

國立清華大學 101 學年度碩士班考試入學試題

系所班組別：生醫工程與環境科學系 乙組（環境分子科學組）

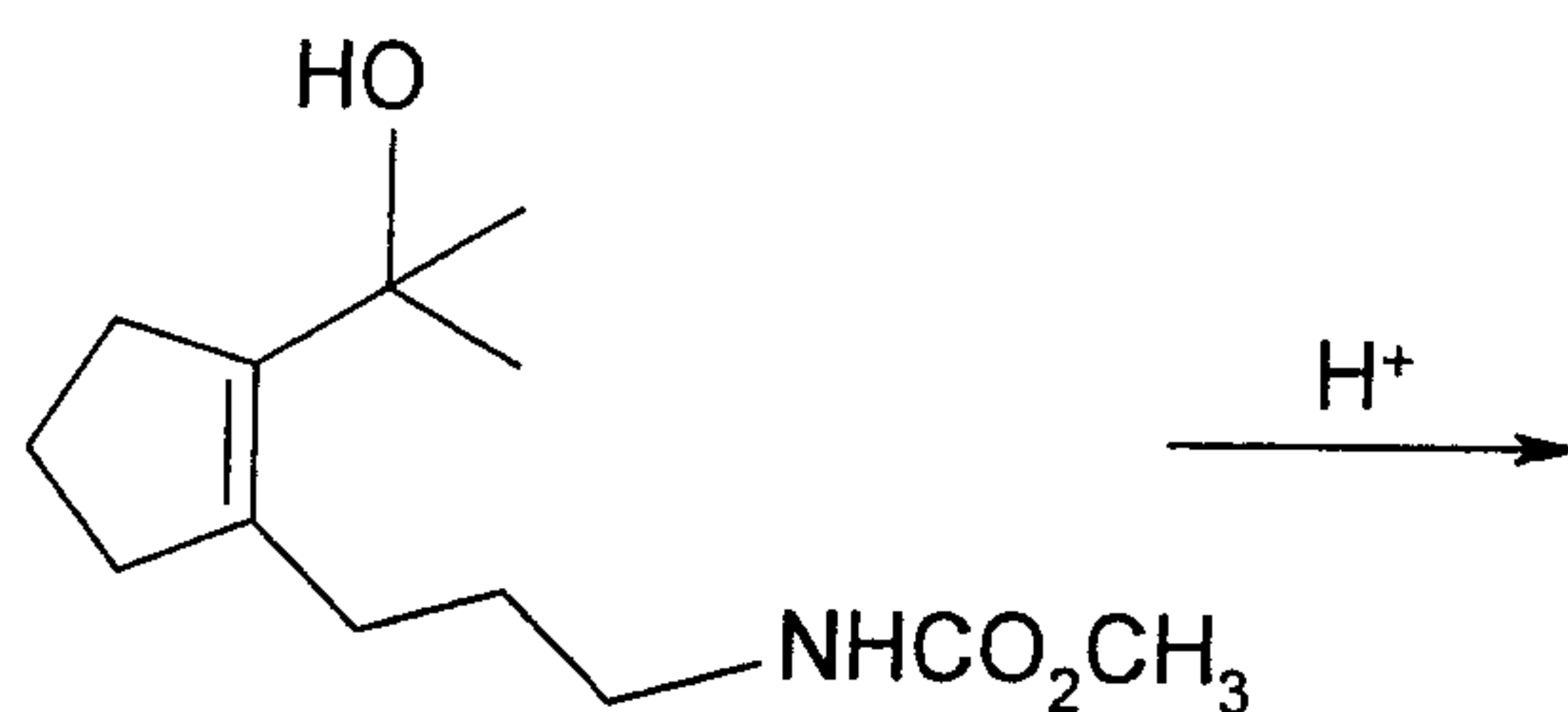
考試科目（代碼）：有機化學與物理化學 (2304)

