



اللجنة الأكاديمية للهندسة المدنية

دفتر

اساسيات الكيمياء العامة

زكي بطارسة

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[Jgo] ٥١٦١ ٤٤٥

Ch-3 Mass ~~collection~~ Relationship in Chemical Reaction (12XN)

International System

(SI) unit of measuring amount in
Substaine (mole)

mole: ~~Avogadro's~~ number of C^{12} atoms in
a 12 g sample.

$$= 6.023 \times 10^{23} \text{ atom}$$

avogadros. number (N_A)

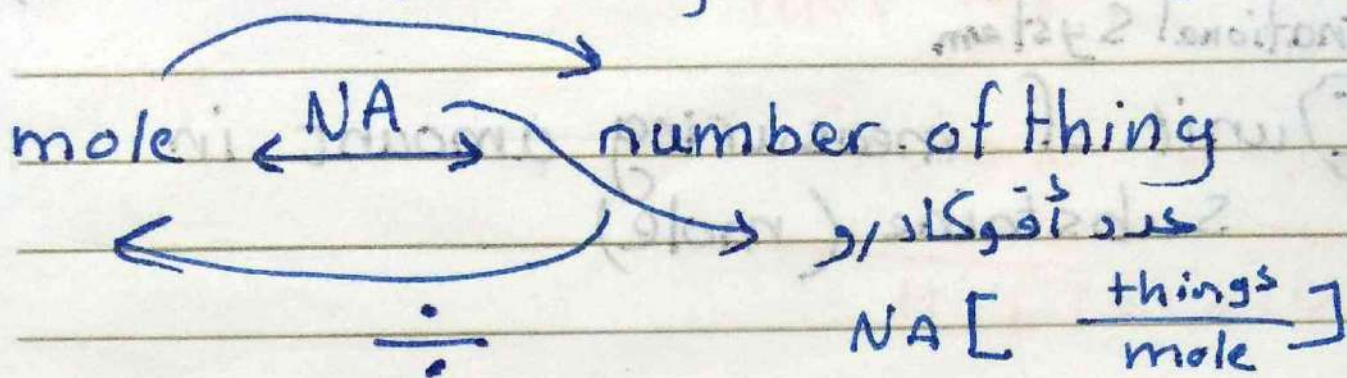
1 mole of pencint = 6.023×10^{23} pencil

1 mole of books = 6.023×10^{23} books

1 mole of Na atom = 6.023×10^{23} atoms

1 mole of H_2O molecule = 6.023×10^{23} molecule

$$\text{mole (n)} = \frac{\text{number of things}}{\text{Avogadro's number (N}_A\text{)}}$$



what is the number of moles in 6×10^9 atoms Na Sample?

$$\text{moles} = \frac{\text{Na atoms}}{N_A} = \frac{6 \times 10^9}{6.023 \times 10^{23}}$$

$$= \approx 1 \times 10^{-14} \text{ mole}$$

what the number of atoms in 0.6 mole Carbon Sample?

$$\text{Number of atoms} = 0.6 \text{ mole} \times N_A$$

$$= 0.6 \times 6.023 \times 10^{23}$$

atom $\rightarrow$

(M.M)

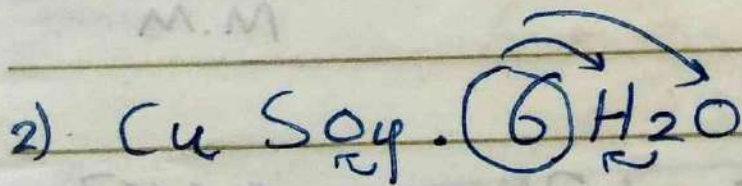
Molar Mass : the mass of one mole of Substance.

(12) → عدد ذري (بروتونات)
 (6) ← عدد ذري (بروتونات)
 وحدة

$$\text{molar mass of C} = 12 \left[\frac{\text{g}}{\text{mole}} \right]$$

calculate (M.M) of H_2O using periodic table

$$\begin{aligned} 1) \text{H}_2\text{O} &= 2 \times \text{H} = 2 \times 1 = 2 \\ &1 \times \text{O} = 1 \times 16 = 16 \\ &= 2 + 16 = \boxed{18} \text{ g/mol} \end{aligned}$$



$$\text{Cu} = 1 \times \text{Cu} \quad 1 \times 63.5$$

$$\text{S} = 1 \times \text{S} \quad 1 \times 32$$

$$\text{O}_4 = 4 \times \text{O} \quad 4 \times 16$$

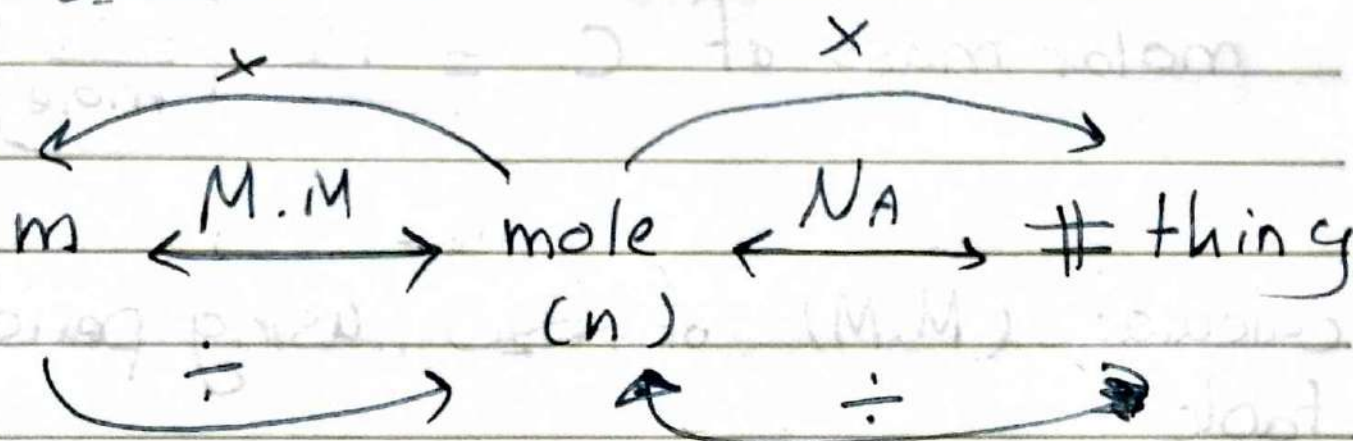
$$6 \times (\text{H}_2 = 2 \times \text{H}) \quad 12 \times 1$$

