Reading Quiz #7

1. A 10g can of aluminum (atomic # 13, atomic mass = 27) contains how many atoms?

[✓ a) $\frac{10}{27} N_A$]

b) $\frac{10}{13} N_A$

c) $10 N_A$

d) $\frac{0.01}{27} N_A$

N_A = Avagadro's number

2. The unit of Pressure, 1 Pascal (Pa) equals:

a) $1 \ N m^2$

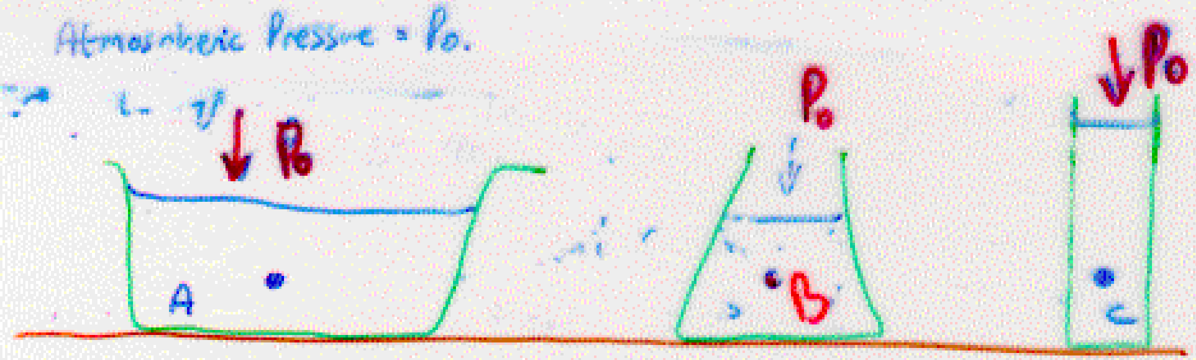
b) $1 \ N/m$

[✓ c) $1 \ N/m^2$]

d) $1 \ Nm$ (= 1 J)

Atmospheric Pressure = Po.

3.



Points A, B, C are at the same height from the table surface

Containers A, B are filled to the same height

B, C contain the same volume.

Compared to point A, the pressure at B and C is

a) same, same   Same, same

b) higher, lower   higher, lower

c) same, higher   [✓ Same, higher]

d) lower, higher   lower, higher

4. A force of 8N stretches a spring by 2cm. Its spring constant is then:

a) $K = 0{\cdot}16$ Nm

b) K 400 N/m^2

[✓ c) $K = 400$ N/m] ✓

d) $K = 2 \times 10^4$ N/m^2

$F = ks$

$k = F/s$ [N/m]

$k \; \frac{8N}{0{\cdot}02m}$

23/1

Solids, Liquids, and Gases (9.1–9.6;

Atoms: "single most important concept in science"
(R. Feynman)

Microscopic atoms/molecules → macroscopic behavior

Dalton (~1800): found <u>relative</u> atomic masses
(→ Periodic Table)

How many atoms?

$$\boxed{\text{Avagadro's Number } N_A = 6.02\times10^{23} \text{ /mole}}$$

$$\left.\begin{array}{llll} 1\text{g} & \text{of } H & \text{contains} \sim & N_A \text{ atoms} \\ 12\text{g} & {}^{12}C & & \text{"} \quad \text{"} \\ 2\times16 = 32\text{g} & O_2 & & \text{"} \quad \text{"} \end{array}\right\} \triangleq 1 \text{ "mole"}$$

e.g. 1 mole of ^{12}C + 2 moles of H_2 → 1 mole CH_4 (16g).
(= 4 moles of H)

½ liter water bottle contains 500 g of H_2O (molecular mass $m = 18$)

$$\therefore \#\text{ of moles } n = \frac{500\text{g}}{18\text{g}} = 27.78 \text{ moles}$$

$$\Rightarrow \#\text{ of molecules } N = n N_A = 27.78 \times 6.02\times10^{23}$$

$$= 1.67 \times 10^{25}$$

23/2

Atomic Sizes

First find $\boxed{\text{density } \rho = \frac{\text{mass}}{\text{volume}}}$ of sample (kg/m³)

e.g. water has $\rho = 1000$ kg/m³, air at room temp., pressure has $\rho \approx 1$ kg/m³.

