شركة تدريب هندسي

E.CAMP

الطريق الدائري بجوار المدرسة المعمارية

01064763583

PHYSICS 1

2021 - 2022 No.15

CH.7: Temperature

A Definitions (تعريفات هامة)

1 Temperature:

→ Is the degree of hotness or coldness of a body and is related to the kinetic energy of molecules of substance

* درجة الحرارة: هي درجة سخونة أو برودة الجسم وترتبط بطاقة حركة الجزيئات في العينة

2 Thermal equilibrum: الإتزان الحراري

→ A thermal equilibrum exists between two bodies when they are in thermal contact with each other and there is no net flow of heat between them.

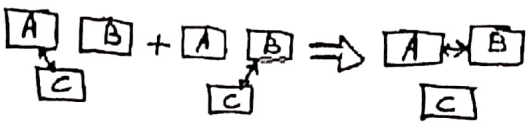
* يحدث الإتزان الحراري بين جسمين إذا كانوا متصلين مع بعض وكانت محصلة انتقال الطاقة الحرارية بينهما تساوي صفر

if $T_A = T_B \Rightarrow$ Heat = Zero

3 Zeroth Law of thermodynamic:

القانون الصفرى للديناميكا الحرارية

→ If two bodies A and B are in thermal equilibrium with a third body C, then A and B are in thermal equilibrium with each other.

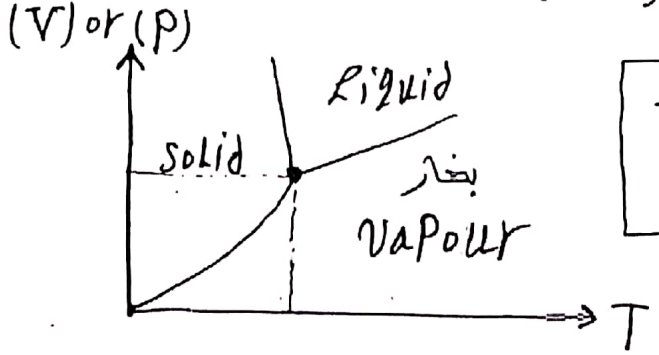


← إذا كان جسمان B ، A فى إتزان حرارى مع جسم ثالث C فإن B ، A فى إتزان حرارى مع بعضهم.

4 Triple Point: النقطة الثلاثية

→ Is the point where the three phases of the material (solid - liquid - gas) are exist in equilibrium.

← هى النقطة التى توجد عندها المادة فى حالاتها الثلاث (صلب - سائل - غاز) فى حالة إتزان.



$T_{water} = 273.16K$

B Temperature scales: مقاييس الحرارة

(1) Kelvin scale: (thermodynamic scale) كلفن هام

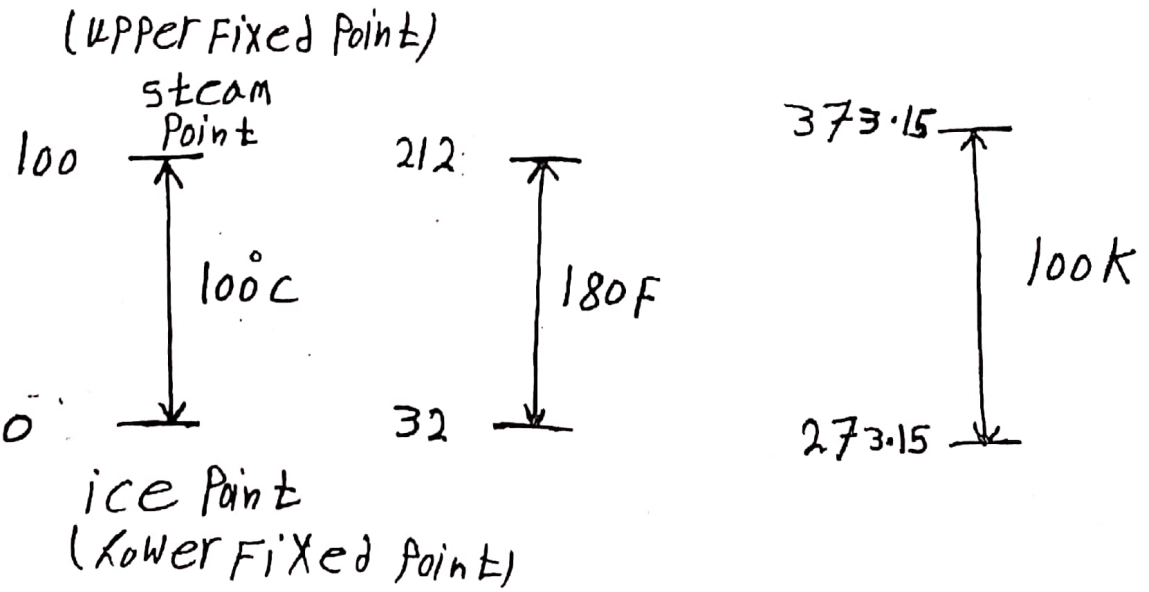
$$T_K = T_C^\circ + 273 \Rightarrow dT_K = dT_C^\circ$$

