Hands on Experiment : Determining the enthalpy change of a reaction with the use of Arduino system

Setup for the Experiment

Determining the enthalpy change of metal displacement reaction

 $Zn(s) + CuSO_4(aq) \longrightarrow Cu(s) + ZnSO_4(aq)$

Using Arduino system with temperature sensor to record the temperature change during the reaction





Equipment required for Arduino system



Basic: Solderless breadboard(麵包板)



http://www.sciencebuddies.org/science-fair-projects/how-to-use-a-breadboard.shtml

A B C D E F G H I J 1 0 2 0 3 0 4 0 5 0 6 0 7 0 8 0 9 0 11 0 12 0 14 0 15 0 16 0 17 0 18 0 19 0 22 0 23 0 24 0 16 0 17 0 18 0 19 0 21 0 22 0 23 0 24 0 25 0 26 0 27 0 28 0 29 0 210 0 22 0 23 0 24	A B C D E 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	F G H I J	A B C D E 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	F G H I J 1

Positive	Negative			
Power	Ground			
Plus sign (+)	Minus sign (-)			
Red	Blue or black			



Operation of the Arduino system 1. Wiring of temperature sensor in Arduino system



Identify the pins

Signal: 2



Power: 5V (+) GND (-)

Connect red jumper wire to 5V



Connect black jumper wire to GND



Connect Yellow jumper wire to 2



Connect another end of red jumper wire to breadboard +



Connect another end of black jumper wire to breadboard -



Bend the 4.7k ohm resistor to "C" shape



Connect the bended resistor to breadboard + and A12



Connect another end of yellow jumper wire to breadboard B12



Connect red and black wire of temp sensor to breadboard + and - respectively



Connect yellow wire of temp sensor to breadboard E12



Check all wires and resistor to see all are firmly secured on Arduino and breadboard



https://www.youtube.com/watch?v=p6AN6rPWzfI

Experimental Setup



Points to note







Magnetic Stir bar should not to contact with temp sensor



3. Upload Arduino code



Waterproof DS18B20 Temperature Sensor

Open Arduino IDE software

Copy the code into Arduino IDE

Save the Arduino Sketch as "temp"

💿 temp Arduino 1.8.1	
File Edit Sketch Tools Help	
	P
temp	
#include <onewire.h> #include <dallastemperature.h></dallastemperature.h></onewire.h>	^
// Arduino數位腳位2接到1-Wire装置 #define ONE_WIRE_BUS 2	
// 運用程式庫建立物件 OneWire oneWire(ONE_WIRE_BUS); DallasTemperature sensors(&oneWire);	
<pre>void setup(void) { Serial.begin(9600); Serial.println("Temperature Sensor"); // 初始伯 sensors.begin(); Serial.println("CLEARDATA"); Serial.println("LABEL.Time.Temperature"); }</pre>	E
<pre>void loop(void) { Serial.print("DATA,TIME,");</pre>	
// 要求匯流排上的所有感測器進行溫度轉換 sensors.requestTemperatures();	_
// 取得溫度讀數 (攝氏) 並輸出, // 參數0代表匯流排上第0個1-Wire裝置 <mark>Serial.println(sensors.getTempCByIndex(0));</mark>	
//delay(1000); }	-

