CHAPTER 8

عزم الدوران Torque 8

$+\circlearrowleft$ Torque $\overset{\text{عزم}}{\tau} = rF\sin\theta$ τ

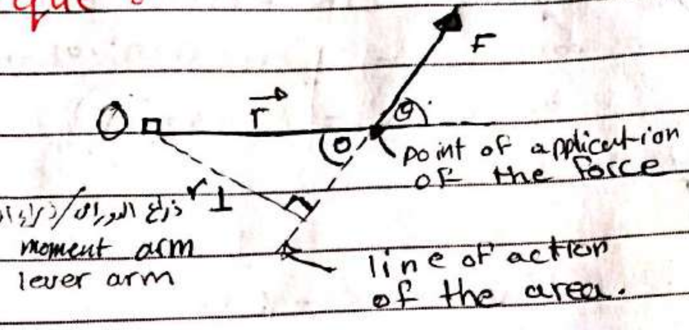
$= (r\sin\theta)\,F$ $(N\cdot m)$

$= r_{\perp} F$

$$\boxed{\tau = rF\sin\theta}$$

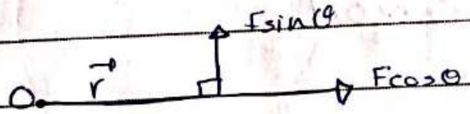
$\tau \propto r$

$\propto F$

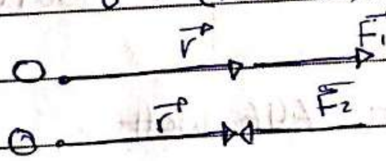


* max τ when $\theta = 90°$

* If force $\vec{F}$ is parallel $(\theta = 0)$ or anti parallel $(180°)$ to $\vec{r} \Rightarrow \tau = 0$



$\tau = (F\sin\theta)\,r$

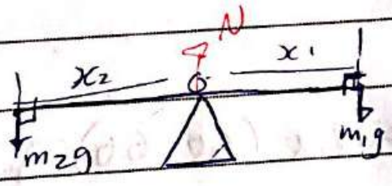


$\theta = 0, \ \tau = 0$

$\theta = 180°, \ \tau = 0$

Ex 8

لعبة السيسو



$+\circlearrowleft$ $\tau = -(m_1 g)\,x_1 + m_2 g\,x_2$

$\tau = m_2 g x_2 - m_1 g x_1$

* If static equilibrium $\Rightarrow \tau = 0$

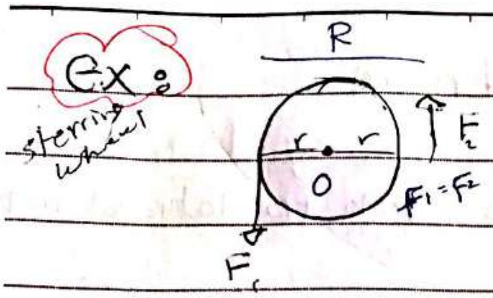
$m_2 \cancel{g} x_2 = m_1 \cancel{g} x_1$

$m_2 x_2 = m_1 x_1$

$\dfrac{m_2}{m_1} = \dfrac{x_1}{x_2}$

If $m_1 = m_2 \Rightarrow x_1 = x_2$

Ex:

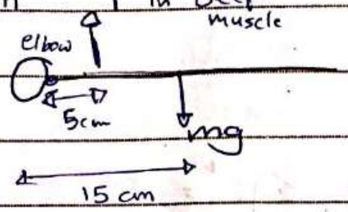


$+\circlearrowleft$ $\tau = rF + rF \Rightarrow 2rF$ couple

$\tau = RF$

Ex: forearm

Assume static equilibrium



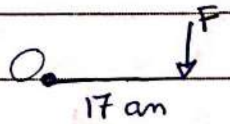
$\circlearrowleft O)\ \tau = 0$

$\tau = T(0.05) - mg(0.15) = 0$

$T - 3mg = 0$

$T = 3mg$

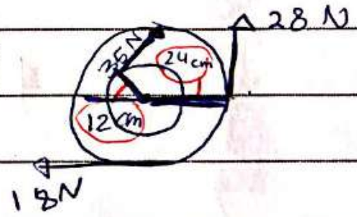
six $\boxed{11}$ $m = 52$ Kg



$+\circlearrowleft O)\ \tau = -(0.17) F \sin 90°$ or for τ_{max}

$= -(0.17)(52g)$

$\boxed{25}$



$+\circlearrowleft O)$

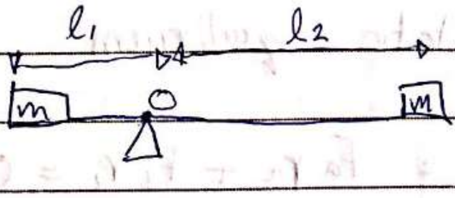
$\tau = 28(0.24) - 35(0.12)$

$= -18(0.24) = -1.8$ N.m

$\tau_{friction} = 0.6$ N.m

$\tau_{net} = 0.6 - 1.8 = -1.2$ N.m

$\boxed{27}$



$\tau_{net} = mg\,l_1 - mg\,l_2$

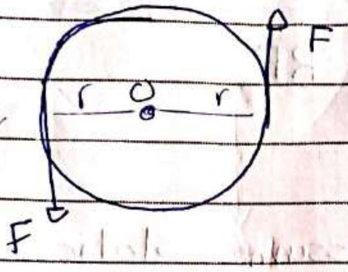
clockwise since l_2 greater than l_1

$l_2 > l_1$

and masses are equal

CHAPTER 9

Conditions for static Equilbrium



Not static equilibrium

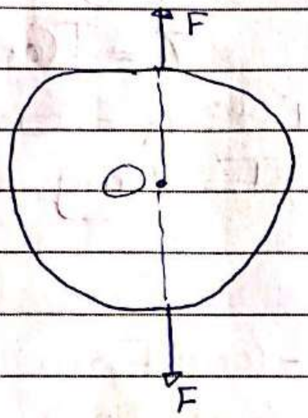
حركة انتقالية

$\Sigma \vec{F} = 0 \Rightarrow$ No translational motion

but

حركة دورانية (دوران الجسم)

$+\circlearrowleft O)\quad \tau = 2rF \Rightarrow$ rotational motion



conditions: No Translation, No rotational

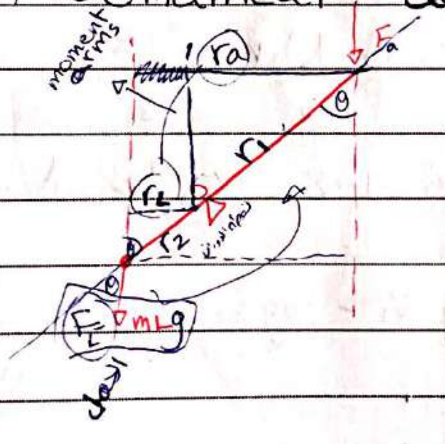
① $\Sigma \vec{F} = 0$

② $\Sigma \tau = 0$

$\Rightarrow$ static equilbrium

الفائدة الميكانيكية

Mechanical advantage



$r_a = r_1 \sin\theta$

$r_L = r_2 \sin\theta$

At static equilbrium

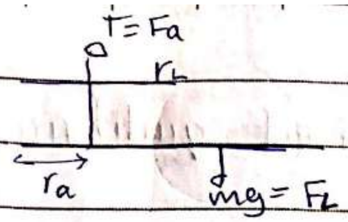
$+\circlearrowleft O)\quad \tau = -F_a r_a + F_L r_L = 0$

$F_a r_a = F_L r_L$

Mechanical adv. $\therefore \dfrac{F_L}{F_a} = \dfrac{r_a}{r_L}$ good

$$\boxed{M.A = \frac{F_L}{F_a} = \frac{r_a}{r_L} > 1}$$

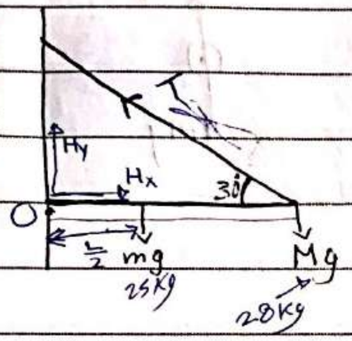
$r_a > r_L$



$$\frac{F_L}{F_a} = \frac{mg}{\text{Tension}} = \frac{r_a}{r_L} << 1$$

كبيرة احتاج قوة
وزن لارفع
صغير (bad lift)

Ex:



Hing force : H

static equilibrium

$\Sigma \vec{F} = 0$

$\Sigma \vec{\tau} = 0$

$\uparrow^{+}$ $T\sin 30 + Hg - mg - Mg = 0$

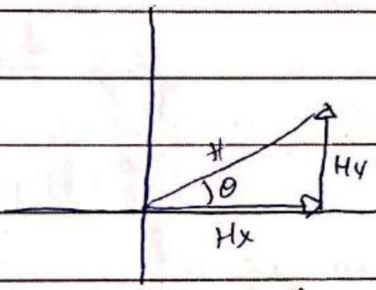
$+\circlearrowleft_{O}$ $(T\sin\theta)L - mg(\frac{L}{2}) - MgL = 0$

$T \sim 794$ N.

