



Lecture: **محاضرة 1 حرارة**

By: **Saif Abdel Hamid
Fahmy**

اللَّهُمَّ انْفَعْنِي
بِمَا عَلَّمْتَنِي
وَعَلَّمْنِي مَا
يَنْفَعُنِي وَزِدْنِي
عِلْمًا



Ch: 1 ⇒ Temperature

thermodynamics: the study of heat transformation into other forms of energy.

الديناميكا الحرارية هي دراسة تحويلات الحرارة إلى أشكال أخرى من الطاقة

Temperature is a measure of how hot or cold an object is and represents the thermal energy of atoms or molecules in a substance.

هي مقياس مقدار سخونة أو برودة الجسم وتعتبر عن الطاقة الحرارية للذرات أو الجزيئات في المادة.

▶ Types of temperature measurement أنواع درجة الحرارة

[1] Celsius ($^{\circ}\text{C}$) [2] Kelvin ($^{\circ}\text{K}$) [3] Fahrenheit ($^{\circ}\text{F}$)

(100:0) $^{\circ}\text{C}$

مقياس السيلسيوس مقسم إلى 100 جزء مساوٍ من

(212:32) $^{\circ}\text{F}$

مقياس فهرنهايت مقسم إلى 180 جزء مساوٍ من

(80:0) $^{\circ}\text{R}$

مقياس رينومر مقسم إلى 80 جزء مساوٍ من

310.15 $^{\circ}\text{K}$ ←

← غليان الماء عند 100°C

37 $^{\circ}\text{C}$ ←

← درجة حرارة جسم الإنسان

98.6 $^{\circ}\text{F}$ ←

ضغط الهواء $\leftarrow \text{Pa} = 76 \text{ cm Hg} = 760 \text{ mm Hg} = 760 \text{ Torr}$

$= 1.013 \times 10^5 \text{ N/m}^2 = 1.013 \times 10^5 \text{ Pa} \rightarrow$ باسكال



سليسيوس
C°

فهرنهايت
F°

ريومور
R°

Boiling point of water

212

80

Freezing point of ice

32

0

$$\frac{C-0}{100-0} = \frac{F-32}{212-32} = \frac{R-0}{80-0}$$

هناخذ فكه عنه
بس مش عليا

$$\therefore \frac{C}{100} = \frac{F-32}{180} \quad (\div 10) \rightarrow \frac{C}{10} = \frac{F-32}{18} \quad (\div 2)$$

$$\therefore \frac{C}{5} = \frac{F-32}{9} \quad \therefore C = \frac{5}{9} (F-32)$$

$$\therefore F = \frac{9}{5} C + 32 \rightarrow \text{وهو المطلوب ايجاده}$$

EX: determine the temperature of container when the Fahrenheit reading is double the celsius reading, and find the temperature at which the reading are the same.

First $\rightarrow F = 2C$ ① $\sim F = \frac{9}{5} C + 32$ ②

② في ① بالتعويض من ① في ② $2C = \frac{9}{5} C + 32$ $C = 160 C^\circ$
 $\therefore F = 2C = 2 \times 160 = 320 F^\circ$ # أولي

Also, $F = C$ $C = \frac{9}{5} C + 32$ $C = -40 C^\circ$
 $F = -40 F^\circ$

Ex: If a Celsius thermometer reads 35 degrees Celsius, what will a Fahrenheit thermometer read in the same room? What is the Fahrenheit temperature on a day with a temperature of -20°C ?

$$\text{At } C = 35^{\circ} \quad \therefore F = \frac{9}{5} C + 32 \rightarrow F = \frac{9}{5} \times 35 + 32 = 95^{\circ}\text{F}$$

ثانياً $C = -10^{\circ} \quad F = \frac{9}{5} \times -10 + 32 = 14^{\circ}\text{F}$

← يتساوى 6°C عند درجة حرارة معينة (-40) كما في [ex 1]

المقياس المطلق كلف "Absolute Kelvin Scale" →

* الصفر المطلق هو درجة الحرارة التي لا شيء عندها حجم الغاز نظرياً

عند التجمد $0^{\circ}\text{C} = 273^{\circ}\text{K}$

عند الغليان $100^{\circ}\text{C} = 373^{\circ}\text{K}$

الترمومتر الزئبقي ← يستخدم الزئبق لقياس درجة الحرارة

يبلغ -40°C إلى 357°C

درجة التجمد "درجة الغليان"

لما المستخدم لقياس درجة حرارة الإنسان يكون مدرج من

35°C (إلى 42°C) أو 95°F (إلى 110°F)

قل درجة حرارة تكون ذات
طبيعية لو قلت عن كده
الموت الإنسان



* مميزات الزيت :

- 1 لا يمتد بانتظام معتم لذلك يمكن رؤيته بسهولة من خلال الزجاج .
- 2 لا يلتحق بالزجاج .
- 3 معامل تمدده كبير نسبياً .
- 4 يأخذ درجة حرارة ما يقرب من الأشياء بسرعة .



Lecture: **محاضرة 2 حرارة**

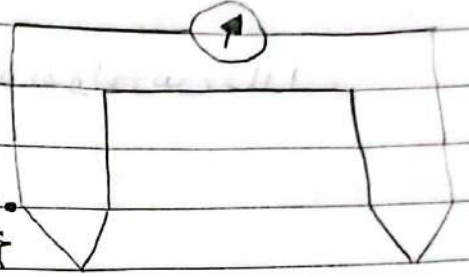
By: **Saif Abdel Hamid Fahmy**

اللَّهُمَّ انْفَعْنِي
بِمَا عَلَّمْتَنِي
وَعَلَّمْنِي مَا
يَنْفَعُنِي وَزِدْنِي
عِلْمًا



→ Thermocouple

* When two different metals like iron and copper.



معدنيت مختلفين مثل الحديد والنحاس عند
أي تسخين أحد الوصلتين تتولد قوة كهربائية

- فرق الجهد يعتمد على فرق درجة الحرارة بين الوصلتين
- يتم معايرته بوضع الوصلة الباردة في الثلج (0°) و
الوصلة الساخنة في الماء المغلي (100°) وتنقسم الخراف
الجافانومتر إلى 10 قسم كل منهما يمثل 1°C

→ Expansion of Solids تمدد المواد الصلبة

When the temperature of an object increases, the kinetic energy of its molecules rise, causing an increase in the amplitude of their vibration, this results in an expansion of the object.

عند ارتفاع درجة الحرارة تزداد طاقة الجزيئات مما يؤدي إلى
زيادة المسافة بينهما وبالتالي يحدث التمدد

• أنواع التمدد

- ← طول
- ← حجم
- ← سطحي



→ Longitudinal expansion of Solids

التغير الطولي للمواد الصلبة

$$\Delta L = L_2 - L_1$$

$$\Delta L \propto L_1 \Delta T$$

$$\Delta L \propto L_1 (T_2 - T_1) \leftarrow \text{الزيادة في الطول}$$

$$\Delta L = \alpha L_1 \Delta T \quad \alpha \text{ ثابت}$$

$$[2] \quad L_2 = L_1 + \Delta L$$

$$[1] \quad \Delta L = \alpha L_1 \Delta T \Rightarrow \Delta T = (T_2 - T_1)$$

Ex3 في الكتاب $L_1 = 10 \text{ cm} \quad T_1 = 20^\circ \text{C} \quad T_2 = 420^\circ \text{C}$
 $\alpha = 3 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$

[a] amount of elongation (ΔL) (b) L_2

$$\Delta L = \alpha L_1 \Delta T = \alpha L_1 (T_2 - T_1)$$

$$[a] \quad \Delta L = 3 \times 10^{-6} \times 10 \times (420 - 20) = 0.012 \text{ cm}$$

$$[b] \quad L_2 = L_1 + \Delta L = 10 + 0.012 = 10.012 \text{ cm}$$

Ex4 في الكتاب $L_1 = 50 \text{ cm} \quad T_1 = 200^\circ \text{C} \quad T_2 = 400^\circ \text{C}$
 $\alpha = 18 \times 10^{-6} \text{ } ^\circ\text{C}^{-1} \quad \Delta L = ??$

$$\Delta L = \alpha L_1 (T_2 - T_1)$$

$$= 18 \times 10^{-6} \times 50 \times (400 - 200) = 0.18 \text{ cm}$$

$$L_2 = L_1 + \Delta L = 50 + 0.18 = 50.18 \text{ cm}$$



a) The amount of elongation.
B) The new length of the wire after raising its temperature from 20 °C to 420 °C? Knowing that $\alpha = 3 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$

$$\Delta L = \alpha L_1(T_2 - T_1) = 3 \times 10^{-6} \times 10 \times (420 - 20) = 0.012 \text{ cm}$$
$$L_2 = L_1\{1 + \alpha(T_2 - T_1)\} = 10\{1 + 3 \times 10^{-6}(420 - 20)\} = 10.012 \text{ cm}$$
$$\text{Also, } L_2 = L_1 + \Delta L = 10 + 0.012 = 10.012 \text{ cm}$$