Arduino/Genuino Uno on COM

4. Checking the port of Arduino system to record the temperature data

💿 temperature Ar	duino 1.8.1			💿 temperature Ar	duino 1.8.1				
File Edit Sketch To	ools Help			File Edit Sketch To	ools Help				
File Edit Sketch To temperature #include <onewire.h #include <onewire.h #include <dellestem // Arduino數位腳位2 #define ONE_WIRE_BU // 運用程式庫建立物 OneWire oneWire(ONE DellesTemperature s void setup(void) { Serial.begin(9600) Serial.println("Te // 初始伯 sensors.begin();</dellestem </onewire.h </onewire.h 	bols Help Auto Format Archive Sketch Fix Encoding & Reload Serial Monitor Serial Plotter WiFi101 Firmware Updater ArduBlock Board: "Arduino/Genuino Uno Port Get Board Info Programmer: "AVRISP mkII" Burn Bootloader	Ctrl+T Ctrl+Shift+M Ctrl+Shift+L	Serial ports COM1	File Edit Sketch To temperature #include <onewire.h #include <onewire.h #include <dellesten // Arduino數位歸位2 #define ONE_WIRE_BU // 運用程式庫建立物 OneWire oneWire(ONE DellesTemperature s void setup(void) Serial.begin(96D) Serial.println("Te // 初始伯 sensors.begin();</dellesten </onewire.h </onewire.h 	ools Help Auto Format Archive Sketch Fix Encoding & Reload Serial Monitor Serial Plotter WiFi101 Firmware Updater ArduBlock Board: "Arduino/Genuino Unc Port Get Board Info Programmer: "AVRISP mkII" Burn Bootloader	Ctrl+T Ctrl+Shift+M Ctrl+Shift+L	Serial ports COM1 COM4 (Arduino,	Genuino Uno)	
Serial.println("CLEAR Serial.println("LABEL } void loop(void) { Serial.print("DATA,TI // 要求匯流排上的所有 sensors.requestTemper // 取得溫度讀數(攝民 // 發數0代表匯流排上)	DATA"); ,Time,Temperature"); ME,"); ;國[測器進行溫度轉換 ratures(); f) 並輸出, 第0個1-Wire裝置		Ţ	sensors.oegin(); Serial.println("CLEAR Serial.println("LABEL } void loop(void) { Serial.print("DATA,TI // 要求匯流排上的所考 sensors.requestTempe // 取得溫度讀數 (攝尼 // 参數0代表匯流排上	DATA"); ,Time,Temperature"); ME,"); ;風測器進行溫度轉換 ratures(); 5) 並輸出, 第0個1-Wire装置		•		
		Arduino	/Genuino Uno on COM8			Arduine/	Board Info BN: Arduino VID: 2A03 PID: 0043 SN: 8553130	/Genuino Uno 343135191D15 OK	

5. Uploading of code into Arduino Board

		💿 temperature Arduino 1.8.1	
💿 temperature Arduino 1.8.1		File Edit Sketch Tools Help	
File Edit Sketch Tools Help			Ø
🕑 📀 🛅 🔛 🛂 Upload	₽ [.]		
temperature		temperature	
#include <onewire.h></onewire.h>	•	#include <dallastemperature.h></dallastemperature.h>	- I I I I I I I I I I I I I I I I I I I
#include < DallasTemperature .h>			
		// Arduino數位腳位2接到1-Wire裝置	
// Xiuino數位加加立法到1-Wire装置 #define ONE_WIRE_BUS 2		#define UNE_WIKE_BUS 2	
		// 運用程式庫建立物件	
// 運用程式庫建立物件		OneWire oneWire(ONE_WIRE_BUS);	
DallasTemperature sensors(&oneWire);		DallasTemperature sensors(&oneWire);	
		<pre>void setup(void) {</pre>	
void setup(void) {		Serial.begin(9600);	=
Serial nrintln("Temperature Sensor"):	=	<pre>Serial.println("Temperature Sensor");</pre>	
// 初始化			
<pre>sensors.begin();</pre>		Serial println("CLEARDATA"):	
<pre>Serial.println("CLEARDATA");</pre>		<pre>Serial.println("LABEL,Time,Temperature");</pre>	
Serial.println("LABEL,Time,Temperature"); }		3	
		unid low(unid) [
<pre>void loop(void) {</pre>		Serial.print("DATA.TIME.");	
Serial.print("DALA, LIME,");			
// 要求匯流排上的所有感測器進行溫度轉換		// 要求匯流排上的所有感測器進行溫度轉換	
<pre>sensors.requestTemperatures();</pre>		sensors.requestlemperatures();	
// 取得溫度讀數(攝氏) 並輸出,		// 取得温度讀數(攝氏)並輸出,	
// 參數0代表匯流排上第0個1-Wire裝置	-	// 参數O代表匯流排上第O個1-Wire裝置	-
		Done uploading.	
		Sketch uses 5566 bytes (17%) of program <u>storage space</u> . Maximum is 32256 bytes.	
		Global variables use 299 bytes (14%) of dynamic memory, leaving 1749 bytes for loc	al variables. Maximum
		· · · · · · · · · · · · · · · · · · ·	4
	Arduino/Genuino Uno on COM4	Arduino/	/Genuino Uno on COM4