$$6 \times \text{O} = 6 \times 16$$

$$M.M = \frac{\text{mass}}{\text{moles}}$$

$$M.M = \frac{m}{n}$$

تحويل
مقابل



Calculate number of moles in 12 g H_2O

$$M.M = \frac{m}{n} \rightarrow n = \frac{m}{M.M}$$

$$= \frac{12g}{18g/mol} = 0.6667 \text{ mol}$$

Subject _____

Day _____

Date _____ # thing

calculate the mass of 7×10^9 molecules
 $\text{Ca}(\text{NO}_3)_2$

$$n = \frac{\# \text{ things}}{N_A}$$

$$n = \frac{7 \times 10^9}{6.023 \times 10^{23}}$$

$$n = 1.162 \times 10^{-14}$$

$$M.M = \frac{m}{n}$$

$$n * M.M = \text{mass}$$

$$M.M = 1 * \text{Ca} = 40 * 1$$

$$\frac{\text{g}}{\text{mole}} * \text{mole} \quad 2 * \text{N} = 14 * 2$$

$$6 * \text{O} = 6 * 16$$

$$164$$

$$m = 190.56 \times 10^{-14}$$

g

Converge amount between (2) Substance or more.

Using stoichiometric equivalence ration (mole ration).

(1)
in a chemical formula.
or in chemical reaction.

(2)

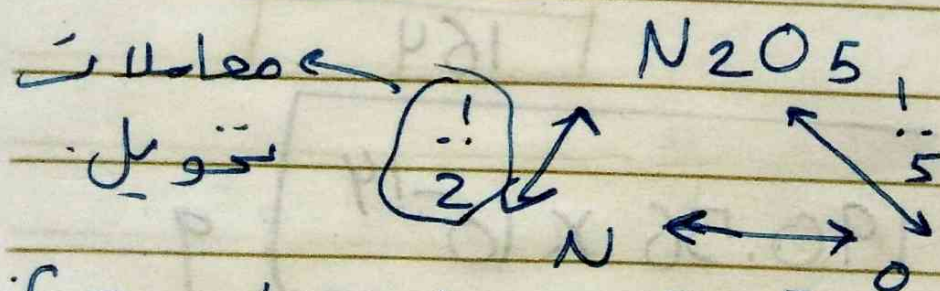


(1) chemical formula.

2 mole N : 5 mole O

2 mole N : 1 mole of N_2O_5

5 mole O : 1 mole of N_2O_5



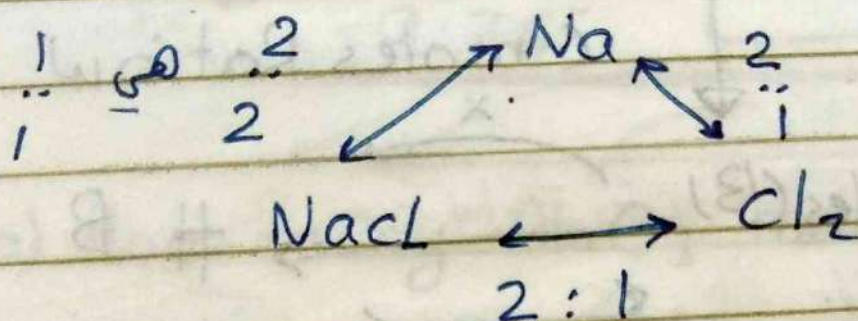
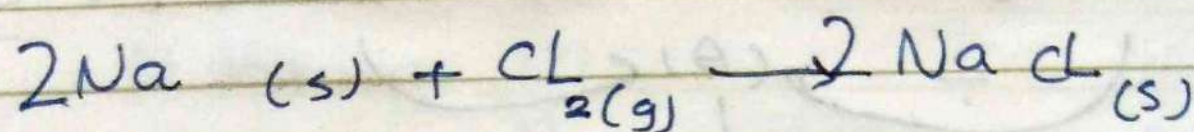
if Sample contain 0.2 mole N how many

1) O mole = $0.2 \times \frac{5}{2} = 0.5$

2) N_2O_5 moles = $0.2 \times \frac{1}{2} = 0.1$

Balanced Reaction

(2) Chemical (RXN)



if 0.3 mol mole reacted Cl_2

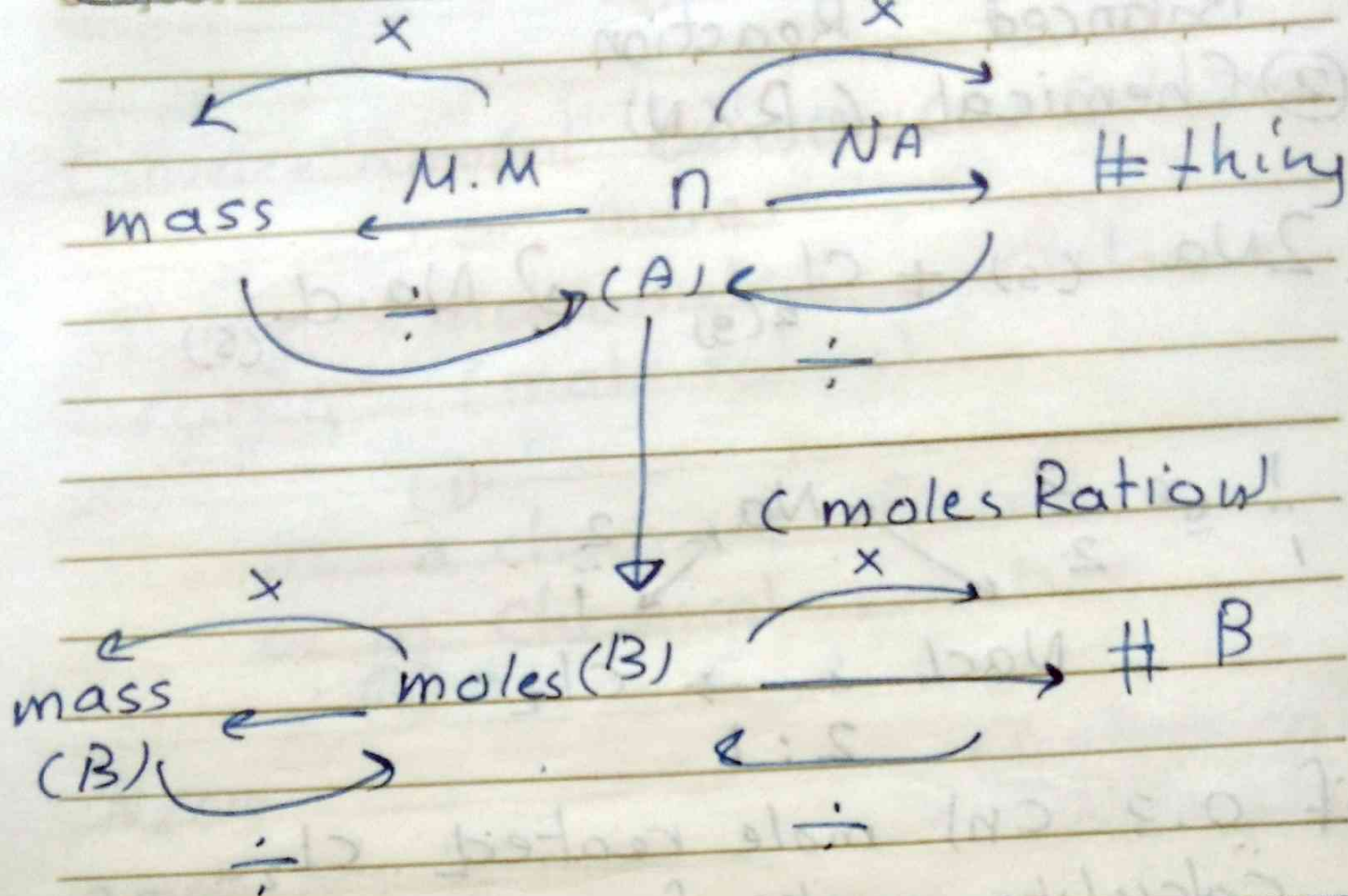
Calculate moles of = $2 \times 0.3 = 0.6$ mole