Solution:

$$\Delta L = \alpha L_1 [T_2 - T_1] = 18 \times 10^{-6} \times 50 \times (400 - 200)$$
$$\Delta L = 0.18 \text{ cm} \rightarrow L_2 = L_1 + \Delta L = 50 + 0.18 = 50.18 \text{ cm}$$

EX (5) في الكتاب

جسر ماكيناك

Mackinac Bridge

$$L_1 = 1158 \text{ m}$$

$$T_1 = -50^\circ \text{C}$$

$$T_2 = 50^\circ \text{C}$$

$$\Delta L = ?$$

$$\alpha = 13 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$$

$$\Delta L = \alpha L_1 (T_2 - T_1)$$

$$= 13 \times 10^{-6} \times 1158 \times (50 - (-50)) = 1.5 \text{ m}$$

← تغير كبير إلى حد ما

• يحتوي الجسر على مفاصل تمدد ويحتوي على
 [P] مفاصلين أصبعين كبيرين، الاستيعاب تمدد الأجزاء المعلقة
 من الطريق

[A] 11 مفصل أصبعي أصغر

[B] 5 مفاصل انزلاقية موزعة غير الإمتداد الرئيسي للجسر.

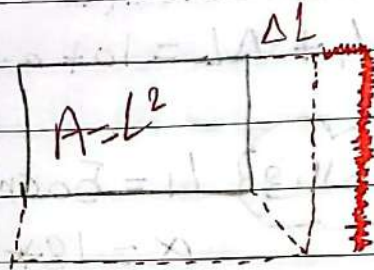
[A] Area expansion

$$A = L^2$$

$$\Delta A = 2L \Delta L$$

$$\Delta A = 2L (\alpha L \Delta T)$$

$$\Delta A = 2L^2 \alpha \Delta T$$



$$\Delta A = 2 \alpha A \Delta T \Rightarrow \Delta T = (T_2 - T_1)$$

[B] Volume expansion

$$V = L^3$$

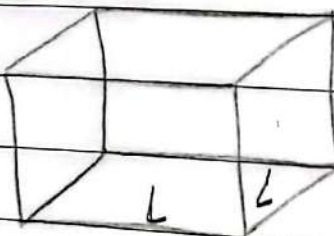
$$\Delta V = 3L^2 \Delta L$$

$$\Delta V = 3L^2 (\alpha L \Delta T)$$

$$\Delta V = 3L^3 \alpha \Delta T$$

$$\Delta V = 3 \alpha V \Delta T$$

$$\Delta V = 3 \alpha V \Delta T \Rightarrow \Delta T = (T_2 - T_1)$$



Thermal expansion of the Mackinac Bridge:

Example (5) The main span of the Mackinac Bridge (see the Figure) has a length of 1158 m. The bridge is built of steel. Assume that the lowest possible temperature experienced by the bridge is $-50\text{ }^{\circ}\text{C}$ and the highest possible temperature is $50\text{ }^{\circ}\text{C}$. How much room must be made available for thermal expansion of the center span of the Mackinac Bridge?

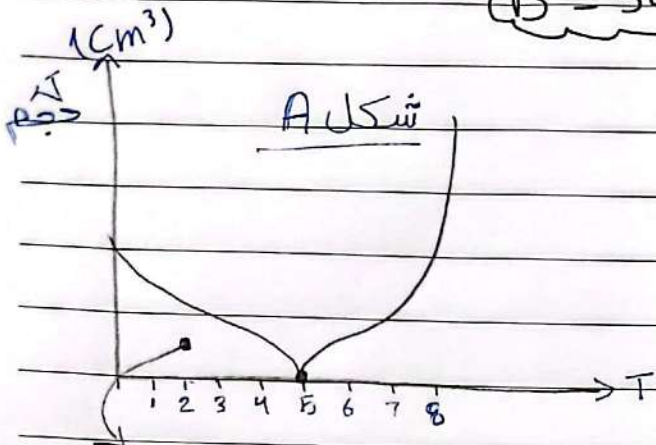


Solution: The linear expansion coefficient of steel is $\alpha = 13 \times 10^{-6}\text{ }^{\circ}\text{C}^{-1}$. Thus, the total linear expansion of the center span of the bridge that must be allowed for is given by $\Delta L = \alpha L \Delta T = 13 \times 10^{-6} \times 1158 \times (50 - (-50)) = 1.5\text{ m}$

ملاحظات

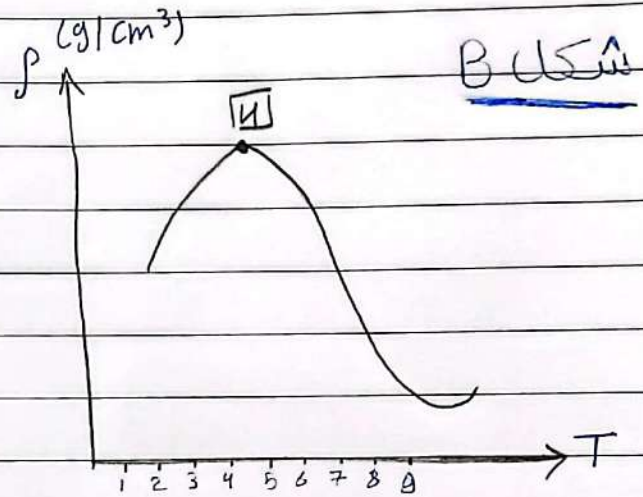
معامل التمدد الحجمي يساوي (3) أمثال الأول

$\beta = 3\alpha$



تزيد
تقل

↓ ↑
T T



في شكل (A) الماء بين 4 درجات مئوية يتصرف بشكل استثنائي، حيث ينكمش بدلاً من أن يتمدد عند ارتفاع الحرارة.

في شكل (B) فوق (4) درجات مئوية، يصبح الماء الأكثر كثافة مما يؤثر على كيفية تجمد البحيرات في الشتاء.

ملحوظة هامة

عند 1°C يكون

$$B = -47.8 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$$

في الكتاب (6) EX

$$T_2 = 40 \quad V = 55 \text{ L} \quad T_1 = 12^\circ\text{C}$$

$$B = 950 \times 10^{-6} \text{ } ^\circ\text{C}^{-1} \quad \Delta V = ?$$

$$\Delta V = BV\Delta T = BV(T_2 - T_1)$$

$$\therefore \Delta V = 950 \times 10^{-6} \times 55 \times (40 - 12)$$

$$\Delta V = 1.46$$

///

ملحوظة

مهم! عند انخفاض درجة الحرارة يبقى الماء بارد على السطح ويتجمد بينما يبقى الماء الدافئ في الأسفل مما يسمح ببقاء المياه في البحيرات خلال الشتاء.



Example 6: You pull your car into a gas station on a hot summer day, when the air temperature is 40 °C. You fill your empty 55-L gas tank with gasoline that comes from an underground storage tank where the temperature is 12 °C. After paying for the gas, you decide to walk to the restaurant next door and have lunch. Two hours later, you come back to your car and discover that gasoline has spilled out of the gas tank onto the ground.

Problem: How much gasoline has spilled?



Solution: We know the following: The temperature of the gasoline you put in the tank starts out at 12 °C. The gasoline warms up to the outside air temperature of 40 °C. The volume expansion coefficient of gasoline is $950 \times 10^{-6} \text{ }^{\circ}\text{C}^{-1}$.

While you were gone, the temperature of the gasoline changed from 12 °C to 40 °C. We can find the change in volume of the gasoline as the temperature increases using the equation: $\Delta V = \beta V \Delta T = (950 \times 10^{-6} \text{ }^{\circ}\text{C}^{-1}) (55 \text{ L}) (40 \text{ }^{\circ}\text{C} - 12 \text{ }^{\circ}\text{C}) = 1.5 \text{ L}$.



