i lithium carbonate – aluminum oxide

ii aluminum – lithium

(2) Which of the following statements is correct?

i Lithium carbonate and aluminum are pure substances.

ii Lithium brine and natural gas are pure substances.

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

/continued on page 8/

ג. **(1)** Explain the statement: "An alpha particle is in fact the nucleus of a helium atom, ^{4}He ".

(2) Consider the radioactive decay process, shown below, in which we obtain the nucleus of a helium atom:

$$X \longrightarrow {}^{234}_{90}Th + \alpha$$

The letter X represents an isotope of an element from which helium is formed.

Determine the symbol, atomic number, and mass number of the given isotope X.

ד. Read the following two statements regarding a helium weather balloon. Which statement is the correct one?

i The higher in the atmosphere the balloon rises, the greater the number of helium particles inside it.

ii The higher in the atmosphere the balloon rises, the smaller the gas pressure inside it.

The passage discusses three gases that are present in a natural gas mixture: methane, nitrogen, and helium.

ה. The given boiling points of these gases are: $4K$, $77K$, $112K$.

Of the given temperatures, determine which one is the boiling point of helium. Name the factor that determined your answer.

Item **ו** is an optional item. If you choose to answer it, do <u>not</u> answer Item **ז**.

ו. Calculate the volume of 4 grams of the gas helium when the pressure is 0.5 atm and the temperature is $200K$. <u>Show detailed calculations</u>.

We know that $R = 0.082 \frac{atm \cdot liter}{mol \cdot K}$.

Item **ז** is an optional item. If you choose to answer it, do <u>not</u> answer Item **ו**.

ז. In 2022, the United States produced 860,000 metric tons of aluminum using the process described in the passage.

Calculate how many metric tons of oxide this required. <u>Show detailed calculations</u>.

We know that 1 metric ton = 1×10^{6} gram.

/continued on page 9/

Part Two (60 points)

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

Atomic Structure, Structure and Bonding

10. Consider the following five oxide formulas (oxides are compounds that contain oxygen).
The oxides' state of matter is not given, so each is labeled with a question mark (?).

I $Cs_2O_{(?)}$

II $N_2O_{(?)}$

III $SiO_{2(?)}$

IV $SO_{2(?)}$

V $MgO_{(?)}$

א. **(1)** For each oxide, write the type of substance: covalent network [אטומרי], ionic, or molecular.

Two of the given oxides are gaseous at room temperature, and the others are solid.

(2) Determine which of the given oxides are solid at room temperature. Explain your answers.
In your explanations, discuss the types of bonds between the particles in each oxide.

(3) Write the formula of each oxide including its state of matter.

ב. The substance $SO_{2(?)}$ forms naturally during volcanic eruptions. During volcanic eruptions, zinc sulfide, $ZnS_{(s)}$, found deep inside the earth, reacts with oxygen in the air producing $ZnO_{(s)}$ and $SO_{2(?)}$.

(1) Formulate and balance the reaction between $ZnS_{(s)}$ and oxygen. You must include the state of matter.

(2) For each substance in the reaction, determine whether it is an oxide.

ג. The oxide whose formula is $Cs_2O_{(?)}$ is widely used in electronic devices.

(1) Write the symbols of the particles composing the oxide $Cs_2O_{(?)}$ using chemistry notation [שפת הכימאים].

(2) The mass number of one of the cesium isotopes, Cs , is 135 .
How many protons, how many neutrons, and how many electrons are there in a particle of cesium 135 in the oxide $Cs_2O_{(?)}$?

ד. The magnesium oxide $MgO_{(?)}$ has many different uses in industry.

(1) Write the Lewis electron dot formula of the particles composing the oxide $MgO_{(?)}$.

(2) Write the electron configuration of each of the particles you listed in Sub-Item ד(1).

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

/continued on page 10/

ה. One of the uses of the substance $N_2O_{(?)}$ is in rocket fuel mixtures.

The substance decomposes into oxygen, $O_{2(g)}$, and nitrogen, $N_{2(g)}$.

Consider the equation of the decomposition reaction of $N_2O_{(?)}$:

$$2N_2O_{(?)} \longrightarrow 2N_{2(g)} + O_{2(g)}$$

Now consider the engine of a rocket in which the pressure is 100 atm and the temperature is $3300\ ^oC$.

What is the volume of oxygen created when 200 moles of the substance $N_2O_{(?)}$ decompose under the given conditions? Show detailed calculations.

We know that $R = 0.082 \frac{atm \cdot liter}{mol \cdot K}$.

