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

〔 高中一年級 〕

目次 Table of Contents

★主題一 物質的組成★
The Structure of Substance

國立彰化師範大學化學系　方宣幃、邱韋慈
國立彰化師範大學英語系　劉俊億、徐毓瑩

■ 前言 Introduction

國中階段學生已學過物質的分類，並了解物質分離的方法，已初步認識「原子說」，教師在此階段應先為學生提供相關背景知識，再延伸出倍比定律及定比定律，並藉由原子說導入亞佛加厥定律。接著透過國中階段所學過的原子發展史，了解原子內的基本粒子的不同特性，並透過原子中電子的排列，以了解元素的分類和週期性。利用八隅體規則，教師帶學生以路易斯電子點式，畫出價電子的排列方式，以了解不同類型的化學鍵。

在學生參與課堂的過程中，需要透過學習建議的專有詞彙，有利於未來以物質作為基礎的化學課程進行。建議老師在課程中多提供學生清楚表達詞彙意義的機會，並輔以「對比、舉例」以及比較級與最高級等功能之句型，以利師生間的提問與發表，並了解專有詞彙定義。

1-1 物質的分類與分離
The Classification and Separation of Substance

■ 前言 Introduction

國中階段時，學生已認識元素與化合物等之分類，及元素與化合物有特定的化學符號表示法，並認識元素與化合物在生活中常見的對應實例。因此，教師在本階段期望能讓學生藉由理論與實驗更深入物質的三相圖，理解物質的形態、性質及分類。同時運用物質的分類與物質的特性，教師也能透過實驗搭配說明，呈現物質分離及鑑定方法。

就語言來說，在本課程中除了教師教學會使用到的基礎字彙外，教師能提供用於定義不同物質分類及舉例之句型，讓學生進而理解分解與分離的不同。在過程中，學生可能會發現物質會呈現不同的形態，因此教師可以以表示變化之句型引導學生觀察物質型態的變化。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
thin Layer Chromatography	薄層層析法	gas	氣態
boiling point	沸點	distillation	蒸餾法
separate	分離	pure substance	純物質
decompose/break down	分解	supercritical fluid	超臨界流體
freezing	凝固	precipitation	沉澱
deposition	凝華	chromatography	色層分析
condensation	凝結	sublimation	昇華

critical point	臨界點	solubility	溶解度
filter paper	濾紙	melting point	熔點
solid	固態	melt	熔化
filter	過濾	extract	萃取
mixture	混合物	liquid	液態
decantation	傾析	pressure	壓力
compound	化合物	physical change	物理變化
chemical change	化學變化	substance	物質
crystallization	結晶	microscopic	微觀
macroscopic	巨觀	temperature	溫度
vaporization	汽化	element	元素

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

❶ _____ can be separated into _____.

例句：Mixtures **can be separated into their component matter**.

混合物能分離成其組成物質。

❷ _____ can be decomposed into _____/ _____ can be broke down into _____.

例句(1)：Upon heating, sodium hydrogen carbonate **can be decomposed into** sodium carbonate, water, and carbon dioxide.

碳酸氫鈉在加熱時可以分解成碳酸鈉、水和二氧化碳。

例句(2)：Compounds **can be broken down into** elements.

化合物分解成元素。

❸ _____ can be categorized into _____ by _____.

例句：Matter **can be categorized into** pure substances and mixtures **by** whether they can be separated by physical means.

物質可以藉由能否被物理方式分離而分為純物質與混合物。

❹ _____ is an example of _____.

例句：Seawater **is an example of** salt mixtures.

海水是一種含鹽類混合物的例子。

❺ _____ is changed into _____/_____ is transferred into _____/_____turn into _____.

例句：When solid ice is at a temperature of zero degrees Celsius, the ice begin to melt and will **turn into** liquid water.

當固態冰的溫度為零攝氏度時，冰將開始熔化並變成液態水。

❻ It is possible to separate compounds through _____.

例句：**It is possible to separate compounds through** distillation, using the differences in their boiling points to isolate substances.

可以通過蒸餾法分離化合物，利用物之間沸點的不同來分離物質。

■ 問題講解 Explanation of Problems

ଔ 學習目標 ଛ

一、學生可以學習到利用純物質及混合物的特性差異來分類生活中出現的物質。

Students can learn to use the differences in the characteristics of pure substances and mixtures to classify matter appearing in life.

二、學生能利用蒸餾、萃取、色層分析、硬水軟化及海水純化等等特殊方法將混合物分離或純化，進而確認其組成。

Students can learn special methods such as distillation, extraction, chromatography, hard water softening and seawater purification to separate or purify the mixture, and then confirm its composition.

☙ 例題講解 ಬ

例題一

說明：學生可以以純物質、混合物及化合物的異同來判斷選項中物質的分類型態敘述是否正確。

Students can determine whether the description of the classification of substances in the options is correct based on the similarities and differences of pure substances, mixtures and compounds.

（英文）Which of the following statements about the classification of common substances is correct?

(A) The main component of table salt is sodium chloride, which is a pure substance.

(B) Pure water can generate hydrogen and oxygen through electrolysis, so it is not a pure substance.

(C) The solution of sugar is composed of pure sugar and pure water, and therefore it is a pure substance.

(D) Stainless steel is not easy to rust, so it is a pure substance.

(E) Hydrogen peroxide contains oxygen atoms and hydrogen atoms, and therefore it is a mixture.

（中文）下列有關常見物質分類的敘述，何者正確？

(A)食鹽的主要成分為氯化鈉，是純物質。

(B)純水可經由電解生成氫氣及氧氣，所以不是純物質。

(C)糖水為純糖溶於純水組成，是純物質。

(D)不鏽鋼不易生鏽，所以是純物質。

(E)過氧化氫含有氧原子及氫原子，是混合物。

（南一版 110 上課本（化學全）第一章 第 15 頁 例題）

解題 Solution：

(B)純水是化合物，所以是純物質；(C)是混合物；(D)不鏽鋼為含鐵、鉻及鎳的合金，所以是混合物；(E)過氧化氫是化合物，所以是純物質。

Pure water in option (B) is a compound, so it is a pure substance; the solution of sugar in option (C) is a mixture; stainless steel in option (D) is an alloy containing iron, chromium and nickel, so it is a mixture; hydrogen peroxide in option (E) is a compound, so it is a pure substance.

Teacher: The question item mentions the classification of common substances. What are the classification of substances that we have learned in class?

Student: Matter can be divided into pure substances, mixtures, and pure substances can be subdivided into elements and compounds.

Teacher: So how should we differentiate?

Student: Mixtures can be separated into pure substances by physical methods. Compounds in pure substances can break down into other compounds or elements.

Teacher: Is option (A) correct, based on the classification?

Student: It is correct. Sodium chloride is a pure substance.

Teacher: Is option (B) correct?

Student: It is incorrect. Pure water is a compound, so it is a pure substance.

Teacher: Is option (C) correct?

Student: It is incorrect. The solution of sugar is a mixture of water and sugar.

Teacher: Is option (D) correct?

Student: It is incorrect. Stainless steel is an alloy containing iron, chromium and nickel, so it is a mixture.

Teacher: Is option (E) correct?

Student: It is incorrect. Hydrogen peroxide is a compound, so it is a pure substance.

老師： 題幹中提到常見物質的分類，請問我們在課堂中學到物質可以分成哪幾類？

學生： 可以分成純物質、混合物，而純物質又可以細分成元素和化合物。

老師： 那請問我們該如何區分呢？

學生： 混合物可以透過物理方法分離成純物質。純物質中的化合物可以再透過化學方法分解成其他化合物或元素。

老師： 那根據這個分類方式，選項(A)正確嗎？

學生： 正確。氯化鈉是純物質。

老師： 選項(B)正確嗎？

學生： 不正確。純水是化合物，所以是純物質。

老師： 選項(C)正確嗎？

學生： 不正確。糖水是由水跟糖組成的混合物。

老師： 選項(D)正確嗎？

學生： 不正確。不鏽鋼為含鐵、鉻及鎳的合金，所以是混合物。

老師： 選項(E)正確嗎？

學生： 不正確。過氧化氫是化合物，所以是純物質。

例題二

說明：學生可以了解如何運用混合物的特性並採用特定的分離方式來分離該混合物。
Students can understand how to use the properties of the mixture and specific separation methods to separate the mixture.

（英文）After mixing the two matter in each option, they will be separated by distillation. Which option would be less effective in its separation? (The boiling point of the substance is shown in parentheses.)

(A) Ethyl acetate (77°C) and Diethyl ether (35°C).

(B) Alcohol (78°C) and Acetone (56°C).

(C) Toluene (111°C) and Benzene (80°C).

(D) n-Hexane (68°C) and Cyclohexane (81°C).

(E) Diethyl ether (35°C) and Dichloromethane (39°C).

（中文）下列各選項中的兩種物質混合後，再以蒸餾法分離，何者的分離效果最差？（括弧內為該物質之沸點）

(A)乙酸乙酯（77°C）與乙醚（35°C）。

(B)酒精（78°C）與丙酮（56°C）。

(C)甲苯（111°C）與苯（80°C）。

(D)正己烷（68°C）與環己烷（81°C）。

(E)乙醚（35°C）與二氯甲烷（39°C）。

（翰林版化學（全）課本　第一章　物質的分類與組成　範例 1-2）

解題 Solution：

蒸餾法是利用沸點差異以分離物質，故沸點差異愈小者，分離效果愈差。故選(E)。

Distillation is a method that uses differences in boiling point to separate matter, so the less different the two substances are in their boiling points, the less effective the separation would be. Therefore, we should choose (E).

Teacher:　The question item mentions the distillation method. In which part of the lesson have we learned this method, and what is it?

Student:　We have learned this method in the section "Separation of Mixtures" that distillation is a method used to separate pure substances in mixtures. It makes use of the difference in boiling point of substances to separate mixtures, so the bigger the difference in boiling point the compounds in the mixture have, the more effective the separation will be. In other words, the smaller the difference in boiling point the

compounds in the mixture have, the less effective the separation will be.

Teacher: Then, which pair of the compounds in the following option has the smallest difference in boiling point?

Student: The boiling point in option (A) is 42°C; in option (B) is 22°C; in option (C) is 31°C; in option (D) is 13°C; in option (E) is 4°C. The compounds in option (E) have the smallest difference in boiling point, and therefore they will have the least effective separation by distillation.

老師： 這題題幹中提到蒸餾法，請問我們在課堂中的哪個小節有學到過？那蒸餾法是什麼？

學生： 我們在「混合物的分離」小節中有學過，蒸餾法是一種用來分離混合物中的純物質的方法，它是利用物質沸點的差異來分離混合物，故混合物中的不同化合物沸點差異愈大，分離效果愈好；換句話說，差異愈小，分離效果愈差。

老師： 那選項中的化合物的沸點差異最小的為何者？

學生： (A)選項的沸點差 42°C；(B)選項的沸點差 22°C；(C)選項的沸點差 31°C；(D)選項的沸點差 13°C；(E)選項的沸點差 4°C。(E)選項沸點差異最小，因此用蒸餾法分離效果最差。

1-2 道耳頓的原子說
Dalton's Atomic Theory

■ 前言 Introduction

本節首先提及質量守恆定律，接著認識道耳頓的原子說以及分子概念，透過科學發展史的過程認識原子說與分子概念。首先比較道耳頓原子說與現今觀點的不同，進一步認識定比定律與倍比定律；再透過氣體化合體積定律和亞佛加厥定律，了解氣體體積與分子個數的關係。老師應帶領學生探討例題，試著分析題目的線索與所學的知識，讓學生更熟悉這些定理的運用，有助於學生的理解和學習。

語言方面，因為本節將學到許多新的定律，所以必須先認識定律的名稱。在進行課堂活動和講解例題時，老師可以反覆地讓學生說出這些定律的內涵，以加深學生對定律的熟悉度，因此需要提供學生描述條件、構成、與因果的句型，幫助學生能夠解釋定律內容。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
law of multiple proportions	倍比定律	law of combining volumes of gasses	氣體化和體積定律
ratio	比率	property	性質
indivisible	不可分割的	mass	質量
arrangement	排列	conservation of mass	質量守恆
molecule	分子	phlogiston theory	燃素說
law of definite proportions	定比定律	Avogadro's law	亞佛加厥定律

isotope	同位素	mercuric oxide	氧化汞
grain	格令	atom	原子
compound	化合物	atomism / atomic theory	原子說

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

❶ **No matter _____, _____.**

例句：**No matter** how the compound is made, the mass ratio of its constituent elements is fixed.
無論此化合物是如何製成，其組成元素的質量比不變。

❷ **Regardless of _____, _____.**

例句：**Regardless of** the state of this compound changes, the mass ratio of its constituent elements

is fixed.

無論此化合物的狀態如何變化，其組成元素的質量比不變。

❸ **_____ be made up of _____.**

例句：All matter **is made up of** tiny particles called atoms.
所有物質皆是由被稱為原子的微小粒子所構成。

❹ **_____ consist(s) of _____.**

例句：Atoms **consist of** electrons, protons, and neutrons.
原子由電子、質子和中子所組成。

❺ **_____ because of _____.**

例句：**Because of** the discovery of isotopes, we know that the same elements do not necessarily

have the same mass.
由於同位素的發現，我們得知相同的元素不一定具有相同的質量。

❻ _____ thanks to _____.

例句：**Thanks to** the discovery of isotopes, we know that the same elements do not necessarily have the same mass.

由於同位素的發現，我們得知相同的元素不一定具有相同的質量。

❼ _____ account for _____.

例句：Sodium **accounts for** about 40% of the weight of sodium chloride.

鈉在氯化鈉中大約佔 40%的重量。

❽ At the beginning, _____.

例句：**At the beginning,** people thought burning is a process of breaking down and releasing phlogiston.

一開始，人們認為燃燒是分解和釋放燃素的過程。

❾ _____, however, _____.

例句：Lavoisier's experiment**, however,** found that the total mass of the substance didn't change before and after the chemical reaction.

然而拉瓦節的實驗發現質量反應前後，物質的總質量不變。

❿ Later, _____.

例句：**Later,** scientists speculated that there is a proportional relationship between reactants and products.

後來，科學家推測到反應物和產物之間存在比例關係。

■ 問題講解 Explanation of Problems

❧ 學習目標 ❧

一、學生可以學習到利用化學發展的脈絡，及認識質量守恆定律、定比定律、倍比定律及原子說的內容與用途。

Students can learn to understand the content and application of the law of conservation of mass, the law of definite proportions, the law of multiple proportions, and the atomic theory by using the historical context of chemical development.

二、學生可以認識到氣體化合體積定律、亞佛加厥定律等分子說的內容和用途。

Teachers can use the context of chemical development to guide students to understand the content and use of molecular theories such as the law of combining volumes of gases and Avogadro's law.

❧ 例題講解 ❧

例題一

說明：學生需要先透過化合物中元素的質量百分比，推導出原子數比與原子量；再利用元素的質量百分比和固定一元素的質量說明倍比定律。

Students need to first deduce the atomic number ratio and atomic weight through the mass percentage of the elements in the compound; and then use the mass percentage of the element and fix the mass of an element to explain the law of multiple proportions.

（英文）An unknown element M has two oxides A and B. The mass percentage of element M is 70.0% and 77.8%, respectively.　Please answer the following questions: (atomic weight: O = 16.0)

(1) We know that the atomic number ratio of M to O in compound A is 2:3. Find the atomic weight of M.

(2) Find the atomic number ratio of M to O in compound B.

(3) Explain the law of multiple proportions according to the above data.

（中文）某元素 M 的兩種氧化物甲與乙中，元素 M 的質量百分比依序為 70.0%、77.8%，回答下列問題：(原子量：O = 16.0)

(1)已知化合物甲中 M 與 O 的原子數比為 2：3，求 M 的原子量。

(2)求化合物乙， M 與 O 的原子數比。

(3)依上列數據說明倍比定律。

（翰林版化學（全）課本 第一章 物質的分類與組成 範例 1-3）

解題 Solution：

(1)設 M 的原子量為 X ，取 100.0 克化合物甲，含 70.0 克 M、30.0 克 O

$$\frac{70.0}{X} : \frac{30.0}{16.0} = 2 : 3$$

解得 X = 56.0 ，即 M 的原子量為 56.0。

(2)利用(1)的結果：

$$\frac{77.8}{56.0} : \frac{22.2}{16.0} = 1 : 1$$

(3)化合物甲中，M、O 質量比為

70.0%：(1−70.0%) = 70.0/30.0：30.0/30.0 = 2.33：1

化合物乙中，M、O 質量比為

77.8%：(1−77.8%) = 77.8/22.2：22.2/22.2 = 3.50：1

固定甲、乙中 O 的質量，M 的質量比為 2.33：3.50 ＝ 2：3，為簡單整數比，故符合倍比定律。

(1) Let the mass of M be X. Take 100.0 g of compound A, containing 70.0 g of M and 30.0 g of O

$$\frac{70.0}{X} : \frac{30.0}{16.0} = 2 : 3$$

We can get that X = 56.0; that is, the atomic weight of M is 56.0.

(2) Using the result of (1)

$$\frac{77.8}{56.0} : \frac{22.2}{16.0} = 1 : 1$$

(3) In compound A, the mass ratio of M and O is

70.0/30.0：30.0/30.0 = 2.33：1

In compound B, the mass ratio of M and O is

77.8%：(1−77.8%) = 77.8/22.2：22.2/22.2 = 3.50：1

If we fix the mass of O in compound A and B, the mass ratio of M is 2.33：3.50 = 2:3.

2:3 is a simple integer ratio, so it conforms to the law of multiple proportions.

Teacher:	The questions show the mass percentage of compounds A and B. Based on the knowledge we learned in junior high school, what does mass percentage mean?
Student:	The mass ratio of an element in a compound.
Teacher:	Yes. The mass percentage of element M is 70.0%, which means that element M accounts for 70.0% of the weight of substance A. If we take 100 grams of substance A, it will contain 70 grams of element A and 30 grams of oxygen. The question mentioned that the atomic number ratio of M to O in compound A is 2:3. How do you find the atomic number?
Student:	We divide element mass by atomic weight.

Teacher: If the mass of M is X, how do you solve X?

Student: 70 grams of M divided by X to 30 grams of O divided by 16. We can get that the atomic weight X is 56.0.

Teacher: Great. We can solve the second question in the same way. If we take 100 grams of compound B, it will contain M element 77.8 g and O element 22.2 g. How can we use the answer in the first question to deduce the atomic number ratio of compound B?

Student: 77.8 g M divided by atomic weight 56.0 to 22.2 g O divided by atomic weight 16, the atomic number ratio is about 1:1.

Teacher: Very good. Do you remember the law of multiple proportions that we learn today?

Student: Given that two elements can form two or more compounds. If the mass of one element is fixed, the mass of the other element will become a simple integer ratio.

Teacher: We have to fix the mass of M or O before we distinguish whether these elements conform to the law of multiple proportions. Suppose we fix the mass of O. How should we write the formula?

Student: For compound A, the mass ratio of M to O is

$70.0\% : (1 - 70.0\%)$

$= 70.0/30.0 : 30.0/30.0$

$= 2.33 : 1.$

For compound B, the mass ratio of M to O is

$77.8\% : (1 - 77.8\%) = 77.8/22.2 : 22.2/22.2 = 3.50 : 1.$

Teacher: After fixing the mass of O, what is the mass ratio of M between the two substances?

Student: $2.33 : 3.50 = 2 : 3.$

Teacher: This is a simple integer ratio, so it conforms to the law of multiple proportions.

老師： 題目提供了元素 M 在化合物甲、乙的質量百分比，根據國中所學到的知識，質量百分比的意思是什麼？

學生： 化合物中某元素所占的質量比率。

老師： 沒錯，元素 M 的質量百分比為 70.0%，也就是說元素 M 在化合物甲中占 70.0% 的質量。假設我們取 100 克的化合物甲，則代表含有 70 克的元素 M 和 30 克的 O；題目也提到化合物甲中 M 與 O 的原子數比為 2：3，要如何算出原子數？

學生： 元素所佔質量除以原子量。

老師： 假設 M 的質量為 X，該如何解出 X？

學生：　70 克 M 除以原子量 X 比 30 克 O 除以原子量 16 等於 2:3，可算出原子量 X 是

56.0。$\dfrac{70.0}{X} : \dfrac{30.0}{16.0} = 2 : 3$　　解得 X = 56.0。

老師：　沒錯，第二小題同理，假設取物質乙 100 克，其中含有 M 元素 77.8 和 O 元素 22.2，我們如何利用第一小題的結果推得化合物乙的原子數比呢？

學生：　77.8 克 M 除以原子量 56.0 比 22.2 克 O 除以原子量 16，得原子數大約比 1:1。

$$\dfrac{77.8}{56.0} : \dfrac{22.2}{16.0} = 1 : 1$$

老師：　非常好，我們這堂課學過倍比定律，你們還記得何謂倍比定律嗎？

學生：　兩種元素可以形成兩種以上的化合物，這些化合物中，其中一個元素質量固定，則另一元素的質量將會成簡單整數比。

老師：　所以我們得先固定 M 或 O 的質量，才能判斷這些元素是否符合倍比定律。

學生：　將化合物甲的 M 與 O 的質量比化簡為
70.0%：(1－70.0%) = 70.0/30.0：30.0/30.0 = 2.33：1；
將化合物乙的 M 與 O 的質量比化簡為
77.8%：(1－77.8%) = 77.8/22.2：22.2/22.2 = 3.50：1。

老師：　固定 O 的質量後，兩物質的 M 質量比為多少？

學生：　2.33：3.50＝2：3。

老師：　此為簡單整數比，故符合倍比定律。

例題二

說明：學生需要先理解拉瓦節的質量守恆定律和道耳頓原子說，即可完成此題。

Students need to understand Lavoisier's law of conservation of mass and the Dalton atomic theory to answer this question.

（英文）Which of the following is the most appropriate explanation for the law of conservation of mass?

(A) The number of molecules remains unchanged before and after the reaction.

(B) At the same temperature and pressure, the same volume of gas contains the same number of molecules.

(C) In general reaction, the type and number of atoms remain unchanged.

(D) Energy cannot be destroyed.

(E) For a compound, the mass ratio of its elements is a fixed value.

（中文）關於質量守恆定律，下列何種解釋最恰當？

(A) 反應前後分子數目不變。

(B) 同溫、同壓下，同體積的氣體含相同分子數。

(C) 一般反應中原子種類及個數不變。

(D) 能量不滅。

(E) 對某一化合物而言，各個元素間的質量比為定值

（南一版 110 上課本（化學全）第一章 第 34 頁 第 7 題）

解題 Solution：

(A) 反應前後原子數目不變。

(B) 同溫、同壓下，同體積的氣體含相同分子數是亞佛加厥定律。

(C) 正確。

(D) 原子不滅 。

(E) 此為定比定律的敘述。

(A) The number of atoms remains unchanged before and after the reaction.