共 5 頁，第 1 頁 *請在【答案卷、卡】作答

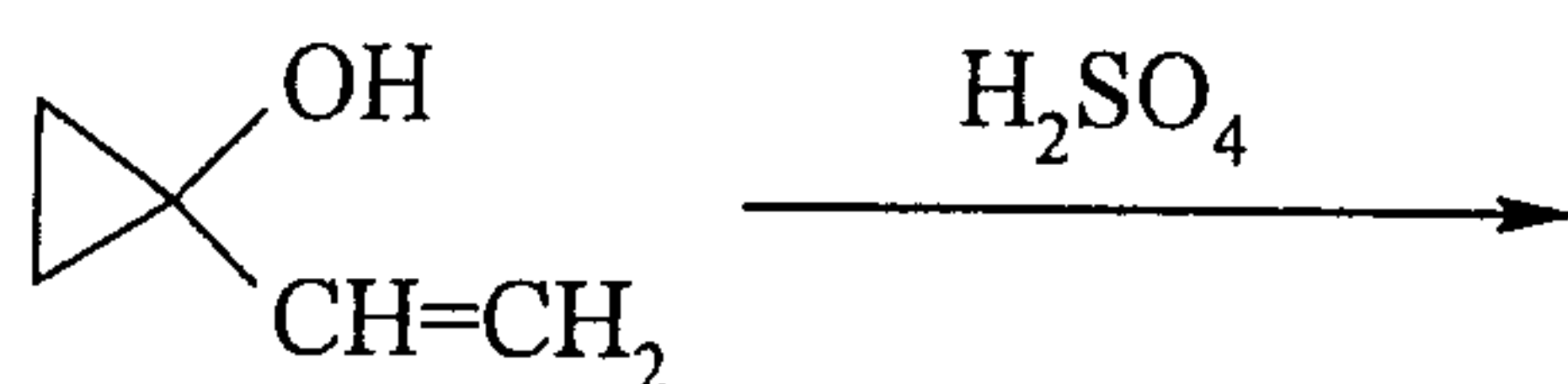
一、有機化學 (50%；務必作答於答案卷內)

1. Please provide the structure of the major product for each of the following reactions, and include stereochemistry where appropriate. (24%, 3 % of each)

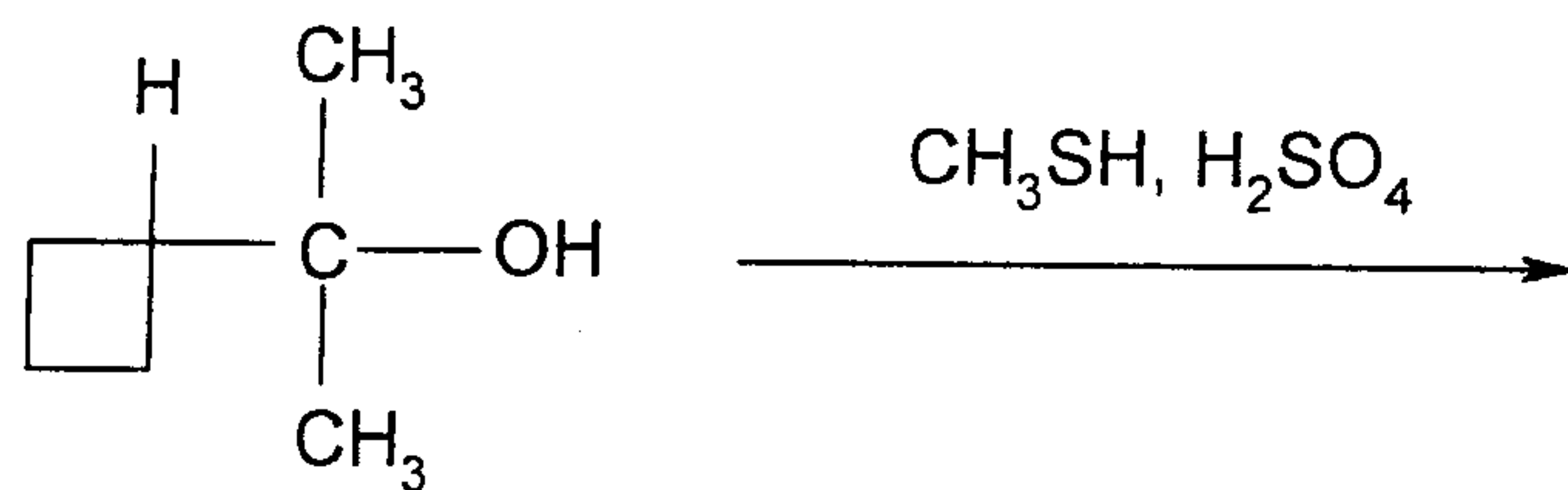
(a)



