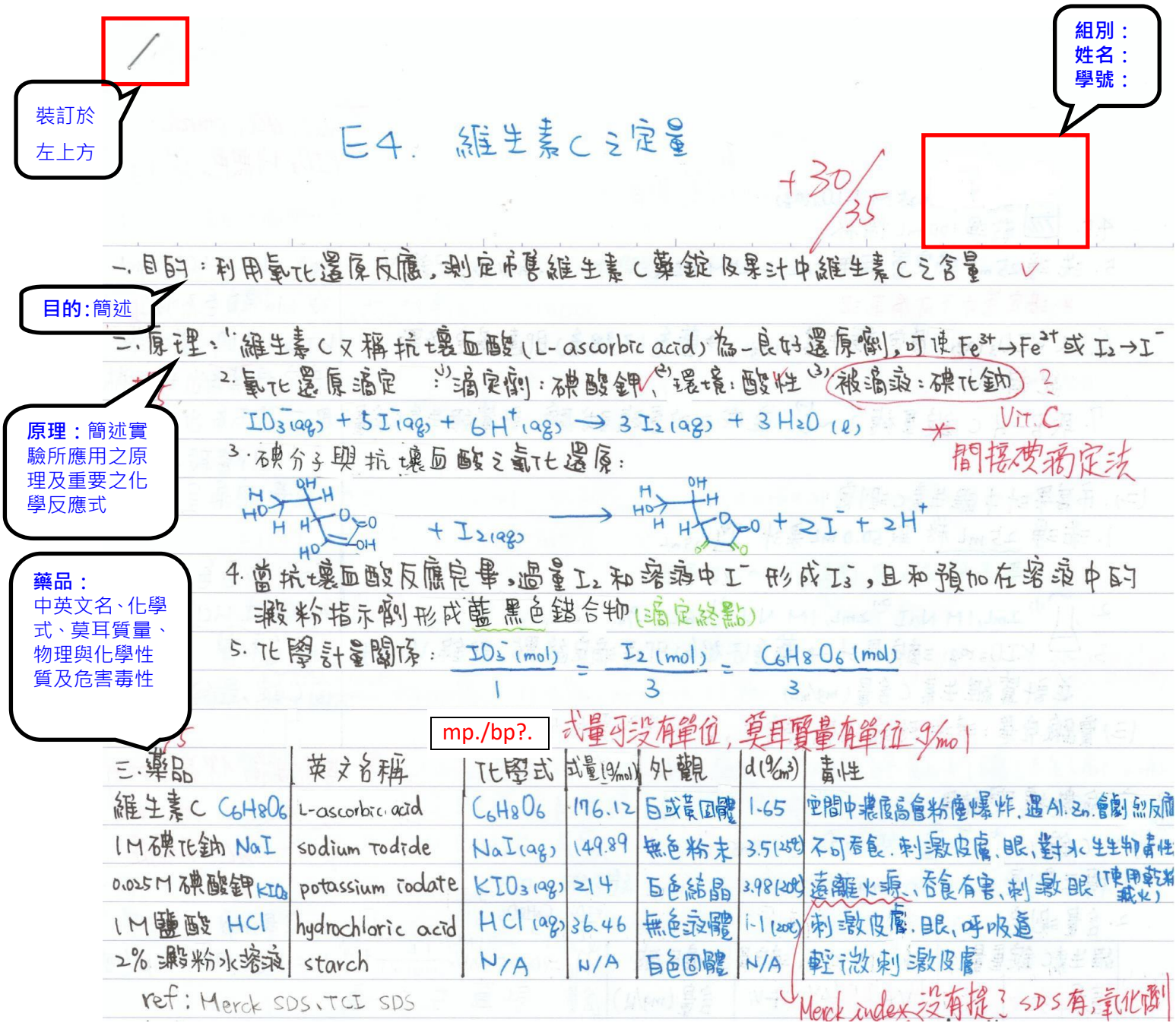
普通化學實驗『精簡報告』書寫範例

I. 預報包括：
   a. 目的：簡述。
   b. 原理：簡述實驗所應用之原理及重要之化學反應式。
   c. 藥品：需清楚瞭解所用藥品之性質，含中英文名、化學式、莫耳質量、物理與化學性質及危害毒性。
   d. 步驟：簡要條列或流程表示，繪製裝置圖，留右側 1/3 頁面書寫觀察