(B) At the same temperature and pressure, Avogadro's law states that the same volume of gas contains the same number of molecules.

(C) correct.

(D) Atomic particles do not die out.

(E) This is a statement of the law of definite proportions.

Teacher:	Based on what we learn in this class, what does the law of conservation of mass mean?
Student:	The total mass of the substance doesn't change before and after the chemical reaction.
Teacher:	Yes, only the atoms rearrange, and the type and number of atoms do not change before and after the chemical reaction? So, (C) is correct. Then why is (A) incorrect?
Student:	The number of molecules may change before and after the reaction. For example, when hydrogen and oxygen produce water molecules, the number of molecules changes. The balanced equation for the reaction is $2H_2 + O_2 \rightarrow 2H_2O$. There are 3 moles before the reaction and 2 molecules after the reaction. However, the number of atoms before and after the reaction remains the same.
Teacher:	Yes, the number of "atoms" remains unchanged before and after the reaction. Why is option (B) incorrect?
Student:	Because option (B) describes Avogadro's law, not the law of conservation of mass.
Teacher:	Why is the (D) option incorrect?
Student:	It is correct to change "energy never disappears" to "atoms never disappear".

Teacher: Good job. What is the error of option (E)?

Student: This is the statement of the law of definite proportions.

老師： 根據這堂課所學，質量守恆定律的意義是什麼？

學生： 化學反應前後，物質總質量不變。

老師： 沒錯，因為化學反應前後，只有原子重新排列，原子的種類與個數沒有改變，所以(C)正確。那麼(A)選項為何錯誤？

學生： 反應前後分子數量可能會發生變化，例如:氫氣與氧氣產生水分子的分子數量變化，$2H_2 + O_2 \rightarrow 2H_2O$，反應前分子有 3 個，反應後分子有 2 個，但是反應前後原子數量不變。

老師： 沒錯，是反應前後「原子」數目不變。那(B)選項為何錯誤？

學生： 因為(B)選項在描述的是亞佛加厥定律，並非質量守恆定律。

老師： 那(D)選項為何錯誤？

學生： 要把「能量不滅」改成「原子不滅」才對。

老師： 很好，請問(E)選項為什麼錯誤？

學生： 這是定比定律的敘述。

1-3 原子結構與元素週期表
Atomic Structure and Periodic Table of Elements

■ 前言 Introduction

學生已學過原子序、質量數、初步認識同位素及元素週期表。本節將介紹原子的三種基本粒子的質量、電荷及表示法，並詳細介紹同位素的異同與應用，並利用元素週期表依據元素的原子序大小順序，有規律的排列的特性，了解元素的分類、大小、得失電子的規律性。學生在本單元第一次認識電子殼層，建議教師以填入電子的方式讓學生了解價電子和價殼層，並利用殼層來解釋原子的大小與電子得失原因。

本節的語言聚焦在能夠讓學生認識原子結構相關理論的句型，包括了解原子結構之名稱、定理之解釋及定理中細節之敘述，以利學生在學習後能夠向他人闡述原子的基本結構。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
semiconductor	半導體	alkaline earth metal	鹼土金屬
nonmetal	非金屬	alkali metal	鹼金屬
representative elements	典型元素	metal	金屬
electrically neutral	電中性	mass number	質量數
electron	電子	proton	質子
electron cloud	電子雲	main-group elements	主族元素
noble gas	鈍氣	neutron	中子
isotope	同位素	malleability	展性

halogen	鹵素	period	週期
metalloid	類金屬	group	族
transition element	過渡元素	ductility	延性
shell	殼層	periodic table of element	元素週期表
valence electron	價電子	atomic number	原子序
alence shell	價殼層		

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

❶ _____ be called _____. / _____ be also known as _____.

例句：Group 17 elements **are called** halogens.
　　　第 17 族元素稱為鹵素。

❷ from _____ to _____.

例句：The shells are called K, L, M, and N sequentially **from** inside **to** outside.
　　　殼層由內而外依次稱為 K、L、M、N。

❸ The _____-er _____, the _____-er _____.

例句：**The more** charged the nucleus are, **the stronger** the attraction of the outermost electrons are, which brings them closer to the nucleus.
　　　核電荷越多，最外層電子吸引力越強，使其越靠近原子核。

❹ _____, _____, and _____ respectively.

例句：The maximum number of electrons that can be accommodated in the K-shell, the L-shell, and the M-shell is 2, 8, **and** 18 **respectively**.
　　　K 層、L 層、M 層最多可容納的電子數分別為 2、8、18。

❺ _____ be accommodated in _____.

例句：The maximum number of electrons that can **be accommodated in** the N-shell is 32.

N 層最多可以容納 32 個電子。

■ 問題講解 Explanation of Problems

❧ 學習目標 ❧

一. 學生能了解同位素的異同與應用。

Students can understand the similarities and differences and applications of isotopes.

二. 學生可以用元素週期表了解元素的分類、電子排列、原子半徑、金屬特性等，再以電子排列預測元素失去或獲得電子的傾向。

Students can use the periodic table to understand the classification, electronic arrangement, atomic radius, metal properties, etc. of elements, and then use electronic arrangement to predict the tendency of elements to lose or gain electrons.

❧ 例題講解 ❧

例題一

說明：學生能從電子數、中子數、質子數判斷同位素。

Students can identify isotopes from the number of electrons, neutrons, and protons.

（英文）The number of protons, electrons and neutrons contained in the four atoms a, b, c, and d are shown in the table below. Which two are isotopes?

	number of protons	number of electrons	number of neutrons
a	8	8	9
b	8	8	10
c	9	9	10
d	11	11	12

(A)a、c　**(B)a、b**　(C)b、c　(D)c、d　(E)b、d

（中文）a、b、c、d 四個原子所含的質子數、電子數和中子數如下表所示，試問哪兩者為同位素？

原子	質子數	電子數	中子數
a	8	8	9
b	8	8	10
c	9	9	10
d	11	11	12

(A)a、c　　**(B)a、b**　　(C)b、c　　(D)c、d　　(E)b、d

（康軒版化學課本　第一章　第 59 頁　習題第 7 題）

解題 Solution：

同位素具有相同的電子數、質子數，但有不同的中子數及質量數。a 與 b 原子的電子數和質子數相同，但中子數不同，故選(B)。

Isotopes have the same number of electrons and protons, but different numbers of neutrons and masses. a and b have the same number of electrons and protons, but different numbers of neutrons, so choose (B).

Teacher:　What is the definition of isotope?

Student:　Atoms with the same atomic number but different mass numbers.

Teacher:　Therefore, which of the isotopes will have the same number of electrons, protons, and neutrons?

Student:　Number of electrons and protons.

Teacher:　That's right. Which one would be different?

Student:　Number of neutrons.

Teacher:　So which two in the table fit the definition of an isotope?

Student:　a and b, because they have the same number of electrons and protons, but different numbers of neutrons.

老師：　同位素的定義是什麼？

學生：　原子序相同但質量數不同的原子。

老師：　因此同位素的電子、質子、中子數量何者會相同？

學生：　電子數和質子數。

老師：　沒錯，哪一個會不同？

學生： 中子數。

老師： 所以表格中哪兩個符合同位素的定義？

學生： a 和 b，因為他們電子數和質子數相同，但中子數不同。

例題二

說明：學生能利用原子序推理出原子的性質。

Students can use the atomic number to deduce the properties of atoms.

（英文）It is known that the element with atomic number 54 is a noble gas. Which of the following properties is correct for element A with atomic number 56?

(A) It belongs to group 13.

(B) It tends to lose 1 electron during the reaction.

(C) Its oxide is soluble in water, showing acidity.

(D) A reacts with chlorine to obtain a molecular compound.

(E) It belongs to the element of the sixth period.

（中文）已知原子序 54 的元素為鈍氣，下列有關原子序 56 的元素 A 之相關性質，何者正確？

(A)屬於第 13 族。

(B)反應時趨向失去 1 個電子。

(C)其氧化物溶於水，呈現酸性。

(D)A 與氯氣反應後得到分子化合物。

(E)屬於第六週期的元素。

（翰林版化學(全)課本　第一章　物質的分類與組成　第 31 頁第 16 題）

解題 Solution：

元素 A 應為金屬鋇 $_{56}Ba$，(A)54＋2＝56，屬於第 2 族。(B)反應時趨向失去 2 個電子。(C)其氧化物溶於水，呈現鹼性。(D) A 與氯氣反應後得到離子化合物。(E) 2＋8＋8＋18＋18＋2＝56，屬於第六週期的元素。

Element A should be metal barium $_{56}Ba$. (A) 54+2=56, belonging to group 2. (B) The reaction tends to lose 2 electrons. (C) Its oxide is soluble in water and is alkaline. (D) The ionic compound is obtained after A reacts with chlorine gas. (E) 2+8+8+18+18+2=56, which belongs to the element of the sixth period.

Teacher: From the title, we can know that atomic number 54 is a noble gas of group 18, so it can be inferred which group element is atomic number 56?

Student: It should be Group 2.

Teacher: That's right, so is it a metal, a metalloid, or a non-metal?

Student: Metals, elements of group 2 are all metals.

Teacher: So his oxide dissolves in water. Is it acidic or basic?

Student: Metal oxides dissolve in water and are alkaline

Teacher: Very good, elements of group 2 tend to lose a few electrons and become stable ions?

Student: 2, because the outer shell has two valence electrons.

Teacher: So what period should the atomic number 56 be?

Student: The sixth period, because 2+8+8+18+18+2.

Teacher: Chlorine is easy to form anions, and the atoms in the question are easy to form cations. What compounds will be formed by the combination of anions and cations?

Student: Ionic compounds.

Teacher: Excellent, so the answer to this question is (E).

老師： 從題目可以知道原子序 54 是第 18 族的鈍氣,所以可以推測原子序 56 是哪一族元素?

學生： 應該是第 2 族。

老師： 沒錯,所以他是金屬、類金屬還是非金屬?

學生： 金屬,第 2 族的元素都是金屬。

老師： 所以他的氧化物溶於水是酸性或鹼性?

學生： 金屬氧化物溶於水呈鹼性。

老師： 非常好,第 2 族的元素容易失去幾個電子而成為穩定離子?

學生： 2 個,因為最外層有兩個價電子。

老師： 那麼原子序 56 應該是第幾週期的元素?

學生： 第六週期,因為 56=2+8+8+18+18+2。

老師： 氯容易形成陰離子,題目中的原子容易形成陽離子,陰陽離子結合會形成什麼化合物?

學生： 離子化合物。

老師： 太優秀了,所以這題答案是(E)。

1-4 化學鍵
Chemical Bonds

■ 前言 Introduction

在國中階段已學習過原子與分子的概念，其種類又細分為單原子分子、雙原子分子及多原子分子，在此階段教師可以先為學生複習後，再透過八隅體規則與路易斯電子點式，導入化學鍵的種類及概念。

語言方面，在教學中需要提供學生能敘述化學鍵概念的句型，以利學生學習化學鍵時能進行區分及定義。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
octet rule	八隅體規則	chemical bond	化學鍵
electron transfer	電子轉移	metallic bond	金屬鍵
electron sea	電子海	bonding electron pair	鍵結電子對
monoatomic molecular	單原子分子	electrostatic attraction	靜電引力
multi-atomic ion	多原子離子	crystal	晶體
allotrope	同素異形體	valence electron	價電子
ionic bond	離子鍵	silicon	矽
ionic compound	離子化合物	double bond	雙鍵
Lewis electron dot structure	路易斯電子點式	quartz	石英

covalent bond	共價鍵	molten state	熔融態
covalent molecule	共價分子	triple bond	參鍵
covalent network solid	共價網狀固體	ductility	延展性
lone electron pair	孤電子對	fragility	易碎性

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

❶ _____ be bonded by _____.

例句：Nonmetal atoms **are** often **bonded by** sharing valence electrons.

非金屬原子時常藉由共用價電子的方式來結合。

❷ _____ combine with _____ to form_____.

例句：The sodium ion **combines with** the hydroxide ion **to form** an ionic bond.

鈉離子與氫氧根離子形成離子鍵。

❸ _____ have higher/lower melting points and boiling points than _____.

例句：Solids formed from covalent molecules generally **have lower melting and boiling points than** ionic compounds.

由共價分子形成的固體通常比離子化合物具有更低的熔點和沸點。

❹ ____ be confined to ____. /_____ be limited to _____.

例句：Valence electrons in the metal can move freely throughout the crystal and **are** not **confined to** the in-between of two nucleuses.

金屬中的價電子可以在整個晶體中自由移動，並不局限於兩個原子核間。

■ 問題講解 Explanation of Problems

ભ 學習目標 ঙ

一、學生能了解由不同化學鍵（離子鍵、共價鍵、金屬鍵）所組成的化合物之性質。

Students can understand the properties of compounds based on different chemical bonds.

二、學生能判斷出各類不同物質的鍵結方式。

Students can determine the bonding types of various substances.

ঙ 例題講解 ભ

例題一

說明：解離子化合物的組成方式及特性。

To learn about the composition and properties of ionic compounds.

（英文）Knowing that both A and B are elements in the third column, and there are 2 valence electrons in A and 7 valence electrons in B, which of the following statements about the compounds formed by A and B are correct?

(A) Its chemical formula is A_2B.

(B) It is gas at room temperature.

(C) It has a high melting point.

(D) It lacks ductility.

(E) Its solid state and molten state cannot conduct electricity, but its aqueous solution can.

（中文）已知 A、B 皆為第三列元素，且 A 中有 2 個價電子，B 中有 7 個價電子，則下列有關 A、B 形成的化合物之敘述，哪些正確？

(A) 其化學式為 A_2B。

(B) 常溫下為氣體。

(C) 具有高熔點。

(D) 無延展性。

(E) 固態及熔融態不能導電，但水溶液可導電。

（南一版 110 上課本（化學全）第一章 第 62 頁 例題）

解題 Solution：

A 有兩個價電子，為鹼土族元素，B 有 7 個價電子，為鹵素，因此選項(A)應改為「A 與 B 生成離子化合物 AB_2」；(B)改為「常溫下離子化合物為固體」；(E)改為「固態時，離子化合物不能導電；但熔融態及水溶液時，離子化合物可導電」。

A has two valence electrons and is an alkaline earth element, B has seven valence electrons and is a halogen, so option (A) should be changed to "A and B generate an ionic compound AB_2"; (B) should be changed to "an ionic compound at room temperature" is a solid"; (E) is changed to "Ionic compounds cannot conduct electricity in solid state; However, in the molten state and aqueous solution, ionic compounds can conduct electricity."

Teacher:	From the question, we know that "A and B are elements in the third row, and there are respectively 2 and 7 valence electrons in A and B", so what elements A and B are, based on our inference?
Student:	A is magnesium, and B is chlorine.
Teacher:	Very good, we have learned from the class that the magnesium atoms of group 2A are easy to form positive divalent magnesium ions, while the chlorine atoms of group 7A are easy to form negative monovalent chloride ions, so when A and B are combined into a compound, what is the chemical formula?
Student:	AB_2.
Teacher:	How do A and B combine to form a compound?
Student:	Anions and cations attract each other with opposite charges to form ionic compounds.
Teacher:	That's right, what are the properties of ionic compounds?
Student:	It is solid at room temperature. It has a high melting point and is without ductility, and can conduct electricity in molten and aqueous solutions.

老師： 由題目可知「A、B 皆為第三列元素，且 A 中有 2 個價電子，B 中有 7 個價電子」，因此我們可以推論出 A 和 B 分別為什麼元素？

學生： A 為鎂，B 為氯。

老師： 很好，從課堂中我們學過 2A 族的鎂原子容易形成正二價的鎂離子，而 7A 族的氯原子容易形成負一價的氯離子，因此當 A 和 B 結合成化合物時，化學式該如何表示？

學生： AB₂。

老師： A 和 B 是以何種形式結合成化合物？

學生： 陰、陽離子以相反電荷相互吸引形成離子化合物。

老師： 沒錯，離子化合物的特性為何？

學生： 常溫下為固體、具有高熔點、無延展性，熔融態及水溶液皆可導電。

例題二

說明：能判斷出各類不同物質的鍵結方式。

To determine the bonding types of various substances.

（英文）Which of the following statements about the chemical bonds of the following substances is correct?

(A) NaOH has only ionic bonds.

(B) CH₃OH has only covalent bonds.

(C) KNO₃ has covalent and ionic bonds.

(D) CH₃COOH has covalent and ionic bonds.

(E) Mg is a metallic bond.

（中文）關於下列物質之化學鍵的敘述,哪些是正確的？

(A) NaOH 僅有離子鍵。

(B) CH₃OH 僅有共價鍵。

(C) KNO₃ 有共價鍵與離子鍵。

(D) CH₃COOH 有共價鍵與離子鍵。

(E) Mg 為金屬鍵。

（翰林版化學(全)備課用書_第 2 章 物質的構造 第 113 頁 習題 7）

解題 Solution：

選項(A)NaOH 含有離子鍵和共價鍵，選項(D)CH₃COOH 僅有共價鍵。

Option (A) NaOH contains both ionic and covalent bonds, and option (D) CH_3COOH has only covalent bonds.

Teacher: From what we have learned in the classroom, we know that when various substances are formed, what are the forces that bind atoms to each other?

Student: Ionic bond, covalent bond, metallic bond.

Teacher: That's right, and what rules do the formation methods need to follow?

Student: The octet rule.

Teacher: Therefore you know from the question whether option A is correct?

Student: No, because in addition to the sodium ion combined with the hydroxide ion as an ionic bond, the hydroxide ion itself is bonded by a covalent bond.

Teacher: Very good. Besides option A, which is wrong?

Student: Option D, because the acetic acid molecules are all formed in the form of covalent bonds, and there is no ionic bond.

Teacher: Very good, so the answer to this question should be (B)(C)(E).

老師： 由課堂中所學，我們知道形成各種物質時，原子間互相結合的作用力有哪些？

學生： 離子鍵、共價鍵、金屬鍵。

老師： 沒錯，且形成方式皆需要以什麼規則來進行？

學生： 八隅體規則。

老師： 因此從題目知道選項 A 是否正確？

學生： 錯誤，因為鈉離子除了和氫氧根離子結合為離子鍵外，氫氧根離子本身的鍵結方式為共價鍵。

老師： 很好，除了選項A是錯誤的以外還有哪些是錯誤的？

學生： 選項 D，因為醋酸分子皆以共價鍵形式形成。

老師： 很好，因此此題答案要選(B)(C)(E)。

★主題二 物質間的反應★
Reaction between Substances

國立彰化師範大學化學系　方宣幃、邱韋慈
國立彰化師範大學英語系　劉俊億、徐毓瑩

■ 前言 Introduction

本章主要教導學生認識化學式的種類及使用時機，接著介紹如何以化學反應式來描述化學變化，並利用原子不滅定律來平衡反應式，藉此教導學生如何以化學反應式來描述化學變化，利用化學反應式的係數比，進行一般的化學計量，其次，介紹熱化學反應式，即反應式中包含反應熱者稱之，並說明反應熱的定義及熱化學反應式的寫法。

本章出現的專有名詞適合運用「定義、解釋、補充說明」的句型，讓學生更明白這些名詞的意義。另外本章需要學生進行運算，學生必須學會基本數學計算的句型，並利用口述的方式描述自己的計算過程。最後，老師可以補充關於「比較、順序、相同相異」等句型，讓學生應用在小組討論中，有助於問題分析、同儕討論與口頭報告。

2-1 化學式
Chemical Formula

■ 前言 Introduction

在此小節教師介紹四種表示化學式的表示方法：分子式、結構式、實驗式與示性式。並帶學生了解其不同表示方式的意義，教師應透過常見的例子，導入此小節的觀念，並為學生建模擴充。

教師在教學過程中可以提供學生定義及解釋用途相關的句型，來讓學生分辨四種化學式表示方法，必要時可以提供延伸句型讓學生舉例。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
molecular formula	分子式	hydroxyl group	羥基
molecular model	分子模型	weight percentage	重量百分比
isomers	同分異構物	esters	酯類
ionic compound	離子化合物	empirical formula	實驗式
covalent compound	共價化合物	formula weight	式量
covalent network solid	共價網狀固體	rational formula	示性式
antioxidant	抗氧化劑	carboxyl group	羧基
structural formula	結構式	alkyl group	烷基

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

❶ _____ be used to _____.

例句：Rational formulas can **be used to** represent similar properties of certain molecules.

示性式可以用來表示某些分子的類似性質。

❷ _____ be used to _____, while _____ be used to _____.

例句：Molecular formulas **are used to** express the exact number of constituent elements and atoms contained in the molecule, **while** structural formulas can **be** further **used to** express the connection between the atoms in the molecule.

分子式用於表達分子中組成元素種類與所含原子的確切個數，而結構式可以進一步表示分子內原子間的連接情形。

❸ _____ be used for _____, such as _____.

例句：Empirical formulas **are** often **used for** ionic compounds, **such as** sodium chloride, and covalent network compounds, such as silica.

實驗式常用來表示離子化合物（如氯化鈉），與共價網狀化合物（如二氧化矽）。

❹ _____ refers to _____.

例句：The weight percentage **refers to** the percentage of the mass of each element in the compound to the total mass of the compound.

重量百分組成是指化合物中各元素質量佔該化合物總質量之百分比。

❺ _____ refers to _____; for example, _____.

例句：Isomers **refer to** substances with the same molecular formula but different atomic arrangements**; for example,** the two compounds, ethanol and methyl ether, have the same molecular formula as C_2H_6O, but they have different properties.

同分異構物是指分子式相同但原子排列結構不同的物質，例如，乙醇與甲醚兩種化合物，分子式同為 C_2H_6O，但性質不同。

■ 問題講解 Explanation of Problems

⊂ 學習目標 ∞

一、學生能學會四種化學式的表示方式，並了解其個別意義

Students can learn the four different representations of chemical formulas and understand their individual meanings.

∞ 例題講解 ⊂

例題一

說明：學生學會判斷各物質化學式的表達方式。

Students can learn to judge the expression of chemical formulas of various substances.

（英文）Which of the following chemical formulas is correct?

　　　(A) C_{60} -empirical formula.

　　　(B) $MgCl_2$ -empirical formula.

　　　(C) H_2O -molecular formula.

　　　(D) $CH_3COOC_5H_5$ -structural formula.

　　　(E) $C_{12}H_{22}O_{11}$ - rational formula.

