香港考試及評核局
Hong Kong Examinations and Assessment Authority

HKDSE 2019 Chemistry Paper 2

Q.1 & Q.3

Focus areas

- Basic chemical knowledge
- Experimental work
- Effective communication
- Calculations
- Unknown Deduction
- Unfamiliar Context

Basic Chemical Knowledge

- Question 1(a)(i)

  … why … Haber process … crop yield ?

Expected

Haber process produces ammonia … fertilisers

Comments:

~two-thirds of the candidates were able to suggest the ammonia produced from the Haber process can be used to manufacture fertilisers contributing to an increase in crop yield.

Basic Chemical Knowledge

- Question 1(a)(i)

  Exemplars:

Better mention NH_3 production

Version A:

Haber process can facilitate the production of fertilizer, which help increase the crop yield.

Version B: [較佳]

哈柏法能夠製備 NH_3，而 NH_3 作為肥料可增加農作物產量。

Basic Chemical Knowledge

- 1. (a) (ii) (1)

  … chemical equation … for … syngas from methane

- **Expected**:

  $CH_4 + H_2O \rightarrow CO + 3H_2$

- **Comments**:

  ~two-thirds of the candidates were able to write the chemical equation

Basic Chemical Knowledge

- 1. (a) (ii) (2)

  Syngas … from … biomass. … why … advancement of the methanol production technology.

Expected:

Biomass is a renewable energy resource.

Comments:

~a third of candidates were able to suggest biomass as a renewable energy resource .

Basic Chemical Knowledge

- 1. (a) (iii)

Trial	[A(aq)] / mol dm^{-3}	[B(aq)] / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	0.0836	0.202	0.26×10^{-4}
2	0.0836	0.404	1.04×10^{-4}
3	0.0418	0.404	0.52×10^{-4}

- **Expected:**

  Trial 3 & Trial 2: [A] doubles, initial rate doubles => 1st order w.r.t. A(aq).

  Trial 1 & Trial 2: [B] doubles, initial rate four times => 2nd order w.r.t. B(aq).

Basic Chemical Knowledge

- 1. (a)(iii)

  Comments:

  – *A very high proportion of candidates were able to deduce the respective order of reaction to **A**(aq) and **B**(aq)*

Basic Chemical Knowledge

- 1. (b)(ii)

  NaOCl … from products … Write a chemical equation for its formation

- **Expected:**

  $Cl_2(g) + 2NaOH(aq) \rightarrow$

  $NaCl(aq) + NaOCl(aq) + H_2O(l)$

- **Comments**:

  ~a third of the candidates were able to write the chemical equation for the production of sodium hypochlorite

Basic Chemical Knowledge

- 1. (b) (ii) **Exemplars**:
- Version A:

b)II) $NaOH + Cl_2 \rightarrow NaOCl + HCl$

- Version B:

$4NaOH + 2Cl_2 + O_2 \longrightarrow 4NaOCl + 2H_2O$

- Version C: [Better]

$Cl_2 + 2NaOH \rightarrow NaOCl + NaCl + H_2O$

Basic Chemical Knowledge

- 1. (b) (iii) …

  $NaOCl + 2NH_3 \rightarrow H_2NNH_2 + NaCl + H_2O$ (I)

  $H_2O_2 + 2NH_3 \rightarrow H_2NNH_2 + 2H_2O$ (II)

  … calculating … atom economy …which … greener?
- **Expected**:

  Reaction (I) = 32/108.5 = 29.5%

  Reaction (II) = 32 / 68 = 47.1%

  Reaction (II) is greener as it has a higher atom economy.

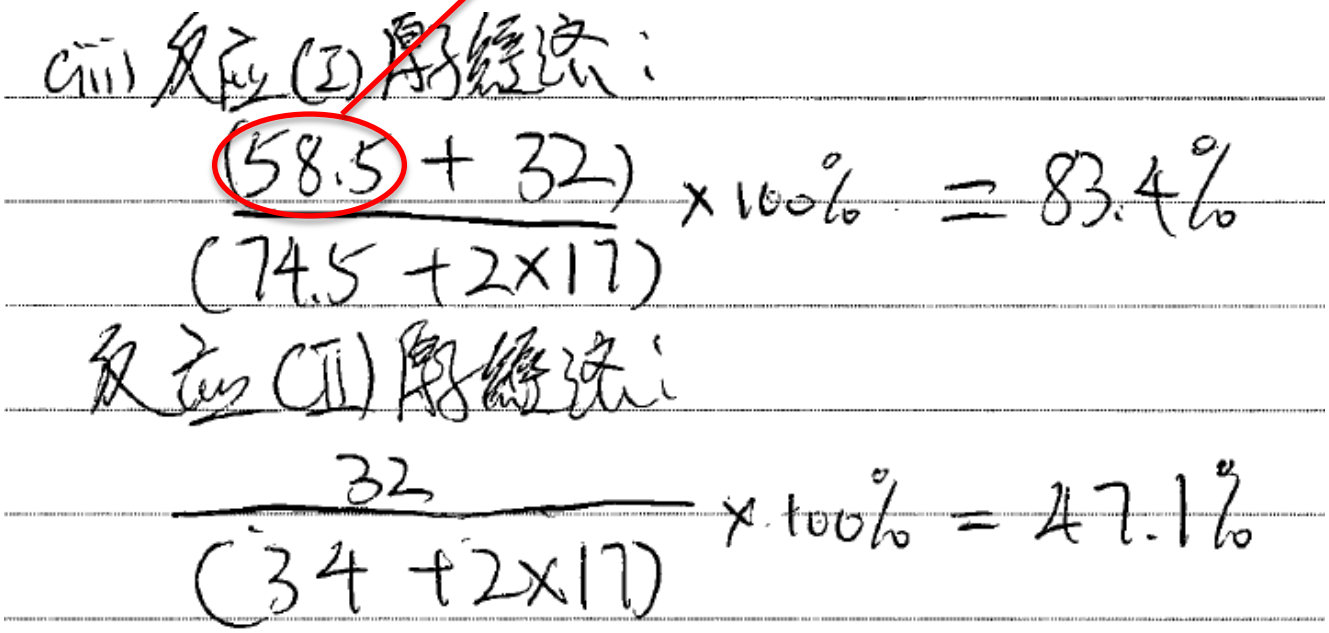
Basic Chemical Knowledge

- **Comments**:

  ~three quarters of the candidates were able to calculate the respective atom economy of Reactions (I) and (II) and use the result to determine which of them can be considered as greener

Basic Chemical Knowledge

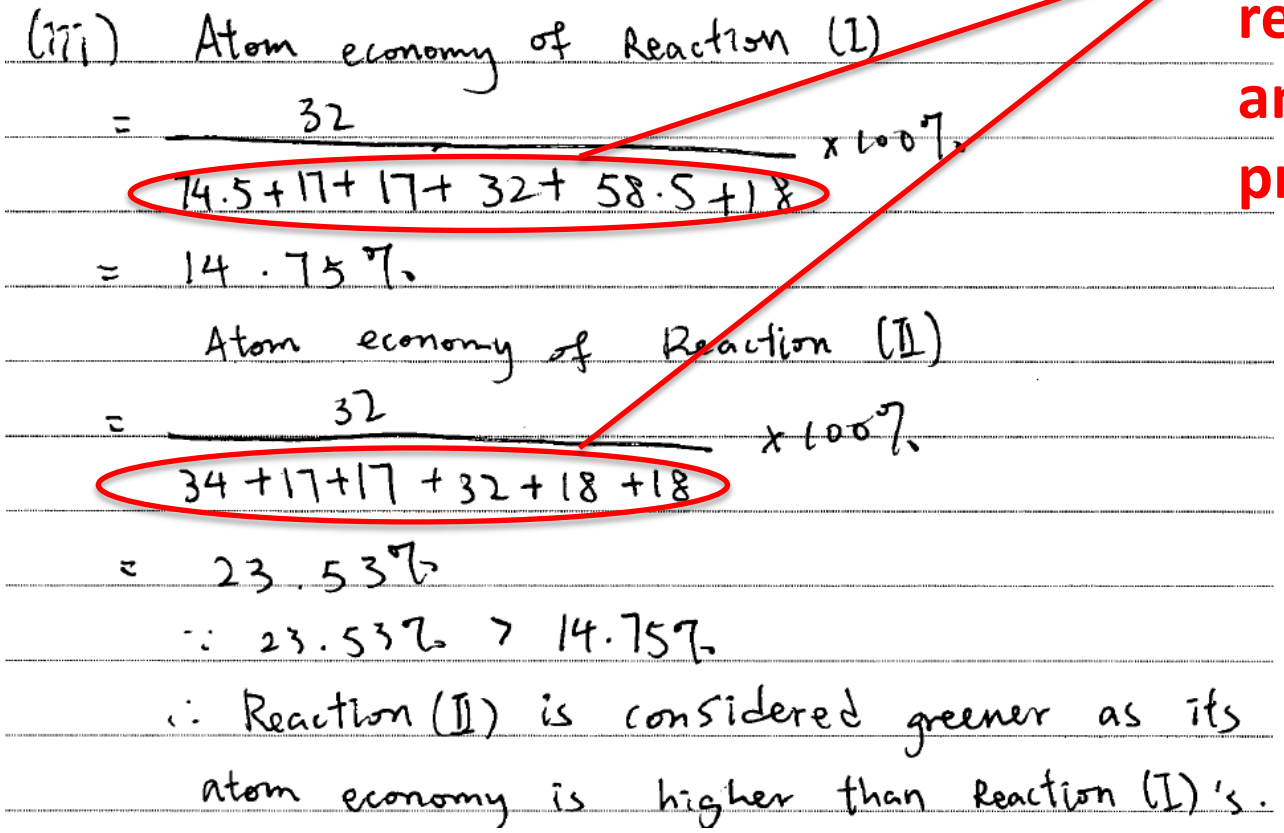
- Exemplars:
- Version A:



∵反應(I)的原子經濟較反應(II)高，∴反應(I)被視為較綠色。

Basic Chemical Knowledge

- Version B:



Use ALL the formula masses of reactants and products

Basic Chemical Knowledge

- Version C: [較佳]

b)(iii) 反應(1)的原子經濟：

$$\text{原子經濟} = \frac{32}{74.5 + 17 \times 2} \times 100\%$$

$$= 29.5\%$$

反應(2)的原子經濟：

$$\text{原子經濟} = \frac{32}{34 + 17 \times 2} \times 100\%$$

$$= 47.1\%$$

所以反應(2)較綠色，因原子經濟較高。

Basic Chemical Knowledge

- 1. (c) (i) State one feedstock for $CaCO_3(s)$.
- **Expected**:

  limestone / marble or any suitable mineral
- **Comments**:

  ~half of the candidates were able to state a feedstock such as limestone for $CaCO_3(s)$

Basic Chemical Knowledge

- 3. (a) (ii)

  … solvents should dissolve the organic compounds … State one other property … solvents …

- **Expected**:

  Immiscible with water / low b.p. / easily evaporate

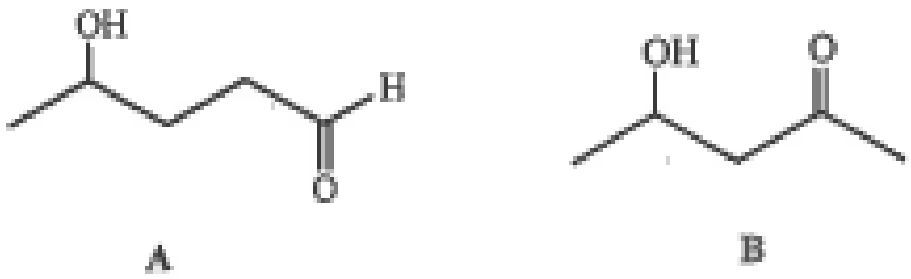
- **Comments**:

  ~a third of the candidates were able to suggest a property of the solvent such as its high volatility

Basic Chemical Knowledge

- 3.(a) (iii)

  Chemical test to distinguish:



Basic Chemical Knowledge

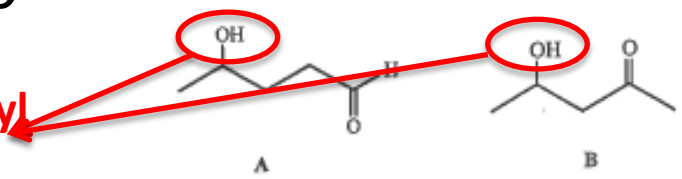
- 3. (a) (iii)
- **Expected**:

  Reagent: Heating with Tollen's reagent

  Observation: Only A gives silver mirror.

- **Comments**:

  *~two thirds of the candidates were able to describe a chemical test to distinguish compounds **A** and **B**. Some candidates **wrongly used acidified sodium dichromate solution** to distinguish the two compounds despite both having the oxidisable hydroxyl group*



Oxidisable hydroxyl group

Basic Chemical Knowledge

- **Exemplars:**
- **Version A:**

(iii). Add 2,4-dihydrophenylhydrazine to both A and B solution, B would give red precipitate but A will not.

- **Version B** [較佳] 正確試劑

(iii) 用托倫斯試劑 A 會有反應生成一光滑銀色表面在試管，而 B 則沒有反應。

正確觀察

Basic Chemical Knowledge

- 3. (c) (iii) … dioxins …

  (1) … why …. need … measure dioxin …
- **Expected**:

  Dioxin causes cancer / is toxic.
- **Comments**:

  ~two thirds of the candidates were able to suggest that there is a need to measure dioxin levels as dioxin is toxic.

Basic Chemical Knowledge

- 3. (c) (iii) … dioxins …

(2) …dioxin levels…using modern instrumentation

- **Expected**:

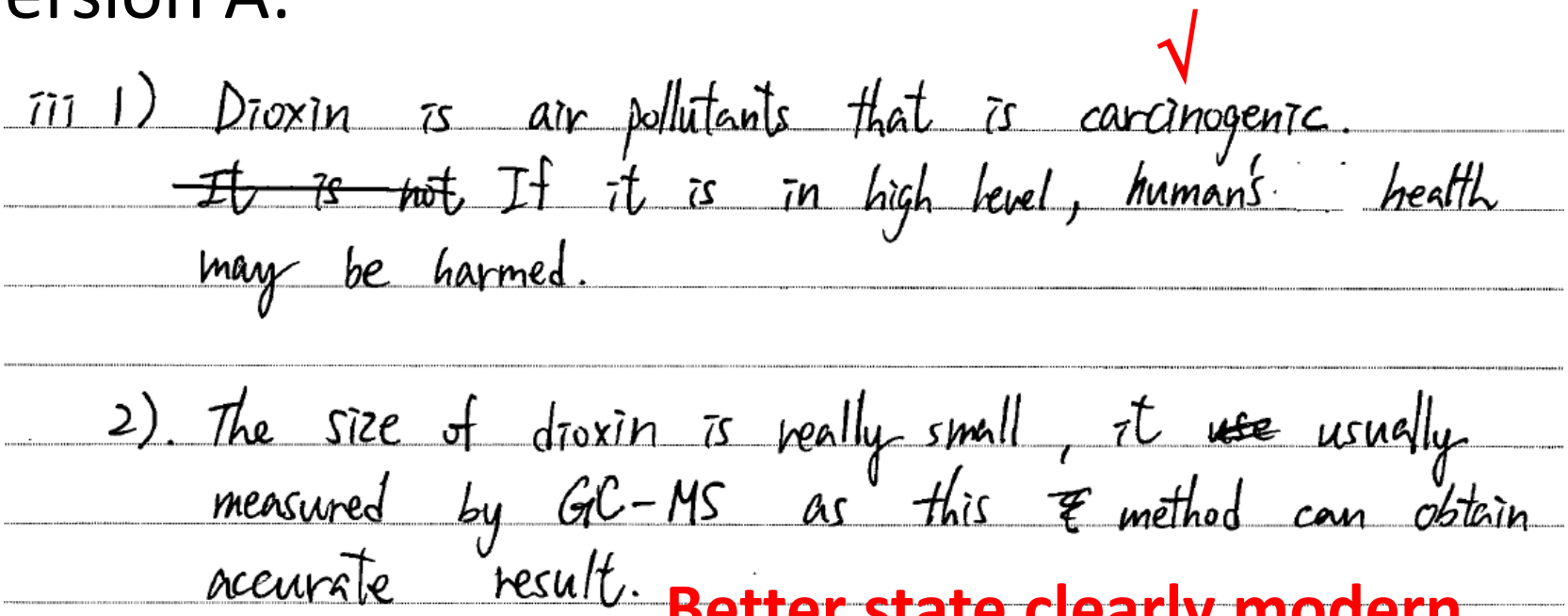
  Accurate and sensitive

- **Comments**:

  ~a quarter of the candidates were able to suggest that modern instrumentation is more able to measure low levels of dioxin

Basic Chemical Knowledge

- **Exemplars**:
- Version A:

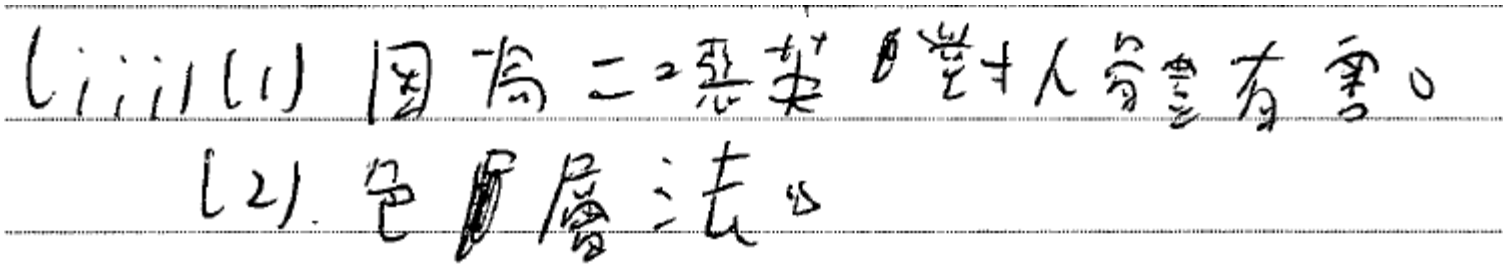

iii 1) Dioxin is air pollutants that is carcinogenic. √
~~It is not~~ If it is in high level, human's health may be harmed.