$\xrightarrow{+}$ $H_x - T\cos 30 = 0$

$H_X = T\cos 30 = 688$ N

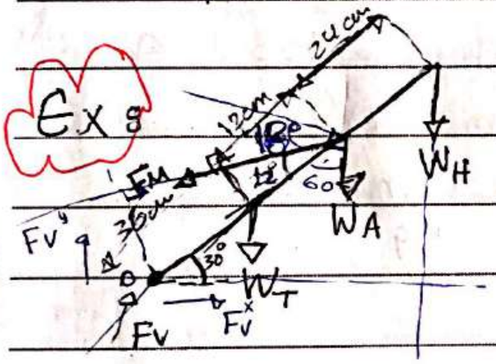
$H_Y = 122$ N (upward)



$\tan\theta = \frac{H_y}{H_x}$

$\theta = 10.1°$

Ex 8



static equilibrium $+\circlearrowleft_{O}$ $= (F_M \sin 12°)(0.48) - W_H$

$W_H = 0.07W$

① $(0.72)\cos 30 - W_A(0.48\cos 30)$

$W_A = 0.12W$

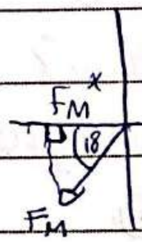
$- W_T(0.36\cos 30) = 0$

$W_T = 0.46W$ $\Rightarrow$ ② $\xrightarrow{+}$ $F_V^x - F_M\cos 18° = 0$

③ $+\uparrow$ $F_V^y - F_M\sin 18 - W_T - W_A - W_H =$

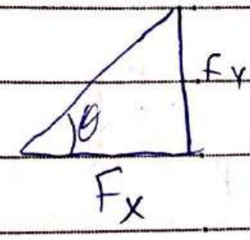
$F_M = 2.4W$

$F_V = 2.6W$

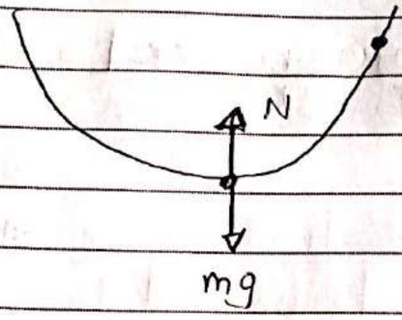


$F_V^x = 2.3W$

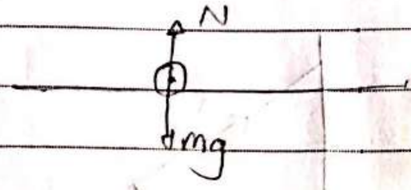
$F_V^y = 1.4W$



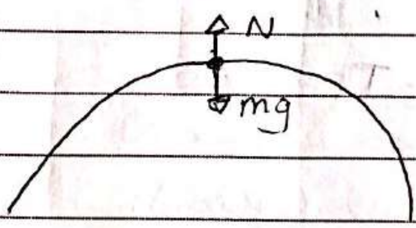
Stable equilibrium



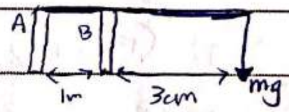
Neutral equilibrium



Unstable equilibrium



4|

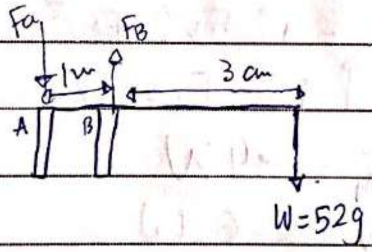


$\tau_{mg} = 1800 \text{ N.m}$ about A

$\tau_{mg} = mg(4) = 1800$

$\therefore m = \dfrac{1800}{4g} \text{ Kg} =$

5|



Static equilibrium

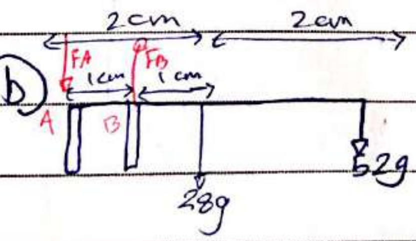
a) $+\circlearrowleft_A$ $F_B(1) - 52g(4) = 0$

$F_B = 4 \times 52g$

$\sum \vec{F} = 0$ $\uparrow^+$ $F_B - F_A - 52g = 0$

$F_B = F_A + 52g$

b)

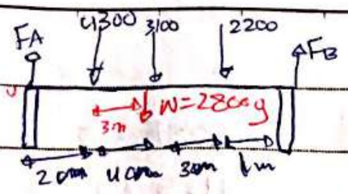


$+\circlearrowleft_A$ $F_B(1) - 28g(2) - 52g(4) = 0$

$F_B = 52 \times 4g + 2 \times 28 \times g$

$\uparrow^+$ $F_B - F_A - 28g - 52g = 0$

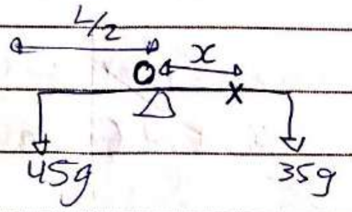
16|



$\Sigma \vec{\tau} = 0 \quad \Sigma \vec{F} = 0$

$+\circlearrowleft_{O}$

17|



static equilibrium

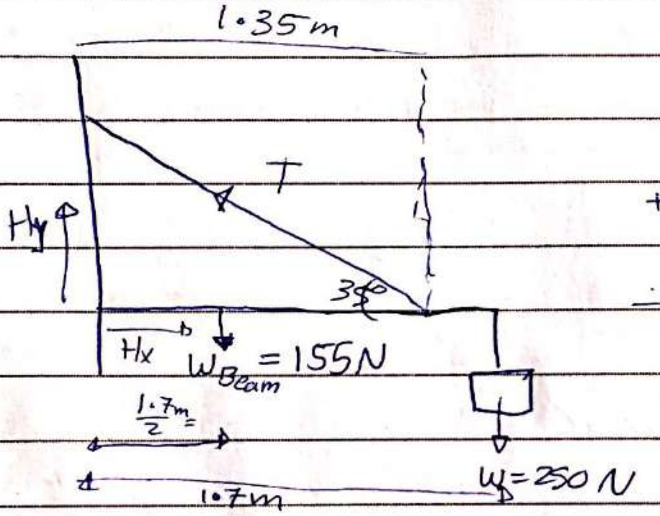
$+\circlearrowleft_{O} \quad 45 \cancel{g}\left(\frac{L}{2}\right) - 25\cancel{g}x - 35\cancel{g}\frac{(L)}{2} = 0$

$\frac{45-35}{2} = 5$

$5L - 25x = 0$

$x = \frac{5L}{25} = \frac{L}{5}$

18|



$\Sigma \vec{F} = 0$

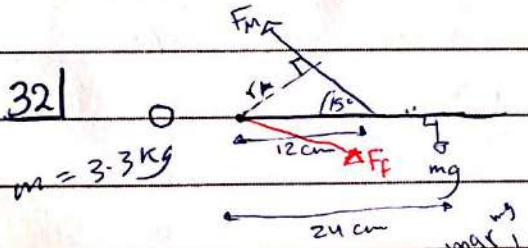
$+\uparrow \quad T\sin 35 - 250 - 155$

$\xrightarrow{+} \quad H_x - T\cos 35 = 0$

$+\circlearrowleft_{O} \quad (T\sin 35)(1.35) - 155\left(\frac{1.7}{2}\right)$

$- 250(1.7) = 0$

32|



$\tau = r_{\perp}F = mgr$

$F_M r_M$

$+\circlearrowleft_{O} \quad \tau = (F_M \sin 15)(0.12) - mg(0.24) = 0$

$F_M \sim 250 N$

$\frac{F_L}{F_A} = \frac{r_A}{r_L}$

$\frac{mg}{F_M} = \frac{0.12\sin 15}{0.24} = \frac{1}{2}\sin 15$

$\frac{F_L}{F_A} << 1$

$$F_M r_\perp^M - mg\, r_\perp^{mg} = 0$$

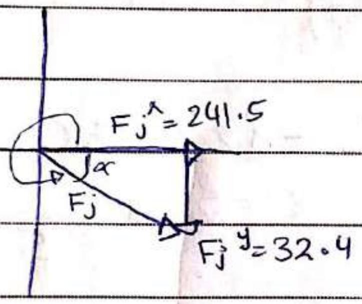
$$\Sigma \vec{F} = 0$$

$\xrightarrow{+}$ $F_j^x - F_M \cos 15 = 0$

$F_j^x = 241.5\ N$

$\uparrow^{+}$ $F_M \sin 15 + F_j^y - mg = 0$

$F_j^y = -32.4\ N$ (downwards)



$$F_j = \sqrt{(F_j^x)^2 + (F_j^y)^2}$$

$$\tan\alpha = \frac{32.4}{241.5} \sim 7.6^\circ$$

$$\theta = 360 - 7.6 = 352.4$$

Fluid

CHAPTER 10

* 4 Phases :
  1. Solids : Fixed volume, Fixed shape
  2. liquids : Fixed Volume, Variable shape
  3. gases : No Fixed Volume, No fixed shape
  4. Plasma : mixture of + & − ions.

$\text{Density} = \frac{\text{mass}}{\text{Volume}} = \frac{kg}{m^3} = \frac{g}{cm^3}$ $\qquad \vec{a} = \frac{\vec{F}}{m}$

Density

$\rho_{\text{Purewater}} = \frac{1000\,kg}{m^3}, \frac{1\,g}{cm^3}$

$\text{Specific Gravity (SG)} = \frac{\text{density of substance}}{\text{density of water at } 4°C}$

Pressure : scalar $\qquad P_{\text{ressure}} = \frac{\text{Force}}{\text{Area}} = \frac{N}{m^2} = \boxed{Pa}$ $\qquad$ pressure is a scalar quantity

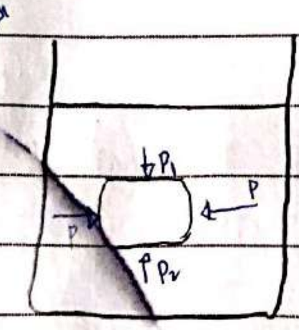
$\boxed{Ex}$ The two feet of a 60 kg person cover an area of 500 cm^2

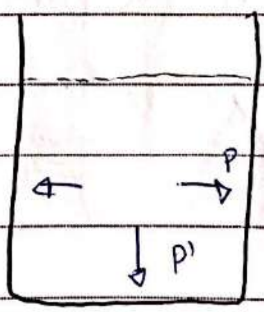
(i) Find the pressure on the ground when he stends at rest.

$P = \frac{60 \times 10}{500 \times 10^{-4}} = 12 \times 10^3 \,N/m^2 = 1200$ Pascal

(ii) If he stands on one foot.