（中文）下列各物質的化學式表達方式何者正確？

　　　(A) C_{60} -實驗式。

　　　(B) $MgCl_2$ -實驗式。

　　　(C) H_2O -分子式。

　　　(D) $CH_3COOC_5H_5$ -結構式。

　　　(E) $C_{12}H_{22}O_{11}$ -示性式。

（龍騰版 110 上課本（化學全）第二章 第 70 頁 練習 2-1）

解題 Solution：

(A)(C)(E)屬於分子式，用於非金屬元素所形成之分子化合物。

(B)屬於實驗式，常用於表達離子化合物、共價網狀固體。

結構式表達分子中原子在三度空間的排列情形，(D)屬於示性式，表達出有機化合物的官能基。

(A) (C) (E) belong to the molecular formula and are used for molecular compounds formed by non-metallic elements.

(B) is an experimental formula, commonly used to express ionic compounds, and covalent network solids.

The structural formula expresses the arrangement of atoms in the three-dimensional space of the molecule, (D) belongs to the representative formula, expressing the functional group of the organic compound.

Teacher:	What is this question asking for?
Student:	Various representations of chemical formulas.
Teacher:	What are some types of representations?
Student:	There are molecular formulas, empirical formulas, structural formulas, rational formulas.
Teacher:	Which of the options are molecular formulas?
Student:	(A), (C) and (E) are molecular formulas.
Teacher:	Why?
Student:	It's because they are all compounds formed by non-metallic elements.
Teacher:	Yes, then which of the options are empirical formulas?
Student:	(B) is an empirical formula.
Teacher:	Why?
Student:	It appears to be an ionic compound.
Teacher:	Yes, which of the options are structural formulas?
Student:	None of them seems to be a structural formula.
Teacher:	What is the structural formula?
Student:	Structural formula expresses the arrangement of atoms in three-dimensional space.
Teacher:	Yes, is option (D) a rational formula?
Student:	Yes.
Teacher:	Why?
Student:	It's because rational formula has functional groups that express organic compounds.

老師： 這一題在問什麼呢？
學生： 化學式的表示方法。
老師： 那麼化學式有哪些表示方式呢？
學生： 分子式、實驗式、結構式、示性式。
老師： 選項中哪些是分子式呢？

學生： (A)、(C)及(E)是分子式。

老師： 為什麼呢？

學生： 因為他們都是非金屬元素所形成的分子化合物。

老師： 對的，選項中哪些是實驗式呢？

學生： (B)是實驗式。

老師： 為什麼呢？

學生： 因為是離子化合物。

老師： 對的，那選項中哪些是結構式呢？

學生： 好像沒有。

老師： 那結構式是什麼呢？

學生： 結構式表達分子中原子在三度空間的排列情形。

老師： 對的，那選項(D)是示性式嗎？

學生： 是。

老師： 為什麼呢？

學生： 因為示性式表達出有機化合物的官能基。

例題二

說明： 學生能了解化學式表示方式所代表的意義。

Students can understand the meaning of different chemical formulas.

（英文）Which of the following statements about different chemical formulas are false?

(A) Experimental formula: It is commonly used to express ionic compounds, and covalent network solids.

(B) Molecular formula: It is used for molecular compounds formed by non-metallic elements.

(C) Structural formula: It expresses an atomic group in organic compounds with specific properties.

(D) Rational formula: It expresses the arrangement of atoms in three-dimensional space.

（中文）有關下列對不同化學式的敘述何者錯誤？

  (A)實驗式：常用於表達離子化合物、共價網狀固體。

  (B)分子式：用於非金屬元素所形成之分子化合物。

  (C)結構式：表達有機化合物具有特定性質之原子團。

  (D)示性式：表達分子中原子在三度空間的排列情形。

      （龍騰版 110 上課本（化學全）第二章 第 70 頁 例題 2-1）

解題 Solution：

(C)結構式表達分子中原子在三度空間的排列情形

(D)示性式表達有機化合物具有特定性質之原子團。

(C)Structural formula: It expresses the arrangement of atoms in three-dimensional space

(D)Rational formula: an atomic group that expresses organic compounds with specific properties.

Teacher: What is this question asking for?

Student: Various representations of chemical formulas.

Teacher: So what are types of representations?

Student: There are molecular formulas, empirical formulas, structural formulas, rational formulas.

Teacher: Then what is a molecular formula?

Student: It is often used for molecular compounds formed by non-metallic elements.

Teacher: Right, so what is an empirical formula?

Student: It is commonly used to express ionic compounds, and covalent network solids.

Teacher: Right, so what is a structural formula?

Student: It expresses the arrangement of atoms in three-dimensional space.

Teacher: Yes, what is a rational formula?

Student: It has functional groups that express organic compounds.

Teacher: So the descriptions of (C) and (D) are reversed, right?

Student: That's right.

老師： 這一題問什麼呢？

學生： 化學式的表示方法。

老師： 那麼化學式有哪些表示方式呢？

學生： 分子式、實驗式、結構式、示性式。

老師： 那什麼是分子式呢？

學生： 分子式常用於非金屬元素所形成之分子化合物。

老師： 對的，那什麼是實驗式呢？

學生： 實驗式常用於表達離子化合物、共價網狀固體。

老師： 對的，那結構式呢？

學生： 結構式表達分子中原子在三度空間的排列情形。

老師： 對的，那示性式呢？

學生： 因為它表達出有機化合物的官能基。

老師： 所以(C)跟(D)的答案顛倒了，對吧？

學生： 對的。

2-2 化學反應的原理
Principles of Chemical Reactions

■ 前言 Introduction

學生在國中已學過化學反應式的表示方法，並能夠平衡簡單的反應式。在高中階段需利用原子不滅定律、觀察法和代數法平衡化學反應式，並更進階的利用電荷不滅平衡化學反應式。

學生在本節中，應運用反應式平衡之句型，練習以口語方式表達反應與莫耳數的平衡。

此外，教師應補充表達「相等」、「相同」及表達「順序」的句型，讓學生得出平衡反應式。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
reaction conditions	反應條件	coefficient	係數
reactant	反應物	product	生成物
algebra method	代數法	catalyst	催化劑
simultaneous equations	聯立方程式	state of matter	物質狀態
observation method	觀察法	atom conservation	原子不滅
chemical equation	化學反應式		

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

❶ _____ mole(s) of _____ react with/through _____ to give _____ mole(s) of _____.

例句：One **mole of** ammonium dichromate will **decompose upon** heating **to give** one mole of chromium trioxide, one **mole of** nitrogen gas and four moles of water.

一莫耳的二鉻酸銨在加熱過程中分解，產生一莫耳的三氧化二鉻、一莫耳的氮氣與四莫耳的水。

❷ _____ be equivalent to _____. /_____ be identical to _____. /_____ be the same as _____.

例句：The mole of reactants i**s equivalent to** the mole of products produced.

反應物消耗的莫耳數等同與生成物生成的莫耳數。

❸ To begin with, _____.

例句：**To begin with,** we should set the coefficient of the most complex reactant to 1.

首先，令最複雜的反應物係數為 1。

❹ Eventually, _____. /In the end, _____.

例句：**Eventually,** we will have the balanced formula: One mole of ammonium dichromate will decompose upon heating to give one mole of chromium trioxide, one mole of nitrogen gas and four moles of water.

最後我們將得到平衡式：一莫耳的二鉻酸銨經過加熱分解後將產生一莫耳的三氧化二鉻、一莫耳的氮氣與四莫耳的水。

■ 問題講解 Explanation of Problems

 學習目標

一、學生能應用觀察法及代數法平衡化學反應式。

　　Students can apply observation and algebra methods to balance chemical reactions.

二、學生能利用原子不滅定律與電荷守恆定律平衡化學反應式。

　　Students can use the law of conservation of mass and the law of conservation of charge to balance chemical reactions.

 例題講解

例題一

說明：學生能利用觀察法平衡化學反應式。

　　　Students can balance chemical equation through observation.

（英文）The thermal decomposition of copper nitrate can be represented by the following chemical equation: $2\,Cu(NO_3)_2(s) \rightarrow 2\,CuO(s) + n\,X(g) + O_2(g)$ where X is a compound, try to figure out what is the value of the equilibrium coefficient n ?

（A）2 （B）3 **(C)4** （D）5 （E）6

（中文）硝酸銅受熱分解，可用下列反應式表示：$2\,Cu(NO_3)_2(s) \rightarrow 2\,CuO(s) + n\,X(g) + O_2(g)$ 式中 X 為化合物，試推出平衡係數 n 值為何？

（A）2 （B）3 **(C)4** （D）5 （E）6

（龍騰版 110 上課本（化學全）第二章 第 96 頁 練習 3）

Teacher: What are the principles of balancing chemical equations?

Student: Using conservation of atoms to compare whether the number of atoms before and after the reaction is the same.

Teacher: Then what substances are still missing in the question if we would like to balance it?

Student: 4 nitrogens and 8 oxygens are still missing.

Teacher: Then we can know that their proportional relationship of N and O is 4 to 8, so we can deduce X by proposing a common factor. Does anyone know what X is?

Student: Yes, I guess X is NO_2.

Teacher: What is the balance coefficient n?

 Student: The balance coefficient n is 4.

老師：　平衡化學反應式的準則是什麼呢？

學生：　利用原子不滅，比較反應前後原子個數是否相同。

老師：　那題目中還缺哪些原子才能平衡呢？

學生：　還缺少 4 個 N 和 8 個 O。

老師：　那我們可以知道他們的比例關係為 N:O=4:8，因此我們可以透過提出公因數來
　　　　推測出 X，請問有沒有人知道 X 是什麼？

學生：　可以，X 推測為 NO_2。

老師：　那平衡係數 n 是多少呢？

學生：　平衡係數 n 為 4。

例題二

說明：學生能利用代數法平衡化學反應式。

　　　　Students can use algebra methods to balance chemical reactions.

（英文）The activity of copper is less than that of hydrogen. Putting copper in dilute hydrochloric acid or dilute sulfuric acid will not react, but putting copper in dilute nitric acid will immediately produce copper nitrate, nitric oxide and water. Try to balance this chemical equation:

$Cu(s) + HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + NO(g) + H_2O(l)$

（中文）銅的活性小於氫，將銅放入稀鹽酸或稀硫酸皆不會有反應，但是將銅放入稀硝酸中，立即產生硝酸銅、一氧化氮及水，試平衡此化學反應式：

$Cu(s) + HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + NO(g) + H_2O(l)$

（翰林版化學(全)課本　第 3 章　化學式與化學計量　範例 3-5）

Teacher: If we want to balance the coefficients though algebra method, what strategy should we use first?

 Student: We should first make assumption that

a $Cu(s) + b\ HNO_3(aq) \rightarrow c\ Cu(NO_3)_2(aq) + d\ NO(g) + e\ H_2O(l)$.

And then make use of the relationship between the elements of reactants and products to write the chemical equation.

Teacher: First of all, what can we get after balancing the chemical reaction formula of Cu according to the conservation of atom?

Student: We can get a = c.

Teacher: Then what can we get after balancing the N atom?

Student: We can get b = 2c + d.

Teacher: Then what can we get after balancing the O atom?

Student: We can get 3b = 6c + d + e.

Teacher: What can we get after balancing the H atom?

Student: We can get b = 2e.

Teacher: Then how do we use the four equations obtained by atomic conservation to solve the coefficients?

Student: Take b = 2e into the equation and solve the simultaneous equation with b = 2c+d and 3b = 6c + d + e to get the proportional relationship e = (4/3)c and d=(2/3)c. After sorting out, we can get a relationship, a = c, b = (8/3)c, d = (2/3)c, e = (4/3)c, a : b : c : d : e = c : (8/3)c : c : (2/3)c : (4/3)c = 3 : 8 : 3 : 2 : 4. Therefore, the coefficients of a, b, c, d, e are 3.8.3.2.4 respectively.

Teacher: Yes, so what is the complete chemical balanced reaction formula?

Student: $3\ Cu(s) + 8\ HNO_3(aq) \rightarrow 3\ Cu(NO_3)_2(aq) + 2\ NO(g) + 4\ H_2O(l)$.

老師： 如果我們要用代數法平衡係數，我們的策略應該怎麼做？

學生： 我們應該假設 $a\ Cu(s) + b\ HNO_3(aq) \rightarrow c\ Cu(NO_3)_2(aq) + d\ NO(g) + e\ H_2O(l)$。並利用反應物和生成物之間各原子守恆的關係，寫出方程式解出來。

老師： 那首先，根據原子不滅，平衡 Cu 原子的化學反應式後可以看出什麼？

學生： 我們可以得到 a = c。

老師： 那我們平衡 N 原子後可以得到什麼？

學生： 我們可以得到 b = 2c + d。

老師： 那我們平衡 O 原子後可以得到什麼？

學生： 我們可以得到 3b = 6c + d + e。

老師： 那我們平衡 H 原子後可以得到什麼？

學生： b = 2e。

老師： 接著我們如何利用原子個數守恆得到的四個方程式解出係數？

學生： 以 b = 2e 代入 b = 2c + d 和 3b = 6c + d + e，解聯立方程式，得比例關係 e = (4/3)c。以 b = e = (8/3)c 代入 b = 2c+ + d 得 d = (2/3)c；整理後可得到關係

式，$a = c$，$b = (8/3)c$，$d = (2/3)c$，$e = (4/3)c$，

$a : b : c : d : e = c : (8/3)c : c : (2/3)c : (4/3)c = 3 : 8 : 3 : 2 : 4$。因此可得 a，b，c，

d，e 的係數分別為 $3, 8, 3, 2, 4$。

老師：　沒錯，所以完整的化學平衡反應式子為何？

學生：　$3\ Cu(s) + 8\ HNO_3(aq) \rightarrow 3\ Cu(NO_3)_2(aq) + 2\ NO(g) + 4\ H_2O(l)$。

2-3 化學計量
Stoichiometry

■ 前言 Introduction

此小節學生已在國中階段有初步了解，在高中階段將更深入學習其概念及基本原理並計算，教師可透過引導的方式先爲學生複習國中所學之內容再帶學生熟悉化學計量的計算。在化學計量這個小節中，學生需要說出專有名詞的定義，因此時常會運用到定義或描述別稱的句型。此小節中也需要描述自己的計算過程，老師可多以口語的方式讓學生練習說出自己如何求出答案。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
mole fraction	莫耳分率	limited reagent	限量試劑
mole	莫耳	conservation of mass	質量守恆
molar mass	莫耳質量	combustion	燃燒
molecular weight	分子量	formula weight	式量
carbon	碳	Avogadro's number	亞佛加厥數
stoichiometry	化學計量	atomic weight	原子量
coefficient	係數		

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

❶ define _____ as _____.

例句：International Union of Pure and Applied Chemistry (IUPAC) **defines** Carbon-12 **as** the comparative benchmark of atomic weight.

國際純化學暨應用化學聯合會定碳 12 為原子量的比較基準。

❷ _____ be called _____. /_____ be also known as _____.

例句：1 mole of atoms contains about 6.02×10^{23} atoms, which **is** also **called** an Avogadro's number.

1 莫耳的原子數量約為 6.02×10^{23} 個，又稱為一個亞佛加厥數

❸ _____ in order to _____.

例句：We should balance the coefficient ratio of the equation **in order to** find out the ratio relation of mole number consumed by reactants and that produced by products.

我們應該先平衡方程式的係數比，就可以找出反應物消耗莫耳數與生成物生成莫耳數的比率關係。

❹ _____; therefore _____.

例句：Atomic weight is a relative value**; therefore,** it has no unit.

由於原子量是個相對比較值，因此原子量並無單位。

■ 問題講解 Explanation of Problems

⌘ 學習目標 ⌘

一、學生能培養出應用化學計量計算的能力。

　　Students can develop the ability to apply stoichiometric calculations in chemistry.

二、學生能平衡化學反應式。

　　Students can balance chemical reactions.

三、學生能熟悉莫耳數的計算方法。

　　Students can be familiar with the calculation methods of moles.

⌘ 例題講解 ⌘

例題一

說明：學生能利用質量和分子量計算出莫耳數，並學會寫出化學反應式以應用到化學計量的計算。

　　Students can use mass and molecular weight to calculate the number of moles, and write chemical equations for stoichiometric calculations.

（英文）Polysilicon can be prepared by burning silicon tetrafluoride and sodium metal in a high-temperature furnace. How many grams of sodium metal are needed to react with 52.05g of silicon tetrafluoride? How many grams of silicon can be produced at most? (SiF$_4$=104.1, Na=22.99, Si=28.09)

（中文）多晶矽可由四氟化矽和鈉金屬在高溫爐中燃燒製備，試問 52.05g 的四氟化矽需與多少克的鈉金屬反應？最多可生成多少克的矽元素？（SiF$_4$＝104.1、Na＝22.99、Si＝28.09）

（110 上南一版課本(化學全)_第 03 章第 101 頁例題）

解題 Solution：

(1) 先寫出正確的化學反應式並平衡：

　　$SiF_4(g) + 4\,Na(s) \rightarrow Si(s) + 4\,NaF(s)$。
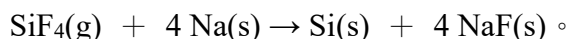
(2) 求出四氟化矽之莫耳數＝52.05/104.1=0.5000（mol）。

(3) 反應式中四氟化矽與矽及四氟化矽與鈉的係數比（1：1 及 1：4），求出矽（Si）與鈉
　　（Na）的莫耳數：

　　＝ ⇒ Si 的莫耳數＝0.5000（mol）。

　　＝ ⇒ Na 的莫耳數＝2.000（mol）。

(4) 將莫耳數換算成重量：

　　消耗 Na 重＝22.99 g／mol × 2.000 mol＝45.98 g。

　　生成 Si 重＝28.09 g／mol × 0.5000 mol＝14.05 g。

(1) Write the correct chemical equation and balance it:

　　$SiF_4(g) + 4\,Na(s) \rightarrow Si(s) + 4\ \ NaF(s)$.

(2) Calculate the number of moles of silicon tetrafluoride = 52.05/104.1 = 0.5000 (mol).

(3) Coefficient ratio of silicon tetrafluoride to silicon and silicon tetrafluoride to sodium in the
　　reaction formula (1:1 and 1:4), find the molar numbers of silicon (Si) and sodium (Na):

　　= ⇒ Molar of Si = 0.5000 (mol).

　　= ⇒ moles of Na = 2.000 (mol).

(4) Convert moles to weight:

　　Consumption of Na weight = 22.99 g/mol × 2.000 mol = 45.98 g.

　　Formed Si weight = 28.09 g/mol × 0.5000 mol = 14.05 g.

Teacher: How do we know the ratio of consumption to productions between reactants and products?

Student: We can learn from the chemical equation whose coefficient has been balanced.

Teacher: The combustion of silicon tetrafluoride and sodium will produce silicon and sodium fluoride. We have learned how to balance the coefficients of chemical equations. What is the chemical equation with balanced coefficients?

Student: $SiF4(g) + 4\,Na(s) \rightarrow Si(s) + 4\,NaF(s)$.

Teacher: Wonderful. What can we know from the coefficient ratio?

Student: The coefficient ratio is equal to the molar ratio.

Teacher: Yes. How many moles does the 52.05g silicon tetrafluoride have?

Student: The mass of the substance divided by the molar mass is equal to the number of moles, so 52.05/104.1 = 0.5000 moles.

Teacher: We can see from the chemical equation that the coefficient ratio of silicon tetrafluoride to silicon is 1:1, and the coefficient ratio of silicon tetrafluoride to sodium is 1:4. How to find the molar number of silicon (Si) and sodium (Na)?

Student: The ratio of silicon tetrafluoride to silicon is 1:1, which is equal to 0.5000 mol to

0.5000 mol. The ratio of silicon tetrafluoride to sodium tetrafluoride is 1:4, which is equal to 0.5000 mol to 2.0000 mol.

Teacher: How do we convert the mole number to the mass?

Student: The molar mass multiplied by the number of moles is equal to the molecular mass.

Teacher: How many grams of sodium will the chemical reaction consume and how many grams of silicon will the chemical reaction produce?

Student: The molar mass of sodium is 22.99 g / mol. We multiplied 22.99 g/ mol by 2.000 mol, and then we can get 45.98 g of sodium. The molar mass of silicon is 28.09 g / mol. We multiplied 28.09 g/ mol by 0.5000 mol, and then we can get 14.05 g of silicon.

老師： 我們要如何知道反應物與生成物之間的消耗與生成比例關係？

學生： 我們可以從已平衡係數的化學反應式看出來。

老師： 四氟化矽與鈉燃燒會產生矽與氟化鈉，我們已學過平衡化學反應式係數的方法，請問平衡後的化學反應式為何？

學生： $SiF_4(g) + 4\,Na(s) \rightarrow Si(s) + 4\,NaF(s)$。

老師： 很好，我們可以從係數比看出什麼呢？

學生： 係數比等於莫耳數比。

老師： 正確!那麼請問 52.05g 的四氟化矽具有多少莫耳？

學生： 課堂上學到 1 莫耳物質的質量稱為莫耳質量。因此物質質量除以該物質 1 莫耳質量等於莫耳數，1 莫耳四氟化矽的質量是 104.1 克，所以 52.05 克/104.1 克 =0.5000 莫耳。

老師： 我們從化學反應式中可以看出四氟化矽與矽的係數比為 1:1，四氟化矽與鈉的係數比為 1:4，要如何求出矽（Si）與鈉（Na）的莫耳數？

學生： 四氟化矽與矽的係數比為 1:1，等於 0.5000 莫耳比 0.5000 莫耳；四氟化矽與鈉的係數比為 1:4，等於 0.5000 莫耳比 2.0000 莫耳。

老師： 要如何將莫耳數轉換成質量呢？

學生： 莫耳質量乘以莫耳數等於分子質量。

老師： 所以會消耗多少公克的鈉與生成多少公克的矽呢？

學生： 鈉的莫耳質量為 22.99 g／mol 乘以 2.000 莫耳等於 45.98 g；矽的莫耳質量為 28.09 g／mol 乘以 0.5000 mol 等於 14.05 g。所以分別會消耗鈉 45.98 g 與生成矽 14.05 g。

例題二

說明：測驗學生是否具備計算密度、質量、莫耳數、平衡化學反應式和化學計量的能力。
To test students' ability to calculate density, mass, moles, balance the chemical equations and stoichiometry.

