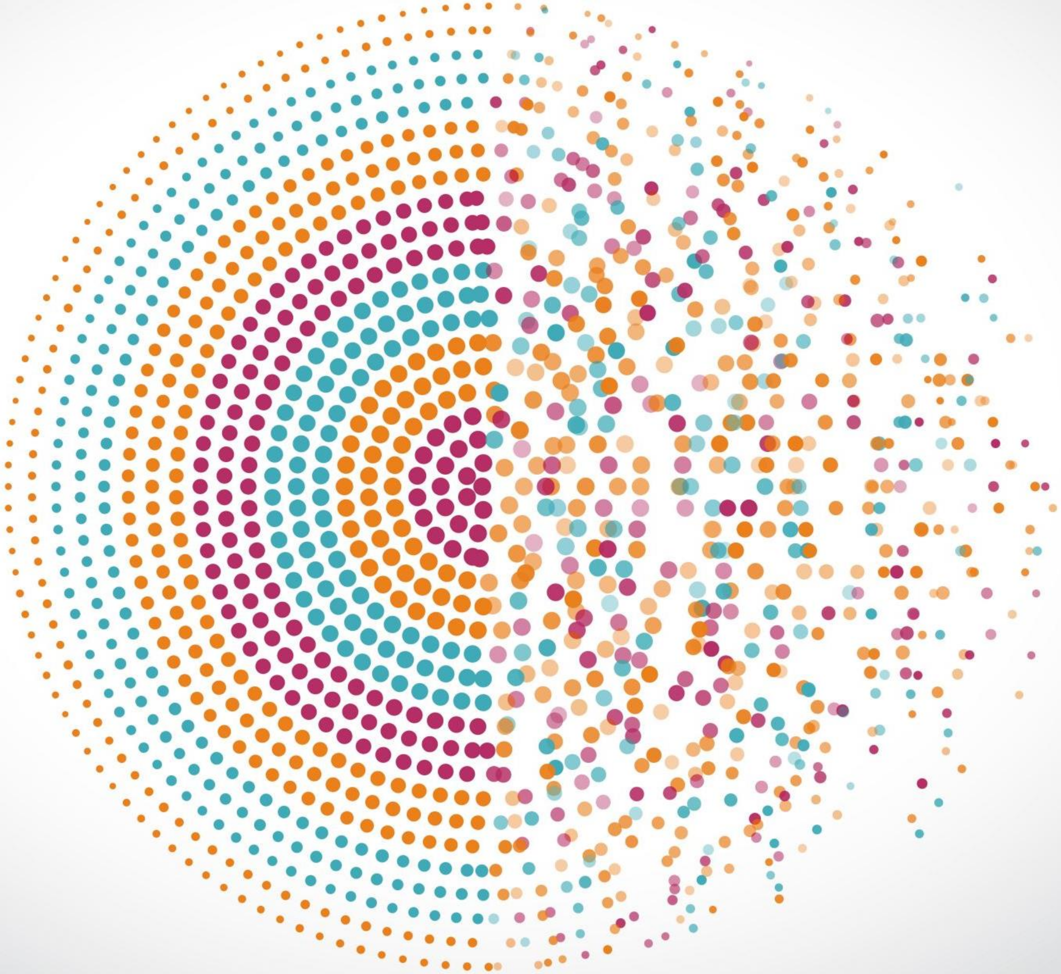

CHEM1128-EXAM 1REVIEW

By Q-Center

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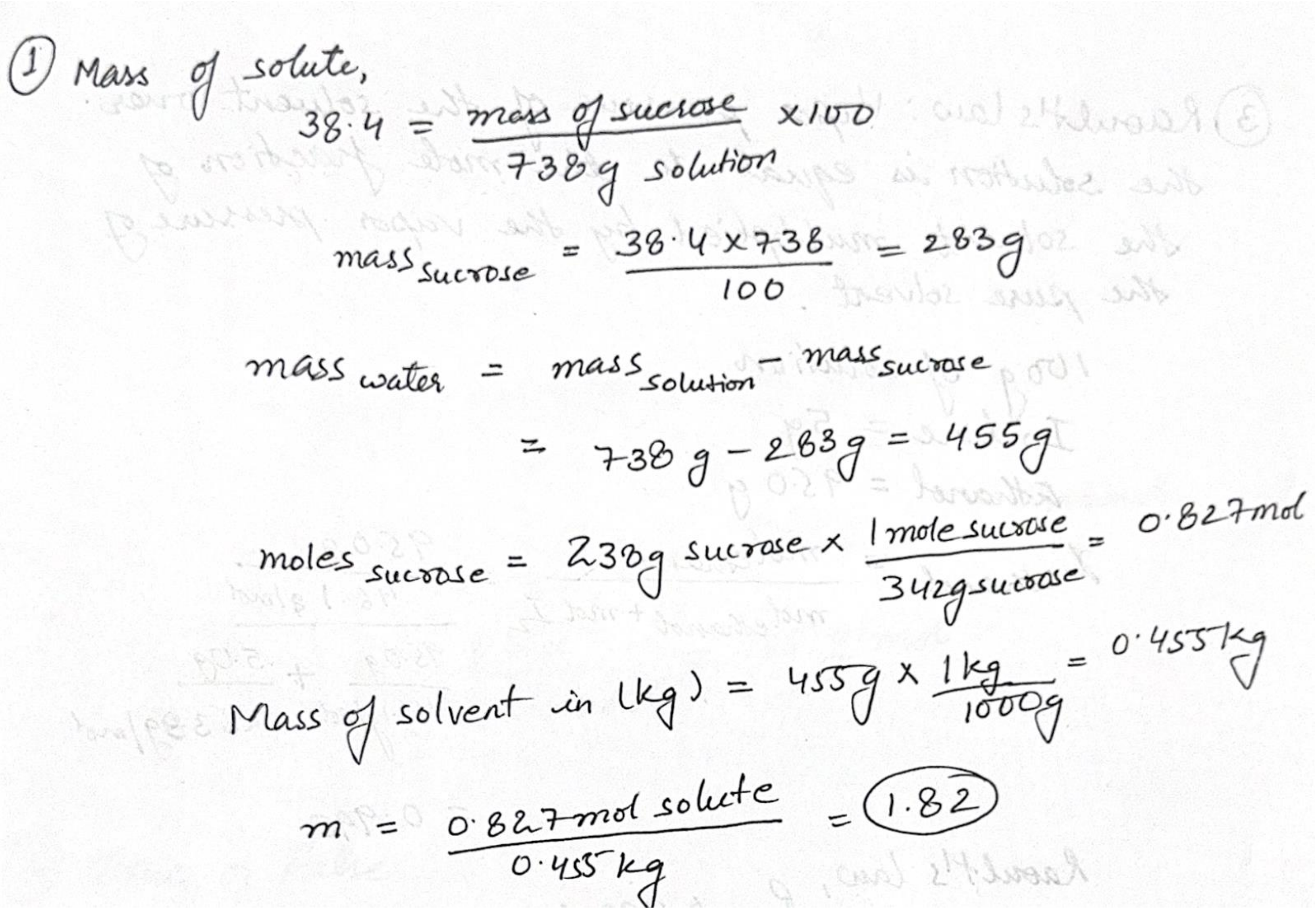
02/19/2025

CHAPTER 13

Solubility and Colligative Properties

1. A solution contains sucrose in water ($C_{12}H_{22}O_{11}$) in water. The solution has a total mass of 738g and the mass percent of sucrose in the solution is 38.4%. Calculate the molality of the solution.