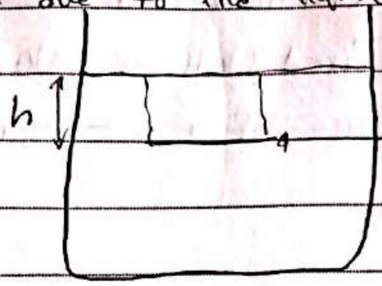
$P = \frac{60 \times 10}{\left(\frac{500 \times 10^{-4}}{2}\right)} = 24000\ Pa$





*** How to calculate pressure**

find the p. due to the liquid only



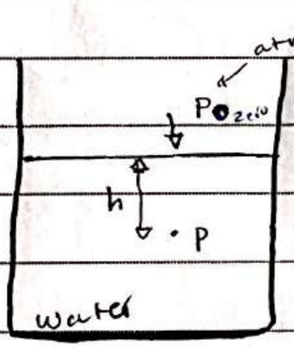
mass of water on top of area A

$$P = \frac{F}{A} = \frac{mg}{A} = \frac{(\rho V)g}{A}$$

$$P = \frac{\rho \cancel{A} h g}{\cancel{A}} \longrightarrow P = \rho g h$$

law

*



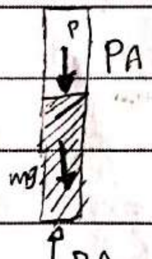
Open to atmosphere

$P_{atmospheric} = P_o = 760\ mmHg$

atm $= 1.013 \times 10^5$ Pascal

$= 1.013$ bar

* Straw



If liquid in static equilibrium $\Rightarrow \sum \vec{F} = 0$

$+\uparrow\ P_oA - PA - mg = 0$

$P_oA = mg + PA$

$P_o = \frac{mg}{A} + P$

$= \frac{\rho(\cancel{A}h)}{\cancel{A}} g + P$

$P_o = \rho g h + P$

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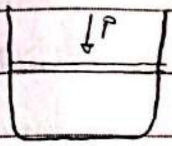
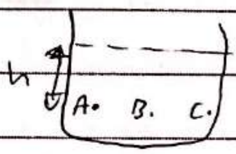
Pascal's Principle :

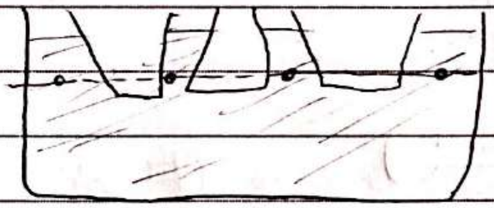


* when an external pressure is applied to a confined fluid the pressure at every point in the fluid increases by that amount



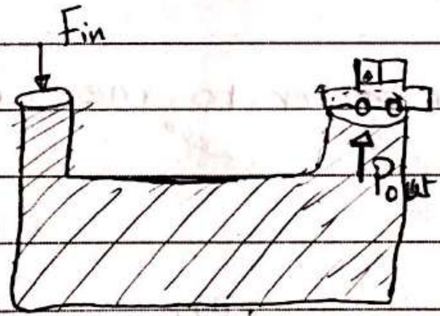
$P = P_0 + \rho g h$

$P_A = P_B = P_C = P_0 + \rho g h$



All points at this level have the same pressure.

Ex: P_{in}, A_{in}



$F_{out} = P_{out} \times A_{out}$

If liquids at the same height $\Rightarrow P_{in} = P_{out}$

$\frac{F_{in}}{A_{in}} = \frac{F_{out}}{A_{out}} \Rightarrow \frac{\overset{F_{load}}{F_{out}}}{\underset{F_{applied}}{F_{in}}} = \frac{A_{out}}{A_{in}} \quad \therefore \frac{F_{load}}{F_{app}} = 20$

1st wieght of car

$mg = 1000 \times 10$ N $= F_{load}$

What is F_{app} ?

$\frac{10000}{F_{app}} = 20$

$F_{app} = 500$ N

so we need 500 N to lift a 10000 N car.

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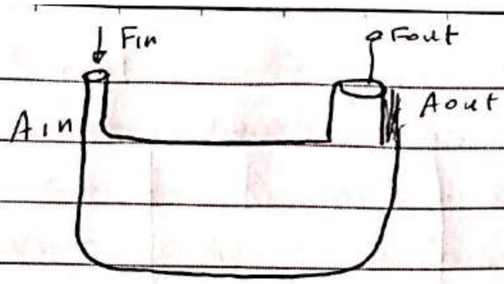


Assuming liquid hieght is the same

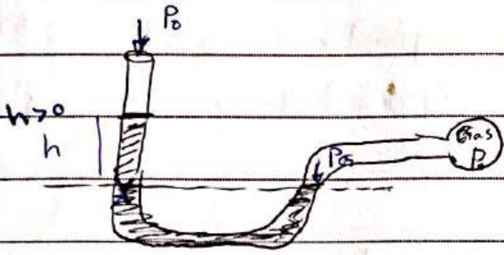
$P_{in} = P_{out}$

$\frac{F_{in}}{A_{in}} = \frac{F_{out}}{A_{out}}$

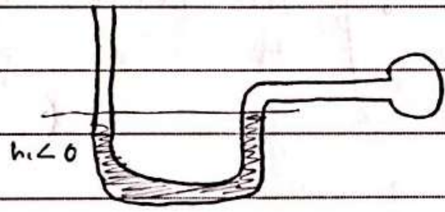
$\frac{F_L}{F_A} \quad \frac{F_{out}}{F_{in}} = \frac{A_{out}}{A_{in}} >> 1$

How to measure Pressure

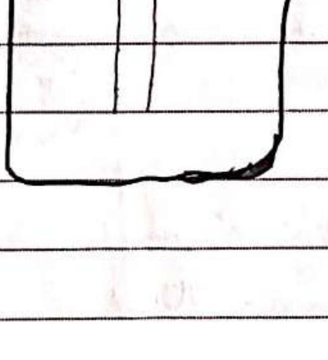
$P_G = P_0 + \rho g h$



$P_G = P_0 - \rho g h_1$



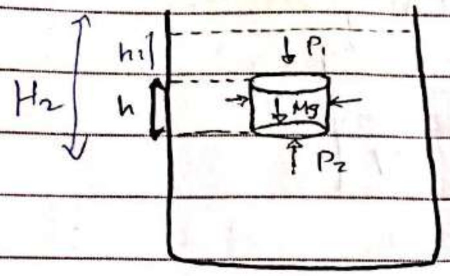
* We use the barometer to measure atmospheric pressure.



* level of mercury rises in the tube until the pressure of the mercury hight equals the atmospheric pressure $P_0 = 760\ mmHg$ $= 1.013 \times 10^5$ pascal

Archimedes' Principle : (Buoyant Force)

قوة الطفو



* cylinder has area A height h.

$F_1 = P_1 A$

$F_2 = P_2 A$

$+\uparrow \; F_B = F_2 - F_1 = P_2 A - P_1 A$

$F_B = (P_2 - P_1) A$

$F_B = \rho_F g (h_2 - h_1) A$

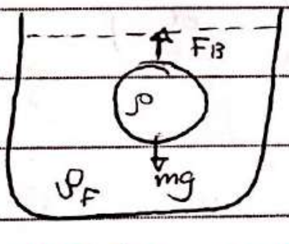
$F_B = \rho_F g h A$

$F_B = \rho_F V g$

V: volume of displaced liquid.

$$\boxed{F_B = \rho_F V g}$$

* Buoyant force equals the weight of the displaced fluid. (Archimedes priciple)



$+\uparrow$ resultant force

$F_R = F_B - Mg$

$= \rho_F V g - \rho V g$

$= (\rho_F - \rho) V g$

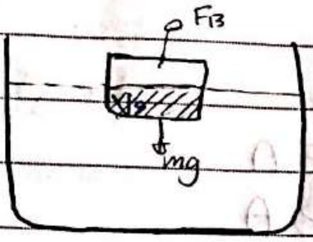
* $\rho_F > \rho \Rightarrow F_R \uparrow$ & object floats

* $\rho_F < \rho \Rightarrow F_R \downarrow$ & object sinks

الانغمار الجزئي

Partial Submersion:

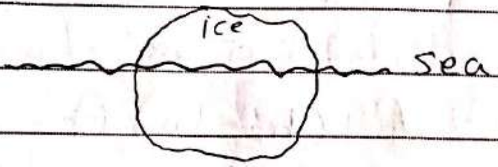
static equilibrium



$$F_B = mg$$

$$\rho_F V_s \cancel{g} = \rho V \cancel{g}$$

$$\boxed{\frac{\rho}{\rho_F} = \frac{V_s}{V}}$$



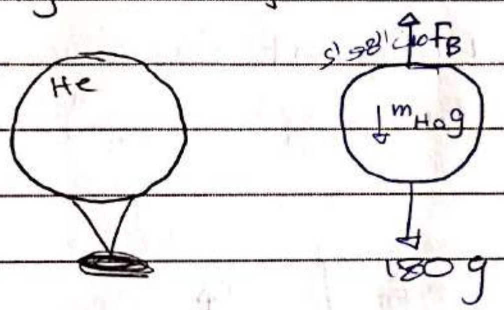
$\rho_{seawater} = 1025 \ kg/m^3$

$\rho_{ice} = 980 \ kg/m^3$

$$\frac{\rho_{ice}}{\rho_{seawater}} = \frac{V_s}{V} = \frac{980}{1025} \simeq 0.9$$

Balloon's:

What Volume of a helium balloon is needed to lift a load of 180 kg (including the mass of the rubber of the balloon)



$$F_B = m_{He}g + 180g$$

$$\rho_{air} V g = \rho_{He} V g + 180 \cancel{g}$$

$$(\rho_{air} - \rho_{He}) V = 180$$

ρ_{air}: 1.29 kg/m³ $\quad \rho_{He}$: 0.179 kg/m³

Rania

Fluids in Motion:

Assume flowing fluid to be non-viscous (No viscosity)

* Two types of flow:

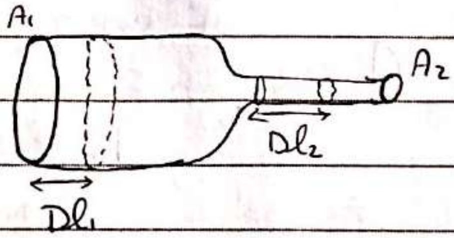
1- laminar

2- turbulant

Continuity Equation:

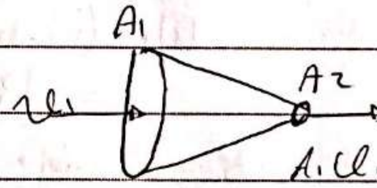
Assume: * non-viscous fluid

* Incompressible fluid (Volume doesn't change under pressure)



$$A_1 \frac{\Delta l_1}{\Delta t} = A_2 \frac{\Delta l_2}{\Delta t}$$

$$A_1 v_1 = A_2 v_2$$



$A_1 v_1 = A_2 v_2$

$\frac{\Delta V}{\Delta t}$: volume flow rate

$\frac{\Delta m}{\Delta t} = \frac{\rho \Delta V}{\Delta t}$: mass flow rate

$\rho_1 A_1 \Delta l_1 = \rho_2 A_2 \Delta l_2$ (in general if $\rho_1 \neq \rho_2$)