（英文）Gasoline is a hydrocarbon with 5 to 12 carbon atoms that emit CO_2, when burned, which is one of the reasons for the increase in CO_2 in the air. If octane (C_8H_{18}) represents the composition of gasoline, and octane can burn completely when the engine is running. The reaction formula is as follows:

$C_8H_{18(l)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(l)}$ (coefficient not yet balanced)
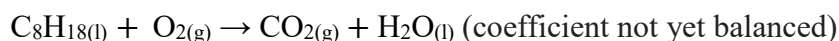
When 50 liters of octane are in a car's fuel tank, an arena of forest can absorb an average of 16 kg of CO_2 per day. If it is completely burned, approximately how many days of absorption in an arena of the forest would be needed? (C_8H_{18}: Density = 0.70 g/cm3, molecular weight = 114)

(A) 0.84

(B) 2.2

(C) 6.8

(D) 14

(E) 54

（中文）CO_2 汽油是含 CO_2 有 5 至 12 個碳原子的碳氫化合物，燃燒時排放出 CO_2 ，是造成空氣中 CO_2 增加的原因之一。假如以辛烷(C_8H_{18})代表汽油的成分，而且辛烷在引擎運轉時，可完全燃燒，其反應式如下：

$C_8H_{18(l)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(l)}$ (係數尚未平衡)
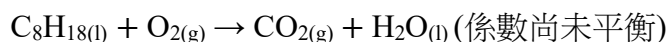
若一公畝的森林平均每天可吸收 16 公斤的 CO_2,當汽車油箱中 50 升的辛烷完全燃燒，則所產生的 CO_2 約為一公畝森林多少天的吸收量？
(C_8H_{18}：密度 = 0.70 克/立方公分、分子量 = 114)

(A) 0.84

(B) 2.2

(C) 6.8

(D) 14

(E) 54

（111 年學測 14）

解題 Solution：

辛烷 50 升＝50000 立方公分，質量＝體積×密度＝50000×0.70＝35000(克)

平衡辛烷完全燃燒的反應式為 $2\ C_8H_{18(l)} + 25\ O_{2(g)} \rightarrow 16\ CO_{2(g)} + 18\ H_2O_{(l)}$

假設完全燃燒可生成 W 公斤的 CO_2

由係數比＝莫耳數比

可知 $C_8H_{18}：CO_2 = 2:16 = 35000/114：W × 1000/44$

因此 W 約等於 108 kg 的 CO_2

又一公畝的森林平均每天可吸收 16 公斤的 CO_2，則 108/16＝6.8(天)。

Octane50(L) = 50000cm^3, mass = volume × density = 50000 × 0.70 = 35000(g)

The chemical equation for complete combustion of octane can be shown:

$2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$
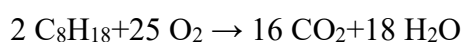
Assuming complete combustion produces w kg of CO_2

From coefficient ratio = molar ratio, it can be known that

$C_8H_{18}：CO_2 = 2 : 16 = 35000/114 : W × 1000/44$

So W is approximately equal to 108 kg of CO_2

One arena of forest can absorb an average of 16 kg of CO_2 per day, so 108/16 = 6.8 (days).

Teacher: According to the statement of this question, when 50 liters of octane in the fuel tank of the car is completely burned, how many days is CO_2 absorbed by one acre of forest? How do we calculate CO_2 emissions?

Student: First, calculate the mass of 50 liters of octane, and then use the chemical equation to calculate the CO_2 emissions.

Teacher: What is the mass of 50 liters of octane?

Student: 50 liters of octane, volume = 50 liters = 5000 cubic centimeters. density = 0.70 g/cm^3. According to the density formula, the mass of octane is
M = V × d = 5000 × 0.70 = 35000(g).

Teacher: What is the result of $C_8H_{18(l)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(l)}$ after the formula is balanced?

Student: $2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18H_2O$。

Teacher: Excellent! The coefficient ratio of the chemical equation is equal to the molar ratio. How can we calculate the molar number?

Student: We can divide mass by molecular weight.

Teacher: Yes. Assuming that complete combustion can generate W kg of CO_2, please use the coefficient ratio of the reaction formula, the mass of C_8H_{18}, the molar mass of C_8H_{18} and CO_2 to calculate the mass of CO_2.

Student: The coefficient ratio is equal to the molar ratio, so

$C_8H_{18} : CO_2 = 2 : 16 = 35000/114 : W \times 1000/44$. W is about 108 kg CO_2.

Teacher: If an acre of forest can absorb 16 kg of CO_2 on average every day, how many days will it take to absorb 108 kg of CO_2?

Student: $108/16 = 6.8$(days).

Teacher: That's correct. The answer is (C).

老師： 題目問汽車油箱中 50 升的辛烷完全燃燒時,所產生的 CO_2 約為一公畝森林多少天的吸收量。請問求出 CO_2 的排放量有哪些步驟？

學生： 先求 50 升辛烷的質量，再利用化學反應式求出 CO_2 的排放量。

老師： 請問 50 升辛烷的質量是多少？

學生： 50 升辛烷，體積= 50 升= 5000 立方公分、密度= 0.70 克/立方公分，根據密度公式 M = Vd 可知，辛烷的質量是 5000×0.70 = 35000(g)。

老師： 請問平衡化學反應式 $C_8H_{18(l)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(l)}$ 平衡後的結果如何？

學生： $2\,C_8H_{18} + 25\,O_2 \rightarrow 16\,CO_2 + 18H_2O$。

老師： 很好！因為反應式的係數比等於莫耳數比，請問如何算出莫耳數呢？

學生： 50 升辛烷的質量除以 1 莫耳辛烷的質量。

老師： 對。假設完全燃燒可生成 W 公斤的 CO_2，請利用反應式的係數比、C_8H_{18} 的質量、C_8H_{18} 的莫耳質量和二氧化的碳莫耳質量求出產生的 CO2 的質量。

學生： 由係數比等於莫耳數比可知 C_8H_{18}：CO_2 = 2:16 = 35000/114 : W × 1000/44，因此 W 約等於 108 kg 的 CO_2。

老師： 如果一公畝的森林平均每天可吸收 16 公斤的 CO_2，那 108 公斤的 CO_2 大約需要吸收幾天？

學生： $108/16 = 6.8$(天)。

老師： 很好，這題答案為(C)。

2-4 化學反應熱
Heat of Chemical Reaction

■ 前言 Introduction

學生在國中已學過吸熱與放熱反應，但反應熱與熱含量的概念為第一次接觸。教師可以先複習吸熱與放熱反應的定義後，再說明反應熱的定義及熟悉熱化學反應式的表示法，並了解 ΔH 的涵義，知道化學變化時能量的轉換過程，必須遵守能量守恆。

當老師或學生在描述放熱、吸熱、熱含量的定義時，需要用「比較」的句型來說明熱量的變化。在進行活動或練習題目時，可以利用「舉例」的句型，讓學生說出哪些反應分別屬於吸熱反應或放熱反應。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
heat of reaction	反應熱	calorie	熱量
exothermic reaction	放熱反應	thermochemistry	熱化學
energy conservation law	能量守恆定律	thermochemical equation	熱化學反應式
joule	焦耳	enthalpy; heat content	熱含量
endothermic reaction	吸熱反應		

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

❶ _____ be more than _____/_____ be less than _____.

例句：If the total heat content of the products **is more than** that of the reactants, the reaction is endothermic.

若生成物的熱含量總和高於反應物的熱含量總和，該反應為吸熱反應。

❷ one _____ the other _____.

例句：There are two ways to write thermochemical equations: **one** is to write the heat of reaction after the chemical equation, **and the other** is to write it directly in the chemical equation.

寫熱化學方程有兩種方法：一種是在化學反應式之後寫反應熱，另一種是直接寫在化學反應式中。

❸ For example, /instance, _____.

例句：**For example,** methane combustion is an exothermic reaction.

舉例來說，甲烷燃燒為放熱反應。

❹ be clsaaified into _____ and _____.

例句：Chemical reactions can **be classified into** endothermic **and** exothermic reactions.

化學反應可分爲吸熱反應和放熱反應。

■ 問題講解 Explanation of Problems

�□ 學習目標

一、學生能了解應熱與熱含量的概念，並知道ΔH 的正負值所代表的意義。

Students can understand the concepts of heat and heat content, and understand the meaning of the positive and negative values of ΔH.

二、學生能藉由熱含量變化圖，判斷放熱與吸熱反應的熱化學反應式。

Students can use the heat content change diagram to determine the thermochemical reaction equations for exothermic and endothermic reactions.
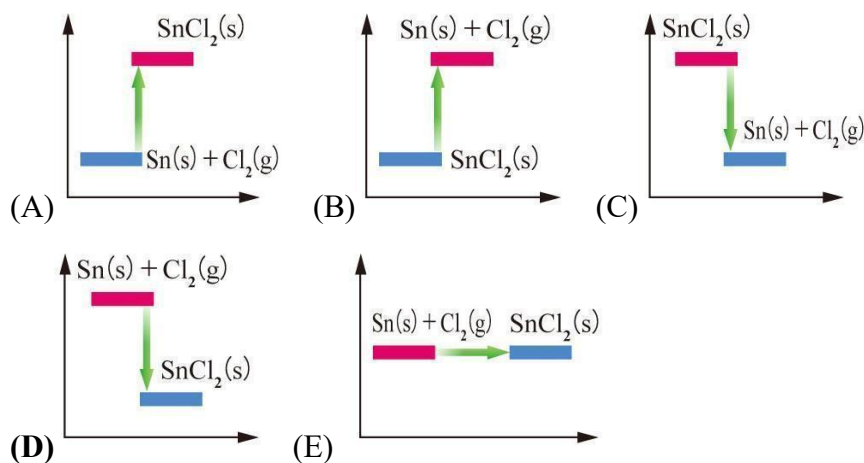
∞ 例題講解 ∞

例題一

說明：學生能知道 ΔH 的正負值代表放熱或吸熱反應，並能畫出熱含量變化圖。
Students can know that positive and negative values of ΔH represent an exothermic or endothermic reaction, and draw a graph of the change in enthalpy.

（英文）Which of the following five figures represents the change in energy (enthalpy) of the following reaction?(The horizontal axis represents the reaction process, and the vertical axis represents the enthalpy)

$$Sn(s) + Cl_2(g) \rightarrow SnCl_2(s) \quad \Delta H = -350kJ$$
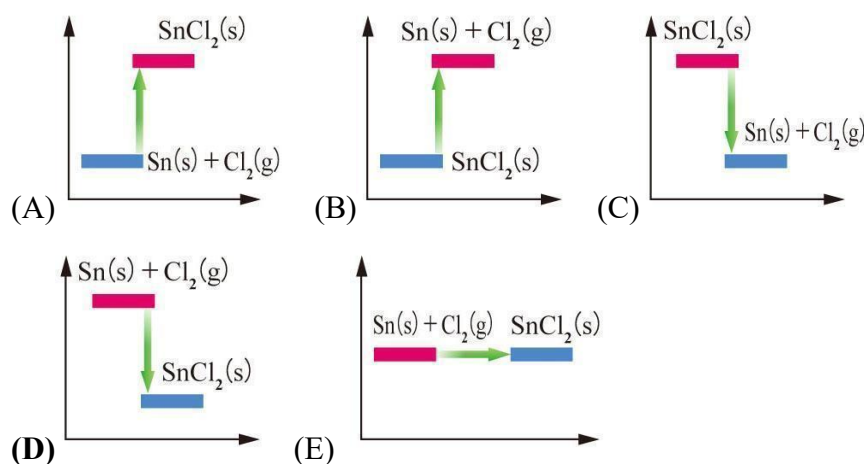
（中文）下列五圖中，何者表示下列反應之能量（熱含量）變化？（橫軸表反應過程，縱軸為熱含量）

$$Sn(s) + Cl_2(g) \rightarrow SnCl_2(s) \quad \Delta H = -350kJ$$

（翰林版化學(全)課本　第 3 章 化學式與化學計量 習題 10）

解題 Solution：

ΔH＝−350 kJ 為負值，是放熱反應，因此熱含量：反應物＞生成物，故選(D)

ΔH＝−350 kJ is a negative value, it is an exothermic reaction, so the heat content:

reactant > product, so choose (D)

Teacher:	We learned about endothermic and exothermic reactions in this class. What is an endothermic reaction? What is an exothermic reaction?
Student:	When the total heat content of the products is more than the total heat content of the reactions, the chemical reaction is the endothermic reaction. When the total heat content of the products is less than the total heat content of the reactions, the chemical reaction is the exothermic reaction.
Teacher:	What is the reaction heat Δ H?
Student:	When the heat content changes during the chemical reaction, it is called the reaction heat Δ H. That is, the total of the heat content in the product minus the total of the heat content in the reactant.
Teacher:	Therefore, when the reaction heat Δ H is negative, which one is higher, the heat content of the reactant or the heat content of the product?
Student:	The heat content of the reactant is higher.
Teacher:	Hence, this is an exothermic reaction. Let's look at the line in the figure. How should it change?
Student:	The two reactants before the reaction will be at a higher position, and then fall down to a lower position.
Teacher:	Let's finally compare the reaction formula given by the question. Which option should we choose?
Student:	We should choose (D).

老師：	我們這堂課學到，什麼是放熱反應?什麼是吸熱反應？
學生：	吸熱反應是生成物中的熱含量總和大於反應物的熱含量總和，而放熱反應是生成物中的熱含量總和小於反應物的熱含量總和。
老師：	請問何謂反應熱 ΔH？
學生：	化學反應中所產生的熱量變化，也就是生成物中的熱含量總和減反應物中的熱含量總和。
老師：	所以當反應熱 ΔH 為負值時，是反應物的熱含量較高還是生成物的熱含量較高？
學生：	反應物的熱含量較高。

老師： 所以此反應是放熱反應。那我們看一下圖中的線條，它應該如何變化呢？

學生： 反應前的兩個反應物會在比較高的位置，之後往下掉到比較低的位置。
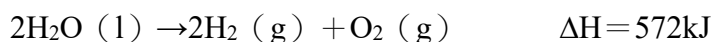
老師： 那我們最後對比一下題目給的反應式，我們應該要選哪個選項呢？

學生： 我們應該選(D)。

例題二

說明：學生能知道反應熱會受溫度、壓力、物質狀態、反應物物質的量影響。

Students can know that the heat of reaction is affected by temperature, pressure, state of matter, and the amount of substance of reactants.

（英文）It is known that the chemical reaction formula of electrolyzed water at 25°C and 1atm is as follows:

$2H_2O（l）\rightarrow 2H_2（g）+O_2（g）$ 　　　　$\Delta H＝572kJ$

How much energy change will occur when we electrolyze 72 grams of water?

(A) Endothermic 572kJ

(B) Exothermic 572kJ

(C) Endothermic 1144kJ

(D) Exothermic 1144kJ

(E) Endothermic 1716kJ

（中文）已知 25°C、1atm 下，進行電解水的化學反應式如下：

$2H_2O（l）\rightarrow 2H_2（g）+O_2（g）$ 　　$\Delta H＝572kJ$

則電解 72 克的水，會產生多少能量變化？

(A)吸熱 572kJ

(B)放熱 572kJ

(C)吸熱 1144kJ

(D)放熱 1144kJ

(E)吸熱 1716kJ

（翰林版化學(全)課本　第 3 章　化學式與化學計量　習題 12）

解題 Solution：

反應式代表 2 mol H_2O 電解需吸熱 572 kJ，故 72 g H_2O = 4 mol，需要 572 × 2 = 1144（kJ）能量，故選(C)。

The reaction formula represents that the electrolysis of 2 mol H_2O requires an endothermic 572 kJ, so 72 g H_2O = 4 mol, and 572 × 2 = 1144 (kJ) energy is required, so choose (C).

Teacher: What is the reaction heat ΔH that we have learned in class?

Student: The heat change produced in a chemical reaction is the sum of the heat contents in the products minus the sum of the heat contents in the reactants.

Teacher: What does the positive and negative value of ΔH represent?

Student: A positive value of ΔH means endothermic reaction, and a negative value of ΔH means exothermic reaction.

Teacher: Therefore, by observing this equation, we can know how much heat needs to be absorbed by 2 mol H_2O electrolysis?

Student: 572 kJ.

Teacher: How many moles does 72 g H_2O have?

Student: 4 moles.

Teacher: How much energy is required for 4 moles of H_2O?

Student: 572 × 2 = 1144（kJ）.

Teacher: Excellent. The answer is (C).

老師： 這堂課學過的反應熱ΔH 是表示什麼？

學生： 化學反應中所產生的熱量變化，也就是生成物中的熱含量總和減反應物中的熱含量總和。

老師： 那麼ΔH 的正負值表示什麼呢？

學生： ΔH 為正值表示吸熱反應，ΔH 為負值表示放熱反應。

老師： 因此，觀察此方程式，我們可知電解 2 mol H_2O 需吸熱多少熱量？

學生： 572 kJ。

老師： 那麼 72 g H_2O 有多少莫耳？

學生： 4 莫耳。

老師： 4 莫耳 H_2O 需要多少的能量？

學生： 572 × 2 = 1144（kJ）。

老師： 很好，答案選(C)。

★主題三 溶液與反應★
Solutions and Reactions

國立彰化師範大學化學系　方宣幃、邱韋慈

國立彰化師範大學英語系　劉俊億、徐毓瑩

■ 前言 Introduction

本章說明溶液的定義、種類，濃度的表示法及溶解度，並說明影響溶解度的因素。接著介紹酸鹼反應、電解質及氧化還原的反應。介紹酸與鹼時，同時介紹酸鹼指示劑，並利用離子概念之出現，複習化學式的寫法，再介紹離子電荷的表達方式，以及利用水的解離，引進 pH 值的介紹。教師講解氧化還原反應時，列出日常生活中常見的氧化劑與還原劑及其應用實例。

在學生參與課堂的過程中，會遇到些許國中階段已學過的專有詞彙，教師得以複習並運用於課堂活動中。建議老師在課程中多提供學生分辨詞彙意義的機會，並輔以「分類、對比、說明」以及描述外觀與特性等功能之句型，以利師生間的提問與發表。

3-1 溶液的種類與特性
Types and Properties of Solutions

■ 前言 Introduction

教師先為學生複習國中階段已學過的溶液、溶劑、溶質之定義，再引導介紹出溶液的種類，包括真溶液、膠體溶液及懸浮液的區別，並說明膠體溶液廷得耳效應的成因。

語言方面，學生先前已學過分類的用法，因此本章將以對比的方式，讓學生藉由觀察溶液特性之不同處來幫助學生分類。在學習過程中，學生會需要練習觀察圖片，因此也會使用到描述圖片及位置的用法。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
Brownian motion	布朗運動	ion	離子
molecule	分子	mixture	混合物
dispersed substance	分散質	colloidal solution	膠體溶液
dispersion/dispersing medium	分散媒	suspension liquid	懸浮液
dispersing system	分散系	true solution	真溶液
electrolyte	電解質	aqueous solution	水溶液
Tyndall effect	廷得耳效應	solution	溶液
nanometer	奈米	solvent	溶劑

| particle | 粒子 | solute | 溶質 |

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

❶ _____ be classified by _____ into _____ and _____.

例句：Solutions can **be classified by** the size of the solute particles **into** true **and** colloidal solutions.

依溶質粒子的大小，溶液可分為真溶液與膠體溶液。

❷ _____, resulting in _____.

例句：The Tyndall effect occurs when light shines on a colloidal solution, causing the larger colloidal particles to scatter light, **resulting in** the observation of a visible beam within the solution.

廷德爾效應是指當光線照射到膠體溶液時，由於膠體顆粒相對較大，它們會散射光線，因此在溶液中可以看到一道光帶。

❸ _____ is greatly/slightly different from _____ in _____.

例句：Salt water **is greatly different from** milk **in** their light transmittance.

食鹽水與牛奶的明顯差異在於透光性。

❹ As is shown in _____, _____.

例句：**As is shown in** this picture, we can observe a band of light in the milk.

如圖所示，我們能在牛奶中觀察到一條光帶。

❺ _____, whereas _____.

例句：True and colloidal solutions cannot be separated using filter paper, **whereas** suspension liquid, with larger suspended particles, can be separated using filter paper.

真正溶液和膠體溶液無法使用濾紙分離，然而，懸浮液中的較大懸浮粒子可以使用濾紙進行分離。

■ 問題講解 Explanation of Problems

ଓ 學習目標 ଓ

在學習完本單元後，學生應習得以下觀念：

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

一、學生能學會依溶質粒子大小來區分溶液的種類及了解其特性。

Students can learn to distinguish the types of solutions according to the size of solute particles and understand their characteristics.

二、學生能了解膠體溶液的原理及性質。

Students can understand the principle and properties of colloidal solutions.

ଓ 例題講解 ଓ

例題一

說明：學生能了解不同種類的溶液特性。

Students can understand the properties of different types of solutions.

（英文）Which of the following statements about solutions is correct?

(A) Add iron powder into water, and the mixture after thorough stirring is a liquid solution.

(B) Iodine is a non-aqueous solution formed from alcohol as a solvent.

(C) The dispersoid of the colloidal solution corresponds to the solvent of the true solution.

(D) The dispersoid is mixed with the dispersing medium to form a dispersion system.

(E) The Tyndall effect is a phenomenon caused by the scattering of light by colloidal particles.

（中文）下列有關溶液的敘述，哪些正確？

> (A)將鐵粉加入水中，充分攪拌後所得的混合物為液態溶液。
>
> **(B)碘酒是以酒精為溶劑所形成的非水溶液。**
>
> (C)膠體溶液的分散質相當於真溶液的溶劑。
>
> **(D)分散質與分散媒混合組成分散系。**
>
> **(E)廷得耳效應是膠體粒子散射光線所造成的現象。**

（翰林版 110 上課本（化學全）第四章　範例 4-1）

Teacher: According to the description of the options in this question, how do we tell the right answers from the wrong ones?

Student: We have to understand the properties of different types of solutions.

Teacher: Is option (A) right or wrong?

Student: (A) is wrong. Iron powder is insoluble in water and cannot form a solution after stirring.

Teacher: Is option (B) right or wrong?

Student: (B) is correct, iodine is a non-aqueous solution formed by alcohol as a solvent.

Teacher: Is option (C) right or wrong?

Student: (C) is wrong, the dispersoid of a colloidal solution is equivalent to the solute of a true solution

Teacher: Is option (D) right or wrong?

Student: (D) is correct, the dispersoid is mixed with the dispersing medium to form a dispersion system.

Teacher: Is option (E) right or wrong?

Student: (E) is correct. The Tyndall effect is a phenomenon caused by the scattering of light by colloidal particles.

Teacher: So in the end we have to choose (B)(D)(E).

老師：　依據本題選項的敘述，我們要怎麼判斷對錯？

學生：　我們要了解不同種類的溶液特性。

老師：　選項(A)鐵粉會溶於水嗎？

學生：　不會，所以無法形成水溶液。

老師：　沒錯，選項(B)那碘酒的溶劑是什麼呢？

學生：　是酒精，所以是非水溶液。

老師： 很棒，選項(C)膠體溶液的分散質是真溶液的什麼呢

學生： 是溶質。

老師： 非常棒，選項(D)分散質與分散媒混合組成什麼呢？

學生： 分散系。

老師： 沒錯，選項(E)廷得耳效應是什麼呢？

學生： 是膠體粒子散射光線所造成的現象。

老師： 你們很優秀，所以最後我們要選(B)(D)(E)。

例題二

說明：能了解膠體溶液的特性並理解膠體溶液與布朗運動的關係。

Students can understand the properties of colloidal solutions and the relationship between colloidal solutions and Brownian motion.

