Physics 1 (15)

2019

Prep Engineering Level (1)

Inspiration & Development

IDC

Center

&

PCS

Photo Copy Store

CH·5: Temperature

A Definitions (تعريفات هامة)

1 Temperature:

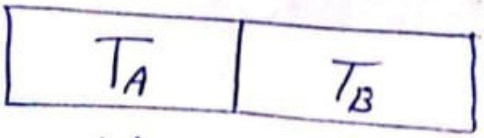
→ Is the degree of hotness or coldness of a body and is related to the kinetic energy of molecules of substance

* درجة الحرارة: هى درجة سخونة أو برودة الجسم وترتبط بطاقة حركة الجزيئات فى العينة

2 Thermal equilibrum: الإتزان الحرارى

→ 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 الحرارى بين جسمين إذا كانوا متصلين ع بعض وكانت محصلة إنتقال الطاقة الحرارية بينهما تساوى صفر

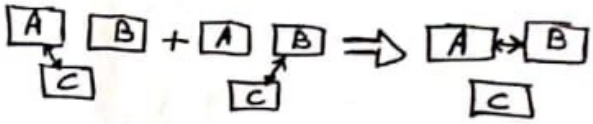


if $T_A = T_B \Rightarrow Heat = Zero$

3 Zeroth Law of thermodynamic :

القانون الصفرى للديناميكا الحرارية

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



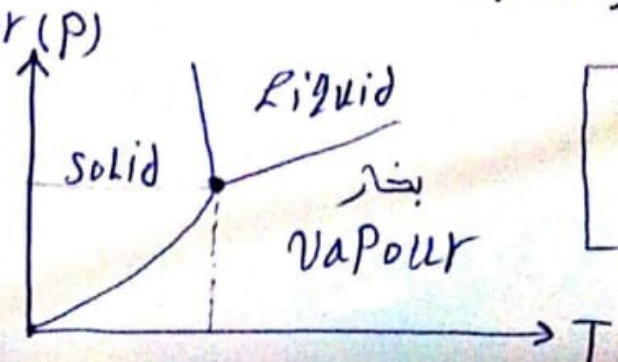
← اذا كان جسمان A ، B فى اتزان حرارى مع جسم ثالث C فان A ، B فى اتزان حرارى مع بعضهم.

---

4 Triple Point : النقطة الثلاثية

→ Is the Point where the three Phases of the material (solid - Liquid - gas) are exist in equilibrum.

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



$T|_{Water} = 273.16K$

B Temperature scales: مقاييس الحرارة

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

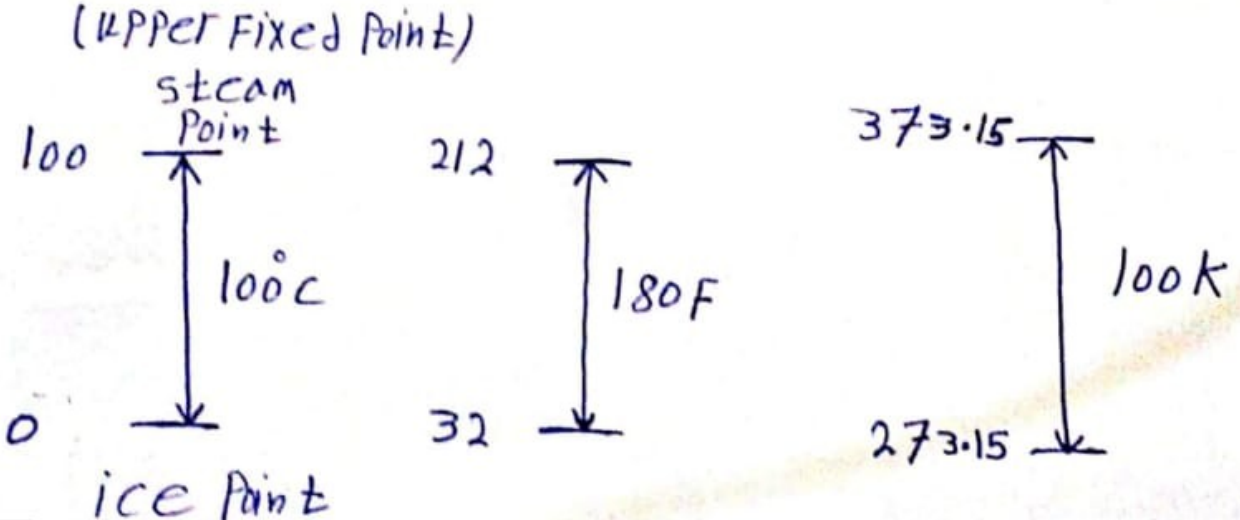
$$T_k = T_c^\circ + 273 \Rightarrow dT_k = dT_c^\circ$$