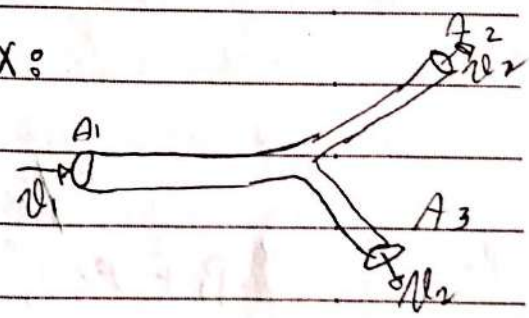
$\rho_1 A_1 \frac{\Delta l_1}{\Delta t} = \rho_2 A_2 \frac{\Delta l_2}{\Delta t}$

$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$

For incompressible fluid $\rho_1 = \rho_2 = \rho$

$A_1 v_1 = A_2 v_2$

ex:



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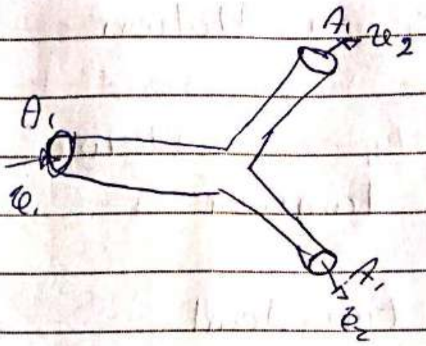
$A_1 = 2A_2 \quad v_1 A_1 = 2A_2 v_2$

$v_1 (2A_2) = 2A_2 v_2$

$v_1 = v_2$



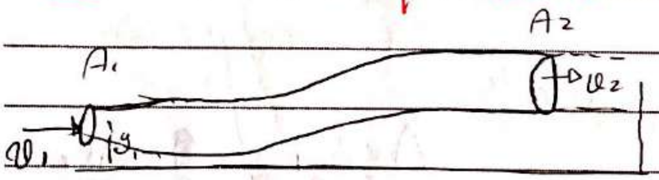
if $A_1 = A_2 = A_3$

$A_1 v_1 = 2(A_2 v_2)$

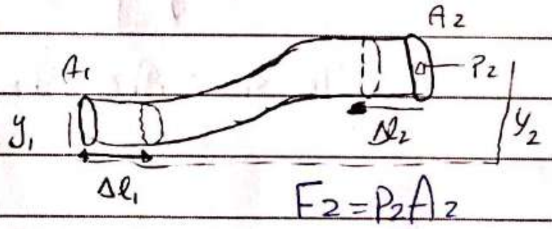
$A_1 v_1 = 2(A_1 v_2)$

$v_1 = 2v_2$

Bernollis Equation: (statement of conservation of energy)



$F_1 = P_1 A_1$



$F_2 = P_2 A_2$

left side:

$W_1 = (P_1 A_1)\Delta l_1$

$= P_1 V_1$

Right side:

$W_2 = -P_2 A_2 \Delta l_2 = -P_2 V_2$ ($\cos 180°$)

$W_g = -mg(y_2 - y_1)$

$W_{Total} = \Delta K$

$P_1 V_1 - P_2 V_2 - mgy_2 + mgy_1 = \frac{1}{2} m (v_2^2 - v_1^2)$

but $V_1 = V_2 = V$ since incompressible fluid

$P_1 V - mgy_2 + mgy_1 - P_2 V = \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2$

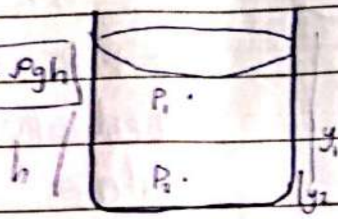
$\div V \Rightarrow P_1 - P_2 + \frac{m}{V} g y_1 - \frac{m}{V} g y_2 = \frac{1}{2}\frac{m}{V} v_2^2 - \frac{1}{2}\frac{m}{V} v_1^2$

for non-viscous incompressible fluid $P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$

* Special Cases :

(i) static fluid

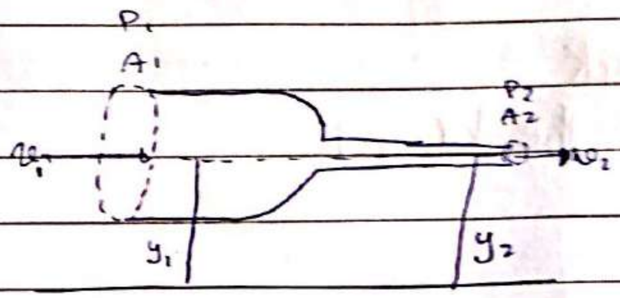
$\boxed{P_2 = P_1 + \rho g h}$



$P_1 + \rho g y_1 + 0 = P_2 + \rho g y_2 + 0$

$P_1 + \rho g (y_1 - y_2) = P_2$

$\boxed{P_1 + \rho g h = P_2}$



$P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$

note $y_1 = y_2 = y$

$P_1 + \frac{1}{2} \rho v_1^2 = P_2 + \frac{1}{2} \rho v_2^2$

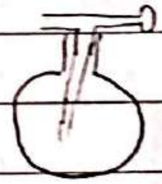
$v_2 > v_1$ since $A_2 < A_1$

$[A_1 v_1 = A_2 v_2]$

$\Rightarrow P_2 < P_1$ high speed low pressure

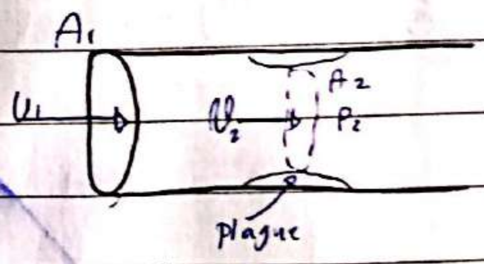
Examples of Bernoulli's principle

* Perfume Atomizer



* Ping-Pong ball in jet of air

Medical Applications



$A_2 < A_1 \Rightarrow v_2 > v_1 \Rightarrow P_2$ is less than the pressure of surrounding tissues

→ this closes the artery

→ opening & closing

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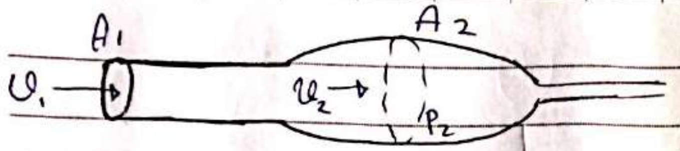
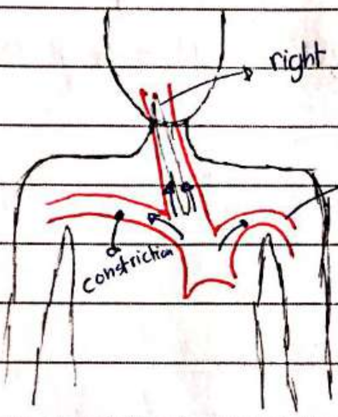


$A_2 > A_1 \Rightarrow v_2 < v_1$

$\Rightarrow P_2$ higher pressure.
eventually could rupture the arteries or veins.

TIA :- transient ischemic attack
(Lack of blood to the brain)



*Check the book p.g 278
Fig. 10-28

27- $m = 63.5$ grams in air
$m' = 55.4$ grams in water

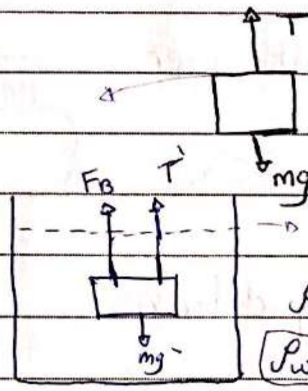
$T - mg = 0$

$T = mg$

$0.0635 g = mg = \rho V g$

$\boxed{0.0635 = \rho V}$ ①

density of object



$\Rightarrow F_B + T' = mg$

$\rho_w V g + 0.0554 g = 0.0635 g$

$\boxed{\rho_w V = 0.0081}$ - ②

$$\frac{\rho V}{\rho_w V} = \frac{0.0635}{0.0081} \Rightarrow \rho = 7840\ Kg/m^3$$

iron or steel

5- 35 g

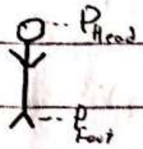
$m_w = (98.44 - 35)\, g$

$m_f = (89.22 - 35)\, g$

$SG = \frac{\rho_F}{\rho_w} = \frac{(89.22-35)\, g / \cancel{V}}{(98.44-35)\, g / \cancel{V}}$ (gram)

$\simeq 0.855$

10-



$P_F = P_H + \rho_{blood}\, g h$

$760\ mmHg = 1\ atm = 1.013 \times 10^5\ Pa$

$P_F - P_H = \rho_{blood}\, g\, (1.75)$

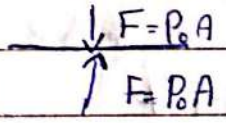
$\simeq 18170$ Pascal

$= 18170 \times \frac{760\ mmHg}{1.013 \times 10^5} \sim 136\ mmHg$

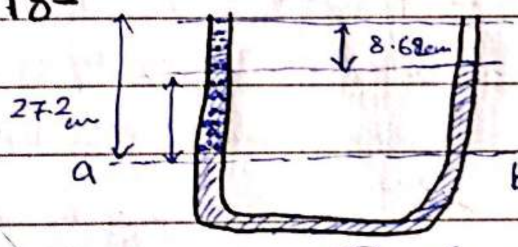
11- ⓐ $F = P_0 A$

$= 1.013 \times 10^5 \left(\frac{N}{m^2}\right) (1.7 \times 2.6)\, m^2$

$= 447746$ Newton.