（英文）The chemical properties of silver are inactive. However, after forming silver colloidal particles, it is highly active, which is used for sterilization and deodorization. A silver colloid aqueous solution is stable and conductive. Which of the following statements is correct? (Choose two answers)

(A) **Silver colloidal particles can undergo Brownian motion in water.**

(B) The silver colloid and water can be separated by filtration.

(C) **There is a clear light path when irradiated with a laser pointer.**

(D) After adding a large amount of salt to the solution, the silver colloidal particles can still be stable in water.

(E) Silver nanoparticles decompose into silver ions in water.

（中文）金屬銀的化性不活潑，但形成銀膠體粒子後具有高度的化學活性，可用於殺菌和除臭。銀膠體水溶液穩定且具有導電性，下列敘述哪些正確？（應選兩項）

(A) **銀膠體粒子可在水中進行布朗運動。**

(B) 可用過濾方式將銀膠體和水分離。

(C) **使用雷射筆照射時會有明顯光徑。**

(D) 加入大量食鹽至溶液後，銀膠體粒子仍能穩定於水中。

(E) 銀奈米粒子於水中會分解成銀離子。

（龍騰版 110 上課本（化學全）第三章 第 106 頁 例題 3-1）

Teacher: According to the description of the options in this question, how do we tell the right answers from the wrong ones?

Student: We have to understand the properties of colloidal solutions and Brownian motion.

Teacher: What does Brownian motion mean in option (A)?

Student: Brownian motion is the result of colloidal particles being bombarded by unbalanced collisions of solvent molecules.

Teacher: Correct, so Brownian motion occurs in colloidal solutions. Option (B), can we separate colloids and water by filtration?

Student: No, we can't, because the particles in colloidal solutions are too small.

Teacher: Excellent. Option (C), we did an experiment before. What can we see when a laser pointer shines on a colloidal solution?

Student: We can see the path of light.

Teacher: Correct, it seems like you did the experiment seriously. Option (D), can we stabilize the colloid particles in water?

Student: No, we can't, because the colloidal particles are same charged on the surface, and a large amount of salt (electrolyte) will reduce the same charge on the surface, so they will agglomerate and precipitate. Option (D) is wrong.

Teacher: Excellent. Option (E), will silver nanoparticles decompose into silver ions in water?

Student: No, nanoparticles can exist stably in water.

Teacher: So what's the answer?

Student: The answer is (A) and (C).

老師：　依據本題選項的敘述，我們要怎麼判斷對錯？

學生：　我們要了解膠體溶液的特性和布朗運動。

老師：　選項(A)什麼是布朗運動呢？

學生：　布朗運動是膠體粒子受到溶劑分子不平衡碰撞的結果。

老師：　沒錯，所以布朗運動會發生在膠體溶液。選項(B)我們可以用過濾方式將膠體和水分離嗎？

學生：　不行，因為膠體溶液顆粒太小。

老師：　很棒，選項(C)我們之前有做過實驗，雷射筆照射膠體溶液會看到什麼？

學生：　可以看到光的行徑路線。

老師：　沒錯，看來你們很認真做實驗。選項(D)加入大量食鹽至溶液後，銀膠體粒子仍能穩定於水中嗎？

學生：　不能，因為膠體粒子表面帶有相同電荷，大量食鹽（電解質）會降低其表面相同的電荷量，故會凝聚析出。所以選項(D)是錯的。

老師：　非常棒。選項(E)銀奈米粒子在水中會分解成銀離子嗎？

學生：　不會，奈米粒子於水中會穩定存在。

老師：　所以答案是什麼呢？

學生：　答案是(A)(C)。

3-2 水溶液的濃度
The Concentration of the Aqueous Solution

■ 前言 Introduction

在此小節教師介紹各種濃度的表達方式：重量百分濃度（％）、體積莫耳濃度(M)及百萬分點(ppm)，接著透過課本中的例題引導學生配置溶液以應用練習濃度的計算。

本章語言部份著重在定義與舉例，學生充分了解不同濃度計算方式的定義後，也能對於理解濃度計算公式有所幫助。此外，因為濃度的計算與溶液的配製都與步驟有關，因此教師需要花一些時間教導學生實驗及計算的步驟與順序，讓學生能完整敘述單一事件的流程。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
parts per million	百萬分點	potassium permanganate	過錳酸鉀
graduated pipet	分度吸量管	sodium hydroxide	氫氧化鈉
buret	滴定管	volumetric flask	容量瓶
molarity	體積莫耳濃度	hydrochloric acid	鹽酸
concentration	濃度	transfer pipet	移液吸管
weight percentage concentration	重量百分率濃度		

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

❶ _____ is known as _____.

例句：Sarin drip **is** commonly **known as** saline solution.

沙林點滴液俗稱生理食鹽水。

❷ _____ is defined as _____.

例句：The weight percent concentration **is** often **defined as** grams of solute per 100 grams of solution.

重量百分率濃度是指每 100 克溶液中所含溶質的克數。

❸ There are _____ steps to _____: first, _____; second, _____; finally, _____.

例句：**There are** six **steps to** prepare a 100 ml, 0.10 M potassium permanganate aqueous solution: **first,** calculate the required weight of potassium permanganate and use a balance to weigh it**; second,** take a beaker and add an appropriate amount of water and put the weighted solute into a beaker to fully dissolve it**; third,** pour the dissolved solution into a 100 ml volumetric flask through a funnel**; fourth,** rinse the beaker with an appropriate amount of solvent at least three times and pour it into the volumetric flask in order to avoid the concentration error**; fifth,** remove the funnel and add the solvent gradually until the meniscus formed by the solution volume is aligned with the scale of the volumetric flask; **finally,** invert and shake several times to mix the solution in the bottle evenly.

配製 100 毫升，0.10 M 過錳酸鉀水溶液總共有六個步驟：第一步，計算所需過錳酸鉀的重量，並使用天平稱取之；第二步，取一燒杯先加入適量的水。將稱取的溶質置入燒杯中，使其充分溶解；第三步，溶解後的溶液經由漏斗傾倒於 100 毫升的容量瓶內；第四步，用適量溶劑沖洗燒杯至少三次並倒入容量瓶內、以避免造成濃度誤差；第五步，移除漏斗，逐量加入溶劑，至溶液體積所形成的彎月面與容量瓶刻度對齊；第六步，蓋妥瓶塞，將瓶身上下顛倒、搖晃重複數次，使瓶內溶液完全均勻混合。

❹ _____ in representation of _____.

例句：Molarity is a concentration notation often used by chemists for experiments and stoichiometry, **in representation of** the number of moles of solute contained in a liter of solution.

體積莫耳濃度是化學家進行實驗及化學計量時常使用的濃度表示法，其代表每升溶液中所含溶質的莫耳數。

■ 問題講解 Explanation of Problems

ભ 學習目標 ଔ

在學習完本單元後，學生應習得以下觀念：

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

一、學生能學會應用不同濃度公式去計算重量百分濃度與體積百分濃度。

Students can learn to apply different concentration formulas to calculate weight percent concentration and volume molarity.

ଔ 例題講解 ભ

例題一

說明：學生能理解並應用體積莫耳濃度計算。

Students can understand and calculate molarity.

（英文）Generally, the concentration of glucose ($C_6H_{12}O_6$) in the blood of adults on an empty stomach is less than 100 mg/dl. If the concentration of glucose in someone's blood measured by a blood glucose meter is 180mg/dl, what is the molarity of blood sugar? (atomic weight C=12, H=1, O=16) 1dL=0.1L

(A) 0.1

(B) 0.01

(C) 0.001

(D) 0.0001

（中文）一般成人空腹時血液中葡萄糖($C_6H_{12}O_6$)濃度低於 100mg/dL。以血糖計測得某人血液中葡萄糖的濃度為 180mg/dL，則血糖的體積莫耳濃度為多少 M？(原子量 C=12, H=1, O=16) 1dL=0.1L

(A) 0.1

(B) 0.01

(C) 0.001

(D) 0.0001

（龍騰版 110 上課本（化學全）第三章 第 110 頁 例題 3-3）

Teacher: What is the main point of this question?

Student: Molarity.

Teacher: What is the definition of molarity?

Student: The number of moles of solute per liter of solution

Teacher: How can we calculate the molarity?

Student: Molarity is equal to the number of moles of solute (mol) divided by the volume of solution (L).

Teacher: That's right. Then in this question, we know that the molar mass of glucose is 180g/mole. How should it be calculated?

Student: [(180(mg) × 10^{-3}(g/mg) /180(g/mol)] / 0.1L=0.01M

Teacher: Excellent, so the answer is (B).

老師： 根據題幹，本題重點是什麼呢？

學生： 體積莫耳濃度。

老師： 體積莫耳濃度的定義是什麼呢？

學生： 每 1 公升的溶液中含有溶質的莫耳數。

老師： 體積莫耳濃度要如何計算呢？

學生： 體積莫耳濃度等於溶質莫耳數(mol)除以溶液體積(L)。

老師： 所以在這題中，我們知道葡萄糖的莫耳質量為 180g/mole。那應該怎麼計算呢？

學生： [180(mg) × 10^{-3}(g/mg) / 180(g/mol)] / 0.1L=0.01M

老師： 很棒，所以答案選(B)。

例題二

說明：測驗學生是否具備溶液重量百分率濃度的概念與混合的計算能力。

To test whether students understand the concept of weight percentage concentration of solutions and the ability to perform calculations involving mixing.

（英文）Eels can sense salinity to find the right river. It is known that the salinity of the Kuroshio water in the surface layer is 33‰, and the salinity of river water is 1‰, assuming that the water is fully mixed, when the salinity of the water where the eel is located is 25‰, the Kuroshio water and the river water are mixed. What is the combined weight ratio?

(A)3:1

(B)2:3

(C)1:1

(D)3:2

(E)1:2

（中文）鰻魚可感知鹽度以找尋適當河川。已知表層之黑潮水鹽度為 33‰，河水鹽度為 1‰，假設水體充分混合，當鰻魚所在水域之鹽度為 25‰ 時,黑潮水與河水混合的重量比例為何？

(A)3:1

(B)2:3

(C)1:1

(D)3:2

(E)1:2

（111 年高中學測 36）

解題 Solution：

假設黑潮水的重量為 X 克，河水的重量為 Y 克，

則 $(X \times 33‰ + Y \times 1‰) / (X + Y) = 25‰$，解得 $X : Y = 3 : 1$。

Assuming the weight of the Kuroshio water is X grams and the weight of the river water is Y grams,

then $(X \times 33‰ + Y \times 1‰)/(X + Y) = 25‰$, the solution is $X : Y = 3 : 1$.

> Teacher: Actually, this question is asking you what weight ratio of river water and Kuroshio water should be mixed to obtain water with a salinity of 25‰. What is the definition of weight ratio?

Student: The ratio of solute weight to solution weight.

Teacher: Correct. If we assume the weight of Kuroshio water is X grams and the weight of river water is Y grams, how do we calculate the solute weight of Kuroshio water?

Student: X × 33‰.

Teacher: Excellent. How do we calculate the solute weight of river water?

Student: Y × 1‰.

Teacher: So, when mixed together, what is the total solute weight and total solution weight?

Student: The total solute weight is X × 33‰ + Y × 1‰, and the total solution weight is X + Y.

Teacher: Correct. Now, we can use the definition of weight ratio to form an equation: (X × 33‰ + Y × 1‰) / (X + Y) = 25‰. So, what is X : Y?

Student: X : Y = 3 : 1.

老師：　這題其實是問你們，河水和黑潮水要用多少重量比例混合才能到鹽度 25‰的水，那重量比例的定義是什麼呢？

學生：　溶質重量與溶液重量的比例。

老師：　沒錯，如果我們假設黑潮水的重量為 X 克，河水的重量為 Y 克，黑潮水的溶質重怎麼算？

學生：　X × 33‰

老師：　很棒，那河水的溶質重怎麼算？

學生：　Y × 1‰

老師：　所以混合起來，總溶質重和總溶液重分別為多少？

學生：　總溶質重是 X × 33‰ + Y × 1‰，總溶液重是 X + Y。

老師：　沒錯，再來利用重量比例的定義列式：(X × 33‰ + Y × 1‰) / (X + Y) = 25‰，所以 X : Y 是多少？

學生：　X : Y = 3 : 1。

3-3 溶解度
Solubility

■ 前言 Introduction

學生國中已學過溶解度的定義，在此節教師可先複習先備知識，再介紹溶解平衡，以及加入的溶質與最大濃度的關係，可分為未飽和、飽和、過飽和溶液。教師可利用生活中的例子和實驗，介紹影響溶解度的因素有溫度，以及固體和液體在溫度不同時，溶解度的變化情形。

語言需要使用到定義的句型，讓同學說出溶解度、未飽和、飽和、過飽和溶液的定義。在進行活動或計算時，老師須帶領學生說出溶液溶解或析出，以及說出溫度高低與溶解度關係的句型。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
saturated solution	飽和溶液	precipitation	沈澱;析出
dynamic equilibrium	動態平衡	precipitate	沈澱物
like dissolves like	同類溶解	dissolve	溶解
insoluble	難溶的	dissolution equilibrium	溶解平衡
supersaturated solution	過飽和溶液	solubility	溶解度
soluble	可溶的	slightly soluble	微溶的
crystallization	結晶	unsaturated solution	未飽和溶液

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

❶ _____ be called _____.

例句：When the dissolved solute does not reach the maximum concentration, it **is called** an unsaturated solution.

當溶解的溶質未達濃度最大值時，被稱為未飽和溶液。

❷ _____ be known as _____.

例句：When the dissolved solute is more than the maximum concentration, it **is known as** a supersaturated solution.

當溶解的溶質大於濃度最大值時，被稱為過飽和溶液。

❸ _____ be dissolved in _____.

例句：36.0 g of sodium chloride **are dissolved in** water.

36.0 克的氯化鈉被溶入水中。

❹ _____ be separated out _____.

例句：10.0 g of sodium chloride **are separated out** from the solution.

10.0 克的氯化鈉從溶液中被析出。

❺ The greater _____, the more _____.

例句：**The greater** the solubility is, **the more** solute can be dissolved in the water.

溶解度越大，水中可溶解的溶質越多。

■ 問題講解 Explanation of Problems

❧ 學習目標 ❧

一、學生可從國中已學過溶解度的定義，了解溶質與最大濃度的關係，並將溶液分類為
分為未飽和、飽和、過飽和溶液。

Students can learn the definition of solubility from middle school to understand the relationship between solute and maximum concentration, and classify solutions into unsaturated, saturated, and supersaturated solutions.

二、學生能以生活中的例子聯想實驗介紹影響溶解度的因素有溫度等。

Students can relate the experiment introducing factors that affect solubility, such as temperature, to examples from daily life.

三、學生可以用英文說出未飽和、飽和、過飽和溶液的定義。

Students can articulate the definitions of unsaturated, saturated, and supersaturated solutions in English.

❧ 例題講解 ❧

例題一

說明：學生能知道配置飽和溶液與過飽和溶液的方法。

Students can know how to prepare saturated and supersaturated solutions.

> （英文）At a constant temperature, add rock sugar to the saturated sugar water. After a period of time, what happens to the solution?
>
> (A) become a supersaturated solution.
>
> (B) Increased sweetness.
>
> **(C) There will be sugar of the same quality as the added rock sugar to precipitate out.**
>
> **(D) After filtering the solution, the concentration of the solution is equal to that before adding rock sugar.**
>
> (E) Decrease in transmittance of the solution.

（中文）定溫時，於飽和糖水中加入冰糖，一段時間後，此溶液出現何種現象？

    (A) 變成過飽和溶液。

    (B) 甜度增加。

    (C) 會有與加入的冰糖等質量的糖沉澱出來。

    (D) 將溶液過濾後，溶液的濃度與未加入冰糖前相等。

    (E) 溶液的透光度下降。

（翰林版 110 上課本（化學全）第四章練習題 4-4）

Teacher: We learned solubility in junior high school. What is solubility?

Student: The solubility is defined as the concentration when the solute dissolved in the saturated solution has reached the maximum amount at a given temperature and pressure.

Teacher: Excellent! How do we distinguish unsaturated, saturated and supersaturated solutions?

Student: When the added solute does not reach the maximum concentration, it is called an unsaturated solution. When the solute is equal to the maximum concentration, it is called a saturated solution. When the solute exceeds the maximum concentration, it is called a supersaturated solution.

Teacher: What happens if we add solute to a saturated solution?

Student: The added solute will be separated out and the solution will remain saturated.

Teacher: Yes. Therefore, the (C)(D) is correct.

老師：　我們國中時已經學過，請問什麼是溶解度呢？

學生：　溶解度被定義為在定溫、定壓下，飽和溶液中溶解的溶質達到最大量時的濃度。

老師：　很好！那怎麼分別未飽和、飽和及過飽和溶液呢？

學生：　當加入的溶質未達濃度最大值時，稱為未飽和溶液；當溶質等於濃度最大值時，稱為飽和溶液；當溶質超過濃度最大值時，稱為過飽和溶液。

老師：　如果在飽和溶液中加入溶質，會怎麼樣呢？

學生：　多加的溶質會沉澱，而溶液維持飽和。

老師：　沒錯，所以選項(C)(D)是正確的。

例題二

說明：學生能從溶解度曲線圖判斷各物質的溶解度大小，並判斷改變溫度後析出晶體的多寡。

Students can determine the relative solubilities of different matter from the solubility curve diagram and the amount of crystal precipitation after changing the temperature.

（英文）The following figure shows the relationship between the solubility of NaCl, NaNO3, KCl, KNO₃ and temperature. Now, 100 grams of each of the four salts were added to 4 beakers containing 100 grams of pure water each, and heated to 100°C, filtered while hot, and the filtrate was slowly cooled to 20°C to precipitate solid crystals. Comparing the weights of crystals precipitated in 4 beakers, which of the following statements is correct?

(A) KCl is the most, NaCl is the least

(B) KNO₃ is the most, NaNO₃ is the least

(C) KNO₃ is the most, NaCl is the least

(D) KCl is the most, KNO₃ is the least

(E) KNO₃ is the most, KCl is the least

（中文）下圖為 NaCl、NaNO₃、KCl、KNO₃ 之溶解度與溫度的關係圖。今將此 4 種鹽類各 100 克分別加入各含 100 克純水之 4 個燒杯中，並加熱至 100°C，趁熱過濾，濾液慢慢冷卻至 20°C，使固體結晶析出。比較 4 個燒杯中所析出晶體的重量，下列敘述何者正確？

(A)KCl 最多，NaCl 最少

(B)KNO₃ 最多，NaNO₃ 最少

**(C)KNO₃ 最多，NaCl 最少**

(D)KCl 最多，KNO₃ 最少

(E)KNO₃ 最多，KCl 最少
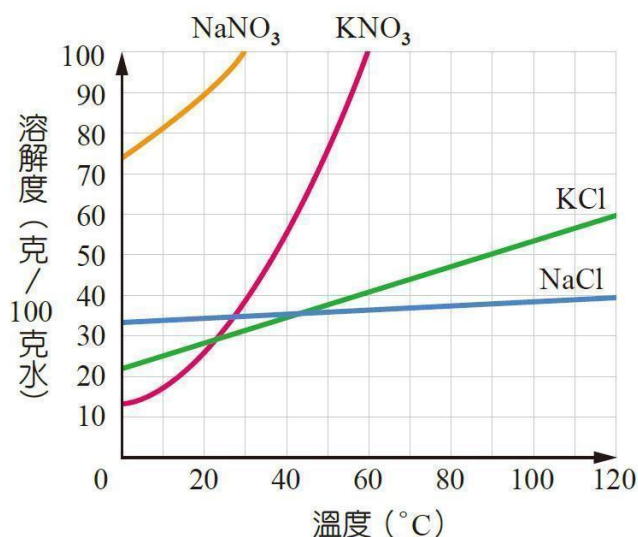
（翰林版 110 上課本（化學全）第四章 142 頁 習題第 3 題）

例題二

Teacher: We learned solubility in junior high school. What is solubility?

Student: The solubility is defined as the concentration when the solute dissolved in the saturated solution has reached the maximum amount at a given temperature and pressure.

Teacher: This question is about adding 100 grams of NaCl, NaNO$_3$, KCl, and KNO$_3$ respectively to 100 grams of pure water in separate beakers. After we heat them to 100°C, filter them while hot, and allow the filtrate to cool to 20°C, how much crystal will precipitate? Because the solubility of a substance changes with temperature, excess solute will precipitate as crystals. We will first draw a line parallel to the y-axis from the graph below, and then determine the solubility of each substance at 20°C and 100°C.
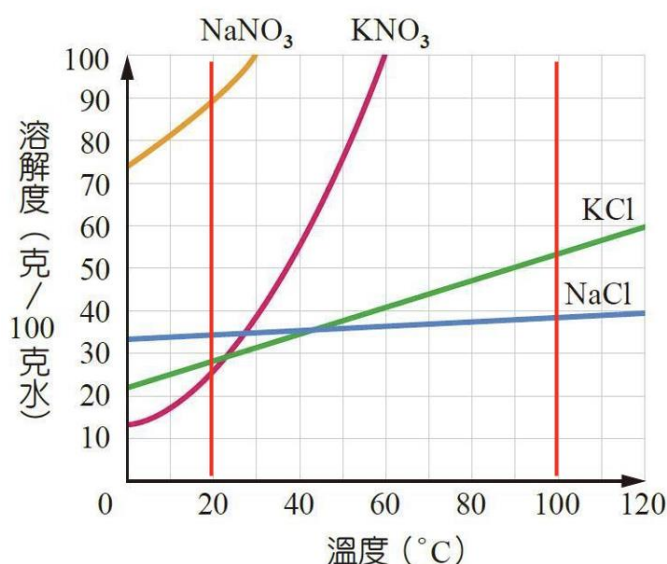
Teacher: At 100 ° C, how many grams of each substance can be dissolved in the picture?

Student: NaCl is 39g. NaNO$_3$ is 100g. KCl is 52g. KNO$_3$ is 100g.

Teacher: At 20 ° C, how many grams of each substance can be dissolved in the picture?

Student: NaCl is 35g. NaNO$_3$ is 90g. KCl is 29g. KNO$_3$ is 25g.

Teacher: When the solution drops from 100 ° C to 20 ° C, how many grams of each substance can be separated out?

Student: NaCl is 4g. NaNO$_3$ is 10g. KCl is 23g. KNO$_3$ is 75g.

Teacher: The solubility difference of KNO$_3$ is the largest, and the precipitated crystals are the most. The solubility difference of NaCl is the smallest, and the precipitated crystals are the least. Therefore, we should choose (C).