= NaCl mole = $2 \times 0.3 = 0.6$ mole.

mole (n)
(A)

(mole Ratio.)

mole
(B)



How many grams produce of Al_2O_3 when 41.5 g AL Reacted?

$$\text{(AL)} \quad \frac{\text{mass}}{\text{M.M.}} = \frac{41.5 \text{ g}}{27 \text{ g/mol}} = 1.53 \text{ mol AL}$$

mole Ratio

$$\text{moles} \times \left(\frac{\text{moles of } \text{Al}_2\text{O}_3}{\text{moles of } \text{AL}}$$

$$1.53 \times \frac{1}{2} = 0.765 \text{ mol } \text{Al}_2\text{O}_3$$

M.M (102)

moles of $(Al_2O_3) \rightarrow$

$$M.M = \frac{m}{n}$$

$$\frac{102}{0.765} = \frac{m}{n} \quad \boxed{\text{mass} = 78 \text{ g } Al_2O_3}$$

2) How many Al_2O_3 molecules.moles of $(Al_2O_3) = 0.765$ mole.

$$n = \frac{\# \text{ molecules}}{N_A}$$

$$\begin{aligned} \# \text{ molecules} &= 0.765 \times 6.023 \times 10^{23} \\ &= 4.60 \times 10^{23} \text{ molecules.} \end{aligned}$$

what is the number of atoms in 0.4 g Sample of $C_{11}H_{20}O_{10}$?

what is Total atoms?

Molecular and Empirical formula.

(M.F)

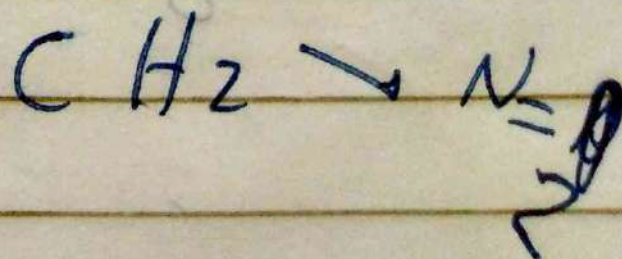
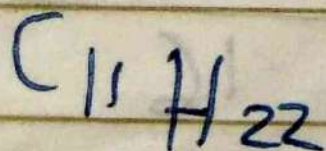
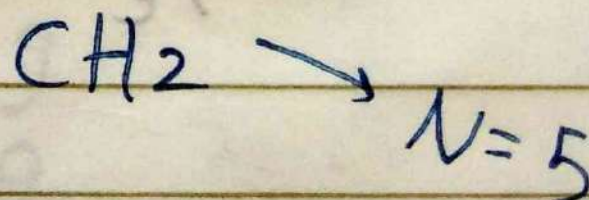
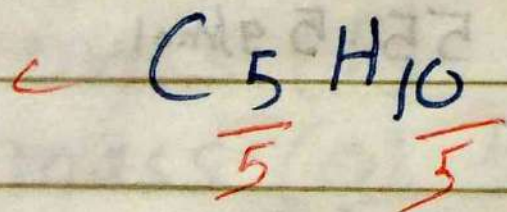
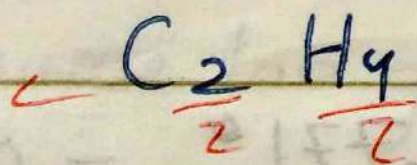
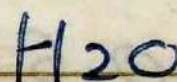
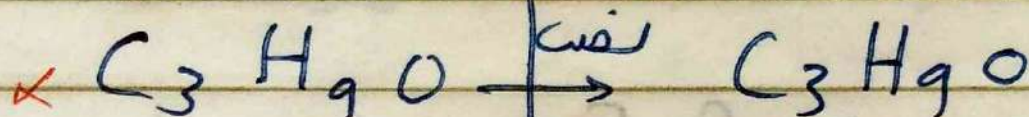
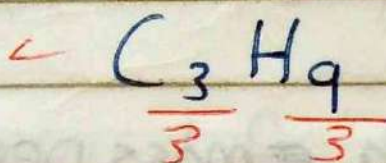
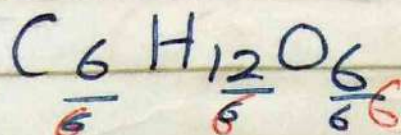
6

(E.F)

المركب / المركب

(M.F)

(E.F)



Subject

الاسماء والرقام الكيميائية

Date

number

(E.F) → Simplest whole ratio between atoms.

(M.F) → exact whole number of atoms

يشتري كوني نسبة المولات

عدد صحيح

$$(M.F) = N (E.F)$$

①

Calculate moks each atom

* E.F Calculation

1) direct Method → using mass percent

~~2)~~

A compound of Fe and O has 1.77 g Fe and 0.677 g O Calculate Empirical Formula?

$$n_{Fe} = \frac{m}{M.M} = \frac{1.771^g}{55.5 \text{ g/mol}} = 0.0317 \text{ mol}$$

$$n_O = \frac{m}{M.M} = \frac{0.677}{16} = 0.0423$$

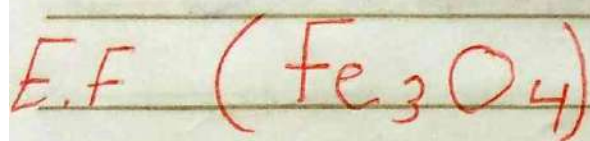
$$\begin{array}{rcl} \text{mol Fe} & : & \text{mol O} \\ 0.0317 & : & 0.0423 \\ \hline 0.0317 & & 0.0317 \end{array}$$

divid
Small

$$(1 : 1.33) \times 3$$

$$(3 : 4)$$

Mass
↓
mole



Compound of P and O has 43.64% P
and 56.36 % O ?