2). The size of dioxin is really small, it ~~use~~ usually measured by GC-MS as this 方 method can obtain accurate result.

Better state clearly modern instrumentation is more sensitive to low levels of dioxin

Basic Chemical Knowledge

- Version B:



(1)沒有明確說明有毒或致癌
(2)答非所問

Basic Chemical Knowledge

- Version C: [Better]

iii (1) Dioxin is carcinogenic.
(2) Modern instrumentation give a more accurate measurement and also more sensitive to the dioxins.

Focus areas

- Basic chemical knowledge
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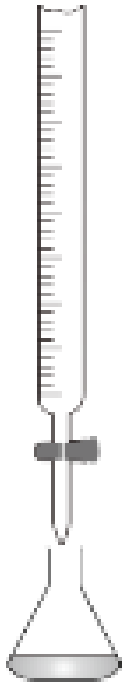
Experimental work

- 3. (b) (ii)

  Draw … set-up … in titration, labelling all …

- **Expected**:



Correct labelling:
Burette,
conical flask,
KSCN(aq),
acidified bacon sample with $AgNO_3(aq)$

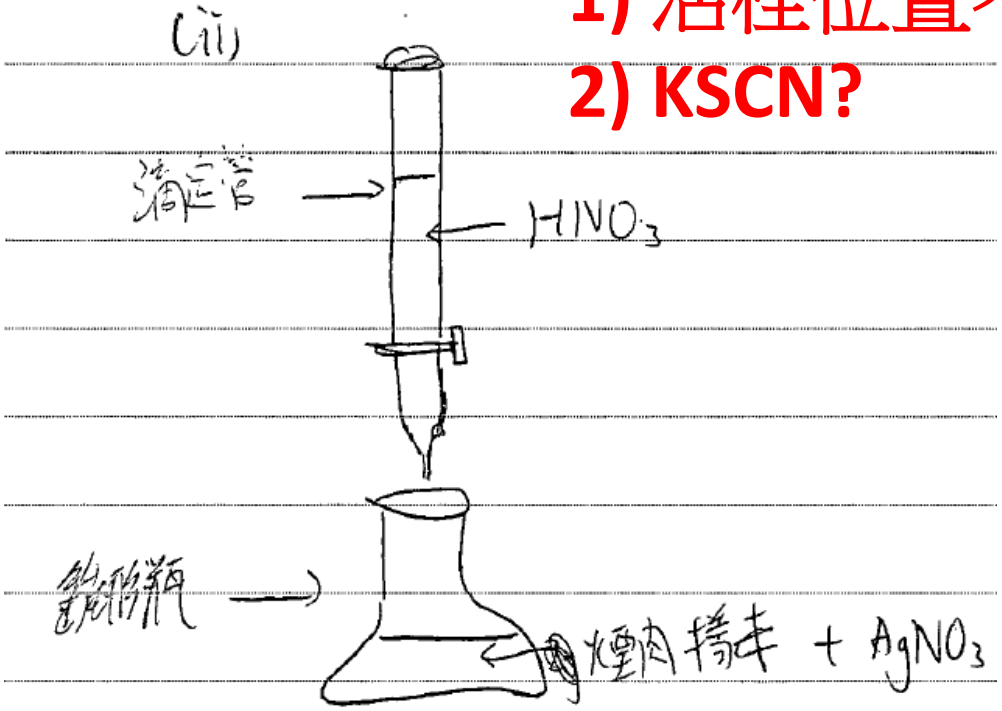
Experimental Work

- **Comments**:

  ~two thirds of the candidates were able to draw a labelled diagram to be used in the titration. Some candidates failed to draw the stopcock and some candidates wrongly used a beaker instead of a conical flask

Experimental Work:

- Version A:

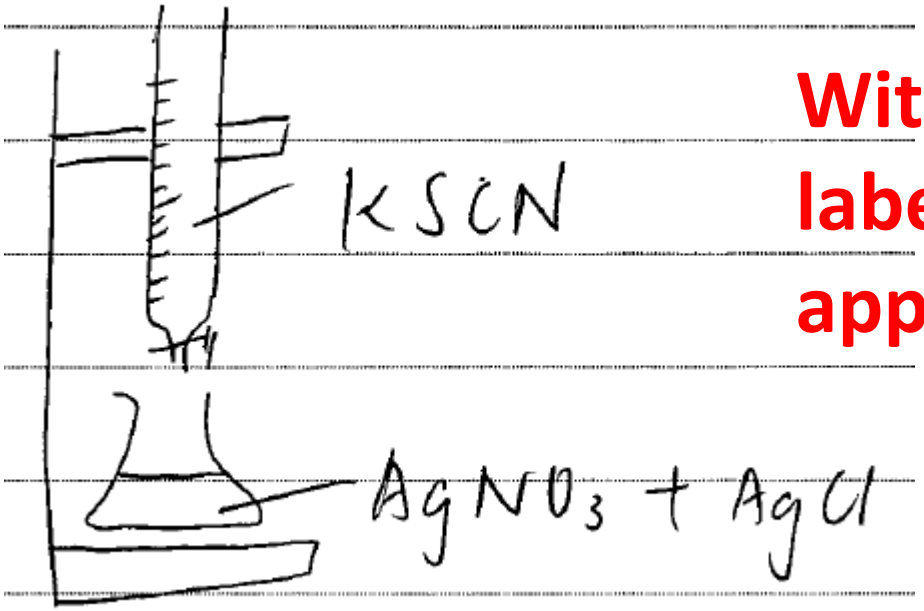


1) 活栓位置不正確

2) KSCN?

Experimental Work

- Version B:

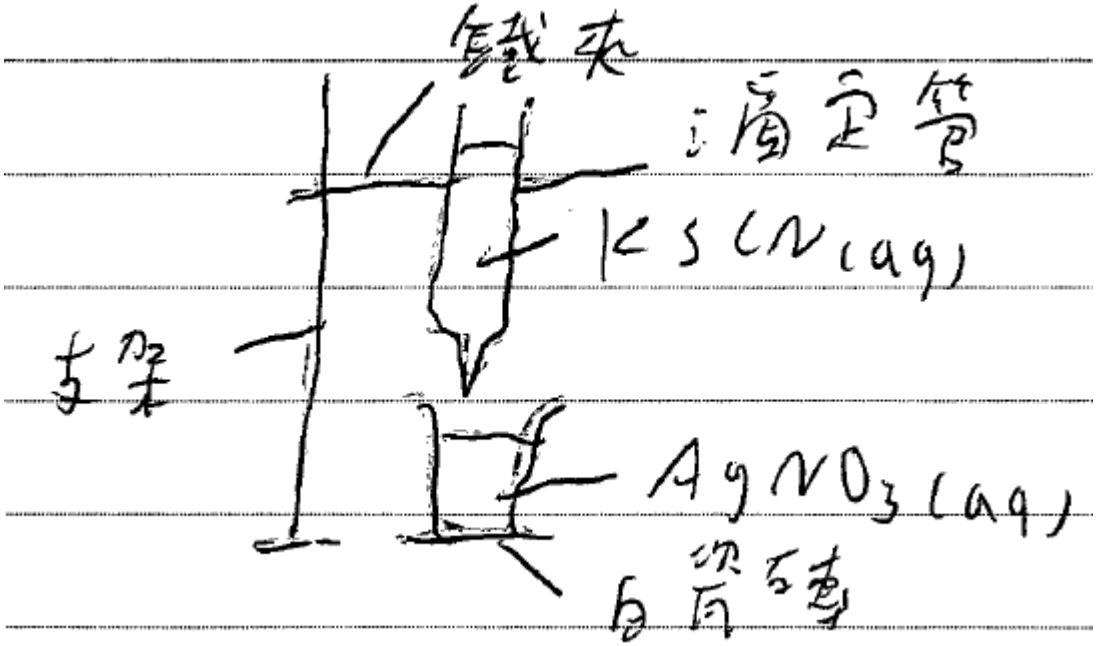


Without labelling the apparatus

Experimental Work

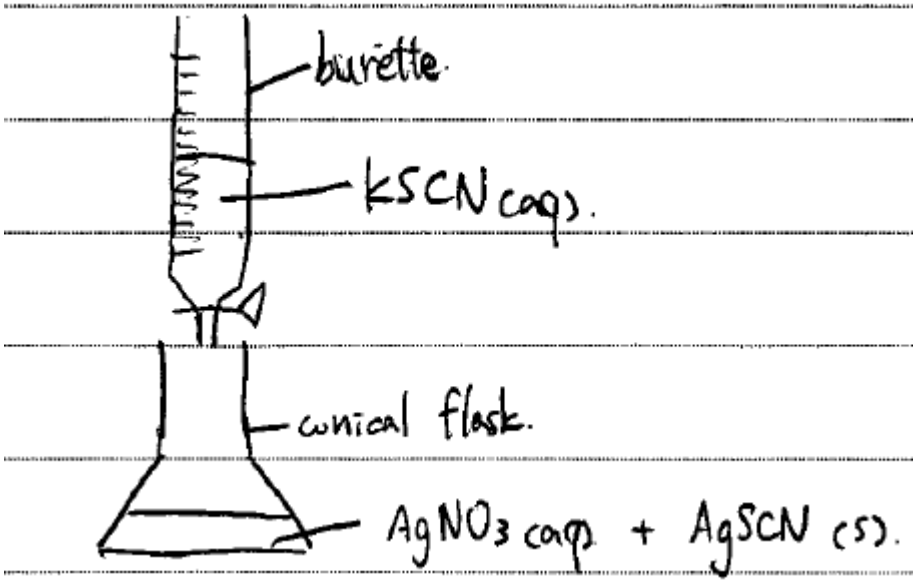
- Version C:

1) 沒有活栓
2) 使用了疑似燒杯物體代替錐形瓶進行滴定



Experimental Work

- Version D: [Better]



Experimental Work

- 3. (c) (i) … TLC..

  (1) … why chromatography … separate a mixture.

- **Expected**:
- *Because different substances have different adsorptivity to the stationary phase and different solubility in mobile phase*

  [Concept of a property difference and involving 2 different phases]

Experimental Work

- **Comments**:

  Just below half of the candidates were able to explain the separation of a mixture by chromatography in terms of different solubility and adsorptivity of the components in the mobile phase and stationary phase.

Experimental Work

- **Exemplars**:
- Version A:

1) Different solven has different solubility. Solution dissolve in different layer.

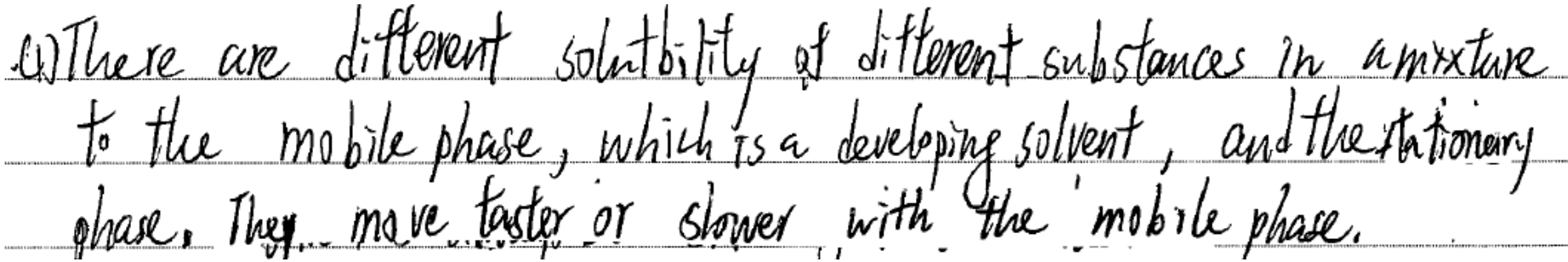
- Version B:

Lack of concept of different phases

1) 因為利用混合物中不同化合物的極性。
產回化合物不同極性，包層法使能分離混合物。

Experimental Work

- Version C: [Better]



Has the concept of a difference in a property and 2 phases

Experimental Work

- 3. (c) (i)
  (2) … result in TLC, suggest a method …
  separate a large amount …
- **Expected**:
  Column chromatography
- **Comments**:
  Just below half of the candidates were able to suggest column chromatography to separate a large amount of the mixture

Focus areas

- Basic chemical knowledge
- Experimental work
- Effective communication
- Calculations
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- Unfamiliar Context

Effective Communication

- 1. (b) (i)

  With the help of **chemical equations**, briefly describe how **hydrogen, chlorine and sodium hydroxide** are produced in a membrane electrolytic cell.

- **Expected**:

  Raw material: brine / conc. NaCl as electrolyte

  Chemical equations:

  $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

  $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

  Function of membrane

  Membrane is permeable to cations but not anions and sodium hydroxide is obtained in the cathode.

Effective Communication

- 1. (b) (i)
- **Comments**:
- *~half of the candidates were able to describe the production of hydrogen, chlorine and sodium hydroxide in a membrane electrolytic cell. Some candidates failed to give the raw material and / or the two half equations in the production of hydrogen and chlorine.*

Effective Communication

- **Exemplars**:
- Version A:

正確化學方程式

(b) (i) $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

$2H^+(aq) + 2e^- \rightarrow H_2(g)$

$Na^+(aq) + OH^-(aq) \rightarrow NaOH(aq)$

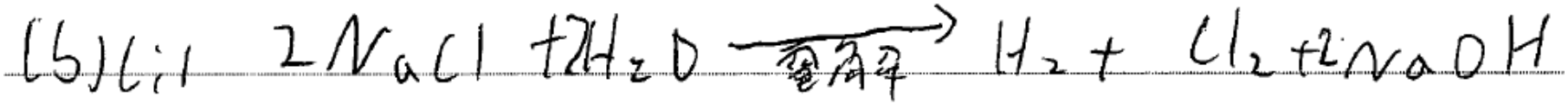
氯氣在陽極室中產生，而氫氣在陰極室中產生，當中 Na^+ 透過薄膜，滲透進陰極室中，与 OH^- 產生反应，形成 $NaOH(aq)$

正確陳述: 說明功能

如果能寫下原料更佳

Effective Communication

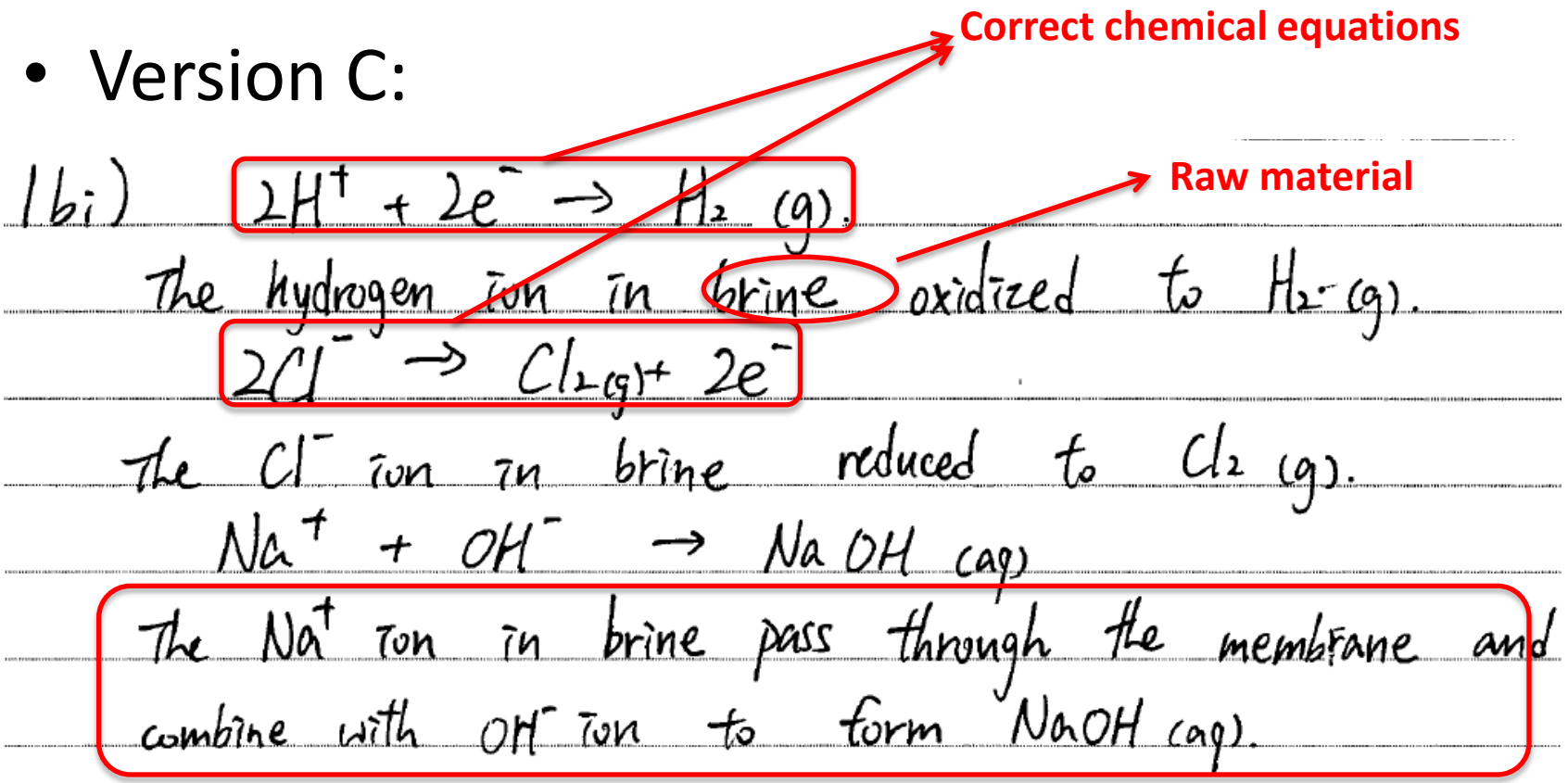
- Version B:



1. 如果寫下產品(H_2 & Cl_2) 各自化學方程式會較佳
2. 題目要求簡述

Effective Communication

- Version C:

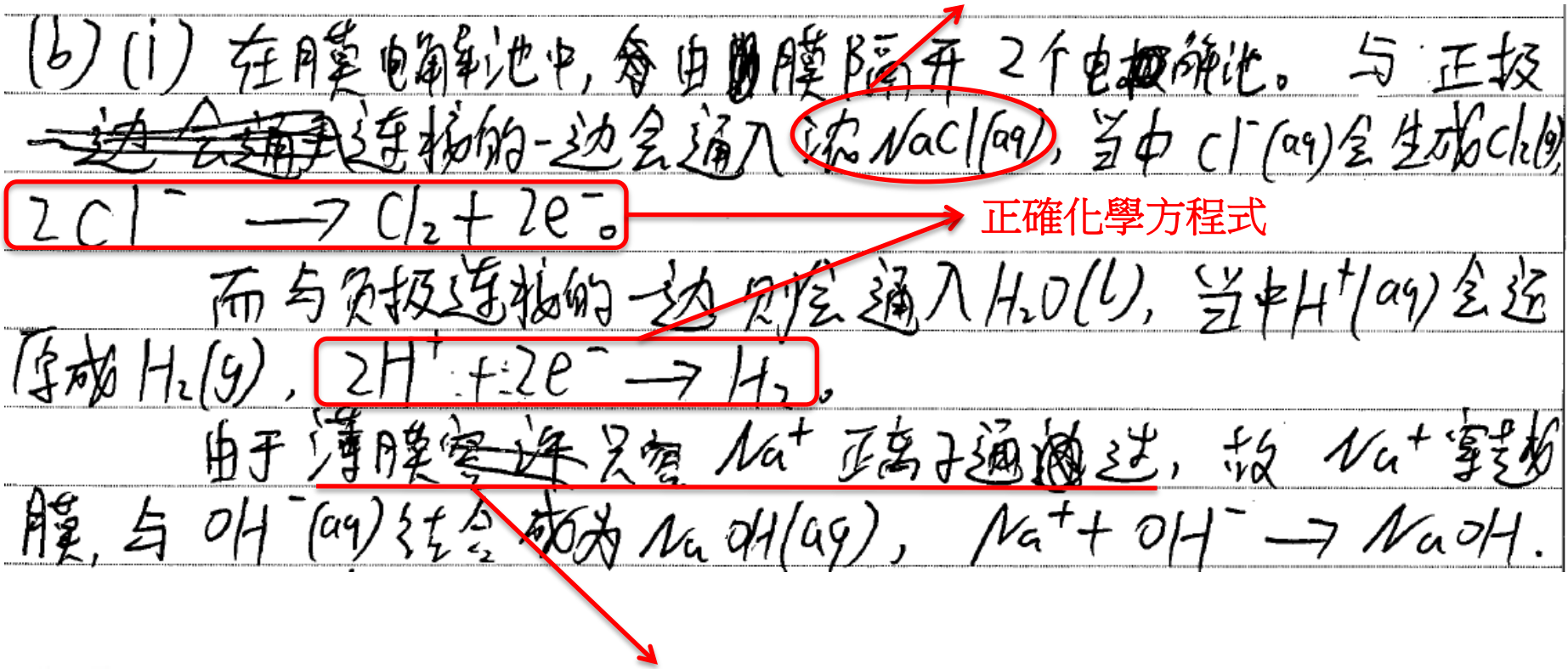


Attempted to mention the function of membrane and how NaOH is formed

Better: if the function of membrane and the position for NaOH formation are mentioned more explicitly.

Effective Communication

- Version D: [較佳]



Focus areas

- Basic chemical knowledge
- Experimental work
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- Unfamiliar Context

Calculations

- 1. (c) (iv) The activation energy … 160 kJ mol^{-1}. Calculate the ratio of … rate constant at 1500 K to … 1200 K …
- **Expected**:

$$\log\left(\frac{k_2}{k_1}\right) = \frac{E_a}{2.3R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\log\left(\frac{k_2}{k_1}\right) = \frac{160 \times 10^3}{2.3 \times 8.31}\left(\frac{1}{1200} - \frac{1}{1500}\right)$$

$$\frac{k_2}{k_1} = 24.8$$

1) **Make use of Arrhenius equation**
2) **Correct substitution of data**
3) **Correct answer**

Calculations

- **Comments**:

  Just below half of the candidates were able to calculate the ratio of the rate constant at 1500 K to the rate constant at 1200 K for the decomposition of $CaCO_3(s)$. Some candidates failed to use the Arrhenius equation in their calculations.

Calculations

- **Exemplars**:
- Version A:

Without conversion of 160 kJ mol^{-1} to 160000 J mol^{-1}

iv) $\log\left(\frac{k_2}{k_1}\right) = \frac{E_a}{2.3R} \left(\frac{1}{T_1} - \frac{1}{T_2}\right)$.

Let k_2 be rate constant at 1500 k, k_1 be rate constant at 1200 k.

$\log\left(\frac{k_2}{k_1}\right) = \frac{160}{2.3(8.31)} \left(\frac{1}{1200-498} - \frac{1}{1500-498}\right)$

$\frac{k_2}{k_1} = 10^{3.57 \times 10^{-2}}$

$= 1.008$.

Therefore ratio of rate constant at 1500 k : rate constant at 1200 k

$= 1 : 1$.

Calculations

- Version B: [較佳]

1.(c) (iv) 在1500K的速率常數 $k_1 = Ae^{\frac{-160000}{8.31 \times 1500}}$，A為常數

在1200K時的速率常數 k_2 $Ae^{\frac{-160000}{8.31 \times 1200}}$，A為常數

二者比例為: $\frac{e^{-12.83594063}}{e^{-16.04492579}}$

$\frac{k_1}{k_2} = \frac{24.75}{1}$

$k_1 : k_2 = 25 : 1$

Calculations

- 3. (b) (iii) … sodium contents … 2.0 g … bacon …

  … 2.50 cm^3 of 1.0 M $AgNO_3(aq)$. … filtrate … titrated with 0.10 M KSCN(aq) … mean volume of the KSCN … 9.42 cm^3.

Calculations

- **Expected**:
- No. of mole of KSCN(aq) = No. of mole of Ag^+(aq) left in the mixture = No. of mol of Ag^+(aq) reacted with KSCN(aq) = 0.1 x 0.00942
- No. of mol of AgCl formed