18-

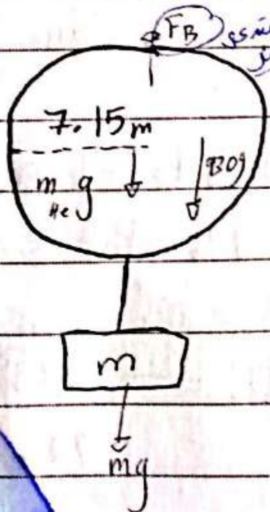


$P_a = P_b$

$\cancel{P_0} + \rho_{oil}\, g\, (27.2 \times 10^{-2}) = P_0 + \rho_{water}\, g\, (27.2 - 8.6\,?) \times 10^{-2}$

$\rho_{oil} = 683\ kg/m^3$

26-



Assume system in static equilibrium

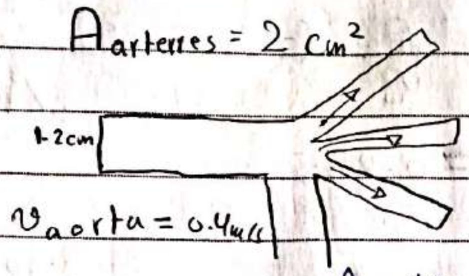
$F_B - M_{He}\, g - 930 g - mg = 0$

$\rho_{air} V \cancel{g} - \rho_{He} V \cancel{g} - 930 \cancel{g} = m \cancel{g}$

$(\rho_{air} - \rho_{He}) \frac{4}{3} \pi (7.15)^3 - 930 = m$

$m \simeq 771\ kg$

38- $A_{arteries} = 2\ cm^2$



$A_{aorta} v_{aorta} = A_{arteries} \times v_{arteries}$

$\pi(1.2\times10^{-2})^2 (0.4) = (2\times10^{-4}) \times v_{arteries}$

$v_{arteries} = 0.9\ m/s$

$A_{aorta} , v_{aorta} = N(A_{each\ artery}) v_{artery}$

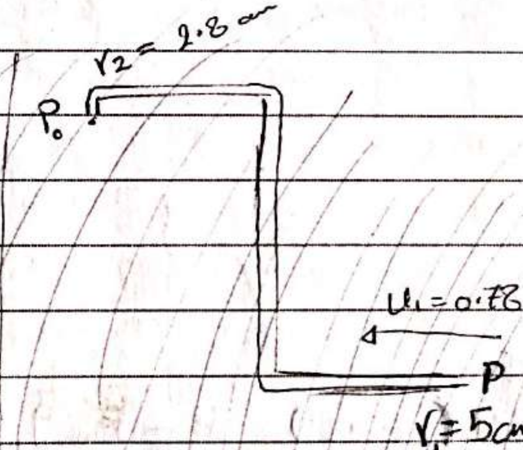
45-

$Av \to m^2 \cdot \frac{m}{s} = \frac{m^3}{s}$

volume flow rate

$\rho A v$ mass flow rate

48-



$P_{gauge} = 3.8$ atm

$= 3.8 \times (1.013\times10^5)$ Pascal

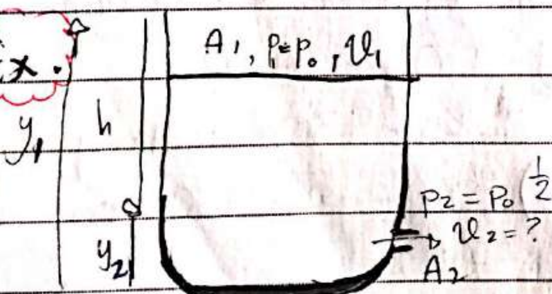
$P_1 + \frac{1}{2}\rho v_1^2 + \rho g(0)$

$= P_0 + \frac{1}{2}\rho v_2^2 + \rho g(16)$

$\underbrace{(P_1 - P_0)}_{P_{gauge}} + \frac{1}{2}\rho_w v_1^2 - \rho_w g(16) = \frac{1}{2}\rho_w \boxed{v_2^2}$

$P_{gauge} = P - P_a$ atmospheric pressure

Ex.



Find $v_2 = ?$

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2 =$ cons

$P_0 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_0 + \frac{1}{2}\rho v_2^2 + \rho g y_2$

$\frac{1}{2}\rho v_1^2 + \rho g(y_1 - y_2) = \frac{1}{2}\rho v_2^2$

$v_1^2 + 2gh = v_2^2 \Longrightarrow v_2^2 = 2gh$

$v_2 = \sqrt{2gh}$

since $A_1 \gg A_2$

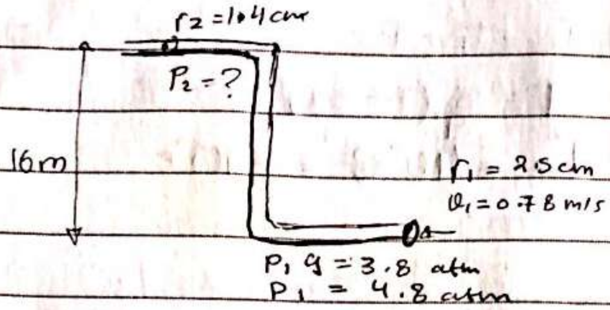
$\Longrightarrow v_2 \gg v_1$

$v_1 \simeq 0$

$v_f^2 - v_i^2 = 2gh$

$v_f = \sqrt{2gh}$

48-



$A_1 v_1 = A_2 v_2$

$v_2 = \frac{A_1}{A_2} v_1 = \frac{\pi r_1^2}{\pi r_2^2} v_1$

$= \left(\frac{r_1}{r_2}\right)^2 v_1 = \left(\frac{2.5}{1.4}\right)^2 (0.78)$

$v_2 \approx 2.5$ m/s

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$

$P_2 = 3.23 \times 10^5$ Pa

$P_{2g} = P_2 - P_0$

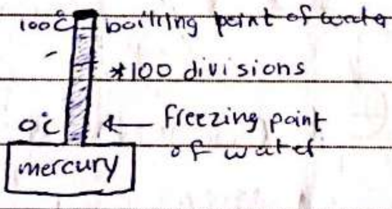
atmospheric pressure

CHAPTER 13 : Temperature & Kinetic Theory

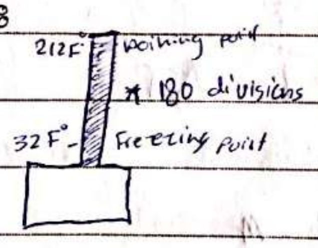
* Temperature is a measure of the avg. kinetic energy
  - In measuring temp. we depend on the variation of given property of a material with temp.

Temperature Scales :

1- Celsius Scale :



2- Fahrenheit Scale :



$\frac{100}{180} = \frac{5}{9}$

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

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

$T_F = \frac{9}{5} T_C + 32$

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$T_C = \frac{5}{9}(T_F - 32)$ $\quad$ $T_C = T_F = T$

$T = \frac{5}{9}(T - 32)$

درجة الحرارة الوحيدة الي بيتفقوا عليها $\quad T = -40°C = -40°F$

Thermal Equilibrium :

*Heat : Energy being transferred from one point to the other

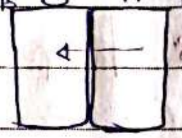
*Zeroth law of thermodynamics

- need to define thermal equilibrium first.

[∘ No Net heat flow from one point to the other]

Net heat flow = 0

T_B B A T_A $\quad$ $T_A > T_B$



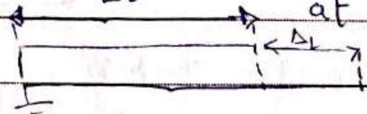
⟹ Net heat flow from A → B

* This Net heat flow continues until $T_A = T_B$

Zeroth law : If A & B are in thermal equilibrium.
If B & C are also in " "
⟹ A & C are also in thermal equilibrium

Thermal Expansion :

① Linear Expansion $\quad L_o \quad$ at T_o



$\frac{\Delta L}{2}$ $\quad L_o \quad$ $\frac{\Delta L}{2}$

$\Delta L = \alpha L_o \Delta T$ $\quad$ has units

↑

coefficient of linear expansion

each material has its own α.

Aluminum $\alpha = 25 \times 10^{-6}$ °C

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Ex: The steel bed of a suspension bridge is 200 m at 20°C. If the extremes of temperature are -30°C → 40°C.

How will it contract & expand?

$(\alpha = 12\times10^{-6}\ °C^{-1})$

at 40°C $\Delta L = (12\times10^{-6})(200)(\overset{T_f - T_i}{40-20}) = 4.8\times10^{-2}\ m$

at -30°C $\Delta L = (12\times10^{-6})(200)(-30-20) = -12\times10^{-2}\ m$

Joint must accommodate ~ 17 cm

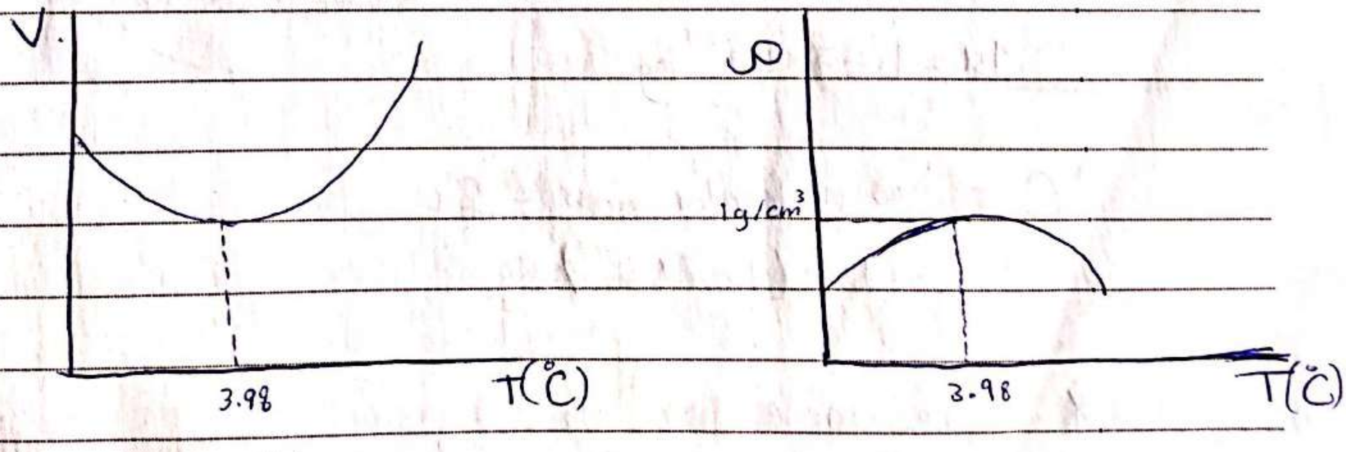
Volume Expansion:

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

β ↑ coefficient of volume expansion

- has units of $\frac{1}{T}$

Anomalous behavior of water



$$\rho = \frac{M}{V}$$

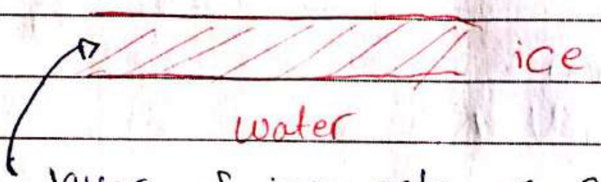
cooler & denser

warmer & has less dense

lake surface

surface water starts to cool at ~4° surface has maximum density & hence sinks.