① Mass of solute,

$$38.4 = \frac{\text{mass of sucrose}}{738\,\text{g solution}} \times 100$$

$$\text{mass}_{\text{sucrose}} = \frac{38.4 \times 738}{100} = 283\,\text{g}$$

$$\text{mass}_{\text{water}} = \text{mass}_{\text{solution}} - \text{mass}_{\text{sucrose}}$$

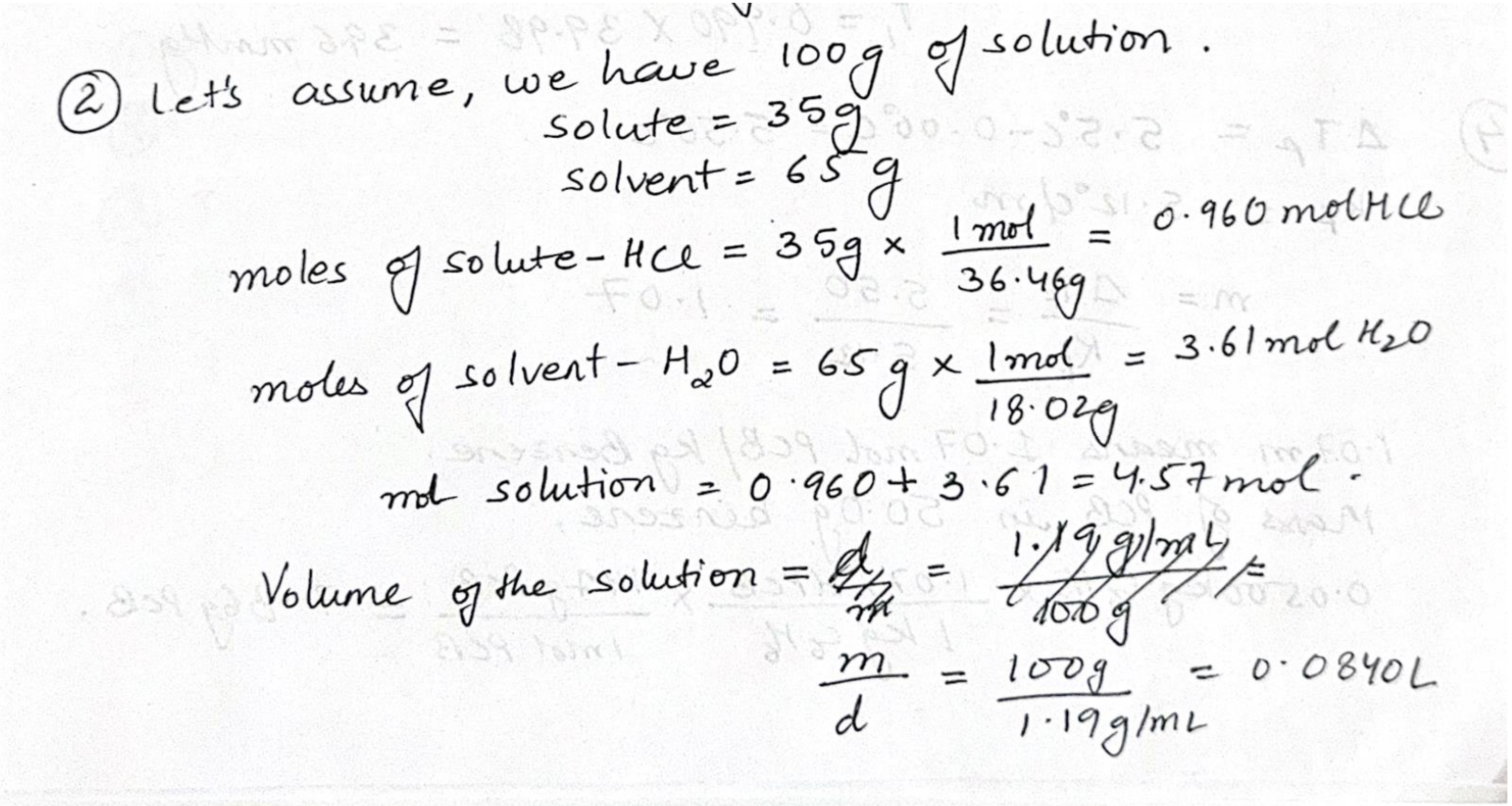
$$= 738\,\text{g} - 283\,\text{g} = 455\,\text{g}$$

$$\text{moles}_{\text{sucrose}} = 238\,\text{g sucrose} \times \frac{1\ \text{mole sucrose}}{342\,\text{g sucrose}} = 0.827\,\text{mol}$$

$$\text{Mass of solvent in (kg)} = 455\,\text{g} \times \frac{1\,\text{kg}}{1000\,\text{g}} = 0.455\,\text{kg}$$

$$m = \frac{0.827\,\text{mol solute}}{0.455\,\text{kg}} = \boxed{1.82}$$

2. What is the molarity of an aqueous solution of HCl that is 35.0% by mass and whose density is 1.19g/mL?



② Let's assume, we have 100g of solution.

Solute = 35g

solvent = 65 g

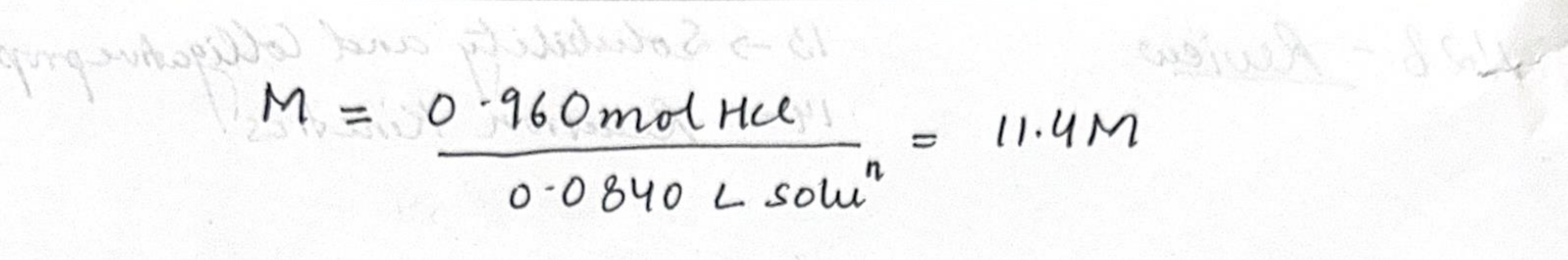
moles of solute - HCl = $35g \times \frac{1\ mol}{36.46g} = 0.960\ mol\ HCl$

moles of solvent - H_2O = $65g \times \frac{1\ mol}{18.02g} = 3.61\ mol\ H_2O$

mol solution = 0.960 + 3.61 = 4.57 mol.

