只有一句话可以传给后代：（科学知识会然丢失）

P2

Feynman

原子假设（事实）：所有的物体都是由原子构成的——这些原子是小小的粒子，它们一直不停地运动着，当彼此略微离开时相互吸引，当彼此过于挤紧时又互相排斥。

atomic hypothesis (or the atomic fact, or whatever you wish to call it) that all things are made of atoms — little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon be squeezed into one another.

P22.

还有一门由物理学与化学为了同发展起来的极其重要的分支，这就是把统计学的方法应用于力学定律起作用的场合，这般将当把称为**统计力学**。

There is also a branch of physics and chemistry which was developed by both sciences together, and which is extremely important. This is the method of statistics applied in a situation in which there are mechanical laws, which is aptly called statistical mechanics.

热学不是半权宜律支配的有别于力学的关

它内容，我们学习不一样的数学分析方法。

教训：概率论的学科理论是希望的。

而且：原子的实际行为并不遵循经典力学

机制，而是量子力学

→ 已经进入微观世界

（回想一下：为何说刚体

刚体在平动意义上是质点

且非微观（宏观研究对象

$N_A = 10^{23}$

为什么不直接学量子力学，要如此计再来？

— It is a difficult subject, and the best way to learn it is to do it slowly!

the people: try to write down eqns,
then solve it

→ failures in this field

the real successes come to those who start from a physical point of view, people who have a rough idea where they are going and then begin by making the right kind of approximations, knowing what is big and what is small in a given complicated situation.

in high school:

the same p, V, T

the same # of molecules

— Avogadro (1776-1856)

Italian physicist, chemist

the law of multiple proportions :

倍比

simple integral proportions in a chemical reaction

Q : Why do they have equal numbers of atoms? Can we deduce from Newton's laws ?

生活场景：压缩 → 变热

加热 → 膨胀

两件事互相联系，from the machinery underneath.

—— thermodynamics

Nova acta eruditorum (1751) 125-135, 162-176

一个质点系的动能：

质心参考系下 (second part)

$$E_k = \sum_i \frac{1}{2} m_i v_i^2 = \sum_i \frac{1}{2} m_i (\vec{v}_c + \vec{v}_i')^2$$

$$= \frac{1}{2} m v_c^2 + \sum_i m_i \vec{v}_c \cdot \vec{v}_i' + \sum_i \frac{1}{2} m_i v_i'^2$$

$$\sum_i m_i \vec{v}_i' = 0$$

E_{kc}

$$= \frac{1}{2} m v_c^2 + \sum_i \frac{1}{2} m_i v_i'^2 \qquad E_{k,in}$$

$\frac{1}{2} m v_c^2$ → 轨道动能 / 质心动能 (宏观整体移动)

$\sum_i \frac{1}{2} m_i v_i'^2$ → 内动能 (所有分子无规则运动的动能之和)

— König theorem

Johann Samuel König

First part: $\vec{L} = \sum_i \vec{r}_i' \times m_i \vec{v}_i' + M \vec{r}_c \times \vec{v}_c$

$(\vec{r}_i = \vec{r}_c + \vec{r}_i' \,,\ \vec{v}_i = \vec{v}_c + \vec{v}_i')$

Pauli : time does not appear as variable in the framework, except for its direction

Limited to equilibrium theory (statics)

Thermodynamic variables :

definition ~ are measurable macroscopic quantities which characterize a system.

在没有形成温度的定义前，

$\Delta Q \propto m$，这一与物质子温度的相关

（符合直觉）

热量和温度是同一个概念吗？

1° 小孩手里的小烟花棒，2000°C 火花温度

but 火花滋到手上不烫吗？

2° 同样温度的木块和铁，摸起来铁冷。

3° 桑拿房 VS 温泉池

80°C 40°C

4° 风扇吹过，凉快，降温了吗？

温度计：热力学第零定律

↓

标度，线的刻度

（冰，水，沸腾和烟）

（瑞典 天文学家 Anders Celcius）

1742，
（1701-1744）

x °C

y °F （华氏）荷兰人

（1686-1736）

Daniel Fahrenheit

1714，华氏定标.

$$y = 32 + 1.8x$$

$$x = (y - 32) / 1.8$$

salt water mixture's ice temperature 0°F

Human body's temperature 100°F

① R. Boyle. 1662

(1627-1691)

$pV = C$ (T不变)

冰水混合物 ↑ 或 reservior

② L·J. Gay-Lussac 1802

(1778-1850)

被3③ credit 给 charles

(1808? 1809?)