* deeper warmer water rises to the surface ⟹ O_2 is taken deep into the water, which is imp. for aquatic life. This continues untill water is completly mixed
* Water surface cools more below 4°C & freezes first.
* Water in a lake freezes from the surface downwords



layer of ice acts as a heat insulating.

The Gas laws & absolute temperature

H_2 : has molecular mass = 2u

atomic mass unit

$1u = 1.67 \times 10^{-27}$ Kg

^{12}C : has molecular mass = 12 u

$= 12 \times (1.67 \times 10^{-27})$ Kg

* One mole of H_2 2 grams
* One mole of ^{12}C has a mass of 12 grams

$M(CO_2) = 12 + (2 \times 16) = 44u$

1 mole of CO_2 has a mass of 44 grams

Ideal gas laws

* Properties of an ideal gas:

① monoatomic

② law density so that no interactions between Particles

③ Collision between Particles are elastic.

*need for this high temp & low pressure

$$PV = nRT$$ - ideal gas law

(n: number of moles; R: gas constant; T: temp. K)

*gas constant = 8.314 J/(mole/K) J/(mole·K)

$R = \frac{PV}{nT}$ $\frac{J}{mol\,K}$

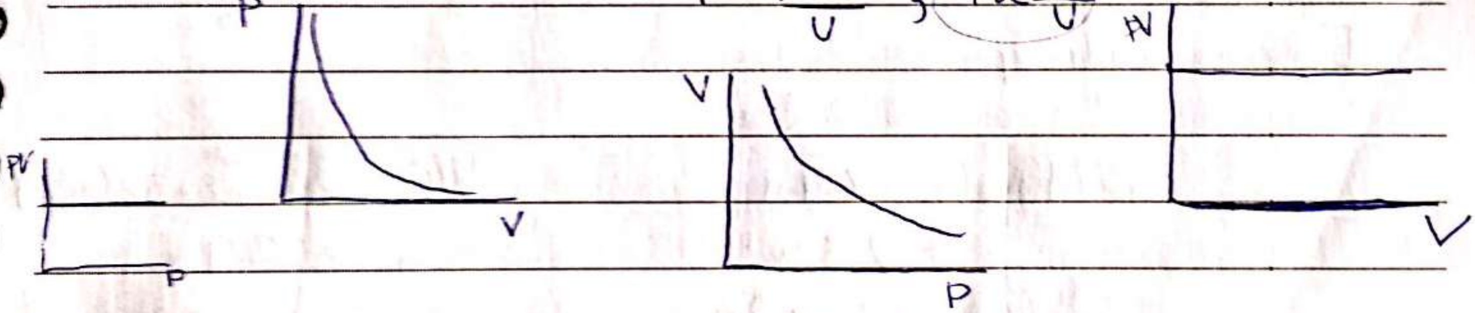
(i) Boyl's law:

PV = nRT at constant pressure

PV = constant

$P = \frac{nRT}{V}$, $P \propto \frac{1}{V}$

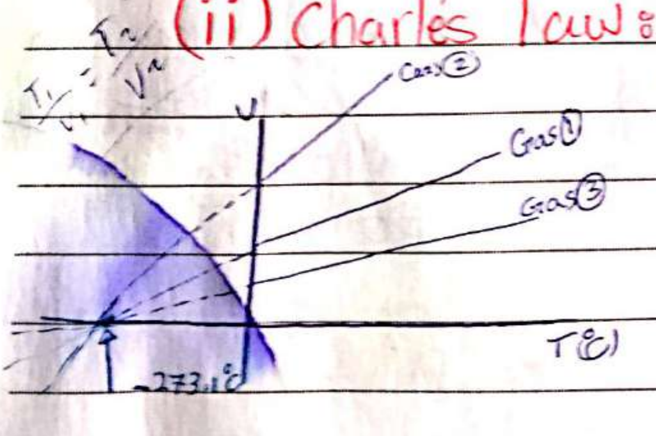
$P_1V_1 = P_2V_2$



(ii) Charles law:

At constant pressure $V = \left(\frac{nR}{P}\right) T$ (constant)

$V \propto T$



* All curves regardless of the gas used cross the T axis at the same Point

T = -273.1 °C ⟹ define absolute Temp. -273.1°C = 0 Kelvin

$$T_K = T_C + 273$$

$$T_C = T_K - 273$$

$1m^3 = 1000$ liters

$$\boxed{\begin{array}{l}\Delta T_C = \Delta T_K \\ \Delta T_C = \frac{5}{9}\Delta T_F\end{array}}$$

Ex: What is the Volume of one mole g an ideal gas at STP.

$$\overset{Pascal}{P}\,\overset{m^3}{V} = n\,R\,\overset{K}{T} \qquad \frac{J}{mol \cdot K} = 8.314$$

$$V = \frac{nRT}{P} = 22.4 \times 10^{-3}\ m^3$$
$$= 22.4 \text{ liters}$$

Ex: Helium balloon has a radius of 18 cm at 20°. Its internal pressure is 1.05 atm. Find the number of moles of helium in the balloon.

$$n = \frac{PV}{RT} = \frac{(1.05 \times 1.013 \times 10^5)\left(\frac{4}{3}\pi(0.18)^3\right)}{8.314 \times 293} = 1.066 \text{ mole}$$

Ex: Find the mass of air in a room with dimensions $5 \times 3 \times 2.5\ m^3$ at $\boxed{STP.}$

$$n = \frac{\text{Volume of room}}{\text{Volume per mole}} = \frac{5 \times 3 \times 2.5\ m^3}{22.4 \times 10^{-3}\ \frac{m^3}{mole}} \approx 1700 \text{ mole}$$

[air is made up of $0.8\ N_2$
$\sim 0.2\ O_2$

$M(N_2) = 2 \times 14\,u$
$= 28\,u$

$M(O_2) = 16 \times 2\,u$
$= 32\,u$

$M(air) = \overset{g/mole}{28} \times 0.8 + 32(0.2)$
$= 29\,u$

* mass of 1 mole 29 grams
* mass of air in this room
$= 1700 \text{ mole} \times 29 \frac{grams}{mole}$
$= 50\,000$ gram
$= 50$ Kg

الصفحة اللي فاتت

Kinetic Theory

each mole of a substance contains Avogadro's # of particles

$N_A = 6.023 \times 10^{23}$

avg. kinetic energy

$PV = \frac{2}{3} N \bar{K}$

number of particles

$\bar{K} = \frac{1}{2} m v^2$

$PV = nRT$

$\therefore nRT = \frac{2}{3} N \bar{K}$

$\bar{K} = \frac{3}{2} \frac{n}{N} RT$

$= \frac{3}{2} \frac{\cancel{N}}{N_A} \times \frac{1}{\cancel{N}} RT$

$\bar{K} = \frac{3}{2} \frac{R}{N_A} T$

$K = \frac{3}{2} K_B T$ مهم $[\bar{K} \propto T]$

Boltzman constant $= 1.38 \times 10^{-23}$

[Equipartistion of energy] $= \frac{1}{2} K_B T + \frac{1}{2} K_B T + \frac{1}{2} K_B T$

due to motion along x-axis

" " y-axis

z-axis

* $\bar{K}$ number of dimensions

- $\frac{1}{2} K_B T$ 1 (x-axis)
- $1 K_B T$ 2 (x-y)
- $\frac{3}{2} K_B T$ 3 (y, x, z)

$\bar{K} = \frac{1}{2} m \overline{v^2}$

$v^2 = \frac{2K}{m}$

مهم $v_{rms} = \sqrt{\overline{v^2}} = \sqrt{\frac{2\bar{K}}{m}}$

root mean squar velocity (speed)

$PV = nRT$

$nRT = \frac{2}{3} N \bar{K}$

$\bar{K} = \frac{3}{2} \frac{n}{N} RT$

$= \frac{3}{2} K_B T \Rightarrow$

$v_{rms} = \sqrt{\frac{2}{m} \times \frac{3}{2} K_B T}$

$= \sqrt{\frac{3 K_B T}{m}}$

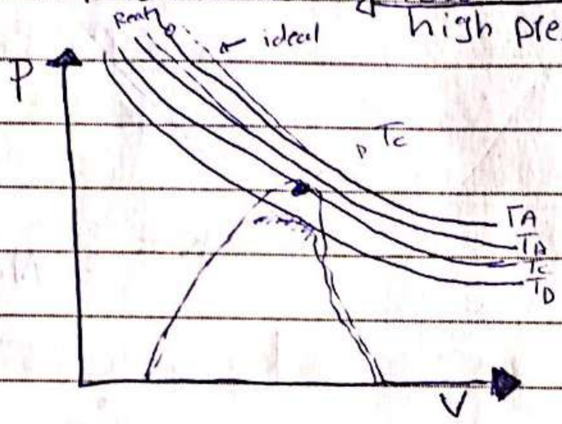
مهم $v_{rms} \propto \sqrt{\frac{T}{m}}$

Real Gases & Phase change

gas $\longrightarrow$ liquid $\Longrightarrow$ {Phase change
liquid $\Longrightarrow$ Solid $\longrightarrow$

Real Gas $\xrightarrow[\text{low press.}]{\text{high temp.}}$ ideal gas

Real Gas $\xleftarrow[\text{high press.}]{\text{low temp.}}$ ideal gas



$P \propto \frac{1}{V}$

$T_A > T_B > T_C \ngtr T_D$

* What Shall I Know?