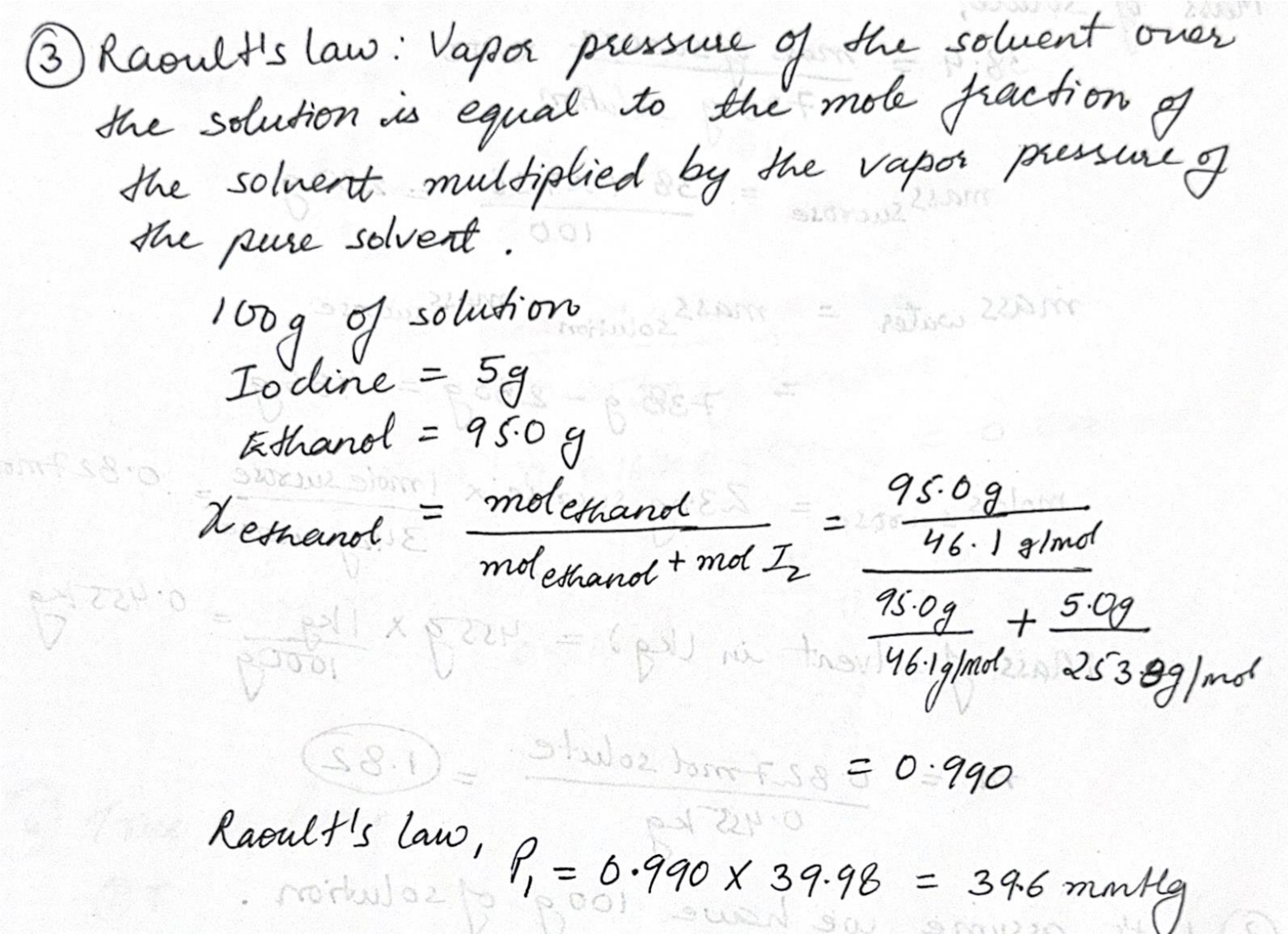
Volume of the solution = $\cancel{\frac{d}{m}} = \cancel{\frac{1.19\ g/mL}{100\ g}}$

$$\frac{m}{d} = \frac{100g}{1.19g/mL} = 0.0840L$$



$$M = \frac{0.960\ mol\ HCl}{0.0840\ L\ soln} = 11.4M$$

3. The vapor pressure of pure ethanol (C_2H_5OH) at 20°C is 39.98mm Hg. What is the vapor pressure of ethanol over a solution containing 5.0% of mass of iodine?



③ Raoult's law: Vapor pressure of the solvent over the solution is equal to the mole fraction of the solvent multiplied by the vapor pressure of the pure solvent.

100g of solution

Iodine = 5g

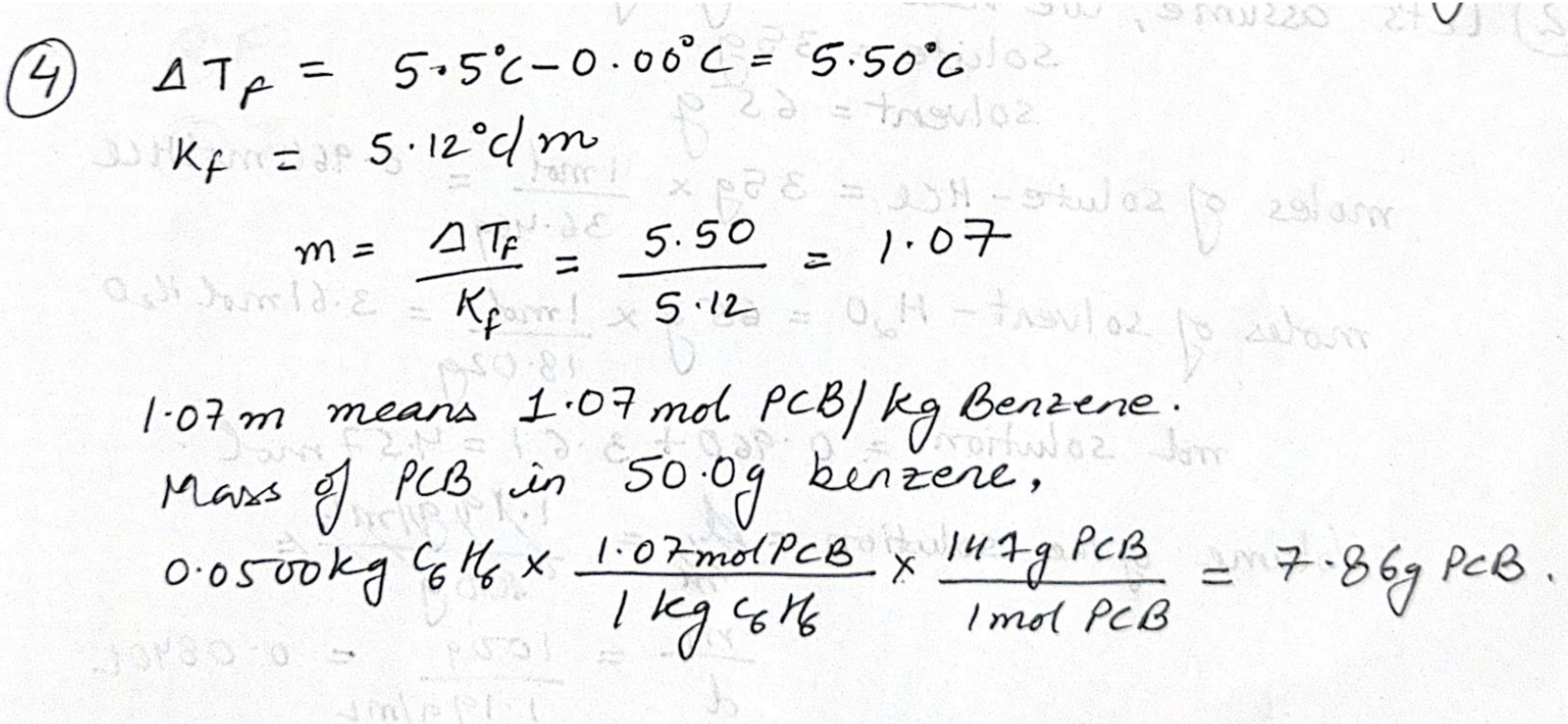
Ethanol = 95.0 g

$$x_{ethanol} = \frac{mol_{ethanol}}{mol_{ethanol} + mol\ I_2} = \frac{\frac{95.0g}{46.1\ g/mol}}{\frac{95.0g}{46.1g/mol} + \frac{5.0g}{253.8g/mol}}$$

$$= 0.990$$

Raoult's law, $P_1 = 0.990 \times 39.98 = 39.6$ mmHg

4. The freezing point of benzene is 5.50ºC. Its freezing point constant is 5.12ºC/m. How much p-dichlorobenzene ($C_6H_4Cl_2$) must be added to 50.0g of benzene (C_6H_6) to lower the freezing point of the solution to that of pure water?