老師： 我們國中時已經學過，請問什麼是溶解度呢？

學生： 溶解度被定義為在定溫、定壓下飽和溶液中溶解的溶質達到最大量時的濃度。

老師： 這題是比較 NaCl、NaNO₃、KCl、KNO₃ 各 100 克，分別加入各含 100 克純水
之燒杯中，加熱至 100°C，趁熱過濾，濾液冷卻至 20°C 時，會析出多少晶體。
因為溶液會因為溫度改變，造成溶解度不同，超過飽和的溶質會析出成晶體。
我們先由下圖從平行 y 軸畫線，再找出各物質 20°C、100°C 時的溶解度。
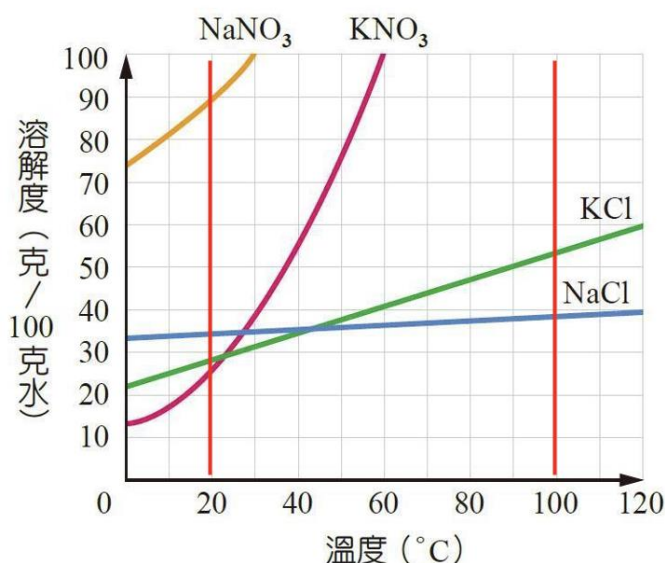
老師： 請問圖中在 100°C 時，各物質大約可溶解多少克？

學生： 100°C 時，NaCl 為 39g、NaNO₃ 為 100g、KCl 為 52g、KNO₃ 為 100g。

老師： 請問圖中在 20°C 時，各物質大約可溶解多少克？

學生： 20°C 時，NaCl 為 35g、NaNO₃ 為 90g、KCl 為 29g、KNO₃ 為 25g。

老師： 當溶液從 100°C 下降到 20°C，各物質大約可析出多少克？

學生： NaCl 為 4g、NaNO₃ 為 10g、KCl 為 23g、KNO₃ 為 75g。

老師： KNO₃ 的溶解度相差最大，析出的晶體最多，NaCl 的溶解度相差最小，析出的
晶體最少，故選(C)。

3-4 氧化還原反應
Heat of Chemical Reaction

■ 前言 Introduction

學生在國中階段已學過狹義的氧化還原反應，在此小節，教師應先為學生引導先備知識，進而介紹到廣義的氧化還原概念，及電子得失所代表的意義。

英語教學時，老師先讓學生複習氧化還原反應之概念與定義，可以給學生例子，讓學生用英文句型說出這些例子屬於氧化反應或是還原反應。課程後半部，為氧化還原在生活中的應用，需要學生學會何種物質為氧化劑，何種物質為還原劑，因此在課堂活動中，可以讓學生說出物質在化學反應中扮演氧化劑還是還原劑的角色。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
electron transfer	電子轉移	net ionic equation	淨離子反應式
antioxidant	抗氧化劑	disproportionation	自身氧化還原
reduction reaction	還原反應	oxidation reaction	氧化反應
reducing agent	還原劑	redox reaction/ oxidation-reduction reaction	氧化還原反應
activity of metals	金屬活性	oxidizing agent	氧化劑

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

❶ **I can see** _____ **in my daily life.**

例句：**I can see** oxidation reactions and reduction reactions **in my daily life**.

我在日常生活中可以看到氧化反應與化學反應。

❷ _____ **is a common example (of** _____**).**

例句：Rusted nail **is a common example of** oxidation reaction.

生鏽的鐵釘是氧化反應的常見例子。

❸ _____ **acts as an oxidizing agent/ a reducing agent** _____.

例句：Zinc **acts as a reducing agent** in carbon zinc batteries.

鋅在碳鋅電池中作為還原劑。

❹ _____ **is an oxidation reaction.**

例句：The rusting of iron **is an oxidation reaction.**

鐵生鏽是一種氧化反應。

❺ _____ **is a reduction reaction.**

例句：When copper oxide is heated with carbon, the copper oxide is reduced to copper, which **is a reduction reaction.**

當氧化銅與碳一起加熱時，氧化銅還原成銅是種還原反應。

■ 問題講解 Explanation of Problems

❧ 學習目標 ❧

一、學生以狹義氧化還原的定義延伸學習其廣義的定義，並練習如何從電子數的變化判斷氧化或還原反應。

　　Students extend the narrow definition of redox to learn its broad definition, and practice how to determine oxidation or reduction reactions from changes in the number of electrons.

二、學生可以利用句型描述物質得失電子的狀態，並且在回答過程中進行後設反思。

　　Students can use sentence structures to describe the gain or loss of electrons in matter and conduct meta-reflection during the answering process.
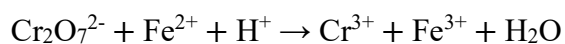
### ❧ 例題講解 ❧

例題一

說明：學生能利用反應前後得失電子的變化平衡化學反應式。

　　Students can balance chemical equations by using the change in electron gain or loss before and after the reaction.

（英文）Xiaomei learned the following chemical equation in chemistry class:

$$Cr_2O_7^{2-} + Fe^{2+} + H^+ \rightarrow Cr^{3+} + Fe^{3+} + H_2O$$

please write the coefficient of the equilibrium chemical equation (the coefficient is the ratio of the simplest integer).

（中文）小美於化學課中學到如下的反應式：

$$Cr_2O_7^{2-} + Fe^{2+} + H^+ \rightarrow Cr^{3+} + Fe^{3+} + H_2O$$
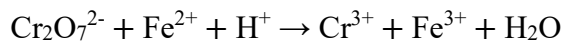
請寫出平衡反應式的係數（係數為最簡單整數比）。

（111 年高中學測 57）

Teacher: When we use observation to balance the coefficients of a chemical equation, what should we do?

Student: Because the reaction formula of $Cr_2O_7^{2-}$ is the most complicated, we should first let its coefficient be 1.

Teacher: According to the law of atomic conservation, what are the coefficients of Cr^{3+}, H_2O, and H^+?

Student: From the atomic conservation of Cr, the coefficient of Cr^{3+} is 2. From the atomic conservation of O, the coefficient of H_2O is 7. From the atomic conservation of H, the coefficient of H^+ is 14.

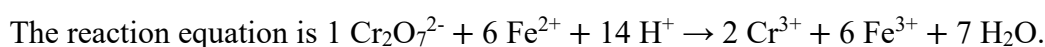Teacher: If the coefficient of Fe^{2+} is a, how do we list the chemical formula currently obtained?

Student: The coefficient of Fe^{3+} can be obtained from the atomic conservation of Fe is also a:

$1\ Cr_2O_7^{2-} + a\ Fe^{2+} + 14\ H^+ \rightarrow 2\ Cr^{3+} + a\ Fe^{3+} + 7\ H_2O$.
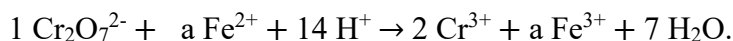
Teacher: According to the conservation of charge, how do we find the value of a?

Student: $1 \times (-2) + a \times (+2) + 14 \times (+1) = 2 \times (+3) + a \times (+3)$. The solution is a = 6.

Teacher: Great!

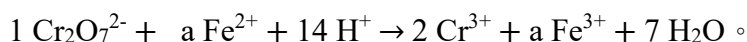The reaction equation is $1\ Cr_2O_7^{2-} + 6\ Fe^{2+} + 14\ H^+ \rightarrow 2\ Cr^{3+} + 6\ Fe^{3+} + 7\ H_2O$.

老師： 當我們利用觀察法來平衡化學式的係數時，我們該怎麼做呢？

學生： $Cr_2O_7^{2-}$是反應式最複雜的，所以先令 $Cr_2O_7^{2-}$的係數為 1。

老師： 根據原子守恆定律，Cr^{3+}、H_2O、H^+的係數為何？

學生： 由 Cr 的原子守恆可得 Cr^{3+} 的係數為 2；由 O 的原子守恆可得 H_2O 的係數為 7；由 H 的原子守恆可得 H^+ 的係數為 14。

老師： 設 Fe^{2+} 的係數為 a，該如何列出目前得到的化學式？

學生： 由 Fe 的原子守恆可得 Fe^{3+} 的係數亦為 a：

$1\ Cr_2O_7^{2-} + a\ Fe^{2+} + 14\ H^+ \rightarrow 2\ Cr^{3+} + a\ Fe^{3+} + 7\ H_2O$。

老師： 根據電荷守恆，如何求出 a 的值？

學生： $1 \times (-2) + a \times (+2) + 14 \times (+1) = 2 \times (+3) + a \times (+3)$，解得 a = 6。

老師： 很好！反應式為：$1\ Cr_2O_7^{2-} + 6\ Fe^{2+} + 14\ H^+ \rightarrow 2\ Cr^{3+} + 6\ Fe^{3+} + 7\ H_2O$。

例題二

說明：學生能從反應式判斷氧化或還原反應。

Students can determine the oxidation or reduction reaction from the reaction equation.

（英文）Put the copper wire into 0.1M silver nitrate solution, the solution gradually changes from colorless to blue, and metal attachments are formed on the copper wire. The reaction formula is $Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2 (aq) + 2Ag (s)$. Which of the following statements about this experiment is correct?

(A) This reaction is a redox reaction.

(B) Copper is oxidized to form colorless copper ions.

(C) Copper is reduced to form blue copper ions.

(D) Silver ions are reduced to form silver attached to the copper wire.

(E) Silver ions are blue.

（中文）將銅線放入 0.1M 硝酸銀溶液中，溶液由無色逐漸變為藍色，且在銅線上產生金屬附著物，其反應式為 $Cu（s）+ 2AgNO3（aq）\rightarrow Cu(NO3)2（aq）+ 2Ag（s）$。下列關於本實驗的敘述，哪些正確？

(A)此反應為氧化還原反應。

(B)銅被氧化，形成無色的銅離子。

(C)銅被還原，形成藍色的銅離子。

(D)銀離子被還原，形成銀附著於銅線上。

(E)銀離子呈藍色。

（翰林版 110 上課本（化學全）第四章 練習題 4-9）

Teacher: After we put the copper wire into the silver nitrate solution, the solution gradually changes from colorless to blue, and there are metal deposits on the copper wire. What is the reaction?

Student: Oxidation-reduction reaction.

Teacher: How can we judge the oxidation or reduction reaction from the reaction formula?

Student: Copper loses electrons and becomes copper ions, so it is an oxidation reaction. Silver ions obtain the electrons and become silver, so it is a reduction reaction.

Teacher: Why does the solution change from colorless to blue?

Student: Copper is oxidized to blue copper ions.

Teacher: What is the metal attachment on the copper wire?

Student: The colorless silver ions are reduced. It becomes silver and attaches to the copper wire.

Teacher: That's correct. The answers are (A)(D).

老師： 題目銅線放入硝酸銀溶液中，溶液由無色逐漸變為藍色，且在銅線上產生金屬附著物，是什麼反應呢？

學生： 氧化還原反應。

老師： 我們要如何從反應式判斷氧化或還原反應呢？

學生： 銅失去電子變成銅離子，故為氧化反應；銀離子得到電子變成銀，故為還原反應。

老師： 請問為何溶液由無色逐漸變為藍色？

學生： 因為銅被氧化成藍色的銅離子。

老師： 請問銅線上的金屬附著物為何？

學生： 無色的銀離子被還原，形成銀附著於銅線上。

老師： 沒錯，所以正確答案為(A)(D)。

3-5 水溶液的酸鹼反應
Acid-Base Reaction in Aqueous Solution

■ 前言 Introduction

學生在國中已學過酸鹼性質、酸鹼的解離、pH 值，此節進一步介紹離子積濃度和阿瑞尼斯學說，在介紹酸鹼時，同時介紹酸鹼指示劑，並利用寫出常見的離子，複習化學式的寫法，再利用水的解離及介紹常見的酸鹼，引進 pH 值的介紹及計算方式。

學生在本章除了運用分別酸鹼值的句型外，更重要的是能根據數據來推測與判斷結果，因此本節中學生被期望能夠在表現任務中使用具有推測功能的動詞，並嘗試表達在某些情況下會產生的結果。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
pH meter	pH 計	methyl orange	甲基橙
pH value	pH 值	base	鹼
phenolphthalein	酚酞	hydrogen ion	氫離子
phenol red	酚紅	hydroxide ion	氫氧根離子
electrolyte	電解質	bromothymol blue	溴瑞香草酚藍
theory of electrolytic dissociation	電解質解離說	litmus	石蕊
ion product constant	離子積常數	acid	酸
universal indicator	廣用指示劑	acid-base indicator	酸鹼指示劑

| methyl red | 甲基紅 | Arrhenius theory | 阿瑞尼斯學說 |

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

❶ **When the temperature _____, the ion product constant of _____ increases.**

例句：**When the temperature** rises, **the ion product constant of** water **increases.**
當溫度升高時，水的離子積常數會升高。

❷ **Regardless of _____, _____.**

例句：The ion product constant is a fixed constant representing the product of the concentrations of hydrogen ions and hydroxide ions in a solution. **Regardless of** the acidity and alkalinity of the solution, the ion product constant is constant.
離子積常數是指溶液中氫離子和氫氧根離子濃度的乘積，其值是一個固定的常數。
無論溶液酸鹼性，離子積常數都為定值。

❸ **The ____ of ____ is higher than that of ____; therefore, _____.**

例句：**The** concentration **of** hydrogen ions **is higher than that of** hydroxide ion; **therefore,** this solution is acidic.
氫離子濃度大於氫氧離子濃度；因此，這個溶液屬於酸性。

❹ **I suggest that _____ based on _____.**

例句：**I suggest that** oranges are more acidic than lemons **based on** the pH value.
我根據 pH 值推測，橘子相對於檸檬較酸。

❺ **_____ solution will turn _____ when it encounters _____.**

例句：Acidic **solution will turn** red **when it encounters** blue litmus test paper.
酸性的溶液遇到藍色石蕊試紙會變紅色。

■ 問題講解 Explanation of Problems

ଓ 學習目標 ଓ

一、學生以已學過的酸鹼概念，再進一步理解為阿瑞尼斯學說。

Students use the acid-base concepts they have learned to further understand the Arenis theory.

二、學生以對 pH 值的先備知識，學習其計算方式，並且學習測量酸鹼性的方法。

With the prior knowledge of pH value, students learn its method and the method of measuring acidity and alkalinity.

三、學生可以利用比較級句型比較氫離子濃度的大小。。

Students can comparative sentence structures to compare the concentration of hydrogen ions.

ଓ 例題講解 ଓ

例題一

說明：學生能知道純水的氫離子與氫氧離子濃度的關係。

Students can learn the relationship between hydrogen ion and hydroxide ion concentration in pure water.

> （英文）When the temperature is 80°C, the ion product constant of water is 25×10^{-14}.
> What are the concentrations of hydrogen ions and hydroxide ions in pure water?
>
> （中文）溫度為 80°C 時，水的離子積常數為 25×10^{-14}，純水的氫離子與氫氧離子濃度為何？
>
> （龍騰版 110 上課本（化學全）第三章 第 124 頁 例題 3-7）

解題 Solution：

純水中$[H^+] = [OH^-]$且 $K_W = 25\times10^{-14}$

因此可算出$[H^+] = [OH^-] = \sqrt{K_w} = 5\times10^{-7}$

In pure water$[H^+] = [OH^-]$且 $K_W = 25\times10^{-14}$

Therefore it can be calculated$[H^+] = [OH^-] = \sqrt{K_w} = 5\times10^{-7}$

> Teacher: At the beginning of our class, we mentioned the dissociation of aqueous solution. What is the relationship between the concentration of hydrogen ions and hydroxide ions in pure water?

Student: The concentration of hydrogen ions is equal to that of hydroxide ion.

Teacher: We also learned "ion product constant". What is the ion product constant?

Student: A value obtained by multiplying the hydrogen ion concentration by the hydroxide ion concentration.

Teacher: Yes. That is, $[H^+] \times [OH^-] = K_W = 25 \times 10^{-14}$.

What are the hydrogen ion concentration and the hydroxide ion concentration?

Student: $[H^+] = [OH^-]$, so $[H^+] = [OH^-] = K_w = 5 \times 10^{-7}$.

Teacher: Excellent. Both the hydrogen ion concentration and the hydroxide ion concentration are 5×10^{-7}.

老師： 我們課堂中一開始便提到水溶液的解離。請問純水中氫離子與氫氧離子濃度的關係為何？

學生： 氫離子濃度與氫氧離子濃度相等。

老師： 我們也學到「離子積常數」，請問何謂離子積常數？

學生： 氫離子濃度乘以氫氧離子濃度的值。

老師： 很好。這題是問溫度為 80°C 時，純水的氫離子濃度和氫氧離子濃度各為多少？你們會如何解題呢？

學生： 由題目中知道溫度為 80°C 時，水的離子積常數為 25×10^{-14} 因為 $K_W = [H^+] \times [OH^-]=25 \times 10^{-14}$，及 $[H^+] = [OH^-]$，所以$[H^+] = [OH^-] = K_w = 5 \times 10^{-7}$。

老師： 很好！氫離子濃度和氫氧離子濃度皆為 $5×10^{-7}$。

例題二

說明：學生能了解不同強弱的酸性溶液的性質。

Students can understand the properties of acidic solutions in different strengths.

（英文）At 25°C, two beakers A and B each contain 100 mL of 0.1M acetic acid and 0.1M hydrochloric acid. Which of the following comparisons about the properties of the two solutions is correct?

(A) Both solutions contain $[H^+] = 0.1$M

(B) In the B beaker, the pH value of the solution is higher

(C) In A beaker, the hydroxide ion concentration of the solution is relatively large.

(D) In the B beaker, the ion product constant K_w of water is larger

(E) The conductivity of the A solution is less

（中文）25°C 時，A、B 兩燒杯各盛有 100 mL 的 0.1M 醋酸與 0.1M 鹽酸，下列有關兩溶液性質的比較，哪些正確？

(A)兩溶液所含[H^+]均為 0.1M。

(B)B 燒杯中，溶液的 pH 值較大。

(C)A 燒杯中，溶液的氫氧離子濃度較大。

(D)B 燒杯中，水的離子積常數 K_w 較大。

(E)A 燒杯溶液的導電度較小。

（翰林版 110 上課本（化學全）第四章 習題第 6 題）

解題 Solution：

(A)醋酸為弱酸，因此解離出的氫離子濃度比 0.1M 小。

(B)鹽酸[H^+] > 醋酸[H^+]，因此鹽酸 pH 值 < 醋酸 pH 值。

(C)鹽酸[H^+] > 醋酸[H^+]，相反的鹽酸[OH^-] < 醋酸[OH^-]。

(D)25°C 時，水的離子積常數 K_w 皆為 $1×10^{-14}$。

(E)同樣濃度的強酸和弱酸，弱酸導電度較小。

(A) Acetic acid is a weak acid, so the dissociated hydrogen ion concentration is less than 0.1M.

(B) Hydrochloric acid [H^+] > Acetic acid [H^+], so pH value of hydrochloric acid < pH value of acetic acid.

(C) Hydrochloric acid [H^+] > Acetic acid [H^+], the opposite hydrochloric acid [OH^-] < Acetic acid [OH^-].

(D) At 25°C, the ion product constant K_w of water is all $1×10^{-14}$.

(E) With the same concentration of strong acid and weak acid, the conductivity of weak acid is smaller.

Teacher: We have just learned the strong-weak relationship of acid and alkali. Which is the stronger acid, acetic acid or hydrochloric acid? Which one is a weak acid?

Student: Acetic acid is a weak acid and hydrochloric acid is a strong acid.

Teacher: What is the difference between weak acid and strong acid?

Student: The degree of dissociation in water is the major difference: hydrochloric acid is completely dissociated in water, and the hydrogen ion concentration is high, so it is a strong acid; acetic acid is partially dissociated in water, and the hydrogen ion concentration is low, so it is a weak acid.

Teacher: Very good; then is (A) correct?

Student: (A) is not correct, acetic acid is a weak acid, so the dissociated hydrogen ion concentration is less than 0.1M.

Teacher: Which of the two cups has the greater pH?

Student: Hydrochloric acid [H⁺] > acetic acid [H⁺], so the pH value of hydrochloric acid is lower than that of acetic acid.

Teacher: Very good, option (B) is wrong. The hydrogen ion concentration of beaker A is lower, which means that the hydroxide ion concentration is higher, so option (C) is correct. What is the ionic product constant K_w of water?

Student: At 25°C, the ion product constant K_w of water is all 1×10^{-14}.

Teacher: Yes, so option (D) is wrong. Finally, what factors affect conductivity?

Student: The degree of dissociation. The greater the degree of dissociation, the greater the conductivity. That is, the conductivity of a strong acid will be greater than that of a weak acid.

Teacher: Very good, so (E) is correct.