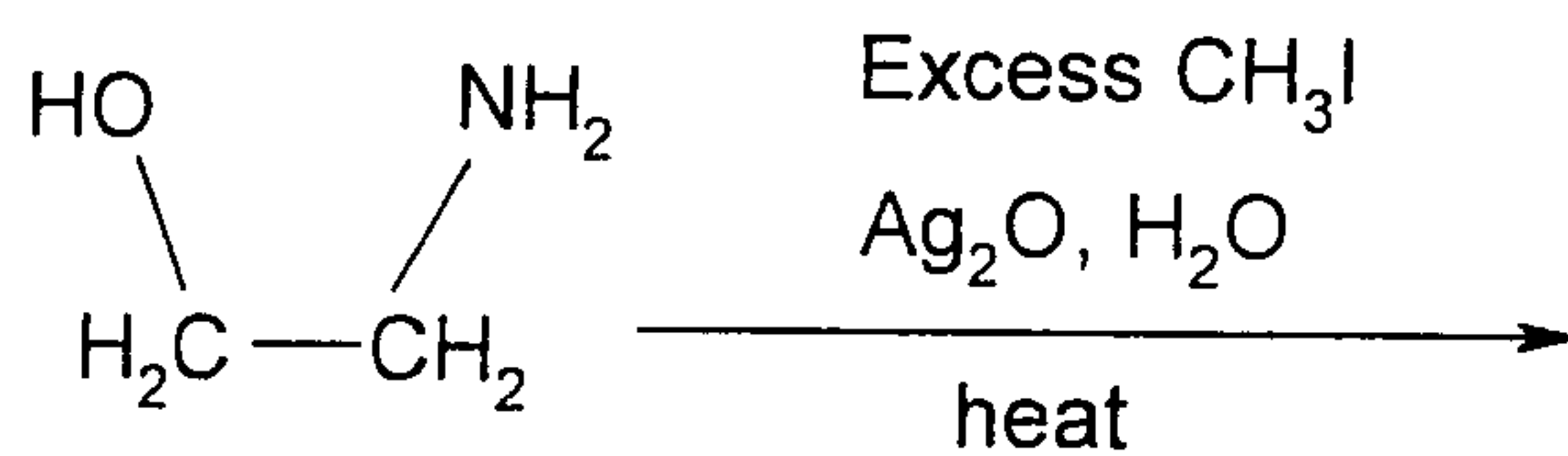
(b)



(c)



(d)