$\bar{K} \propto T$

$V_{rms} = \sqrt{u^{-2}}$

$V_{rms} \propto \sqrt{\frac{T}{m}}$ [Real gases & Phase change]

gas $\longrightarrow$ liquid (Phase change)

liquid $\longrightarrow$ Solid (Phase change)

Real gas $\xrightarrow[\text{Low press}]{\text{high temp}}$ Ideal gas

Real gas $\xleftarrow[\text{high Press}]{\text{low temp}}$ Ideal gas

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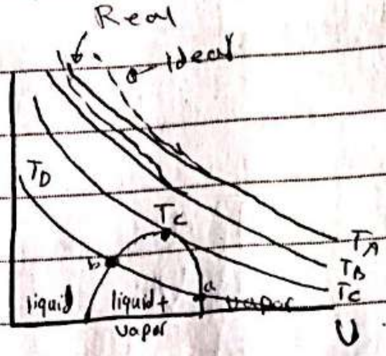
$P \propto \frac{1}{V}$



$T_A > T_B > T_C > T_D$

.... ideal gas

—— real gas

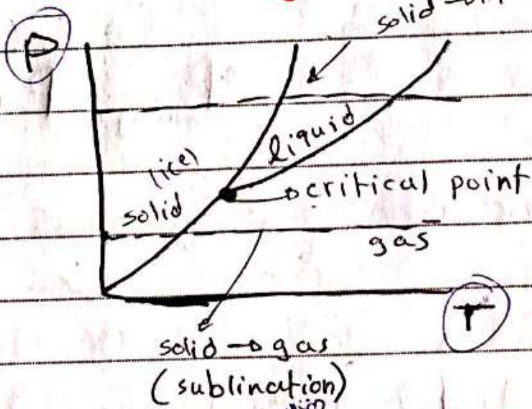
$P = \frac{\text{constant}}{V}$

C :- critical temp.

above it u can never turn gas into liquid no matter how high the Pressure is.

* at Tc or below it we can turn a gas into liquid.

Phase Diagram 8



$\boxed{3}$ $T_C = \frac{5}{9}(T_F - 32)$

$\boxed{a}$ $68°F \rightarrow 20°C$

$\boxed{b}$ $1960°C \Rightarrow T_F = \frac{9}{5} T_C + 32$

$= 34.52 F°$

$\boxed{10}$ $L_0 = 12 m$ at $15°C$

$T \rightarrow -30°C \rightarrow +50°C$

تقدر

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

$= (12 \times 10^{-6})(12)(50 - 15) = 0.005 m = 0.5 cm$

$(-30 - 15)$ تقدر

23) $P_i = P_0$, $T_i = 293\ K$, V_i

$P_f = 40\ atm$ $\qquad V_f = \frac{1}{9} V_i$

$P_i V_i = n R T_i$

$P_f V_f = n R T_f$ $\qquad \frac{P_f V_f}{P_i V_i} = \frac{T_f}{T_i}$

$$\frac{40\ atm\ \ V_i/9}{1\ atm\ \ V_i} = \frac{T_f}{293}$$

$T_f = 1302\ K$

24) (a) $n = 16$ moles of He gas

$T_i = 10^\circ c = 283\ K$

$P_{gauge} = 0.35\ atm$

$P_i = P_g^i + 1\ atm$

$= 1.35\ atm$

$P_i V_i = n R T_i$

$V_i = 0.275 m^3$

(b) $T_f = ??$ $\quad V_f = \frac{1}{2} V_i$

$P_g^f = 1\ atm$

$P_f = 2\ atm$

$P_f V_f = n R T_f$

$T_f = 209\ K$

$P_{gauge} = P + P_0$ 1 atm

36) STP :- Standard temp & press

temp → 0°C (273 K°) ; press → 1 atm

(a) at stp $\rho_{water} = 999.9\ kg/m^2 \sim 1000\ kg/m^3$

molecular mass M $(H_2O) = 2(1.007944) + 1(15.99944)$

$= 18.015284$ moles

mass of one mole of $H_2O = 18.01528$ grams

$1 m^3$ of one liter of water $= \frac{1}{1000} \times 1000\ kg = 1\ kg = 1000 g$

number of moles $= \frac{1000 \text{ grams}}{18.01528\ g/moles} = 55.5$ moles

(b) number of water molecules

$n N_A = 3.34 \times 10^{25}$ molecules

$$\text{Number of particles} = \frac{N_A \times n_{moles}}{1\ mole} \quad N_A = 6.022 \times 10^{23}$$

$\boxed{40}$ @ $T_k = \frac{3}{2} K_B T$ at stP $T = 273K$

$$= \frac{3}{2}(1.38 \times 10^{-23}) \times 273$$

$$= 5.565 \times 10^{-21}\ g$$

for one Nitrogen molecule

* if asked that it moves in one dimension we multiply by $\frac{1}{2}$ on 1_d instead of $\frac{3}{2}$

ⓑ $\bar{K}_{total} = N_A \times \frac{3}{2}(1.38 \times 10^{-23})(298) = 7306 J$

since one mole

$\boxed{44}$ V_{rms} : root-mean-square speed

$$\bar{K} = \frac{1}{2} m \overline{v^2}$$

$$\overline{v^2} = \frac{2\bar{K}}{m}$$

$$V_{rms} = \sqrt{\overline{v^2}} = \sqrt{\frac{2\bar{K}}{m}}$$

$$= \sqrt{\frac{\cancel{2}}{m} \times \frac{3}{\cancel{2}} K_B T} = \sqrt{\frac{3K_bT}{m}}$$

$$P_iV_i = nRT_i \qquad P_fV_f = nRT_f$$

$$\frac{P_fV_f}{P_iV_i} = \frac{T_f}{T_i}$$

$$\frac{3P_iV_f}{P_iV_i} = \frac{T_f}{T_i}$$

$$\boxed{T_f = 3T_i} \rightarrow$$

$$V_{rms}^i = \sqrt{\frac{3K_b}{m} T_i}$$

$$V_{rms}^f = \sqrt{\frac{3K_b}{m} T_f}$$

$$= \sqrt{\frac{3K_B}{m} 3T_i}$$

$$V_{rms}^f = \sqrt{3}\, V_{rms}^i$$

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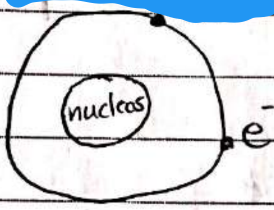
Note : Two gases Ⓐ & Ⓑ at the same temp.

Find $\frac{U_{rms}^{A}}{U_{rms}^{B}} = \frac{\sqrt{\frac{3}{m_A} K_B T}}{\sqrt{\frac{3K_B}{m_B} T}} = \sqrt{\frac{m_B}{m_A}}$

Nuclear Physics & Radioactivity



Atom

Atom = nucleas + ~~Orbiting~~ e^-

Protons + Neutrons

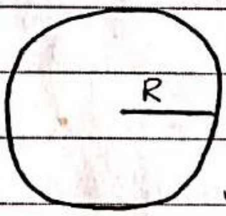
$$A = N + Z$$

$${}^{A}_{Z}X_{N}$$

A → Mass #

N → # of neutrons

Z → # of protons (atomic number)



Nucleas

$$R = 1.2\, A^{1/3}\, fm$$

nuclear Radius

Fermi $= 10^{-15}$ m

$$\frac{R_{atom}}{R_{nucleas}} \sim 10^{5}$$

$m_p = 1.667 \times 10^{-27}$ Kg $= m_n$

Proton charge $= +1.6 \times 10^{-19}$ C

neotron charge = 0

Unstable emit radiation

→ Types of radiation

1. α - Particles $\left({}^{4}_{2}He_2^{++}\right)$
2. β^+ (Positron) e^+
3. β^- (electron) e^-
4. γ - radiation

$${}^{226}_{88}Ra \longrightarrow {}^{222}_{86}Rn + \underset{{}^{4}_{2}He}{\alpha}$$

$A \to A-4$

$Z \to Z-2$

$N \to N-2$

β^+ - decay

$$P \longrightarrow n + e^+ + \nu_e$$

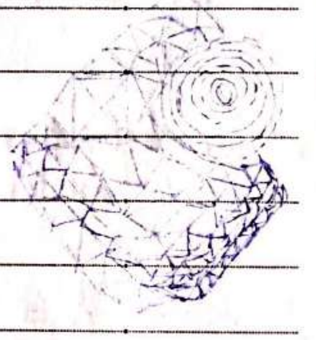
$${}^{19}_{10}Ne_9 \longrightarrow {}^{19}_{9}F_{10} + {}^{0}_{1}e + \nu_e$$

β^- - decay

$$n \longrightarrow P + e^- + \bar{\nu}_e$$

$${}^{14}_{6}C_8 \longrightarrow {}^{14}_{7}N_7 + e^- + \bar{\nu}_e$$

$${}^{A}_{Z}X^{*\,\text{excited}} \longrightarrow {}^{A}_{Z}X + \gamma$$



Half life

$$N_0 \xrightarrow[t_{\frac{1}{2}}]{\text{at } t=0} \frac{N_0}{2} \xrightarrow{t_{\frac{1}{2}}} \frac{N_0}{4} \longrightarrow \frac{N_0}{8}$$

$t=0$ $\quad t_{\frac{1}{2}}$ $\quad 2t_{\frac{1}{2}}$

$$N_0 \longrightarrow \frac{N_0}{2} \longrightarrow \frac{N_0}{4} \longrightarrow \frac{N_0}{8} \longrightarrow \frac{N_0}{16} \cdots$$

→ How many life times are required for $N_0 \longrightarrow \frac{N_0}{64}$ 6 half times

$$N = \frac{N_0}{64} \Rightarrow \frac{N}{N_0} = \frac{1}{64} = \left(\frac{1}{2}\right)^{n} \text{ half lives}$$

$$n = 6 \Leftarrow \frac{1}{64} = \left(\frac{1}{2}\right)^n$$

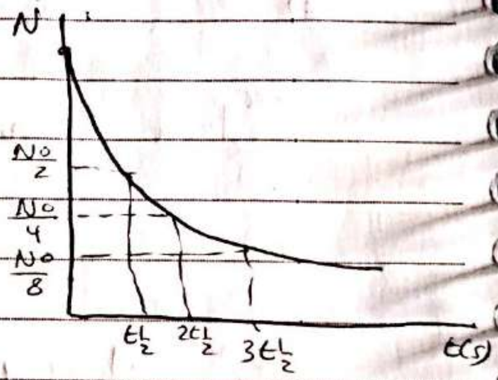
---

remaining Nucle $N = N_0 e^{-\lambda t}$

المتحللة decaying nuclei $= N_0 - N$

ثابت التحلل λ :- decay constant

$$[\lambda] = \frac{1}{\text{time}}$$



$$N = \frac{N_0}{2} \Rightarrow \frac{\cancel{N_0}}{2} = \cancel{N_0}\, e^{-\lambda t_{\frac{1}{2}}}$$

$$\ln\frac{1}{2} = -\lambda t_{\frac{1}{2}} \Rightarrow -\ln 2 = -\lambda t_{\frac{1}{2}}$$

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}} = \frac{0.693}{t_{\frac{1}{2}}}$$

عدد الأنوية التي تتحلل بالثانية الواحدة

$$\text{Activity} = \frac{-dN}{dt}$$

$$A = -\frac{dN}{dt} = -\frac{d}{dt}\left(N_0 e^{-\lambda t}\right)$$

$$A = -N_0\left[-\lambda e^{-\lambda t}\right]$$

$$A = \lambda \boxed{N_0 e^{-\lambda t}} = A_0 e^{-\lambda t}$$

initial activity $= N_0 \lambda$

$$A = \lambda N$$

Unit of activity : decay / second = Bequerel

1 curie $= 3.7 \times 10^{10}$ decays / second

$= 3.7 \times 10^{10}$ Bq

Ex: The isotope $^{14}_{6}C$ has $t_{\frac{1}{2}} = 5730$ yrs. N

→ if at some time a sample contains 1×10^{22} ^{14}C nuclei, what is the activity of the sample?