Mass
Percentage

$$\sum \text{Mass percent \%} = 100 \%$$

$$100 \% - 43.64 \% = 56.36 \%$$

افتراض

100 للتبسيط

Assume 100 g Sample

mass (P) 43.64 g

mass (O) 56.36 g

Subject _____

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$$n(P) = \frac{m}{M.M} = \frac{43.64}{31} = 1.409 \text{ mole}$$

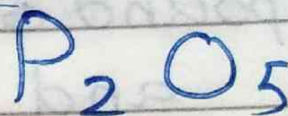
$$n(O) = \frac{m}{M.M} = \frac{56.36}{16} = 3.523 \text{ mole}$$

$$\text{mol (P)} : \text{mol (O)}$$

$$\frac{1.409}{1.409} : \frac{3.523}{1.409}$$

$$(1 : 2.5) \times 2$$

$$2 : 5$$



$$M.F = N.(E.F)$$

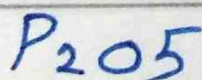
if Compound
Molar (M.M)

284 Calculate

$\boxed{M.F}$

$$\boxed{N = \frac{M.F}{N.F}}$$

$$= \frac{M.M}{M.M}$$



$$1 \times 31 + (5 \times 16)$$

$$142 =$$

$$N = \frac{284}{142} = \boxed{2}$$



E.F calculations

2. Indirect Method.

Combustion Reactions. $\rightarrow$ Hydrocarbon
(C, H)H Converts to H_2O C Converts to CO_2

+

 O_2

Combustion



$$\left[\begin{array}{l} \text{mol H} = \frac{2}{1} * H_2O \text{ moles} \\ \text{mol C} = \text{mol } CO_2 \end{array} \right]$$

A Sample of a Compound of C and H was burned and gave 7.406 g CO_2 and 4.512 g H_2O Calculate E.F?

$$n_{H_2O} = \frac{m}{M.M} = \frac{4.512 \text{ g}}{18 \text{ g/mol}} = \cancel{0.2506} \text{ mol} = 0.2506$$

$$n_{CO_2} = \frac{m}{M.M} = \frac{7.406}{44 \text{ g/mol}} = 0.1683 \text{ mol } CO_2$$

$$n(H) = 2 * \text{mol } (H_2O) \\ 2 * 0.2506 \\ = \boxed{0.509}$$

$$n(C) = \frac{1}{1} \boxed{0.1683}$$

H	:	C
0.509	:	0.1683
<u>0.1683</u>		<u>0.1683</u>

$$3 : 1$$



5.2179

Sample of a Compound C, H and O was burned and gave: 7.406 g CO_2 and 4.512 g H_2O . Calculate its E.F.??

نقطة

السؤال في

$$n_{\text{H}} = 0.509 \rightarrow \text{mass}_{(\text{H})} = n \times \text{M.M} = 0.509$$

$$n_{\text{C}} = 0.1683 \rightarrow \text{mass}_{(\text{C})} = n \times \text{M.M} = 2.0196$$

$$\text{Mass O} = 5.217 - (0.509 + 2.0196) = 2.69$$

$$\text{mass O} = 2.69 \text{ g}$$

$$n_{\text{O}} = \frac{2.69}{16} = 0.1682$$

C : H : O

$$\frac{0.1683}{0.1682} : \frac{0.509}{0.1682} : \frac{0.1682}{0.1682}$$

1 : 3 : 1

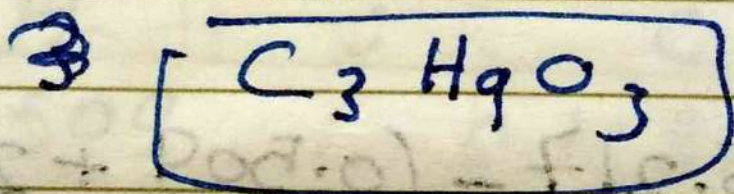
CH_3O

Subject _____ Day _____ Date _____
- If the Compound M.M 93 g/mol
Find M.F

$$N = \frac{\text{M.M. M.F}}{\text{M.M. E.F}} = \frac{\text{CH}_3\text{O}}{12 + 3 + 16 \times 1} = \frac{15 + 16}{17} = 1$$

$$\text{M.M} \times n = 93 = 31 \text{ g/mol}$$

$$N = \frac{93}{31} = 3$$



Subject _____

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(Regant)

Limiting Reactant (LR) [المحدد]

group A + group B $\rightarrow$ Team of 2
(1 person From each group)



6 person + 4 Person

excess
Regant

Limiting Reatant

6 A + 4 B $\rightarrow$ AB

$\rightarrow$ 4 teams

فالقن

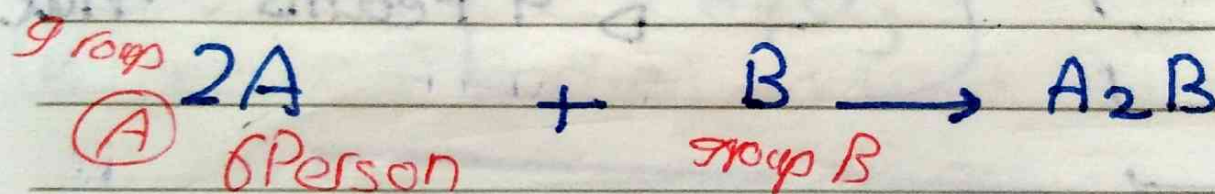
Properties

L.R 1) Completely Consumed in (RXN)

2) relatively Lower amount

3) determine the product amount and reacted amount

group A + group B $\rightarrow$ Team of 3
 (1 person B + 2 person from A)



EXCESS

The L.R is (A)