(2) Fahrenheit scale: (فهرنهيت) هام

$$T_F = \frac{9}{5} T_C^\circ + 32 \Rightarrow dT_F = \frac{9}{5} dT_C^\circ$$

(3) Rankine scale: (رانكن) فرانة

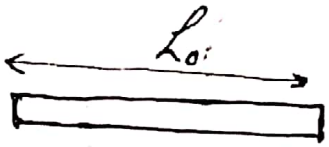
$$T_R = \frac{9}{5} T_K \Rightarrow dT_R = \frac{9}{5} dT_K$$



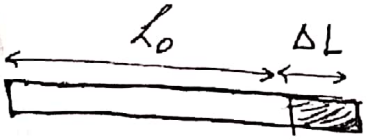
C Thermal expansion of solids:

التمدد الحراري للمواد الصلبة

(a) Linear expansion: التمدد الطولي



$T = T_o$



$T = T$

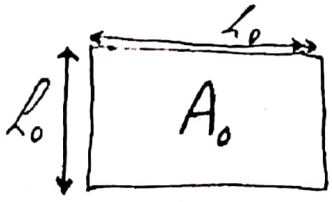
حفظ

$$\Delta L = \alpha L_o \Delta T = \alpha L_o (T - T_o)$$

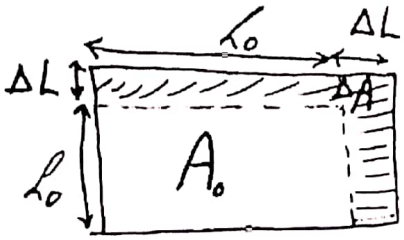
* Linear expansion coefficient (α):

معامل التمدد الطولي وهو معامل الزيادة في الطول مع زيادة درجة الحرارة ($^\circ C^{-1}$ أو K^{-1})

(b) surface expansion: التمدد السطحي



$T = T_o$



$T = T$

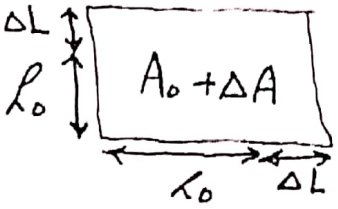
$$\boxed{\Delta A = \gamma A_0 \Delta T = \gamma A_0 (T - T_0)}$$ حفظا

* surface expansion coefficient (γ): لتعريف

معامل التمدد السطحي وهو معامل الزيادة في المساحة مع زيادة درجة الحرارة (K^{-1} or C^{-1})