II. 實驗紀錄：簡要、詳細、條列式記錄

a. 反應物與產物之狀態與顏色。

b. 進行實驗之條件。

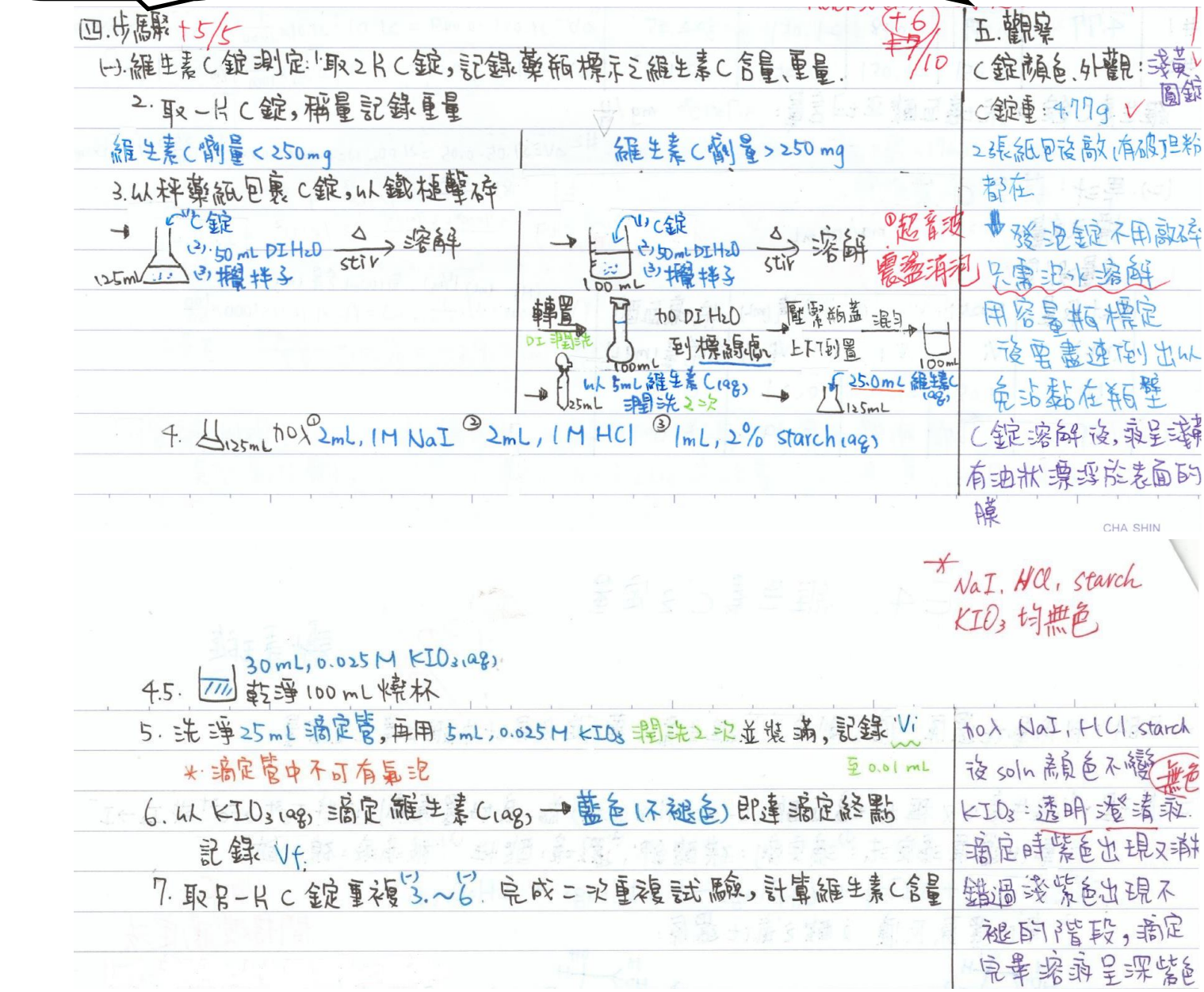
c. 操作過程。

d. 反應過程顏色、沉澱、吸熱放熱等變化。

e. 數據：參考實驗課本的格式或自創，但記錄整齊。

步驟:
以簡單清楚流程圖表示，繪製裝置圖

實驗紀錄：
a. 反應物與產物之狀態與顏色
b. 實際進行實驗之條件
c. 操作過程
d. 反應過程溶液顏色、沉澱、吸熱放熱等變化



(二). 市售果汁中維生素C測定：

1. 洗淨 25 mL 滴管，取 50.0 mL 果汁 125mL

果汁潤洗2次（若含果肉→改用量筒）

2. (1) 2mL, 1M NaI (2) 2mL, 1M HCl (3) 1mL, 2% starch(aq)

3. 以 KIO_3(aq) 滴定果汁 → 藍色(不褪色)即達滴定終點，記錄 Vi, Vf

並計算維生素C含量(mg/mL)

(三) 實驗完畢：清洗移液吸管、滴定管，並倒來於滴定管夾上

果汁：灰白色液體

原color 加入 NaI, HCl, starch 後

顏色不變

因C錠，最終呈深紫色

助理助教章

※ 要記錄，你是1000mg

故 dilute to 100.0 mL

取 25.0 mL 作滴定

III. 結果報告：

a. 數據處理：詳列計算過程，結果須具正確有效數字及單位。

六. 實驗數據與結果

(一). C錠：森萊富 維他命C 1000 ✓

1. 標示劑量：1000 ✓ mg/片 (Na: 326 mg, 纖維 0.3 g

2. 含量測定

	維生素C錠	0.025 M KIO_3 滴定體積(mL)			抗壞血酸
	重量(g)	Vi	Vf	ΔV = Vf − Vi	含量(mg/片)
#1	4.77 ✓	0.05	21.06	21.01	1.1×10^3
#2		0.05	21.05	21.00	1.1×10^3

計算在下一頁

維生素C錠中抗壞血酸平均含量：1.1×10^3 mg/片

(二). 果汁：蘋果C 品牌

1. 標示含量：7.5 mg/100 mL ✓ 不太適合的試樣

2. 含量測定

果汁取量	0.025 M KIO_3 滴定體積(mL)			抗壞血酸
(mL)	Vi	Vf	ΔV = Vf − Vi	含量(mg/100mL)
50	21.05	21.26	0.21	5.6
50	21.27	21.46	0.19	5.0

SHE

大助簽核章

計算.

(一). C錠(高劑量) +9/10

高劑量, 配100mL 取25mL ← 一片

$n_{C_6H_8O_6} = 3\,n_{KIO_3} = 3\times0.025\times\Delta V\times\frac{1}{1000}\times\frac{100}{25}$

$W_{C_6H_8O_6}(mg) = n_{C_6H_8O_6}\times176.12\times1000$

#1: $\Delta V = 21.06-0.05 = 21.01\ mL \Rightarrow W_{C_6H_8O_6} = 3\times0.025\times21.01\times\frac{1}{1000}\times\frac{100}{25}\times176.12\times1000$

$= 1110.1\ mg \xrightarrow{s.f=2} 1.1\times10^3\ mg/片$ ✓

#2 $\Delta V = 21.05-0.05 = 21.00\ mL \Rightarrow W_{C_6H_8O_6} = 3\times0.025\times21.00\times\frac{1}{1000}\times\frac{100}{25}\times176.12\times1000$

$= 1109.5 \xrightarrow{s.f=2} 1.1\times10^3\ mg/片$ ✓

平均: $\frac{1.1\times10^3+1.1\times10^3}{2} = 1.1\times10^3\ mg$. 平均 $1.1\times10^3\ mg/片$ ✓

誤差 $\frac{1.1\times10^3-1000}{1000}\times100\% = 11.0\% \xrightarrow{s.f=2} 11\%$ ✓

* 精簡報告, 可不誤差討論

實驗得到之 $C_6H_8O_6$ 量較標示多, 可能原因: (1) 滴定終點判讀: 大約都多滴1~2滴, 溶液呈深藍紫色才停下 (2) C錠中有其他還原劑存在, 耗掉的 KIO_3 並非只和 $C_6H_8O_6$ 反應 ✓

(二). $C_6H_8O_6$

果汁: $n_{C_6H_8O_6} = 3\,n_{KIO_3} = 3\times0.025\times\Delta V\times\frac{1}{1000}\times\frac{100}{50}$ ← 取50mL果汁, 求100mL中含量

$W_{C_6H_8O_6} = n_{C_6H_8O_6}\times176.12\times1000$

* $V_{eq.} = 0.21\ mL$ 太少, 誤差會很大, 避免用此類果汁.

#1: $\Delta V = 21.26-21.05 = 0.21\ mL \Rightarrow W_{C_6H_8O_6} = 3\times0.025\times0.21\times\frac{1}{1000}\times\frac{100}{50}\times176.12\times1000$

$= 5.55 \xrightarrow{s.f=2} 5.6\ mg$

#2: $\Delta V = 21.46-21.27 = 0.19\ mL \Rightarrow W_{C_6H_8O_6} \Rightarrow 3\times0.025\times0.21\times\frac{1}{1000}\times\frac{100}{50}\times176.12\times1000$

$= 5.02 \xrightarrow{s.f=2} 5.0\ mg$

平均: $\frac{5.6+5.0}{2} = 5.3 \xrightarrow{s.f=2} 5.3\ mg$.

* 列式、計算、s.f.、正確、good.

誤差: $\frac{5.3-7.5}{7.5}\times100\% = -29.5\% \xrightarrow{s.f=2} -30\%$.

