This is a Class 1 exam

Lebanon Evangelical School
for Boys and Girls
Loueizeh - Baabda

Stage Exam 01

11NOV2022

Do NOT write in this box. Your MARK will be placed here.

Subject :	Chemistry	
Class :	12E and 12M	
Teacher :	Mrs. Saydeh Nasrallah	
Duration :	1 hour	
Graph paper is needed.		
Your name :		*Time taken to complete exam*
Your Class :		
Exam Room :		
How many sheets, including cover sheet :		

- Do not open this paper until the teacher in charge instructs you to do so.
- The most important thing to remember in taking an exam is NEVER PANIC.
- If you are caught cheating in this exam, you will be awarded zero for ALL exams that are taken on this day.

Exercise 1 (3 points)

In this exercise, give, with justification, the letter of the correct answer for each of the following questions.

1. The reaction between carbon monoxide and hydrogen reaches a dynamic equilibrium.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

Which of these statements about a dynamic equilibrium is **not** true?

A The forward rate of reaction is equal to the backward rate of reaction.
B The concentrations of the products and reactants do not change.
C The concentrations of the products and reactants are equal.
D The equilibrium can be approached from either direction.

2. Hydrogen and iodine, both with an initial concentration of $0.010\,mol.dm^{-3}$, were allowed to react. At equilibrium, the concentration of hydrogen iodide was $0.0030\,mol.dm^{-3}$.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

K_c is calculated using the values

	$H_2(g)$ / mol dm^{-3}	$I_2(g)$ / mol dm^{-3}	$HI(g)$ / mol dm^{-3}
A	0.0070	0.0070	0.0030
B	0.0040	0.0040	0.0030
C	0.0040	0.0040	0.0060
D	0.0085	0.0085	0.0030

3. The Haber process is used to make ammonia from nitrogen and hydrogen at 450 °C.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92.0\ kJ/mol$$

When the total pressure of the system is increased

A K_p decreases.
B K_p increases.
C K_p stays the same.
D K_p first decreases and then increases.

Exercise 2 (7 points) **Kinetic Study of the Oxidation of an Alcohol**

The mild oxidation of 2-propanol by a potassium permanganate solution ($K^+ + MnO_4^-$) in acidic medium takes place according to a slow and complete reaction represented by the equation given below:

$$5C_3H_8O + 2MnO_4^- + 6H^+ \rightarrow 5C_3H_6O + 2Mn^{2+} + 8H_2O$$

The aim of this exercise is to study the kinetic of this reaction.

Given: The density of 2-propanol: $d(C_3H_8O) = 0.79\,g.mL^{-1}$

Molar masses in $g.mol^{-1}$: $M(KMnO_4) = 158$; $M(C_3H_8O) = 60$

1. Preparation of a Solution (S) of Potassium Permanganate

1.1. Calculate the mass of solid $KMnO_4$ necessary to prepare 250 mL of a solution (S) of potassium permanganate ($K^+ + MnO_4^-$) of concentration $C = 0.1\,mol.L^{-1}$.

1.2. List the essential materials needed to realize the preparation of this solution (S).

2. Kinetic Study

To study the kinetic of this reaction, a volume V = 100 mL of the solution (S) of potassium permanganate of concentration $C = 0.1\,mol.L^{-1}$ is introduced into an Erlenmeyer flask then few mL of concentrated sulfuric acid solution are added. (sulfuric acid is in excess)

At instant **t – 0**, $1\,mL$ of pure 2-propanol is added to the content of the Erlenmeyer flask.

At different instants **t**, a volume V_1 = 10.0 mL of the reacting mixture is removed and poured into a beaker containing 40mL of ice water.

By an appropriate method, the permanganate ions MnO_4^- contained in the beaker are titrated, and then the number of moles of C_3H_6O formed is deduced at each instant **t**.
The obtained results are given in the table of **document-1**.

t (min)	1	2	3	4	6	10	15	20
n(C_3H_6O) (mmol)	3.5	5.5	6.8	7.8	9.3	11	12	12.6

Document-1

2.1. Plot the curve representing the variation of the number of moles of (C_3H_6O) as a function of time: $n(C_3H_6O) = f(t)$ in the interval of time [0 – 20 min].
Take the following scales: **In abscissa:** 1cm for 2 min **In ordinates:** 1cm for 1 mmol.

2.2. Show that C_3H_8O is the limiting reactant.

2.3. Determine the half life time of the reaction $t_{1/2}$.

2.4. Specify whether each of the following propositions is true or false.

2.4.1. The introduction of volume V_1 = 10.0 mL of the reacting mixture into a beaker containing 40 mL of ice water blocks the oxidation reaction of 2-propanol.