L.R

Relative amount

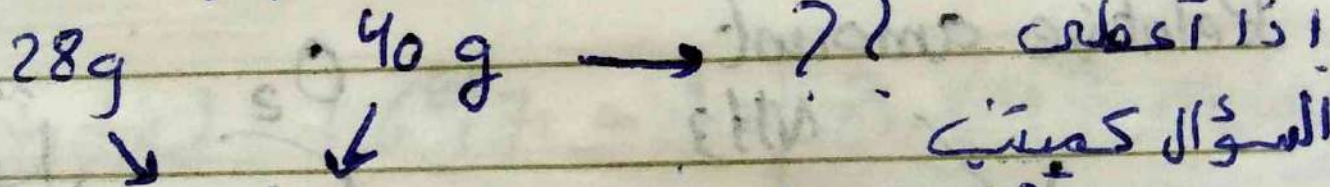
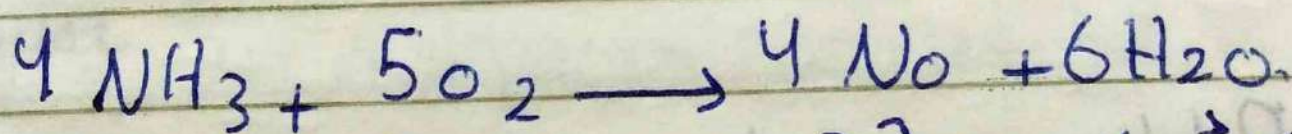
$$\frac{6}{2} : \frac{4}{1}$$

أقل نسبياً

للفرد

$$(3) : 4$$

How many grams of NO can form when 28g NH_3 and 40g O_2 react according to

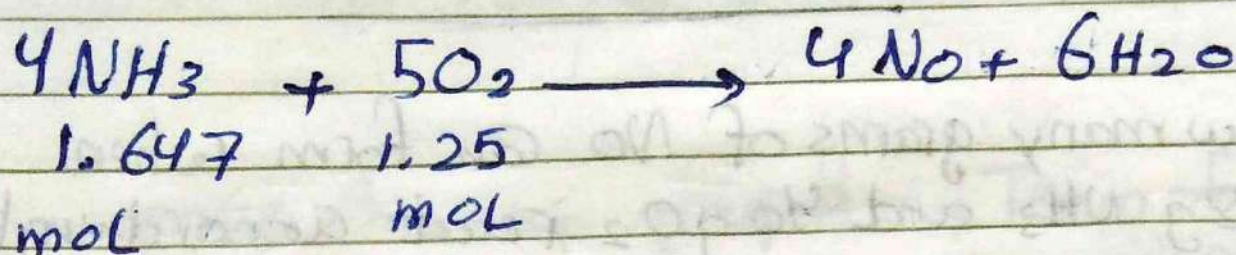


-Which one to use in calculation? (L.R.)

(need to determine L.R.)

$$n_{\text{NH}_3} = \frac{m}{M.M} = \frac{28.9}{17 \text{ g/mol}} = 1.647 \text{ mol}$$

$$n_{\text{O}_2} = \frac{m}{M.M} = \frac{40.9}{32 \text{ g/mol}} = 1.25 \text{ mole}$$



Relative amount

$$\begin{array}{c}
 \text{NH}_3 \\
 \hline
 1.647 \\
 4
 \end{array}$$

$$\begin{array}{c}
 \text{O}_2 \\
 \hline
 1.25 \\
 5
 \end{array}$$

~~to~~ Calculate using

$$n_{\text{NO}} = 1.25 \times \frac{4}{5} = 1 \text{ mol NO}$$

$$\begin{aligned}
 m &= M.M \times n = 30 \times 1 \\
 &= 30
 \end{aligned}$$

2. Calculate unreacted mass of the excess.

The excess $(\text{NH}_3) \rightarrow 1.647 \text{ mol}$

NH_3 Reacted Amount depend (L.R)

$$n_{\text{NH}_3 \text{ Reacted}} = 1.25 \times \frac{4}{5} = 1 \text{ mol NH}_3$$

$$\text{unreacted } 1.647 - 1 = \boxed{0.647 \text{ moles}}$$

$$m_{\text{unreacted}} = M.M \times n$$

$$= 0.647 \times 17$$

$$= 10.99 \text{ g}$$

$$1 \times 17 = 17 \text{ g}$$

$$28 - 17 = 11 \text{ g}$$

الحدود النسبية
 percentag yield (% yield)
 باختبر معطاة بال (g)

$$\% \text{ Yield} = \frac{\text{Actual Yield} \times 100\%}{\text{Theoretical yield}}$$

النظري

↓ By Calculation

Actual < Theoretical

Actual

In the previous example is 25 No was

produced Calculate percent yield?

we calculate Theoretical (30)

$$\frac{25}{30} \times 100\%$$

$$\boxed{83.3\%}$$

[Ch. 5 Gases]

Interchangeable physical properties of gases?
 خاصية property unit

1- Volume (V)	$\text{mL, L, m}^3, \text{cm}^3$ $1\text{L} = 10^3\text{mL} = 10^3\text{cm}^3$
2- pressure (P)	atm, torr, mm Hg $1\text{atm} = 760\text{torr}$ $\text{torr} = \text{mmHg}$
3- Temperature (T)	kelvin (K) $K = 273.15 + C^\circ$
4- mole (n)	mol

1- Boyle's Law (P) (V)
 Relation between (pressure, volume) at const
 (T) and (n)

$$P \propto \frac{1}{V} \quad \text{and} \quad V \propto \frac{1}{P}$$

$$\frac{P_1 V_1}{\cancel{T_1}} = \frac{P_2 V_2}{\cancel{T_2}}$$

2. Charles's law

relation between (V and T) at Const
(p and n)

$$\text{ثابت } \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$V \propto T$$

علاقة طردية

مع ثبات الباقي

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

3. Gay-Lussac's Law

relation between p and T at constant
 V and n

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$P \propto T$$

علاقة طردية

مع ثبات الباقي

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Combined gas Law

$$p \propto \frac{T}{V}$$

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

$$T \propto pV$$

فيلوسوفيا غازات حبابية

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

at Constant mole (n)

$$k = \frac{PV}{T}$$

Same unit

$$k = \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} = \frac{P_3 V_3}{T_3} \dots$$

(must be in kelvin)

A Sample of Gas has pressure at 0.5 atm at 25 °C what is pressure in torr at 80 °C.

$$\frac{P_1 \cancel{V_1}}{T_1} = \frac{P_2 \cancel{V_2}}{T_2}$$

$$25^\circ + 273 = 298 \text{ K}$$

$$80 + 273 = 353 \text{ K}$$

$$\frac{0.5 \text{ atm}}{298 \text{ K}} = \frac{P_2}{353 \text{ K}}$$

$$P_2 = 0.6 \text{ atm}$$

$$= 0.6 \times 760$$

$$= 456 \text{ torr}$$

5- avogadro's principle.