④ $\Delta T_f = 5.5°C - 0.00°C = 5.50°C$

$K_f = 5.12°C/m$

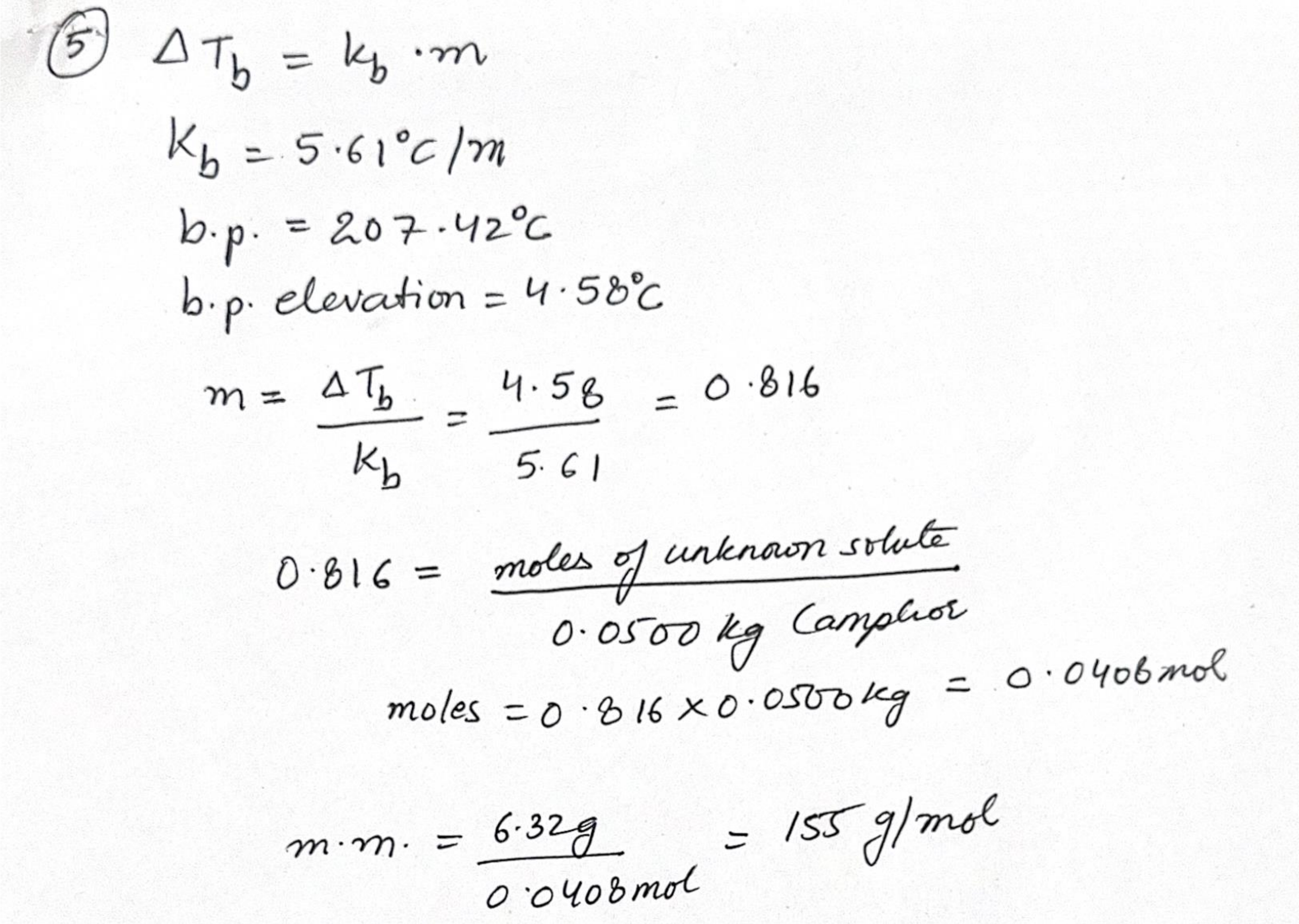
$$m = \frac{\Delta T_F}{K_f} = \frac{5.50}{5.12} = 1.07$$

1.07 m means 1.07 mol PCB/ kg Benzene.

Mass of PCB in 50.0g benzene,

$$0.0500\,kg\ C_6H_6 \times \frac{1.07\,mol\,PCB}{1\,kg\ C_6H_6} \times \frac{147\,g\ PCB}{1\,mol\ PCB} = 7.86\,g\ PCB.$$

5. When 6.32 g of an unknown solid is added to 50.0g of camphor, the solution formed has a boiling point of 212.0ºC. Calculate the molar mass of unknown solid.



⑤ $\Delta T_b = k_b \cdot m$

$K_b = 5.61°C/m$

b.p. = 207.42°C

b.p. elevation = 4.58°C

$$m = \frac{\Delta T_b}{K_b} = \frac{4.58}{5.61} = 0.816$$

$$0.816 = \frac{\text{moles of unknown solute}}{0.0500\ \text{kg Camphor}}$$

moles = 0.816 × 0.0500 kg = 0.0408 mol

$$m.m. = \frac{6.32\,g}{0.0408\,mol} = 155\ g/mol$$

True or False

1. The solubility of CO2 in water is less than the solubility of CH_3OH in water at 25ºC. TRUE

2. The osmotic pressure of a solution at 100ºC is equal to the osmotic pressure of the same solution at 0ºC. FALSE

Consider 3 beakers. Each beaker has a solution made up of 1 mol of solute in 100g of solvent. Each of the solutions has a different density.

   a) Beaker 1 has C_2H_5OH (ethyl alcohol) in water.
   b) Beaker 2 has $C_{12}H_{22}O_{11}$ (sugar) in water.
   c) Beaker 3 has NaCl in water.

3. All the solutions have the same molality. TRUE

4. All solutions have same molarity. FALSE

5. Each of the three solutions has a different mass percent of solute. TRUE

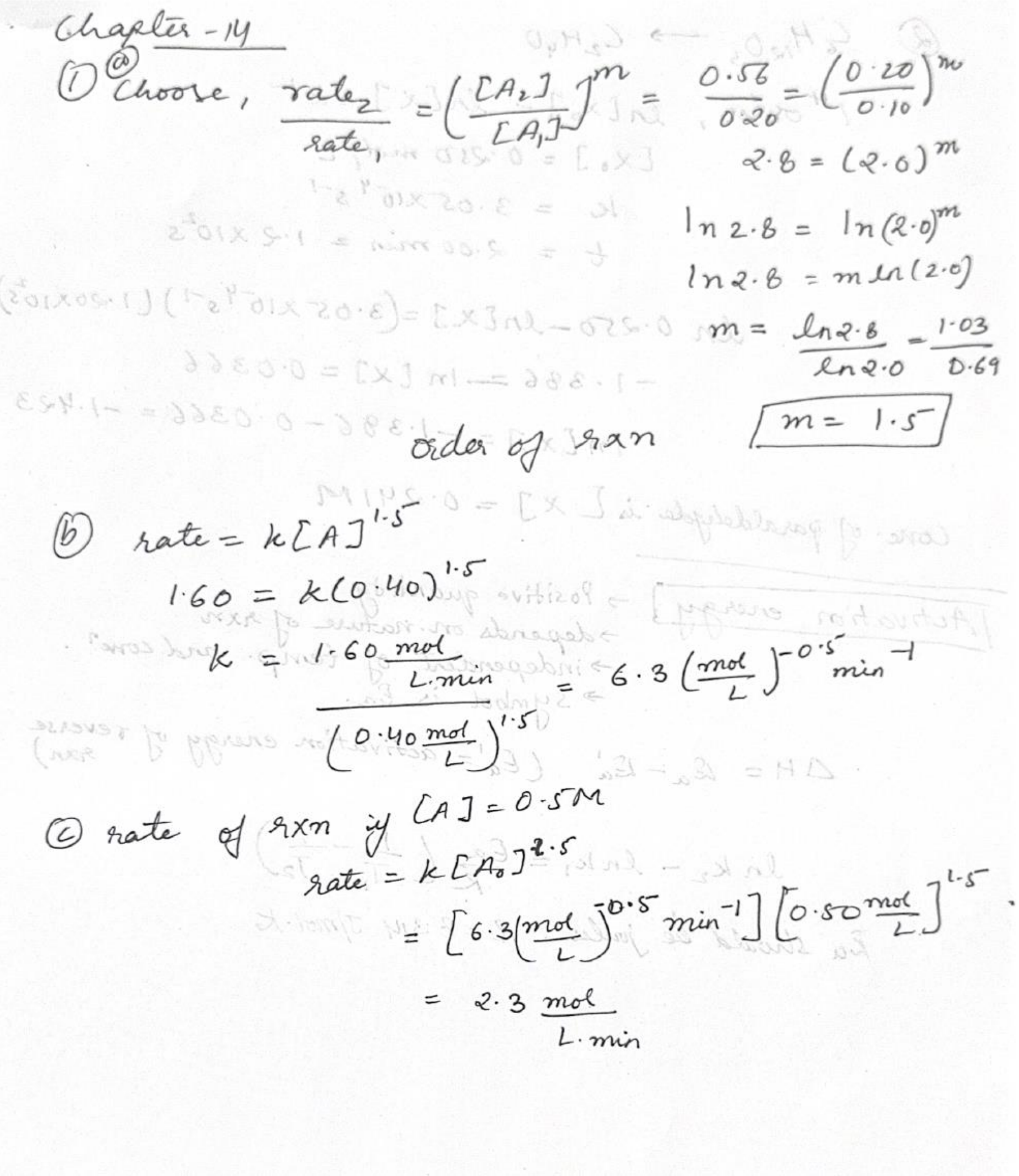
6. The solution in beaker 1 and beaker 3 have the same boiling point. FALSE