/continued on page 11/

Oxidation-Reduction, Stoicheometry (calculations)

11. This question discusses the element bromine and some of its compounds. The element symbol of bromine is $_{35}Br$.

Dead Sea water is rich in bromide ions, $Br^-_{(aq)}$.

Bromine is produced from Dead Sea water in a reaction between bromide ions, $Br^-_{(aq)}$, and gaseous chlorine, $C\ell_{2(g)}$.

Consider the net ionic equation for this reaction (Reaction 1):

1. $2Br^-_{(aq)} + C\ell_{2(g)} \longrightarrow Br_{2(\ell)} + 2C\ell^-_{(aq)}$

א. Determine which is the oxidizer and which is the reducer in Reaction 1. Explain <u>both</u> answers.

The concentration of $Br^-_{(aq)}$ ions in Dead Sea water is about 5 grams per liter.

ב. Calculate the concentration of $Br^-_{(aq)}$ ions in Dead Sea water in units of mole per liter (M). <u>Show detailed calculations</u>.

Bromine is a toxic liquid, which is why it is stored in special containers.

If bromine leaks from the containers, it can be reacted with ammonia, $NH_{3(g)}$, to prevent it from spreading.

In this reaction we obtain the ionic compound $NH_4Br_{(s)}$, and the gas nitrogen, $N_{2(g)}$.

Consider the equation for this reaction (Reaction 2):

2. $3Br_{2(\ell)} + 8NH_{3(g)} \longrightarrow 6NH_4Br_{(s)} + N_{2(g)}$

ג. Based on the equation of Reaction 2, determine whether <u>each</u> of the statements below is true or false. <u>Explain your answers</u>.

i. The nitrogen molecules, $N_{2(g)}$, are the product of a reduction process.

ii The atoms in the bromine molecules, $Br_{2(\ell)}$, underwent reduction.

Bromine compounds have many different uses.

The compound hydrogen bromide, $HBr_{(g)}$, is used to produce several substances.

Hydrogen bromide, $HBr_{(g)}$, is produced from hydrogen, $H_{2(g)}$, and the gas bromine, $Br_{2(g)}$.

ד. **(1)** Write a balanced equation of the reaction for producing $HBr_{(g)}$.

(2) What is the mass of $HBr_{(g)}$ obtained in a reaction of 10 g $H_{2(g)}$ with a suitable number of moles of $Br_{2(g)}$? <u>Show detailed calculations</u>.

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

/continued on page 12/

A concentrated aqueous solution of calcium bromide, $CaBr_{2(aq)}$, is used in oil drills.
The solution is prepared by adding an aqueous solution of $HBr_{(aq)}$ to calcium oxide, $CaO_{(s)}$.
Consider the equation for this reaction (Reaction 3):

3. $CaO_{(s)} + 2H_3O^+_{(aq)} + 2Br^-_{(aq)} \longrightarrow Ca^{2+}_{(aq)} + 2Br^-_{(aq)} + 3H_2O_{(\ell)}$

ה. Is Reaction 3 an oxidation-reduction reaction? Explain your answer.

The compound silver bromide, $AgBr_{(s)}$, is used in photography on surfaces like metal plates or paper.
$AgBr_{(s)}$ can be prepared by precipitation of a sodium bromide solution, $NaBr_{(aq)}$, with a silver nitrate solution, $AgNO_{3(aq)}$.

ו. Consider the net ionic equation for the precipitation of $AgBr_{(s)}$ (Reaction 4).

4. $Ag^+_{(aq)} + Br^-_{(aq)} \longrightarrow AgBr_{(s)}$

100 ml of sodium bromide solution, $NaBr_{(aq)}$, were mixed with 100 ml of silver nitrate solution, $AgNO_{3(aq)}$.
The concentration of each of the solutions is 1M. All the substances reacted completely.
What is the mass of the precipitate that was obtained? Show detailed calculations.

/continued on page 13/

Acids and Bases, Energy

12. This question describes three experiments.

Experiment 1

Students poured four clear solutions into four beakers marked A, B, C, D, as shown in the table below:

Beaker	A	B	C	D
Liquid	$NaOH_{(aq)}$ solution	$HC\ell_{(aq)}$ solution	$Ba(OH)_{2(aq)}$ solution	$HC\ell_{(aq)}$ solution
Volume (ml)	100	100	100	100
Concentration (M)	1	1	1	**0.01**

The temperature of **all** the solutions was 22°C .

The students measured the pH of all the solutions.

א. **(1)** Rank the solutions in order of increasing pH.

(2) List the symbols of all the types of aqueous ions in each of the beakers, A , B , C , D .