Relation between V and n at constat.
 p and T

$$V \propto n$$

$$n \propto V$$

$$k = \frac{V}{n}$$

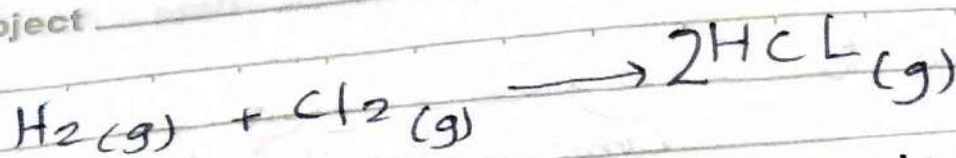
$$V = k \cdot n$$

$$k = \frac{V_1}{n_1} = \frac{V_2}{n_2} = \frac{V_3}{n_3}$$

So

$$\frac{V_1}{V_2} = \frac{n_1}{n_2}$$

→ mole
Ratio



1 mol H_2 : 1 mol Cl_2 : 2 mol HCl

Volume Ratio

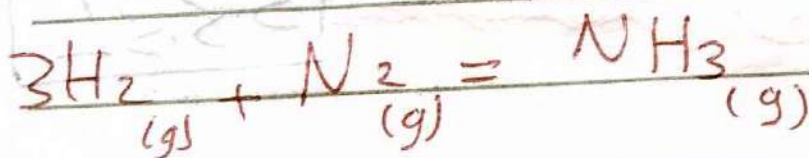
1 L H_2 : 1 L Cl_2 : 2 L HCl

if 0.3 L H_2 Reacted what is HCl volume produce

$$(V) \text{HCl} = \frac{2}{1} * (V) \text{H}_2$$

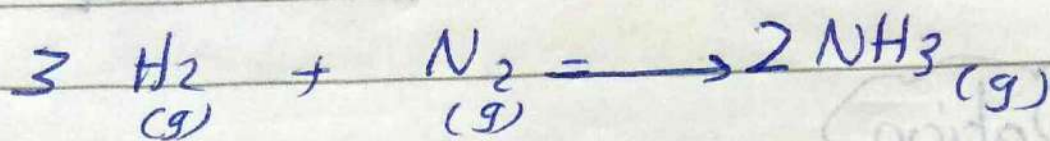
$$= \boxed{0.6 \text{ L}}$$

(HCl)



if 50 L H_2 Reacted with 20 N_2 Calculate NH_3 volume produce.

we have to حدد المتفاعل المحدود
 Limit Reactor المحدود المتفاعل



50 L 20 L

(1) Relative mass

$$\frac{50}{3} < \frac{20}{1}$$

$$16.6 < 20$$

$$V_{\text{NH}_3} = 50 \times \frac{2}{3} = \cancel{16.6}$$

$$33.3 \text{ L}$$

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$$V \propto \frac{n \cdot T}{P}$$

$$V = R \frac{n T}{P}$$

لا يوجد تقريب

$$V \cdot P = n R T$$

Ideal gas Law

universal gas constant
ثابت الغازات العالمية

$$R = \frac{PV}{nT}$$

atm

mol

k

$$\frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2}$$

بما أن الثابت عالمي

$$R = 0.0821 \left[\frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{kelvin}} \right]$$

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$$\text{كثافة الغاز} = \frac{m}{M.M} = \frac{PV}{RT} \rightarrow \text{only for gasses}$$

↓
in general

(S.T.P) Standard Temperature and pressure

$$T = 0^{\circ}C = 273 \text{ kelvin}$$

$$P = 1 \text{ atm} = 760 \text{ torr}$$

Standard Molar volume

Volume of 1 mol gas at STP

$$V = \frac{nRT}{P} = \frac{1 \times 0.0821 \times 273}{1} = 22.4 \text{ L/mol}$$

لتر لكل مول

$$\text{if 2 moles} = 2 \times 22.4 = 44.8$$

$$\text{or 0.5 mole} = \boxed{11.2}$$

Volume Ratio

نسبت حجم

حجمی نسبت

Subject

Day

Date

Liters

How many of N_2 gas are produced at STP when 150 g in NaN_3 react as



mole Ratio

$$V = \frac{nRT}{P}$$

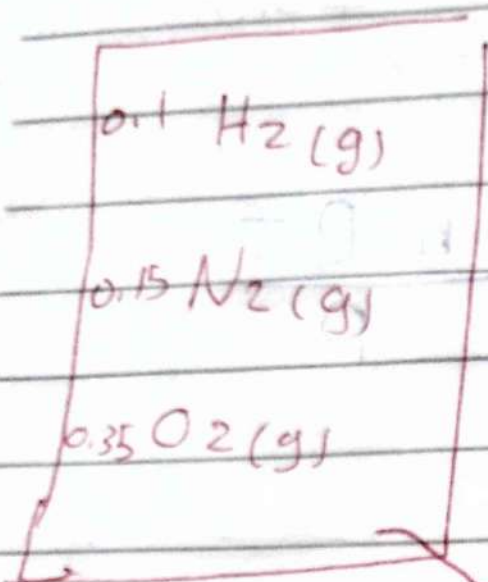
$$n = \frac{m}{MM} = \frac{150}{65} =$$

2.3 mol NaN_3

$$n_{(N_2)} = 2.3 \times \frac{3}{2} = 3.46 \text{ moles}$$

$$V = \frac{(3.46)(0.0821)(273)}{1} = 77.5 \text{ L}$$

Dalton's partial pressure



$$P_{\text{Total}} = \sum \text{partial pressure}$$

$$P_{\text{Total}} = P_{\text{H}_2} + P_{\text{N}_2} + P_{\text{O}_2}$$

$$= 0.6 \text{ atm}$$

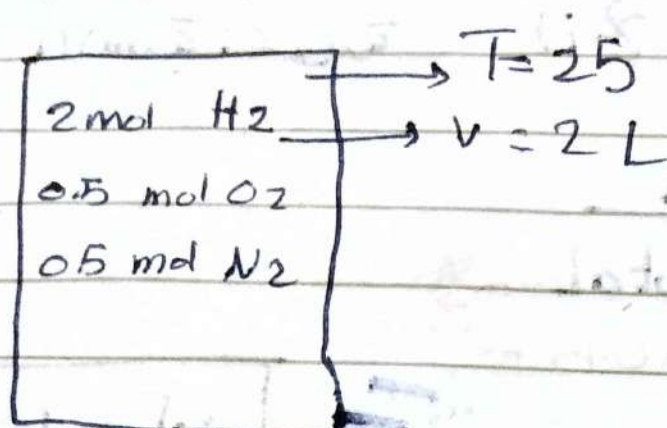
Same container Temperature
Same for all gases.

and V is same for all
gasses

- 1) Same Temperature
- 2) Same Volume.