CHAPTER 14
Kinetics

1. The initial rate of decomposition of a compound A to its products B and C, was measured at a series of different concentrations with the following results. Using the data, determine the order of reaction. Calculate the rate constant. What is the rate of reaction if [A] is 0.50 M?

$$A(g) \longrightarrow B(g) + C(g)$$

[A] (M)	0.10	0.20	0.30	0.4
RATE (M/min)	0.20	0.56	1.04	1.60



Chapter - 14

① ⓐ Choose, $\frac{rate_2}{rate_1} = \left(\frac{[A_2]}{[A_1]}\right)^m = \frac{0.56}{0.20} = \left(\frac{0.20}{0.10}\right)^m$

$2.8 = (2.0)^m$

$\ln 2.8 = \ln (2.0)^m$

$\ln 2.8 = m \ln(2.0)$

$m = \frac{\ln 2.8}{\ln 2.0} = \frac{1.03}{0.69}$

order of rxn $\boxed{m = 1.5}$

ⓑ $rate = k[A]^{1.5}$

$1.60 = k(0.40)^{1.5}$

$k = \frac{1.60 \frac{mol}{L.min}}{\left(0.40 \frac{mol}{L}\right)^{1.5}} = 6.3 \left(\frac{mol}{L}\right)^{-0.5} min^{-1}$

ⓒ rate of rxn if $[A] = 0.5M$

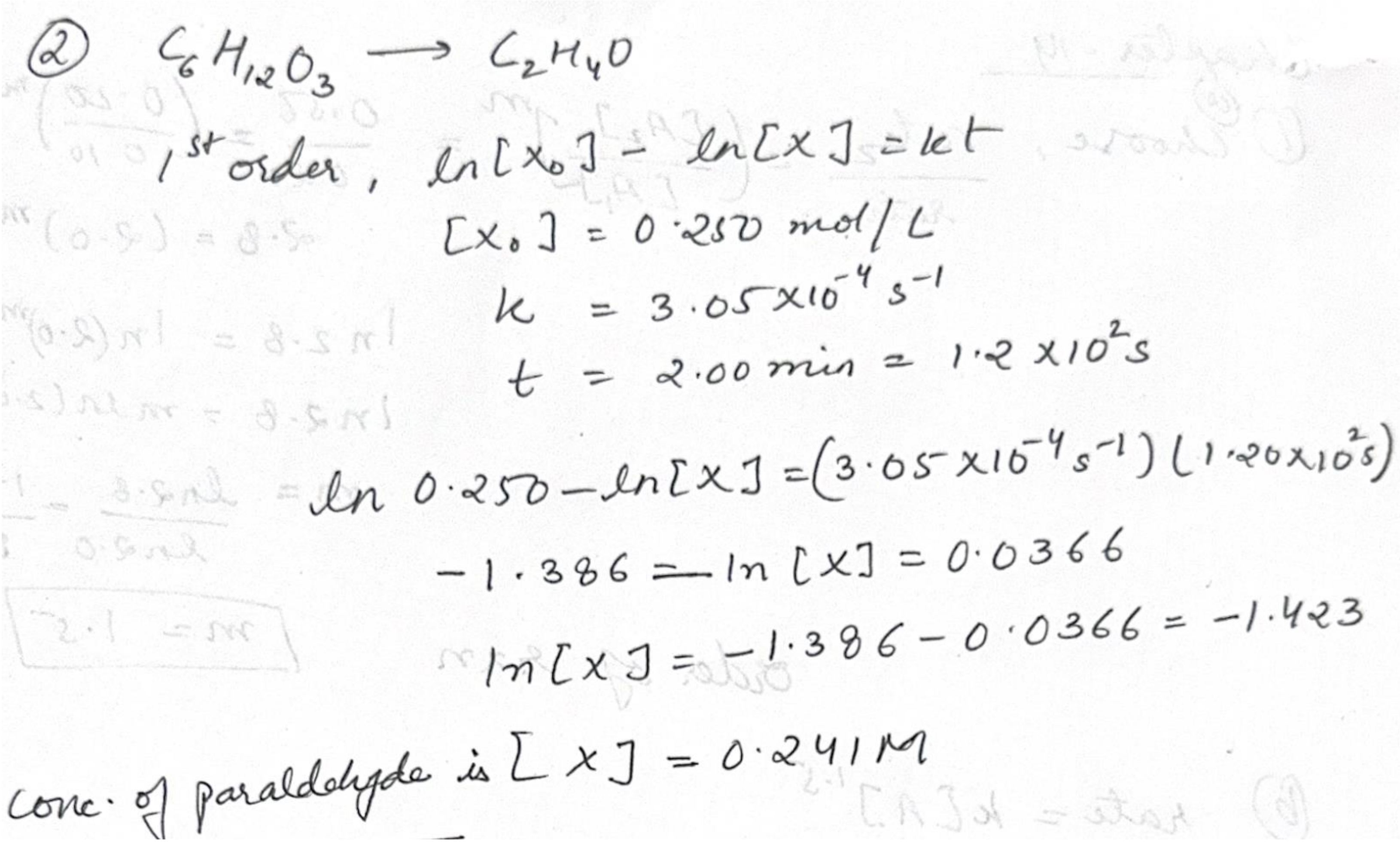
$rate = k[A_0]^{2.5}$

$= \left[6.3\left(\frac{mol}{L}\right)^{-0.5} min^{-1}\right]\left[0.50 \frac{mol}{L}\right]^{1.5}$

$= 2.3 \frac{mol}{L \cdot min}$

2. Paraldehyde ($C_6H_{12}O_3$) decomposes by a first-order reaction at 225°C to acetaldehyde (C_2H_4O). The equation is $C_6H_{12}O_3(g) \longrightarrow 3\,C_2H_4O(g)$

The rate constant for this reaction at 225°C is $3.05 \times 10^{-4}\ s^{-1}$. If we start with a 0.250M concentration of paraldehyde, what will its concentration be after 2.00 minutes?