(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) فرانهة

$$T_R = \frac{9}{5} T_k \Rightarrow dT_R = \frac{9}{5} dT_k$$



C Thermal expansion of solids: التمدد الحراري للمواد الصلبة

(a) Linear expansion: التمدد الطولي

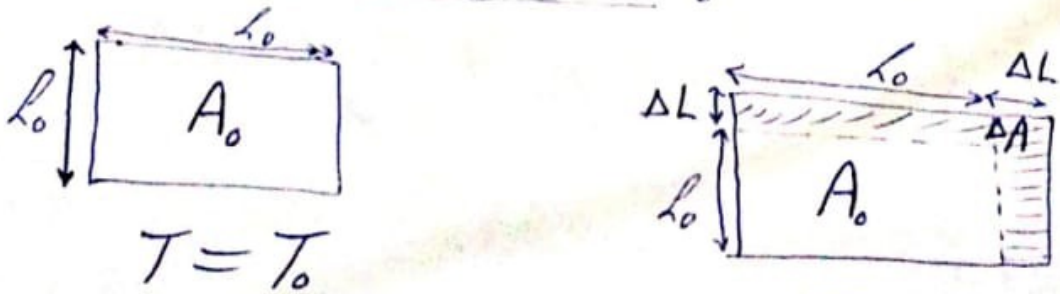
$T = T_o$ $\quad$ $T = T$

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 (C° أو K°)

(b) surface expansion: التمدد السطحي



$T = T_o$ $\quad$ $T = T$

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

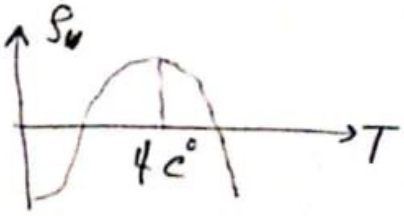
ans: E

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.

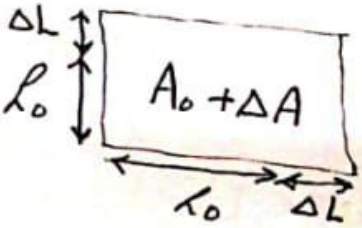
$$\boxed{\Delta A = \gamma A_0 \Delta T = \gamma A_0 (T - T_0)}$$ حفظ

لتعريف * surface expansion coefficient (γ):
معامل التمدد السطحي وهو معامل الزيادة في المساحة مع زيادة درجة الحرارة (K^{-1} or C^{-1})

إثبات 1,

* Prove that $\gamma = 2\alpha$

- 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

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

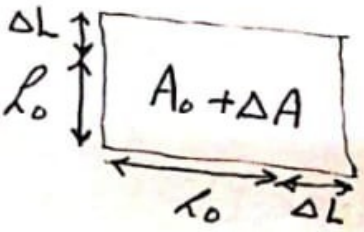
لتعريف * Volume expansion coefficient: (β)
معامل التمدد الحجمي وهو معدل الزيادة في الحجم مع زيادة درجة الحرارة
(K^{-1} or C^{-1})

$$\boxed{\Delta A = \gamma A_o \Delta T = \gamma A_o (T - T_o)}$$ حفظ

لتعريف
* surface expansion coefficient (γ):
معامل التمدد السطحي وهو معامل الزيادة في المساحة مع زيادة درجة الحرارة (K^{-1} or C^{-1})

إثبات 1,
* Prove that $\gamma = 2\alpha$

- Proof -



$$A_o + \Delta A = (\ell_o + \Delta \ell)^2$$
$$A_o + \Delta A = \ell_o^2 + 2\ell_o \Delta L + \Delta \ell^2$$ ← very small
$$A_o + \Delta A = A_o + 2\ell_o (\alpha \ell_o \Delta T)$$
$$\therefore \Delta A = 2\alpha \ell_o^2 \Delta T$$
$$\therefore \Delta A = (2\alpha) A_o \Delta T$$
$$\therefore \Delta A = (\gamma) A_o \Delta T \quad \therefore \boxed{\gamma = 2\alpha}$$

(C) Volume expansion: التمدد الحجمي

$$\boxed{\Delta V = \beta V_o \Delta T = \beta V_o (T - T_o)}$$ حفظ

لتعريف
* Volume expansion coefficient: (β)
معامل التمدد الحجمي وهو معدل الزيادة في الحجم مع زيادة درجة الحرارة (K^{-1} or C^{-1})

إثبات 2

* 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

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

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

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

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

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

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

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

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

"Tempreture -- Problems"

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

"answer"

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

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

---

[2] The temperture 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) $\because T_K = T_c + 273.15$

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

---

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

~ answer

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

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

---

[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 ~

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

شريط معدني

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

"answer"

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

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

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

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

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

وعاء ملئ تماماً

7 glass flask of volume 200cm3 is just filled with mercury at 20C. How much فيضان 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 $0\ ^\circ c$ is filled level full of mercury, when the flask and mercury are heated to $100\ ^\circ c$, $15.2\ cm^3$ 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 ~

$$\Delta V_{over} = \Delta V_{Hg} - \Delta V_{glass}$$
$$= \beta_{Hg} V \Delta T - \beta_{glass} V \Delta T$$
$$= V \Delta T (\beta_{Hg} - \beta_{glass})$$
$$15.2 = 1000\ (100\ ^\circ c - 0\ ^\circ c)\ [0.000182 - \beta_{glass}]$$
$$15.2 = 18.2 - 10^5\ \beta_{glass}$$
$$\therefore \beta_{glass} = \frac{18.2 - 15.2}{10^5} = 3 * 10^{-5}\ ^\circ c^{-1}$$
$$\because \alpha = \frac{\beta}{3} \qquad (\beta = 3\alpha)$$
$$\therefore \boxed{\alpha_{glass} = 1 * 10^{-5}\ ^\circ c^{-1}}$$

"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:

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

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

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

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

---

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