$$P_{\text{Total}} = \frac{n_{\text{Total}} R T}{V}$$

V



$$P_{total} = \frac{n_{total} RT}{V}$$

$$\frac{(1 + 0.5 + 0.5) \times 0.0821 \times (298)}{2}$$

$P_{total} = 36.7$

 atm

$$P_{H_2} = \frac{n_{H_2} RT}{V} = \frac{1 \times 0.0821 \times 298}{2}$$

$$P_{Total} = \sum \text{Partial pressure} = \text{OR } \boxed{\frac{n_{total} RT}{V}}$$

mole fraction (x_i) المصفاة المولية

$$x_i = \frac{n_i}{n_{\text{total}}}$$

$0.10 + 0.15 + 0.25$

$$x_{\text{H}_2} = \frac{n_i}{n_{\text{total}}} = \frac{0.1}{0.5} = \boxed{0.2}$$

$$x_{\text{N}_2} = \frac{0.25}{0.50} = \boxed{0.5}$$

0.1 mol
H ₂
0.25 mol
N ₂
0.15 mol
O ₂

$$x_{\text{O}_2} = \frac{0.15}{0.50} = \boxed{0.3}$$

The

$$\sum x_i = 1$$

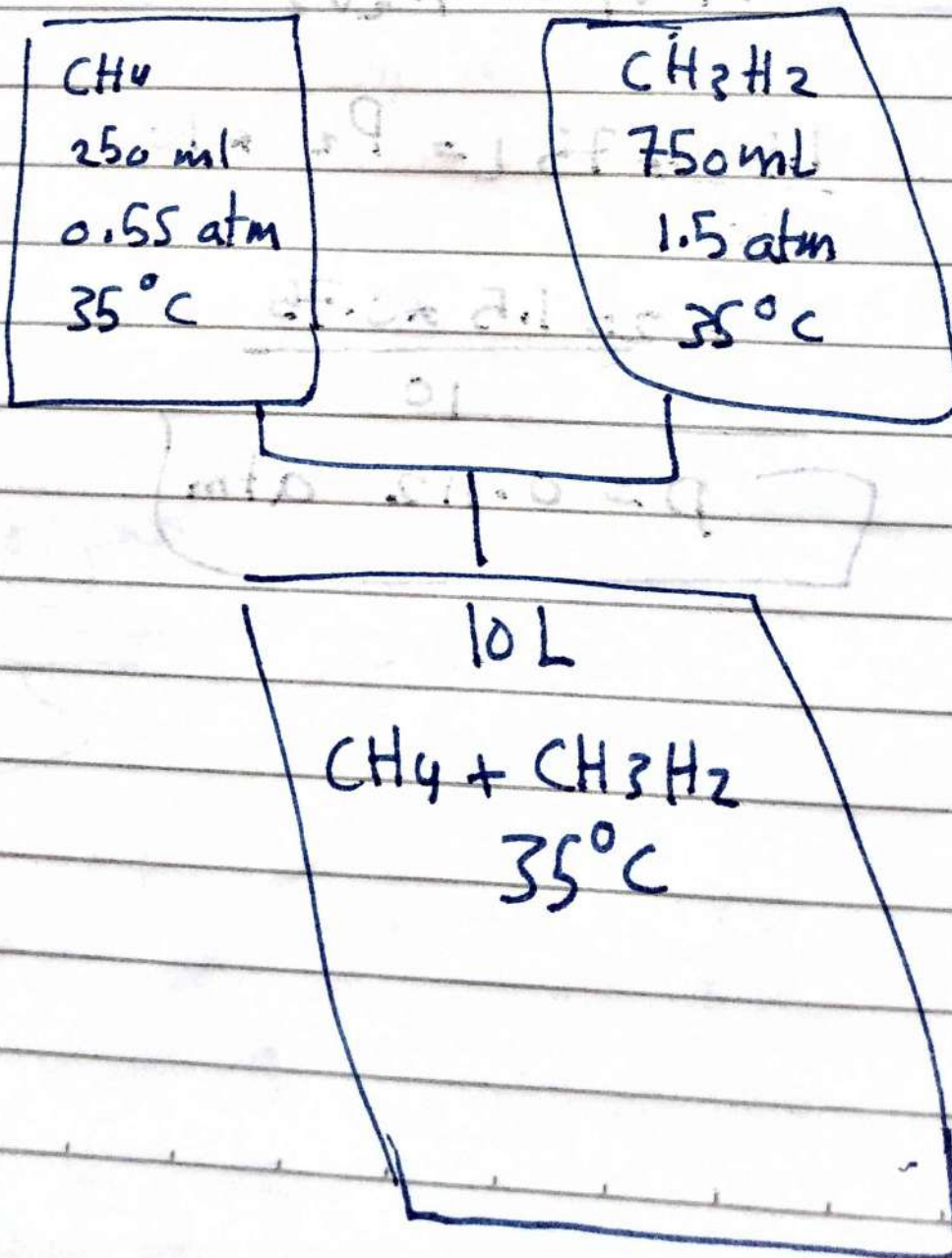
$$x_{\text{O}_2} = 1 - (0.2 + 0.5)$$

$$= 1 - 0.7$$

$$= \boxed{0.3}$$

$$x_i = \frac{n_i}{n_{\text{total}}} = \frac{P_i V}{R T} = \frac{P_i}{P_{\text{total}}}$$

250 mL CH_4 gas at 35°C and 0.55 atm and 750 mL CH_3H_2 gas at 35°C and 1.5 atm were transferred into a 10 L container. Calculate partial pressure of each gas and mole fraction.



Subject _____

Day _____

$$n = \frac{PV}{RT}$$

$$P_1 V_1 = P_2 V_2$$

$$n = \frac{PV}{RT}$$

For CH_4

$$\frac{0.55 \text{ atm} \times 0.25}{10} = 10 \times P_2$$

$$P = 0.013$$

For C_3H_8

$$P_1 V_1 = P_2 V_2$$

$$\frac{1.5}{10} \times 75 \text{ L} = P_2 \times 10$$

$$P_2 = \frac{1.5 \times 0.75}{10}$$

$$P = 0.112 \text{ atm}$$

$$X_{CH_4} = \frac{P_i}{P_{total}} = \frac{n_i}{n_{total}}$$

$$M.M = \frac{0.013}{0.013 + 0.112} = 0.1$$

$$X_{C_3H_8} = \frac{P_i}{P_{total}} = \frac{0.112}{0.013 + 0.112} = 0.9$$

$$X_{C_3H_8} = 1 - 0.1 = 0.9$$

A mixture of N_2 and O_2 gasses has pressure has pressure of 0.5 atm at $25^\circ C$ if mole fraction of N_2 is 0.35 calculate partial pressure of each gas.

