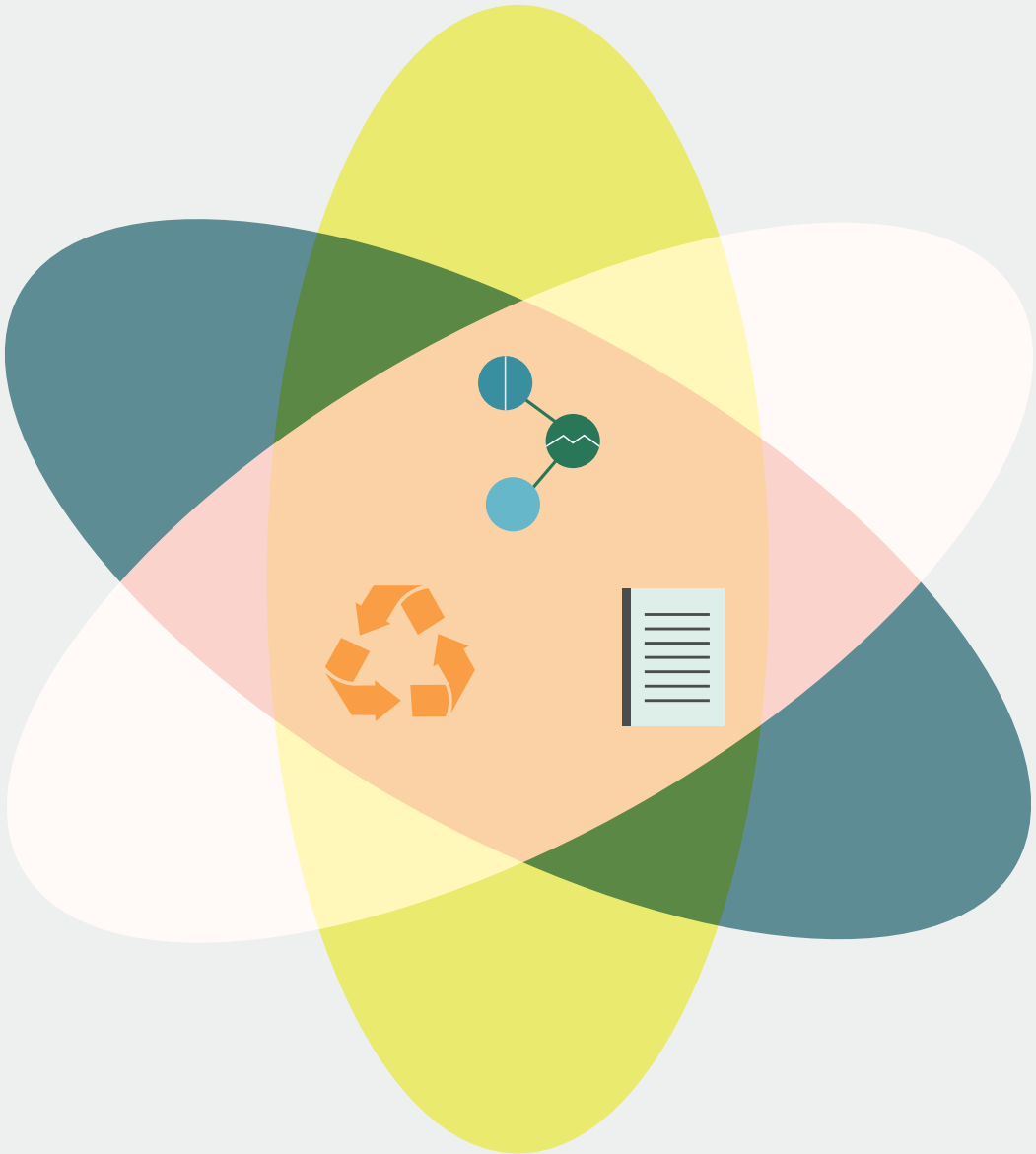
高中自然領域

雙語教學資源手冊

化學科 英語授課用語

A Reference Handbook for Senior High School Bilingual Teachers in the Domain of Natural Sciences (Chemistry): Instructional Language in English

〔高中選修(V)〕



國立彰化師範大學雙語教學研究中心 發行

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■ 前言 Introduction

此章節介紹有機化學是一個龐大的章節，教師可以善用分子模型介紹有機化合物的官能基，接著介紹不同官能基的基本性質、反應及應用，在此教師可以多使用生活中常見對應的有機化合物當作例子連結學生的生活經驗，最後在介紹聚合物的性質、種類及應用。在語言方面，這一章的焦點之一是有機化學的命名。教師可以運用歸納法引導學生理解有機化學的命名規則。此外，教師可以提供「比較」、「組成」和「推論」的句型，協助學生練習描述化合物的化學結構。最後，可以使用「應用」的句型，鼓勵學生舉例說明該化合物在實際應用中的用途。

1-1 有機化合物的結構與組成
Structure and Composition of Organic Compounds

■ 前言 Introduction

在此小節教師可先幫學生複習同分異構物的定義，再利用分子模型帶學生認識不同的結構異構物及立體異構物，接著帶學生認識有機化合物的組成並學會決定化合物結構式的流程。

在語言方面，學生過去已學習過定義和解釋名詞的相關句型。在本小節中，學生可以運用之前學過的句型來解釋不同異構物的特徵以及它們之間的區別。同時，教師可以引導學生學習連接方式的表達，讓他們能描述碳原子與各種官能基的連接方式、連接方式的模式，以及如何形成不同的異構物。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
isomer	同分異構物	structural isomer	結構異構物
stereoisomer	立體異構物	line-angle formula	線角式
structural formula	結構式	combustion analysis method	燃燒分析法
empirical formula	實驗式	hydroxyl group	羥基
chain isomer	鏈異構物	positional isomer	位置異構物
functional group isomer	官能基異構物	cis-trans isomer	順反異構物

organic compound	有機化合物	inorganic compound	無機化合物
isolation and purification	分離純化	quantitative analysis	定量分析

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ be bonded to _____.

例句：In the molecule with the chemical formula CH_2=CHBr, the carbon atom on the left **is bonded to** two identical hydrogen atoms, and there are no cis-trans isomers.

在化學式為 CH_2=CHBr 的分子中，左邊碳原子連接 2 個相同的氫原子，沒有順反異構物。

❷ _____, and there are no _____.

例句：In the molecule with the chemical formula $(CH_3)_2C$＝$CHCH_2CH_3$, the carbon atom on the left is bonded to two identical methyl groups**, and there are no** cis-trans isomers.

在化學式為$(CH_3)_2C$＝$CHCH_2CH_3$的分子中，左邊碳原子連接 2 個相同甲基，沒有順反異構物。

❸ By _____, _____ can be calculated.

例句：**By** determining the mass composition of organic compound elements**,** the empirical formula **can be calculated**.

確定有機化合物元素的質量組成，即可求出實驗式。

❹ _____, making them _____ isomers.

例句：Ethyl methyl ether, 1-propanol, and 2-propanol exhibit different atomic connectivity**, making them** structural **isomers**.

甲乙醚、1-丙醇、2-丙醇原子連接方式不同，為結構異構物。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應習得以下觀念：

After studying this chapter, students should be able to know that:

一、學生能了解同分異構物的分類及了解如何決定有機化合物的組成。

Students can understand the classification of isomers and how to determine the composition of organic compounds.

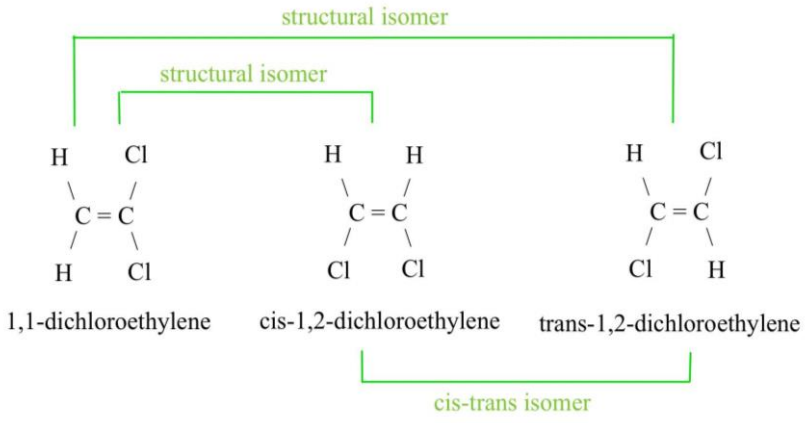
❧ 例題講解 ☙

例題一

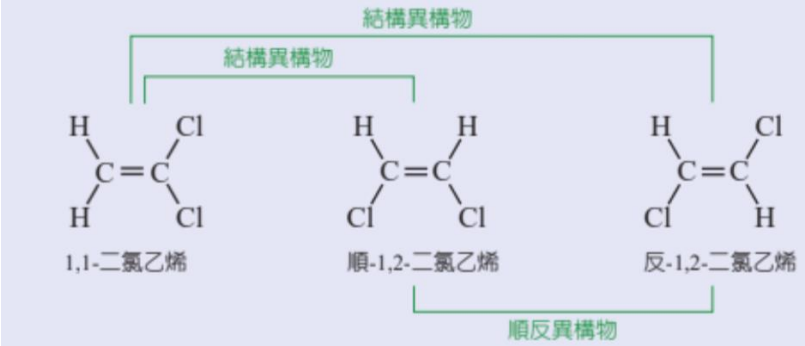
說明：學生能了解同分異構物的分類。

Students can understand the classification of isomers.

Hydrogen atoms in organic compounds can be replaced by organic halides. If two hydrogen atoms in an ethylene molecule are replaced by two chlorine atoms, you can obtain dichloroethylene ($C_2H_2Cl_2$). Draw the possible structural formulas of $C_2H_2Cl_2$. Which ones are structural isomers? Which ones are cis-trans isomers?



有機化合物中的氫原子，可以被鹵素取代，而得到有機鹵化物。乙烯分子若有兩個氫原子被兩個氯原子取代，可得到二氯乙烯($C_2H_2Cl_2$)。畫出 $C_2H_2Cl_2$ 可能的結構式，其中有哪些為結構異構物？哪些為順反異構物？



（翰林版 110 下課本（選修化學 V）第一章 範例 1-1）

Teacher: We have learned that isomers have the same molecular formula but different structures. Isomers are further divided into structural isomers and stereoisomers. What is the difference between these two types of isomers?

Student: The distinction between these two types of isomers can be based on whether the arrangement of atomic connections is the same. If the arrangement is the same, it is a case of stereoisomers. If it is different, it is a case of structural isomers.

Teacher: Yes, we can start by drawing C=C, with two H and two Cl atoms around it. How many different ways can the C atom be bonded?

Student: One C atom can bond with two identical H or Cl atoms, or with one H and one Cl atom.

Teacher: Yes, so we can start by drawing the structure of 1,1-dichloroethylene, where two identical elements are bonded. However, when it comes to bonding with one H and one Cl, we need to consider that rotation around the C=C bond is not possible. As a result, this leads to the generation of stereoisomers. So, what other structure can we draw?

Student: Cis-1,2-dichloroethylene and trans-1,2-dichloroethylene.

Teacher: Excellent, the cis and trans isomers of 1,2-dichloroethylene are cis-trans isomers among stereoisomers. And these two structures are what type of isomers with respect to the different atomic connectivity of 1,1-dichloroethylene?

Student: Structural isomers.

老師： 我們學過異構物是具有相同的分子式但是結構式不同，而異構物又分成了結構異構物及立體異構物，請問這兩種異構物的差別是什麼？

學生： 可以藉由原子連接方式是否相同作為判斷兩種異構物的依據，若是原子連接方式相同為立體異構物，若不同則為結構異構物。

老師： 沒錯，我們可以先畫出 C=C，周圍原子有兩個 H 及兩個 Cl，C 原子有幾種接法呢？

學生： 一個 C 可以接兩個同種元素的 H 或 Cl，或是接一個 H 及一個 Cl。

老師： 沒錯，因此我們可以先畫出接兩個同種元素的 1,1-二氯乙烯，而接一個 H 及一個 Cl 的畫法需要考慮因為 C=C 無法旋轉，如此一來會有立體異構物的產生，因此我們還可以畫出什麼結構呢？

學生： 順-1,2-二氯乙烯及反-1,2-二氯乙烯。

老師： 很好，順反-1,2-二氯乙烯互為立體異構物中的順反異構物，而這兩種結構又與原子連接方式不同的 1,1-二氯乙烯互為何種異構物？

學生： 結構異構物。

例題二

說明：學生能學會利用燃燒分析法分析有機化合物的元素組成。

Students can learn to use combustion analysis to analyze the elemental composition of organic compounds.

For a certain liquid organic compound, through combustion analysis, it is determined that this compound contains only three elements: carbon, hydrogen, and oxygen. The organic compound is placed in pure oxygen and completely combusted with a mass of 4.40 milligrams. The products first pass through an absorption tube containing magnesium perchlorate, and then through an absorption tube containing sodium hydroxide. The masses of the two tubes increase by 3.60 milligrams and 8.80 milligrams, respectively.

Given that the molecular weight of the unknown substance is 88.0. What are the empirical and molecular formulas of this organic compound?

Answer: The empirical formula is C_2H_4O, and the molecular formula is $C_4H_8O_2$.

某一液態有機化合物，經由燃燒分析法，得知此化合物只含碳、氫、氧三種元素。將此有機物 4.40 毫克置於純氧中完全燃燒，產物先通過含過氯酸鎂的吸收管，再經過含氫氧化鈉的吸收管，兩管質量分別增加 3.60 毫克及 8.80 毫克。已知該未知物的分子量為 88.0。則此有機物的實驗式及分子式分別為何？

答：實驗式為 C_2H_4O，分子式為 $C_4H_8O_2$

（龍騰版 110 下課本（選修化學 V）第一章 P10 例題 1-1 ）

Teacher: In class, we learned that combustion analysis can be used to analyze the composition of organic compounds. As mentioned in the question, the products will pass through magnesium perchlorate and sodium hydroxide, resulting in an increase in the mass of the two tubes. What substances are absorbed by these two tubes?

Student: Magnesium perchlorate absorbs water, while sodium hydroxide absorbs carbon dioxide.

Teacher: Yes, from the products of combustion, we can deduce that the water absorbed by magnesium perchlorate contains H originating from the reactants, while the carbon dioxide absorbed by sodium hydroxide also contains carbon (C) originating from the reactants. So how can we determine the carbon and hydrogen weights of this compound?

Student: The weight of water absorbed by magnesium perchlorate is multiplied by the proportion of hydrogen in the entire molecule, resulting in the hydrogen weight = 3.6 * 2/18 = 0.4 mg. The weight of carbon dioxide absorbed by sodium hydroxide is multiplied by the proportion of carbon in the whole molecule, resulting in the carbon weight = 8.8 * 12/44 = 2.4 mg.

Teacher: Great, after determining the weights of carbon and hydrogen, we can utilize the principle of mass conservation, where mass remains constant before and after a reaction. How can we calculate the weight of oxygen?