Note: As molecular mass ↑ for solids, liquids : ρ ↑ also

so most have volume / mole $V = \frac{\text{mol. weight}}{\text{density}} \sim 10 - 20\text{ cm}^3$

e.g. 1 mole water has $M = 18$g ; density $\rho = 1000$ kg/m³

Vol (of 1 mole) has $V = \frac{18 \times 10^{-3}\text{kg}}{1000\text{ kg/m}^3} = 18 \times 10^{-6}\text{m}^3$

or 18 cm³

first

1 mole Al has $M = 26$g, density $\rho = 2.7 \times 10^3$ kg/m³

$\Rightarrow$ 1 mole has $V = \frac{26 \times 10^{-3}\text{kg}}{2.7 \times 10^3} = 9.6\text{ cm}^3$

Take a 1 mole cube of side L, volume $\underline{V}$

$\Rightarrow$ contains N_A molecules

$\Rightarrow$ Size of atoms $L = \left(\frac{V}{N_A}\right)^{1/3} = \left(\frac{\text{molar mass (kg)}}{\rho\, N_A}\right)^{1/3}$

[Only works for solids, liquids · gases will "fill" any volume]

e.g. for water $L = \frac{\overset{0.018\text{ kg/mol}}{\cancel{0.018}\text{ kg/mol}}}{N_A \times 1000\text{ kg/m}^3} = \underline{\underline{0.3\text{nm}}} = 3 \times 10^{-10}$m.

27/[illegible]/3

States of Matter

"State" depends on K.E. of molecules and forces between them

Solid: Maintains shape and volume

- amorphous or (poly-) crystalline
  irregular regular structure (see CD)

Liquid: Maintains volume, shape conforms to container

i.e. cannot sustain a 'shear' (sliding) force

Viscosity determines ability to flow (glass, honey, water)

most solids, liquids relatively incompressible

Gas: Conforms to shape and volume of container.

Volume depends on pressure and temperature

- determined by intra-molecular separation

e.g. Air at sea level has $\sim 3 \times 10^{25}$ molecules / m^3

→ separation ~ 10 × molecular size,

$v \approx 0.5$ km/s (c.f. escape speed $V_{esc} = \sqrt{\frac{2GM}{R}}$

~ 11.2 km/s)

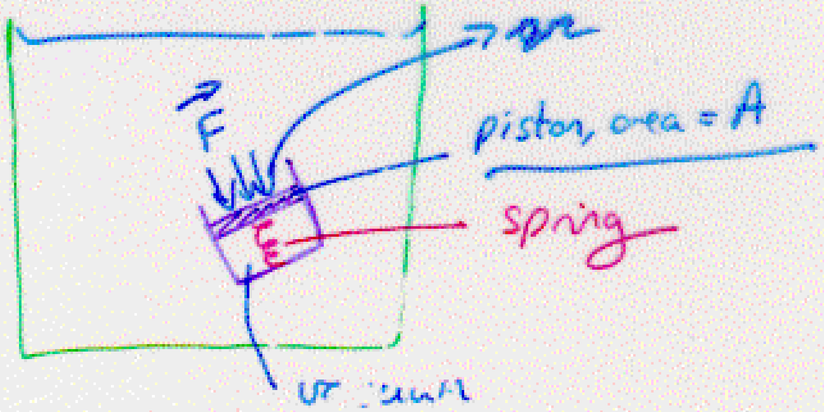
23/4

Fluids and Forces - Fluid Statics

Fluids exert a force on any surface inside them

Direction : $\perp$ to the area (no shear forces possible)

Size : $\propto$ area

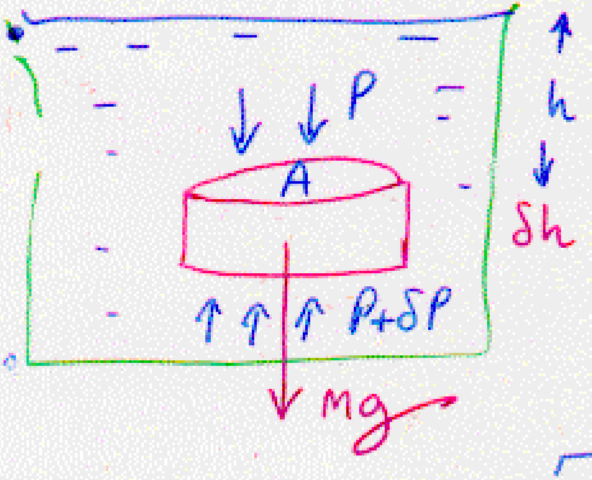


Define Pressure $P = \dfrac{\text{Force}}{\text{Area}}$ [N/m² or Pascal (Pa)]

Hydrostatic Pressure: At eqm., fluid supports its own weight

Hydrostatic

cylindrical element height δh, area A



Pressure difference supports weight (mg)

Weight of fluid element $mg = \rho V g = \rho \overbrace{A \delta h}^{V} g = \overset{\uparrow}{(P+\delta P)A} - \overset{\downarrow}{P.A}$

$\Rightarrow \rho g \delta h = \delta P$

$$\Rightarrow \boxed{\frac{dP}{dh} = \rho g \quad \text{Hydrostatic Equilibrium "pressure gradient"}}$$