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This Exam Includes Three Exercises. It Is Inscribed On 4 Pages Numbered from 1 to 4.
The Use of a Non-Programmable Calculator Is Allowed.

Answer The Three Following Exercises:

Exercise 1 **Kinetics of the decomposition of Mercuric oxide**

Mercuric Oxide is a yellow to orange-yellow, odorless, crystalline powder. It is used in alkaline batteries and pigments, as a seed protectant, and as a preservative in cosmetics.

The decomposition of mercuric oxide (HgO) on heating, resulting in the formation of mercury (Hg) and oxygen (O_2), is represented by the following chemical equation:

$$2HgO_{(s)} \rightarrow 2Hg_{(l)} + O_{2(g)}$$

Given

$V_m = 24\ L.mol^{-1}$

1) Preparation of the solution of HgO

The label of a commercial bottle of HgO reads the following:

- % by mass HgO = 10.85 %
- Density of the solution, $\rho = 11.14\ g.mL^{-1}$
- $M(HgO) = 216\ g.mol^{-1}$.

1.1) Show that the C_0, the concentration of the solution (S_0) is 5.6 $mol.L^{-1}$.

1.2) 10 mL of the commercial solution (S_0) are diluted 40 times to prepare a solution (S_1) of concentration C_1.

1.2.1) Deduce the concentration C_1 of the solution (S_1).

1.2.2) Choose from document-1, the most precise glassware for the preparation of (S_1):

- Volumetric Pipet : 10 mL et 20 mL
- Volumetric Flask : 100 mL, 200 mL, et 400 mL
- Graduated Pipet: 10 mL et 20 mL
- Graduated Cylinders: 10 mL et 20mL.

Document 1

2) Kinetic Study

At time t=0 min, a volume V = 50 mL of the solution (S_1) are poured into an empty flask at T = 20 °C. Using an appropriate method, the molar concentration of mercuric oxide HgO in the flask is determined at each instant t.

The results are listed in the table of **document-2**.

Time (min)	0	5	10	15	20	25	30
$[HgO] \times 10^{-3}\ mol.L^{-1}$	140	70	30	18	14	12	10.5

Document-2

2.1) Calculate the initial mol number of HgO.

2.2) Deduce the volume of O_2 at the end of the reaction.

2.3) Plot, on graph paper, the curve [HgO] = f(t) in the interval of time [0 – 30 min].

Take the following scale: Abscissa: 1cm for 5 min and ordinate: 1cm for $10 \times 10^{-4}\ mol.L^{-1}$.

2.4) Determine graphically the half-reaction time.

2.5) The rate of disappearance of HgO at t = 10 min is 5×10^{-3} mol.L^{-1}min^{-1}.

2.5.1) Choose from the following two values that correspond to the initial rate of disappearance of HgO:

a) $r_1 = 3.6 \times 10^{-3}$ mol.L^{-1}min^{-1} **b)** $r_2 = 17.6 \times 10^{-3}$ mol.L^{-1}min^{-1}

2.5.2) Specify the kinetic factor responsible for the variation in the rate of disappearance of HgO.

2.5.3) Deduce the rate of formation of O_2 at t = 10 min.

2.6) In a second experiment, the reaction is carried out at a temperature of 40°C. The following propositions are given:

Proposition 1: the molar concentration of HgO remaining in the 5th minute is less than 70×10^{-4} mol.L^{-1}.

Proposition 2: the volume of O_2 obtained at the end of the reaction in the second experiment is greater than that obtained in the first experiment.

If the proposition is correct justify it, and if it is false correct it.

Exercise 2 — Identification of Three Organic Compounds

Given, in the table of document-1, the chemical formulas of three organic compounds:

Organic Compound	Chemical formula
(A)	$C_8H_{16}O_2$ with %C = 48.64 %
(B)	$C_4H_{10}O$
(E)	$C_7H_{14}O_2$

Document-1

The aim of this exercise is to identify these compounds.

1) Identification of (A)

The analysis of (A) shows that its condensed structural formula includes a carboxyl group.

1.1) Write the formula of the carboxyl group and indicate the chemical family of (A).

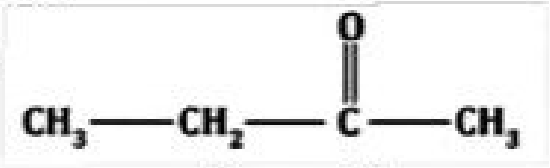
1.2) Determine the molecular formula of (A).