6.Checking the port of Arduino system to start record the temperature data by PLX-DAQ

File Edit Sketch Tools Help Image: Construction of the second
Image: Control of the second secon
temp Fix Encoding & Reload Finclude <dallastem Fix Encoding & Reload Serial Monitor Ctrl+Shift+M</dallastem
// Arduino數位腳位2 WiFi101 Firmware Updater // 運用程式庫建立物 ArduBlock
UneWire oneWire(UNE DallasTemperature s Board: "Arduino/Genuino Uno"
Port: "COM7 (Arduino/Genuino Uno)" Serial ports
void setup(void) { Get Board Info Serial.begin(9600) Programmer: "AVRISP mkII" // 初始伯 Burn Bootloader
<pre>Serial.println("CLEARDATA"); Serial.println("LABEL,Time,Temperature"); } void loop(void) { Serial.print("DATA.TIME,"); // 要求匯流排上的所有感測器進行溫度轉換 sensors.requestTemperatures(); // 取得溫度讀數 (攝氏) 並輸出, // 發動O代表匯流排上第0個1-Wire裝置 Serial.println(sensors.getTempCByIndex(0)); //delay(1000); }</pre>
Arduino/Genuino Uno on COM7



	А	В	С
1	Time	Temperature	
2	9:11:51	24.06	
3	9:11:51	24.06	
4	9:11:51	24.06	
5	9:11:51	24.06	
6	9:11:51	24.06	
7	9:11:51	24.06	
8	9:11:52	24.06	
9	9:11:52	24.06	
10	9:11:52	24.06	
11	9:11:52	24.06	
12	9:11:52	24.00	
13	9:11:52	24.00	
14	9:11:52	24.00	
15	9:11:53	24.06	
16	9:11:54	24.00	
17	9:11:54	24.06	

7.Data Collection by Excel plug-ins

л	D
Time	Temperature
上午 10:11:43	20.19
上午 10:11:45	20.19
上午 10:11:47	20.19
上午 10:11:48	20.19
上午 10:11:50	20.19
上午 10:11:52	20.19
上午 10:11:54	20.19
上午 10:11:56	20.19
上午 10:11:57	20.19
上午 10:11:59	20.19
上午 10:12:01	20.19
上午 10:12:03	20.19
上午 10:12:05	20.19
上午 10:12:06	20.19
上午 10:12:08	20.19
上午 10:12:10	20.19
上午 10:12:12	20.19
上午 10:12:13	20.19
上午 10:12:15	20.19
上午 10:12:17	20.19
上午 10:12:19	20.19
上午 10:12:21	20.19
上午 10:12:22	20.19
上午 10:12:24	20.19
	Time 上午 10:11:43 上午 10:11:47 上午 10:11:47 上午 10:11:50 上午 10:11:50 上午 10:11:54 上午 10:11:54 上午 10:11:54 上午 10:11:54 上午 10:11:54 上午 10:11:50 上午 10:12:01 上午 10:12:03 上午 10:12:03 上午 10:12:04 上午 10:12:05 上午 10:12:06 上午 10:12:01 上午 10:12:02 上午 10:12:12 上午 10:12:12 上午 10:12:13 上午 10:12:14 上午 10:12:15 上午 10:12:14 上午 10:12:15 上午 10:12:12 上午 10:12:12 上午 10:12:22 上午 10:12:22 上午 10:12:24