  = 1.0 x 0.0025 **–** 0.1 x 0.00942 = 0.001558
- Percentage by mass of sodium

  = (0.001558 x **23.0 / 2.0**) x 100%

  = 1.79%

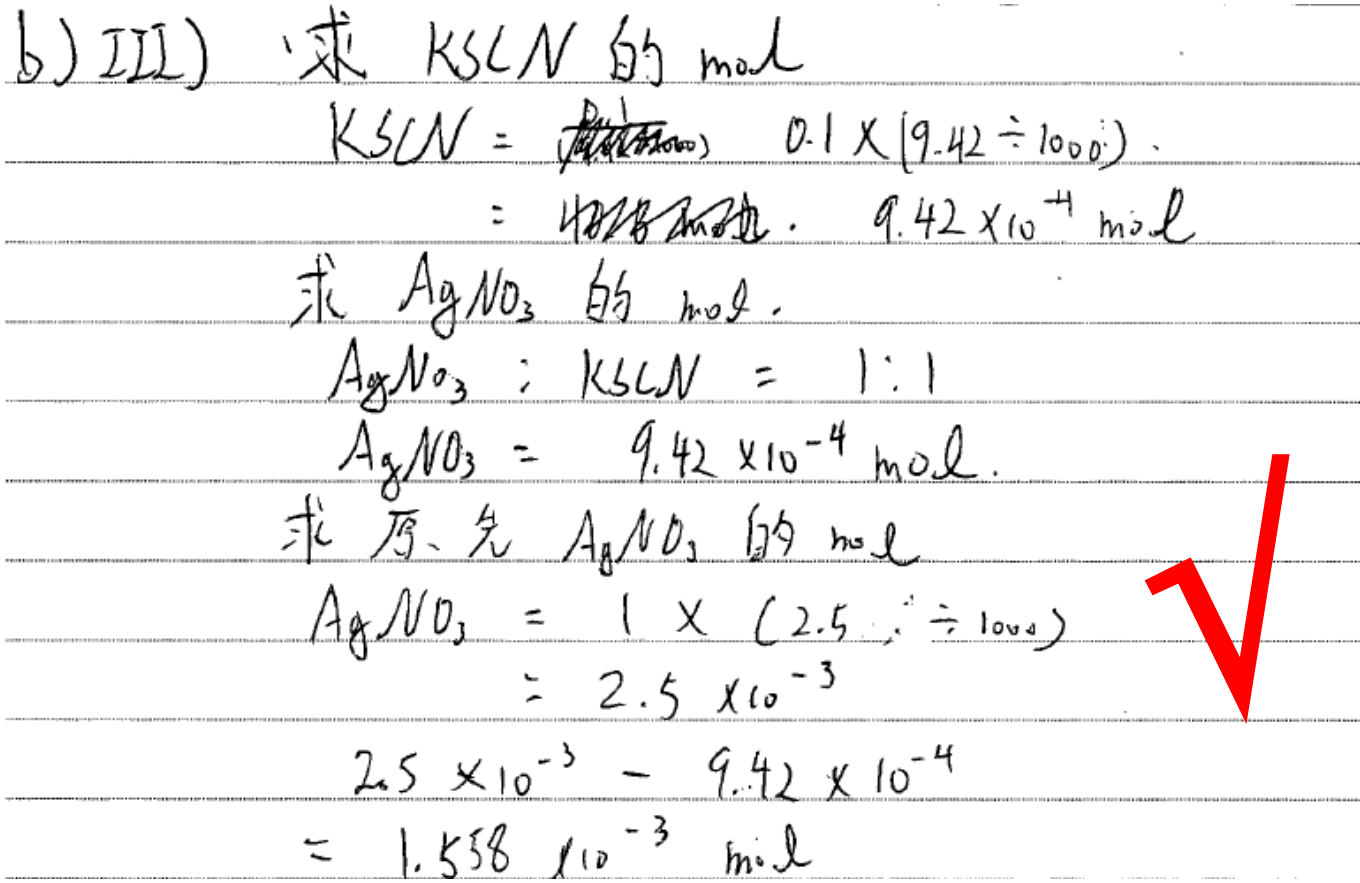
Calculations

- **Comments**:

  ~half of the candidates were able to calculate the percentage by mass of sodium in the bacon sample

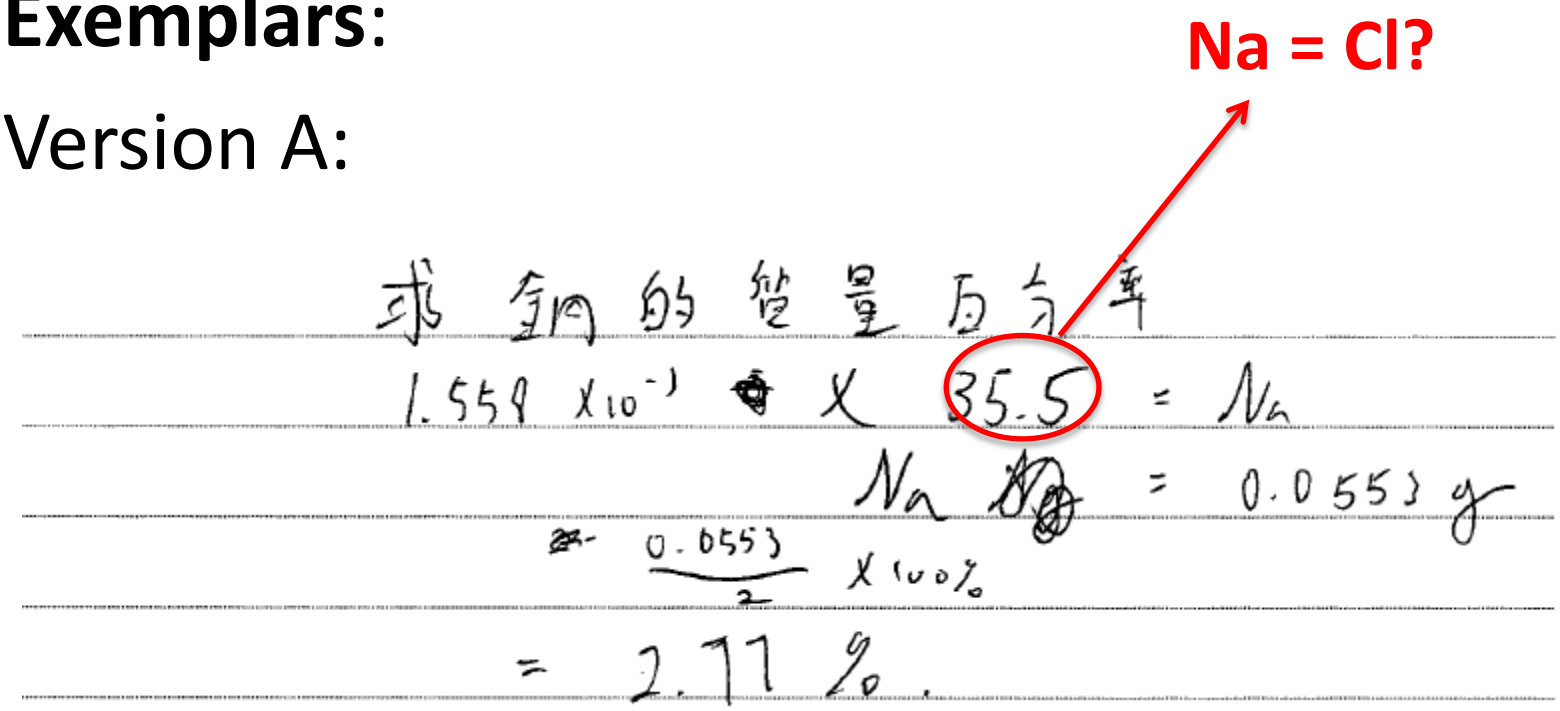
Calculations

- **Exemplars**:
- Version A:



Calculations

- **Exemplars**:
- Version A:



Calculations

- Version B: [Better]

3biii number of mole of excess $AgNO_3$

$= \frac{9.42}{1000} \times 0.1 \text{ mol}$

$= 9.42 \times 10^{-4} \text{ mol}$

number of mol of $AgNO_3$ reacted

$= \frac{2.5}{1000} \times 1 - 9.42 \times 10^{-4}$

$= 1.558 \times 10^{-3} \text{ mol}$

Calculations

- Version B: [Better]

If write as sodium, it will be better.

mass of NaCl = $(1.558 \times 10^{-3} \times 23)$ g

= 0.0358 g

percentage by mass of Na in the LaCon sample

$$= \frac{0.0358}{2} \times 100\%$$

= 1.79%

Focus areas

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- Unknown Deduction
- Unfamiliar Context

Unknown Deduction

- 3. (a) (i) … relative molecular mass = 40.0 …

  IR absorption peak at around 2150 cm^{-1}

… deduce … structural formula … hydrocarbon.

- **Expected**:

  2150 cm^{-1} in IR spectrum => C≡C

  molecular mass = 40.0 => $HC{\equiv}CCH_3$

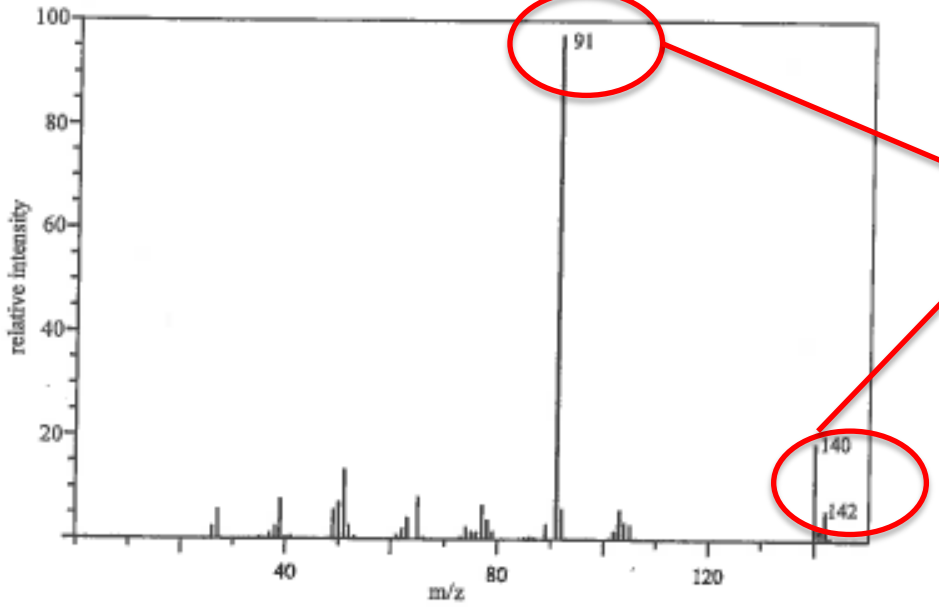
Unknown Deduction

- **Comments**:

  ~three quarters of the candidates were able to make use of the infra-red data and the relative molecular mass to work out the possible structural formula. Some candidates failed to give the structural formula as $HC{\equiv}CCH_3$.