Lecture: **محاضرة 3 حرارة**

By: **Saif Abdel Hamid Fahmy**

اللَّهُمَّ انْفَعْنِي
بِمَا عَلَّمْتَنِي
وَعَلَّمْنِي مَا
يَنْفَعُنِي وَزِدْنِي
عِلْمًا



→ Heat Capacity

السعة الحرارية

$$Q = C (T_f - T_i) \rightarrow C \rightarrow \text{Heat Capacity}$$

$$Q \propto \Delta T$$

$$Q \propto (T_f - T_i)$$

→ Heat Capacity → it is the amount of heat needed to raise the body temperature by one degree Celsius where Q is the amount of heat, $C = \frac{\Delta Q}{\Delta T}$

كمية
هي الحرارة اللازمة لرفع درجة الحرارة الجسم درجة واحدة
مئوية حيث Q هي كمية الحرارة

← ملاحظة :

السعة الحرارية اعين مميزات الجسم حيث تتغير بتغير الجسم وبتغير مميزات حتى لو من نفس المادة

→ Specific heat

$$Q \propto (T_f - T_i) m$$

$$Q = m s \Delta T$$

Specific heat

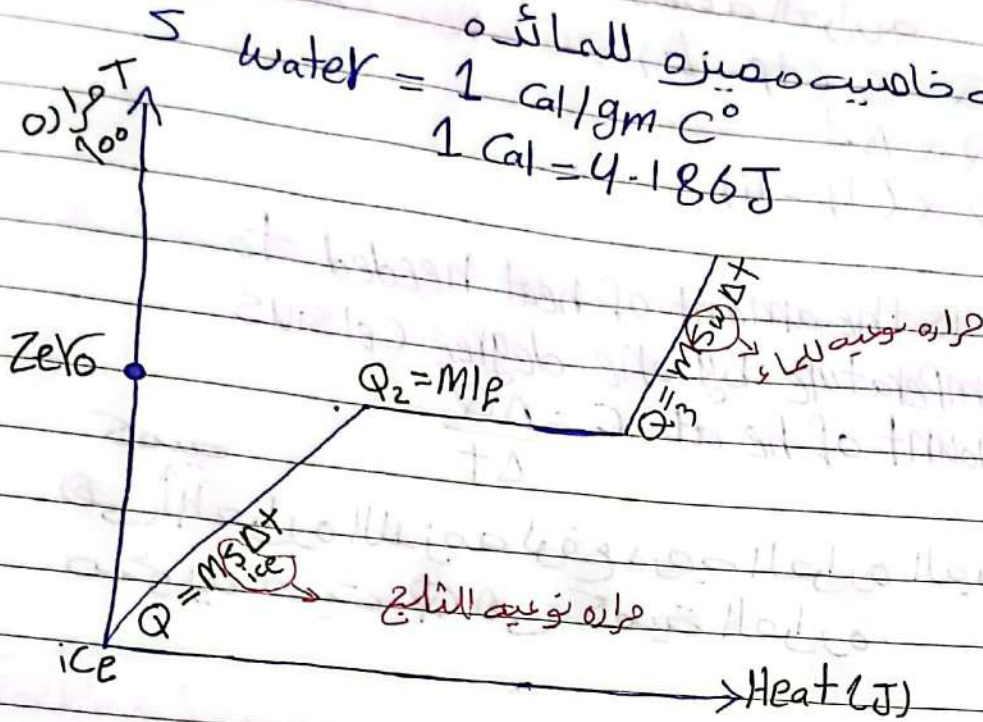
→ Specific heat → it is the amount of heat needed to raise the temperature of a unit mass of a substance by one degree the formula for it is as follow $s = \frac{\Delta Q}{m \Delta T}$

هي كمية الحرارة اللازمة لرفع درجة الحرارة وحدة كتلة من مادة ما درجة واحدة حيث $\frac{\Delta Q}{m \Delta T}$



ملحوظة

الحرارة النوعية خاصية مميزة للمادة
 $\text{water} = 1 \text{ cal/gm } ^\circ\text{C}$
 $1 \text{ cal} = 4.186 \text{ J}$



لتحويل الناتج إلى
 ماء يتم على 3 مراحل
 كما في الرسم

الحرارة النوعية للماء تعتبر من أعلى الحرارة النوعية في المواد
 كلها

كما زادت درجة الحرارة فزادت حركة الجسيمات

⇒ melting point :-

the substance has changed from a solid to a liquid.

تكون المادة قد تحولت من الحالة الصلبة إلى الحالة السائلة

⇒ Boiling point :-

the substance has changed from a liquid to a gases state

تكون المادة قد تحولت من الحالة السائلة إلى الحالة الغازية



⇒ Heat Required to melt a solid. $Q = m L_f$
الحرارة اللازمة لإذابة مادة صلبة

⇒ Heat Required to Vaporize a liquid. $Q = m L_v$
الحرارة اللازمة لتبخير السائل

ملاحظة: The amount of heat lost = the amount of heat gained.

كمية الحرارة المكتسبة = كمية الحرارة المفقودة

ex 7: في الكتاب
 $m = 720 \text{ gm}$ و $S_{ice} = 2220 \text{ J/kg} \cdot \text{K}^\circ$
 $L = 333 \times 10^3 \text{ J/g}$ و $S_{water} = 4190 \text{ J/kg} \cdot \text{K}^\circ$
أوجد كمية الحرارة اللازمة لتحويل القطع من الثلج للماء في
لتحويل الثلج لماء يتم على 3 خطوات كما في الشكل
المرسوم في الصفحة التالية

مرحلة أولى → $T_i = -10^\circ \text{C}$ $Q_1 = m S_{ice} \Delta T$
 $T_f = 0^\circ \text{C}$

$$Q_1 = 720 \times 10^{-3} \times 2220 \times (0 - (-10)) = 15984 \text{ J}$$

مرحلة ثانية → $Q = m L$ $Q_2 = 720 \times 10^{-3} \times 333 \times 10^3$
 $Q_2 = 239760 \text{ J}$

مرحلة ثالثة → $T_i = 0^\circ \text{C}$
 $T_f = 15^\circ \text{C} \Rightarrow Q_3 = m S_{water} \Delta T$

$$Q_3 = 720 \times 10^{-3} \times 4190 \times (15 - 0) = 45252 \text{ J}$$

$$Q_{\text{total}} = Q_1 + Q_2 + Q_3 = 15984 + 239760 + 45252 = 300996 \text{ J}$$



Example (7) what is the amount of heat required to convert a piece of ice of mass 720gm at a temperature of -10°C to a liquid state at a temperature of 15°C .

Knowing that $S_{ice} = 2220\text{J} / \text{kg} \cdot \text{K}^{\circ}$, $L = 333 \times 10^3\text{J} / \text{Kg}$, $S_{water} = 4190\text{J} / \text{kg} \cdot \text{K}^{\circ}$?

The solution

First stage: from ice at -10°C to ice at zero $^{\circ}\text{C}$

$$Q_1 = ms\Delta T = ms(T_f - T_i), \quad T_i = -10^{\circ}\text{C}, T_f = 0^{\circ}\text{C} \rightarrow$$

$$Q_1 = 0.72 \times 2220(0 - (-10)) = 15984\text{J}$$

Phase 2: Change from ice at zero $^{\circ}\text{C}$ to water at zero $^{\circ}\text{C}$

$$Q_2 = mL = 0.72 \times 333 \times 10^3 = 239760\text{J}$$

The third stage: from water at zero $^{\circ}\text{C}$ to water at 15°C

13Page |

٢٢/١٢

Ch1: Temperature and Thermal Energy

$$Q_3 = ms\Delta T = ms(T_f - T_i), T_i = 0^{\circ}\text{C}, T_f = 15^{\circ}\text{C} \rightarrow$$

$$Q_3 = 0.72 \times 4190(15 - 0) = 45252\text{J}$$

$$Q = Q_1 + Q_2 + Q_3 = 300996\text{J}$$



Lecture: محاضرة رابعة حرارية جروب
A

By: Kholoud Nader

اللَّهُمَّ انْفَعْنِي
بِمَا عَلَّمْتَنِي
وَعَلَّمْنِي مَا
يَنْفَعُنِي وَزِدْنِي
عِلْمًا

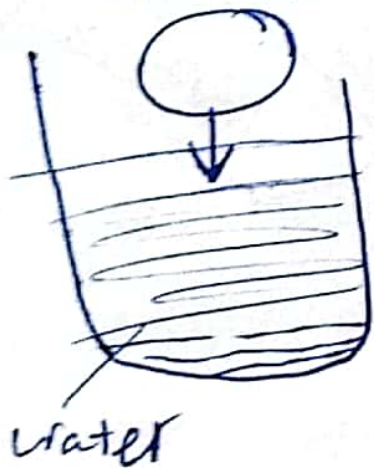


✓ Example (8) ✗

2-3-2023.