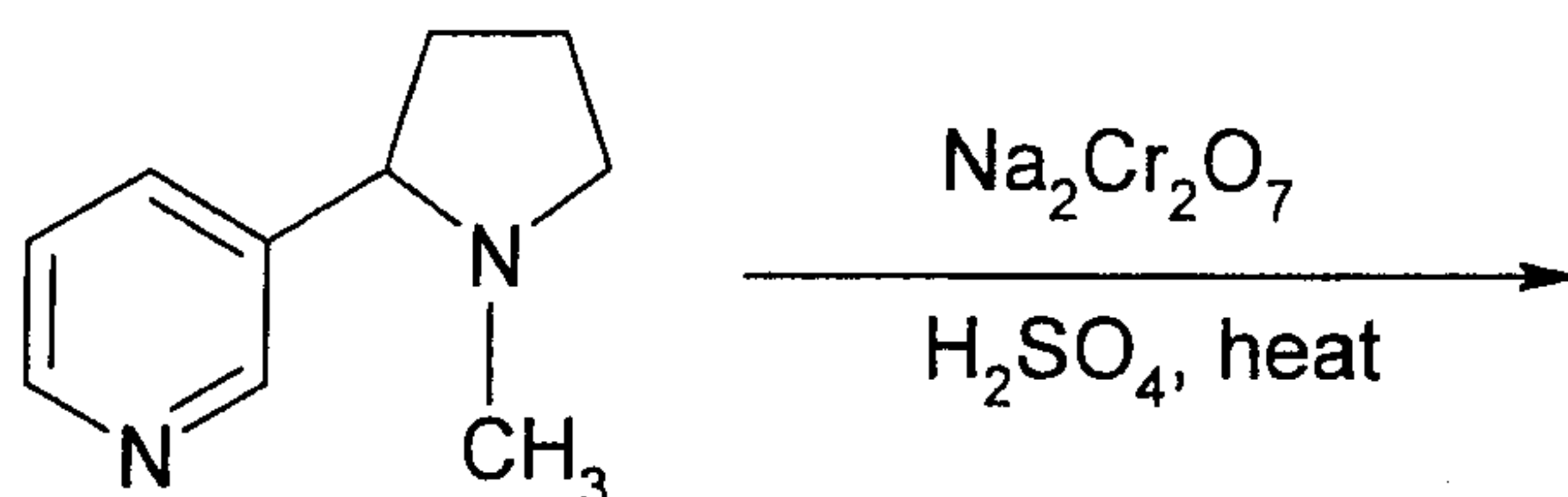
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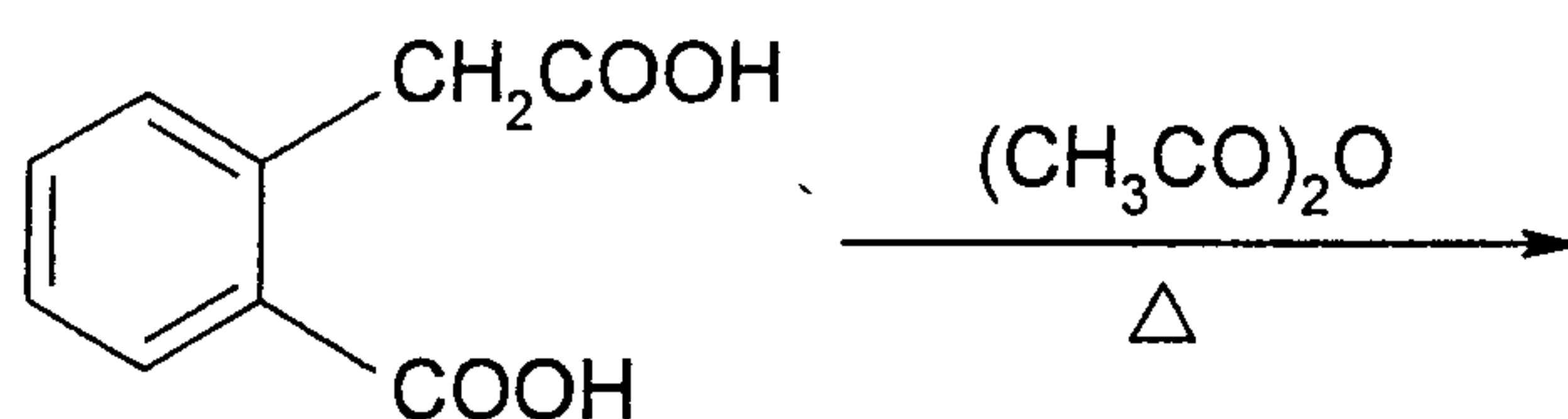
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共 5 頁，第 2 頁 *請在【答案卷、卡】作答

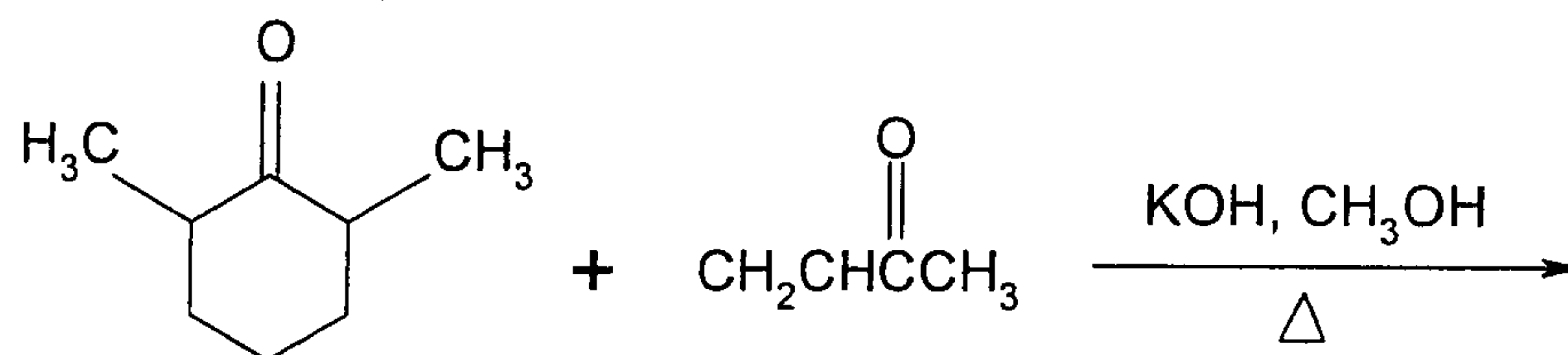
(e)