Unknown Deduction

- 3. (c) (ii) … chlorine has … ^{35}Cl and ^{37}Cl.



Has to make use of these data

Deduce a possible structure …

Unknown Deduction

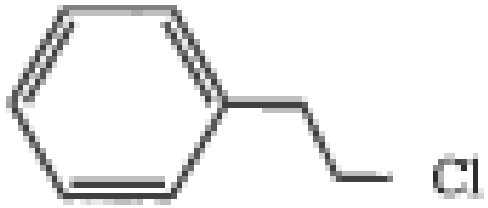
- **Expected**:

  m/z = 91: $C_6H_5CH_2^+$

  m/z = 140: $C_6H_5CH_2CH_2{}^{35}Cl^+$

  m/z = 142: $C_6H_5CH_2CH_2{}^{37}Cl^+$

  Possible structure:



Unknown Deduction

- **Comments**:

  Just below half of the candidates were able to deduce the structure of the compound by making use of the labelled peaks in the mass spectrum provided. Some candidates failed to recognise the m/z peaks corresponding to 140 and 142 are due to the presence of the two isotopes of chlorine.

Unknown Deduction

- **Exemplars**:
- Version A:

From the peak of m/z = 91, it should be a fragment ion of  . There are a difference of 49 between m/z = 140 and m/z = 91, it would be a Cl-CH_2^+ fragment. Therefore, the structure of the compound:

1) **Indicate m/z peak 91 with the correct chemical species**
2) **Able to draw a possible structure of the compound.**
3) **Cannot show clearly the concept of isotopes for m/z peaks 140 & 142.**

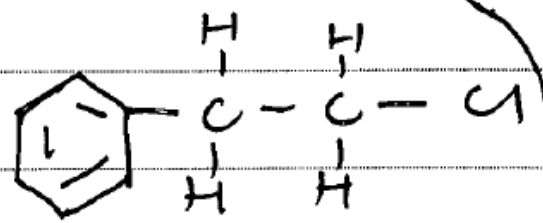
Unknown Deduction

- Version B: [較佳]

(ii) 在 m/z = 91 時，含有 $C_7H_7^+$ 離子

在 m/z = 140 時，含有 $C_7H_7CH_2Cl^+$ 離子

由此推斷化合物的結構：



而在 m/z = 140 的 Cl 是 ^{35}Cl

而在 m/z = 142 時的 Cl 是 ^{37}Cl

Focus areas

- Basic chemical knowledge
- Question requirement
- Experimental work
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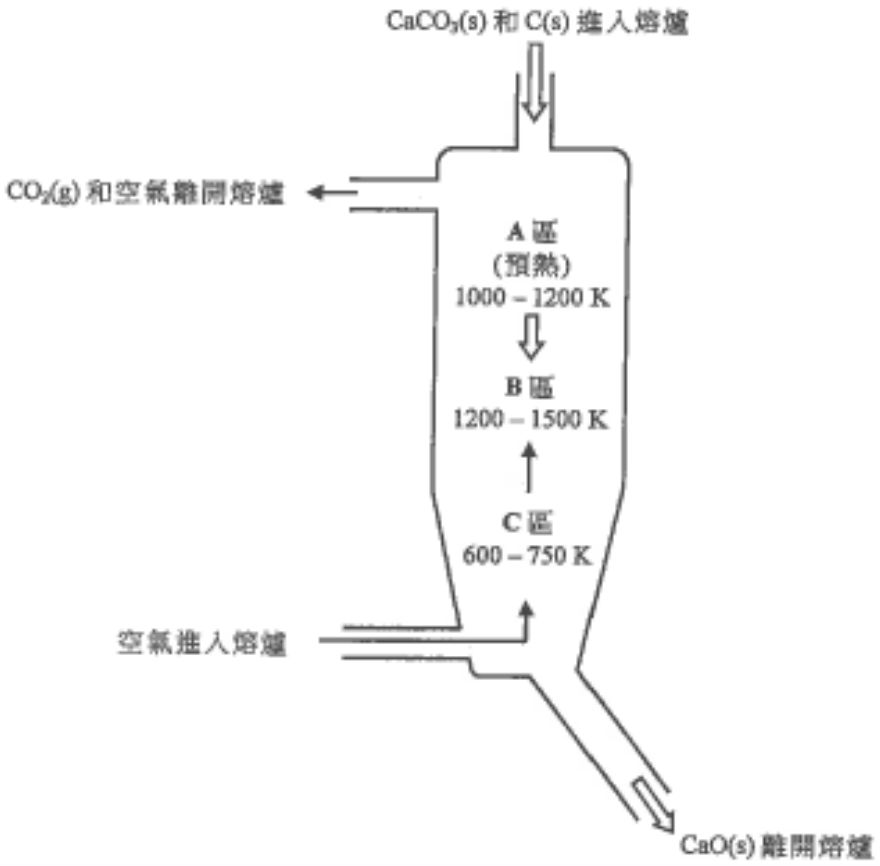
Unfamiliar Context

- 1. (c)



Unfamiliar Context

- 1. (c) (ii)

  Explain why … C(s) and air … higher average temperature in zone **B** than in zone **A**.
- **Expected**:

  Carbon burns in air to produce heat.
- **Comments**:

  *Just below half of the candidates were able to state the exothermic reaction between carbon and air would result in a higher average temperature in zone **B** than in zone **A**.*

Unfamiliar Context

- **Exemplars**:
- Version A:

(ii) 因為在A區中，$C_{(s)}$ 和空氣反應形成 $CO_{2(g)}$，$CO_{2(g)}$ 的濃度上升，平衡位置向左移；而反應是吸熱反應，要升溫才會令到平衡位置向右移；因此在B中的溫度要比A高

錯誤地運用
化學平衡
概念解釋

Unfamiliar Context

- Version B: [Better]

ii, The combustion of C in air is exothermic, as it more deeper, C combust more to give out more heat to the environment.

Unfamiliar Context

- (ii) … 1 atm. Give TWO reasons … higher …
  pressure is not preferred.
- **Expected**:
  High operation pressure needs high construction cost.
  High operation pressure shifts the equilibrium position to the left, decreasing the yield.
- **Comments**:
  about two thirds of the candidates were able to give two reasons in terms of cost and equilibrium position to account for not using a higher operation pressure.

Unfamiliar Context

- **Exemplars**:
- Version A:

(iii) Higher operation pressure will increase the cost and also cause ~~[illegible]~~ risk of explosion.

Better also explain in terms of the shift of equilibrium position

Unfamiliar Context

- Version B: [Better]

(iii) A higher operation pressure may increase the construction and maintainence cost of the plant. Moreover, as the product of the reaction contain gas, increase in pressure might shift the equilibrium position to left and lower the yield of the reaction.

Unfamiliar Context

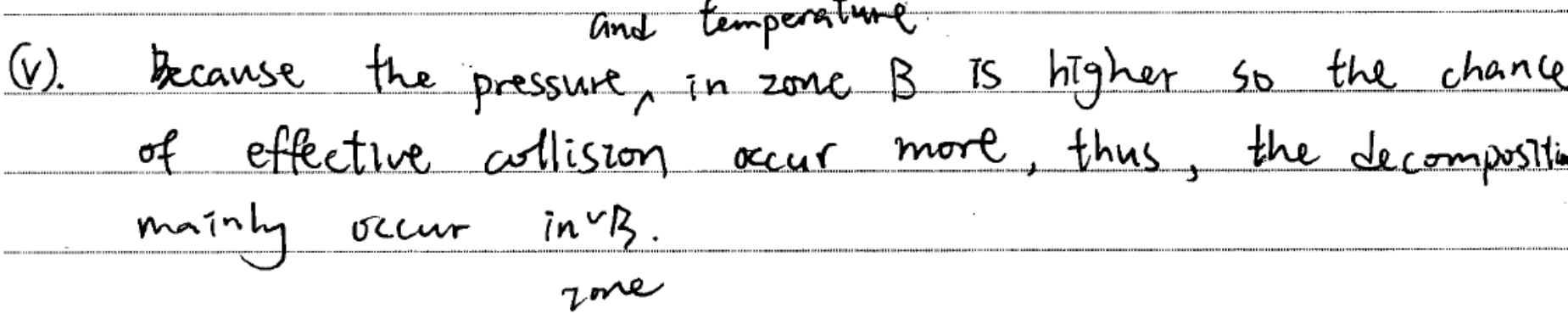
- 1. (c) (v) … chemical equilibrium, … decomposition of $CaCO_3(s)$ … zone **B**.
- **Expected**:

  Higher temperature shifts the equilibrium position to the right, increasing the yield.
- **Comments**:

  *~half of the candidates were able to suggest why the decomposition of $CaCO_3(s)$ mainly occurs in zone **B***

Unfamiliar Context

- **Exemplars**:
- Version A:



Not explain in terms of chemical equilibrium

Unfamiliar Context

- Version B: [Better]

v. The decomposition of $CaCO_3(s)$ is endothermic, as zone B have the highest temperature, the reaction there have the highest yield as the equilibrium shifted to right. Moreover, ahigh temperature also provide higher rate.