Lee 4

A copper ball of mass $m=75\text{gm}$ is heated to a temperature $T=312^\circ\text{C}$. The ball is dropped into a beaker containing water of mass $m=220\text{ gm}$, the heat capacity of the beaker is $C=45\text{ cal/k}$ and the initial temperature of the water and glass is $T=12^\circ\text{C}$. Find the final temperature T_f of the copper ball, the beaker, and the water at thermal equilibrium, knowing that:



$$s = 0.092 \text{ cal/g.k}, s_w = 1 \text{ cal/g}^\circ\text{C}$$

$$m_{\text{copper}} = 75\text{gm}, T_{\text{copper}} = 312^\circ\text{C}$$

$$m_{\text{water}} = 220\text{gm}, C_{\text{beaker}} = 45 \text{ cal/k}^\circ\text{C}, T_i = 12^\circ\text{C}$$

$$T_b = 12^\circ\text{C}$$

The solution
مفتوحة

The amount of heat gained = the amount of heat lost

$$T_F = ??$$

Ch1: Temperature and Thermal Energy

$$Q_{copper} = Q_{water} + Q_{beaker}$$

m b s b

$$m_c s_c (T_f - T_i) = m_w s_w (T_f - T_i) + c_b (T_f - T_i) C_b$$

$$75 \times 0.092 (312 - T_f) = 220 \times 1 (T_f - 12) + 45 (T_f - 12) \quad T_F =$$

$$2152.8 - 6.9 T_f = 220 T_f - 2640 + 45 T_f - 540$$

$$5332.8 = 271.9 T_f \rightarrow T_f = 19.61^\circ C$$

$$x = 19.6$$

$$T_F = 19.6$$

Transmission of heat انتقال الحرارة

There are three different ways in which heat is transferred from one place to another:

التوصيل . الحمل . الإشعاع
conduction, convection, and radiation.

Conduction التوصيل (لا يتم يكون في جدران) لازم يكون فيه وسط الحرارة

If you hold a metal rod at one end and then place the other end in a flame, you will soon feel the metal rod getting hot, indicating that heat has been transferred through it. On the other hand, if you hold a slice of wood by one end and then place the other end in the fire, the heat will not be transferred even a little bit, even if the end in the fire starts to ignite. In other words, metal is a good conductor of heat, while wood is a poor conductor of heat. The word "conduction" is used to mean heat transfer in solids.

Thermal conductivity is defined as follows: It is the process by which heat is transferred from one point to another through solids without moving the molecules of the material itself.

In the previous example, we find that when the end of the metal rod that is exposed to the flame is heated, the molecules of this end will vibrate capacitively from one molecule to another neighboring molecule, and so the process continues until the heat is transferred from the hot end to the cold end.

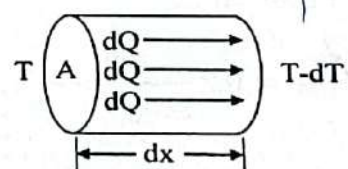


Figure (4)

رسم

Suppose we have a section of a metal rod with thickness dx, cross-sectional area A, temperature at one end T and the other end (T-dT) as shown in figure (4). The heat flow rate (the amount of heat flowing in a unit of time) is directly proportional to the cross-sectional area of the rod A and the difference in the temperatures between the two sides of the rod

$$\text{i.e. } \frac{dQ}{dt} \propto A (-dT),$$

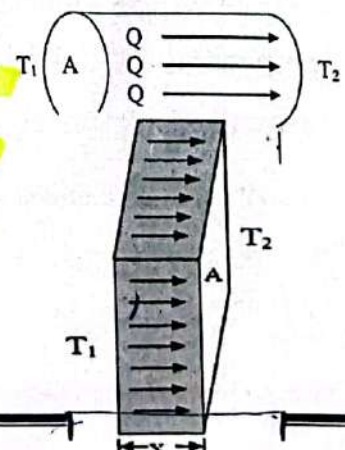


Figure (6)

Ch1: Temperature and Thermal Energy

And inversely proportional to the thickness dx i.e

$$\frac{dQ}{dt} \propto \frac{1}{dx} \rightarrow \frac{dQ}{dt} \propto \frac{A(-dT)}{dx}$$

$$\therefore \frac{dQ}{dt} = K \frac{A(-dT)}{dx} = -K \frac{A(T_2 - T_1)}{dx}$$

$$\therefore \frac{dQ}{dt} = K \frac{A(T_1 - T_2)}{dx}$$

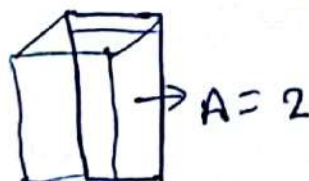
Where K is the coefficient of thermal conductivity and its unit is $\text{cal/cm sec } ^\circ\text{C}$

The quantity dT/dx represents the rate of change of temperature with respect to distance. when the temperature decreases as the distance from the hot end of the rod increases, the quantity dT/dx is negative and is called the temperature gradient. See Figure (5).

In the steady state, when a metal rod of length x has temperatures T_1 and T_2 at its two ends, the difference between T_2 and T_1 remains constant. To prevent thermal energy loss, it is necessary to isolate the rod from the external medium. The amount of heat passing through the rod during time t can be calculated as follows: $Q = K \frac{A(T_1 - T_2)}{x} t$

Example (9) a metal slide is 0.2 cm thick and has a surface area of 200 cm^2 . If the temperature difference between the two opposite surfaces is 100°C , find the amount of heat that will be transferred through the slide in a time of one minute, given that $k = 0.2 \text{ cal/sec.cm.}^\circ\text{C}$

The solution:



$k = 0.2 \frac{\text{cal}}{\text{sec.cm.}^\circ\text{C}}, A = 200 \text{ cm}^2, x = 0.2 \text{ cm}, t = 1 \text{ min} = 60, T_1 - T_2 = 100^\circ\text{C}$

$$Q = K \frac{A(T_1 - T_2)}{x} t = \frac{0.2 \times 200 \times 100 \times 60}{0.2} = 1.2 \times 10^6 \text{ cal} = 12 \times 10^5 \text{ cal}$$

Ch1: Temperature and Thermal Energy

Free convection currents: It is a phenomenon resulting from the effect of gravity and this transfer process is governed by the following law:

$$Q = \alpha A h t (T_1 - T_2)$$

Where T_1 and T_2 are the temperatures of the hot and cold regions, respectively. In addition, α is the convection coefficient, h is the thickness of the hot medium, A area of the hot medium and t is the heat transfer time.

Forced convection currents:

In this type of conduction, the fluid is forcibly moved by fans or pumps.

Newton's Law of Cooling

Newton's Law of Cooling states, "The rate of heat loss from a hot object $\frac{\Delta Q}{\Delta t}$ to the surrounding medium is proportional to the difference between the temperature of the hot object T and the temperature of the medium T_r ."

$$\frac{\Delta Q}{\Delta t} = K (T - T_r)$$

Handwritten notes: معدل تبريد الجسم $\frac{\Delta Q}{\Delta t}$ = K (درجة حرارة الجسم - درجة حرارة الوسط)

Example (12) If we make a flat vertical wall with an area of 6 m^2 at a constant temperature of 116°C while the air on its sides at a temperature of 35°C , what is the heat lost from the wall in an hour due to natural convection. Knowing that the wall thickness is 1 m and the convection coefficient in this case $\alpha = 1.27 \times 10^{-3} \text{ cal/m}^2\text{s}^\circ\text{C}$

Assume that the amount of heat transferred from each side can be found from the relationship:

$$Q = \alpha A h t (T_1 - T_2) = 1.27 \times 10^{-3} \times 6 \times 1 \times 60 \times 60 \times (116 - 35) = 2222 \text{ cal}$$

Radiation heat transfer:

In this type of heat transfer method, heat is transferred without the need for a means of transportation as thermal radiation is electromagnetic waves and the relationship between the amount of heat transferred by radiation and temperature is described by Stefan-Boltzmann's law, which states that ((the amount of heat radiated by a black body per unit area per unit time is proportional to the fourth power of the absolute temperature)),

$$\frac{dQ}{dt} = \sigma A (\Delta T)^4$$

Black body: A black body is an object that absorbs all the radiation energy falling on it and radiates energy continuously, and the best example of a black body is a gap in a wall. When any radiation enters, it suffers from several reflections inside the gap, so it loses all its energy

Ch1: Temperature and Thermal Energy

during successive reflections inside the gap, and this indicates that the black body's absorption coefficient is equal to one and therefore its reflection coefficient is equal to zero.

The radiative power of a black body:

It is known that hot objects lose heat at greater rates than cold objects. This phenomenon was demonstrated by the two scientists Steifen and Boltzmann after series of experiments in what is known as Stephen's law of radiation, which states that "the total radiation rate emitted from the unit area of the black body is proportional to the fourth exponent of its absolute temperature".

That is, $E = \sigma T^4$, where σ is a constant known as Stephen's constant and is equal to $(5.672 \times 10^{-8} \text{ J/m}^2\text{sk})$. For any body (which is not quite black), another amount is added called the degree of blackness ϵ which gives the amount of blackness in the ratio between the radiation emitted by the object to the radiation emitted by the black body at the same temperature.

For a non-black body, we write the Stephen-Boltzmann law as follows: $E = \epsilon \sigma T^4$, so the amount of heat transferred by radiation from a hot object to the surrounding medium can be written as $E = A \epsilon \sigma (T^4 - T_1^4)$ where T and T_1 are the temperatures of the hot object and the ambient medium, respectively.