老師：　我們剛剛有學到酸鹼的強度，請問醋酸和鹽酸何者為強酸？何者為弱酸？

學生：　醋酸為弱酸，鹽酸為強酸。

老師：　請問弱酸和強酸的差異在哪裡？

學生：　在水中的解離程度，鹽酸在水中完全解離，氫離子濃度較高，所以為強酸；醋酸在水中部份解離，氫離子濃度較低，所以為弱酸。

老師：　很好，那(A)是否正確？

學生：　(A)錯誤，醋酸為弱酸，因此解離出的氫離子濃度比 0.1M 小。

老師：　兩杯的 pH 值何者較大？

學生：　鹽酸[H⁺] > 醋酸[H⁺]，因此鹽酸 pH 值 < 醋酸 pH 值。

老師：　很好，(B)選項錯誤。A 燒杯的氫離子濃度較低，也就代表氫氧離子濃度較高，故(C)選項正確。請問水的離子積常數 Kw 為多少？

學生：　25°C 時，水的離子積常數 K_w 皆為 1×10^{-14}。

老師：　是的，所以(D)選項錯誤。最後，什麼因素會影響導電度？

學生：　解離程度。解離程度越大，導電度越大。也就是說強酸的導電度會比弱酸的導電度大。

老師：　非常好，所以(E)是正確的。

★主題四 生活中的化學★
Chemistry in Life

國立彰化師範大學化學系　方宣幃、邱韋慈
國立彰化師範大學英語系　劉俊億、徐毓瑩

■ 前言 Introduction

本章首先介紹日常生活中的化學物質的組成及其功能，內容包括食品中的醣類及蛋白質；生命體中重要的物質－蛋白質、脂質及核酸；界面活性劑（肥皂與清潔劑）及常見的藥物，例如胃藥、消炎劑及止痛劑。除此之外，在化學領域中也有許多先進科技材料的發現，例如奈米碳管和奈米光觸媒；最後說明綠色化學概念及符合綠色化學製程的十二原則與永續發展。

本章在進行以英語授課時，語言與生活可以相結合；因此教師可以從簡單的短句延伸到特定情境中，再請學生慢慢加長語句；或是顛倒過來透過較長的情境語句，來讓學生拆分出各個生活情境中會用到的英語短句。

4-1 生物分子
Biomolecules

■ 前言 Introduction

在此小節，教師應先複習國中階段已學過的有機化合物之概念，接著以生活中常見的例子作為引導，介紹出醣類、蛋白質、脂質及核酸的組成及其功能。

本章在進行以英語授課時，教師可以提供學生生活常見的句型，讓學生透過日常生活中的觀察，來描述不同生物體分子有機化合物的特性及應用。再讓學生進行語言輸出前，教師應該補充對應的專業字彙，以利學生表現。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
galactose	半乳糖	nucleic acid	核酸
glucose	葡萄糖	ribonucleic acid	核糖核酸
maltose	麥芽糖	polymerization	聚合
molecule	分子	hydroxyl group	羥基
protein	蛋白質	deoxyribonucleic acid	去氧核糖核酸
starch	澱粉	cellulose	纖維素
monosaccharide	單醣	fat	脂肪
polysaccharide	多醣	sucrose	蔗糖
saccharide; carbohydrate	醣類	disaccharide	雙醣

dehydration	脱水	lactose	乳糖
fructose	果糖	carboxyl group	羧基
glycogen	肝糖	triglycerides/triacylglycerol	三酸甘油酯
oligosaccharide	寡醣	organic compound	有機化合物
oligopeptide	寡肽	amino acid	氨基酸
chemical formula	化學式	amino group	氨基

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

❶ _____ is a compound which is composed of _____, _____ and _____.
= _____ is a compound composed of _____, _____ and _____.

例句：Carbohydrates **are compounds which are composed of** carbon, hydrogen, **and** oxygen.

= Carbohydrates **are compounds composed of** carbon, hydrogen, **and** oxygen.

醣類是碳、氫、氧組成的化合物。

❷ _____, including _____, tend to _____.

例句：Monosaccharides**, including** glucose, fructose, and galactose, **tend to** easily dissolve in water and have a sweet taste.

單醣，包含葡萄糖、果糖、半乳糖，易溶於水且具有甜味。

❸ _____ can be found in _____.

例句：Fructose **can be found in** fruits and honey, and is the natural sugar with the highest sweetness value.

果糖存在於水果、蜂蜜中，屬於甜度最高的天然醣類。

❹ _____ has been applied in_____.

= _____ has been used in_____.

例句：Artificial fats **had been applied in** replacement of extracted fats from milk to make butter because of their high temperature resistance and easy preservation.

= Artificial fats **had been used in** replacement of extracted fats from milk to make butter because of their high temperature resistance and easy preservation.

人造脂肪曾因耐高溫且容易保存，而被運用於取代牛乳中的提取脂肪而製成的奶油。

■ 問題講解 Explanation of Problems

❈ 學習目標 ❈

一、　學生能了解生物體中含有的有機物之種類及性質，包括醣類、油酯、蛋白質及核酸。

Students can understand the types and properties of organic substances contained in organisms, including saccharide, fat, protein and nucleic acid.

二、　學生可以利用「組成」的句型描述生物體中有機物的組成。。

Students can use "composition" sentence structures to describe the composition of organic compounds in living organisms.

☜ 例題講解 ☞

例題一

說明：學生能了解醣類化合物的種類以及特性。

Students can understand the types of saccharides and their properties.

（英文）Saccharides are common organic compounds in daily life. Which of the following statements is correct?

(A) Saccharides are also called carbohydrates, and $(CH_2O)_n$ can represent their chemical formula.

(B) The viscous maltose is a giant molecule made from the polymerization of monosaccharides.

(C) Cellulose and starch can be hydrolyzed to produce fructose.

(D) 1 mole of fructose is completely oxidized to form carbon dioxide and water and release energy, and 6 moles of oxygen is required.

(E) Glucose and fructose are produced by hydrolysis of disaccharides.

（中文）醣類化合物是日常生活中常見的有機化合物，下列敘述何者正確？

(A) 醣類又稱碳水化合物，其化學式均可以$(CH_2O)_n$表示。

(B) 黏稠狀的麥芽糖是一種由單醣聚合而成的巨大分子。

(C) 纖維素與澱粉，經水解後可產生果糖。

(D) 1 莫耳的果糖完全氧化生成二氧化碳與水並放出能量，過程中需 6 莫耳的氧氣。

(E) 雙醣水解都可產生葡萄糖與果糖。

（南一版 110 上課本（化學全）第四章 第 158 頁 練習 1）

Teacher: What is the main point of this question?

Student: Check the characteristics of the saccharides compounds in the description.

Teacher: Looking at option (A) first, do you remember the molecular formula of monosaccharides and polysaccharides?

Student: Monosaccharide is $C_6H_{12}O_6$. Polysaccharide is $(C_6H_{10}O_5)_n$.

Teacher: Teacher: Yes, it can be found that the general formula can be written as $C_m(H_2O)_n$, but think about whether there are exceptions?

Student: Yes, the chemical formula of deoxyribose is $C_5H_{10}O_4$, which is an exception.

Teacher: Great. Is maltose in the option (B) monosaccharide, disaccharide or polysaccharide?

Student: Disaccharide.

Teacher: How do monosaccharides form disaccharides?

Student: It is formed by removing one molecule of water from two molecules of glucose.

Teacher: Yes, can cellulose in option (C) be hydrolyzed?

Student: No, it can't dissolve in water.

Teacher: Yes, do you still remember what starch is made of?

Student: Glucose.

Teacher: Good job, so starch hydrolysis will produce glucose. In option (D), we can know from the chemical equation that fructose reacts with oxygen to form carbon dioxide and water. How can we write the chemical equation?

Student: $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$

Teacher: Yes. Then we need the balance equation. By using the observation method, set the coefficient of the most complex $C_6H_{12}O_6$ to 1 first, and then you can balance it.

Student: $C_6H_{12}O_6 + O_2 \rightarrow 6\,CO_2 + 6\,H_2O$

Teacher: Yes, it can be known from the coefficient ratio equal to the molar number ratio that how much oxygen is needed for 1 mole of fructose to generate carbon dioxide and water?

Student: 6 moles.

Teacher: Great. What are the disaccharides of option (E)?

Student: Lactose, sucrose and maltose.

Teacher: Yes, which two sugars will they hydrolyze into?

Student: Lactose will be hydrolyzed into glucose and galactose. Sucrose will be hydrolyzed into glucose and fructose. Maltose will be hydrolyzed into two glucose.

Teacher: Excellent, so the disaccharides produced by hydrolysis are different. What should I choose for this question?

Student: Option (D).

老師：　這一題的關鍵在於什麼呢？

學生：　檢查敘述中的醣類化合物的特性有沒有問題。

老師：　先看(A)選項，還記得單醣和多醣的分子式是什麼嗎？

學生：　單醣是 $C_6H_{12}O_6$，多醣是（$C_6H_{10}O_5$）$_n$

老師：　沒錯，可以發現通式可以寫成 $C_m(H_2O)_n$，但想想看有沒有例外？

學生：　有，去氧核糖化學式為 $C_5H_{10}O_4$ 就是例外。

老師：　很棒，那(B)選項麥芽糖是單醣、雙醣還是多醣呢？

學生：　雙醣。

老師：　單醣是怎麼形成雙醣的呢？

學生：　由兩分子的葡萄糖脫去一分子的水形成。

老師：　沒錯，(C)選項纖維素能水解嗎？

學生：　不行，他不溶於水。

老師：　對，那還記得澱粉是由什麼組成的嗎？

學生：　葡萄糖。

老師：　很棒，所以澱粉水解會產生葡萄糖。(D)選項我們可以從化學方程式得知，果糖和氧氣反應生成二氧化碳和水，要怎麼寫呢？

學生：　$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$

老師：　沒錯，再來要平衡方程式，利用觀察法，先把最複雜的 $C_6H_{12}O_6$ 設係數為 1，再來你們平衡看看。

學生：　$C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O$

老師：　沒錯，由係數比等於莫耳數比可以知道，1 莫耳的果糖生成二氧化碳與水，需幾莫耳的氧氣呢？

學生：　6 莫耳。

老師：　非常棒，那(E)選項雙醣有哪些呢？

學生：　乳糖、蔗糖和麥芽糖。

老師：　對，他們分別會水解成哪兩種醣類呢？

學生：　乳糖會水解成葡萄糖和半乳糖，蔗糖會水解成葡萄糖和果糖，麥芽糖會水解成兩個葡萄糖。

老師：　很優秀，所以雙醣水解產生的醣類都不一樣。所以這題答案應該選什麼？

學生：　(D)選項。

例題二

說明：學生能了解不同醣類和蛋白質的水解。
　　　　Students can learn about the hydrolysis of different carbohydrates and proteins.

（英文）Certain edible substances can be hydrolyzed under appropriate conditions. Which of the following statements is true?

　　　a. Eggs are hydrolyzed to produce amino acids.

　　　b. Rice is hydrolyzed to produce glucose.

　　　c. Sucrose is hydrolyzed to produce oligosaccharides and fructose.

　　　d. Cheese is hydrolyzed to produce cellulose and minerals.

（中文）某些食用物質於適當條件下會水解，下列敘述哪些正確？

　　　a.雞蛋水解產生胺基酸　　　b.米飯水解產生葡萄糖

　　　c.蔗糖水解產生寡糖和果糖　d.起司水解產生纖維素和礦物質

　　　(A) a、b

　　　(B) c、d

　　　(C) a、c

　　　(D) b、d

　　　(E) a、d

　　　　　　　　　　　　（翰林版 110 上課本（化學全）第四章 第 159 頁 補充範例）

解題 Solution：

a.雞蛋為蛋白質，經水解後產生氨基酸。

b.米飯為澱粉，經水解後最終得到單醣中的葡萄糖。

c.蔗糖經過水解後產生葡萄糖和果糖。

d.起司主要成分為蛋白質，經水解後得到氨基酸。

a. Eggs are protein, and amino acids are produced after hydrolysis.

b. Rice is starch, and after hydrolysis, glucose in monosaccharides is finally obtained.

c. Sucrose is hydrolyzed to produce glucose and fructose.

d. The main component of cheese is protein, and amino acids are obtained after hydrolysis.

Teacher:　What is the main point of this question?

Student:　We have to know whether the substance produced after hydrolysis is correct.

Teacher:　What happens after the egg is hydrolyzed?

Student:　Eggs are proteins, which can be hydrolyzed to produce amino acids.

Teacher: What happens after the rice is hydrolyzed?

Student: Rice is starch, which is hydrolyzed to obtain glucose in monosaccharides.

Teacher: What happens when sucrose is hydrolyzed?

Student: Sucrose is hydrolyzed to produce glucose and fructose.

Teacher: What happens after the cheese is hydrolyzed?

Student: The main component of cheese is protein, which is hydrolyzed to obtain amino acids.

Teacher: So which of our options are correct?

Student: a and b.

Teacher: Yes, that's excellent.

老師：　這一題的關鍵在哪呢？

學生：　食物水解後產生的物質是否正確。

老師：　那雞蛋水解後會產生什麼呢？

學生：　雞蛋是蛋白質，水解後會產生氨基酸。

老師：　那米飯水解後會產生什麼呢？

學生：　米飯為澱粉，經水解後最終得到單醣中的葡萄糖。

老師：　那蔗糖水解後會產生什麼呢？

學生：　蔗糖經過水解後產生葡萄糖和果糖。

老師：　那起司水解後會產生什麼呢？

學生：　起司主要成分為蛋白質，經水解後得到氨基酸。

老師：　那我們的選項中那些是對的呢？

學生：　a 和 b。

老師：　對的，很棒。

4-2 藥物與界面活性劑
Drugs and Surfactants

■ 前言 Introduction

教師在此小節教導藥物時，可讓學生觀察常見藥品含有的成分及用途。介紹界面活性劑時，應複習學生國中已學過的先備知識，再深入介紹界面活性劑的構造及去污原理。

因本節運用許多生活中常見的藥品及生活用品，因此本節語言可以以描述用途、成分及比較差異等句型，讓學生可以以認識這些常見的藥品及界面活性劑為目標進行語言活動，課程結束前可以讓學生運用句型以口頭報告方式分享被分配到的相關主題。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
主要成分 paracetamol 乙醯胺酚 acetaminophen 乙醯胺酚 / 商品名 Panadol	普拿疼	penicillin	青黴素
penicillin	盤尼西林	anti-inflammatory	消炎藥
antipyretic	退燒藥	branched chain	支鏈
salicylic acid	柳酸	straight chain	直鏈
steroid	類固醇	painkiller	止痛劑
antibacterial	抗菌劑	antacid	制酸劑
antibiotic	抗生素	lecithin	卵磷脂
sulfonamides	磺胺類藥物	acetyl	乙醯
synthetic detergent	合成清潔劑	hard water	硬水

surfactant	界面活性劑	micelle	微胞
cloudifier	起雲劑	stomach acid	胃酸
hydrophilic	親水端	aspirin	阿斯匹靈
hydrophobic	親油端		

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

❶ _____ not only _____ but also _____.
= Not only _____ but _____ also _____.

例句：Aspirin is **not only** used to relieve pain**, but also** to reduce inflammation.

=**Not only** is Aspirin used to relieve pain, **but** it is **also** used to reduce inflammation.
阿斯匹靈不僅可以用於止痛，還可以用來消炎。

❷ **The main ingredient of _____ is _____.**
=_____ **is mainly composed of _____.**

例句：**The main ingredient of** Panadol **is** acetaminophen.

= Panadol **is mainly composed of** acetaminophen.
普拿疼的主要成分為乙醯胺酚。

❸ _____, **which is commonly known as** _____, **can be used to** _____.
=_____, **commonly known as** _____, **can be used to** _____.
=_____, **a.k.a.** _____, **can be used to** _____.

例句：Antacids, **which are commonly known as** stomach medicines, **can be used to** neutralize stomach acid secreted by the body.

=Antacids**, commonly known as** stomach medicines**, can be used to** neutralize stomach acid secreted by the body.

=Antacids, **a.k.a.** stomach medicines, **can be used to** neutralize stomach acid secreted by the body.

制酸劑一般稱為胃藥，可以用來中和人體分泌的胃酸。

❹ **The former _____ and the latter _____.**

例句：Detergents can be divided into linear and branched types based on their characteristics.
The former is a soft detergent, which is easily decomposed by microorganisms, **and the latte**r is a hard detergent, which is not easily decomposed by microorganisms.

清潔劑依特性可以分為直鏈型與支鏈型，前者為軟性清潔劑，易被微生物分解，後者為硬性清潔劑，不易被微生物分解。

■ 問題講解 Explanation of Problems

⟡ 學習目標 ⟡

一、學生觀察藥品含有的成分及其英文後再嘗試進行介紹。

Students observe the ingredients contained in the medicine and try to introduce them in English.

二、學生以學過界面活性劑的概念及單字，深入了解肥皂及合成清潔劑的結構和成分。

After learning the concept and vocabulary of surfactants, students have a deeper understanding of the structure and composition of soaps and synthetic detergents.

ᔤ **例題講解** ᕀ

例題一

說明：學生能區分藥物的成分與作用。

Students are able to distinguish the components and their effects of drugs

---

（英文）Which of the following statements about drugs is correct?

(A) Sodium bicarbonate refers to the most common class of antidiarrheal drugs.

(B) Penicillin, commonly known as paracetamol, is an antibiotic.

(C) Aluminum hydroxide will neutralize stomach acid and have antacid effect.

(D) Sulfonamides are a type of antibacterial drugs.

(E) The common name for Panadol is aspirin, which is an analgesic.

（中文）下列有關藥物的敘述，哪些正確？

(A)碳酸氫鈉是止瀉藥物中最普遍的一類。

(B)青黴素俗稱普拿疼，是一種抗生素。

(C)氫氧化鋁會中和胃酸反應，有制酸作用。

(D)磺胺類藥物是抗菌類藥物的一種。

(E)普拿疼的俗名為阿斯匹靈，是一種止痛藥。

（龍騰版 110 上課本（化學全）第四章 習題 第 3 題）

解題 Solution：

(A) 碳酸鹽類中和胃酸時會產生二氧化碳，增加胃內壓力，因此較常使用氫氧化物為止瀉藥物。

(B) 青黴素俗稱盤尼西林。

(E) 普拿疼的主要成分是對乙醯氨酚，與阿斯匹靈是不同藥物。

(A) Carbonates produce carbon dioxide when they neutralize stomach acid, increasing the pressure in the stomach, so hydroxides are more commonly used as antidiarrheal drugs.

(B) Penicillin is commonly known as penicillin.

(E) The main component of Panadol is acetaminophen, which is a different drug from aspirin.

Teacher: According to the description of the question, we need to judge whether the statement about the drug is correct. In option (A), both carbonates and hydroxides can be used as antidiarrheal drugs, but which one is more common?

Student: Hydroxides.

Teacher: Why?

Student: When carbonates neutralize gastric acid, carbon dioxide will be produced, which will increase the pressure in the stomach, so hydroxide antidiarrheal drugs are often used.

Teacher: Great, how about option (B)?

Student: No.

Teacher: Why?

Student: Penicillin is commonly known as penicillin, not Panadol.

Teacher: What is the ingredient of Panadol?

Student: Paracetamol.

Teacher: Great, how about option (C)?

Student: Yes, aluminum hydroxide will neutralize the reaction of gastric acid, and has the effect of antacid.

Teacher: Why do aluminum hydroxide have the effect of antacid?

Student: Because it is a hydroxide, it can conduct acid-base neutralization reactions.

Teacher: Great, what about option (D)?

Student: Yes, sulfonamides are a type of antibacterial drugs.

Teacher: Great, what about option (E)?

Student: No.

Teacher: Why?

Student: The main component of Panadol is acetaminophen, which is a different drug from aspirin.

Teacher: Very good, so we will choose (C)(D).

老師： 根據題意，我們要來判斷關於藥物的敘述是否正確，(A)選項碳酸鹽類和氫氧化物都會當作止瀉藥物，但那個比較常見呢？

學生： 氫氧化物。

老師： 為什麼呢？

學生： 因為碳酸鹽類中和胃酸時會產生二氧化碳，增加胃內壓力，因此較常使用氫氧化物為止瀉藥物。

老師： 很棒，那(B)選項呢？

學生： 不對。

老師： 為什麼呢？

學生： 青黴素俗稱盤尼西林，而非普拿疼。

老師： 普拿疼的成份是什麼呢？

學生：　乙醯胺酚。

老師：　很棒，那(C)選項呢？

學生：　對，氫氧化鋁會中和胃酸反應，有制酸作用。

老師：　為什麼氫氧化鋁能制酸呢？

學生：　因為是氫氧化物，能進行酸鹼中和反應。

老師：　很棒，那(D)選項呢？

學生：　對，磺胺類藥物是抗菌類藥物的一種。

老師：　很棒，那(E)選項呢？

學生：　不對。

老師：　為什麼呢？

學生：　普拿疼的主要成分是對乙醯胺酚，與阿斯匹靈是不同藥物。

老師：　很棒，所以我們會選出(C)(D)。

例題二

說明：學生能了解硬水影響肥皂去污效果的原因。

Students can understand why hard water affects the cleaning effect of soaps.

（英文）What are the main reasons why synthetic detergents are more powerful than soap in hard water?

(A) The sodium salt of synthetic detergent is soluble in water, while the sodium salt of soap is insoluble in water.

(B) Synthetic cleaners will interact with acids, while soaps do not.

(C) Soap will decompose in hard water whereas synthetic cleaners will not.

(D) Calcium salts of synthetic detergents are soluble in water, while calcium salts of soaps are insoluble in water.

(E) Synthetic detergents are neutral and soaps are alkaline.

（中文）在硬水中，合成的清潔劑比肥皂更具有洗滌能力，其主要原因為何？

　　　(A)合成清潔劑的鈉鹽溶於水，而肥皂的鈉鹽不溶於水。

　　　(B)合成清潔劑會與酸作用，而肥皂不與酸作用。

　　　(C)肥皂會在硬水中分解，而合成清潔劑不會分解。

　　　(D)合成清潔劑的鈣鹽溶於水，而肥皂的鈣鹽不溶於水。

　　　(E)合成清潔劑為中性，肥皂為鹼性。

（南一版 110 上課本（化學全）第四章 習題 單選第 10 題）

解題 Solution：

肥皂會在含鈣離子和鎂離子的硬水中會產生沉澱，影響肥皂的去污效果，故選(D)。

Soap will precipitate in hard water containing calcium ions and magnesium ions, which will affect the cleaning effect of soap, so choose (D).

Teacher:	As mentioned in the question, we need to compare soaps and synthetic detergents. What factors will affect the cleaning power?
Student:	It is mentioned in the textbook that synthetic detergents have better decontamination effects than soaps in hard water, mainly because soaps will interact with calcium ions or magnesium ions in hard water to form insoluble gray-white calcium soaps or magnesium soaps.
Teacher:	So you think that such a chemical reaction will affect the decontamination function of the soap, right?
Student:	Right.
Teacher:	Which of the options fits with what you just described?
Student:	(D).
Teacher:	Yes, that's great.

老師：	從題幹中，我們要比較肥皂及合成清潔劑，請問哪些因素會影響清潔力？
學生：	課本中提到在硬水中，合成清潔劑較肥皂去汙效果更好，主要是因為肥皂中會與硬水中鈣離子或鎂離子作用，生成不溶性的灰白色鈣皂或鎂皂。
老師：	所以你推測這樣的化學反應會影響肥皂的去污功能，對吧？
學生：	對的。
老師：	那選項中，哪個符合你剛剛的敘述呢？
學生：	(D)。
老師：	對的，很棒。

4-3 環境與化學
Environment and Chemistry

■ 前言 Introduction

此節可結合新聞報導讓學生反思化學對於環境的影響，教師再深入講解造成污染的原因和預防方式，應注意學生對於環境污染的因素可能擁有另有概念，教師應協助學生進行調適。

本小節語言要認識許多環境污染的專有名詞，可以試著引導學生用英文描述造成污染的原因、後果與防治方式。可以安排活動或習題演練，讓學生能閱讀一小段落，並配對段落所描述的環境問題。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
non-renewable energy	非再生能源	particulate matter	懸浮微粒
solar power	太陽能	deodorization	除臭
reverse osmosis	逆滲透	precipitation	沉澱
ion-exchange resin	離子交換樹脂	ozone layer	臭氧層
filter	過濾	biochemical oxygen demand	生化需氧量
air pollution	空氣污染	biomass energy	生質能
fossil fuel	化石燃料	ultraviolet	紫外線
active carbon	活性碳	renewable energy	再生能源
infrared	紅外線	acid rain	酸雨

nuclear energy	核能	eutrophication	優養化
global warming	全球暖化	greenhouse effect	溫室效應
sanitize	消毒		

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

❶ _____ be classified into _____.