Student: By subtracting the weights of hydrogen and carbon from the weight of this compound, we get 4.4 - 0.4 - 2.4 = 1.6 mg.

Teacher: That's correct, therefore we can utilize weight divided by atomic weight to determine the empirical formula of this compound. How can we calculate it?

Student: C:H:O=2.4/12 : 0.4/1 : 1.6/16=2:4:1, which means the empirical formula is C_2H_4O.

Teacher: The question states that the molecular weight is 88, so how can we use this information to determine the molecular formula?

Student: You can first calculate the formula weight which is 44, and the empirical formula is $(C_2H_4O)_n$, where n = 88/44 = 2. Therefore, the molecular formula is $C_4H_8O_2$.

老師： 在課堂中我們學過燃燒分析法可以用來分析有機化合物的組成，由題目所述產物會通過過氯酸鎂及氫氧化鈉，導致兩管的質量增加，請問這兩管分別吸收的是什麼物質？

學生： 過氯酸鎂會吸收水而氫氧化鈉會吸收二氧化碳。

老師： 沒錯，因此我們可以從燃燒的產物中知道，過氯酸鎂吸收的水，其中的 H 來自於反應物，而氫氧化鈉吸收的二氧化碳之 C 也來自於反應物，所以我們可以如何求出此化合物碳重與氫重？

學生： 過氯酸鎂吸收的水的重量去乘以氫佔整個分子的重量，即氫重=3.6 * 2/18 = 0.4 mg。氫氧化鈉吸收的二氧化碳之重量乘以碳佔整個分子的重量，即碳重=8.8 * 12/44 = 2.4 mg

老師： 很好，求出碳及氫的重量後，我們可以利用質量守恆的原理，反應前後質量不變，如何求出氧的質量？

學生： 利用此化合物的重量減掉氫及碳的重量，4.4 - 0.4 - 2.4 = 1.6 mg

老師： 對的，因此我們可以利用重量/原子量來找出此化合物的實驗式，請問該怎麼求呢？

學生： C:H:O=2.4/12 : 0.4/1 : 1.6/16=2:4:1，即實驗式為 C_2H_4O。

老師： 題目說分子量為 88，因此我們可以如何利用這個資訊找出分子式？

學生： 可以先求出式量＝44，而分子式為$(C_2H_4O)_n$，n = 88/44 = 2，所以分子式為 $C_4H_8O_2$。

1-2 官能基 Functional Group

■ 前言 Introduction

在此小節教師介紹常見的官能基結構並可以利用分子模型來讓學生了解，接著介紹不同官能基的特性及舉出生活中常見的例子，再帶學生了解有機化合物的命名規則。

在語言方面，學生之前已經學過「組成」的句型，現在教師需要協助學生運用這個句型來描述官能基的原子構成。在這個小節中，學生需要嘗試使用條件句來說明如何區分主鏈和支鏈，進而根據這些判斷來命名化合物。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
functional group	官能基	alkane	烷類
hydrocarbon	烴類	alkyne	炔類
alkene	烯類	aromatic hydrocarbon	芳香烴
alkylbenzene	烷基苯	alcohol	醇類
halohydrocarbon	鹵烴	ether	醚類
phenol	酚類	aldehyde	醛類
amine	胺類	carboxylic acid	羧酸類
carboxyl	羧基	amide	醯胺類
ketone	酮類	scientific name	學名

ester	酯類	systematic nomenclature	系統命名法
trivial name	俗名	cycloalkene	環烯
substituent	取代基	main chain	主鏈
cycloalkane	環烷	branch chain	支鏈

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ consists of _____.

例句：Methane **consists of** one carbon atom connected by covalent bonds to four hydrogen atoms.
甲烷由 1 個碳原子以共價鍵連接 4 個氫原子所組成。

❷ If _____, then _____.

例句：**If** two carbon chains are both the longest chains**, then** the one with more substituents is the main chain.
若兩條碳鏈都是最長鏈，則以取代基較多者為主鏈

❸ _____, starting from _____.

例句：Number the carbons on the main chain using Arabic numerals**, starting from** the end closer to the branch.
以阿拉伯數字標示主鏈上碳的編號，以較接近支鏈之一端先編號。

❹ _____ be based on _____.

例句：Hydrogen atoms in hydrocarbons are replaced by halogen groups to form halohydrocarbons, and their naming **is based on** the parent alkane.
烴的氫原子被鹵基取代得到鹵烴，其命名以母體烷烴為主名。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應習得以下觀念：

After studying this chapter, students should be able to know that:

一、學生能了解常見有機化合物的官能基之結構式及命名。

Students can comprehend the structural formulas and nomenclature of common organic compound functional groups.

❧ 例題講解 ☙

例題一

說明：學生能了解官能基的結構式並學會判斷出參與鍵結之混成軌域。

Students can understand the structural formulas of functional groups and learn to determine the hybrid orbitals involved in bonding.

Non-hydrogen atoms in organic compounds typically participate in bonding using sp, sp^2, and sp^3 hybridization to form organic compound molecules. Which of the following atoms participate in bonding with sp^2 hybridization?

(A) The oxygen atom in methanol.

(B) The carbon atom in ethylene.

(C) The carbon atom in benzene.

(D) The carbon atom in formaldehyde.

(E) The oxygen atom in acetone.

有機化合物的非氫原子，通常以 sp、sp^2、sp^3 混成軌域參與鍵結，結合成有機化合物分子。下列哪些原子以 sp^2 混成軌域參與鍵結？

(A) 甲醇的 O 原子

(B) 乙烯的 C 原子

(C) 苯的 C 原子

(D) 甲醛的 C 原子

(E) 丙酮的 O 原子

（翰林版 110 下課本（選修化學 V）第一章 p34 範例 1-3）

Teacher: In our previous class, we learned about hybrid orbitals, which refers to the process where the central atom, when forming bonds with other atoms, reshuffles valence orbitals with similar energies to create a set of new orbitals equal in number to the original ones. Different types of hybrid orbitals result in different molecular shapes, and in our previous class, we discussed three types of hybridization: sp, sp^2, and sp^3. Do you remember the specifics of how these three types of hybrid orbitals are formed?

Student: One's orbital combined with one p orbital forms two sp hybrid orbitals. One's orbital combined with two p orbitals forms three sp^2 hybrid orbitals. One's orbital combined with three p orbitals forms four sp^3 hybrid orbitals.

Teacher: That's correct. Let's determine the hybrid orbitals for each option. How are they bonded?

Student: The oxygen atom in methanol contains 2 lone pairs of electrons and 2 σ bonds, thus it participates in bonding using sp^3 hybrid orbitals. The carbon atom in ethene lacks lone pairs, has 3 σ bonds, and therefore participates in bonding using sp^2 hybrid orbitals. The carbon atoms in benzene do not have any lone pairs, have 3 σ bonds each, and participate in bonding with sp^2 hybrid orbitals. The carbon atom in formaldehyde does not have any lone pairs, has 3 σ bonds, and participates in bonding with sp^2 hybrid orbitals. The oxygen atom in acetone has 2 lone pairs of electrons and 1 σ bond, thus participating in bonding with sp^2 hybrid orbitals.

Teacher: That's correct. We should choose (B)(C)(D)(E).

老師： 我們在先前的課堂中學過混成軌域，指的是中心原子在與其他原子形成鍵結時，中心原子會將能量相近的價軌域重新混合，形成和原來軌域數量相等的新軌域，而不同的類型的混合軌域會有不同的位向而來決定出分子的形狀，而先前的課程中有介紹過的混成軌域有 sp、sp^2、sp^3。請問同學是否記得這三種混成軌域如何形成？

學生： 一個 s 與一個 p 軌域混成形成兩個 sp 混成軌域，一個 s 與兩個 p 軌域混成形成三個 sp^2 混成軌域，一個 s 與三個 p 軌域混成形成四個 sp^3 混成軌域。

老師： 沒錯，接著來判斷各個選項的混成軌域，請問是以何種方式鍵結？

學生：甲醇的 O 原子含有 2 對孤對電子及 2 個 σ 鍵,因此以 sp^3 混成軌域參與鍵結。乙烯的 C 原子不含孤對電子，有 3 個 σ 鍵,因此以 sp^2 混成軌域參與鍵結。苯的 C 原子不含孤對電子，有 3 個 σ 鍵,因此以 sp^2 混成軌域參與鍵結。甲醛的 C 原子不含孤對電子，有 3 個 σ 鍵,因此以 sp^2 混成軌域參與鍵結。丙酮的 O 原子含有 2 對孤對電子及 1 個 σ 鍵,因此以 sp^2 混成軌域參與鍵結。

老師：沒錯，因此答案選(B)(C)(D)(E)。

例題二

說明：學生能認識常見有機化合物的官能基。

Students can recognize the functional groups of common organic compounds.

Paracetamol is a common pain reliever, and its structural formula is shown below.

What functional groups are present in the paracetamol molecule?

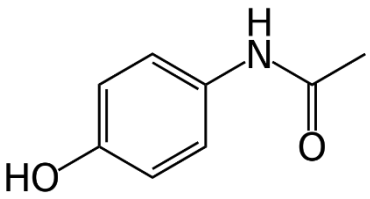
(A) hydroxyl group

(B) aldehyde group

(C) amino group

(D) carboxyl group

(E) amide group



普拿疼是常見的止痛藥，其結構式如下圖，則普拿疼分子中具有哪些官能基？

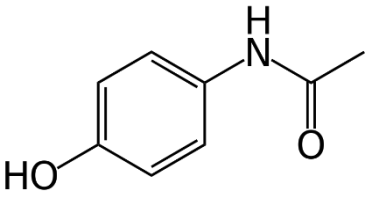
(A) 羥基

(B) 醛基

(C) 胺基

(D) 羧基

(E) 醯胺基



（龍騰版 110 下教學講義（選修化學 V）第一章 p7 第 10 題）

Teacher: In class, we learned that specific groups of atoms in organic compounds are referred to as functional groups. Different functional groups have distinct properties and are typically represented using rational formulas. From the structure of paracetamol, what functional groups can we observe?

Student: There is an OH, so it has a hydroxyl group.

Teacher: Great, are there any other functional groups apart from this?

Student: There is a C=O and a C connected to N, so there is an amide.

Teacher: That's correct. From the structure of paracetamol, are there aldehyde groups, amine groups, or carboxyl groups?

Student: No, because an aldehyde group is HC=O, an amine group involves N bonded to an alkyl group, and a carboxyl group is COOH.

Teacher: Yes, so the answer is (A)(E).

老師： 在課堂中我們學過有機化合物中有特定的原子團就稱為官能基，不同的官能基會有不同的性質，通常以示性式表示，請問從普拿疼結構中我們能看到什麼官能基？

學生： 有 OH，所以有羥基。

老師： 很好，除此之外還有什麼官能基呢？

學生： 有 C=O 且 C 的旁邊接了 N，所以有醯胺基。

老師： 沒錯，那從普拿疼的結構來看是否有醛基、胺基、羧基？

學生： 沒有，因為醛基為 HC=O，胺基為 N 接烴基、羧基為 COOH。

老師： 對，因此答案選(A)(E)。

1-3 烴
Hydrocarbon

■ 前言 Introduction

在本小節教師可先連結學生的經驗以化石燃料為例介紹烴類，並讓學生了解烴的分類，接著介紹常見的烴類之性質以及用途。

在語言方面，學生已經學會使用「...而...」這種轉折句型，以表達兩種相對的情境。老師可以引導學生運用這句型，幫助他們區分不同的化學物質，判斷它們是否為飽和烷烴或不飽和烯烴。此外，單詞如「烴、烷、烯、炔、環烷」等擁有特定的結構規則，老師可以引導學生發現這些詞彙的共同特徵。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
aliphatic hydrocarbon	脂肪烴	aromatic hydrocarbon	芳香烴
saturated hydrocarbon	飽和烴	unsaturated hydrocarbon	不飽和烴
alkane	烷(烴)	cycloalkane	環烷(烴)
alkene	烯(烴)	cycloalkene	環烯(烴)
alkyne	炔(烴)	naphthalene	萘
anthracene	蒽	phenanthrene	菲
substitution reaction	取代反應	cracking reaction	裂解反應

addition reaction	加成反應	hydrogenation reaction	氫化反應
halogenation reaction	鹵化反應	hydration reaction	水和反應
hydrohalogenation reaction	氫鹵化反應	dispersion force	分散力
bond angle	鍵角	π bond	π 鍵
Markovnikov's rule	馬可尼可夫法則	polymer	聚合物
polyethylene, PE	聚乙烯	carbide	電石 (碳化物)

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ The general formula for _____ is _____.

例句：**The general formula for** alkanes **is** C_nH_{2n+2}.

烷的通式為 C_nH_{2n+2}。

❷ _____ have (a) _____ structure(s).

例句：Aliphatic hydrocarbons typically **have** carbon-carbon chains or cyclic **structures** as their primary structures, while aromatic hydrocarbons often **have a** benzene ring **structure**.

脂肪烴通常以碳-碳相連的碳鏈或環狀為主要結構，芳香烴常具有苯環結構。

❸ _____ be divided into _____.

例句：Aliphatic hydrocarbon can **be divided into** saturated hydrocarbon, which contain only carbon-carbon single bonds, and unsaturated hydrocarbons, which contain carbon-carbon multiple bonds.

脂肪烴可以分成只含有碳-碳單鍵的飽和烴與含有碳-碳多鍵的不飽和烴。

❹ _____, leading to _____.

例句：Under high temperature and with the action of a catalyst, the carbon-carbon or carbon-hydrogen bonds in alkanes can break**, leading to** a cracking reaction.

在高溫與催化劑作用下，烷的碳-碳或碳-氫鍵斷裂，產生裂解反應。

❺ _____ have _____ reactivity than _____.

例句：Aromatic hydrocarbons **have** slightly higher **reactivity than** alkanes, and their common reaction is substitution.

芳香烴活性略高於烷，常見反應為取代反應。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應習得以下觀念：

After studying this chapter, students should be able to know that:

一、學生能分辨烴的種類及了解不同烴類的性質。

Students can distinguish between different types of hydrocarbons and understand the properties of various hydrocarbons.

❧ 例題講解 ☙

例題一

說明：學生能了解不同烴類並能寫出其通式

Students can understand different hydrocarbons and write the general formulas.

Student Lin discovered a bottle of unidentified organic medication in the medicine cabinet. Based on the residual label with a molecular formula of C_6H_{12}, which of the following types of compounds could this compound possibly belong to? (Select 2 options)

(A) straight chain alkane　**(B) cycloalkane**　**(C) alkene**

(D) cycloalkene　(E) alkyne

林同學在藥品櫃發現一瓶標示不明的有機藥品，由殘餘標籤得知其分子式為 C_6H_{12}，該化合物可能為下列哪幾類化合物？(應選 2 項)

(A) 直鏈烷烴

(B) 環烷烴

(C) 烯烴

(D) 環烯烴

(E) 炔烴

（103 學測 第 55 題）

Teacher: In class, we have learned that hydrocarbons can be classified into two major categories based on their properties. What are these two categories?