具體結論

實驗測得之 $C_6H_8O_6$ 較標示少, 可能原因: (1) 果汁中其他成份影響: 果汁中可能含有其他氧化劑, 使得實驗中加入的 KIO_3 消耗量下降, 測得 $C_6H_8O_6$ 較少

* 其他: VitC含量太少、$V_{eq.}$ 太少、滴定誤差大、SHE、

CHA SHIN

普通化學實驗『完整報告』書寫範例

I. 預報包括：

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b. 原理：簡述實驗所應用之原理及重要之化學反應式。
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裝訂於左上方

組別：
姓名：
學號：

E8. 碘鐘實驗—碘鐘交響曲

37/50

目的：簡述

一. 目的：以定量 $S_2O_3^{2-}$ 與 I_2 的氧化還原反應測量 $S_2O_8^{2-}$ 與 I^- 的反應速率。學習以初始反應速率法求定反應級數、速率常數

原理：簡述實驗所應用之原理及重要之化學反應式

二. 原理：(一). 反應速率、反應級數：化學動力學：探討反應速率及影響因素。 +5

反應速率：單位時間內 Δ[產物] 或 Δ[反應物]。若 $aA+bB \rightarrow cC$，速率 $= \frac{-d[A]}{a\,dt} = \frac{-d[B]}{b\,dt} = \frac{+d[C]}{c\,dt}$

[反應物] 會影響速率，可用速率定律式 $rate = k[A]^m[B]^n$ 表示。k：速率常數、m.n 分別為 A.B 的反應級數，總反應級數為 m+n。反應級數可為整、負、分數，不從平衡方程式係數影響，只能由實驗測得。常用：1. 初始反應速率法 2. 積分作圖法測級數

(二). $S_2O_8^{2-}$、I^- 反應速率測定：本實驗以初始反應速率法測 $S_2O_8^{2-}$、I^- 的速率定律式。利用限量 $S_2O_3^{2-}$ 作為計時劑

$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$ 會立刻消耗掉

$rate = k[S_2O_8^{2-}]^m[I^-]^n$

$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$ 當 $[S_2O_3^{2-}]=0 \Rightarrow I_2(aq) + I^-(aq) \rightarrow I_3^-(aq)$ 並和澱粉指示劑形成藍黑色錯合物（出現時間即 Δt）

$\Delta[S_2O_3^{2-}] = 2\Delta[S_2O_8^{2-}]$

$rate = \frac{-\Delta[S_2O_8^{2-}]}{\Delta t} = \frac{-\frac{1}{2}\Delta[S_2O_3^{2-}]}{\Delta t}$

(三). 初始反應速率法：改[某一反應物]。其他維持不變進行一系列試驗，求 Δ濃度對初速率影響。本實驗分次將 $[S_2O_8^{2-}]$ 及 $[I^-]$ 增為 2 倍，其餘不變

$\frac{r_2}{r_1} = \frac{k(2.0[S_2O_8^{2-}]_1)^m([I]_1)^n}{k([S_2O_8^{2-}]_1)^m([I^-]_1)^n} = 2.0^m$ ∴ $\frac{r_3}{r_1} = \frac{k([S_2O_8^{2-}]_1)^m(2.0[I^-]_1)^n}{k([S_2O_8^{2-}]_1)^m([I^-]_1)^n} = 2.0^n$

藥品：中英文名、化學式、莫耳質量、物理與化學性質及危害毒性

+4

三. 藥品

	英文名稱	化學式	式量(g)	外觀顏色	d(g/mL)	毒性
0.20M 碘化鈉	Sodium Iodide	NaI	149.89	無色粉末	3.5(25°C)	吞食有害、刺激皮膚、眼睛
0.10M 過硫酸鉀	potassium persulfate	$K_2S_4O_8$	270.33	白色固體	2.477	氧化劑，吞食有害、刺激皮膚、眼、呼吸道
0.20M 氯化鈉	sodium chloride	NaCl	58.44	無色固體	2.16(25°C)	吞食有害、刺激皮膚、眼、呼吸道
0.10M 硫酸鉀	potassium sulfate	K_2SO_4	174.26	無色固體	2.662	勿吞食、刺激皮膚、眼
2% 澱粉溶液	starch	N/A	N/A	白色固體	N/A	輕微皮膚刺激
0.0050M 硫代硫酸鈉	sodium thiosulfate	$Na_2S_2O_3$	248.18	無色固體	1.74(20°C)	勿吞食，輕微刺激皮膚、眼睛

ref: Merck 致化性？

編頁碼

II. 實驗紀錄：簡要、詳細、條列式記錄

a. 反應物與產物之狀態與顏色。
b. 進行實驗之條件。
c. 操作過程。
d. 反應過程顏色、沉澱、吸熱放熱等變化。
e. 數據：參考實驗課本的格式或自創，但記錄整齊。

實驗紀錄：
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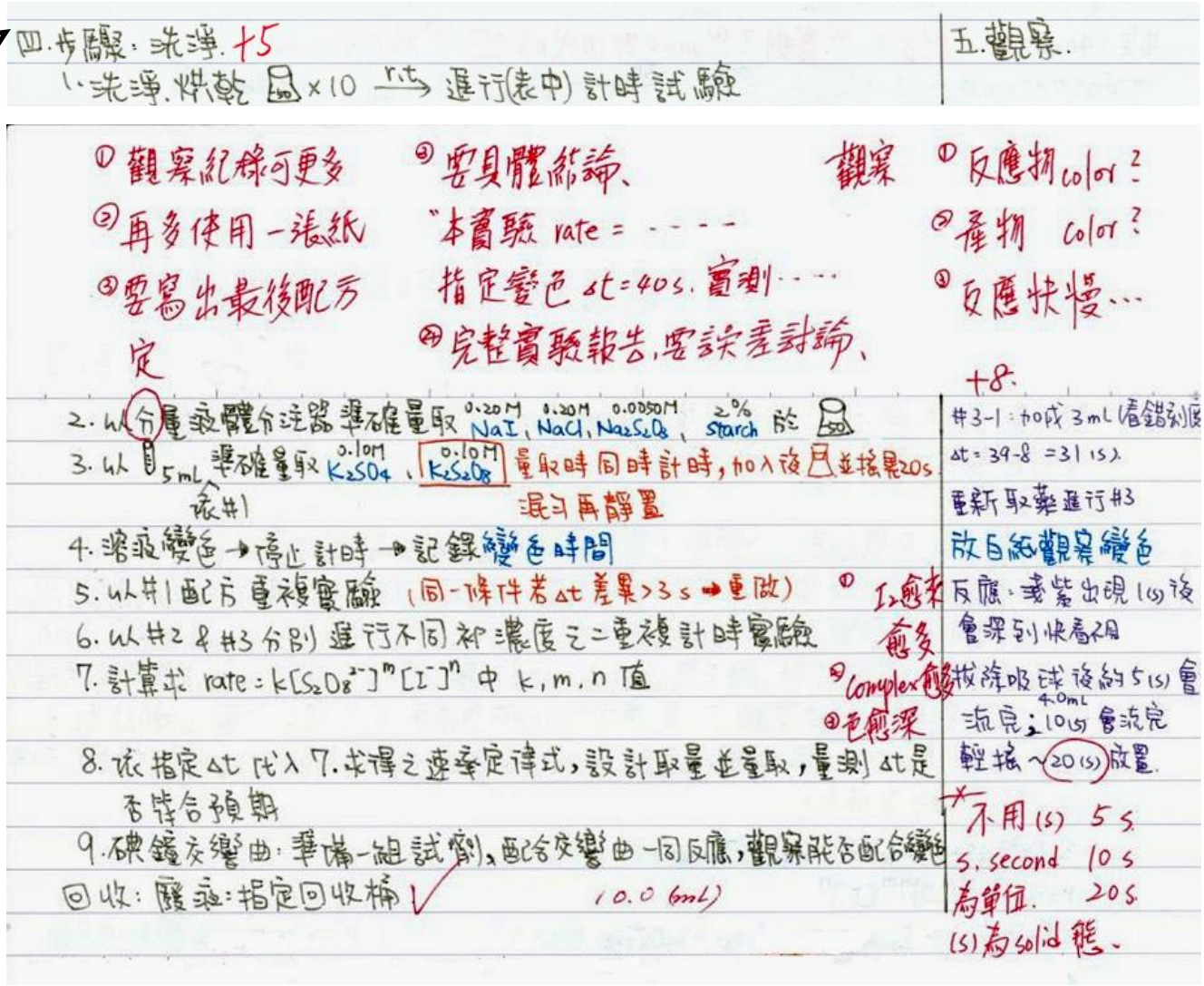
步驟：
以簡單清楚流程圖表示，繪製裝置圖