② $C_6H_{12}O_3 \longrightarrow C_2H_4O$

1st order, $\ln[X_0] - \ln[X] = kt$

$[X_0] = 0.250$ mol/L

$k = 3.05 \times 10^{-4}\ s^{-1}$

$t = 2.00$ min $= 1.2 \times 10^2$ s

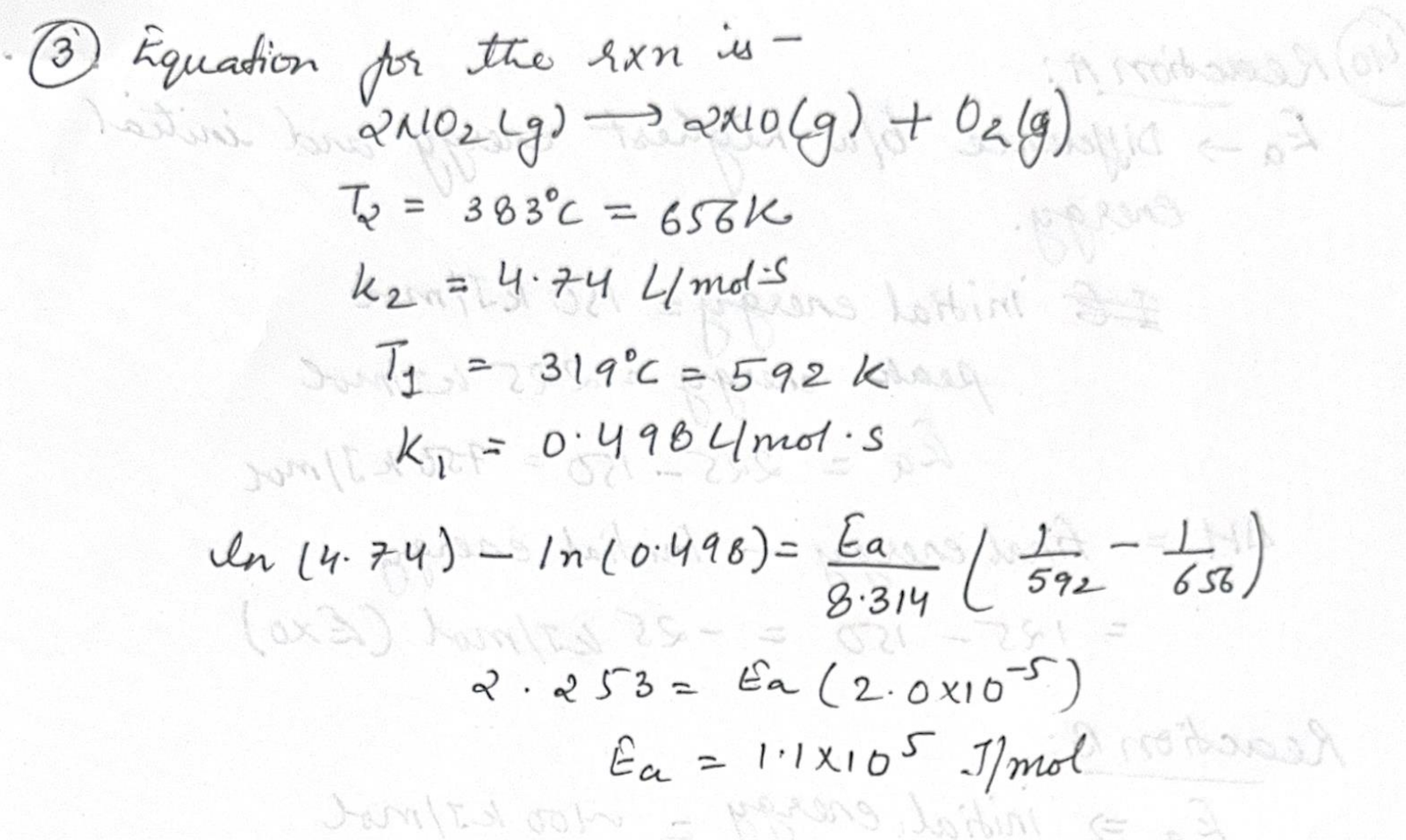
$\ln 0.250 - \ln[X] = (3.05 \times 10^{-4}\ s^{-1})(1.20 \times 10^2\ s)$

$-1.386 - \ln[X] = 0.0366$

$\ln[X] = -1.386 - 0.0366 = -1.423$

conc. of paraldehyde is $[X] = 0.241$ M

3. Nitrogen dioxide decomposes into nitrogen oxide and oxygen. At 319ºC its rate constant is 0.498 L/mol.s and at 383ºC its rate constant is 4.74 L/mol.s. Claculate the activation energy for this reaction.



③ Equation for the rxn is –

$$2NO_2(g) \longrightarrow 2NO(g) + O_2(g)$$

$T_2 = 383°C = 656K$

$k_2 = 4.74$ L/mol·s

$T_1 = 319°C = 592$ K

$k_1 = 0.498$ L/mol·s

$$\ln(4.74) - \ln(0.498) = \frac{E_a}{8.314}\left(\frac{1}{592} - \frac{1}{656}\right)$$

$$2.253 = E_a(2.0\times10^{-5})$$

$$E_a = 1.1\times10^{5} \text{ J/mol}$$

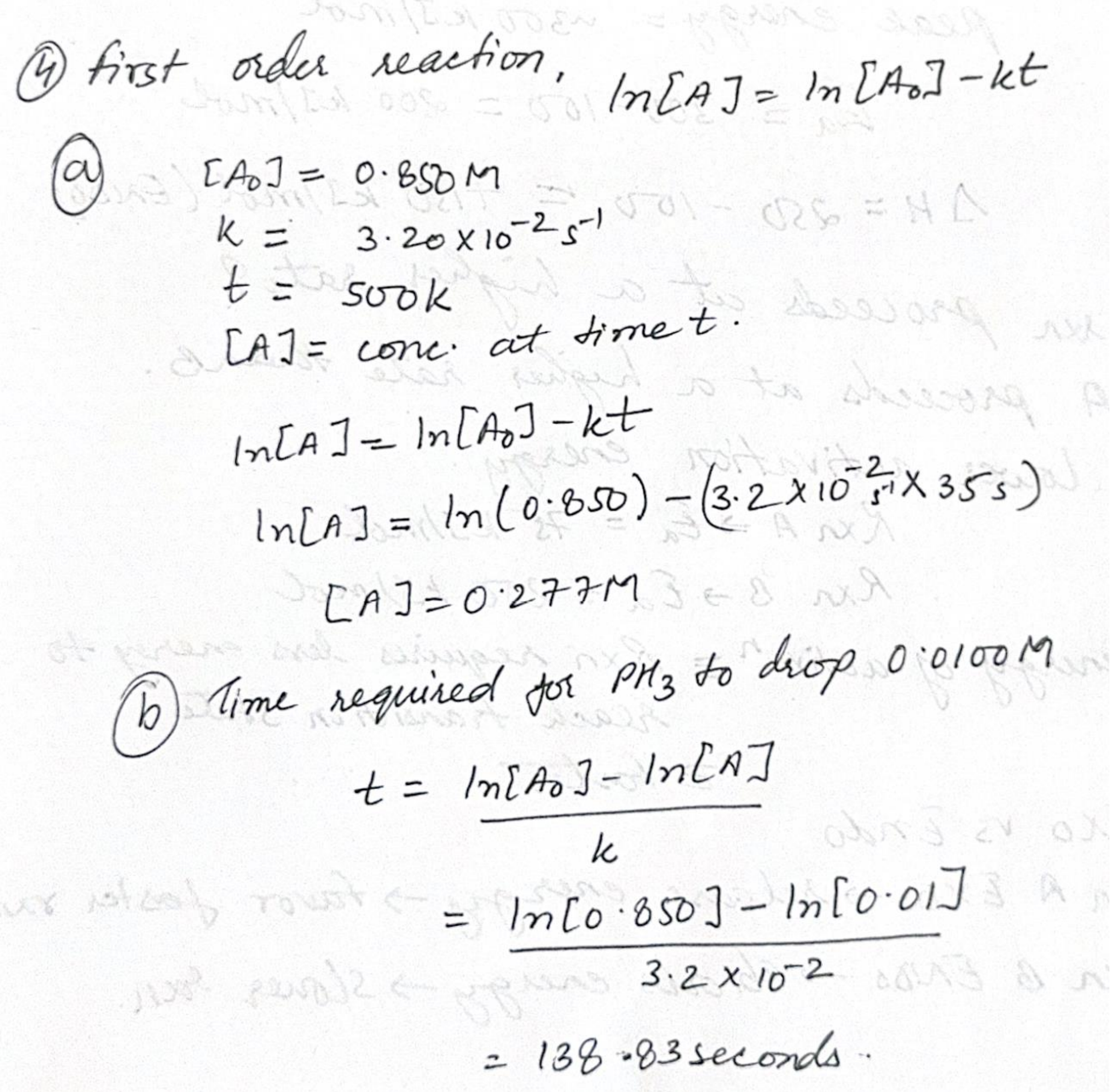
4. The decomposition of phosphine (PH_3) is a first-order reaction with a rate constant of $3.20\times10^{-2}\,s^{-1}$ at 500 K:

$$PH_3(g) \rightarrow P(s) + 3/2 H_2(g)$$

The initial concentration of PH_3 is 0.850 M.

