

# GD: Playing With Thermodynamics

## 活動單元：熱力學

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### 0. Introduction 簡介

In this activity unit, you will perform virtual experiments with public domain physics simulations dealing with thermodynamics. Before you start answering the questions, play with each simulation. Get Familiar with the simulations. Run the simulations in both Chinese and English so you can be bilingual! Remember to reset everything before you begin the other parts of this activity.

在這個活動單元中，你將要用虛擬實驗，來瞭解熱力學現象。在開始回答問題之前，請大家先玩線上的模擬實驗，並熟悉模擬系統。玩模擬實驗的時候，可以使用中文和英文兩種界面，大家就可以學到中英文關鍵字的對應。在開始本活動的其他部分之前，請記得要重置所有內容哦。

### 1. States of Matter 物質狀態

A Play with the PhET Simulation: "States of Matter" 下載並玩 PhET 模擬：「物質狀態」



B Observe: Three States of Matter. [Left button: "States"] 觀察：物質的三個狀態 [左鍵：“狀態”]

1. Compare the solid, liquid and gas states of **argon**. Record your observations. Use pictures. Summarize: What is the same? What is different? 比較氬氣的固態，液態和氣態，並記錄你的觀察結果。使用圖片，並總結：(a) 有什麼相同？(b) 有什麼不同？

Solid 固態	Liquid 液態	Gas 氣態

2. Compare the **solid** state of oxygen, neon, argon and water. Record your observations. Use pictures. Summarize: 比較氧氣，氖氣，氬氣和水的固態，並記錄你的觀察結果。使用圖片，並總結：

What is the same? 有什麼相同？	What is different? 有什麼不同？

3. Compare the **liquid** state of oxygen, neon, argon and water. Record your observations. Use pictures. Summarize: 比較氧氣，氖氣，氬氣和水的液態，並記錄你的觀察結果。使用圖片，並總結：

What is the same? 有什麼相同？	What is different? 有什麼不同？

4. Compare the **gas** state of oxygen, neon, argon and water. Record your observations. Use pictures.  
Summarize: 比較氧氣，氖氣，氬氣和水的氣態，並記錄你的觀察結果。使用圖片，並總結：

<b>What is the same? 有什麼相同?</b>	<b>What is different? 有什麼不同?</b>

5. Summarize your results and make conclusions. 總結你的結果並得出結論。


**C Observe: Transition between States of Matter.** 觀察：物質狀態之間的過渡

1. Reset the Simulation. Cool **Neon** to 1 K. Heat until you reach the gas state. Then cool the Neon back down to 1 K. Summarize in diagrams the changes that occur 重置模擬，並將氖氣冷卻至 1K。加熱直到達到氣態，然後將氖氣冷卻回 1K。在圖表中總結發生的變化。

Solid 固態	Liquid 液態	Gas 氣態	Liquid 液態	Solid 固態

2. Reset the Simulation. Cool **Water** to 1 K. Heat until you reach the gas state. Then cool the Water back down to 1 K. Summarize in diagrams the changes that occur. 重置模擬，並將水冷卻至 1K。加熱直到達到氣態，然後將水冷卻回 1K。在圖表中總結發生的變化。

Solid 固態	Liquid 液態	Gas 氣態	Liquid 液態	Solid 固態

**D Interpret: Discuss the differences between water and Neon (other molecules). Consider differences occurring between the liquid and solid state.** 解釋：討論水和氖氣（其他分子）之間的區別，記得考慮液態和固態之間的差異。


**E Apply: Why is this difference important in nature?** 應用：為什麼這種差異在自然界中很重要？


## 2. Phase Diagrams 相圖

A View the Video “Animation Phase Diagram” (<https://youtu.be/ejg27ozbPA8>) 觀看視頻 “動畫相圖”

B Summarize the Information Presented by the Video. 總結視頻介紹的信息

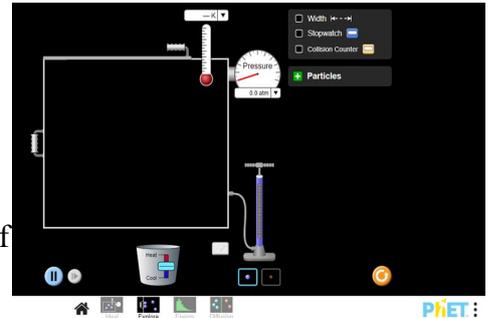
1. For what is the diagram used? 該圖用於什麼？	
2. What are the 2 axis? 兩軸是什麼？	
3. What do the three areas in the diagram represent? 圖中的三個區域代表什麼？	
4. What do the lines in the diagram represent? 圖中的線代表什麼？	
5. What “Phase” is in the upper left part of the diagram? 圖的左上方是什麼“相位”？	
6. What “Phase” is in the lower right part of the diagram? 圖的右下方是什麼“相位”？	
7. What is the “Critical point”? 什麼是“臨界點”？	
8. What is the “Triple Point”? 什麼是“三相點”？	