Absorptive capacity and Kirchhoff's law :

The radiation capacity (α) is the ratio between the amount of radiation absorbed by an object to the amount of radiation falling on it, and Kirchhoff's law expresses the relationship between radiation capacity and absorption capacity. This law states that the ratio between the radiant power of a natural object and its absorptive capacity is a constant amount.

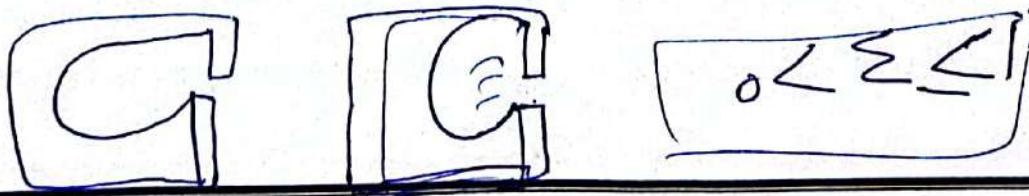
✓ **Example (13)** a black spherical object has diameter of 10 cm is stationary at a constant temperature of 327°C and the temperature of the medium is 27°C . What is the power radiated? ✓

Consider $\epsilon = 1$ knowing that $\sigma = 5.67 \times \frac{10^{-8} \text{ W}}{\text{m}^2\text{K}^4}$.

The solution

$$E = \epsilon \sigma A (T^4 - T_1^4) = (5.67 \times 10^{-8}) (4\pi (0.05)^2) \{ (327 + 273)^4 - (27 + 273)^4 \}$$
$$= (5.67 \times 10^{-8}) (4\pi (0.05)^2) \{ (600)^4 - (300)^4 \} = 216.43 \text{ W}$$

$4\pi r^2$





Lecture: محاضرة خامسة حرارية جروب A

By: Kholoud Nader

اللَّهُمَّ انْفَعْنِي
بِمَا عَلَّمْتَنِي
وَعَلَّمْنِي مَا
يَنْفَعُنِي وَزِدْنِي
عِلْمًا



$$Q = K \frac{A (T_1 - T_2)}{x} t = \frac{0.2 \times 200 \times 100}{0.2} = 1.2 \times 10^5 \text{ cal} = 12 \text{ kcal}$$

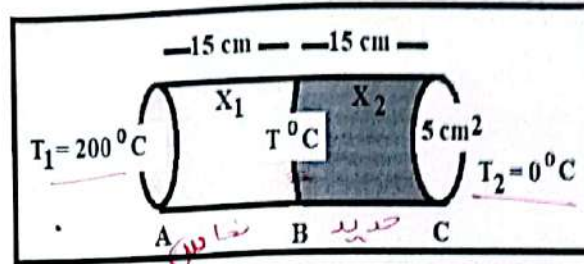
Lec 5 9-3-2023

Example (10) a rod with a length of 30cm and a cross-sectional area equal to 5cm^2 consists of two parts of equal length. Part **AB** is made of copper and part **BC** is made of iron. Their point of connection is point **B**. As shown in the figure, the end **A** is kept at a temperature of 200°C and the end **C** at a temperature of 0°C . If the sides of the rod are thermally isolated, calculate the rate of heat flow along the length of the rod when steady state is reached. Given that $K_1 = K_{\text{copp}} = 0.09 \frac{\text{cal}}{\text{sec.cm.}^\circ\text{C}}$, $K_2 = K_{\text{iron}} = 0.12 \frac{\text{cal}}{\text{sec.cm.}^\circ\text{C}}$

معدل تدفق الحرارة في
الجزء 1

Ch1: Temperature and Thermal Energy

Solution:



$$x_1 = x_2 = 15 \text{ cm}, A = 5 \text{ cm}^2, \Delta T_1 = 200 - T, \Delta T_2 = T - 0$$

Since steady state has been reached, the rate of heat flow through first part AB is equal to the rate of heat flow through second part BC, so

$$\left(\frac{dQ}{dt}\right)_1 = \left(\frac{dQ}{dt}\right)_2 \rightarrow K_1 \frac{A(200 - T)}{x_1} t = K_2 \frac{A(T - 0)}{x_2} t$$

$$K_1(200 - T) = K_2(T - 0) \rightarrow 0.09(200 - T) = 0.12 T$$

$$18 - 0.09T = 0.12T \rightarrow 0.21T = 18 \rightarrow T = 85.71^\circ\text{C}$$

$$\left(\frac{dQ}{dt}\right)_1 = K_1 \frac{A(200 - T)}{x_1} = 0.09 \times \frac{5(200 - 85.71)}{15} = 3.43 \text{ cal/sec}$$

Example (11) a sheet of asbestos paper with a thickness of 2 mm is used as a barrier between two brass plates. The temperature on one plate is equal to 1000°C and the other plate has a temperature of 200°C. What is the amount of heat passing through an area of 50 cm² from one plate to the other during the time t=20 (min)? Note that the thermal conductivity coefficient of asbestos is $k=5 \times 10^{-4} \text{ cal/cm sec } ^\circ\text{C}$.

The solution

$$Q = k A \frac{T_1 - T_2}{x} t = 5 \times 10^{-4} \times 50 \times \frac{1000 - 200}{0.2} \times 20 \times 60$$

$$Q = 1.2 \times 10^5 \text{ cal} \quad \text{through 1200 s}$$

Convective heat transfer

When heat is transferred in a physical medium by the transfer of some of its parts, the heat is said to be transferred by convection. This is due to the fact that in this scenario, certain portions of the medium carry heat with them as they are being transported. This kind of heat transfer takes place in fluids (including liquids and gases), and we refer to the heat transfer as being caused by convection currents, which can be broken down into two distinct categories.

(*) المسار يؤثر على مقدار وقمة الشغل

Heat and the First Law of Thermodynamics

Our focus in this chapter will be on the concept of internal energy, the first law of thermodynamics, and some applications of this law. The first law of thermodynamics expresses the general principle of conservation of energy. According to this law, an energy transfer to or from a system by either heat or work can change the internal energy of the system.

Heat and Thermal Energy

It is important to make a major distinction between *heat* and *internal energy* (thermal energy).

Internal energy is all the energy of a system that is associated with its microscopic constituents. Internal energy includes kinetic energy of random translational, rotational, and vibrational motion of molecules, potential energy of molecules and between molecules.

Heat is defined as the *transfer of energy* from one system to another due to a temperature difference between them.

Units of Heat, The Mechanical Equivalent of Heat

Previously, heat was measured in terms of its ability to raise the temperature of water. Thus, the **calorie (cal)**, in cgs units, was defined as the amount of heat required to raise the temperature of 1 g of water from 14.5 to 15.5 °C. The 'Calorie' with a capital C, used by nutritionists, is a kilocalorie (1 Cal = 1 kcal = 10³ cal).

The **British Thermal Unit (Btu)** was also defined

as the amount of heat required to raise the temperature of 1 lb of water from 63 to 64 °F.

Since heat is now known as transferred energy, the SI unit for it is the **joule (J)**.

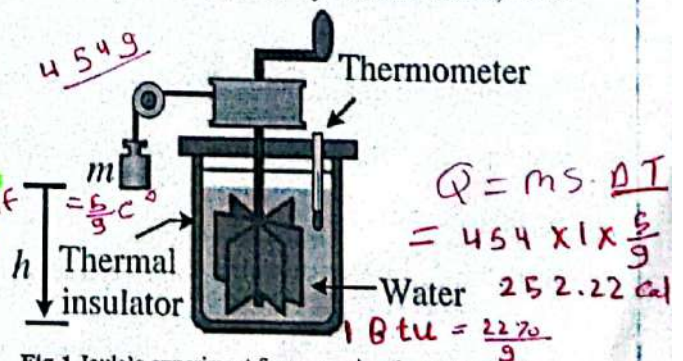


Fig.1 Joule's experiment for measuring the mechanical equivalent of heat from the temperature rise in water

In a famous experiment, see Fig. 1, Joule measured the calorie (cal) by converting mechanical energy into heat energy, expressed as an increase in water temperature. Joule found that the loss in mechanical energy is proportional to the increase in temperature of the water. The proportionality constant was found to be equal to 4,180 J/kg. °C. Hence, 4,180 J of mechanical

Chapter 2 Heat and the First Law of Thermodynamics

energy will raise the temperature of 1 kg of water from 14.5 to 15.5 °C. One kilocalorie (1 kcal) is now defined to be exactly 4,186 J without reference to the heating of substance. Thus:

$$1 \text{ kcal} = 4,186 \text{ J.}$$

Heat and Work

In thermodynamics, when an isolated system is in thermal equilibrium internally, we describe its macroscopic state with the variables P , V , and T to represent pressure, volume and temperature. For such a system, we describe its microscopic state of internal energy with the variable E_{int} (some other textbooks use the symbol U).

