CHAPTER

1

Statistical Physics
P313

Lecture Notes:
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Fundamental Concepts

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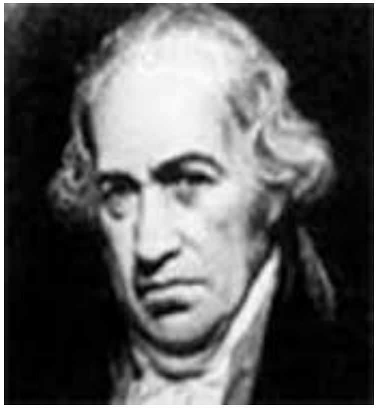
Temperature Scales

- **The 3 main *temperature scales***
  - **Fahrenheit**
  - **Celsius**
  - **Kelvin**

Fahrenheit Scale

- A common scale in everyday use in the US
- Named for Daniel Fahrenheit
- Temperature of the ice point is 32 ^{0}F
  Temperature of the steam point is 212 ^{0}F
- There are 180 divisions (degrees) between the two reference points

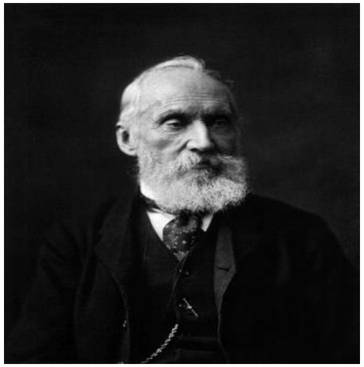


Celsius Scale

- **Named for Anders Celsius**
- **The ice point of water is defined to be 0º C**
- **The steam point of water is defined to be 100º C**
- **The length of the column between these two points is divided into 100 increments, called degrees**

Kelvin Scale

- **Named for William Thomson Lord Kelvin**
- **This temperature is known as ABSOLUTE ZERO**
- ***Absolute Zero = 0 ^{0}K***
- **Temperature of the ice point is 273 ^{0}K**
- **Temperature of the steam point is 373 ^{0}K**
- **There are 100 divisions (degrees) between the two reference points**