(a) Calculate the concentration of PH3 after 35.0 s.

(b) How many seconds will it take for the concentration of PH3 to drop to 0.0100 M?



④ first order reaction, $\ln[A] = \ln[A_0] - kt$

ⓐ $[A_0] = 0.850\,M$

$k = 3.20\times10^{-2}\,s^{-1}$

$t = 500k$

$[A] =$ conc. at time t.

$\ln[A] = \ln[A_0] - kt$

$\ln[A] = \ln(0.850) - (3.2\times10^{-2}\,s^{-1} \times 35\,s)$

$[A] = 0.277M$

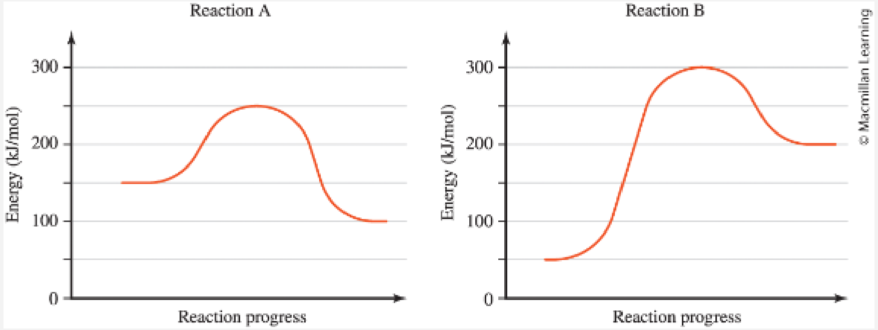
ⓑ Time required for PH_3 to drop 0.0100 M

$$t = \frac{\ln[A_0] - \ln[A]}{k}$$

$$= \frac{\ln[0.850] - \ln[0.01]}{3.2\times10^{-2}}$$

$= 138.83$ seconds.

40. Use the energy diagrams to determine the activation energy, E_a, and enthalpy of reaction, ΔH, for each reaction.



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41. Based on the energy diagrams in the previous problem, predict which reaction proceeds at the higher rate or whether they proceed at the same rate. Explain the reasoning behind your answer.

(40) Reaction A:

$E_a \rightarrow$ Difference b/w highest energy and initial energy.

~~IE~~ initial energy = 150 kJ/mol

peak energy = 225 kJ/mol

E_a = 225 − 150 = 750 kJ/mol

ΔH = final energy − Initial energy

= 125 − 150 = −25 kJ/mol (Exo)

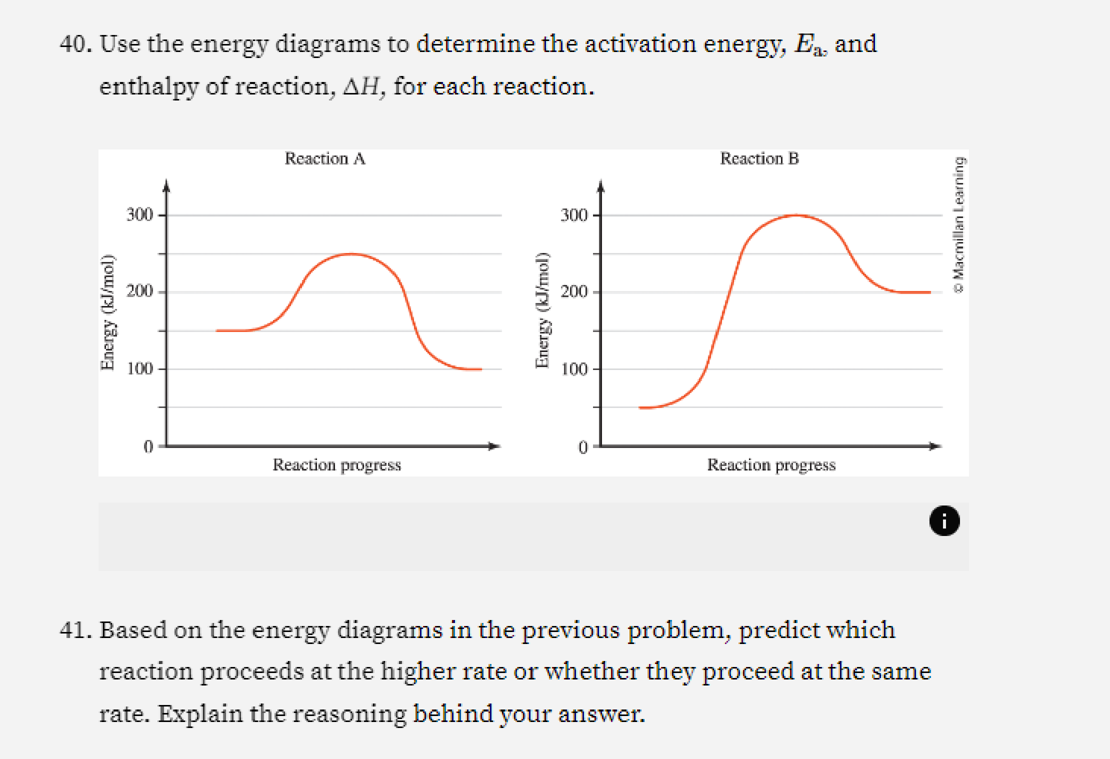
Reaction B:

$E_a \Rightarrow$ initial energy = ~100 kJ/mol

peak energy = ~300 kJ/mol

E_a = 300 − 100 = 200 kJ/mol

ΔH = 250 − 100 = +150 kJ/mol (ENDO)



40. Use the energy diagrams to determine the activation energy, E_a, and enthalpy of reaction, ΔH, for each reaction.

41. Based on the energy diagrams in the previous problem, predict which reaction proceeds at the higher rate or whether they proceed at the same rate. Explain the reasoning behind your answer.

(41) Which rxn proceeds at a higher rate?

Rxn A proceeds at a higher rate than B.

ⓐ lower activation energy.

Rxn A → E_a = 75 kJ/mol

Rxn B → E_a = 200 kJ/mol

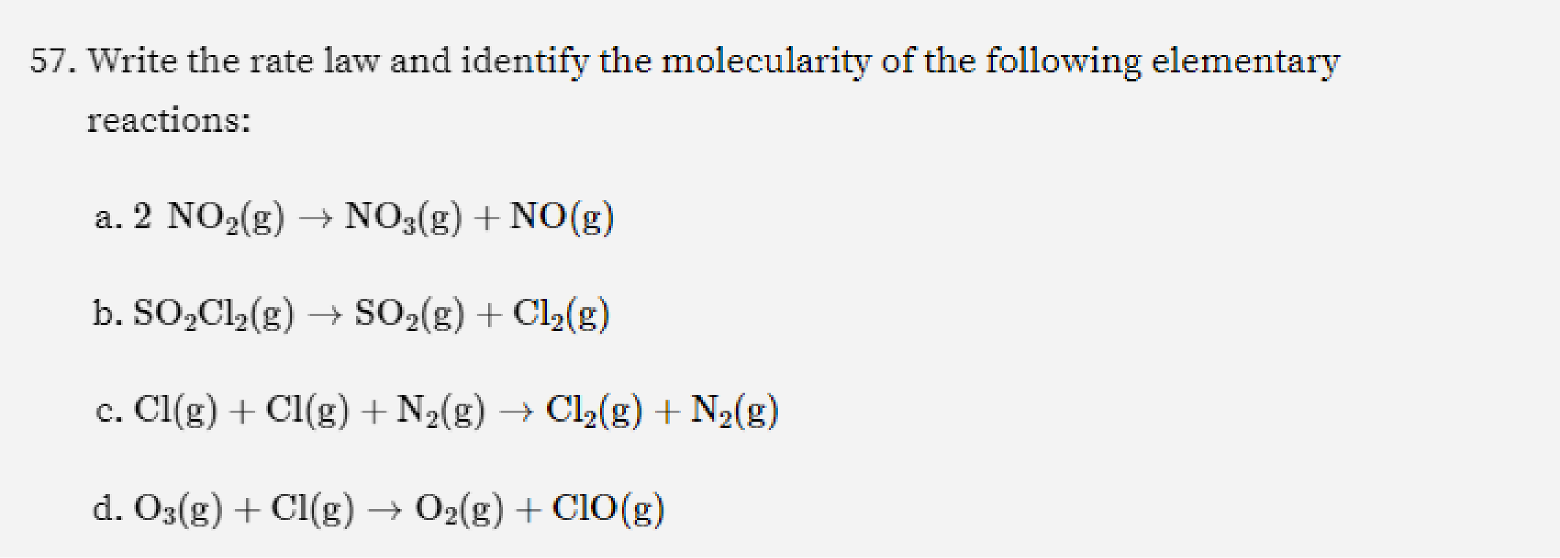
Lower energy of activa^{n} ≡ Rxn requires less energy to reach transition state

≡ faster

ⓑ Exo vs Endo

Rxn A Exo → release energy → favor faster rxn

Rxn B ENDo → absorbs energy → slower rxn.