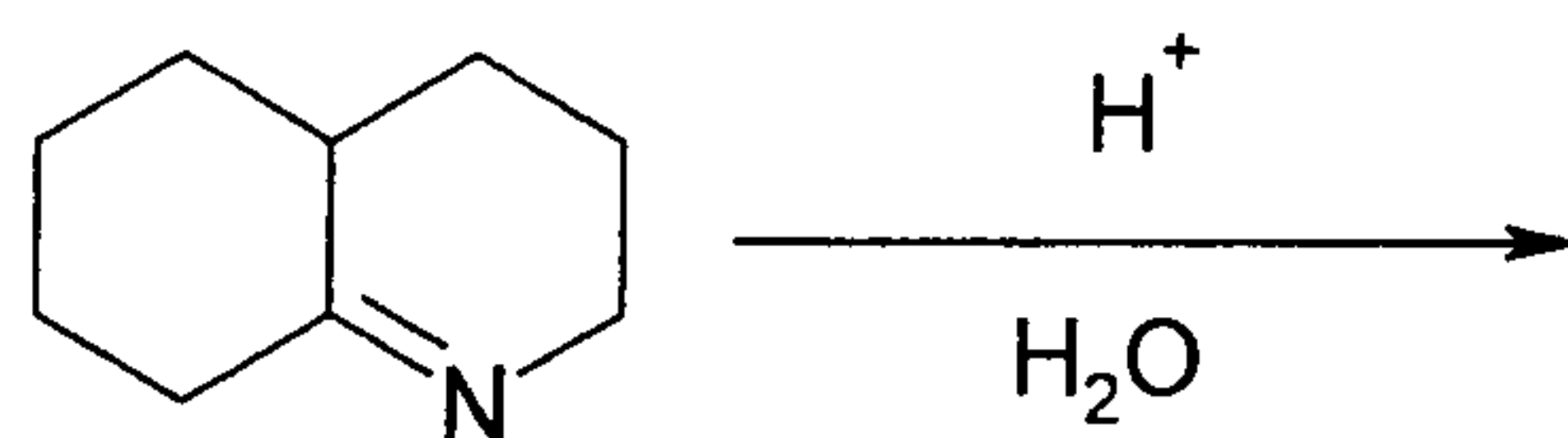
(f)



(g)



(h)



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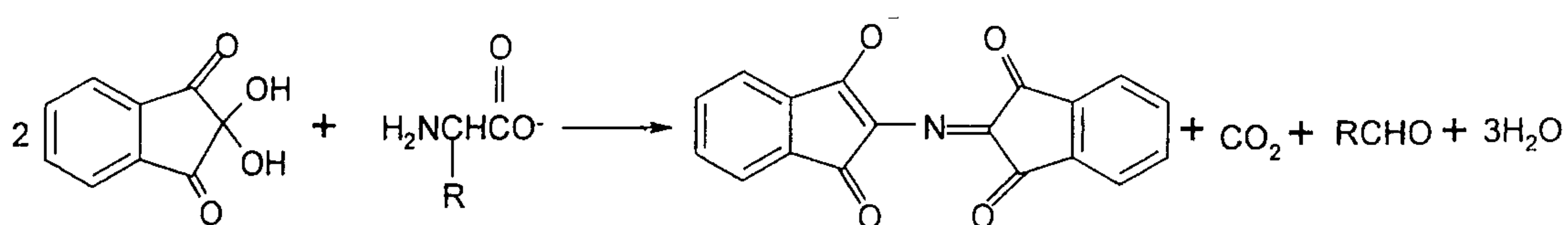
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共 5 頁，第 3 頁 *請在【答案卷、卡】作答