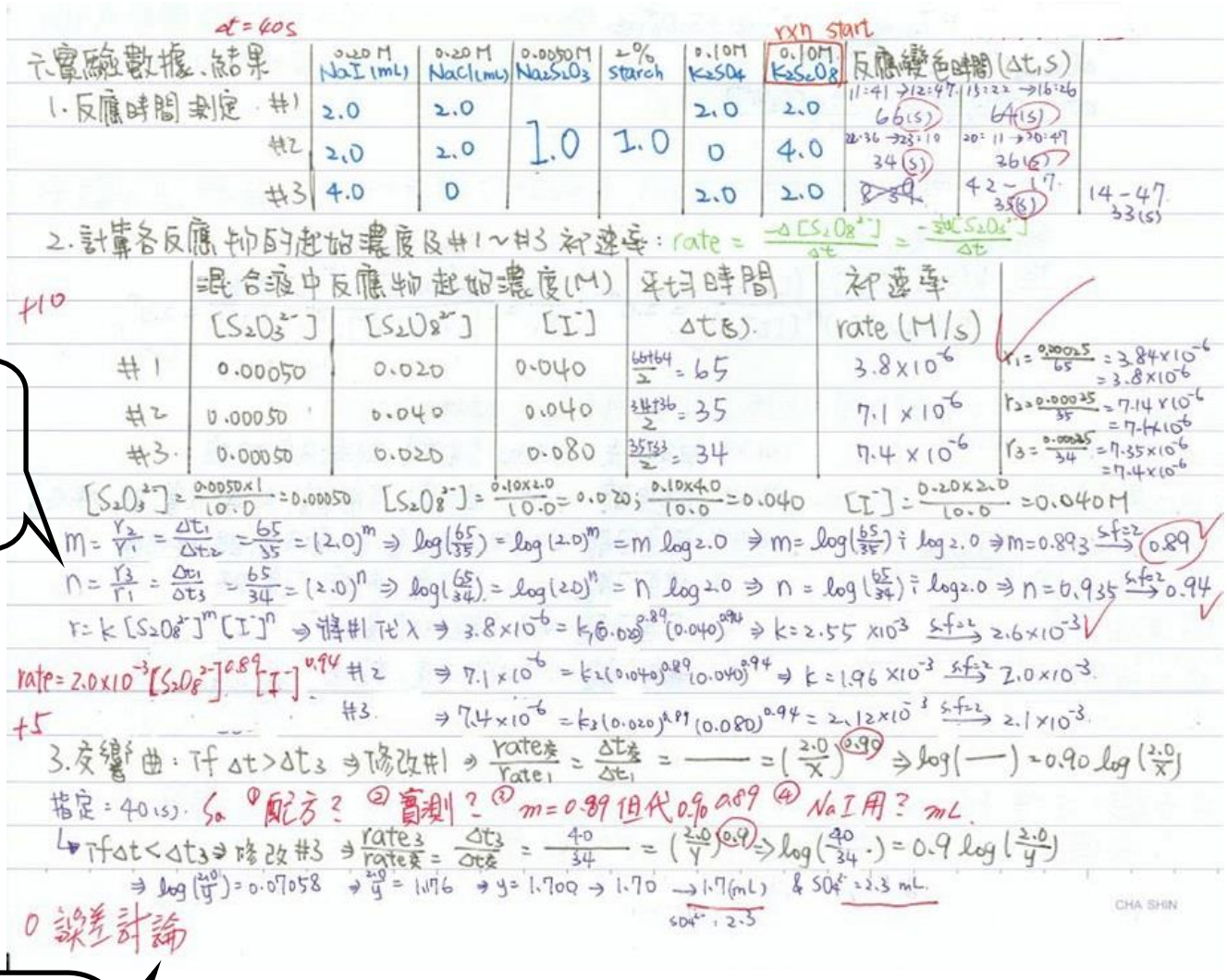


III. 結果報告：

a. 數據處理：詳列計算過程，結果需有正確的有效數字及單位。

b. 檢討：實驗失敗或誤差大，檢討原因及改進方法。

數據：
參考實驗課本的格式或自創，記錄整齊。



數據處理：
詳列計算過程。
注意單位。
注意有效數字的取捨。

誤差討論及操作檢討：
與理論值比較，算出誤差百分比。
實驗失敗或誤差大，檢討原因及改進方法。

需有具體結論！

General Chemistry Experiment "Brief Version Report" Example

I. Prelab Report:

a. Objective: Summarize the goal concisely.

b. Principles: Indicate relevant theories and chemical reactions.

c. Chemicals: Tabulate the physical and chemical properties as well as the toxicity (use The Merck Index and SDS).

d. Procedures: Use a flow chart and cartoon to list the crucial operations, and draw the apparatus in this experiment (you can first watch the lab demo videos online).

Stapled at upper left

Group No. :
Name :
Dept. :
Student ID:

32/35

E1. DETERMINATION OF THE CHEMICAL FORMULA OF A COMPOUND

I. Objective : The purpose of this experiment is to investigate the empirical formula of copper oxide using analytical method.

Objective: Summarize the goal concisely.

II. Principles :

5/5

There are two methods to determine the chemical formula of a compound, which are :

- Analytical method: the compound is broken down into its elements, then the relative amount and the ratio of its element can be determined.
- Synthetical method: an amount of weight for element A is reacted completely with an excess of element B to find a fixed amount of the compound, then the amount of element B and the mole ratio of A and B can be found.

In this experiment, hydrogen gas will be created through the mixing of zinc granules and hydrochloric acid, then use the hydrogen gas to reduce copper oxide to elemental copper upon heating, and also determine the empirical formula of copper oxide and analyze its mass content of copper in the sample.

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

$CuOx(s) + H_2(g) \xrightarrow{\Delta} Cu(s) + H_2O(g)$

Principles: Indicate relevant theories and chemical reactions.

Page number

Chemicals:

- Tabulate the name, chemical formula, formula weight, physical and chemical properties as well as the toxicity.
- List your references, such as The Merck Index online, SDS *et. al*.

Ⅲ. Chemicals : 5%

Name	Formula	Molecular weight (g/mol)	Density (g/cm³)	BP/MP (°C)	Solubility (g/L)	Physical Properties	Chemical Properties	Toxicity
Zinc granules (鋅)	Zn	65.38	7.14	907/419	soluble in acids & alkalies	shiny, silvery gray metal	insoluble in water, strong reducing agent	relatively non-toxic; over toxicity causes nausea
Copper(II) oxide (氧化銅)	CuO	79.55	6.32	2000/1326	soluble in acids	dark colored powder/ granules	compound is canonicalized; insoluble in water	causes skin and eye irritation
Calcium chloride (氯化鈣)	$CaCl_2$	110.98	2.15	1935/782	745	white to off-white solid, odorless	absorbs moisture from air, dissolves in absorbed moisture	toxic, causes eye, skin respiratory irritation
6M Hydrochloric acid (鹽酸)	HCl	36.46	1.05	-85.1/-114.2	823 (0°C) 561 (60°C)	colorless liquid, pungent odor	corrosive (pH=0)	toxic, causes eye damage, nausea, headache
95% ethanol (乙醇)	CH_3CH_2OH	46.07	0.79	78.2/-114.1	≤100	colorless liquid, pungent odor	flammable, compound is canonicalized	toxic, can cause poisoning, pain, internal bleeding

Source : Pubchem, Wikipedia, Experiments in General Chemistry (3rd edition, NTU Press)

II. Lab Notes:

a. Leave ~1/3 page blank space next to the procedure section for recording results and your observations during the experiment.

b. Use ball pen and avoid correction tapes (only the final reports need to be clean and legible).