Let us assume our system consists of gas confined to a cylinder with insulated walls and a movable frictionless piston of area A , as shown in Fig. 2. The cylinder rests on a heat reservoir whose temperature T is controlled by a knob. At equilibrium, the upward force on the piston due to the pressure of the confined gas is equal to the weight of the load on the top of the piston.

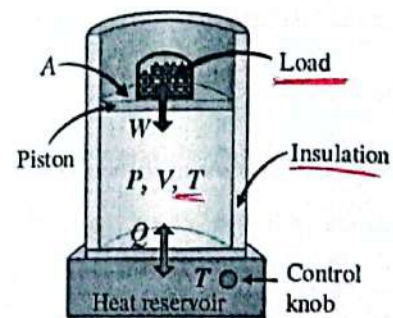


Fig.2 Gas confined to a cylinder with a movable frictionless piston. The gas can do work W to raise or lower the piston. By regulating the temperature T of the thermal reservoir, by means of a control knob, a quantity of heat Q can be added or removed from the gas.

Consider that we start at an *initial state* i , where the system is described to have pressure P_i , volume V_i , and temperature T_i . We then change the system to a *final state* f , described to have pressure P_f , volume V_f , and temperature T_f . The process of changing the system from the initial state to the final state is a **thermodynamic process**. During such a process, work is done *by* the system to raise the piston (positive work) or lower it (negative work). In addition, heat may be transferred into the system from the thermal reservoir (positive heat) or vice versa. We assume that the state of the gas changes **quasi-statically**, i.e. slowly enough to allow the system to remain essentially in a thermodynamic equilibrium at all times.

Now, assume we reduce the load from the piston in such a way that the piston will move upward through a differential displacement $\vec{ds}$ with *almost* constant upward force $\vec{F}$, as shown in Fig. 3. From the definition of pressure, we have $F=PA$, where A is the area of the piston. The differential

work dW done by the gas during the displacement is: $dW = \vec{F} \cdot \vec{ds} = F ds = P A ds$, Since $A ds$ is the differential change in the volume of the gas dV (i.e. $dV = A ds$), we can express the work done by the gas as follows: $dW = P dV$ تغير في حجم في ضغط

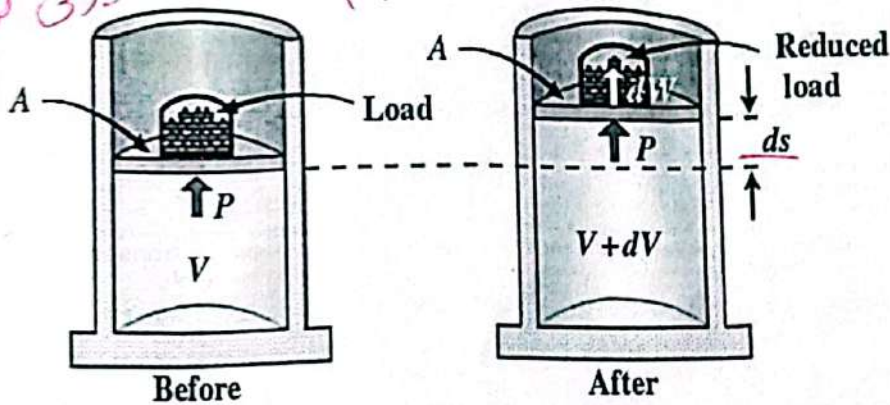


Fig. 3 A confined gas in a cylinder at pressure P does work dW on a free piston as the gas expands from volume V to volume $V + dV$ because of a decreased load

If the gas expands, as in Fig. 4, then dV is positive and the work done by the gas is positive, whereas if the gas is compressed, dV is negative, indicating that the work done by the gas is negative (which can be interpreted as work done on the gas). When we remove an appreciable amount of load from the piston, the volume of the gas changes from V_i to V_f , and the total work done by the gas is:

$$W = \int_{V_i}^{V_f} dw = \int_{V_i}^{V_f} P dV$$

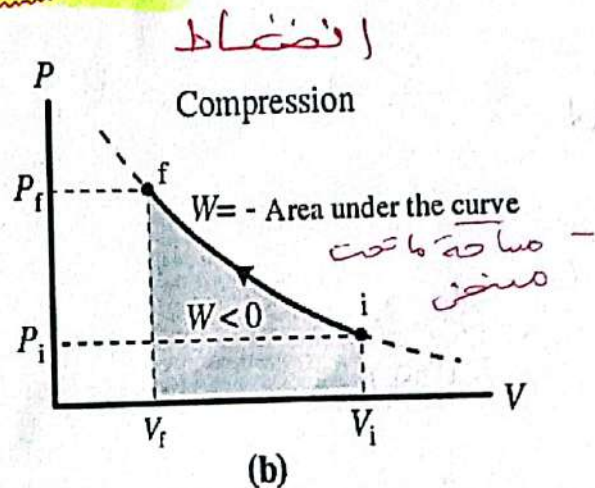
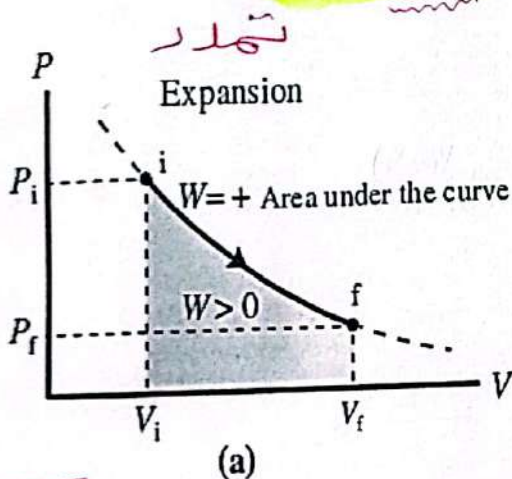


Fig. 4 The figure shows a gas that goes from an initial state i to a final state f by means of a thermodynamic process. (a) When the gas expands, the work done by the gas is positive and equals the area under the PV curve. (b) Similar to (a), except that the gas is compressed and the work done by the gas is negative

الشغل المبذول هو مساحة باءت المنحنى

Chapter 2 Heat and the First Law of Thermodynamics

As seen from Fig. 4, the total work done during the expansion or compression of the gas depends on the specific path taken from the initial state i to the final state f . In Fig. 5, we illustrate this important point further by considering several different paths for the gas along the PV curve, from state i to state f , regardless of how we achieve each path.

Path a: The gas expands from V_i to V_f while the pressure decreases from P_i to P_f . The work done by the gas along this path is positive and represented by the colored area under the curve between i and f .

Path b: The gas first expands from V_i to V_f at constant pressure P_i , and then its pressure is reduced to P_f at constant volume V_f . The work done along this path is $P_i (V_f - V_i)$.

Path c: The pressure of the gas is first reduced from P_i to P_f by cooling at a constant volume V_i , and then allowing the gas to expand from V_i to V_f at constant pressure P_f . The work done along this path is $P_f (V_f - V_i)$.

Path d: The gas is compressed from V_i to V_f while the pressure increases from P_i to P_f . The work done along this path is the negative of the colored area under the curve.

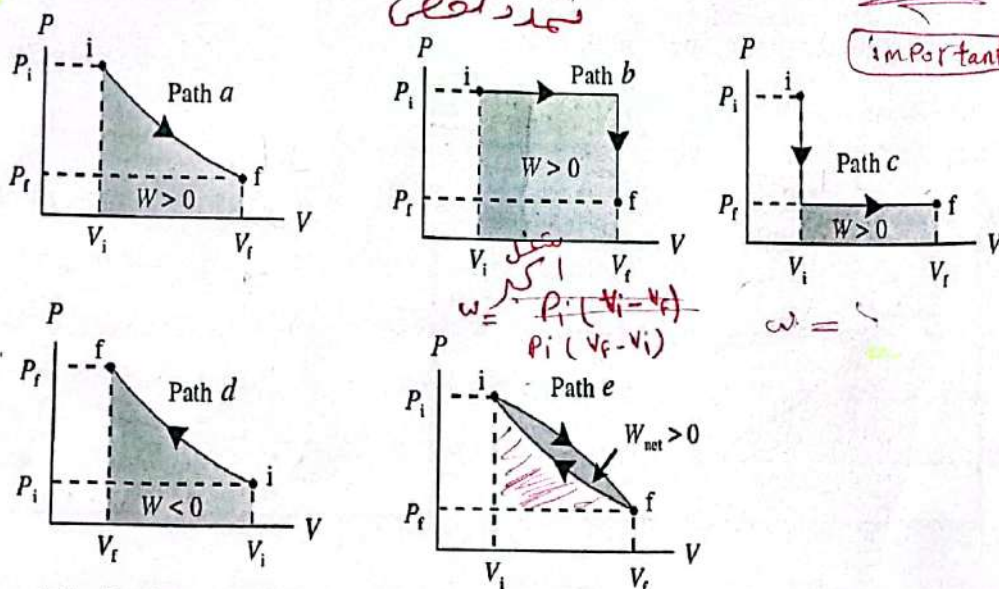


Fig.5 The gas of Fig. 2 goes from an initial state i to a final state f by means of several different thermodynamic processes

Path e: The net work done by the system during a closed cycle is the sum of the positive work done during the expansion and the negative work done during the compression. Here, the net

work done by the gas is positive and is represented by the enclosed area between the two curves. From the graphs of Fig. 5, we see that W could be small or large depending on the thermodynamic path between i and f . Thus:

Spotlight

The net work done by a system W depends on the thermodynamic process (or the path) chosen between its initial and final states.