Student: Aliphatic hydrocarbons and aromatic hydrocarbons with a benzene ring structure.

Teacher: That's correct. Apart from that, if we differentiate aliphatic hydrocarbons based on the different carbon-carbon bond arrangement, what can they be further categorized into?

Student: Saturated hydrocarbons and unsaturated hydrocarbons. Saturated hydrocarbons include alkanes and cycloalkanes. Unsaturated hydrocarbons include alkenes with carbon-carbon double bonds and cycloalkenes, and carbon-carbon triple bonds are found in alkynes.

Teacher: Yes, different types of hydrocarbons have different general formulas. According to the question, with a molecular formula of C_6H_{12}, what could be its general formula?

Student: C_nH_{2n}

Teacher: That's correct. Therefore, we can write the general formulas for the five options to determine which types of compounds this medication might belong to. What are the general formulas for the four options?

Student: The general formula for straight chain alkanes is C_nH_{2n+2}. The general formula for cycloalkanes is C_nH_{2n}. The general formula for olefins is C_nH_{2n}. The general formula for cycloalkenes is C_nH_{2n-2}. The general formula for alkynes is C_nH_{2n-2}.

Teacher: Yes. Therefore, it could be a cycloalkane or an alkene. The answer is (B) and (C).

老師： 在課堂中我們學過依照烴的性質可以分成兩大類，請問是哪兩類？

學生： 脂肪烴和具有苯環結構的芳香烴。

老師： 沒錯，除此之外，若將脂肪烴以不同碳-碳鍵結的方式，可再細分成什麼？

學生： 飽和烴及不飽和烴。飽和烴包括烷類、環烷類，不飽和烴包括了碳-碳雙鍵的烯類及環烯，還有碳-碳三鍵的炔類。

老師： 沒錯，而不同的烴類有不同的通式，依據題目所述，分子式為 C_6H_{12} ，請問可以寫成什麼通式？

學生： C_nH_{2n}

老師： 正確，因此我們可以將五個選項先寫出通式來判斷此藥品可能為哪些種類的化合物，請問四個選項的通式分別是什麼？

學生： 直鏈烷烴的通式為 C_nH_{2n+2}，環烷烴的通式為 C_nH_{2n}，烯烴的通式為 C_nH_{2n}，環烯烴的通式為 C_nH_{2n-2}，炔烴的通式為 C_nH_{2n-2}

老師： 沒錯，因此可能是環烷烴或是烯烴，故答案選(B)(C)。

例題二

說明：學生能了解芳香烴的性質與反應。

Students can comprehend the properties and reactions of aromatic hydrocarbons.

Which of the following statements about benzene, cyclohexane, and cyclohexene are correct?

(A) Both benzene and cyclohexane are unsaturated hydrocarbons, so they can easily decolorize bromine water.

(B) Benzene is an unsaturated hydrocarbon, while cyclohexane is a saturated hydrocarbon, but reactions involving benzene and cyclohexane are primarily substitution reactions.

(C) The carbon-carbon bonds in benzene molecules are shorter than the carbon-carbon bonds in cyclohexane molecules.

(D) The bond angles in benzene molecules are greater than the bond angles in cyclohexane molecules.

(E) Cyclohexene can be hydrogenated to produce cyclohexane under the catalysis of platinum.

下列有關苯、環己烷、及環己烯的敘述，哪些正確？

(A) 苯與環己烷均為不飽和烴，故苯與環己烯皆易使溴水褪色。

(B) 苯為不飽和烴，環己烷為飽和烴，但苯與環己烷發生的反應多為取代反應。

(C) 苯分子中的碳碳鍵長較環己烷分子中的碳碳鍵長來得短。

(D) 苯分子中的鍵角大於環己烷分子的鍵角。

(E) 環己烯在鉑的催化下進行氫化反應，可得到環己烷。

（翰林版 110 下互動式教學講義（選修化學 V）第一章 p41 多選第 2 題）

Teacher: In class, we learned that benzene, cyclohexane, and cyclohexene are all hydrocarbons. If categorized based on the different orders of carbon-carbon bonds, what types of hydrocarbons are benzene, cyclohexane, and cyclohexene, respectively?

Student: Benzene and cyclohexane are unsaturated hydrocarbons, while cyclohexane is a saturated hydrocarbon.

Teacher: That's correct. Based on option (A), the initial statement is accurate. However, in class, we've learned that while benzene is an unsaturated hydrocarbon, it doesn't react with bromine water, so option (A) is incorrect. In common reactions involving aromatic hydrocarbons, we've mentioned that benzene is prone to undergo what reaction?

Student: It is prone to undergo substitution reactions readily and is not prone to undergo addition reactions, so (B) is correct.

Teacher: Excellent. (C) the carbon-carbon bond lengths of benzene and cyclohexane can be compared based on their bonding modes. The bond order of benzene is 1.5, so what should the carbon-carbon bond length be? As for cyclohexane, being a saturated hydrocarbon, what is the carbon-carbon bond length?

Student: The bonding in benzene is quite unique, with a bond order of 1.5, and the bond length should fall between that of a single bond and a double bond. As for cyclohexane, being a saturated hydrocarbon, it has single bonds. Therefore, (C) option is correct

Teacher: Option (D) for determining bond angles, we can judge from the hybrid orbitals of carbon-carbon bonds. What are the hybrid orbitals for benzene and cyclohexane, respectively?

Student: Benzene is sp2 hybridized with a bond angle of 120 degrees, while cyclohexane is sp3 hybridized with a bond angle of 109.5 degrees. Therefore, the bond angle of benzene is greater than that of cyclohexane, making option (D) correct.

Teacher: Lastly, as for option (E), we mentioned that cyclohexene is an unsaturated hydrocarbon. Under platinum catalysis, what does it become

Student: It will become a saturated hydrocarbon, with the product being cyclohexane.

Teacher: That's correct. Therefore, the correct answers are (B), (C), (D), and (E).

老師： 在課堂我們學過苯、環己烷、及環己烯皆為烴類，若依照碳碳鍵級的不同可以分為飽和烴及不飽和烴，請問苯、環己烷、及環己烯分別為哪種烴類？

學生： 苯及環己烯皆為不飽和烴類，而環己烷為飽和烴。

老師： 沒錯，從(A)選項來看，前面敘述是正確的，但在課堂學過，雖然苯是不飽和烴，但不會與溴水反應，因此選項(A)錯誤。而芳香烴常見的反應中，我們說過，苯容易發生什麼反應？

學生： 容易發生取代反應，不容易發生加成反應，因此(B)正確。

老師： 很好，(C)苯和環己烷的碳碳鍵長可從他們鍵結的方式來比較，苯的鍵級是 1.5 鍵，因此碳碳鍵長應該是什麼，而環己烷為飽和烴，碳碳鍵長是什麼？

學生： 苯的鍵結方式很特別，鍵級是 1.5 鍵，鍵長應該介於單鍵和雙鍵之間，而環己烷為飽和烴，鍵結為單鍵，苯的鍵長較短，因此(C)選項正確。

老師： (D)要判斷鍵角，我們可以從碳碳的混成軌域判斷，請問苯和環己烷分別為什麼混成軌域？

學生： 苯為 sp^2，鍵角為 120 度，環己烷為 sp^3，鍵角為 109.5 度。因此苯的鍵角大於環己烷(D)正確。

老師： 最後是(E)我們說過環己烯為不飽和烴，在經過鉑的催化下會變成什麼？

學生： 會變成飽和烴，產物為環己烷。

老師： 沒錯，因此最後正確的答案為(B)(C)(D)(E)。

1-4 醇、醚及酚
Alcohol, Ether, and Phenol

■ 前言 Introduction

在此小節教師介紹可透過結構式及分子模型來讓學生了解醇、醚及酚的基本性質，包括命名規則，以及介紹常見的反應和用途。

在語言教學中，教師可以透過「...易於...」和分類的語法結構，幫助學生描述醇、醚和酚的基本特性。同時，教師也可以利用英文列舉句型引導學生區分不同種類的醇。在教授有關醇、醚及酚的命名規則時，教師可鼓勵學生歸納出甲、乙、丙、丁等字首，以便更有效地記憶。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
alcohol	醇	ether	醚
phenol	酚	hydroxyl	羥
carbolic acid	石碳酸	alcoholic fermentation	醇發酵
glycerin	甘油	propylene glycol	丙二醇
pyridinium chlorochromate	氯鉻酸吡啶	monatomic alcohol	一元醇
diol	二元醇	triol	三元醇
aldehyde	醛	acid	酸
ketone	酮	polar molecule	極性分子

hydrogen bond	氫鍵	antifreeze	抗凍劑
primary alcohol	一級醇	secondary alcohol	二級醇
tertiary alcohol	三級醇		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ be easy to _____.

例句：Alcohols with a low carbon count **are easy to** dissolve in water, such as methanol. As the carbon count increases, solubility decreases.

低碳數的醇易溶於水，如甲醇，隨著碳數增加，溶解度會降低。

❷ If _____ is attached to _____, it belongs to _____.

例句：**If** the hydroxyl group **is attached to** the benzene ring**, it belongs to** phenols. **If** the hydroxyl group **is** not directly **connected to** the benzene ring**,** then **it belongs to** alcohols.

如果羥基連接到苯環上，則它屬於酚。如果羥基不直接連接到苯環，那麼它屬於醇。

❸ _____ be categorized into _____.

例句：Alcohols can **be categorized into** primary alcohols, secondary alcohols, and tertiary alcohols based on the number of carbon atoms they are connected to around the hydroxyl group.

醇依據羥基所連接的碳原子上連接的碳原子數，可分為：一級醇、二級醇及三級醇。

❹ _____ react with _____.

例句：Primary alcohols and secondary alcohols can **react with** a potassium dichromate acidic solution, while tertiary alcohols do not react.

一級醇和二級醇可與酸性的二鉻酸鉀溶液反應，三級醇則不反應。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應習得以下觀念：

After studying this chapter, students should be able to know that:

一、學生能了解醇、醚、酚的基本性質及用途。

Students can understand the basic properties and uses of alcohols, ethers, and phenols.

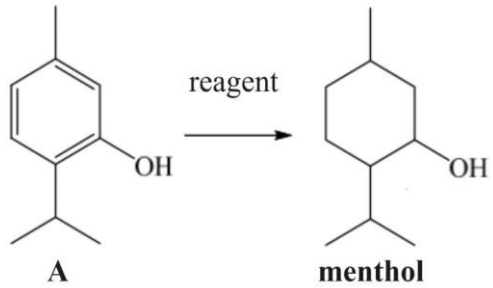
❧ 例題講解 ☙

例題一

說明：學生能了解有機化合物的氧化還原及酚和醇的性質。

Students can understand the oxidation-reduction of organic compounds and the properties of phenols and alcohols.

Menthol is one of the main components of peppermint oil, and its structural formula is shown in Figure 8. Menthol can be obtained by extracting it from natural peppermint leaves, or it can be synthesized in the laboratory using compound A as a starting material in a one-step reaction. Which of the following statements about this reaction and the properties of compound A and peppermint oil is correct?



(Figure 8)

(A) In this chemical reaction process, compound A is reduced.

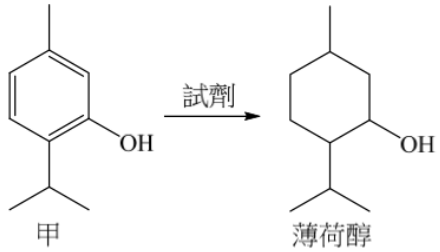
(B) Compound A has weaker acidity compared to menthol.

(C) Under appropriate conditions, menthol can react with a potassium dichromate solution to yield ketone compounds.

(D) The cyclohexane ring in menthol has a planar structure.

(E) The solubility of compound A in sodium hydroxide aqueous solution is higher than its solubility in water.

薄荷醇是薄荷油的主要成分之一，其結構式如圖 8。薄荷醇可由天然薄荷葉片萃取而得，亦可在實驗室以化合物甲為起始物，經一步反應製得。下列有關此反應、化合物甲及薄荷醇性質的敘述，哪些正確？



(圖 8)

(A) 此化學反應過程中，化合物甲被還原。

(B) 化合物甲的酸性較薄荷醇弱。

(C) 薄荷醇在適當的條件下，可與二鉻酸鉀溶液反應得到酮類化合物。

(D) 薄荷醇中的六圓環呈平面結構。

(E) 化合物甲在氫氧化鈉水溶液的溶解度比在水中的溶解度高。

（109 指考 第 23 題）

Teacher: From the structural formula in the question, can we determine what category compound A belongs to?

Student: Phenol.

Teacher: Correct, and through the reaction, it becomes an alcohol. We can speculate that this reaction involves hydrogenation. Based on what we've previously learned, in organic reactions, losing hydrogen is an oxidation reaction. What is the reaction that gains hydrogen?

Student: Reduction reaction, and in this reaction, phenol is transformed into an alcohol, gaining hydrogen, which is a reduction reaction. Option (A) is correct.

Teacher: Very well, for option (B), when comparing the acidity and alkalinity of compound A and menthol, we must make judgments based on the properties of compound A and alcohols. We know that compound A is a phenol, and from our study of the basic properties of phenols, what is their acidity?

Student: Phenols are weakly acidic, while alcohols are neutral; therefore, the acidity of compound A is stronger than that of menthol.

Teacher: We have learned in class that alcohols, under appropriate conditions, can be converted to aldehydes or ketones by adding potassium chromate and sulfuric acid. In this question, when menthol is added to potassium chromate, what kind of product is formed?

Student: Menthol is a secondary alcohol; therefore, after the reaction, it will be converted into a ketone.

Teacher: Option (D), whether the cyclohexane ring of menthol has a planar structure, can be determined from its hybrid orbitals. What is the hybrid orbital of menthol?

Student: It is sp3, so like alkanes, it has a three-dimensional structure and is not planar.

Teacher: Option (E), to determine whether it has a higher solubility in sodium hydroxide aqueous solution or in water, can be assessed based on its acidity. We already know that compound A is a phenol, and phenols are weakly acidic, while sodium hydroxide is alkaline. Can the two react?

Student: Yes, there will be an acid-base neutralization, producing a sodium salt that is soluble in water.

Teacher: That's correct. Therefore, the solubility of compound A in sodium hydroxide will be greater than in water. So, the correct answers are (A)(C)(E).