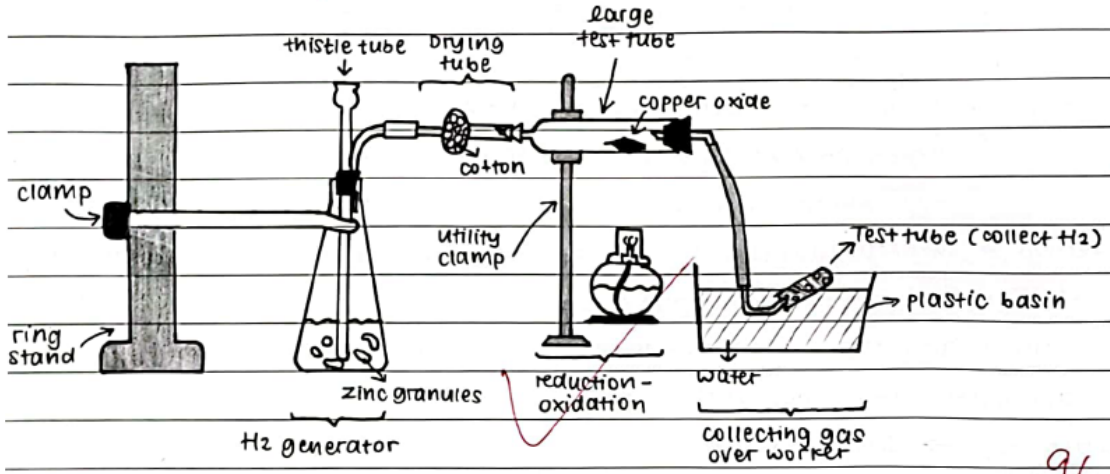
Procedures:

Use a flow chart and cartoon to list the crucial operations, and draw the apparatus in this experiment.

Observation:

a. The appearance and color of reactants and products.
b. Conditions for actual experimentation.
c. Operation procedures.
d. Changes in solution, i.e. color, precipitation, endothermic, exothermic, gas evolution, etc.
e. Reaction rate, fast or slow…

Ⅲ. Procedures : 5/5



① Wash large test tube, dry tube, and let cool.

② Fill drying tube with $CaCl_2$; stuff both ends with just enough cotton to prevent $CaCl_2$ from falling out.

③ Measure and record weight of large test tube (W_1); add 1~1.2g copper oxide to middle of tube and measure weight (W_2).

④ Measure 15 gram zinc granules to erlenmeyer flask and use 100 ml beaker to take 20 ml of 6M HCl.

⑤ · Adjust thistle tube such that end of glass pipe nearly touches bottom of flask.

· Wet rubber tube with water before connecting it to drying tube.

⑥ Fill 10 test tubes with water and invert and immense into plastic basin filled with 2/3 water to collect hydrogen gas.

⑦ Pour 20 ml of 6M $HCl_{(aq)}$ into thistle tube; end of

Ⅳ. Observation : 9/10

· After pouring HCl, the Zn fizzed up and erlenmeyer flask became cloudy.

· Rubber tube in the water started bubbling

· The rubber tube has to be tight, so it produces more bubbles.

· Sound of small test tubes:

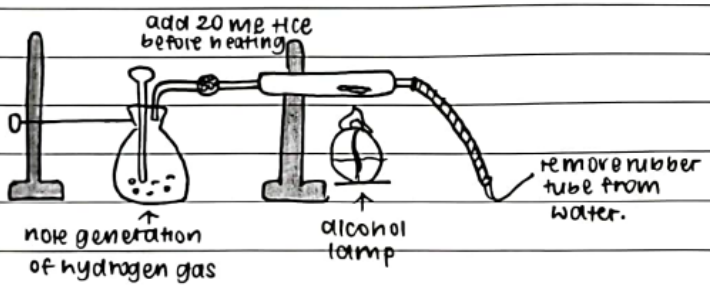
1. X	6. X	(✓ : popped, X : didn't pop)
2. X	7. X	
3. ✓ loud	8. X	
4. X	9. ✓ subtle	
5. ✓ loud	10. X	

thistle tube should be immerse in solution and rubber tube not twisted, and gas flow is free from obstruction.

⑧ Collect hydrogen gas over water; bring flame to opening of inverted tube; when there's a loud "pop" sound, continue collecting gas until sound quiets.

⑨ Before heating, remove rubber tube from water; make sure it's not twisted and gas flow is free from obstruction; add another 20 me of 6M HCe into thistle tube.

⑩ Heat large test tube containing copper oxide with an alcohol lamp until no visible changes in content and no visible moisture in tube; let system cool down



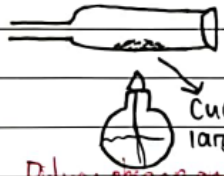
⑪ In the cooling process, maintain connection of apparatus and supply of hydrogen gas to the large test tube.

⑫ Dispose used cotton wool, $CaCe_2$, unreacted Zn granules (rinsed), $HCe_{(aq)}$, and the produced copper.

- When collecting hydrogen gas, not all test tubes popped; only test tube 3, 5, and 9 that popped. Test tube 3 and 5 "pop" sound is loud, but test tube 9 "pop" sound is subtle.

Appearance of:

- Zinc granules — before: solid; after: oxidized
- $CaCe_2$ — before: white; after: yellowish-white (doesn't really change) ← appearance



Did you observe any water in tube during heating? Where was the water? How to remove it?

- When first heating with alcohol lamp, there was moisture concentrated in the end of large test tube.
- After 7 minutes of heating, we add 20 me HCe again into flask.
- After 15 minutes of heating, there's slight color changes at the center part.
- After 18 minutes of heating, 2/3 part change color, and after 20 minutes, 4/5 part change
- After 25 minutes of heating, all of the copper has changed into red, but some are still brown.
- After 27 minutes of heating, all are completely red.

CuO — before: black; powder; after: red; powder but a little rubbery.

III. Final Report:

a. **Observations on the reserved blank space in the prelab report.**
b. **Record raw data with units.**
c. **Complete the data analysis, and the required calculations in the lab manual.**
d. **Conclusion, such as: According to the analysis of the….., it shows that…….**

Experiment Data and Results:

1) Weight of empty test tube (W_1) : 40.8268 g

2) Weight of test tube and copper oxide (W_2) : 41.9316 g

3) Weight of copper oxide ($W_2 - W_1$) : (41.9316 − 40.8268) g = 1.1048 g

4) Weight of test tube and copper (W_3) : 41.7146 g

5) Weight of copper ($W_3 - W_1$) : (41.7146 − 40.8268) g = 0.8878 g

6) Weight of oxygen ($W_2 - W_3$) : (1.1048 − 0.8878) g = 0.2170 g

5/7

7) Empirical formula of copper oxide : CuO

↳ Calculation: ($n = \frac{g}{Mr}$)

	nCu	:	nO
	$\frac{0.8878}{63.55}$	:	$\frac{0.2170}{16.00}$
	0.01397	:	0.01356 = 1.030 : 1.000
	1	:	1.030 → ≈ 1 : 1
	1.000		

3/3

Conclusion

In this experiment, we use 16.70gram of Zn and 20me of HCe to produce the hydrogen gas, which resulting in only 3 of 10 test tubes that popped. (Hydrogen and air moisture makes it popped.)