Focus areas

- Basic chemical knowledge
- Experimental work
- Effective communication
- Calculations
- Unknown Deduction
- Unfamiliar Context

香港考試及評核局
Hong Kong Examinations and Assessment Authority

HKDSE 2019 化學卷 2

第2題 物料化學

討論範圍

- 基本化學知識：
  - 例：纖維素的結構、綠色化學的概念
- 傳意：
  - 例：撰寫簡短文句比較不同物料的性質和用途
  - 例：繪畫PVC的結構圖 / 聚合物單體結構
- 理解關係：
  - 例：硫化作用 / 不同塑膠X、Y、Z的性質

基本化學知識

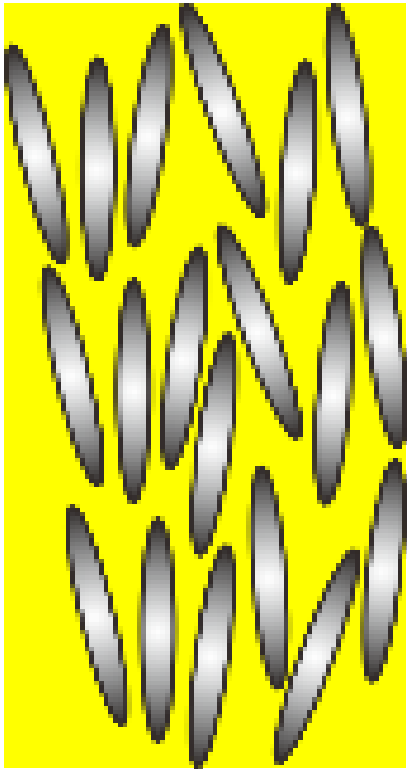
- 纖維素的結構及氫鍵
- 向列相液晶體的結構
- 綠色化學的概念
- 鐵晶體結構圖及其名稱
- 書寫不同化學專用字詞
  - 擠塑 / 注射（成型）
  - 硫
  - 縮合（聚合）
  - 硫化（作用）

基本化學知識 (a) (i)

- 只有少數考生能夠
  - 指出纖維素的結構
  - 使用氫鍵來解釋纖維素和水分子的相互作用

基本化學知識 (a) (ii)

- 約一半考生能夠繪畫向列相液晶分子的結構
  - 大小相約長棒分子
  - 相互平衡
  - 沒有長程序性

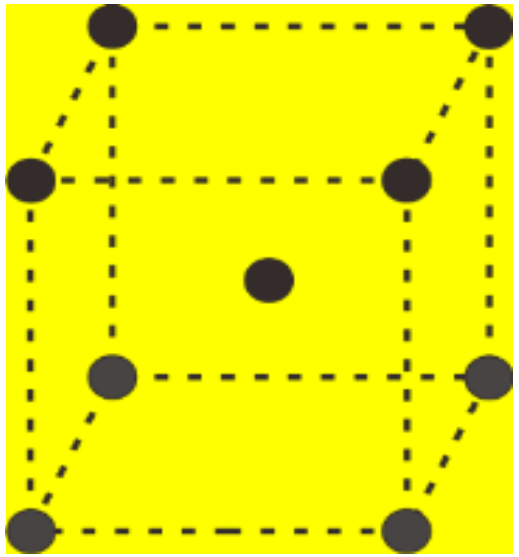


基本化學知識 (a) (iii)

- 剛少於1/2考生能夠提出一個或兩個原因以說明該反應可被視為綠色
- 一些考生誤以為由於該反應涉及「氯」，故被視為綠色

基本化學知識 (b) (i)

- 只有極少數考生能夠
  - 寫出鐵的敞開結構的正確名稱：體心立方
  - 繪畫其結構圖 (BCC)

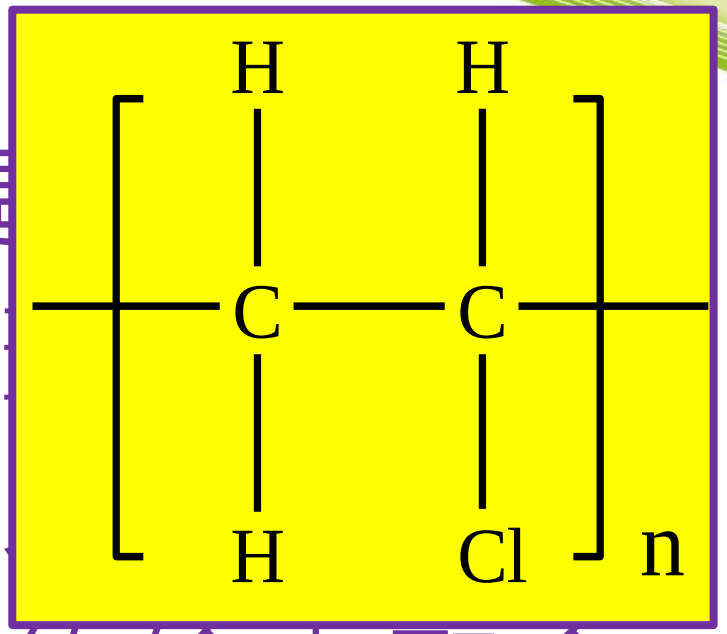


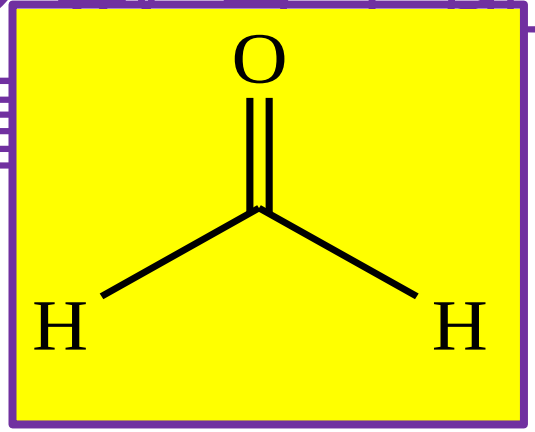
基本化學知識 (b) (ii)

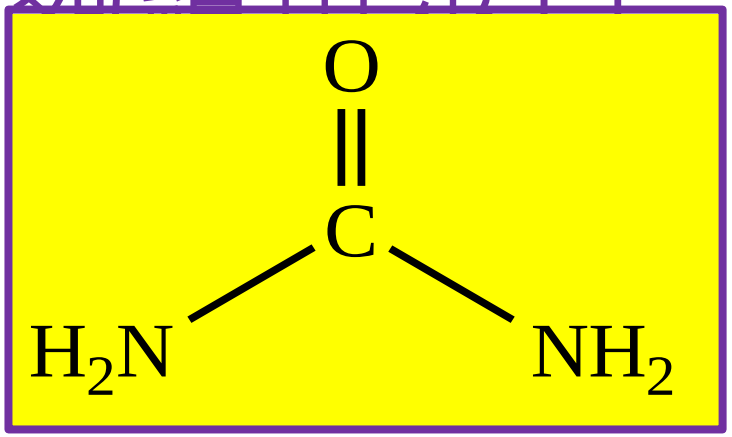
- 約1/2考生能夠提出兩個原因為何應使用合金 B 作為焊料
- 部分考生混淆了鉛和鋅(Sn !)，提出「合金 A 中的鋅有毒」

傳意 (b) (iv), (c) (i) (1)

- 只有1/4考生在這
分數，考生在繪
物的結構式表現
- 只有少數考生能夠繪畫聚合
物的單







理解關係：(b) (ii), (c)(iii)

- 考慮物料的性質和其日常用途的關係
  - –為什麼用合金B而不用合金A或合金C？
- 只有少數考生能夠顯示他們對 X 、 Y 和 Z 的結構和性質有所了解，並作合適的比較。

按性質➔選用途