Experiment 2

The students poured the $NaOH_{(aq)}$ solution from Beaker A into the $HC\ell_{(aq)}$ solution in Beaker B and stirred. As they stirred, the solution's temperature increased to 28°C .

ב. **(1)** Write an equation of the net ionic reaction that took place when the solutions were mixed.

(2) Was the reaction that occurred in the beaker an exothermic or an endothermic reaction? Explain your answer. Discuss energy transfers in your answer.

(3) What ΔH^0 could be correct for the reaction in your equation: –57kJ or +57kJ ? Explain your choice.

(4) Was the pH at the end of the reaction acidic, basic, or neutral? Explain your answer or use a calculation.

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

/continued on page 14/

Experiment 3

The students poured $Ba(OH)_{2(aq)}$ solution from Beaker C into the $HC\ell_{(aq)}$ solution in Beaker D, and stirred. As they stirred, the temperature of the solution changed.

ג. **(1)** Write the net ionic equation of the reaction that occurred when the solutions were mixed.

(2) Did the temperature of the solution increase or decrease after mixing?
Explain your answer.

(3) Is the amount of energy transferred in Experiment 3 between the system and the environment the same as the amount of energy transferred in Experiment 2 between the system and the environment? Explain your answer.

(4) Is the value of ΔH^0 for the equation you formulated in Sub-Item ג(1) the same as the value of ΔH^0 for the equation you formulated in Sub-Item ב(1) or is it different?
Explain your answer.

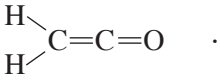
(5) Is the pH at the end of the reaction that occurred in Experiment 3 acidic, basic, or neutral?
Explain your answer or use a calculation.

/continued on page 15/

Structure and Bonding, Energy

13. When smoking an e-cigarette (see figure), a vaporizing solution (usually containing nicotine, vitamin E acetate, flavoring agents, and solvents) is heated until it is vaporized, and then the vapor is inhaled into the lungs. This process uses a battery and a heating element to vaporize the liquid in the cartridge.
A substance called ethenone, $C_2H_2O_{(g)}$, is formed by thermal decomposition (heating) of the vitamin E acetate in the vaporizing solution.

Consider the full structural formula of the ethenone molecule:



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א. Ethenone is an important substance: it reacts easily and is used in many reactions in industry.

(1) Consider the abbreviated structural formula of an acetic acid molecule: CH_3COOH.
Draw the full structural formula of a molecule of acetic acid.

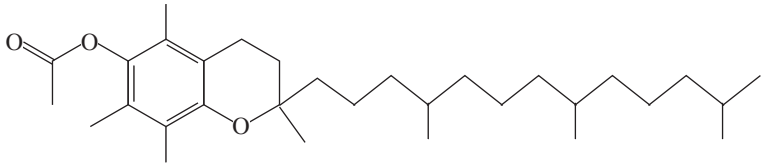
(2) The boiling point of ethenone is lower than the boiling point of acetic acid.
Explain this fact.

Ethenone, $C_2H_2O_{(g)}$, and water vapor, $H_2O_{(g)}$, can be obtained when gaseous acetic acid, $C_2H_4O_{2(g)}$ is heated and then decomposes.
The following equation describes the decomposition reaction of acetic acid:

$$C_2H_4O_{2(g)} \longrightarrow C_2H_2O_{(g)} + H_2O_{(g)}$$

ב. We know that the energy it takes to break the covalent bonds in the molecules of the reactant is <u>higher</u> than the energy emitted when the covalent bonds in the molecules of the products are formed.
Is the given reaction exothermic or endothermic?

Ethenone, $C_2H_2O_{(g)}$, is suspected of being the cause of "vaping illness". "Vaping illness" is a condition that causes lung injury and which e-cigarettes users can develop.
Consider the abbreviated structural formula of vitamin E acetate shown below:



ג. List the names of the functional groups in a molecule of vitamin E acetate.

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

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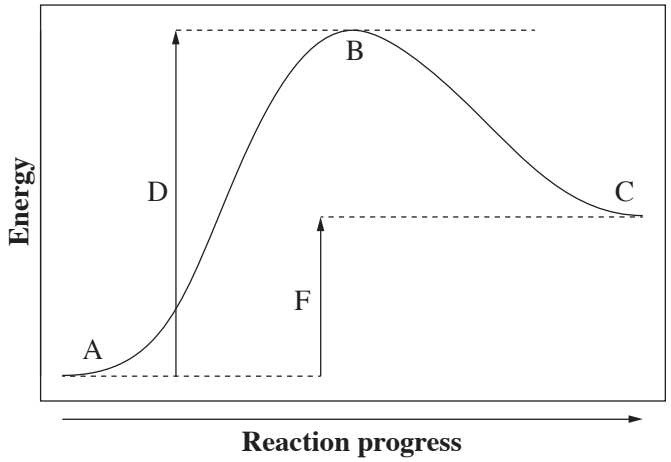
ד. Consider the schematic energy diagram for vitamin E acetate decomposition when it is used in an e-cigarette.