We used the hydrogen to reduce 1.1048g CuO during heating.

After heating and cooling process, we got 0.8878 g and 0.01397 mole of copper (Cu), and also 0.2170g and 0.01356 mole of oxygen. ($nCu : nO \approx 1 : 1$)

So, based on the experiment, the empirical formula of copper oxide is CuO.

Signed by TA

General Chemistry Experiment "Full Version Report" Example

I. Prelab Report:

a. Objective: Summarize the goal concisely.

b. Principles: Indicate relevant theories and chemical reactions.

c. Chemicals: Tabulate the physical and chemical properties as well as the toxicity (use The Merck Index and SDS).

d. Procedures: Use a flow chart and cartoon to list the crucial operations, and draw the apparatus in this experiment (you can first watch the lab demo videos online).

Stapled at upper left

Group No.:
Name:
Dept.:
Student ID

Exp 5 Heat of Reactions

Objective: Summarize the goal concisely.

Objective: Determine the heat of neutralization and solution by home-built calorimeter and use Hess' law to calculate the molar enthalpy of formation of MgO.

Principles: Indicate relevant theories and chemical reactions.

Principles [I] The enthalpy of reaction and calorimeter

If the reaction occurs at constant pressure, the change of energy is called enthalpy (H) change or heat of reaction, denoted by ΔH. ($\Delta H<0$: exothermic) $\Delta H>0$: endothermic

In this exp, we will set up the calorimeter by Styrofoam cups as an adiabatic system ($q_{sys}=0$)

$$\Delta H = -(q_{cal} + q_{aq}) = -(C\cdot\Delta T + m_{aq}\cdot S\cdot\Delta T)$$

C refers to the heat capacity, the amount of energy absorbed or released in changing its T 1 °C, which can determined by: $q_C = q_h + q_{cal} = 0$. i.e. $(m_c\cdot S\cdot\Delta T_c)+(m_h\cdot S\cdot\Delta T_h)+(C\cdot\Delta T_{cal})=0$

[II] Application of Hess' law - Enthalpy of formation of magnesium oxide

The enthalpy of a chemical reaction is path-independent and is equal to the sum of enthalpies of the contributing steps (Hess' law). Hence, we can calculate the enthalpy of formation of magnesium oxide by the reaction and enthalpies we will measure in this exp.

$Mg_{(s)} + 2H^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + H_{2(g)}$, ΔH_1 ; $MgO_{(s)} + 2H^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + H_2O_{(l)}$, ΔH_2

$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$, $\Delta H_f^\circ(H_2O) = -285.8\ kJ/mole = -68.4\ kcal/mole$

$\Rightarrow Mg_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow MgO_{(s)}$, $\Delta H_f^\circ(MgO) = \Delta H_1 - \Delta H_2 + \Delta H_f^\circ(H_2O)$

Page number

Chemicals:

- Tabulate the name, chemical formula, formula weight, physical and chemical properties as well as the toxicity.
- List your references, such as The Merck Index online, SDS *et. al*.

Chemicals

Name	Chemical formula / Molecular weight	Density (g/cm³) / m.p / b.p (°C)	Appearance / Water solubility (g/100ml H_2O, 25°C)	Toxicity and hazards
Magnesium strips	Mg / 24.3050	1.738 / 651 / 1100	silvery-white, close-packed metal; reacts (produce H_2)	flammable solid; substance and mixture which, in contact with water, emits flammable g
Magnesium oxide	MgO / 40.3	3.6 / 2852 / 3600	white, very fine, odorless powder; practically insoluable. reacts	skin/eye damage/irritation; corrosi to metals; respiratory irritation
ammonium chloride	NH_4Cl / 53.49	1.5274 / 338 / 520	colorless, odorless crystals or white, granular ponder; 28.3	acute oral toxicity; Serious eye damage/irritation
1.0 M sodium hydroxide	NaOH / 40.00	1.043 / 318 / 1388	Fused solid with crystalline fracture; 111	strong base; serious eye damage; ski corrosion. Severe skin burn
1.0 M hydrochloric acid	HCl / 36.46	1.098 / -59 / 108	fumes in air, transparent liquid (could be yellow) 32% (g)	strong acid (pH ≈ 0); serious eye damage Skin corrosion; respiratory irritation
1.0 M Acetic acid	CH_3COOH / 60.05	1.053 / 16.7 / 118	colorless liquid (Vinegar-like) miscible	flammable liquid; skin corrosion, irritat ; eye damage, irritation

Ref.: Merck Index Online, Safety Data Sheet (Fisher Scientific)

II. Lab Notes:

a. Leave ~1/3 page blank space next to the procedure section for recording results and your observations during the experiment.

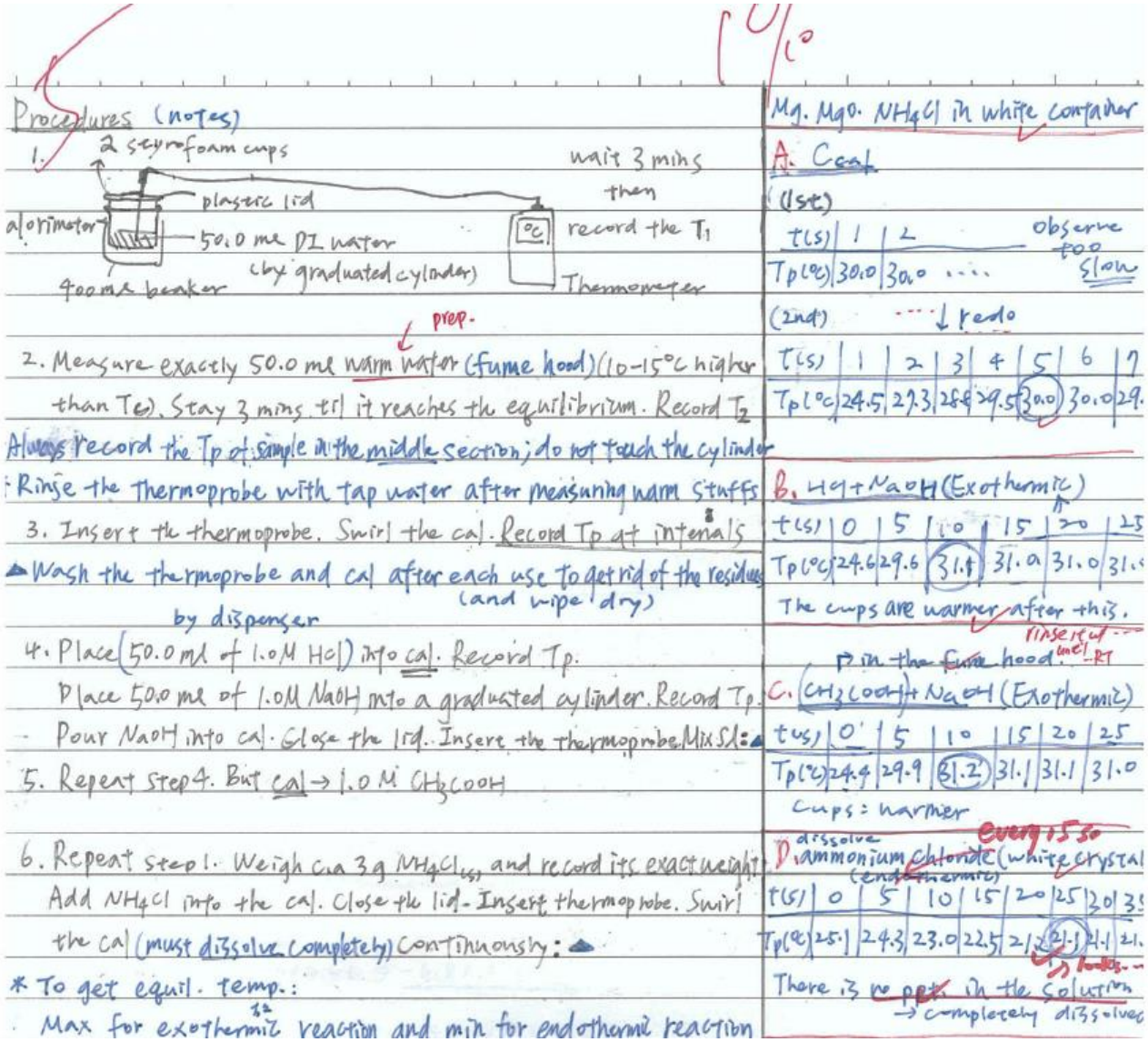
b. Use ball pen and avoid correction tapes (only the final reports need to be clean and legible).