$A = \lambda N$

$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}} \approx 3.83\times10^{-12}\ s^{-1}$ x

نحول للثواني

Years → s

$5730 \times (365\times24\times60\times60)$

$A = 3.83\times10^{10}$ Bq

$A = \frac{3.83\times10^{10}}{3.7\times10^{10}} \sim 1$ Ci

Ex: A laboratory has 1.49 Mgram of pure $^{13}_{7}N$ with $t_{\frac{1}{2}} = 10$ min

[a] How many nuclei are present initially?

1 mole of ^{13}N has a mass of 13 grams

number of moles $n = \frac{1.49\times10^{-6}\ \text{gram}}{13\ \text{gram/mole}}$ = n moles

$N_0 = n_{mole} \times N_A \frac{\text{nuclei}}{\text{mole}}$ Avogadro # $= 6.9\times10^{16}$ nuc

initial Activity? → [b] $A = N\lambda$

$A_0 = N_0\lambda = (6.9\times10^{16})\left(\frac{\ln 2}{10\times60}\right) = 8\times10^{13}$ Bq

[c] What is the activity after one hour?

$A = \lambda N_0 A_0 e^{-\lambda t}$

$= A_0 e^{-\lambda(60\times60)} = 1.25\times10^{12}$ Bq

[d] after how long will A drop to below 1 decay/second?

$A = A_0 e^{-\lambda t} \Rightarrow 1 = A_0 e^{-\lambda t}$

$\ln\left(\frac{1}{A_0}\right) = -\lambda t \qquad t = 27717s$

$t > 27717s$

Suggested problems

2) $R = r_0 A^{\frac{1}{3}} = (1.2)(4)^{\frac{1}{3}}\ fm = 1.59\ fm$

1 Fermi $= 10^{-15}$ m

37) $^{238}_{92}U$ $\quad t_{\frac{1}{2}} = 4.5 \times 10^{4}$ yrs $\quad \lambda = \frac{\ln 2}{t_{\frac{1}{2}}} = \frac{\ln 2}{4.9 \times 10^{9}\ yrs} = 1.54 \times 10^{-10}\ yrs^{-1}$

a) $\lambda = \frac{\ln 2}{t_{\frac{1}{2}}} = \frac{\ln}{4.9 \times 10^{9}\ yss} = 1.54 \times 10^{-10}\ yr^{-1}$

b) $\lambda = \frac{\ln 2}{4.9 \times 10^{9} \times 365 \times 24 \times 60 \times 60} = 4.88 \times 10^{-18}\ s^{-1}$

42) $^{131}_{53}I$ $\quad m = 782\ Mg$ $\quad \underset{\text{initial activity}}{A_0} = \lambda \overset{\text{initial \#}}{N_0}$

One mole of iodine = 131 grams

$n = \frac{782 \times 10^{-6}\ grams}{131\ \frac{grams}{mole}} = 5.969 \times 10^{-6}$ moles

a) $N_0 = 5.969 \times 10^{-6} \times 6.022 \times 10^{-23} = 3.59 \times 10^{18}$

$A_0 = \frac{\ln 2}{t_{\frac{1}{2}}} \times N_0 = \frac{\ln 2}{8.02 \times 24 \times 60 \times 60} \times N_0$

$= 3.59 \times 10^{12}$ decay/s $\equiv$ Bq $= \frac{3.59 \times 10^{12}}{3.7 \times 10^{10}} = 97\ Ci$

b) $A = A_0 e^{-\lambda t}$ $\quad [A = \lambda N = \lambda N_0 e^{-\lambda t}$ $\quad (A_0)$

$A(1.5\ hrs) = A_0 e^{-\lambda(1.5 \times 60 \times 60)}$

$\approx 3.546 \times 10^{12}\ Bq = 95.8\ Ci$

$A(3\ months) = A_0 e^{-\lambda(3 \times 30 \times 24 \times 60 \times 60)}$

$\approx 4.1 \times 10^{-8}\ Ci$

43) ^{238}U $\quad A = \lambda N$ $\quad A = 420$ decay/s Bq

$N = \frac{A}{\lambda} = 8.61 \times 10^{19}$ Nuclei

46) $^{40}_{19}K$ $\quad A_0 = \lambda N_0 = 2.04 \times 10^5$ decay/s

$$N_0 = \frac{A_0}{\lambda} = \frac{A_0}{\frac{\ln 2}{t_{\frac{1}{2}}}} \Longrightarrow N_0 = 1.36 \times 10^{22} \text{ nuclei}$$

$$n = \frac{N_0}{N_A} = 0.0226$$

$$m = n \times M_{mm} = 0.0226 \text{ mole} \times 40 \text{ gram/mole}$$

$$= 0.91 \text{ gram}$$

49) $A = A_0 e^{-\lambda t}$

$$\frac{A}{A_0} = \frac{1}{6} = e^{-\lambda t},\ t = 9.4 \times 60 \text{ s}$$

$$\frac{1}{6} = e^{-\left(\frac{\ln 2}{t_{\frac{1}{2}}}\right) \times 9.4 \times 60}$$

$$\ln \frac{1}{6} = -\frac{\ln 2}{t_{\frac{1}{2}}} \times 9.4 \times 60$$

$$t_{\frac{1}{2}} = 218.2 \text{ s}$$

Nuclear Radiation

- Types of nuclear radiations.

$\alpha, \beta^+, \beta^-, \gamma$

* nuclear radiation is called ionizing radiation.

- When nuclear radiation passes through a medium it leads free $\bar{e}$ & free ions.
- Those ions interfer with the chemical processes in the biological ~~[illegible]~~ tissue for example.
- It could also lead to structural damage for example for the DNA.

$\Longrightarrow$ Radiation damage can be classified into :-

1) Somatic damage :- affects all cells except reproductive cells.

2) Genetic " :- affects reproductive cells, therefore affects future generations.

Exposure

unit :- Roentgen (R)

x-ray or γ-ray → air

• 1 R :- amount of x-ray or γ-ray radiation that deposits 0.878×10^{-2} J of energy per Kg of air.

Absorbed dose :: The energy deposited per Kg in any medium by any nuclear radiation.

AD unit → Gray
1 J/Kg

radiation absorbed dose
Rad   0.01 J/Kg

Gray = 100 Rad

* 50 Kg → AD = 2 gray

Effective Dose :- ← Quality factor

→ ED = AD × QF

takes into account the amount of damge to biological Cells

• Units :-

AD	ED
gray →	siavert
rad →	rem

Radiation type	QF
x-ray, γ-rays	1
β±, fast protons	1
slow neutrons	3
α-particles	20

normal population $5\ \underbrace{mSv}_{\text{millisevert}}$ / year (max. allowed)

X-ray worker 50 mSv/year

$\boxed{38}$ 1rad = 0.01 J/Kg

350 of α particles

$ED_x = ED_{x,\gamma}$

$AD_\alpha QF_\alpha = AD_{x,\gamma} QF_{x,\gamma}$

$(350\ rad) \times 20 = AD_{x\gamma} \times (1)$

$AD_{x\gamma} = 7000\ rad$

$\boxed{40}$ m = 65 Kg

2.5 Gray

total $AD = 65\ \cancel{Kg} \times 2.5\ J/\cancel{Kg}$

$= 162.5\ J$

$\boxed{41}$ $E_{proton} = 1.2\ Mev.$

$m_{Tumor} = 0.2\ kg$

$ED = AD \times QF$

1rem = AD × 1

AD = 1rad = 0.01 J/Kg

How many protons?

Obsorbed energy by tumor = 0.2 × AD

= 0.2 Kg × 0.01 J/kg = 0.002 J

$n_p = \frac{0.002\ J}{(1.2 \times 10^6)(1.6 \times 10^{-19}\ \frac{J}{Proton})} \approx 1.04 \times 10^{10}$ protons

$\boxed{44}$ 16 mCi of $^{32}_{15}P$

32 Grey, $t_{\frac{1}{2}} = 14.3$ days

1 mCi → 10 m Grey/min

1.6 m Ci → ? ⟹ ? = 16 mGrey/

time needed $= \frac{32\ grey}{16m\ Grey/min} = \frac{32000}{16} = 2000$ min

46 $^{57}_{27}Co$ emits 122 keV γ-radiation

$m = 65\,kg$, swallowed $1.55\,\mu Ci$ of ^{57}Co.

$A = 1.55\,\mu Ci = 1.55 \times 10^{-6} \times 3.7 \times 10^{10}$ decay/second

$= 57350$ decay/s

energy radiated per second inside his body.

$= 57350 \times (122 \times 10^{3}) \times (1.6 \times 10^{-19}) = 1.12 \times 10^{-9}$ J/s

$= 1.12 \times 10^{-9} \approx 9.677 \times 10^{-5}$ J/day

$\dfrac{1}{24 \times 60 \times 60}$ $\Longrightarrow$ $\dfrac{9.677 \times 10^{-5}\ \text{J/day} \times 0.5}{65\,kg}$

$= 7.44 \times 10^{-7}$ Grey/day