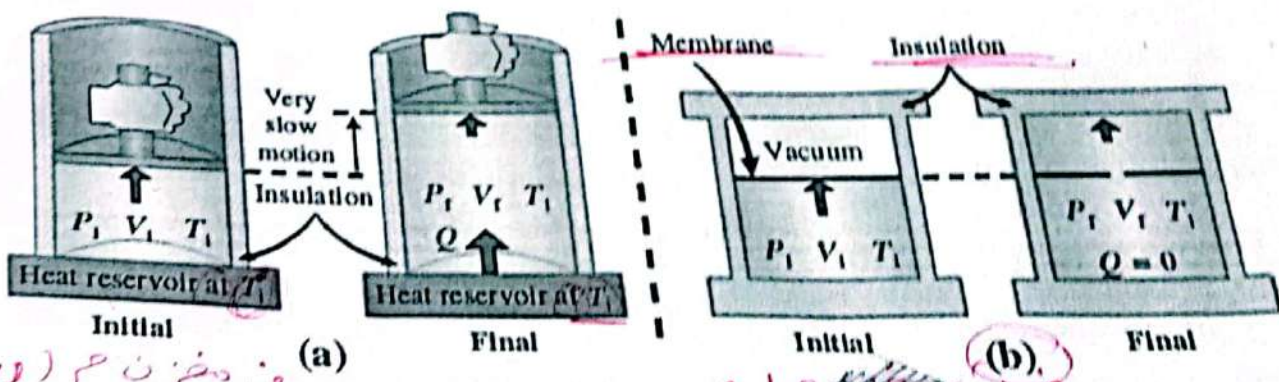
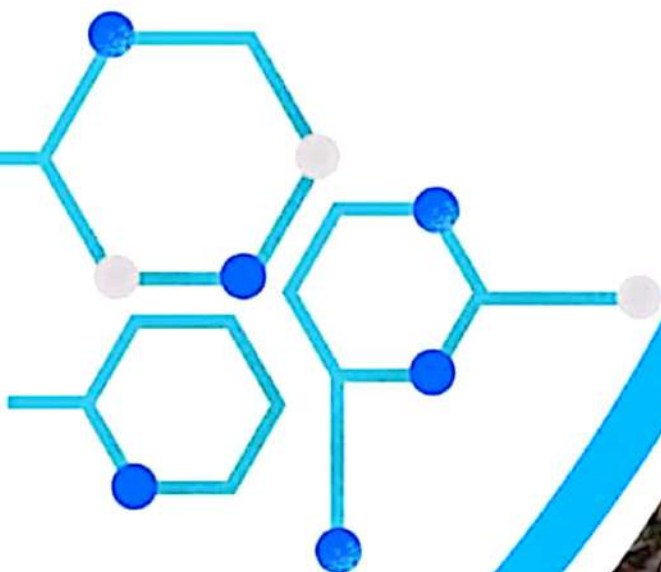


Fig. 6 (a) An ideal gas at temperature T_i expands slowly while absorbing heat energy Q from a reservoir in order to maintain its constant temperature T_i . (b) An ideal gas expands rapidly into an evacuated chamber after a membrane is broken

In a similar manner, we also find that the heat energy transfer Q into or out of a system depends on the thermodynamic process. This can be demonstrated for an ideal gas as shown in Fig. 6.

In Fig. 6 a, the piston is held at a position where the gas is at its initial pressure P_i , volume V_i , and temperature T_i . When the force holding the piston is reduced slightly, the piston rises very slowly to a final pressure P_f and final volume V_f , i.e. the gas is doing work W on the piston. During this expansion process, heat energy Q is transferred from the reservoir to the gas to maintain a constant temperature T_i .

In Fig. 6 b, the thermally insulated gas has the same initial state as in Fig. 6a, but with a membrane replacing the piston. When the membrane is broken, the gas expands rapidly into the vacuum until it acquires a pressure P_f and volume V_f . In this case, the gas does no work, i.e.



Lecture: محاضره 6 حراريه

By: *Omayma samy*

اللَّهُمَّ انْفَعْنِي
بِمَا عَلَّمْتَنِي
وَعَلَّمْنِي مَا
يَنْفَعُنِي وَزِدْنِي
عِلْمًا

16/3/2025

أغسطس
AUGUST
2011

16

Tuesday

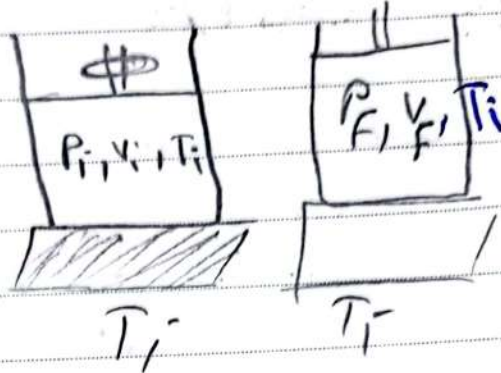
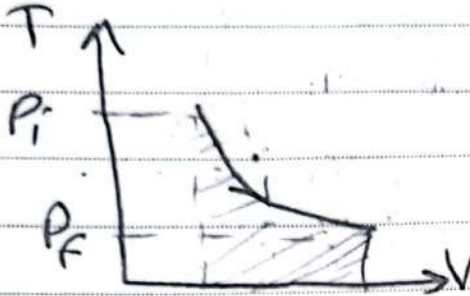
١٦

الثلاثاء

١٠ محرم ١٤٣٢

١٦ رمضان ١٤٣٢

* يوجد شغل مبذول



* النظام المغزول لا يوجد له طاقة ولا شغل عند حدوث انتقال
 $Q = 0$, $W = 0$

* The First Law of Thermodynamics.

$$W = \Delta K + \Delta U + \Delta E_{in}$$

$$\rightarrow \Delta K = 0, \Delta U = 0, W = -W$$

$$Q - W = \Delta E_{in} \Rightarrow dQ - dW = dE_{in}$$

$$Q = W + \Delta E_{in}$$

* الطاقة المحطاة للنظام ممكن تبقى شغل مبذول
 والتعريف فالطاقة الداخلة للنظام

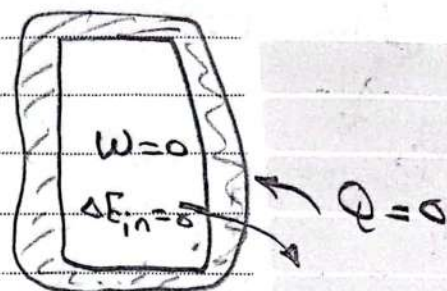
AUGUST

S	6	13
S	7	14
M	1	8 15
T	2	9 16
W	3	10 17
T	4	11 18
F	5	12 19

1) Isolated systems

نظام المعزول

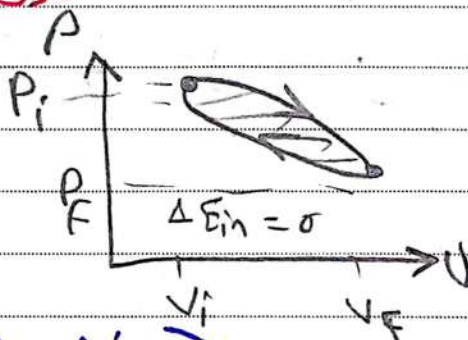
$$W=0, Q=0, \Delta E_{in}=0$$



2) cyclic processes:

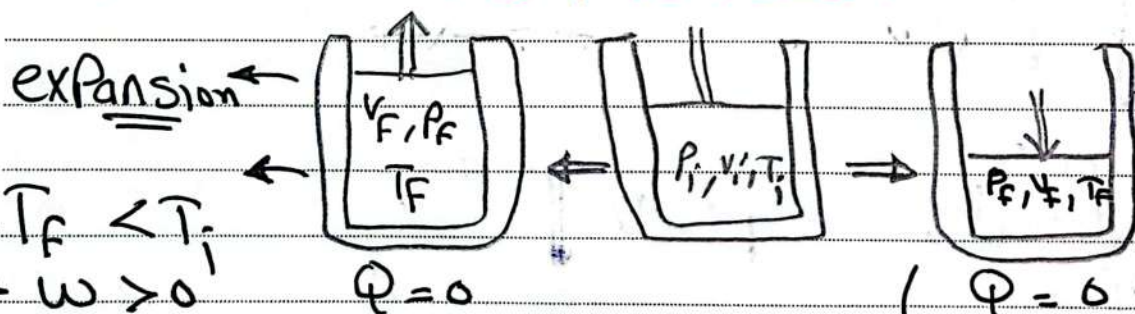
$$\Delta E_{in} = -W + Q = 0$$

$$|Q| = |W|$$



بغرض إن النظام مغلق فيه فقد الطاقة

* Adiabatic Process:



$$* T_F < T_i$$

$$* W > 0$$

$$Q=0$$

$$T_F > T_i$$

$$P V^\gamma = \text{constant}$$

دالة الحالة

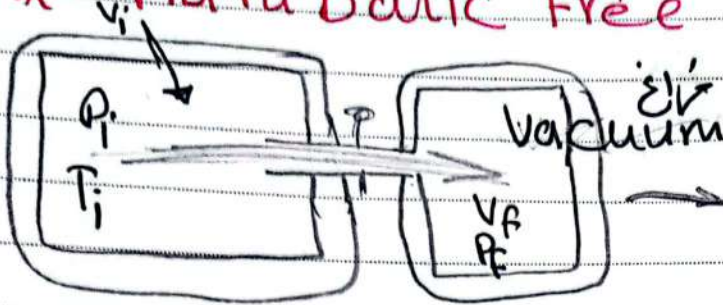
* نظام معزول أو التمدد سريع

$$* Q=0, Q = \Delta E_{in} + W, W = -\Delta E_{in}$$

AUGUST 2011

S	6	13	20	27	
S	7	14	21	28	
M	1	8	15	22	29
T	2	9	16	23	30
W	3	10	17	24	31
T	4	11	18	25	
F	5	12	19	26	

* Adiabatic Free Expansion Process :-



- $Q = 0$
- $W = 0$
- $\Delta E_{in} = 0$

لذا E_{in} يساوي التغير بتاع E_{in} بغير

* isobaric Process :-

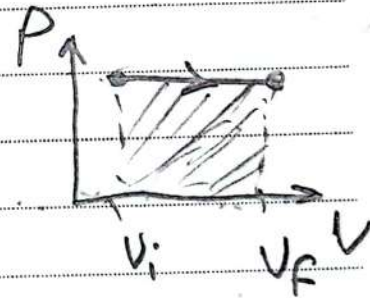
* الضغط فيه بيكون ثابت

$P = \text{constant}$

$$W = \int_{V_i}^{V_F} P dV$$

$$= P \int_{V_i}^{V_F} dV = P \cdot V \Big|_{V_i}^{V_F}$$

$W = P(V_F - V_i)$



AUGUST

S	6	13	20	
S	7	14	21	
M	1	8	15	22
T	2	9	16	23
W	3	10	17	24
T	4	11	18	25
F	5	12	19	26

* Isochoric process:

$V = \text{constant}$

$w = \int p dv = 0$

$\Delta E_{in} = Q - w = Q$

$E_{inf} = E_{in} + Q$

* Isothermal process:

$T = \text{constant}$, $\Delta E_{in} = 0$, $w = Q$

$PV = nRT = \text{constant}$

$w = \int_{v_i}^{v_f} p dv = \int_{v_i}^{v_f} \frac{nRT}{v} dv = nRT \int_{v_i}^{v_f} \frac{dv}{v}$

$w = nRT \ln \frac{v_f}{v_i}$

$w = nRT \ln \frac{v_f}{v_i}$

AUGUST		20
S	6	13
S	7	14
T	1	8
T	2	9
W	3	10
T	4	11
F	5	12

* $\ln > 1$ سالبة ، $\ln < 1$ موجبة

* $PV = NKT$. $n = \frac{N}{NA} \rightarrow$ عدد الجزيئات

$PV = \frac{n}{N} \left(\frac{NA}{K} \right) T$ عدد الجزيئات NA عدد أفجايدرو K

* ex 1 Page (35).

* $V_i = \frac{m}{\rho_i} = \frac{1}{926} = 1.087 \times 10^{-3} \text{ m}^3$

• $V_{\text{liquid}} = V_f = \frac{1}{100} = 10^{-3}$

• $\Delta V = V_f - V_i = 10^{-3} - 1.087 \times 10^{-3} =$

$W = P(V_f - V_i) = 1.013 \times 10^5 \times \Delta V$

• $W = -8.8 \text{ J}$

• $Q = mL_f = 1 \times 3.33 \times 10^5 \text{ J} = 3.33 \times 10^5$

• $\Delta E_{\text{in}} = Q - W = 3.33 \times 10^5 \text{ J} + 8.8 \text{ J}$
 $= 3.33 \times 10^5 \text{ J} \#$

AUGUST 2011					
S	6	13	20	27	
S	7	14	21	28	
M	1	8	15	22	29
T	2	9	16	23	30
W	3	10	17	24	31
T	4	11	18	25	
F	5	12	19	26	

ex 2: Page 36:

• 1 kgm water $V_i = 0.001 \text{ m}^3$

• 1 kgm ~~steam~~ ^{steam} $V_f = 1.671 \text{ m}^3$

• $\Delta V = 1.670 \text{ m}^3$

$W = P(V_f - V_i) = P \Delta V$

$W = -1.013 \times 10^5 \times 1.67 =$

• $W = -169 \times 10^3 \text{ J} = -169 \text{ kJ} \#$

• $Q = m L_v = 1(\text{kg}) \times 2.26 \times 10^6 \text{ (J/kg)}$

• $Q = 2260 \text{ kJ}$

• $\Delta E_{int} = Q - W = 2.26 \times 10^6 - 1.69 \times 10^5 \text{ J}$
 $= 2091 \text{ kJ} \#$

AUGUST		2011			
S	6	13	20	27	
S	7	14	21	28	
M	1	8	15	22	29
T	2	9	16	23	30
W	3	10	17	24	31
T	4	11	18	25	
F	5	12	19	26	



Lecture: محاضره 7 حراريه

By: *Omayma samy*

اللَّهُمَّ انْفَعْنِي
بِمَا عَلَّمْتَنِي
وَعَلَّمْنِي مَا
يَنْفَعُنِي وَزِدْنِي
عِلْمًا

23/3/2025

ex 3: Page 45: $m = 1 \text{ kg}$, $\rho = 2700 \text{ kg/m}^3$

$$V = \frac{m}{\rho} = \frac{1}{2700} = 3.704 \times 10^{-4} \text{ m}^3$$

$$\Delta V = \beta V \Delta T = (7.2 \times 10^{-3}) \times 3.704 \times 10^{-4} \times (55 - 25) = 8 \times 10^{-7} \text{ m}^3 \Rightarrow W = \rho \Delta V$$

$$W = 1.013 \times 10^5 \times 8 \times 10^{-7} = 8.08 \times 10^{-2} \text{ J}$$

$$Q = ms \Delta T = 1 \times 900 \times 30 = 2.7 \times 10^4 \text{ J}$$

$$\Delta E_{int} = Q - W = 2.7 \times 10^4 - 8.08 \times 10^{-2} = 2.689 \times 10^4 \text{ J} \quad \#$$

ex 4: $n = 1000 \text{ mole}$, $T = \text{constant}$, $T = 300 \text{ K}$
 $V_1 = 2 \text{ liter}$, $V_2 = 5 \text{ liter}$

$$W = nRT \ln\left(\frac{V_2}{V_1}\right) = 1000 \times 8.314 \times 300 \ln \frac{5}{2} = 2.29 \times 10^6 \text{ J}$$

AUGUST		2011			
S	6	13	20	27	
S	7	14	21	28	
M	1	8	15	22	29
T	2	9	16	23	30
W	3	10	17	24	31
T	4	11	18	25	
F	5	12	19	26	

STP → standard Temperature and pressure.

معدل الضغط ودرجة الحرارة
 $T = 273 \text{ K} \Rightarrow 0^\circ \text{C}$
 $p = 1 \text{ atm} = 1.013 \times 10^5 \text{ N/m}^2$

$n = 1 \Rightarrow V = 22.405 \text{ liter.}$

الكميات
 $PV = nRT$
 $V = \frac{nRT}{P} = \frac{1 \times 8.314 \times 273}{1.013 \times 10^5}$

$V = 0.022405 \text{ m}^3$

$1 \text{ m}^3 = 1000 \text{ liter}$

$V = 22.4 \text{ liter.}$

8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00