* prove that $\gamma = 2\alpha$ مراعاه نظ

- Proof -



$$A_0 + \Delta A = (\ell_0 + \Delta \ell)^2$$

$$A_0 + \Delta A = \ell_0^2 + 2\ell_0 \Delta L + \Delta \ell^2$$ ← very small

$$A_0 + \Delta A = A_0 + 2\ell_0 (\alpha \ell_0 \Delta T)$$

$$\therefore \Delta A = 2\alpha \ell_0^2 \Delta T$$

$$\therefore \Delta A = (2\alpha) A_0 \Delta T$$

$$\therefore \Delta A = (\gamma) A_0 \Delta T \quad \therefore \boxed{\gamma = 2\alpha}$$

(c) Volume expansion: التمدد الحجمي

$$\boxed{\Delta V = \beta V_0 \Delta T = \beta V_0 (T - T_0)}$$ حفظا

* Volume expansion coefficient: (β) لتعريف

معامل التمدد الحجمي وهو معدل الزيادة في الحجم مع زيادة درجة الحرارة (K^{-1} or C^{-1})

قراده نقط

* Prove that $\beta = 3\alpha$

~ Proof ~

$$\Delta V + V_0 = (l_0 + \Delta l)^3$$

$$\therefore \Delta V + V_0 = l_0^3 + 3 l_0^2 \Delta l + 3 l_0 \Delta l^2 + \Delta l^3$$

(very small can be neglected)

$$\therefore \Delta V - V_0 = V_0 + 3 l_0^2 \Delta l$$

$$\therefore \Delta V = 3 l_0^2 \Delta l$$

$$\therefore \Delta l = \alpha l_0 \Delta T$$

$$\therefore \Delta V = 3 l_0^2 (\alpha l_0 \Delta T)$$

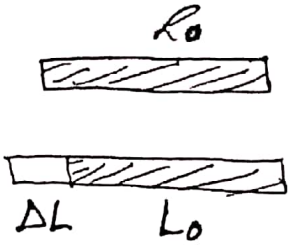
$$= 3 \alpha l_0^3 \Delta T$$

$$\therefore \Delta V = (3\alpha) V_0 \Delta T$$

$$\therefore \Delta V = (\beta) V_0 \Delta T$$

$$\therefore \boxed{\beta = 3\alpha}$$

D Thermal stress: الإجهاد الحراري



$\Rightarrow \Delta L \propto \Delta T$

$\Delta L \propto L_o$

$\therefore \Delta L = \alpha L_o \Delta T$

$$\therefore \boxed{\frac{\Delta L}{L_o} = \alpha \Delta T}$$ thermal strain إنفعال حراري

$$\Rightarrow Y = \frac{F/A}{\Delta L/L_o}$$

$$\therefore \frac{F}{A} = \text{thermal stress} = Y \frac{\Delta L}{L_o}$$

$$= \boxed{Y \alpha \Delta T}$$ الإجهاد الحراري

⇒ Tensile force to avoid change:

$$\boxed{F = -A Y \alpha \Delta T}$$

القوة اللازمة لتفادي تغير الشكل نتيجة الحرارة

Tempreture -- Problems

[1] An object has tempreture of 45°c, What is the tempreture in Fahrenheit ?

answer

$$\therefore T_F = \frac{9}{5} T_c + 32$$

$$\therefore T_F = \frac{9}{5}(45) + 32 = \boxed{113^\circ F}$$

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[2] The tempertute on a warm summer day is 95 degree F, What is

(a) In degree celius

(b) In kelvin

answer

(a) $$\therefore T_F = \frac{9}{5} T_c + 32$$

$$\therefore 95 = \frac{9}{5} T_c + 32$$

$$\therefore \boxed{T_c = 35^\circ C}$$

(b) $\because T_K = T_c + 273.15$

$\therefore T_K = 35 + 273.15 = \boxed{308.15K}$

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3 Find the tempreture at which the celsius scale equal the fahrenhiet scale.

~ answer ~

$$T = \frac{9}{5}T + 32$$

$$\therefore -\frac{4}{5}T = 32 \Rightarrow \boxed{T = -40}$$

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4 Modern eaves are constructed from a roll sheet of aluminium, what is the change in the length of 30m long Al trough.