老師： 從題目中我們可以由結構式知道甲屬於什麼類？

學生： 酚類。

老師： 正確，而經過反應會變成醇類，我們可以推測這個反應進行了加氫，由之前所學中，在有機反應中，失去氫為氧化反應，而得到氫的反應是什麼？

學生： 還原反應，而此反應由酚變為醇，得到氫，為還原反應，(A)選項正確。

老師： 很好，(B)選項在比較甲與薄荷醇的酸鹼性，必須從甲和醇的性質判斷，我們知道甲為酚類，而我們學過酚的基本性質中，他的酸鹼性為何？

學生： 酚為弱酸性，醇為中性，因此甲的酸性較薄荷醇強。

老師： 我們在課堂學過，醇類可以在適當的條件下，添加鉻酸鉀及硫酸讓醇類變成醛類或酮類，而本題薄荷醇加入鉻酸鉀後，會產生何種產物？

學生： 薄荷醇為二級醇，因此反應後會變成酮類。

老師： (D)選項，薄荷醇的六圓環是否為平面結構需要從他的混成軌域判斷，請問薄荷醇的混成軌域為何？

學生： 為 sp^3，因此和烷類一樣是立體結構，並非平面結構。

老師： (E)選項，要比較溶在氫氧化鈉水溶液溶解度高還是溶於水較高，可由酸鹼性來判斷，我們已經知道甲為酚，而酚為弱酸性，而氫氧化鈉為鹼性，請問兩者是否會發生反應？

學生： 會，會發生酸鹼中和，產生可溶於水的鈉鹽。

老師： 沒錯，因此甲溶在氫氧化鈉的溶解度會大於水。因此正確答案為(A)(C)(E)。

例題二

說明：學生能理解醇的分級和過錳酸鉀反應。

Students can understand the classification of alcohols and the reaction with potassium permanganate.

Both propanol and butanol can react with the acidic solution of potassium permanganate. Which of the following statements regarding their reactions is correct?

(a) 1-propanol will produce acetone (b) 2-butanol can produce 2-butanone (c) 2-methyl-2-propanol will produce 2-methyl-2-propanone

(A) only (a)

(B) only (b)

(C) only (c)

(D) (a) and (b)

(E) (b) and (c)

丙醇與丁醇皆可與過錳酸鉀的酸性溶液反應，下列有關其反應的敘述，何者正確？

(甲)1-丙醇會產生丙酮(乙)2-丁醇會產生 2-丁酮(丙)2-甲基 2-丙醇會產生 2-甲基 2-丙酮

(A) 只有甲

(B) 只有乙

(C) 只有丙

(D) 甲與乙

(E) 乙與丙

（106 指考 第 15 題）

Teacher: In class, we have learned that some alcohols react in acidic solutions of potassium permanganate. Do any of the students remember which alcohols react and what the products are?

Student: This translates to: "Alcohols are categorized as primary alcohols, secondary alcohols, and tertiary alcohols. Primary alcohols react under acidic conditions with potassium permanganate to undergo oxidation and produce carboxylic acids. Secondary alcohols react under acidic conditions with potassium permanganate to undergo oxidation and produce ketones. Tertiary alcohols do not undergo any reaction with acidic potassium permanganate."

Teacher: To determine the correctness of the options in this question, we must first draw the structural formulas to ascertain the primary, secondary, or tertiary nature of the starting alcohols and then confirm the products after reacting with potassium permanganate. Therefore, options (A) 1-propanol, (B) 2-butanol, and (C) 2-methyl-2-propanol are of which degree of alcohol, respectively?

Student: Option (A) is a primary alcohol, option (B) is a secondary alcohol, and option (C) is a tertiary alcohol.

Teacher: That's correct. You can then determine the products of the reaction with potassium permanganate. What are the products for each of them?

Student: Option (A) will produce propanoic acid, option (B) will produce 2-butanone, and option (C) is a tertiary alcohol and therefore does not react.

Teacher: Wonderful, so the correct answer is (B).

老師： 在課堂我們學過有些醇類在過錳酸鉀的酸性溶液下會發生反應，請問同學是否記得哪些醇類會反應以及產物為何？

學生： 醇類分成一級醇、二級醇及三級醇，一級醇與過錳酸鉀酸性條件下反應會氧化產生羧酸；二級醇與過錳酸鉀酸性條件下反應會氧化產生酮；三級醇與過錳酸鉀酸性條件下則不發生反應。

老師： 沒錯，要判斷此題選項是否正確，首先我們必須先畫出結構式來判斷起始物的醇類是幾級醇，來與過錳酸鉀反應後確認產物為何，因此選項甲：1-丙醇；乙：2-丁醇；丙：2-甲基 2-丙醇，分別為幾級醇？

學生： 甲為一級醇，乙為二級醇，丙為三級醇。

老師： 沒錯，接著可以判斷與過錳酸鉀反應的產物，請問分別為何？

學生： 甲會產生丙酸，乙會產生 2-丁酮，丙為三級醇因此不反應。

老師： 很好，因此正確選項要選(B)。

1-5 醛、酮、羧酸及酯
Aldehyde, Ketone, Carboxylic Acid, and Ester

■ 前言 Introduction

在此小節教師可利用分子模型排列出醛、酮、羧酸和酯的官能基讓學生有初步的了解，接著介紹各類的定義、命名及常見的反應。

在語言教學方面，教師可以引導學生掌握醛、酮、羧酸和酯等有機官能基的命名規則，以及有機化合物的命名原則。此外，教師可以透過使用轉折詞或採用先前學過的相似和相反的句型結構，幫助學生練習比較不同有機化合物之間的區別。最後，在本小節中介紹了多種有機反應，教師可以運用「...是指...」的句型，讓學生練習解釋這些反應的機理和意義。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
aldehyde	醛	ketone	酮
carboxylic acid	羧酸	Tollens' reagent	多侖試劑
silver nitrate	硝酸銀	aqueous ammonia	氨水
silver mirror reaction	銀鏡反應	electroless plating	無電電鍍
chemical plating	化學浸鍍	Fehling's solution	斐林試液
Benedict's solution	本氏液	ester	酯
esterification	酯化	acyl halide	醯鹵
acid anhydride	酸酐	acetanilide	苯乙醯胺

dimer	二聚物	hydrolysis	水解
aspirin	阿斯匹靈；乙醯柳酸	analgesic	鎮痛劑
fat	脂肪	glycerol	甘油；丙三醇
triglyceride	三酸甘油酯	fatty acid	脂肪酸
saturated fatty acid	飽和脂肪酸	unsaturated fatty acid	不飽和脂肪酸
saponification reaction	皂化反應		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ refer to _____.

例句：The silver mirror reaction **refer**s **to** the reaction of an aldehyde with Tollens' reagent, which contains nitric acid and ammonia, to produce metallic silver" is correct and conveys the intended meaning.

銀鏡反應為醛與成分為硝酸和氨水的多侖試劑反應生成金屬銀。

❷ _____ be considered as _____.

例句：Esters can **be considered as** derivatives of carboxylic acids, where the -OH group in carboxylic acids is replaced by -OR.

酯可被視為羧酸的衍生物，其中羧酸中的-OH 基團被-OR 取代。

❸ Conversely, _____.

例句：Using concentrated sulfuric acid as a catalyst, carboxylic acids react with alcohols to produce esters and water, known as esterification. **Conversely,** esters can be converted back into carboxylic acids and alcohols through a hydrolysis reaction.

利用濃硫酸作為催化劑，羧酸和醇反應生成酯和水，這個過程被稱為酯化反應。相反地，酯可以透過水解反應轉化為羧酸和醇。

❹ _____ be attracted to _____.

例句：The hydrogen from the hydroxyl group on salicylic acid **is attracted to** the oxygen in the carboxyl group, thereby forming an intramolecular hydrogen bond.
柳酸上羥基的 H 會與羧基的 O 互相吸引，因此形成分子內氫鍵。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應習得以下觀念：
After studying this chapter, students should be able to know that:
一、學生能了解醛、酮、羧酸和酯的基本性質和用途。
Students can understand the basic properties and uses of aldehyde, ketone, carboxylic acid, and ester.

❧ 例題講解 ☙

例題一

說明：學生能了解醛、酯官能基，並了解其特性及常見的反應。
Students can understand the functional groups of aldehydes and esters, and comprehend their characteristics and common reactions.

Some manufacturers have added the plasticizer DEHP to food as a clouding agent in the past. DEHP is an endocrine disruptor that has been proven to be harmful to the human body. Figure 4 shows the molecular structure of DEHP.

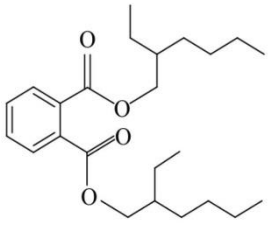


Figure 4

Which of the following statements about DEHP is correct?
(A) There are 6 carbons in the molecule with sp^2 hybridized orbitals.
(B) It has intermolecular hydrogen bonds.
(C) It reacts with Fehling's reagent to produce a red precipitate.
(D) It reacts with Tollen's reagent to produce a silver mirror phenomenon.
(E) After hydrolysis, it yields phthalic acid and 2-ethyl-1-hexanol.

曾有少數廠商於食品中添加塑化劑 DEHP，當作起雲劑使用。DEHP 是一種環境荷爾蒙，已經證實對人體有害，圖 4 為 DEHP 的分子結構。

下列有關 DEHP 的敘述，哪一個選項正確？

(A) 分子內有 6 個碳具有 sp^2 混成軌域

(B) 具有分子間氫鍵

(C) 與斐林試液反應會產生紅色沉澱

(D) 與多侖試劑反應會產生銀鏡現象

(E) 水解後可得鄰苯二甲酸與 2-乙基-1-己醇

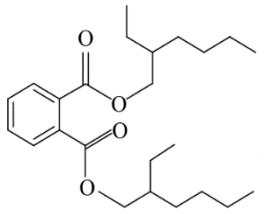


圖 4

（110 指考 第 12 題）

Teacher: To determine from the molecular structure in the question, we should judge how many carbon atoms have sp^2 hybrid orbitals. What methods can be used?

Student: From the bonding situation of carbon and its surrounding atoms, we determine that a sp^2 hybrid orbital results from the hybridization of one s and two p orbitals, which totals to three sp_2 hybrid orbitals. Therefore, based on the structural formula, aside from the six carbons in the benzene ring, the carbon adjacent to -COO- is also a sp^2 hybrid orbital. Hence, there are a total of eight sp^2 hybrid orbitals.

Teacher: Excellent. For option (B), we mentioned that the presence of -OH is required to have intermolecular hydrogen bonding. Based on the structural formula in this question, is there an -OH group?

Student: No, there aren't, therefore, it does not have intermolecular hydrogen bonding.

Teacher: If we judge based on the structural formula, what functional groups can we observe in this structure formula?

Student: R-COOR', which is an ester.

Teacher: That's correct, now do any students still remember which type of organic compounds, as mentioned in options (C) and (D), can react with Fehling's reagent and Tollens' reagent?

Student: Aldehydes with the functional group -CHO.

Teacher: That's correct, so option (C) and (D) are incorrect. For option (E), we know that this structural formula is an ester, and esters are commonly synthesized by the dehydration reaction of a carboxylic acid with an alcohol. Therefore, conversely, what should the hydrolysis of an ester yield?

Student: It can yield carboxylic acid and alcohol.

Teacher: Yes, and hydrolysis breaks the R-COOR' bond to form R-COOH. Therefore, we can infer what this structural formula would become after hydrolysis.

Student: It would generate phthalic acid and two 2-ethyl-1-hexanol.

Teacher: That's correct, so the answer is (E).

老師： 從題目的分子結構來判斷，首先(A)選項要判斷有幾個 C 為 sp^2 混成軌域，請問有什麼方法？

學生： 從 C 的和周圍原子的鍵結情況判斷，sp^2 混成軌域為一個 s 和兩個 p 軌域混成三個 sp^2，因此從結構式判斷，除了苯環的 6 個碳為 sp^2 混成軌域外，旁邊-COO-的 C 也是 sp^2 混成軌域，因此總共有 8 個 sp^2 混成軌域。

老師： 很好，接著(B)選項，我們說能具有分子間氫鍵需要有-OH，請問此題的結構式來看是否有 OH？

學生： 沒有，因此不具有分子間氫鍵。

老師： 若從結構式判斷，我們能看到這個結構式有什麼官能基？

學生： R-COOR'，為酯類。

老師： 沒錯，那(C)(D)選項同學是否還記得是哪種有機化合物能夠和斐林試液及多侖試劑反應？

學生： 具有官能基-CHO 的醛類。

老師： 沒錯，因此(C)(D)選項錯誤。(E)選項，我們知道這個結構式是一個酯類，而酯類常見的合成方法為利用羧酸與醇脫水進行酯化反應生成，因此反之酯類的水解應該可以產生什麼？

學生： 可以產生羧酸加醇。

老師： 沒錯，而水解要將 R-COOR'斷鍵變成 R-COOH，因此我們可以推測此結構式水解後會變成什麼？

學生： 生成一個鄰苯二甲酸與兩個 2-乙基-1-己醇。

老師： 沒錯，因此答案選(E)。

例題二

說明：學生能了解酸類的結構、製備及性質。

Students can understand the structure, preparation, and properties of acids.

Ancient people discovered that salicylic acid, extracted from willow trees and structured as shown in Figure 6, could be used to relieve pain and treat rheumatism. Acetylsalicylic acid, which is aspirin, can be produced by the reaction of salicylic acid with acetic acid or acetic anhydride.

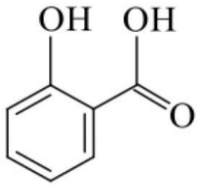


Figure 6

Which of the following statements about acetylsalicylic acid is correct?

(A) Acetylsalicylic acid is easy to dissolve in water at room temperature.

(B) Both salicylic acid and acetylsalicylic acid have intramolecular hydrogen bonds.

(C) Acetylsalicylic acid has 5 π bonds and 17 σ bonds.

(D) The reaction between the hydroxyl group of salicylic acid and the carboxyl group of acetic acid is a type of esterification reaction.

(E) Salicylic acid can react with acetic anhydride, using concentrated sulfuric acid as a catalyst, to prepare acetylsalicylic acid.

古代人們發現，取自於柳樹中的柳酸，構造如圖 6 所示，可以用來止痛及治療風濕。但是，柳酸會造成胃部不適。可利用柳酸與醋酸或乙酐的反應製得乙醯柳酸，就是阿斯匹靈。

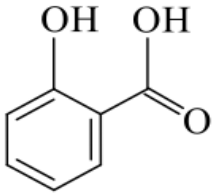


圖 6

下列有關乙醯柳酸的敘述，哪些正確？

(A) 常溫下乙醯柳酸易溶於水中。

(B) 柳酸和乙醯柳酸均有分子內氫鍵。

(C) 乙醯柳酸有 5 個 π 鍵及 17 個 σ 鍵。

(D) 柳酸的羥基和醋酸的羧基進行反應，是一種酯化反應。

(E) 柳酸和乙酐反應，以濃硫酸作為催化劑，可製備乙醯柳酸。

（110 指考 第 18 題）

Teacher: We know that aspirin is produced by the reaction of salicylic acid with acetic anhydride or acetic acid. In our class, we've learned about this reaction. It involves the carboxyl group of acetic acid reacting with which functional group of acetylsalicylic acid?

Student: Esters are formed through esterification, using the carboxyl group of acetic acid and the hydroxyl group of acetylsalicylic acid, catalyzed by concentrated sulfuric acid.

Teacher: That's correct, and we can determine the solubility of esters in water based on their properties.

Student: Esters are not easy to dissolve in water.

Teacher: Wonderful, so currently, we can judge which options are correct and which ones are incorrect?