2.4.2. Sulfuric acid plays the role of a catalyst for this reaction.

2.5. The experiment realized above is repeated, but with one modification: the volume V = 100 mL of the solution (S) of potassium permanganate is introduced in an Erlenmeyer flask containing initially 100 mL of distilled water. Trace, on the same graph of question **2.1**, the shape of the curve representing the variation of the number of moles of (C_3H_6O) as a function of time: $n(C_3H_6O) = g(t)$ in the interval of time [0 – 20 min]. Justify.

Exercise 3 (5 points) **Cracking of methane**

Hydrogen gas, H_2, can be obtained using the thermal cracking of alkanes such as methane, CH_4, which is obtained from the fractional distillation of crude oil.
The thermal cracking of methane gas, CH_4, can be written according to the following equation.

$$CH_4\,(g) \rightleftharpoons C(s) + 2H_2(g) \qquad \Delta H = +75\ kJ/mol$$

1. Write the expression of the pressure equilibrium constant, k_p .
2. An equilibrium was established at 800K and total pressure P = 1atm.
Calculate the partial pressure of each constituent of the equilibrium mixture given that $k_p = 0.4$ at 800K.
3. Calculate the density of the gaseous mixture present at equilibrium relative to hydrogen gas.
4. Express the effect of each of the following factors on the equilibrium position.
4.1. an addition of hydrogen gas, H_2.
4.2. heating the mixture.

Given: M(H) = 1g/mol M(C) = 12g/mol

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Exercise 1

1- At equilibrium, the concentrations of the products and reactants remain constant but not necessarily equal. ✓ (½)

Answer : (C) ✓ (½)

2-

	H_2	+	I_2	⇌	2HI
t=0	0.01		0.01		—
reacted/formed	$\frac{0.003}{2}$		$\frac{0.003}{2}$		0.003
t_{eqm}	0.0085		0.0085		0.0030

✓ ✓ ✓ (½)

Answer : (D) ✓ (½)

3- The equilibrium constant k_p remains unaltered as long as the temperature is constant ✓ (½)

Answer : (C) ✓ (½)

Exercise 2

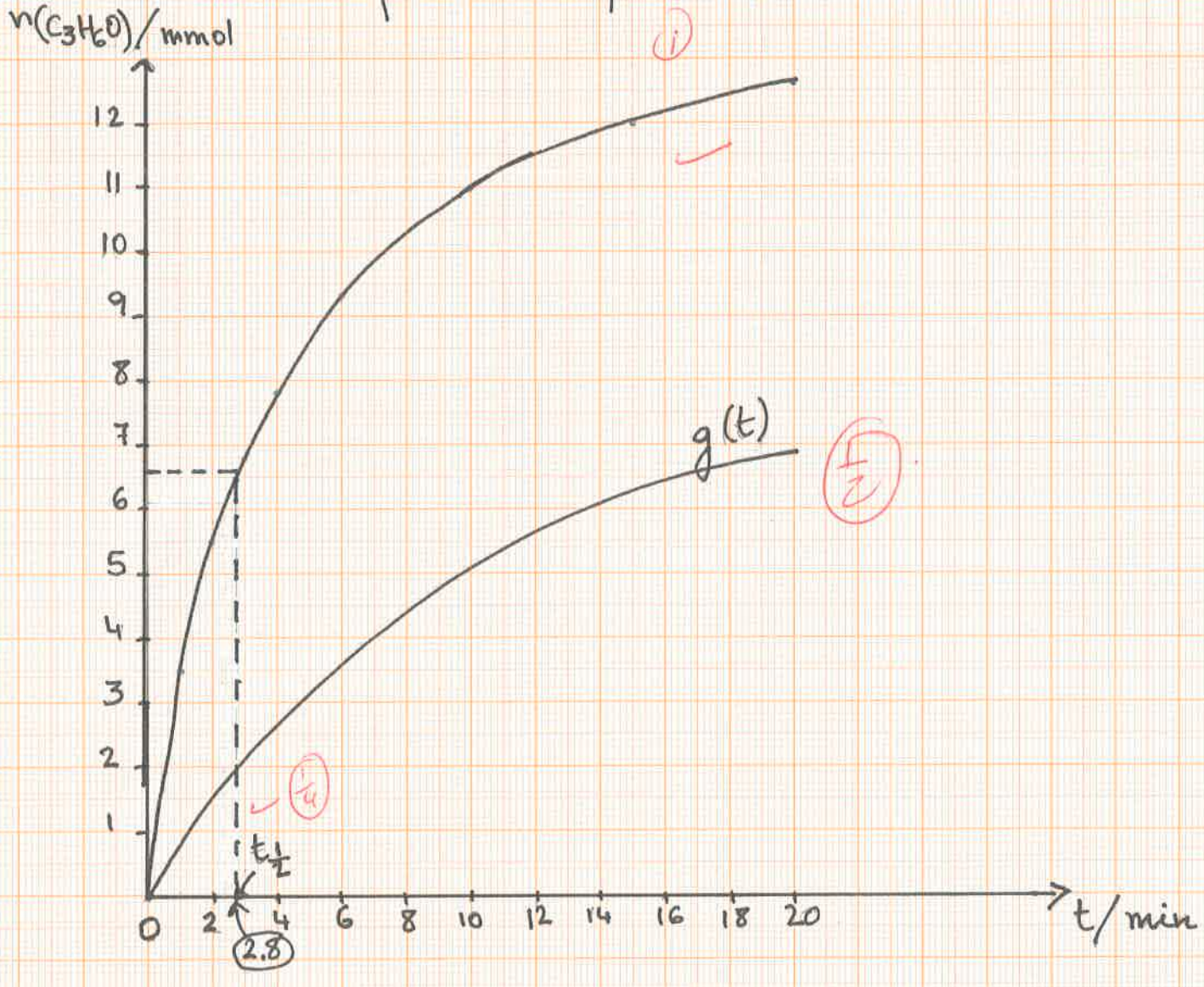
1.1- $n_{KMnO_4} = 0.1 \times 0.25 = 0.025$ mol ✓ (½)