C Application: Making a Phase Diagram to Explain Transitions. 應用：製作相圖以解釋過渡

1. Draw a Simple Phase Diagram (for  $H_2O$ ). 繪製一個簡單的相圖（為水）。
2. Add a horizontal line on the diagram at atmospheric pressure. 在大氣壓力下，在圖中添加一條水平線。
3. Add two vertical lines: one at 0 C and the other at 100 C. 添加兩條垂直線：一個在  $0^\circ C$ ，另一個在  $100^\circ C$ 。
4. It is snowing on the top of the Mount He Huan (合歡山). But it is raining in the valley below the mountain. Draw a line on the phase diagram to show what is happening as  $H_2O$  falls to the ground. 合歡山山頂正在下雪，但山下的山谷正在下雨。在相圖上畫一條線，以顯示當水落在地上時發生了什麼。

### 3. Gas Properties 氣體性質

A Run and Play with the PhET Simulation: "Gas Properties"  
 Choose: Explore 下載並玩 PhET 模擬:「氣體性質」, 選擇: 探索



B Preliminary Question 初步問題:

1. What is the mathematical conversion factor between the units of pressure atm and kPa? 壓力單位 atm 和 kPa 之間的數學轉換係數是多少?

C Observe: Change one parameter at a time and fill in the effect of the change on the temperature (T) and pressure (P) of the gas. 觀察: 一次更改一個參數, 並填寫改變它對氣體的溫度 (T) 和壓力 (P) 的影響。

Parameter 參數	Temperature 溫度 (T)	Pressure 壓力 (P)
Increase Volume (V↑) 增加體積		
Decrease Volume (V↓) 減少體積		
Add Heat (Q↑) 加熱		
Remove Heat (Q↓) 散熱		
Add Molecules (N↑) 填加分子		
Decrease Molecules (N↓) 減少分子		
Replace Light with Heavy Molecules 用重分子取代輕分子		

D Quantify 量化

For each of the following questions: (a) First take experimental data, (b) Graph the data using a spreadsheet, and finally (c) fit your data to a mathematical equation using your spreadsheet as discussed earlier in the course. 對於以下每個問題: (a) 首先獲取實驗數據, (b) 使用電子表格繪製數據圖, 最後 (c) 如本課程前面所述, 使用電子表格將你的數據擬合成數學方程式。

1. Find the relationship between the number of gas molecules (N) in the container and the change in pressure (P) of gas in the chamber for **heavy** molecules. Keep volume (V) constant. Keep temperature (T) constant. 找到容器中氣體分子數 (N) 與腔室中重分子的氣體壓力變化 (P) 之間的關係。維持體積 (V) 和溫度 (T) 的恆定。

Experimental Data 實驗數據 (a)		Graph 圖表 (b)	Curve Fit 曲線擬合 (c)
Number Heavy Molecules 重分子數 (-)	Pressure 壓力 (kPa)		

2. Find the relationship between the temperature (T) in the container and the pressure (P) of gas in the chamber. Keep the volume (V) constant. 找到容器中的溫度 (T) 和腔室內的氣體壓力 (P) 之間的關係。維持體積 (V) 恆定。

(a) Data 實驗數據		(b) Graph 圖表	(c) Curve Fit 曲線擬合
Temperature 溫度 (K)	Pressure 壓力 (kPa)		

3. Find the relationship between the volume (V) of the container and the pressure (P) of gas in the chamber. Keep temperature (T) constant. (Note: One has to remove or add heat to the system.) 找出容器體積 (V) 和腔室內氣體壓力 (P) 之間的關係。維持溫度 (T) 恆定。(注意：必須散發或增加系統的熱量)

(a) Data 實驗數據		(b) Graph 圖表	(c) Curve Fit 曲線擬合
Volume 體積 (V)	Pressure 壓力(kPa)		

4. Find the relationship between the temperature(T) in the container and the volume (V) of gas in the chamber. Keep pressure (P) constant. (Note: One has to remove or add heat to the system.) 找到容器中的溫度 (T) 與腔室中的氣體體積 (V) 之間的關係。維持壓力 (P) 恆定。(注意：必須散發或增加系統的熱量)

(a) Data 實驗數據		(b) Graph 圖表	(c) Curve Fit 曲線擬合
Temperature 溫度(T)	Pressure 壓力 (kPa)		

- E Combine the equations to make a single general equation relate all the quantities to each other., i.e. Your equation should include N, P, V, T and a constant. 合併這些方程以使一個通用方程將所有量相互關聯，i.e. 你的方程應包括 N，P，V，T 和一個常數。