Student: Option (A) is incorrect, while option (D) and (E) are correct.

Teacher: That's correct. Next, to determine if there can be intramolecular hydrogen bonds for option (B), there needs to be OH groups in the molecule that can attract each other. Do both salicylic acid and acetylsalicylic acid meet these conditions?

Student: The hydroxyl group's hydrogen in salicylic acid forms intramolecular hydrogen bonds with the carbonyl group's oxygen. The ester group's oxygen in acetylsalicylic acid forms intramolecular hydrogen bonds with the carboxyl group's hydrogen. Therefore, option (B) is correct.

Teacher: Great. Finally, for option (C), we need to determine which bonds have σ bonds. Single bonds have σ bonds, while double bonds have both σ and π bonds. Therefore, how many σ bonds and π bonds are there in acetylsalicylic acid?

Student: There are 21 σ bonds and 5 π bonds.

Teacher: That's correct, so the answer is (B), (D), and (E).

老師： 我們知道阿斯匹靈是柳酸加上乙酐或醋酸反應製成的，在課堂中我們有學過這個反應，他是利用醋酸的羧基與乙醯柳酸的哪個官能基反應產生的？

學生： 利用醋酸的羧基與乙醯柳酸的羥基經由濃硫酸催化脫水後酯化形成的酯類有基化合物。

老師： 沒錯，而酯類的特性我們可以知道他是否易溶於水？

學生： 酯類有機化合物不易溶於水。

老師： 很好，因此目前我們可以先判斷出哪些選項正確哪些選項錯誤？

學生： (A)錯誤，(D)(E)正確。

老師： 沒錯，接著(B)選項要判斷是否能有分子內氫鍵，需要分子內有可以互相吸引的OH，請問柳酸及乙醯柳酸是否有這樣的條件？

學生： 柳酸上羥基的 H 會與羧基的 O 產生分子內氫鍵，乙醯柳酸上酯基的 O 會與羧基的 H 產生分子內氫鍵，因此(B)選項正確。

老師： 很好，最後是(C)選項，要判斷有 σ 鍵的是單鍵，而雙鍵具有 σ 鍵與 π 鍵，因此請問乙醯柳酸有幾個 σ 鍵與 π 鍵？

學生： 有 21 個 σ 鍵與 5 個 π 鍵。

老師： 沒錯，因此答案選(B)(D)(E)。

1-6 胺與醯胺
Amine and Acid Amide

■ 前言 Introduction

在此小節教師可先舉出生物體內、藥物及食物等生活中常見的胺與醯胺例子來連結學生的生活經驗，接著以分子模型介紹其結構式，來讓學生了解胺與醯胺的基本性質，及介紹常見的反應和用途。

在語言教學方面，教師可以引導學生掌握有關胺和醯胺的英文命名原則。此外，教師可以運用「例如」和「說明應用」等句型，協助學生練習討論胺和醯胺在生活中的應用。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
amine	胺	acid amide	醯胺
dopamine	多巴胺	caffeine	咖啡因
morphine	嗎啡	primary amine	一級胺
secondary amine	二級胺	tertiary amine	三級胺
quaternary amine	四級銨	ammonia gas	氨氣
methylamine	甲胺	benzalkonium chloride	氯化苯二甲烴銨
aniline	苯胺	acyl chloride	醯氯
acetyl chloride	乙醯氯	acetamide	乙醯胺
acetanilide	乙醯胺苯		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____, such as _____.

例句：Amines that exist in nature often possess biological activity**, such as** dopamine and morphine.

自然界存在的胺常具有生物活性，例如多巴胺、嗎啡。

❷ _____ except for _____.

例句：At room temperature and standard pressure, all amides **except for** acetamide are solids.

常溫、常壓下，除了甲醯胺為液體，其他醯胺類皆為固體。

❸ _____ be used for _____.

例句：Amines **are** commonly **used for** various purposes such as the synthesis of rubber, resins, dyes, and pharmaceuticals.

胺常用於合成橡膠、樹脂、染料及醫藥等用途。

❹ _____ be heated with hydrolysis _____.

例句：When acid amides **are heated with hydrolysis** in an alkaline solution, they release ammonia, which can be used to test for acid amides.

醯胺利用在鹼性溶液中加熱水解後，會釋出氨氣，可以用來檢驗醯胺。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應習得以下觀念：

After studying this chapter, students should be able to know that:

一、學生能了解胺與醯胺的基本性質和用途。

Students can understand the general properties and uses of amine and acid amide.

❧ 例題講解 ☙

例題一

說明：學生能了解胺、醯胺的鍵級和反應及性質。

Students can understand the polarity, reactions, and properties of amines and acid amides.

Which of the following statements about amines and acid amides are correct?

(A) $(CH_3)CNH_2$ a tertiary amine.

(B) Amines form hydrogen bonds between molecules.

(C) Aniline doesn't not easily dissolve in water but can dissolve in hydrochloric acid, forming water-soluble chloroaniline.

(D) Benzene reacts with acetamide to produce acetanilide.

(E) Amides, in the presence of acid or alkali, when heated to boiling with water, can undergo hydrolysis reactions.

下列有關胺及醯胺的敘述，哪些正確？

(A) $(CH_3)CNH_2$ 為三級胺

(B) 胺分子間皆有氫鍵

(C) 苯胺不易溶於水，但可溶於鹽酸，生成可溶於水的氯化苯胺

(D) 苯和乙醯胺反應，可生成乙醯胺苯

(E) 醯胺在酸或鹼存在下，與水共熱煮沸，可發生水解反應

（龍騰版 110 下課本（選修化學 V）第二章 p89 例題 2-7）

Teacher: Amines are organic bases. Can you tell me under what conditions we categorize amines into primary, secondary, and tertiary?

Student: It is based on the number of alkyl groups attached to the nitrogen atom.

Teacher: That's correct. Therefore, looking at the structural formula, what degree of amine is $(CH_3)CNH_2$?

Student: It is a primary amine.

Teacher: That's correct. And in class, we mentioned whether all amines have intermolecular hydrogen bonds, didn't we?

Student: No, only primary amines and secondary amines can form intermolecular hydrogen bonds.

Teacher: That's correct. In option (C), we mentioned that acetanilide is an important analgesic. When synthesizing it, what is typically used?

Student: It can be obtained through the reaction of aniline and acetic anhydride.

Teacher: Lastly, in option (E), can amides undergo hydrolysis when heated to boiling with water in the presence of an acid or a base?

Student: Yes, it can, and it will generate carboxylic acids and ammonium ions.

Teacher: That's right, so the correct options are (C) and (E).

老師： 胺類是有機鹼，請問同學我們是依什麼條件來將胺分成一級、二級和三級的？

學生： 是根據氮原子連接的烴基數。

老師： 沒錯因此$(CH_3)CNH_2$ 由結構式來看是幾級胺？

學生： 為一級胺。

老師： 沒錯，而在課堂中我們說過是否所有胺都有分子間氫鍵？

學生： 沒有，只有一級胺和二級胺可以形成分子間氫鍵。

老師： 沒錯，(C)選項我們說乙醯胺苯是重要的鎮痛劑，在合成時通常會以什麼來合成？

學生： 可由苯胺和乙酐反應得到。

老師： 最後(E)選項醯胺在酸或鹼存在下，與水共熱煮沸，使否可發生水解反應？

學生： 可以，會生成羧酸和銨根。

老師： 沒錯，因此正確選項為(C)(E)。

例題二

說明：學生能判斷有機化合物的官能基及性質。

Students can determine the functional groups and properties of organic compounds.

Remdesivir is a medication that has been tested for the treatment of coronavirus disease 2019, also known as COVID-19, in patients. Assuming the structure is as shown in Figure 5, which of the following statements about remdesivir is correct?

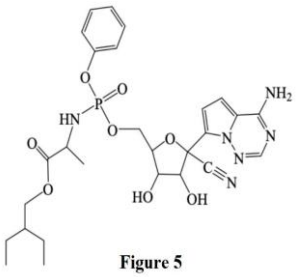


Figure 5

(A) The structure does not have functional groups of amine.

(B) The structure does not have hydroxyl groups.

(C) The structure does not have functional groups of ether.

(D) It undergoes hydrolysis in sodium hydroxide or sulfuric acid aqueous solutions.

(E) It exhibits a slightly acidic nature in water.

瑞德西韋是一種曾被試用於治療嚴重特殊傳染性肺炎(COVID-19)患者的藥物，假設結構如圖 5 所示，則下列有關瑞德西韋的敘述，哪一項正確？

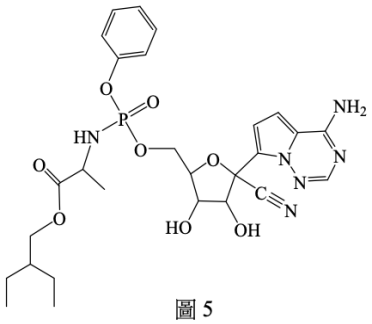


圖 5

(A) 結構不具有胺類官能基。

(B) 結構不具有羥基。

(C) 結構不具醚類官能基。

(D) 在氫氧化鈉或硫酸水溶液中會被水解。

(E) 在水中呈弱酸性。

（109 指考 第 13 題）

Teacher: For this question, we can start by looking at options (A), (B), and (C) together to identify the functional groups present in this structure. First, how do we determine functional groups of amines, hydroxyls, and ethers?

Student: The functional groups for amines are RNH_2, for hydroxyl groups it's -OH, and for ethers, it's ROR'. Therefore, based on this structure, we can determine that remdesivir has functional groups of amines, hydroxyls, and ethers.

Teacher: That's correct. What reaction amines undergo in strong acid or strong base as we learned?

Student: The N-P bond is broken, leading to a hydrolysis reaction.

Teacher: That's correct. Finally, to determine the acidity or alkalinity of this structure, we know that it has amine functional groups. Therefore, in water, what kind of acidity or alkalinity will it exhibit?

Student: It will exhibit alkalinity.

Teacher: That’s correct, so the correct answer is (D).

老師： 此題我們首先可以先將(A)(B)(C)三個選項一起看，來找此結構具有什麼樣的官能基，首先胺類官能基、羥基及醚類官能基如何判斷呢？

學生： 胺的官能基為 RNH2、羥基為-OH、醚類為 ROR’，因此由此結構可以判斷瑞德西韋具有胺類官能基、羥基及醚類官能基。

老師： 沒錯，那我們學過，胺類在強酸或強鹼中會發生什麼反應？

學生： N-P 鍵會被破壞而導致水解反應。

老師： 正確，最後要判斷此結構的酸鹼性，我們知道這個結構具有胺類官能基，因此在水中會呈現什麼酸鹼性。

學生： 會呈現鹼性。

老師： 沒錯，因此該題正確答案選(D)。

1-7 聚合物與聚合反應
Polymer and Polymerization Reaction

■ 前言 Introduction

在此小節教師可先以生活中常見的聚合物當作例子與學生經驗做連結，接著介紹聚合物的基本性質、分類與反應。

在語言教學方面，教師首先可以引導學生瞭解常見聚合物的英文命名原則。在之前已經學過的「分類」句型的基礎上，當教師介紹不同聚合反應類型和聚合物種類時，學生可以運用這些句型進行練習。最後，在介紹聚合物的性質與其單體時，教師可以使用比較差異的句型來幫助學生理解聚合物與其單體之間的異同。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
polymer	聚合物	polymerization reaction	聚合反應
monomer	單體	monomeric unit	單體單元
addition reaction	加成反應	condensation polymerization	縮合聚合
addition polymerization	加成聚合	polyethylene terephthalate	酞酸乙二酯
homopolymer	同元聚合物	copolymer	共聚物
polyvinyl chloride, PVC	聚氯乙烯	Polyethylene, PE	聚乙烯
polystyrene, PS	聚苯乙烯	Nylon	耐綸
ethylene glycol	乙二醇	terephthalic acid	對-酞酸

hexanediamine	己二胺	adipic acid	己二酸
ethene	乙烯	styrene	苯乙烯
dicarboxylic acid	二羧酸		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____ be polymerized into _____.

例句：Ethene can **be polymerized into** polyethylene by adding a catalyst under high pressure and high temperature.

乙烯在高壓與高溫下加入催化劑，可以聚合成聚乙烯。

❷ _____ be divided into _____.

例句：Depending on the way monomers are linked, polymerization reactions can **be divided into** addition polymerization and condensation polymerization.

依單體間結合的方式，聚合反應可分為加成聚合與縮合聚合。

❸ _____, resulting in _____.

例句：Condensation polymerization is a reaction where monomers with the same or different functional groups combine**, resulting in** the elimination of small molecules like water, alcohol, ammonia, or halides.

縮合聚合反應是以相同或不同的官能基單體，彼此結合時，脫去水、醇、氨或鹵化物等小分子。

❹ _____ be identical to _____.

例句：In addition polymerization, the types and numbers of atoms in the polymer's monomer units **are identical to** those in the monomer.

加成聚合反應中，聚合物的單體單元之原子種類以及個數，與單體完全相同。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應習得以下觀念：

After studying this chapter, students should be able to know that:

一、學生能了解聚合物的基本性質及分類。

Students can understand the general properties and classification of polymers.

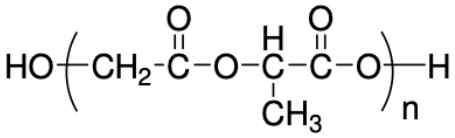
❧ 例題講解 ☙

例題一

說明：學生能透過結構式判斷出聚合物的分類並了解基本性質。

Students can classify polymers and understand their basic properties through structural analysis.

When using biodegradable sutures for wound closure, there is no need to remove the stitches after healing. The commonly used biodegradable suture materials have the following structure: The following statements regarding this polymer, which ones are correct?



(A) This polymer is a polyester compound CH_3.

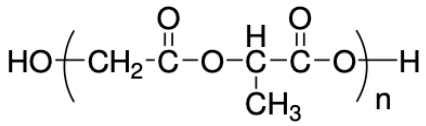
(B) This polymer is formed through polymerization of monomers via an addition reaction.

(C) This suture material contains polymers of different molecular weights.

(D) The constituent units of the polymer are connected by ether linkages, so it is easily degradable by enzymes in the body.

(E) The monomers comprising this polymer each contain two functional groups.

在縫合傷口時，若使用生物可分解的縫線，則在癒合後不需拆線。一般常用的可分解縫線材質，其結構如下：下列有關此聚合物的敘述，哪些正確？



(A) 此聚合物為聚酯類化合物 CH_3。

(B) 此聚合物是由單體以加成反應聚合而成。

(C) 此縫線材質含有不同分子量的聚合物。

(D) 聚合物的構成單元間是以醚基連結，所以容易在生物體內被酵素分解。

(E) 構成此聚合物的單體均含有兩個官能基。

（100 指考 第 20 題）

Teacher: Firstly, we can learn from the picture that it is a polymer. We know that polymers are formed by many monomers covalently bonded to each other, so we need to examine the structure and identify its functional groups to determine the type of polymer. Therefore, we can address options (A) and (D) together. What type of polymer is this, and how are the constituent units connected with what functional groups?