$m_{KMnO_4} = 0.025 \times 158 = 3.95$ g ✓ (½)

1.2- Spatula - watchglass - digital scale - 250 mL volumetric flask - dropper - conical funnel - distilled water ✓ (½)

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2.1 - Curve representing the variation of $n_{C_3H_6O}$ as a function of time



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2.2 - $n_{MnO_4^-} = 0.1 \times 0.1 = 0.01$ mol (1/4)

$\Rightarrow R_{MnO_4^-} = \frac{0.01}{2} = 5 \times 10^{-3}$ (1/4)

$d_{C_3H_8O} = \frac{m_{C_3H_8O}}{V} = \frac{n_{C_3H_8O} \times M_{C_3H_8O}}{V}$ (1/4)

$\Rightarrow n_{C_3H_8O} = \frac{d \times V}{M} = \frac{0.79 \times 1}{60} = 0.0132$ mol

$\Rightarrow R_{C_3H_8O} = \frac{0.0132}{5} = 2.63 \times 10^{-3}$ (1/4)

then $R_{C_3H_8O} < R_{MnO_4^-}$

therefore C_3H_8O is the limiting reagent.

2.3 - The half-life time of a reaction is, by definition, the time taken for half the maximum amount of product to be formed. (1/2)

By stoichiometry : $n_{C_3H_8O\,(t=0)} = n_{C_3H_6O\,(t=\infty)}$ (1/4)

at $t_{1/2}$, $n_{C_3H_6O\,(t_{1/2})} = \frac{0.0132}{2} = 6.6 \times 10^{-3}$ mol (1/4)

Graphically $t_{1/2} = 2.8$ min (1/2)

2.4.1 - Temperature is a kinetic factor. Adding the mixture to ice water will block the oxidation reaction (1/4)

Hence, the statement is true (1/2)

2.4.2- The sulfuric acid appears in the equation and it's not collected intact. (1/4)
Hence, the acid is not a catalyst. (1/2)

2.5_ Adding 100 ml of distilled water would decrease the concentration of reagents in the medium, therefore more time is needed to produce the same number of mol of C_3H_6O. (1/2)
Therefore g(t) would have a lower rate.

Exercise 3.

$$CH_4(g) \rightleftharpoons C(s) + 2H_2(g) \qquad \Delta H = +75\ kJ.mol^{-1}$$

1. $K_p = \dfrac{P_{H_2}^2}{P_{CH_4}}$ at equilibrium. (1)

2. $P_T = 1\ atm \Rightarrow P_{CH_4} = 1 - P_{H_2}$ (1/4)

Then $0.4 = \dfrac{P_{H_2}^2}{1 - P_{H_2}}$

$\Rightarrow P_{H_2}^2 - 0.4 + 0.4P_{H_2} = 0$. (1/4)

$\Rightarrow P_{H_2} = 0.46\ atm$ (1/4) or $P_{H_2} = 0.86\ atm$ (1/4) rejected

$\Rightarrow P_{CH_4} = 0.54\ atm$. (1/2)

3. $\dfrac{d(mixture)}{d_{(H_2)}} = \dfrac{\overline{M}_{(mixture)}}{M_{H_2}} = \dfrac{0.46 \times 2 + 0.54 \times 16}{2} = 4.78.$ (1/2) (1/4)

4.1- Adding H_2 gas, shifts the equilibrium to the reaction consuming the excess of H_2. ✓

(3/4) Hence, the backward reaction is favoured and more CH_4 is formed. ✓

4.2- Heating the mixture, favours the reaction taking in heat, which is the endothermic reaction. ✓

(3/4) In this case, the equilibrium shifts forward. ✓