例句：Energy can **be classified into** non-renewable and renewable energy based on its sustainability of its use.

　　能源可依其使用的永續性分為非再生能源與再生能源。

❷ _____ be divided into _____.

例句：Energy can **be divided into** non-renewable and renewable energy based on its sustainability of its use.

　　能源可依其使用的永續性分為非再生能源與再生能源。

❸ _____ in the form of _____.

例句：The surface of the Earth radiates the absorbed heat to the universe **in the form of** long wavelength infrared.

　　地球表面則會以長波長的紅外線形式，向宇宙散發所吸收的熱量。

❹ In addition to _____, _____.

例句：**In addition to** industrial sulfur-bearing emissions, volcanic eruptions also emit large amounts of sulfur dioxide.

　　除了工業的含硫排放物外，火山爆發也會噴發大量的二氧化硫。

❺ _____meet certain standards _____.

例句：Household water must undergo treatment to meet certain standards for impurities, pH
level, salinity, organic matter, and bacteria content before it can be used.
一般家庭用水必須經處理後，使其雜質、pH 值、溶鹽、有機物及細菌含量都符合一
定標準才能使用。

■ 問題講解 Explanation of Problems

❧ 學習目標 ❧

一、學生可了解造成環境污染之因素的迷思。
Students can dispel myths about pollution factors in their surrounding environment.
二、學生可以利用因果句說出造成汙染的原因。
Students can use causal sentence structures to explain the causes of pollution.

∞ 例題講解 ∞

例題一

說明：學生能了解造成環境污染的原因。

Students can understand the causes of environmental pollution.

（英文）Which of the following statements about environmental pollution is correct?

(A) Carbon monoxide in the air will absorb the infrared rays of sunlight and produce a greenhouse effect.

(B) Nitrogen oxides in the atmosphere, mainly because gasoline reacts in internal combustion engines.

(C) Fatty acid sodium salts are easier to decompose than hard cleaners and less polluting.

(D) The increased concentration of CO in the air caused the ozone layer crisis.

(E) Wastewater from electroplating factories contains fluoride, which can cause itai-itai disease.

（中文）下列有關環境污染的敘述，何者正確？

(A)空氣中的一氧化碳，會吸收太陽光的紅外線，而產生溫室效應。

(B)大氣中的含氮氧化物，主要是因為汽油在內燃機中反應。

(C)脂肪酸鈉鹽比硬性清潔劑更容易分解，污染性較低。

(D)空氣中 CO 濃度增高造成臭氧層危機。

(E)電鍍工廠的廢水含氟化物，會造成痛痛病。

（龍騰版 110 上課本（化學全）第四章 習題 第 5 題）

解題 Solution：

(A) 溫室效應是空氣中的二氧化碳增加導致。

(B) 氮氧化物是因為引擎的高溫使空氣中的氮和氧反應。

(D) 造成臭氧層破洞的原因是氟氯碳化物。

(E) 痛痛病是鎘中毒所造成。

(A) The greenhouse effect is caused by the increase in carbon dioxide in the air.

(B) Nitrogen oxides are caused by the reaction between nitrogen and oxygen in the air due to the high temperature of the engine.

(D) The cause of the hole in the ozone layer is chlorofluorocarbons.

(E) Itai-itai disease is caused by cadmium poisoning.

Teacher: What environmental pollution did we mention in this class?

Student: Global warming, ozone hole, acid rain, particulate matter, and water pollution.

Teacher: What is the cause of global warming?

Student: The increase of carbon dioxide intensifies the greenhouse effect and causes global warming.

Teacher: Yes, the option (A) is incorrect. How is nitrogen oxide produced in the atmosphere?

Student: The high temperature of the engine makes nitrogen in the air combine with oxygen to produce nitrogen oxides.

Teacher: So option (B) is incorrect. Sodium aliphatate is a kind of soft cleaner. Which one is easier to decompose, soft cleaner or hard cleaner?

Student: Soft detergents are easier to decompose than hard detergents, so the soft ones are less polluting.

Teacher: Yes, the option (C) is correct. What is the cause of ozone layer depletion?

Student: When CFCs enter the atmosphere, they will decompose into chlorine, react with ozone, accelerate the decomposition of ozone, and cause the ozone layer depletion.

Teacher: Yes, the option (D) is incorrect. What is the cause of itai-itai disease from pollution?

Student: It is cadmium poisoning, not fluoride pollution.

Teacher: So the option (E) is incorrect.

老師： 請問這一課我們提到了哪些環境汙染？

學生： 全球暖化、臭氧層破洞、酸雨、懸浮微粒、水汙染。

老師： 請問全球暖化的成因是什麼？

學生： 空氣中的二氧化碳增加，使溫室效應加劇，造成全球暖化。

老師： 沒錯，所以(A)選項錯誤。請問大氣中的含氮氧化物是如何產生的？

學生： 引擎的高溫使空氣中的氮和氧反應產生氮氧化物。

老師： 所以(B)錯誤。脂肪酸鈉鹽是種軟性清潔劑，請問軟性和硬性清潔劑何者比較易分解？

學生： 軟性清潔劑比硬性清潔劑更容易分解，所以污染性較低。

老師： 是的(C)正確。請問臭氧層為何會破洞？

學生： 氟氯碳化物進入大氣後會分解出氯氣，會與臭氧反應，加速臭氧的分解，造成臭氧層破洞。

老師： 所以(D)錯誤。請問痛痛病的病因是什麼汙染問題造成的呢？

學生： 是鎘中毒，不是氟化物汙染。

老師： 所以(E)選項錯誤。

例題二

說明：學生能計算生化需氧量並比較污染程度。

Students can calculate BOD and compare pollution levels.

（英文）Biochemical oxygen demand (BOD) refers to the amount of oxygen required by microorganisms in water to decompose organic substances in water within five days under a certain temperature. It is generally measured in ppm. The larger the BOD value, the more organic pollutants in the water. Take the water quality of two rivers for testing:

A river: take 1.0 mL of sample, add distilled water to dilute to 100 mL. The dissolved oxygen content of the solution was measured to be 8.3 ppm after dilution and 2.0 ppm after five days.

River B: Take 1.0 mL of the sample, add distilled water to dilute to 100 mL. The dissolved oxygen content of the solution was measured to be 9.5 ppm after dilution and 4.0 ppm after five days.

How about which river has more serious organic pollution?

（中文）生化需氧量是指在一定溫度下，水中的微生物在五日內將水中有機物分解的過程中，所需要氧氣量，一般以 ppm 為單位。BOD 值越大，表示水中的有機污染物質越多。今取兩條河流的水質進行檢測：

A 河川：取試樣 1.0 mL，加蒸餾水稀釋成 100 mL。稀釋後測得溶液的溶氧量為 8.3 ppm，五日後再測為 2.0 ppm。

B 河川：取試樣 1.0 mL，加蒸餾水稀釋成 100 mL。稀釋後測得溶液的溶氧量為 9.5 ppm，五日後再測為 4.0 ppm。

試問哪一條河川的有機物污染情況較嚴重？

（龍騰版 110 上課本（化學全）第四章 練習 4-5）

解題 Solution：

A 河川的生化需氧量為 8.3 - 2.0 = 6.3。

B 河川的生化需氧量為 9.5 - 4.4 = 5.1。

A 河川的生化需氧量 ＞B 河川的生化需氧量，因此 A 河川污染較嚴重。

The BOD of River A is 8.3 - 2.0 = 6.3.

The BOD of River B is 9.5 - 4.4 = 5.1.

The BOD of river A ＞ The BOD of river B, so the pollution of river A is more serious.

Teacher: According to the question, what is biochemical oxygen demand?

Student: The amount of oxygen consumed by microorganisms in water over 5 days.

Teacher: If biochemical oxygen demand gets higher, will the pollution become more severe?

Student: Yes, it will.

Teacher: How do we calculate the biochemical oxygen demand according to the known condition?

Student: We can use the original dissolved oxygen amount minus the dissolved oxygen amount after five days.

Teacher: How do we calculate the biochemical oxygen demand of river A?

Student: 8.3 ppm − 2.0 ppm = 6.3 ppm.

Teacher: How do we calculate the biochemical oxygen demand of river B?

Student: 9.5 ppm − 4.4 ppm = 5.1 ppm.

Teacher: Which river has higher biochemical oxygen demand?

Student: 6.3 ppm > 5.1 ppm. River A has higher biochemical oxygen demand.

Teacher: Yes, that's correct. Therefore, the pollution of river A is more severe.

老師： 根據題目所述，什麼是生化需氧量？

學生： 水中的微生物經過 5 天的時間所消耗氧氣的量。

老師： 請問生物需氧量愈高則污染程度愈高還是愈低？

學生： 愈高。

老師： 根據已知條件，如何計算生化需氧量？

學生： 我們可以用原本的溶氧量減去五日後的溶氧量。

老師： 如何計算 A 河川的生化需養量？

學生： 8.3 ppm − 2.0 ppm = 6.3 ppm

老師： 如何計算 B 河川的生化需養量？

學生： 9.5 ppm − 4.4 ppm = 5.1 ppm

老師： 哪一條河川的生化需氧量比較高？

學生： 6.3 ppm > 5.1 ppm，A 河川的生化需氧量較高。

老師： 是的，所以 A 河川的污染較嚴重。

4-4 化學的現代應用
Modern application of chemistry

■ 前言 Introduction

在此小節教師帶學生認識生活中常見的奈米材料及介紹其特性及應用，包括奈米碳管以及奈米光觸媒；並初步介紹奈米光觸媒的作用原理，接著帶學生認識何謂綠色化學，了解其意義並能學會計算原子使用效率。

語言教學方面，老師需要讓學生使用英文說明奈米科技原理、描述奈米技術的特性和提出應用的實例，因此可以給定句型讓學生造句練習。在學生計算原子使用效率時，學生可以試著用英文說出原子使用效率的定義與等於、乘法、除法的句型。

■ 詞彙 Vocabulary

單字	中譯	單字	中譯
electron	電子	hydroxide ion	氫氧離子
electron hole	電洞	hydroxyl radical	氫氧自由基
nanometer	奈米	graphene	石墨烯
carbon nanotubes	奈米碳管	catalyst	催化劑
green chemistry	綠色化學	atomic usage efficiency	原子使用效率
photocatalyst	光觸媒		

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

❶ _____ be applied to _____.

例句：Nanotechnology **is applied to** physics, chemistry, biology, and engineering fields.

奈米科技被應用於物理、化學、生物和工程領域。

❷ _____ convert into _____.

例句：Electron hole will **convert** hydroxide ion **into** hydroxyl radicals.

電洞會將氫氧離子轉化為氫氧自由基。

❸ _____ be used in _____.

例句：Titanium dioxide **is** often **used in** correction solutions and sunscreen products.

二氧化鈦常用於修正液與防曬用品。

❹ _____ be equal to _____.

例句：The atomic use efficiency **is equal to** the percentage of the total mass of target products in

the total mass of reactants.

原子使用效率等於目標產物總質量占反應物總質量的百分比。

❺ _____ multiply ____ by _____.

例句：We can **multiply** the molar number **by** the molar mass of the molecule to get the total mass.

我們以莫耳數乘以分子的莫耳質量以得到總質量。

❻ _____ divide ____ by _____.

例句：We can **divide** the total mass **by** the molar mass of the molecule to get the molar number.

我們可以將總質量除以分子的莫耳質量以得到莫耳數。

■ **問題講解 Explanation of Problems**

⊂⊗ 學習目標 ⊗∞

一、學生能了解化學在現代生活中的相關應用及綠色化學的概念。

Students can understand the relevant application of chemistry and the concept of green chemistry in modern life.

二、學生可以用英文說出奈米科技在生活中的應用。

Students can articulate the applications of nanotechnology in everyday life in English.

∞ 例題講解 ⊂⊗

例題一

說明：學生能了解奈米科技在生活中的應用。

　　　Students can understand the application of nanotechnology in life.

（英文）Which of the following statements about nanotechnology is false?

(A) Nanotechnology applications have been distributed in physics, chemistry, biology, and engineering.

(B) Nanotechnology is widely researched because products are developed that reduce resource usage.

(C) Carbon nanotubes have the characteristics of high mechanical strength and high conductivity.

(D) Nanophotocatalysts generate electrons and holes after absorbing ultraviolet rays in sunlight, which can decompose organic matter.

(E) When gold nanoparticles catalyze the reaction of alkenes to form alkanes, the size does not make a difference.

（中文）下列有關奈米科技敘述何者**錯誤**？

(A)奈米科技的應用已分布在物理、化學、生物與工程之中。

(B)奈米科技之所以受到廣泛的研究，是因為開發出的產品可以降低資源使用。

(C)奈米碳管具高機械強度、高傳導性等特質。

(D)奈米光觸媒吸收太陽光中的紫外線後，產生電子與電洞，可分解有機物。

(E)金奈米粒子在催化烯類反應生成烷類時，不受其尺寸大小的影響。

（龍騰版 110 上課本（化學全）第四章 第 185 頁 練習 4-6）

解題 Solution：

金奈米粒子在催化烯類化合物和氫氣反應產生烷類化合物的效率，隨其尺度的增加而下降。

The efficiency of gold nanoparticles in catalyzing the reaction of alkenes and hydrogen to produce alkanes decreases with the increase of their size.

Teacher: After this class, what do you know about nanotechnology?

Student: Nanometer is a very small scale, in which materials have special physical and chemical properties.

Teacher: As we know today, what applications does nanotechnology often have?

Student: Carbon nanotubes and nano photocatalysts.

Teacher: Let's take a look at this question. Has nanotechnology been applied to physics, chemistry, biology, and engineering?

Student: Yes, nanotechnology has already been applied to physics, chemistry, biology, and engineering.

Teacher: So, the option (A) is correct. Is nanotechnology widely studied because its products can reduce the use of resources?

Student: Yes, nanotechnology is widely studied because its products can reduce the use of resources.

Teacher: So, the option (B) is correct. Do carbon nanotubes have the characteristics of high mechanical strength and high conductivity?

Student: Yes, it is often used for cables and electronic components.

Teacher: Wonderful. So, the option (C) is correct. What will happen after a nano photocatalyst absorbs ultraviolet rays in sunlight?

Student: Electrons and electric holes will be generated. And then it will convert hydroxide ions into hydroxyl radicals to decompose organic matters.

Teacher: Yes, so the option (D) is correct. When gold nanoparticles catalyze olefins to produce alkanes, will it be affected by the size?

Student: Yes, it will decrease with the increase of its size.

Teacher: Why?

Student: The smaller the size, the larger the surface area of each atom. Therefore, the catalytic effect will be better.

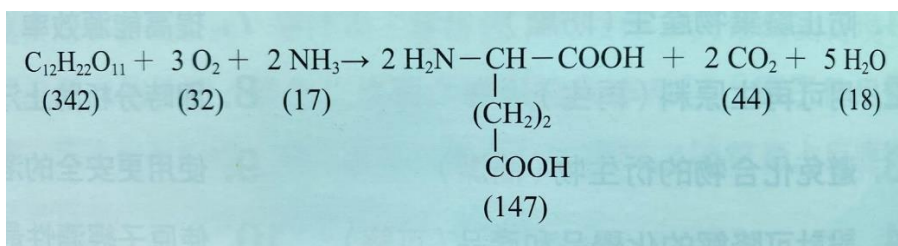Teacher: Yes, so the option (E) is incorrect.

老師：　這堂課上完後，請問你們對奈米科技有哪些認識？

學生：　奈米是一種尺度極小的長度單位，在這種尺度範圍的物質會產生特殊的物理與化學性質。

老師：　那今天我們知道奈米科技常會有什麼樣的應用呢？

學生：　奈米碳管和奈米光觸媒。

老師：　那我們來看題目，請問奈米科技的應用是否已分布在物理、化學、生物與工程之中？

學生：　是，奈米科技的應用已分布在物理、化學、生物與工程之中。

老師：　所以(A)選項正確。請問奈米科技有因為開發出的產品可以降低資源使用而受到廣泛的研究嗎？

學生：　是的，奈米科技因為開發出的產品可以降低資源使用而受到廣泛的研究。

老師：　所以(B)選項正確。請問奈米碳管具高機械強度、高傳導性等特質嗎？

學生：　是的，因此常應用於電纜及電子元件。

老師：　很好，所以(C)選項正確。奈米光觸媒吸收太陽光中的紫外線後會產生什麼變化呢？

學生：　會產生電子與電洞，進而將氫氧離子轉化氫氧自由基，分解有機物。

老師：　是的，所以(D)選項正確。請問金奈米粒子在催化烯類反應生成烷類時，會受尺度大小的影響嗎？

學生：　會，會隨其尺度的增加而下降。

老師：　為什麼呢？

學生：　因為尺寸越小，每顆原子的表面積越大，因此催化效果越好。

老師：　是的，所以(E)選項錯誤。

例題二

說明：學生能了解綠色化學的意義並學會計算原子使用效率。

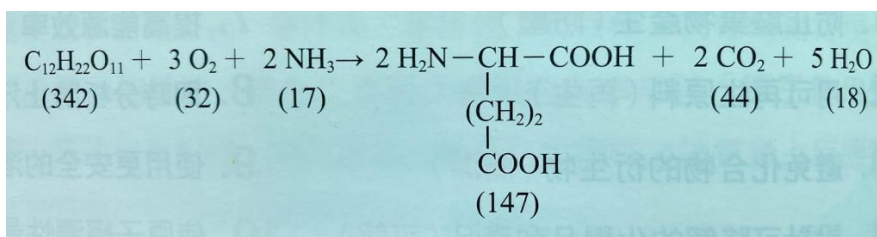Students can understand the meaning of green chemistry and learn to calculate the efficiency of atomic use.

（英文）Glutamic acid reacts with sodium hydroxide to obtain sodium glutamate (monosodium glutamate). In industry, microorganisms are used to convert sugars into glutamic acid, and the reaction formula is as follows

$$C_{12}H_{22}O_{11} + 3\,O_2 + 2\,NH_3 \rightarrow 2\,H_2N-\underset{\underset{\underset{COOH}{|}}{\overset{|}{(CH_2)_2}}}{CH}-COOH + 2\,CO_2 + 5\,H_2O$$

(342)　　(32)　　(17)　　　　　　　　　　　　　　(44)　　(18)

(147)

Given that the number in the parenthesis below the molecule is its molecular weight, which of the following percentages is closest to the atom economy (atom utilization efficiency) of the reaction equation above?

(A) 72

(B) 62

(C) 52

(D) 42

(E) 32

（中文）麩胺酸與氫氧化鈉反應，可得麩胺酸鈉（味精）。工業上是利用微生物將醣類轉換成麩胺酸，其反應式如下：

$$C_{12}H_{22}O_{11} + 3\,O_2 + 2\,NH_3 \rightarrow 2\,H_2N-\underset{\underset{\underset{COOH}{|}}{\overset{|}{(CH_2)_2}}}{CH}-COOH + 2\,CO_2 + 5\,H_2O$$

(342)　　(32)　　(17)　　　　　　　　　　　　　　(44)　　(18)

(147)

已知分子下方括號中的數字為分子量，則上列反應式的原子經濟性（原子使用效率）最接近下列哪一數值％？

(A) 72

(B) 62

(C) 52

(D) 42

(E) 32

（龍騰版 110 上課本（化學全）第四章 第 188 頁 練習題 4-7）

解題 Solution：

原子使用效率等於目標產物總質量占反應物總質量的百分比。

目標產物為麩氨酸，分子量為 147，若產生 2 mole，其產量為（2 × 147）克，反應物的總質量為 342 + (3 × 32) + (2 × 17)，因此，原子使用效率＝

[(2 × 147)/(342 + 3 × 32 + 2 × 17)] × 100% = 62%。

The atomic use efficiency is the percentage of the total mass of target products in the total mass of reactants.

The target product is glutamic acid with a molecular weight of 147. If 2 moles are produced, the yield is (2 × 147) grams, and the total mass of the reactants is 342 + (3 × 32) + (2 × 17).

Therefore, the atom usage efficiency =[(2 × 147)/(342 + 3 × 32 + 2 × 17)] × 100% = 62%.

Teacher: This question is to find the atom economy, which is also called atom usage efficiency. How do we find the atom usage efficiency?

Student: The atomic use efficiency is equal to the percentage of the total mass of target products in the total mass of reactants.

Teacher: What is the target product of this question?

Student: Glutamic acid.

Teacher: Have we learned how to calculate the total mass with the molar number and the molar mass of a molecule in junior high school? What is the mass of the target product?

Student: The total mass is equal to the molar number multiplied by the molar mass of the molecule, so the mass of the target product is 2 × 147g.

Teacher: How to find the total mass of reactants?

Student: 342 + (3 × 32) + (2 × 17).

Teacher: What is the atom usage efficiency?

Student: [(2 × 147)/(342+3 × 32+2 × 17)] × 100%=62%.

Teacher: Therefore, choose the option (B).

老師： 這題是希望求出原子經濟性的數值，也就是原子使用效率。請問如何求出原子使用效率？

學生： 原子使用效率等於目標產物總質量占反應物總質量的百分比。

老師： 那這一題的目標產物是什麼呢？

學生： 麩胺酸。

老師： 國中有學過如何用莫耳數和分子的莫耳質量求出總質量？那目標產物的總質量是多少？

學生：　總質量等於莫耳數乘以分子的莫耳質量，所以目標產物的總質量等於 2×147 克。

老師：　那如何求出反應物總質量？

學生：　$342 + (3 \times 32) + (2 \times 17)$。

老師：　所以原子使用效率是多少？

學生：　$[(2 \times 147)/(342 + 3 \times 32 + 2 \times 17)] \times 100\% = 62\%$。

老師：　所以答案選(B)。

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/

高中自然領域雙語教學資源手冊：**化學科** 英語授課用語

雙語教學資源手冊：化學科 英語授課用語

[十年級]

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

[10th grade]

- 研編單位：國立彰化師範大學雙語教學研究中心

- 指導單位：教育部師資培育及藝術教育司

- 撰稿：方宣幃、邱韋慈、劉俊億、徐毓瑩

- 學科諮詢：鄭碧雲

- 綜合規劃：曾松德

- 編輯排版：吳依靜

- 封面封底：JUPE Design