Total duration : 540 seconds 540 data

8.Data analysis by using Microsoft Excel

	A	B	С	D	E	F	G		Н	Ι	J	K	L	М	
1	Actual Time	Time diff	Duration (sec)	Temp	InitialT	DecreaseT					_				
2	10:11:43	0:00:00	0	20.19	20.19		Temp (°C)	Temp	change of	FZn(s)	+ CuSO ₄ (a	iq)	Temperature Data Collected by	7 Arduino UNC	2
3	10:11:45	0:00:02	2	20.19	20.19		80.00								
4	10:11:47	0:00:04	4	20.19	20.19			_	T ₂						
5	10:11:48	0:00:05	5	20.19	20.19		70.00		2		v = -0.0469x + 77.1	71	Date of Expt:	13/2/2017	
6	10:11:50	0:00:07	7	20.19	20.19						R ² = 0.9991	.,1	Sample Rate :	1 second	
- 7	10:11:52	0:00:09	9	20.19	20.19		60.00		12						
8	10:11:54	0:00:11	11	20.19	20.19		E0.00						Reaction Enthalpy		
9	10:11:56	0:00:13	13	20.19	20.19		50.00		Δ-	г – т	_ т		Zn(s) + CuSO4(aq) → ZnSO4(aq) + Cu(s)	
10	10:11:57	0:00:14	14	20.19	20.19		40.00			I — I	2 1				
11	10:11:59	0:00:16	16	20.19	20.19				*						
12	10:12:01	0:00:18	18	20.19	20.19		30.00		<u>+</u>						
13	10:12:03	0:00:20	20	20.19	20.19				† I ₁						
14	10:12:05	0:00:22	22	20.19	20.19		20.00								
15	10:12:06	0:00:23	23	20.19	20.19				i						
16	10:12:08	0:00:25	25	20.19	20.19		10.00		1						
17	10:12:10	0:00:27	27	20.19	20.19		0.00		i						
18	10:12:12	0:00:29	29	20.19	20.19		0 1	00	200	300	400	500			
19	10:12:13	0:00:30	30	20.19	20.19				Time (se	ec)					
20	10:12:15	0:00:32	32	20.19	20.19]		
21	10:12:17	0:00:34	34	20.19	20.19										
22	10:12:19	0:00:36	36	20.19	20.19										
23	10:12:21	0:00:38	38	20.19	20.19										
24	10:12:22	0:00:39	39	20.19	20.19		Data Collection :						Calculations :		
25	10:12:24	0:00:41	41	20.19	20.19		Metal :		<u>Zinc</u>						
26	10:12:26	0:00:43	43	20.19	20.19		Solution :		<u>Copper (II) sul</u>	<u>phate</u>			mass of solution (m) =	50	g
27	10:12:28	0:00:45	45	20.19	20.19		Time for adding zinc	:	173	Sec			Sp Heat Cap of solution (c)=	4.18	J g ⁻¹ K ⁻¹
28	10:12:29	0:00:46	46	20.19	20.19		Maximum Temp						Temp Diff (ΔT)	48.87	°C
29	10:12:31	0:00:48	48	20.19	20.19		у =		-0.0469	x +	77.171		heat capacity of container (c')	0	J K ⁻¹
30	10:12:33	0:00:50	50	20.19	20.19		T2 =		69.06						
31	10:12:35	0:00:52	52	20.19	20.19								Number of mole		
32	10:12:37	0:00:54	54	20.19	20.19		Initial Temp						zinc	0.0616	mol
33	10:12:38	0:00:55	55	20.19	20.19		T1=		20.19				Copper (II) sulphate	0.0500	mol
34	10:12:40	0:00:57	57	20.19	20.19								Limiting number of mole	0.0500	mol
	🕨 🕨 🛛 San	nple Data	📙 Sample Da	ta Ana	alysis / Pi	rocedure /	Data Analysis 🦯 😓								

Scientific Inquiry opportunity

To investigate the enthalpy change of neutralization