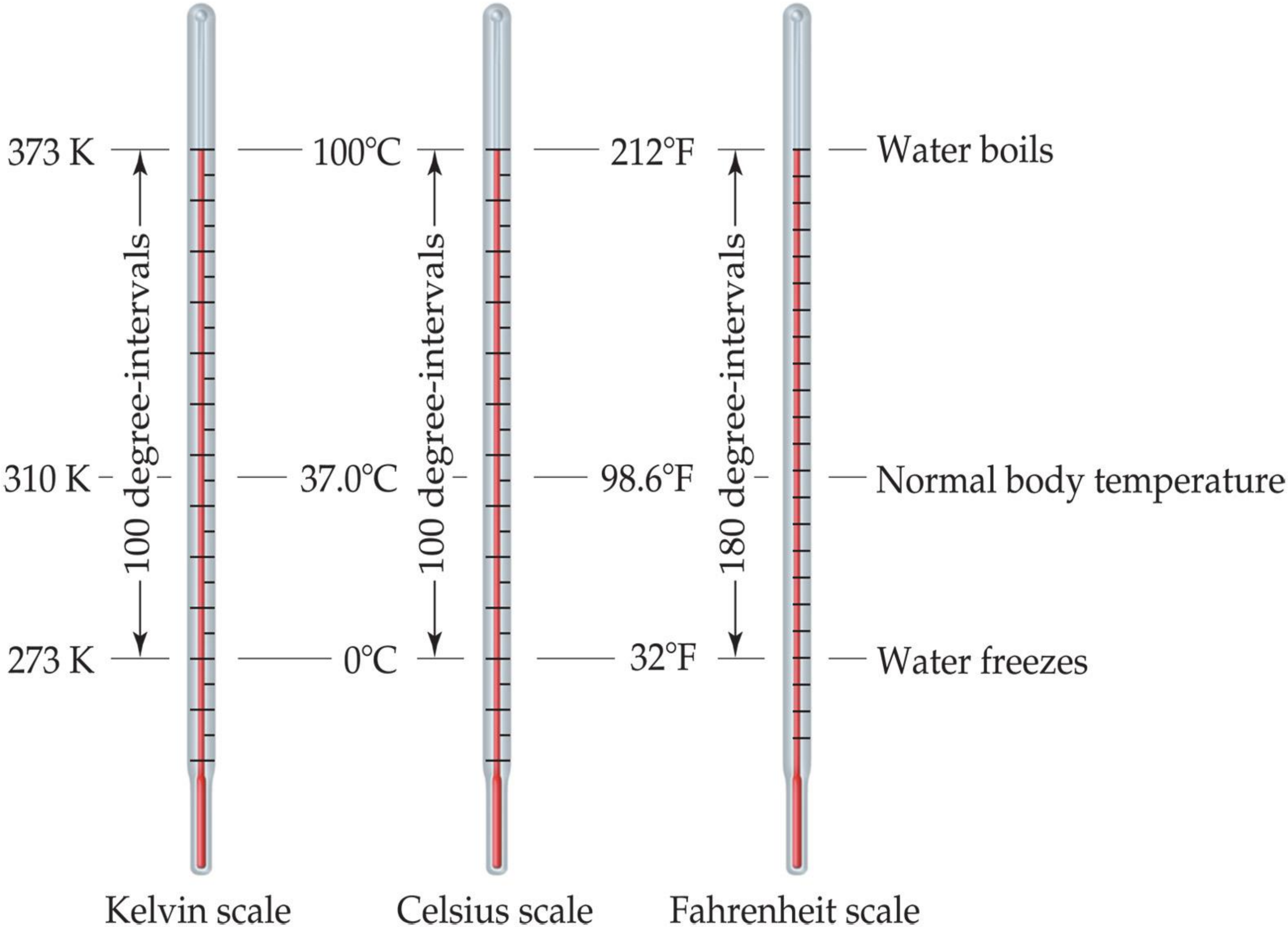
Comparison of Scales

- **Celsius and Kelvin have the same size degrees, but different starting points**

$$T_K = T_C + 273$$

- **Celsius and Fahrenheit have different sized degrees and different starting points**

$$T_C = \frac{5}{9}(T_F - 32^o)$$



373 K
100°C
212°F
Water boils
100 degree-intervals
100 degree-intervals
180 degree-intervals
310 K
37.0°C
98.6°F
Normal body temperature
273 K
0°C
32°F
Water freezes
Kelvin scale
Celsius scale
Fahrenheit scale

Black board example (1)

- **What is the only temperature that is the same for both the Celsius and Fahrenheit Scales?**