Student: This polymer has ester functional groups; therefore, it is a polyester, and the units are connected by ester linkages.

Teacher: That's correct. Let's move on to option (B). We learned in class about the classification of polymers, which can be divided into addition polymerization and condensation polymerization. How can we distinguish between these two classifications?

Student: In addition polymerization, the monomers are identical, whereas in condensation polymerization, there are usually two or more different functional groups involved.

Teacher: That's correct. So, what type of polymer is this question referring to?

Student: Containing two different monomers, both of which have two functional groups, it is therefore a condensation polymer. Hence, this suture material contains polymers of different molecular weights.

Teacher: Yes, the correct answer is (A), (C), and (E).

老師： 首先我們從圖中可以知道他是聚合物，那我們知道聚合物是由許多單體彼此以共價鍵連接所形成的，因此首先要判斷此聚合物是什麼類型，會需要看結構有什麼官能基，因此(A)(D)選項我們可以一起回答，請問此聚合物是什麼類型的聚合物，彼此又是以什麼官能基連結？

學生： 此聚合物有酯類的官能基，因此該聚合物是聚酯類，並且以酯基互相連接。

老師： 沒錯，再來(B)選項，我們在課堂學過聚合物的分類我們可以分成加成聚合及縮合聚合，請問這兩種分類分別如何判斷？

學生： 加成聚合的單體完全相同，而縮合聚合通常含有兩個以上的官能基。

老師： 沒錯，因此該題是哪種類型的聚合物？

學生： 含有兩種單體，單體均含有兩個官能基，因此是縮合聚合，因此該線材含有不同分子量的聚合物。

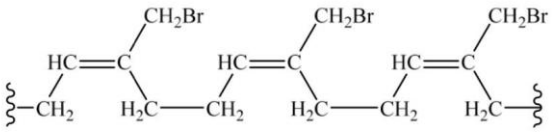
老師： 沒錯，因此正確答案選(A)(C)(E)。

例題二

說明：學生能夠由結構式判斷出聚合物的單體並計算其分子量。

Students can determine the monomers of a polymer from its structural formula and calculate its molecular weight.

Synthetic rubber is commonly used as a material for car tires. The localized chemical structure of a certain synthetic rubber is shown in Picture 6. This synthetic rubber is a linear polymer formed by repeating the process of using compound A as a monomer, where carbon-carbon bonds are formed between them through one end carbon atom. This process does not produce any other byproducts. May I ask, what is the approximate molecular weight of monomer compound A?



Picture 6

(A) 54　(B) 68　(C) 100　**(D) 147**　(E) 161

合成橡膠常做為汽車輪胎的材料。某一合成橡膠的局部化學結構如圖 6 所示。此合成橡膠是以化合物甲為單體，彼此透過一端碳原子進行碳-碳鍵結，如此重複進行而成的鏈狀聚合物，此過程無其他副產物生成。試問單體化合物甲的分子量約為多少？

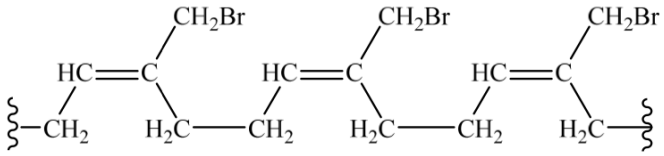


圖 6

(A) 54　　(B) 68　　(C) 100　　**(D) 147**　　(E) 161

（109 指考 第 14 題）

Teacher: From the question, we know that polymer A is formed by the repetition of a single monomer. Therefore, before calculating the molecular weight of monomer A, we first need to identify the monomer in this question. What is the monomer for this problem?

Student: From the structural formula, we can determine that the monomer for this synthetic rubber is CH_2=CH-C(CH_2Br)=CH_2.

Teacher: That's correct. So, we can identify the molecular formula of its monomer. What is the molecular formula?

Student: C_5H_7Br

Teacher: Correct, so now we can calculate its molecular weight. What is the molecular weight?

Student: 146.9, so approximately equal to 147.

Teacher: That's correct, so the answer is (D).

老師： 從題目中我們知道聚合物甲是由一種單體重複進行而成的，因此首先要算單體甲的分子量之前，我們要先找出單體，請問此題的單體是什麼？

學生： 由結構式可以判斷出此合成橡膠的單體是 CH_2=CH-C(CH_2Br)=CH_2。

老師： 沒錯，因此我們可以找出其單體的分子式，請問分子式為何？

學生： C_5H_7Br。

老師： 正確，因此我們就可以算出其分子量了，請問分子量是多少？

學生： 146.9 因此大約等於 147。

老師： 沒錯，因此答案選(D)。

1-8 天然聚合物
Natural Polymer

■ 前言 Introduction

在此小節教師可以先複習高一所學過的生活中的化學包括生物體中的分子，接著在介紹天然橡膠、多醣、蛋白質，及核酸。

語言方面，學生在國中時已學習了「葡萄糖、澱粉等」基本天然聚合物的詞彙。教師可以列出不同種類的澱粉和氨基酸詞彙，協助學生分析這些詞彙是否具有相似的字首或字根。此外，本單元還介紹了許多天然聚合物在日常生活中的應用。教師可以提供用於描述天然聚合物組成或功能的句型，幫助學生練習如何表達天然聚合物的成分以及它們在生活中的應用。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
natural rubber	天然橡膠	starch	澱粉
cellulose	纖維素	protein	蛋白質
amino acid	胺基酸	isoprene	異戊二烯
nucleic acid	核酸	α-glucose	α-葡萄糖
β-glucose	β-葡萄糖	amylose	直鏈澱粉
amylopectin	支鏈澱粉	glycogen	肝醣
animal starch	動物澱粉	camphor	樟腦
celluloid	賽璐珞	nitrocellulose	硝化纖維素
cellulose acetate	醋酸纖維素	aldose	醛醣

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ _____, produced through _____.

例句：Natural rubber is an isoprene polymer, **produced through** the processing of natural latex collected from the rubber tree in Brazil.
天然橡膠是異戊二烯聚合物，由巴西橡膠樹採集的天然乳膠加工製造而得。

❷ _____ break down into _____.

例句：During intense exercise or muscle contraction, glycogen rapidly **breaks down into** glucose, providing the required energy quickly.
當劇烈運動或肌肉收縮時，肝醣會快速分解成葡萄糖，可迅速提供所需能量。

❸ _____ the main component of _____

例句：Cellulose is **the main component of** plant cell walls and is the most widely distributed and abundant polysaccharide in nature.
纖維素為植物細胞壁的主要成分，是自然界分布最廣且含量最多的多醣。

❹ _____ have function that _____.

例句：Cellulose and dietary fiber **have functions that** promote intestinal peristalsis.
纖維素與膳食纖維有促進腸道蠕動的功能。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應習得以下觀念：

After studying this chapter, students should be able to know that:

一、學生能了解天然聚合物的來源與組成。

Students can understand the source and composition of natural polymers.

❧ 例題講解 ☙

例題一

說明：學生能了解胺基酸的來源、組成等基本性質。

Students can understand the fundamental properties of amino acids, such as their source and composition.

There are 20 main amino acids that make up living organisms. Which of the following statements about amino acids are correct?

(A) Insoluble in water.

(B) Contains both amino and carboxyl functional groups.

(C) Is a structural unit that makes up plant cellulose.

(D) Is a structural unit found in many natural enzymes.

(E) Is a structural unit that makes up the primary component of animal hair.

構成生物體的主要胺基酸有 20 種。試問下列有關胺基酸的敘述，哪些正確？

(A) 不溶於水。

(B) 含有胺基與羧基兩種官能基。

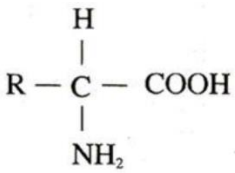
(C) 是組成植物纖維素的結構單元。

(D) 是組成許多天然酵素的結構單元。

(E) 是組成動物毛髮主要成分的結構單元。

（102 指考 第 23 題）

Teacher: We learned the structural formula of amino acids in class. What does the structural formula of amino acids look like?

Student: 

Teacher: Exactly, so based on the structure, can we determine whether amino acids can dissolve in water?

Student: They can dissolve in water, and their solubility varies depending on the characteristics of the R-group.

Teacher: That's correct. So, what functional groups do amino acids possess?

Student: Amino and carboxyl groups.

Teacher: That's correct. We learned that amino acids are the monomers that make up proteins. So, for option (C), may I ask if the structural unit of plant cellulose is composed of amino acids?

Student: That's correct. Plant cellulose is composed of glucose monomers.

Teacher: Very well, what is the translation for option (D), which states that in living organisms, it contains various enzymes, and the structural units that compose them are what?

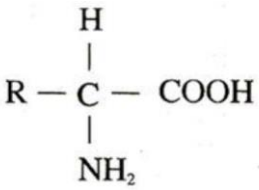
Student: Natural enzymes are primarily proteins, so the structural units are amino acids.

Teacher: Finally, for option (E), what is the structural unit of animal hair?

Student: The main component is protein, so the structural unit is amino acids.

Teacher: Correct, so the answer is (B), (D), and (E).

老師： 我們在課堂中學過胺基酸的結構式，請問胺基酸的結構式長什麼樣子？

學生： 

老師： 沒錯，因此由結構來看胺基酸是否可溶於水？

學生： 可以溶於水，溶解度會依 R 基的部分性質而變。

老師： 沒錯，那胺基酸具有什麼官能基呢？

學生： 胺基及羧基。

老師： 正確，我們學過胺基酸是組成蛋白質的單體，那(C)選項請問植物纖維的單元結構是由胺基酸組成的嗎？

學生： 不是，植物纖維是由葡萄糖單體組成的。
老師： 很好，(D)選項在生物體中含有多種酵素，其組成的結構單元為何？
學生： 天然酵素主要是蛋白質因此結構單元是胺基酸。
老師： 最後是(E)選項，請問動物毛髮的結構單元是什麼？
學生： 主要成分是蛋白質，因此結構單元是胺基酸。
老師： 正確，因此該題答案選(B)(D)(E)。

例題二

說明：學生能了解生物體內有機物質的來源及組成。

Students can understand the sources and composition of organic ma

Which of the following statements about organic matter inside living organisms is correct?

(A) Trans fat belongs to saturated fats.

(B) The structure of a nucleotide includes a five-carbon sugar, a nitrogenous base, and a phosphate group.

(C) Glucose, fructose, and galactose are all monosaccharides, and all three of these monosaccharides belong to aldoses.

(D) Proteins are formed by the polymerization of amino acids, which are linked together by hydrogen bonds.

(E) DNA forms a double helix primarily because of the covalent bonds formed between the base pairs on the two strands.

下列有關生物體內有機物質的敘述，哪一項正確？

(A) 反式脂肪屬於飽和脂肪。

(B) 核苷酸的結構包括五碳醣、含氮鹼基與磷酸根。

(C) 葡萄糖、果糖和半乳糖均為單醣，此三種單醣皆屬於醛醣。

(D) 蛋白質是由胺基酸聚合而成，胺基酸之間是藉由氫鍵結合而成。

(E) DNA 會形成雙股螺旋，主要是因為不同股上的鹼基間形成共價鍵所致。

（103 指考 第 17 題）

Teacher: For option (A), to determine whether it is saturated fat, you need to examine the carbon-carbon structure of its chemical formula. Is trans fat considered saturated fat?

Student: No, trans fat is unsaturated fat because it contains a carbon-carbon double bond structure.

Teacher: That's correct. For option (B), we learned in class that nucleotides are the monomers of nucleic acids, and nucleic acids are formed by a process of dehydration synthesis from nucleotides. Can you please provide the three main components that make up a nucleotide?

Student: Pentose, nitrogenous base, and phosphate group.

Teacher: That's correct. For option (C), we learned that glucose, fructose, and galactose are all monosaccharides, and they are classified based on their ring structure into ketoses and aldoses. What are these three monosaccharides respectively?

Student: Fructose is a ketose, while glucose and galactose are aldoses.

Teacher: Next is option (D). Proteins are formed by the condensation polymerization of amino acids, and amino acids have two functional groups that undergo dehydration to form a bond. Can you please explain why this happens?

Student: Amino and carboxyl groups undergo dehydration to form an amide bond, so it's not a hydrogen bond.

Teacher: Finally, for option (E), we mentioned that DNA forms a double helix because there is an acting force between the nitrogenous bases on the strands. What is that acting force?

Student: It is the hydrogen bonds formed between the nitrogenous bases, and not covalent bonds.

Teacher: That’s correct. The answer is (B).

老師： 首先是(A)選項，要判斷是否為飽和脂肪要看其結構式的碳-碳結構，請問反式脂肪是否屬於飽和脂肪？

學生： 否，因為反式脂肪含有碳-碳雙鍵的結構，為不飽和脂肪。

老師： 沒錯，(B)選項我們在課堂中學過核苷酸是核酸的單體，脫水聚合後可得核酸，請問核苷酸主要是由哪三部分組成的。

學生： 五碳醣、含氮鹼基、磷酸根。

老師： 正確，(C)選項我們學過葡萄糖、果糖、半乳糖皆為單醣，又依開環結構分成酮醣和醛醣，請問三種單醣分別為何？

學生： 果糖為酮醣，葡萄糖及半乳糖為醛醣。

老師： 再來是(D)選項，蛋白質是由胺基酸縮合聚合而成，而胺基酸有兩種官能基，他們會脫水形成一種鍵結，請問為何？

學生： 胺基和羧基會脫水形成醯胺鍵，因此不是氫鍵。

老師： 最後是(E)選項，我們說 DNA 會形成雙股螺旋是因為股上的含氮鹼基之間有一股作用力導致形成的，請問那股作用力是什麼？

學生： 是含氮鹼基之間形成的氫鍵，而非共價鍵。

老師： 沒錯，因此該題答案選(B)。

★ 主題二 環境化學 ★
Environmental Chemistry

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■ 前言 Introduction

現今科技日新月異，在不斷進步下人類生活水準漸漸得到改善，但同時伴隨著許多隱憂；社會經濟的成長使工廠林立，伴隨而來的是重金屬殘留、河川污染，在缺乏環境保護的意識下，大自然在人類追求進步的時代裡早已傷痕累累，但自然環境與我們的生活息息相關密不可分，因此我們應該建立正確的環境保護觀念並將其應用在日常生活中，在確保社會進步的同時實踐永續精神。

2-1 科學、科技、社會及人文
Science, Technology, Society and Humanities

■ 前言 Introduction

科技不斷地進步大幅改善了人類的生活水準，但科技發展的同時社會經濟的差距仍然存在，也伴隨著許多環境污染問題，因此科學家們正努力開創新技術，使其更有效且符合綠色化學，為環境、社會、經濟提供穩定且乾淨的能源、食物、居住地。學生從本節學習綠色化學的內容與其意義，了解科學不僅追求卓越，同時積極尋找更加節能、乾淨的方式來保護地球。

語言方面，學生會練習比較級句型的應用，也了解專業條款所使用的專門術語說法。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
12 Principles of Green Chemistry	十二項綠色化學原則	regenerative material	再生原料
sustainable chemistry	永續化學	derivative	衍生物
atom economy	原子經濟	catalytic reaction	催化反應
energy conservation	節能	degradation reaction	降解反應

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ The definition of green chemistry is _____.