Procedures:

Use a flow chart and cartoon to list the crucial operations, and draw the apparatus in this experiment.

Observation:

a. The appearance and color of reactants and products.
b. Conditions for actual experiments.
c. Operation procedures.
d. Changes in solution, i.e. color, precipitation, endothermic, exothermic, gas evolution, etc.
e. Reaction rate, fast or slow…



B.C.E.F D

7. Repeat Step 6. But ① cal ⇒ excactly 100.0 ml of 1.0M $HCl_{(aq)}$
② Weigh c.a 0.2 g Mg : ▲
(solid reactions must be mixed and reacted completely)

8. Repeat Step 7. But ② c.a 0.7 g MgO : ▲

9. Assume: solution density 1.0 g/cm³ (=water). Do the calculation
specific heat 1.0 cal/g·°C

10. Salt solutions resulting from acid-base neutralization to sink. Clean the styrofoam cups and plastic lid for reuse.

Poison

E. magnesium (+HCl) (silver colored strip) (exo.)

t(s)	0	10	20	30	40	50	60	7
Tp(°C)	24.6	26.5	26.6	27.2	28.8	29.9	32.9	32.

反應時有欣壓，內有滋滋聲，並有泡不停冒出（1 min 後無）反應後，溫度計針上有氣泡 (H_2) soln.

F. magnesium oxide (+HCl) (white/pink powder) (exo.)

t(s)	0	5	10	15	20	25	30	35
Tp(°C)	24.5	30.1	30.8	30.7	30.9	30.8	31.0	31.2

t(s)	40	45	50
Tp(°C)	31.4	31.1	29.5

sl. slightly pink & yellow

Signed by ATA

Signed by TA

III. Final Report:

a. **Observations on the reserved blank space in the prelab report.**
b. **Record raw data with units.**
c. **Complete the data analysis, and the required calculations in the lab manual.**
d. **Conclusion, such as: According to the analysis of the….., it shows that…….**

Calculation and results

HEAT OF REACTIONS

* 1 cal = 4.184 kJ

I. Experimental Data and Results (show all calculations)

1. Heat capacity of calorimeter — second exp

50.0	Volume of cold water (V_1, mL)	50.0	Volume of hot water (V_2, mL)	50.0	50.0
24.8	Temp. of cold water (T_1, °C)	24.0	Temp. of hot water (T_2, °C)	37.2	36.8
30.5	Equilibrium temp. (T_3, °C)	30.0	Heat capacity (C, cal/°C)	10.0	5.3

$V_1 \times 1.0\ g/mL \times 1.0\ cal/g\cdot°C \times (T_3 - T_1) + C \times (T_3 - T_1) = V_2 \times 1.0\ g/mL \times 1.0\ cal/g\cdot°C \times (T_2 - T_3)$

$(50.0)(1.0)(1.0)(30.0-24.0) + C(30.0-24.0) = (50.0)(1.0)(1.0)(37.2-30.0)$

$\Rightarrow (6.0)C = (50.0)(7.2-6.0) \Rightarrow C = 10.0$

$(5.7)C = (50.0)(6.3-5.7) \Rightarrow C = 5.3$

Assumption: $d_{sol} = 1.0\ g/cm^3 \Rightarrow M = V$; $S_{sol} = 1.0\ cal/g\cdot°C$

$\Delta H = -(q_{cal} + q_{sol}) = -(C\cdot\Delta T + m_{sol}\cdot S_{sol}\cdot\Delta T)$

2. Heat of neutralization: HCl + NaOH

Volume of 1.0 M HCl (mL)	50.0	Volume of 1.0 M NaOH (mL)	50.0
Initial temp. of HCl (°C)	24.6	Initial temp. of NaOH (°C) *	24.6
Eqm. temp. after reaction (°C)	31.1	Heat evolved (cal)	-6.8×10^2
Molar heat of neutralization (kJ/mol)		−57	

$\Delta H = -[(5.3)(31.1-24.6) + (50.0)(1.0)(31.1-24.6) + (50.0)(1.0)(31.1-24.6)]$

$= -684.45 \Rightarrow -6.8\times10^2\ (cal)$

$\frac{-6.8\times10^2\ (cal)}{(50.0\times10^{-3}\ L)\times(1.0\ g/cm^3)\times(1.0\ cm^3/mL)} \times \frac{4.184\ (kJ)}{1000\ (cal)} \Rightarrow -57\ kJ/mol$

3. Heat of neutralization: CH_3COOH + NaOH

Volume of 1.0 M CH_3COOH (mL)	50.0	Volume of 1.0 M NaOH (mL)	50.0
Initial temp. of CH_3COOH (°C)	24.4	Initial temp. of NaOH (°C)	24.6
Eqm. temp. after reaction (°C)	31.2	Heat evolved (cal)	-7.1×10^2
* Molar heat of neutralization (kJ/mol)		−59	

$\Delta H = -[(5.3)(31.2-24.4) + (50.0)(1.0)(31.2-24.4) + (50.0)(1.0)(31.2-24.6)]$

$= -706.04 \Rightarrow -7.1\times10^2\ (cal)$

$\frac{-7.1\times10^2\ (cal)}{(50.0\times10^{-3}\ L)\times(1.0\ g/cm^3)\times(1.0\ cm^3/mL)} \times \frac{4.184\ (kJ)}{1000\ (cal)} \Rightarrow -59\ kJ/mol$

$\frac{3.00(g)}{53.49} = 0.05608\ldots \Rightarrow 5.61\times10^{-2}$

4. Heat of solution: ammonium chloride $NH_4Cl = 53.49$

Mass of NH_4Cl (g)	3.00	Volume of water (mL)	50.0
No. of moles of NH_4Cl	5.61×10^{-2}	Initial temp. of water (°C)	25.1
Eqm. temp. after reaction (°C)	21.1	Heat evolved (cal)	2.3×10^{2}
Molar heat of solution (**kJ/mol**)		17	

$\Delta H = -[(5.3)(21.1-25.1) + (3.00_{(g)} + 50.0_{(mL)}(1.0_{(g\cdot cm^3)}))(21.1-25.1)]$

$= 233.2 \Rightarrow 2.3\times10^{2}\ (cal)$

$\frac{2.3\times10^{2}}{5.61\times10^{-2}(mol)} \times \frac{4.184(kJ)}{1000(cal)} \Rightarrow 17\ kJ/mol$