1.3) Write the condensed structural formula of (A) and give its systematic name.

1.4) Write the condensed structural formula of a derivative of (A).

2) Identification of (B)

The equation of the reaction of (B) at T=300°C in the presence of copper (Cu) as a catalyst gives the compound (C) shown in document-2.



Document-2

2.1) Give the name of this reaction.

2.2) Write the condensed structural formula of (B), circle, and name its functional group.

2.3) Give the systematic name of (B).

2.4) Verify that (B) is chiral.

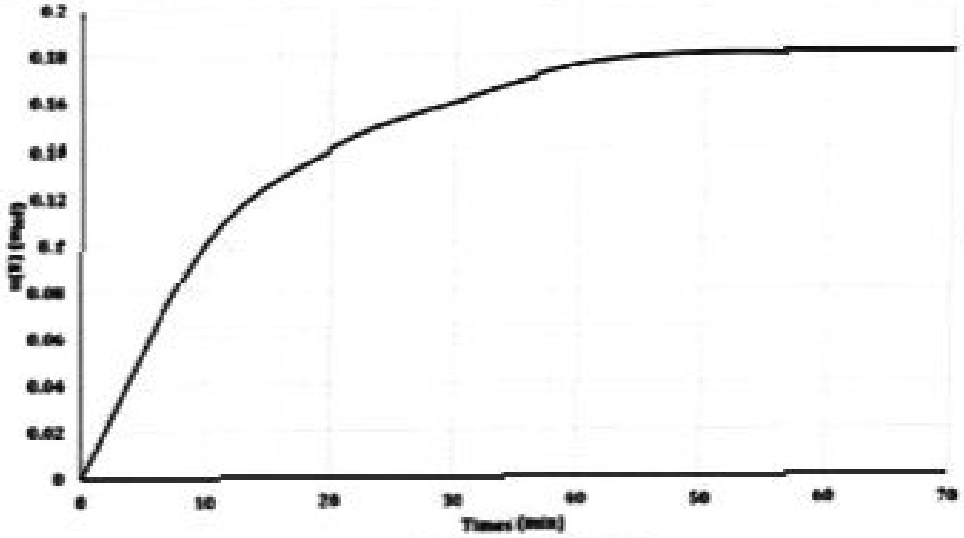
2.5) Represent, according to Cram, the two enantiomers of (B).

2.6) Write the condensed structural formula of a positional isomer of (B).

3) Preparation of (E)

The organic compound (E) is obtained from the reaction between (A) and (B).

At the instant of time, t = 0,0.3 mol of (A) is mixed with 0.3 mol (B), then a few drops of concentrated sulfuric acid are added and the mixture is heated to reflux at constant temperature T. The curve of document-3 represents the evolution of the number of moles of the compound (E) formed as a function of time.



Document-3

3.1) Write, using condensed structural formulas, the equation of the reaction that takes place between (A) and (B).

3.2) Give the systematic name of compound (E).

3.3) Referring to the curve of document-3, justify whether this reaction is slow or fast.

3.4) Calculate the yield of this reaction at equilibrium.

3.5) Another reacting mixture containing 0.2 mol of (A) and 0.3 mol of (B) is prepared.

Choose with justification, the correct answer:

At equilibrium, the yield of this reaction is:

a) 56.66 % **b)** 60 % **c)** 66.66 %

Exercise 3 — Aqua Fortis

Nitric acid (HNO_3), also known as aqua fortis, is a highly corrosive mineral acid. The pure compound is colorless and it used for the production of ammonium nitrate, a major component of fertilizers.

The aim of this exercise is to prepare a nitric acid solution (HNO_3) and to study its titration with sodium hydroxide solution ($Na^+ + HO^-$).

1) Properties of a commercial solution of nitric Acid

The pH of a commercial solution of HNO_3 denoted (S_a) is equal to 2.

1.1) Calculate the initial concentration of the commercial solution (S_a) knowing that HNO_3 is a strong acid.

1.2) Given the following statements. Justify the correct statements and correct the wrong ones.

1.2.1) The dissociation of Nitric acid is partially in water.

1.2.2) NO_3^- is the conjugated base of nitric acid.