2. Please propose a step-by-step reaction mechanism for the following reactions. (14%)

(a)



(b)



3. Three isomeric ketones with the molecular formula $\text{C}_7\text{H}_{14}\text{O}$ are converted into heptanes by Clemmensen reduction. Compound A gives a single product on Baeyer-Villiger oxidation; Compound B gives two different products in very different yields; Compound C gives two different products in virtually a 1:1 ratio. Please identify A, B and C. (4%)

4. *cis*-1-Bromo-2-*tert*-butylcyclohexane and *trans*-1-bromo-2-*tert*-butylcyclohexane both react with sodium ethoxide in ethanol to give 1-*tert*-butylcyclohexane. The *cis* isomer reacts much more rapidly than the *trans* isomer. Please explain this observation. (4%)

5. Phosgene (COCl_2) is known as a poison gas. Please give product that would be formed from the reaction of phosgene with the following reagents: (4%)

- 1) one equivalent of methanol.
- 2) excess methanol
- 3) one equivalent of ethanol followed by one equivalent of methylamine.

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共 5 頁，第 4 頁 *請在【答案卷、卡】作答

二、物理化學（50%；務必作答於答案卷內）

6. Consider a region of the atmosphere of volume 25 dm^3 that at 20°C contain about 1.0 mol of molecules. Take the average molar mass of the molecules as 29 gmol^{-1} . Use the perfect gas law to calculate the pressure of air. Estimate the energy stored as molecular kinetic energy in this volume of air. (10%)
7. The discovery of the element argon by Lord Rayleigh and Sir William Ramsay had its origins in Rayleigh's measurements of the density of nitrogen with an eye toward accurate determination of its molar mass. Rayleigh prepared some samples of nitrogen by chemical reaction of nitrogen-containing compounds; under his standard conditions, a glass globe filled with this 'chemical nitrogen' had a mass of 2.2990 g. He prepared other samples by removing oxygen, carbon dioxide, and water vapor from atmospheric air; under the same conditions, this 'atmospheric nitrogen' had a mass of 2.3102 g. With the hindsight of knowing accurate values for the molar masses of nitrogen and argon, compute the mole fraction of argon in the latter sample on the assumption that the former was pure nitrogen and the latter a mixture of nitrogen and argon. (N: 14.01 g/mol, O: 16.00 g/mol, Ar: 39.95 g/mol) (10%)
8. Consider a reaction
- $$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$
- Assuming that at $t = 0$, $[A] = [A]_0$, $[B] = 0$, and $[C] = 0$,
- (a) present solutions for $[A]$, $[B]$, and $[C]$ as a function of time.
- (b) Consider that $k_1 = k_2 = k$, express $[B]_{\text{max}}$ and t_{max} in terms of k and/or $[A]_0$. (10%)

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9. Using the information given in the following **Table 1**, (a) what is the mole fraction x_1 of toluene in the toluene-benzene solution that boils at 100 °C under 1.013 bar (1.0 atm) pressure, and what is the mole fraction of y_1 of toluene in the vapor using the information given in the following table?
- (b) Sketch the liquid-vapor temperature-composition phase diagram of toluene (component 1) and benzene (component 2) at 1.013 bar (1.0 atm) by marking the points x_1 and y_1 in the figure.
- (c) Please include the bubble point line and dew point line and **label the region**.
- (d) A solution consists of 0.75 mole fraction toluene and 0.25 mole fraction benzene. At what temperature would the mixture begin to boil under 1.013 bar (1.0 atm) pressure?
- (e) Under the conditions in (d), what is the composition of the vapor when boiling first occurs? (20%)

Table 1. Vapor Pressures of Toluene (P_1^*) and Benzene (P_2^*) at different temperatures

	T/°C							
	80.1	88	90	94	98	100	104	110.6
P_1^*/bar	-	0.508	0.543	0.616	0.698	0.742	0.836	1.013
P_2^*/bar	1.013	1.285	1.361	1.526	1.705	1.800	2.004	-