(1) Match each term in the list with the correct letter in the diagram (A , B , C , D , F); one letter for each term.

List of terms:

- change in reaction enthalpy (ΔH^0)
- activation energy (E_a)
- activated complex
- reactants
- products

(2) Based on the given diagram, determine whether the decomposition of vitamin E acetate is an exothermic reaction or an endothermic reaction. Explain your answer.

ה. The metal parts of e-cigarettes catalyze the decomposition of vitamin E acetate.

Determine which of the two magnitudes shown in the diagram, D or F , will change when the reaction proceeds without a catalyst. Explain your answer.

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Calculations (stoichiometry)

14. Ammonium sulfate, $(NH_4)_2SO_{4(s)}$, is used in the food industry to regulate acidity and improve pastry properties.

$(NH_4)_2SO_{4(s)}$ is produced from sulfuric acid, $H_2SO_{4(\ell)}$, and ammonia, $NH_{3(g)}$.

The equation for the reaction of $H_2SO_{4(\ell)}$ with $NH_{3(g)}$ is:

$$H_2SO_{4(\ell)} + 2NH_{3(g)} \longrightarrow (NH_4)_2SO_{4(s)}$$

א. What mass of sulfuric acid, $H_2SO_{4(\ell)}$, is required to produce 66 grams of ammonium sulfate? Show detailed calculations.

Scientists prepared two flasks of ammonia, $NH_{3(g)}$, for an experiment: Flask 1 and Flask 2.

The temperature of the ammonia gas in both flasks was the same.

The number of moles of ammonia in both flasks was the same.

The volume of the flasks with ammonia was different: the volume of Flask 2 was twice the volume of Flask 1.

ב. Determine whether the pressure of $NH_{3(g)}$ in Flask 2 was greater than the pressure of $NH_{3(g)}$ in Flask 1. Explain your answer.

ג. $(NH_4)_2SO_{4(s)}$ can also be obtained by a reaction between $NH_{3(g)}$ and a $H_2SO_{4(aq)}$ solution.

(1) 400 ml of a 10M $H_2SO_{4(aq)}$ solution are reacted with $NH_{3(g)}$.

What mass of $NH_{3(g)}$ is required for this reaction? Show detailed calculations.

(2) What mass of $(NH_4)_2SO_{4(s)}$ is obtained? Show detailed calculations.

Ammonium sulfate, $(NH_4)_2SO_{4(s)}$, decomposes when heated.

Consider the equation for the thermal decomposition reaction of $(NH_4)_2SO_{4(s)}$:

$$2(NH_4)_2SO_{4(s)} \xrightarrow{\text{heat}} 4NH_{3(g)} + 2SO_{2(g)} + 2H_2O_{(g)} + O_{2(g)}$$

ד. 10.56 grams of $(NH_4)_2SO_{4(s)}$ were heated. All the material decomposed.

What is the total volume of products obtained under the conditions of this reaction?

Show detailed calculations.

Assume that the volume of 1 mole of gas under the conditions in which this reaction occurred is 25 liters, and that this volume remained constant.

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

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Ammonium sulfate, $(NH_4)_2SO_{4(s)}$, is also used as a fertilizer in agriculture. It is sold in an ammonium sulfate nitrate solution that contains identical concentrations of $(NH_4)_2SO_{4(aq)}$, and ammonium nitrate, $NH_4NO_{3(aq)}$.

The equation for the dissolution reaction in water of $(NH_4)_2SO_{4(s)}$ is:

$$(NH_4)_2SO_{4(s)} \xrightarrow{H_2O_{(\ell)}} 2NH^+_{4(aq)} + SO^{2-}_{4(aq)}$$

ה. **(1)** Write the equation of the dissolution reaction in water of $NH_4NO_{3(s)}$.

(2) How many moles of ammonium ions, $NH^+_{4(aq)}$, are there in 1 liter of solution in which 1 mole of ammonium sulfate and 1 mole of ammonium nitrate are dissolved?
Assume that all the solids dissolved.
Show detailed calculations.

Good Luck!