例句：**The definition of green chemistry is** a reaction process that does not use toxic substances.
綠色化學的定義是反應過程不使用有毒的物質。

❷ _____ is one of the 12 Principles of Green Chemistry.

例句：Atom economy **is one of the 12 Principles of Green Chemistry**.
原子經濟是十二項綠色化學原則之一。

❸ A high atom economy means the (more) _____, the less _____.

例句：**A high atom economy means the greener** the reaction**, the less** it pollutes the environment.
原子經濟高，代表反應的綠色程度越高，對環境污染越少。

■ 問題講解 Explanation of Problems

學習目標

在學習完本單元後，學生應習得以下觀念：

After studying this chapter, students should be able to know that:

一、學生能了解綠色化學的意義及十二項綠色化學原則的內容，並能計算原子效率用以判斷反應是否符合綠色化學。

Students can understand the meaning of green chemistry and the contents of the twelve green chemistry principles, and can calculate atomic efficiency to determine whether a reaction complies with green chemistry.

例題講解

例題一

說明：學生能了解綠色化學的意義與內容。

Students can understand the meaning and content of green chemistry.

Which of the following is not consistent with green chemistry?

(A) Use less toxic chemicals.

(B) Reduce waste generation.

(C) Improve atomic efficiency.

(D) Reduce the use of catalysts.

(E) Generate degradable products.

下列何項並不符合綠色化學？

(A) 使用毒性較低的化學藥品。

(B) 降低廢棄物的產生。

(C) 提高原子效率。

(D) 減少使用催化劑。

(E) 生成可降解的產物。

Student: Why reducing the use of catalysts is not in line with green chemistry?

Teacher: This is a very good question! What function does a catalyst have in a chemical reaction?

Student: It can lower the activation energy and make the reaction easier to proceed.

Teacher: Very good! Chemical reactions often need to be carried out at specific temperatures and pressures, and adding a catalyst can make the reaction proceed at low temperatures. Therefore, the use of catalysts can achieve the purpose of energy saving. Energy saving is an important principle in green chemistry.

Student: I understand!

學生： 老師，請問為什麼減少使用催化劑不符合綠色化學呢？

老師： 這個問題非常好！同學們先想想催化劑在化學反應中具有什麼樣的功能？

學生： 能夠降低活化能，使反應更容易進行。

老師： 很好！化學反應常需要在特定溫度與壓力下執行，而加入催化劑能夠使反應在低溫條件下進行，因此使用催化劑能夠達到節能的目的，節能是綠色化學中重要的一個原則。

學生： 老師，我理解了！

例題二

說明：學生能計算反應的原子效率。

Students can calculate the atomic efficiency of a reaction.

When you open a bottle of wine, you can smell a natural aroma, which contains ethyl acetate. It is an organic molecule with a fruity smell that can be used as a solvent, such as cleaning circuit boards, or as an indicator. Nail polish remover, caffeine extraction solvent, etc. It is widely popular because of its low toxicity and pleasant smell. Ethyl acetate can be produced by the following two methods:

(A) After mixing acetic acid and ethanol, add sulfuric acid solution as a catalyst to perform esterification reaction, reaction formula:

$$CH_3COOH + CH_3CH_2OH \rightarrow CH_3COOC_2H_5 + H_2O$$

(B) Using silicotungstic acid solid as a catalyst, ethylene and acetic acid are mixed and the reaction produces ester. Reaction formula:

$$CH_2CH_2 + CH_3COOH \rightarrow CH_3COOC_2H_5$$

(Molecular weight: $CH_3COOH = 60$, $CH_3CH_2OH = 46$, $CH_2CH_2 = 28$, $CH_3COOC_2H_5 = 88$)

Please answer the following question:

(1) What are the atomic economies of reactions (A) and (B)? **83%, 100%**

(2) Between the two reactions (A) and (B), which one is more in line with the spirit of sustainable chemistry? Why? **B is more in line with the spirit of sustainable chemistry because its atomic efficiency is 100%, and the catalyst used is silicotungstic acid, which is solid and easier to recycle.**

打開葡萄酒時，可聞到一股天然散發出的香氣，其中含有一種成分是乙酸乙酯。它是一種帶有水果氣味的有機分子，可作為溶劑使用，如清潔電路板，或作為指甲油清除劑、咖啡因萃取的溶劑等。因其毒性低、氣味宜人，所以廣受青睞。乙酸乙酯可由下列兩種方法製得：

(甲)將乙酸和乙醇混合後，加入硫酸溶液作催化劑，進行酯化反應，反應式：

$$CH_3COOH + CH_3CH_2OH \rightarrow CH_3COOC_2H_5 + H_2O$$

(乙)以矽鎢酸固體作催化劑，通入乙烯和乙酸混合後，反應產生酯，反應式：

$$CH_2CH_2 + CH_3COOH \rightarrow CH_3COOC_2H_5$$

（分子量：CH_3COOH＝60、CH_3CH_2OH＝46、CH_2CH_2＝28、$CH_3COOC_2H_5$＝88）

回答下列問題：

(1) (甲)、(乙)兩反應的原子經濟，各為多少？ **83%、100%**

(2) (甲)、(乙)兩反應，何者較符合永續化學精神？理由為何？**乙較符合永續化學精神，因他的原子效率為 100%，且所使用的催化劑矽鎢酸為固體，較容易回收利用。**

（翰林版 110 下課本（選修化學 V）第二章 練習 2-1）

Teacher: Sir, how do we calculate the atomic economy of a reaction?

Student: Atomic economy (%) = (total atomic mass of the target product/total atomic mass of all reactants) * 100%, so first calculate the mass of the target product and each reactant reactants: multiply the molecular weight by the coefficient, and then divide the total mass of the target product by the add up of all mass.

Teacher: I understand! So why is B more in line with the spirit of sustainable chemistry?

Student: Because the atomic efficiency of reaction B is higher and the catalyst is solid, it is easier to recycle after the reaction is completed.

老師： 老師，要如何計算反應的原子經濟呢？

學生： 原子經濟(%)=（目標產物的原子總質量/所有反應物的原子總質量）* 100%，因此先計算目標產物、各反應物的原子量原子總質量：分子量乘上係數，再將目標產物總質量除上所有反應物的質量總總和。

老師： 我懂了！那老師為什麼反應乙較符合永續化學精神呢？

學生： 因為反應乙的原子效率較高，且催化劑為固體，在反應完成後較容易回收利用。

2-2 科學模型的特性與演變
Characteristics and Evolution of Scientific Models

■ 前言 Introduction

科學模型和建模對於化學的學習與研究相當重要，因為模型可以用來解釋、預測自然現象，是一個重要且十分有用的工具。模型可以是一個想法、一個過程或反應的表示，用來解釋那些無法直接體驗的現象，將抽象概念與知識模型化，並簡化真實現象，使其容易解讀或是可視覺化。因此科學建模對於學習科學知識的學生而言不可或缺，從認識模型的特性與演變，藉以了解該建模。

語言方面，學生能夠以英文解釋特定名詞的定義，並以不同的片語使用說明其特色與化學上的功能。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
scientific model	科學模型	enantiomer	鏡像異構物
scientific modeling	科學建模	trans-form	反式
inquiry skill	探究能力	cis-form	順式

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ Scientific modeling is the process of _____.

例句：**Scientific modeling is the process of** modeling abstract concepts and knowledge.
科學建模是將抽象概念與知識模型化的過程。

❷ The evolution of chemical modeling has evolved to _____.

例句：**The evolution of chemical modeling has evolved to** molecular modeling that lies somewhere between theory, observation and experiment.
化學建模的演變，進化到位於理論、觀察和實驗之間的分子建模。

❸ Enantiomers are two stereoisomers that are ____ but ____.

例句：**Enantiomers are two stereoisomers that are** mirror images of each other **but** cannot completely overlap.
鏡像異構物是互為鏡像，但無法完全重疊的兩個立體異構物。

❹ The _____ and _____ storage of energy can be used as _____ for cis and trans isomers.

例句：**The** forward **and** reverse **storage of energy can be used as** a molecular switch **for cis and trans isomers.**
能量的正、逆存放，可作為順、反異構物的分子開關。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應習得以下觀念：

After studying this chapter, students should be able to know that:

一、學生能理解現有科學模型的歷史與模型欲解釋的現象或過程。

Students can understand the history of existing scientific models and the phenomena or processes that the models are intended to explain.

❧ 例題講解 ☙

例題一

說明：學生能夠理解臭氧層的建模與研究史。

Students will be able to understand the history of modeling and research on the ozone layer.

The United Nations ratified the Montreal Protocol to reduce the use and production of what substances to save the ozone layer?

(A) Carbon dioxide.

(B) Nitrogen dioxide.

(C) Chlorocarbons.

(D) Hydrofluorocarbons.

(E) Methane.

聯合國簽署蒙特婁議定書，目的是為減少何種物質的使用與生產，用以挽救臭氧層？

(A) 二氧化碳。

(B) 二氧化氮。

(C) 氟氯碳化物。

(D) 氫氟碳化物。

(E) 甲烷。

Teacher: Scientists have discovered a hole in the ozone layer over the Antarctic. The main cause is the chlorofluorocarbons in the refrigerants or sprayers used by humans every day, which will deplete the ozone in the stratosphere. Therefore, what protocol have been signed?

Student: Montreal Protocol!

Teacher: That's right! Very good, so in order to prevent chlorofluorocarbons in industrial products from continuing to damage the ozone layer, countries signed the Montreal Contract to eliminate such compounds. What kind of compounds will be used to replace them?

Student: Hydrofluorocarbons!

Teacher: Completely correct! Is it all clear?

Student: Yes!

老師： 科學家在南極上空發現臭氧層破洞，主要肇因為人類日常使用的冷媒或噴霧器中的氟氯碳化物，其會消耗平流層的臭氧，因此各國簽訂了哪項合約呢？

學生： 蒙特婁合約！

老師： 沒錯！很好，因此各國為避免工業產品中的氟氯碳化物繼續破壞臭氧層，因此簽訂了蒙特婁合約，將這類的化合物淘汰，以哪種化合物取代呢？

學生： 氫氟碳化物！

老師： 完全正確！這樣子大家理解了嗎？

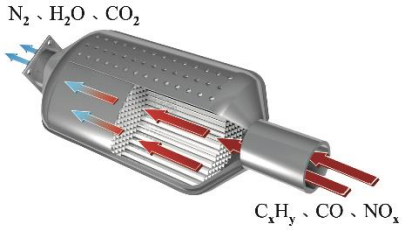
學生： 理解了！

例題二

說明：學生能理解科學模型所解釋的現象與化學反應。

Students can understand phenomena and chemical reactions explained by scientific models.

In order to improve air quality, after cars and motorcycles are equipped with catalytic converters (Pt, Pd, Rh metals), the exhaust gas will be converted into harmless gases and then discharged into the atmosphere, as shown in the figure below. Which of the following statements are correct?



(A) After the CO in the exhaust gas passes through the converter, it can form a C element and be discharged.

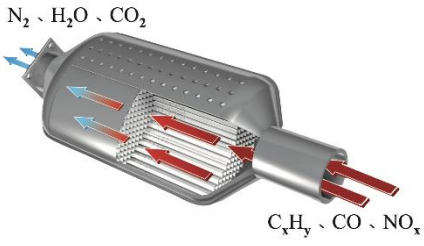
(B) The hydrocarbons in the exhaust gas are converted into H_2O and CO_2 and discharged after passing through the converter.

(C) Pt, Pd, and Rh in the converter are catalysts and will not decrease after the reaction is completed.

(D) The gas discharged from the exhaust pipe contains the smallest proportion of CO_2.

(E) The products of NO_x after passing through the converter are NH_3 and O_2.

為了改善空氣品質，汽、機車加裝觸媒轉化器(Pt、Pd、Rh 金屬)後，廢氣會被轉化為無害的氣體，再排放至大氣中，如下圖所示，則下列敘述哪些正確？



(A) 廢氣中的 CO 經轉化器後，可形成 C 元素而排出。

(B) 廢氣中的碳氫化合物，經轉化器後，轉化成 H_2O 和 CO_2 排出。

(C) 轉化器中的 Pt、Pd、Rh 為催化劑，反應完成後不會減少。

(D) 排氣管所排出的氣體中，含 CO_2 的比率最小。

(E) NO_x 經轉化器後產物為 NH_3 和 O_2。

（來源：翰林版 110 下課本（選修化學 V）第二章 第 140 頁 第 6 題）

Student: Sir, why are the amounts of Pt, Pd and Rh in the converter not reduced?

Teacher: Because Pt, Pd, and Rh act as catalysts to catalyze the reaction, and the mass of the catalyst does not change before and after the reaction.

Student: Got it! What are the products of NO_x after passing through the converter?

Teacher: We can learn from the textbook that the catalytic converter can convert exhaust gas into N_2, H_2O and CO_2, so the product of NO_x after passing through the converter is N_2.

Student: I see. Then the CO in the exhaust gas is converted into CO_2 and then emitted. Is this right?

Teacher: Yes! That's right!

學生： 老師，請問為什麼轉化器中的 Pt、Pd、Rh 量不會減少？

老師： 因為 Pt、Pd、Rh 作為催化劑催化反應進行，而催化劑在反應前後質量不變。

學生： 了解了！那 NO_x 經轉化器後的產物有哪些呢？

老師： 我們從課本可以得知，觸媒轉換器可以將廢氣轉化為 N_2、H_2O 和 CO_2，因此 NO_x 經轉化器後的產物為 N_2。

學生： 原來如此，那廢氣中的 CO 就是轉化成 CO_2 後排出，這樣對嗎？

老師： 沒錯！很棒！

2-3 環境污染與防治
Environmental Pollution and Prevention

■ 前言 Introduction

現今環境污染錯綜複雜，環境污染又分為水污染、空氣污染、土壤污染，而解決環境污染仰賴污染防治技術與環境管理；而過去強調污染防治，現則注重避免污染的發生。學生能夠透過了解環境污染的種類與成因，建立對污染防治的意識，並將其實踐在日常生活中。

語言方面，學生能學會因果關係相關的句型，同時也練習被動句型的用法。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
water pollution	水污染	suspended solids	懸浮物
aerobic waste	需氧廢物	radioactive material	放射性物質
biochemical oxygen demand	生化需氧量	thermal pollution	熱汙染
chemical oxygen demand	化學需氧量	coral bleaching	珊瑚白化
eutrophication	水質優養化		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ **When microbeads are used by people and washed into natural waters, they can cause _____, _____, _____, etc., due to _____.**

例句：**When microbeads are used by people and washed into natural waters, they can cause** poisoning or death of fish, amphibians, birds, large mammals, **etc., due to** accidental ingestion and accumulation in the food chain.