$\frac{p}{T} = C$ (V不变)

③ J.A.C. Charles 1787

(1746-1823)

(未发表)

$\frac{V}{T} = C$ (p不变)

②,③ 容易弄混

timeline

① ③ ② ↓

ideal gas

$n = \frac{M}{M_{mol}}$

$pV = NK_BT = nRT$

$\frac{pV}{T} \sim const$

(1776 - 1856)

Avogadro's law (1812)

Equal volumes of all gas, at the same temperature and pressure, have the same number of molecules

⟶ related experiment

O_2 + H_2 = H_2O

(1L) (2L) (2L)

m(O2) + m(H_2) = m(H_2O)

Kinetic theory of gases

1738 Daniel Bernoulli:

Gases consist of great number of molecules moving in all directions, that their impact on a surface causes the gas pressure that we feel, and what we experience as heat is simply the kinetic energy of their motion.

$$p + \frac{1}{2}\rho v^2 + \rho g h = \text{const}$$

1738

— Bernoulli's equation

(流体运动)

Kelvin　　1824 - 1907　原为 William Thomson

21岁出于剑桥，22岁格拉斯格大学的哲学教授

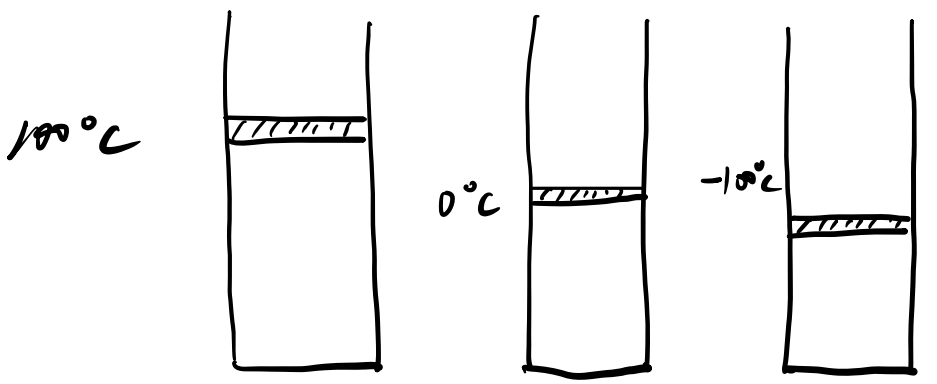
热力学温标　/　理想气体

(K)　　理想气体温标

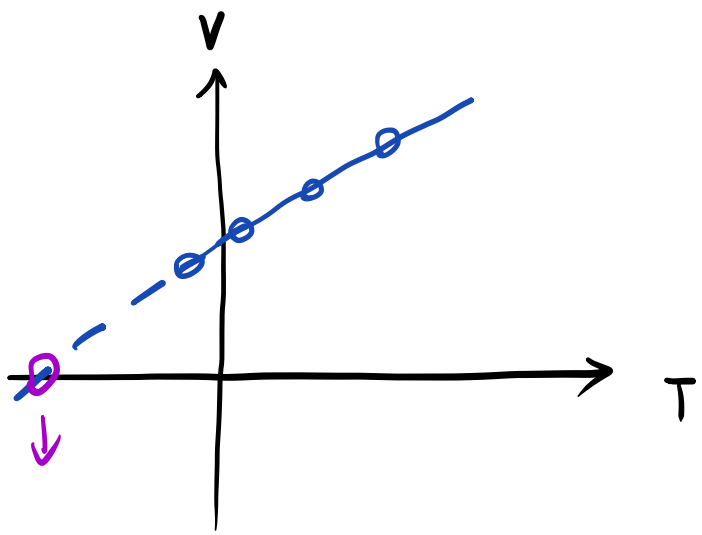
↓

在其有效范围内，和热力学温标完全一致

$V = 1 + \frac{100}{273}$　　$V = 1$　　$V = 1 - \frac{100}{273}$



$V = C\frac{T}{P}$



-273.16°C

所有稀薄气体共同指向 -273.16°C ↓ 绝对零度

理想气体温标 → 绝对温标

热质说（热质流动）

↓ 引出热量

定义 Specific heat $\Delta Q = C m \Delta T$

麦克斯韦：考虑碰与统计力学

麦克斯韦在1857、1858年发表的气体分子运动论中首次将概率概念引入物理学，用微观力学的统计平均来解释气体压强等性质。

麦克斯韦、玻尔兹曼、吉布斯进入引进深化

→ 1902，吉布斯《统计力学的基本原理》

→ 1911，普朗克提出量子统计原理

1° 知识容易丢失，留下一句你觉得最重要的话

热力学的系统框架为什么会走过这么漫长的道路？ —— 聊斋志异

2° 温度就是冷热吗？

热是什么？ 怎么量热？

温度是什么？ 怎么量温度？

3° 相比于力学，什么变量是你在热学里没有发现的， — time, but there is direction

references:

Feynman, pauli, shankar,

kittel, 王竹溪, 张三慧.