5. Enthalpy of formation: magnesium oxide

$Mg = 24.305$

$\frac{0.20(g)}{24.305} \Rightarrow 8.2\times10^{-3}$

Mass of magnesium strips (g)	0.20	Mass of magnesium oxide (g)	0.63
No. of moles of Mg	8.2×10^{-3}	No. of moles of MgO	1.6×10^{-2}
Volume of 1.0 M HCl (mL)	100.0	Volume of 1.0 M HCl (mL)	100.0
Initial temp. of 1.0 M HCl (°C)	24.5	Initial temp. of 1.0 M HCl (°C)	24.5
No. of moles of H^+	0.10	No. of moles of H^+	0.10
Eqm. temp. after reaction (°C)	32.9	Eqm. temp. after reaction (°C)	31.4
Heat evolved (cal)	-8.9×10^{2}	Heat evolved (cal)	-7.4×10^{2}
Molar heat of reaction (**kJ/mol**)	-4.5×10^{2}	Molar heat of reaction (**kJ/mol**)	-1.9×10^{2}

$MgO = 40.3$

$\frac{0.63}{40.3} \Rightarrow 1.6\times10^{-2}$

同左

$mole = M\times V_{(L)} = 1.0\times0.1000 \Rightarrow 0.10$

異氫倫

Signed by TA

$\Delta H = -[(5.3)(32.9-24.5) + (0.20+100.0(1.0))(32.9-24.5)]$

$= -886.2 \Rightarrow -8.9\times10^{2}(cal)$

$\frac{-8.9\times10^{2}(cal)}{8.2\times10^{-3}(mol)} \times \frac{4.184(kJ)}{1000(cal)} \Rightarrow -4.5\times10^{2}\ kJ/mol$

$\Delta H = -[(5.3)(31.4-24.5) + (0.63+100.0(1.0))(31.4-24.5)]$

$= -730.917 \Rightarrow -7.3\times10^{2}(cal)$

$\frac{-7.3\times10^{2}(cal)}{1.6\times10^{-2}(mol)} \times \frac{4.184(kJ)}{1000(cal)} \Rightarrow -1.9\times10^{2}\ kJ/cal$

$Mg_{(s)} + 2H^+_{(aq)} \rightarrow Mg^{2+} + H_{2(g)} \quad \Delta H = -4.5\times10^{2}\ (kJ/mol)$

$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)} \quad \Delta H = -2.858\times10^{2}\ (kJ/mol)$

$+)\ Mg^{2+} + H_2O_{(l)} \rightarrow MgO_{(s)} + 2H^+ \quad \Delta H = 1.9\times10^{2}\ (kJ/mol)$

*化學式還原. ΔH變號.

$Mg_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow MgO_{(s)} \quad \Delta H_f^\circ(MgO) \Rightarrow -5.5\times10^{2}\ (kJ/mol)$

Molar enthalpy of formation of MgO: -5.5×10^{2} (**kJ/mol**)

Error analysis and conclusions

Data analysis and error analysis

We have to calculate the theoretical value of each exp first.

By the Hess' law, we have: $\Delta H^\circ_{rxn} = \sum_n n\Delta H^\circ_f$ product $- \sum_n n\Delta H^\circ_f$ reactants with n being the stoichiometric coefficients and ΔH_f° being the enthalpy of formation.

exp	ΔH_f° of each compound (kJ/mol)	theoretical value of ΔH°_{rxn} (kJ/mol
2. $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$	(-167.15, -469.15, -407.27, -285.830)	[(-407.27)+(-285.830)]-[(-167.15)+(-469.15)] = -56.8
3. $CH_3COOH_{(aq)} + NaOH_{(aq)} \rightarrow CH_3COONa_{(aq)} + H_2O_{(l)}$	(-486.34, -469.15, -726.13, -285.830)	[(-726.13)+(-285.830)]-[(-486.34)+(-469.15)] = -56.4
4. $NH_4Cl_{(s)} \rightarrow NH_4^+_{(aq)} + Cl^-_{(aq)}$	(-314.5, -133.26, -167.08)	[(-133.26)+(-167.08)]-(-314.5) = 14.16
5-1. $Mg_{(s)} + 2H^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + H_{2(g)}$	(0, 0, -467.0, 0)	-467.0
5-2 $MgO_{(s)} + 2H^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + H_2O_{(l)}$	(-601.6, 0, -467.0, -285.830)	[(-285.830)+(-467.0)]-(-601.6) = -151.2
5-3 $Mg_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow MgO_{(s)}$	(0, 0, -601.6)	-601.6

Ref: Lange's Handbook of Chemistry - Fifteen Edition Good to sh

Compare the theoretical value of ΔH°_{rxn} with the experimental value and calculate its detai

Relative error: $\frac{\text{Absolute Error}}{\text{Actual value}} = \frac{\text{Measured value - expected value}}{\text{Actual value}}$ (expressed in %)

exp		experimental value (kJ/mol) 2 s.f.	theoretical value (kJ/mol) >2 s.f.	Relative Error
Heat of neutralization	HCl+NaOH	-57	-56.80	$\frac{(-57)-(-56.80)}{-56.80} \times 100(\%) = 0.35\%$ (2 s.f.)
	CH_3COOH+NaOH	-59	-56.47	$\frac{(-59)-(-56.47)}{-56.47} \times 100(\%) = 4.5\%$
Heat of solution	NH_4Cl	17	14.16	$\frac{17-14.16}{14.16} \times 100(\%) = 20.\%$
Enthalpy of formation	5-1	-4.5×10^2	-467.0	$\frac{(-4.5\times10^2)-(-467.0)}{-467.0} \times 100(\%) = -3.6\%$
	5-2	-1.9×10^2	-151.2	$\frac{(-1.9\times10^2)-(-151.2)}{-151.2} \times 100\% = 20.\%$
	5-3: MgO	-5.5×10^2	-601.6	$\frac{(-5.5\times10^2)-(-601.6)}{-601.6} \times 100(\%) = -8.6\%$

Overall, this exp exist some errors (discuss below) but it did roughly determine the heat of rea

(a.) First, the calorimeter is absolutely not adiabatic. With styrofoam cups in this exp, we ca only roughly seperate the reaction and the surrounding. So there must exists some heat loss.

(b) The relative error of exp: HCl+NaOH & CH_3COOH+NaOH are quite small (better close to the true value compared with other data). Maybe that is because it only involves an easy exothermic reactio of acid-base neutralization and NaOH (strong base) enables it to react completely. Hen the error is lowered. However, the slight positive error may comes from the human error (loss HCl or NaOH during exp, unattended data when recording, the temperature of our hands, et But it did quite precisely determine the heat of neutralization.

(c) The relative error in determining the heat of solution is up to 20%, which is high compared to other data. The main reasons of this significant positive error may derive from: loss of NH_4Cl (Although I observed no ppt. after the solution, there is still some posibility for those "white" crystals stucking on the surface, the small gaps in the white styrofoam cup), incorrect initial temperature (The weather was cold that day. I might lower the T_i = 25.1(°C) I recorded)

(d) The relative error of ΔH_{rxn} of Mg+HCl is -3.6%, a negative error that is really close to the true value. The error may comes from: Measurement error ($Mg_{(s)} + 2H^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + H_{2(g)}\uparrow$. This reaction produces H_2 and I did observe that some little H_2 bubb stick on the thermoproble, which might imply that the device can not very precisely meas the exact temperature of the solution and therefore cause some errors)