當柔珠被人們使用後，沖洗入自然水域，會造成魚類、兩棲類、鳥類、大型哺乳類動物等，因誤食與食物鏈累積，造成中毒或死亡。

❷ **Air pollution refers to the _____, causing harm or discomfort to _____ or _____, or_____.**

例句：**Air pollution refers to the** introduction of chemicals, particulate matter or biological materials into the atmosphere**, causing harm or discomfort to** humans **or** other organisms**, or** damaging ecosystems.

空氣汙染是指將化學物質、顆粒物或生物材料等引入大氣層中，對人類或其他生物造成傷害或不適，或是破壞生態系統。

❸ **The impact of environmental pollution on _____ is unevenly distributed among the population, and there are also population differences in _____, _____, _____, and _____.**

例句：**The impact of environmental pollution on** health **is unevenly distributed among the population, and there are also population differences in** race, ethnicity, socioeconomic status**, and** education level.

環境污染對健康的影響，在人口中分布不均，並且在種族、族裔、社會經濟地位和教育水準方面，也存在著人口的差異。

❹ **_____ can cause _____ or _____, causing _____.**

例句：Cadmium poisoning **can cause** bone loosening **or** softening and kidney failure**, causing** the patient's joints and spine to cry out in extreme pain, hence the name Itai-Itai disease.
鎘中毒會使骨骼疏鬆或軟化以及腎功能衰竭，導致患者的關節和脊骨因極度痛楚而發出叫喊聲，故名為痛痛病。

❺ **Water turbidity refers to the _____ caused by _____. The turbidity standard for drinking water in Taiwan is not to exceed _____ NTU.**

例句：**Water turbidity refers to the** turbidity in water samples **caused by** a large amount of suspended matter visible to the naked eye. **The turbidity standard for drinking water in Taiwan is not to exceed** 2 **NTU**.
水的濁度是指水樣中因為大量肉眼可見懸浮物質而造成的混濁情形，而臺灣飲用水的濁度標準是不得超過 2 NTU。

■ 問題講解 Explanation of Problems

學習目標

在學習完本單元後，學生應習得以下觀念：

After studying this chapter, students should be able to know that:

一、學生能夠辨別環境污染的成因及污染源。

Students can identify the causes and sources of environmental pollution.

例題講解

例題一

說明：學生能分辨造成環境污染之原因。

Students can identify the causes of environmental pollution.

Which of the following pairings of environmental pollution and pollution sources is correct?

(A) Greenhouse effect: NO_2.

(B) Acid rain: O_3.

(C) Eutrophication: volatile organic compounds.

(D) Photochemical smog: CO_2.

(E) Ozone depletion: chlorofluorocarbons.

下列環境污染與污染源的配對，何者正確？

(A) 溫室效應：NO_2。

(B) 酸雨：O_3。

(C) 水質優養化：揮發性有機物。

(D) 光化學煙霧：CO_2。

(E) 臭氧層破洞：氟氯碳化物。

Teacher: Everyone, what kind of pollution source causes the greenhouse effect?

Student: It's the carbon dioxide.

Teacher: Very good! So, what kind of pollution sources cause acid rain?

Student: It's the sulphur dioxide and nitrogen oxides.

Teacher: That's right! So, what kind of pollution sources cause eutrophication?

Student: Industrial wastewater or domestic wastewater.

Teacher: Why does industrial and household wastewater cause eutrophication of water quality? Is it because wastewater contains a large amount of what kind of substances?

Student: Substances that contain nutrients such as phosphorus and nitrogen.

Teacher: Very good. So, what kind of substances are the main sources of pollution causing light smog?

Student: Nitrogen oxides.

Teacher: Great, and what other substances besides nitrogen oxides are the main sources of light smog pollution?
Student: Ozone.
Teacher: Correct!

老師： 各位同學，是何種污染源造成溫室效應呢？
學生： 二氧化碳。
老師： 很好！那何種污染源造成酸雨呢？
學生： 二氧化硫和氮的氧化物。
老師： 沒錯！那何種污染源造成水質優養化呢？
學生： 工業廢水或家庭廢水。
老師： 為什麼工業與家庭廢水會造成水質優養化呢？是因為廢水中含有大量的何種物質？
學生： 含有磷、氮的營養物質。
老師： 非常好。那何種物質是造成光煙霧的主要污染源呢？
學生： 氮氧化物。
老師： 很好，那氮氧化物之外還有哪種物質是光煙霧的主要污染源呢？
學生： 臭氧。
老師： 完全正確！

例題二

說明：學生能分辨造成光化學煙霧污染之原因。

Students can identify the causes of photochemical smog pollution.

Which of the following is not a cause of photochemical smog pollution?

(A) Volatile organic compounds.

(B) Suspended particulate matter PM2.5.

(C) O_3

(D) CO

(E) NO_2

下列何者並非光化學煙霧污染的成因？

(A) 揮發性有機物。

(B) 懸浮微粒 PM2.5。

(C) 臭氧

(D) 一氧化碳

(E) 二氧化氮

Teacher: Everyone, which of the options in this question is not the cause of photochemical smog pollution?

Student: Carbon monoxide.

Teacher: Very good. So, what kind of pollution or harm will CO cause?

Student: Not sure.

Teacher: The harm of carbon monoxide is to block the oxygen-carrying function of human heme, causing hypoxic coma or death. Because carbon monoxide is odorless, colorless and toxic, it is difficult to detect when it leaks, leading to carbon monoxide poisoning without detection.

Student: Wow! Carbon monoxide is so dangerous!

Teacher: That's right! Therefore, everyone must remember to install the water heater at home outdoors. If it is installed on the balcony, remember to open the window to allow air circulation to prevent carbon monoxide produced by incomplete combustion from flowing into the home and causing harm!

老師： 各位同學，此題的選項中何者並非光化學煙霧污染的成因？
學生： 一氧化碳。
老師： 很好。那 CO 會造成哪些污染或危害呢？
學生： 不清楚！
老師： 一氧化碳的危害是阻斷人體血紅素的攜氧功能，造成人體缺氧昏迷或致死。也因一氧化碳無味、無色、有毒，因此在一氧化碳洩漏時很難發覺，導致在未發覺的情況下一氧化碳中毒。
學生： 哇！一氧化碳好危險！
老師： 沒錯！因此大家務必記得將家中熱水器安裝在戶外，若安裝在陽台，也記得打開窗使空氣流通，避免燃燒不完全產生的一氧化碳流入家中，造成危害！

2-4 資源與永續發展
Resources and Sustainable Development

■ 前言 Introduction

延續上一節，在認識環境污染的種類及成因後，此節說明永續發展的核心概念與要素，而永續發展不僅是環境保護，更擴及經濟發展、性別議題、教育品質等。學生能夠從 17 項永續發展目標中，了解其背後的意義與宗旨，並培養學生對永續發展的意識，在追求社會進步的同時，也必須衡量永續發展的各項目標。

語言方面，學生能運用相關片語標達名詞術語的功能，並熟悉聯合國所制定目標之正確英文用語。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
sustainable development	永續發展	industry, innovation, and infrastructure	工業、創新和基礎設施
no poverty	消除貧窮	sustainable cities and communities	建設安全永續的市鎮
zero hunger	終止飢餓	climate action	因應氣候變遷與其衝擊採取行動
quality education	優質教育	life below water	保育和維護海洋資源
gender equality	性別平權	life on land	保育和永續利用陸地生態系統

clean water and sanitation	清潔水資源以及衛生設施	partnerships for the goals	永續發展的全球夥伴關係
decent work and economic growth	促進持續經濟增長，促進就業	nitrogen cycle	氮循環
biomass energy	生質能	biological nitrogen fixation	生物固氮
solar power	太陽能		

■ 教學句型與實用句子 Sentence Frames and Useful Sentences

❶ **Sustainable development is composed of _____, _____, and _____. The coordinated development of the three factors can _____.**

例句：**Sustainable development is composed of** environmental factors, social factors, **and** economic factors. **The coordinated development of the three factors can** promote the overall progress of society.

永續發展是由環境要素、社會要素、經濟要素構成，三要素協調發展，能促進社會的總體進步。

❷ **To achieve the 17 sustainable development goals, _____ plays a vital role. _____'s ability to _____ and serve as a _____ for many technologies means that it can _____.**

例句：**To achieve the 17 sustainable development goals,** chemistry **plays a vital role.** Chemistry**'s ability to** innovate **and serve as a** foundation **for many technologies means that it can** make an important contribution to achieving the Sustainable Development Goals.

實現 17 項永續發展目標，化學扮演著至關重要的角色。化學的創新能力和作為多種技術的基礎能力，意味著其可以為實現可持續發展目標作出重要貢獻。

❸ **Chemistry can play a role in _____, _____ and _____, and can help _____ and _____.**

例句：**Chemistry can play a role in** gender equality, quality education **and** lifelong learning, **and can help** eliminate the military harm of chemical warfare **and** promote disarmament and peaceful uses of technology.

化學可以在性別平等、優質教育和終身學習中發揮作用，並協助消弭化學戰爭的軍事危害以及促進裁軍與和平利用技術。

❹ **Waste generated by _____ and _____ has caused _____, _____ and _____ pollution, worsening _____, and requires _____ to solve it.**

例句：**Waste generated by** transportation **and** fossil fuel combustion **has caused** air, water **and** soil **pollution**, **worsening** the entire ecosystem, **and requires** the cooperation of all mankind **to solve it.**

交通運輸和化石燃料燃燒所產生的廢棄物，造成了空氣、水及土壤的汙染，使得整個生態系統更加惡化，有待全體人類共同合作解決。

■ 問題講解 Explanation of Problems

☙ 學習目標 ❧

在學習完本單元後，學生應習得以下觀念：

After studying this chapter, students should be able to know that:

一、學生能夠了解永續發展的理念與其內容，並能辨別目標是否符合永續發展的理念。

Students can understand the concept of sustainable development and its content, and gain insight into whether the conceptual goals are consistent with the concept of sustainable development.

∞ 例題講解 ∞

例題一

說明：學生能夠認識永續發展目標及其內容。

Students can understand the sustainable development goals and their contents

Which of the following is not one of the 17 sustainable development goals?

(A) No poverty.

(B) Zero hunger.

(C) Democratic society.

(D) Quality education.

(E) Gender equality.

下列何者並非 17 項永續發展目標？

(A) 消除貧窮。

(B) 終止飢餓。

(C) 民主社會。

(D) 優質教育。

(E) 性別平等。

Student: Sir, why are no poverty and zero hunger the goals of sustainable development?

Teacher: Because eliminating poverty and ensuring prosperity is the vision of human development, poverty reduction and inclusion can become the driving force for sustainable economic development and industrialization.

Student: I see! What about quality education and gender equality?

Teacher: Because high-quality education and gender equality can promote the overall progress of society, meet human needs, and prevent benefits in one aspect from being sacrificed in other aspects, thereby damaging the overall benefits of society.

Student: I got it!

Teacher: Good!

學生： 老師，為什麼消除貧窮與終止飢餓是永續發展目標呢？

老師： 因為消除貧窮、確保繁榮，是人類發展的願景，且減貧及包容，可以成為可持續性的經濟發展及工業化的動力。

學生： 原來如此！那優質教育及性別平等呢？

老師： 因為優質教育與性別平等能夠促進社會總體的進步，滿足人類的需求，也預防某方面的受益是建立在其他方面的犧牲，進而損害社會總體的受益。

學生： 我懂了！

老師： 很好！

例題二

說明：學生能夠理解永續發展的理念與要素。

Students can understand the concepts and elements of sustainable development.

Which of the following is not in the three elements of sustainable development?

(A) People's welfare.

(B) Environmental protection.

(C) Economic development.

(D) Social needs.

下列何者並非永續發展三要素？

(A) 人民福利。

(B) 環境保護。

(C) 經濟發展。

(D) 社會需求。

Student: Sir, why does sustainable development need to take into account social needs?

Teacher: This is a great question! Because sustainable development does not require humans to return to primitive society, even if primitive society causes minimal damage to the environment, human beings' own needs must also be taken into consideration while emphasizing sustainable development.

Student: What about economic development?

Teacher: Sustainable development needs to take into account the economic aspect, because only economically profitable projects can be promoted and sustainable, and in order to prevent economically loss-making projects from obtaining compensation from other places, which will cause problems elsewhere Environmental damage, so sustainable development needs to take into account economic factors.

Student: I see!

學生： 老師，請問為什麼永續發展需顧及社會需求呢？

老師： 這是很好的問題！因為永續發展並非要人類回到原始社會，即使原始社會對環境的損害是最小的，因此在強調永續發展的同時也要顧及人類自身的需求。

學生： 那經濟發展方面呢？

老師： 永續發展需兼顧經濟方面，因為唯有在經濟上有利可圖的項目才能夠得到推廣，才有可持續性，且為了預防經濟上虧損的項目，從他處獲取補償，而造成其他地方的環境破壞，所以永續發展需要顧及經濟要素。

學生： 我了解了！

國內外參考資源 More to Explore

Ward's Science featuring Ward's World 提供國中及高中年齡層學生及教師使用，也有影片。也有其他自然科。 https://wardsworld.wardsci.com/chemistry	
Middle School Chemistry 提供國中教師完整教學指引，學習單，教學影片。 https://www.middleschoolchemistry.com/	
American Association of Chemistry Teachers 美國教師化學協會，提供個階段教師資源分享。 https://teachchemistry.org/	
Khan Academy 可汗學院，有分年級的化學教學影片及問題的討論。 https://www.khanacademy.org/	
Interactive Simulations, University of Colorado Boulder 互動式電腦模擬，除了化學，還有其他自然科。 https://phet.colorado.edu/	

自然領域雙語教學資源手冊：化學科英語授課用語
[選修化學(V)]
A Reference Handbook for Senior High School Bilingual Teachers in the Domain of Natural Sciences (Chemistry): Instructional Language in English
[Elective Chemistry (V)]

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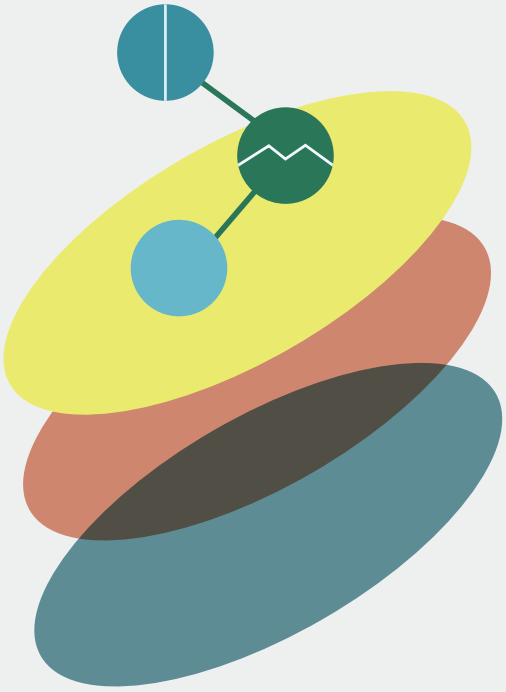

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