

# PBL: Playing With Thermodynamics

## 活動單元：熱力學

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Chinese:

Names	IDs(Last 5 digits)					Gr

### 0. Introduction 簡介

在這個單元，你要用虛擬實驗，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。熟悉每一個特性和按鈕，也確定瞭解怎麼用每一個每個工具。玩模擬實驗的時候，可以使用中文和英文兩種界面，大家就可以同時學到中英文關鍵字的對應囉！

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.

### 1. States of Matter

A 下載模擬器「物質三態」，選「磁棒」分頁。Download, Run and Play with the PhET Simulation: "States of Matter"

B Observe: Three States of Matter. [Left button: "States"]

1. Compare the solid, liquid and gas states of **argon**. Record your observations. Use pictures. Summarize: (a) What is the same? (b) What is different?

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2. Compare the **solid** state of oxygen, neon, argon and water. Record your observations. Use pictures. Summarize: (a) What is the same? (b) What is different?

a. What is different?	
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3. Compare the **liquid** state of oxygen, neon, argon and water. Record your observations. Use pictures. Summarize: (a) What is the same? (b) What is different?

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4. Compare the **gas** state of oxygen, neon, argon and water. Record your observations. Use pictures. Summarize: (a) What is the same? (b) What is different?

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5. Summarize your results and make conclusions.


**C Observe: Transition between States of Matter.**

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

<b>Solid</b>	<b>Liquid</b>	<b>Gas</b>	<b>Liquid</b>	<b>Solid</b>

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.

<b>Solid</b>	<b>Liquid</b>	<b>Gas</b>	<b>Liquid</b>	<b>Solid</b>

**D Interpret: Discuss the differences between water and Neon (other molecules). Consider differences occurring between the liquid and solid state.**


**E Apply: Why is this difference important in nature?**


**2. Phase Diagrams**

A View the Video “Animation Phase Diagram” (<https://youtu.be/ejg27ozbPA8>)

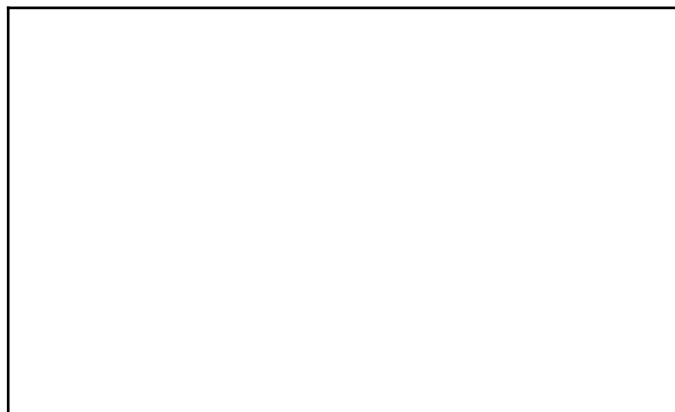
B 總結視頻介紹的信息 Summarize the Information Presented by the Video

1. For what is the diagram used?	
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2. What do the lines in the diagram represent?	
3. What is the “Critical point”?	
4. What is the “Triple Point”	

**C Application: Making a Phase Diagram to Explain Transitions**

1. Draw a Simple Phase Diagram (for Water).
2. Add a line horizontal line on the diagram at atmospheric pressure.
3. Add two vertical lines: one at 0 C and the other at 100 C.
4. It is snowing on at 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<sub>2</sub>O falls to the ground.



**3. Gas Properties**

A 下載模擬器「物質三態」，選「磁棒」分頁。Download, Run and Play with the PhET Simulation: “Gas Properties” Choose: Explore

**B Preliminary Questions:**

1. What is the mathematical conversion factor between the units of pressure atm and kPa?

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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.

Parameter	Temperature (T)	Pressure (P)
Increase Volume (V↑)		
Decrease Volume (V↓)		
Add Heat (Q↑)		
Remove Heat (Q↓)		
Add Molecules (N↑)		
Decrease Molecules (N↓)		
Replace Light with Heavy Molecules		

**D Quantify**

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 youe spreadsheet as discussed earlier in the course.

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.

Experimental Data (a)		Graph	Curve Fit (c)
<b>Number Heavy Molecules (-)</b>	<b>Pressure (kPa)</b>		

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.

Experimental Data (a)		Graph (b)	Curve Fit (c)
<b>Temperature (K)</b>	<b>Pressure (kPa)</b>		

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.)

Experimental Data (a)		Graph (b)	Curve Fit (c)
<b>Volume (V)</b>	<b>Pressure (kPa)</b>		

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.)

Experimental Data (a)		Graph (b)	Curve Fit (c)
<b>Temperature (T)</b>	<b>Pressure (kPa)</b>		

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.


## 4. Energy Forms & Conversion

A Download the simulation “Energy Forms & Conversion”. Use the left Button “Systems”

- Using the teapot, make the light bulb to work. Follow the conversion between forms of energy that are needed to make the incandescent light bulb work.

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- Using the teapot, make the light bulb to work. Follow the conversion between forms of energy that are needed to make the fluorescent light bulb work.

	→		→		→		→		→	

- What is different between the operation of the two types of bulbs?

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## 5. Heat Engines -- A brief Introduction

A Learn a little about heat engines from:  
[https://www.mpoweruk.com/heat\\_engines.htm](https://www.mpoweruk.com/heat_engines.htm)

B On a single P-V graph, plot the following cycles:

- Carnot Cycle
- Otto Cycle
- Brayton Cycle

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## 6. 您的意見 Student Comments

A Did you enjoy the activity? 你喜歡這個活動馬?  
 Choose one”

- LOVED 喜爱   
  75%   
  普通   
  25%   
  HATED 討厭

Why? 為什麼?

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B 提出1個或2個推薦的問題加到本題目卷，如果你的問題被採用，加1分！（最多加5分） Suggest one or two additional questions that could be asked concerning any of the simulations you played with. (If we add your question, you will get 1% bonus marks for the course!)

Activity	Suggested Question	Answer to suggested question

C 有沒有別的建議？ Any other suggestions to improve this activity?

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