$\alpha = 23 \times 10^{-6}\ C^{-1}$, $\Delta T = 100F$

~ answer ~

$$\Delta L = \alpha L_o \Delta T_c$$

$$\therefore \Delta T_F = \frac{9}{5}\Delta T_C$$

$$\therefore \Delta T_C = \frac{5}{9}\Delta T_F = \frac{500}{9}$$

$$\therefore \Delta L = (23\times10^{-6})\times(30)\times\left(\frac{500}{9}\right)$$

$$= \boxed{0.038\ m}$$

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5 An iron bar is kept at constant length while it is heated from 0°c to 10°c

$\alpha_{steel} = 12\times10^{-6}$, $A = 2\ cm^2$

$Y_{steel} = 2\times10^{11}\ N/m^2$

(a) Find the generated stress.

(b) Find the Force to prevent the extension.

"answer"

(a) $\frac{F}{A} = Y\alpha\Delta T = (2\times10^{11})\times(12\times10^{-6})\times10$

$= \boxed{24\times10^{6}\ N/m^2}$

(b) $F = A\,Y\alpha\Delta T = \boxed{48\times10^{2}\ N}$

شريط صلب

6 steel tape 5m long is calibrated at a temperature of 20C. what is its length on a hot summer day of 35C.

~ answer ~

$\alpha_{steel} = 1.2 \times 10^{-5}$

$$\Delta L = \alpha L_0 \Delta T$$

$$\Delta L = (1.2 * 10^{-5})(5)(35-20)$$

$$= 9 \times 10^{-4} m$$

$$L = L_0 + \Delta L = 5 + 9 * 10^{-4} = \boxed{5.0009 m}$$

ملئ تماما

7 glass flask of volume 200cm3 is just filled with mercury at 20C. How much mercury overflows when the temperature of the system is raised to 100C.

$\beta_{glass} = 1.2 * 10^{-5} C^{-1}$, $\beta_{Hg} = 0.000182$

~ answer ~

$$\Delta V_{over} = \Delta V_{Hg} - \Delta V_{glass}$$

$$= \beta_{Hg} V \Delta T - \beta_{glass} V \Delta T$$

$$= (\beta_{Hg} - \beta_{glass}) V \Delta T$$

$$= [0.000182 - 1.2 * 10^{-5}] * 200 * (100-20)$$

$$= \boxed{2.72 \ cm^3}$$

[8] A glass flask whose volume is $1000\ cm^3$ at $0\ \dot{c}$ is filled level full of mercury, when the flask and mercury are heated to $100\ \dot{c}$, $15.2\ cm^3$ of mercury overflow. if coefficient of volume expansion for mercury is 0.000182 per celsius degree

→ compute the coefficient of linear expansion of the glass (α)

~ answer ~

$$\Delta V_{over} = \Delta V_{Hg} - \Delta V_{glass}$$

$$= \beta_{Hg} V \Delta T - \beta_{glass} V \Delta T$$

$$= V \Delta T (\beta_{Hg} - \beta_{glass})$$

$$15.2 = 1000 (100\ \dot{c} - 0\ \dot{c}) [0.000182 - \beta_{glass}]$$

$$15.2 = 18.2 - 10^5 \beta_{glass}$$

$$\therefore \beta_{glass} = \frac{18.2 - 15.2}{10^5} = 3 * 10^{-5}\ \dot{c}^{-1}$$

$$\because \alpha = \frac{\beta}{3} \qquad (\beta = 3\alpha)$$

$$\therefore \boxed{\alpha_{glass} = 1 * 10^{-5}\ \dot{c}^{-1}}$$

"QUIZ 5"

1. If two objects are in thermal equilibrium with each other:

A. they cannot be moving B. they cannot be undergoing an elastic collision C. they cannot have different pressures (D.) they cannot be at different temperatures E. they cannot be falling in Earth's gravitational field

ans: D

2. When two gases separated by a diathermal wall are in thermal equilibrium with each other:

A. only their pressures must be the same B. only their volumes must be the same C. they must have the same number of particles D. they must have the same pressure and the same volume (E.) only their temperatures must be the same

ans: E

3. A balloon is filled with cold air and placed in a warm room. It is NOT in thermal equilibrium with the air of the room until:

A. it rises to the ceiling B. it sinks to the floor (C.) it stops expanding D. it starts to contract E. none of the above

ans: C

4. Suppose object C is in thermal equilibrium with object A and with object B. The zeroth law of thermodynamics states:

A. that C will always be in thermal equilibrium with both A and B B. that C must transfer energy to both A and B (C.) that A is in thermal equilibrium with B D. that A cannot be in thermal equilibrium with B E. nothing about the relationship between A and B

ans: C

5. The zeroth law of thermodynamics allows us to define:

Chapter 5: Temperature

A. work B. pressure (C.) temperature D. thermal equilibrium

E. internal energy

ans: C

6. The international standard thermometer is kept:

A. near Washington, D.C. B. near Paris, France C. near the north pole D. near Rome, Italy (E.) nowhere (there is none)

ans: E

7. In constructing a thermometer it is NECESSARY to use a substance that: A. expands with rising temperature B. expands linearly with rising temperature C. will not freeze D. will not boil (E.) undergoes some change when heated or cooled

ans: E

8. Constant-volume gas thermometers using different gases all indicate nearly the same temperature when in contact with the same object if:

A. the volumes are all extremely large B. the volumes are all the same
D. the pressures are all extremely large C. the pressures are the same
(E.) the particle concentrations are all extremely small

ans: E

9. Which one of the following statements is true?

A. Temperatures differing by 25° on the Fahrenheit scale must differ by 45° on the Celsius scale B. 40 K corresponds to -40° C (C.) Temperatures which differ by 10° on the Celsius scale must differ by 18° on the Fahrenheit

Chapter 5: Temperature

scale D. Water at 90° C is warmer than water at 202° F E. 0° F corresponds to -32° C

ans: C

10. Room temperature is about 20 degrees on the:

A. Kelvin scale (B.) Celsius scale C. Fahrenheit scale D. absolute scale E. C major scale

ans: B

11. A thermometer indicates 98.6° C. It may be:

A. outdoors on a cold day B. in a comfortable room (C.) in a cup of hot tea D. in a normal person's mouth E. in liquid air

ans: C-

12. The two metallic strips that constitute some thermostats must differ in:

A. length B. thickness C. mass D. rate at which they conduct heat (E.) coefficient of linear expansion

ans: E

13. It is more difficult to measure the coefficient of volume expansion of a liquid than that of a solid because:

A. no relation exists between linear and volume expansion coefficients B. a liquid tends to evaporate C. a liquid expands too much when heated D. a liquid expands too little when heated (E.) the containing vessel also expands

ans: E

Unusual behavior of Water →

Note:

(1) maximum density of water at 4°C.

(2) Holes expands like solids.

$\gamma = 2\alpha$

Chapter 5: Temperature $\boxed{\Delta A = 2\Delta L}$

14. When the temperature of a copper penny is increased by 100° C, its diameter increases by 0.17%. The area of one of its faces increases by:

A. 0.17% (B.) 0.34% C. 0.51% D. 0.13% E. 0.27%

ans: B

15. The coefficient of linear expansion of steel is 11×10^{-6} per C° . A steel ball has a volume of exactly 100 cm3 at 0° C. When heated to 100° C, its volume becomes: A. 100.33 cm^3 B. 100.0011 cm^3 C. 100.0033 cm^3 D. 100.000011 cm^3 E. none of these

ans: A

$$\Delta V = \beta V_0 \Delta T$$

$$= 3\alpha V_0 \Delta T$$

$$= 3 \times 11 \times 10^{-6} \times 100 * (100 - 0)$$

$$= 0.33\ cm^3$$

$$\therefore V = V_0 + \Delta V$$

$$= 100 + 0.33$$

$$= \boxed{100.33\ cm^3}$$