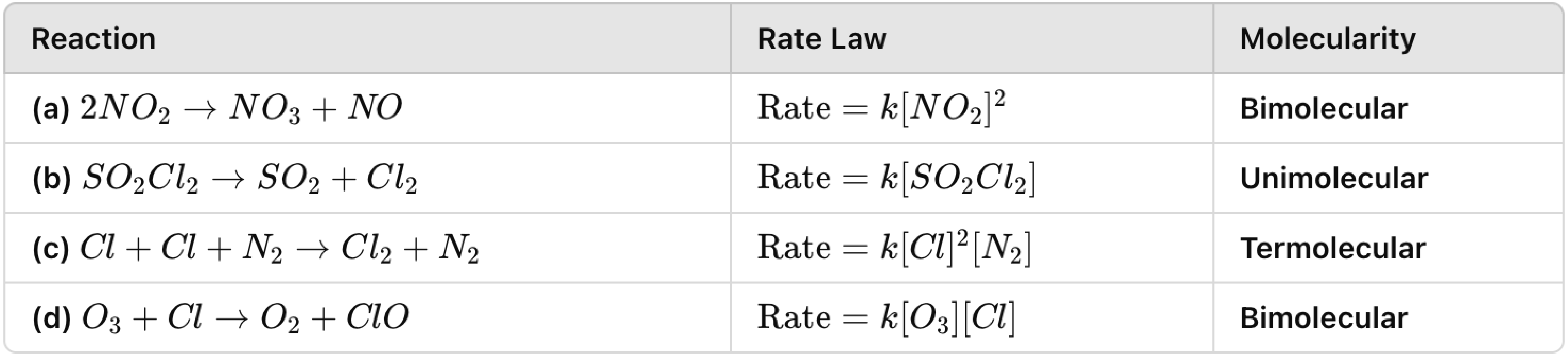
57. Write the rate law and identify the molecularity of the following elementary reactions:

a. $2\ NO_2(g) \rightarrow NO_3(g) + NO(g)$

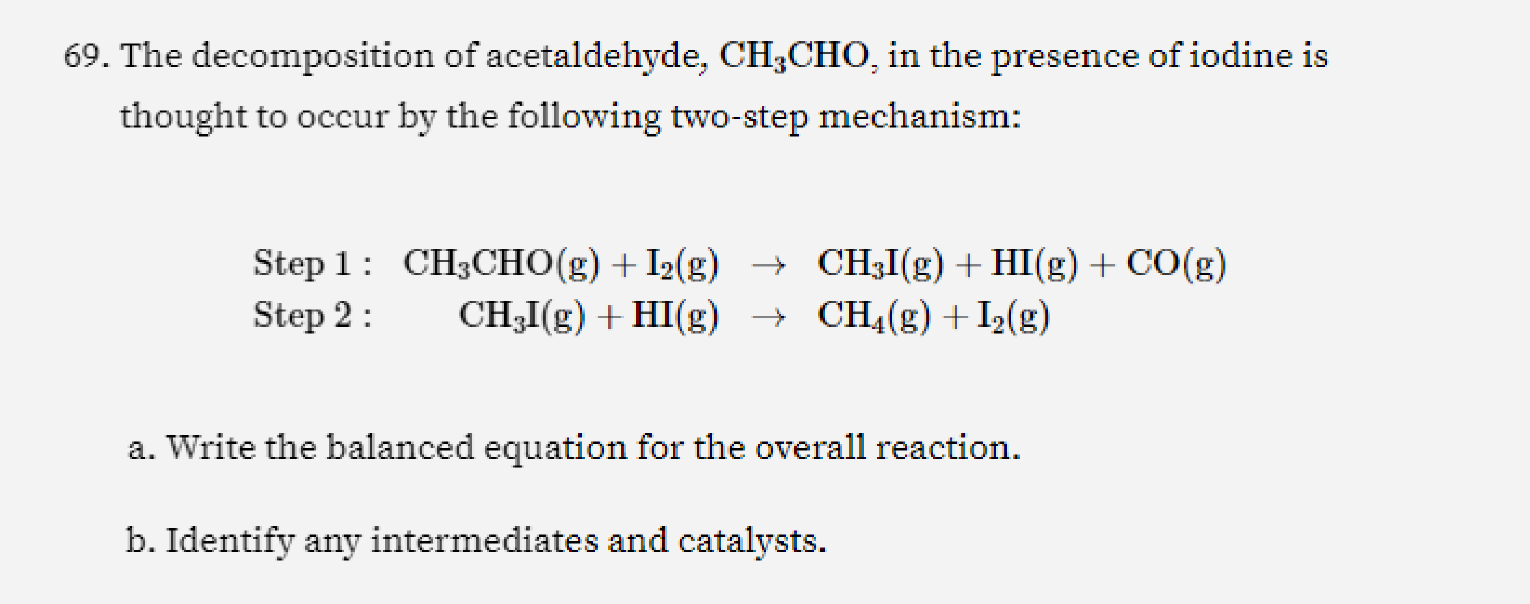
b. $SO_2Cl_2(g) \rightarrow SO_2(g) + Cl_2(g)$

c. $Cl(g) + Cl(g) + N_2(g) \rightarrow Cl_2(g) + N_2(g)$

d. $O_3(g) + Cl(g) \rightarrow O_2(g) + ClO(g)$



Reaction	**Rate Law**	**Molecularity**
(a) $2NO_2 \rightarrow NO_3 + NO$	$\text{Rate} = k[NO_2]^2$	**Bimolecular**
(b) $SO_2Cl_2 \rightarrow SO_2 + Cl_2$	$\text{Rate} = k[SO_2Cl_2]$	**Unimolecular**
(c) $Cl + Cl + N_2 \rightarrow Cl_2 + N_2$	$\text{Rate} = k[Cl]^2[N_2]$	**Termolecular**
(d) $O_3 + Cl \rightarrow O_2 + ClO$	$\text{Rate} = k[O_3][Cl]$	**Bimolecular**



69. The decomposition of acetaldehyde, CH_3CHO, in the presence of iodine is thought to occur by the following two-step mechanism:

$$\begin{aligned} &\text{Step 1:} \quad CH_3CHO(g) + I_2(g) \rightarrow CH_3I(g) + HI(g) + CO(g) \\ &\text{Step 2:} \quad CH_3I(g) + HI(g) \rightarrow CH_4(g) + I_2(g) \end{aligned}$$

a. Write the balanced equation for the overall reaction.

b. Identify any intermediates and catalysts.

$$CH_3CHO(g) \longrightarrow CH_4(g)+CO(g)$$

Intermediates:

Intermediates are species that are produced in one step and consumed in another, meaning they do not appear in the overall reaction.

- $CH_3I(g)$ (formed in Step 1, consumed in Step 2)
- $HI(g)$ (formed in Step 1, consumed in Step 2)

Catalysts:

A catalyst is a species that is used in an earlier step and regenerated in a later step, meaning it appears in the same form in the beginning and end but does not participate in the net reaction.

- $I_2(g)$ (reactant in Step 1, regenerated in Step 2)