a) **50 ^{0}C = 50 ^{0}F**

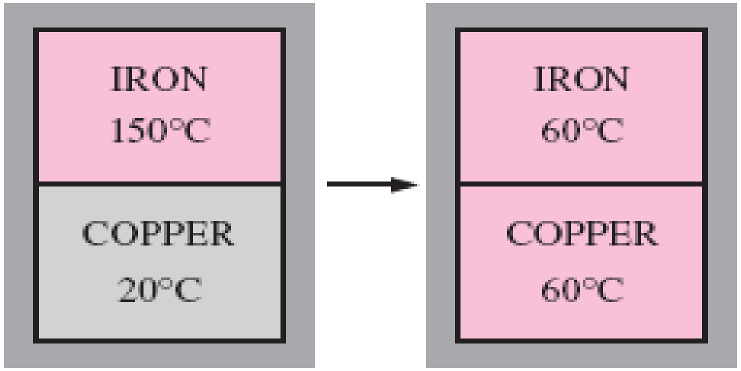
b) **78 ^{0}C = 78 ^{0}F**

c) **- 40 ^{0}C = - 40 ^{0}F**

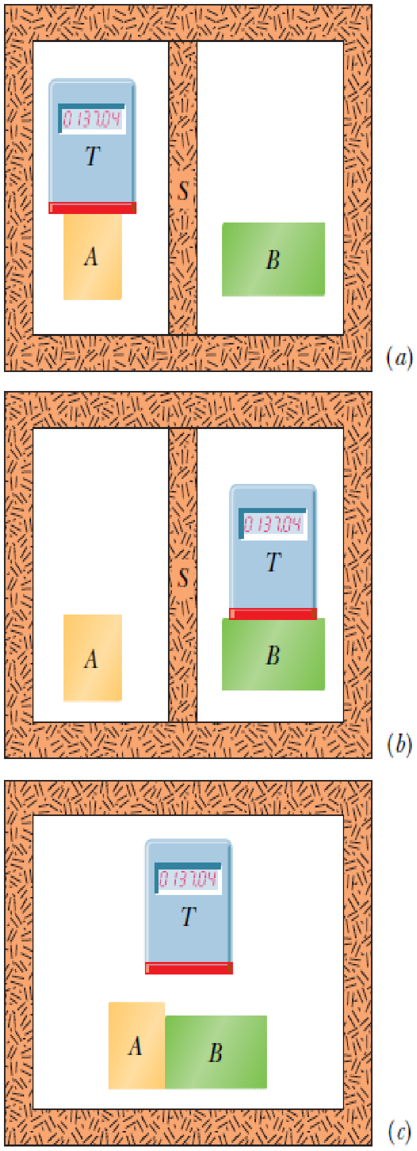
d) **200 ^{0}C = 200 ^{0}F**

Zeroth Law of Thermodynamics

" If two bodies are in thermal equilibrium with a third body, there are also in thermal equilibrium with each other."



Two bodies reaching thermal equilibrium after being brought into contact in an isolated enclosure.



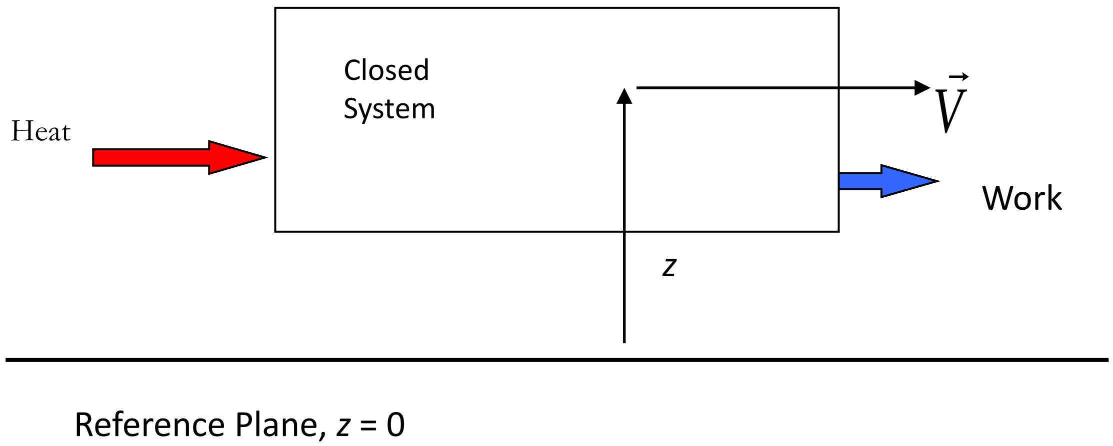
First Law of Thermodynamics

- **The First Law is usually referred to as the Law of Conservation of Energy, i.e.** ***energy can neither be created nor destroyed, but rather transformed from one state to another*****.**

- **The energy balance is maintained within the system being studied/defined boundary.**

- **The various energies associated are then being observed as they cross the boundaries of the system.**

Energy Balance for Closed System



$$\begin{pmatrix}\text{Total energy} \\ \text{entering the system}\end{pmatrix} - \begin{pmatrix}\text{Total energy} \\ \text{leaving the system}\end{pmatrix} = \begin{pmatrix}\text{The change in total} \\ \text{energy of the system}\end{pmatrix}$$

or

$$E_{in} - E_{out} = \Delta E_{system}$$

- **According to classical thermodynamics**

$$Q_{net} - W_{net} = \Delta E_{system}$$

- **The total energy of the system, E_{system}, is given as**

$$E = Internal\ energy\ +\ Kinetic\ energy\ +\ Potential\ energy$$

$$E =\ U\ +\ KE\ +\ PE$$

- **The change in stored energy for the system is**

$$\Delta E = \Delta U + \Delta KE + \Delta PE$$

- **If the system does not move with a velocity and has no change in elevation, the conservation of energy equation is reduced to**

$$Q_{net} - W_{net} = \Delta U$$

- **The first law of thermodynamics in the differential form**

$$\boxed{dQ = dU + dW} \quad \textbf{Or} \quad dQ = dU + P\,dV$$

Enthalpy (H)

- ***Enthalpy:*** **"is the energy stored in a mole of matter".**

- **The *enthalpy* function appears in the state of phase change (i.e. the transition from one state to another state)**

$$dQ = d(PV) - VdP + dU = d(U + PV) - VdP$$

$$\boxed{H = U + P\,V}$$

$$dH = dQ + VdP$$

- ***Latent heat (ℓ)*****: It is the amount of heat required to convert one gram of matter from one state to another when temperature and pressure are constant**

- **In this case the amount of heat is given by the relation**

$$\boxed{\Delta Q = m\ell}$$