المسألة

المسألة

Molar mass and density of gases.

$$PV = nRT$$

$$n = \frac{m}{M.M}$$

$$\text{density} = \frac{\text{Mass}}{\text{Volume}}$$

$$d = \frac{m}{V}$$

$$PV = \frac{m}{M.M} RT$$

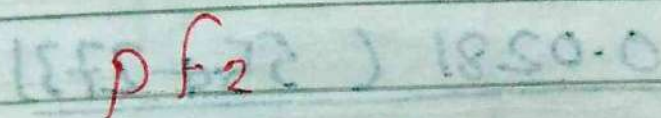
$$PV M.M = \frac{mRT}{P V}$$

$$\rightarrow M.M = \frac{mRT}{P V}$$

$$\rightarrow M.M = \frac{RTd}{P}$$

معرفة هوية كل غاز حسب M.M له

a gas of P and F has E.F PF_2
has density of 5.6 g/L at $23^\circ C$ and
750 torr Calculate M.F formula



$$31(1) + 2(19)$$

$$= 31 + 38$$

$$\frac{69}{2}$$

$$\frac{MF}{EF} = n$$

$$\frac{M.M \quad MF}{M.M \quad E.F} = n$$

$$M.M = \frac{dRT}{P} = \frac{5.6(0.028)(23+273)}{0.98 \text{ atm}}$$

$$= 138 \text{ g/mol}$$

$$= \frac{138}{69} = (2)$$

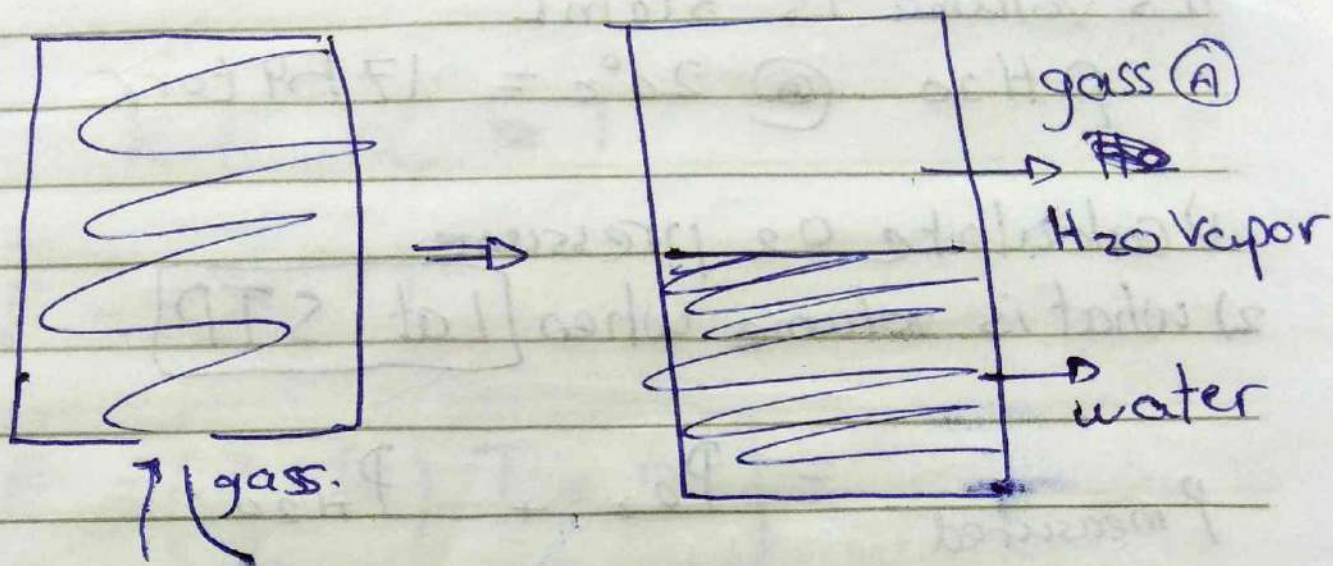
$$M.F = P_2 F_4$$

Subject _____

Day _____

Date _____

Collecting gasses over water.



$$P_{\text{measured}} = P_{\text{gas A}} + P_{\text{H}_2\text{O (g)}}$$

$$P_{\text{gas}} = P_{\text{measured}} - P_{\text{H}_2\text{O (g)}}$$

$$\underline{V_{\text{gas}}} = \underline{V_{\text{H}_2\text{O vapor}}}$$

$$\underline{T_{\text{gas}}} = \underline{T_{\text{H}_2\text{O vapor}}}$$

Sample of O_2 gas is collected over water at $20^\circ C$ is and pressure of 738 torr.
It's volume is 310 mL

$$P_{H_2O} @ 20^\circ C = 17.54 \text{ torr}$$

- 1) calculate O_2 pressure
- 2) what is volume when 1 at STP

$$P_{\text{measured}} = P_{O_2} + P_{H_2O}$$

$$738 = P_{O_2} + 17.54$$

$$\boxed{P_{O_2} = 720.46 \text{ torr}}$$

$$\text{partial } \chi_{O_2} = \frac{P_{O_2}}{P_{\text{Total}}} = \frac{720.46}{738}$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\boxed{V = 274}$$

Kinetic Theory of gases.
Kinetic Energy of gases (K.E)

$$K.E \propto T$$

$$K.E = K \cdot T$$

$$K.E = \left(\frac{3}{2} R \right) T \cdot n$$

$$1 \text{ atm} \cdot L = 101.3 \text{ J}$$

$$R = 8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}}$$

$$R = 0.0821 \frac{\text{atm} \cdot L}{\text{mol} \cdot \text{K}}$$

$$K.E = \frac{1}{2} m u^2$$

$\downarrow$ mass $\downarrow$ Speed

$$\frac{1}{2} m u^2 = \frac{3}{2} R T \cdot n$$

$$\therefore 3 R T = M M u^2$$

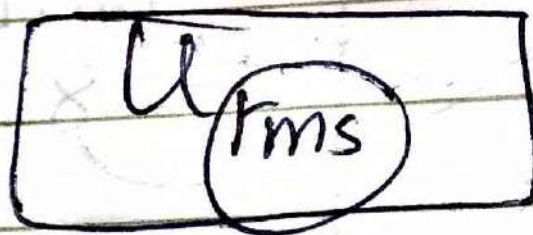
$\bar{u} \Rightarrow$ avg. velocity

$$\bar{u}^2 = \frac{3RT}{M.M}$$

Mean
Square
Speed.

$$u = \sqrt{\frac{3RT}{M.M}}$$

root
mean
square
Speed.

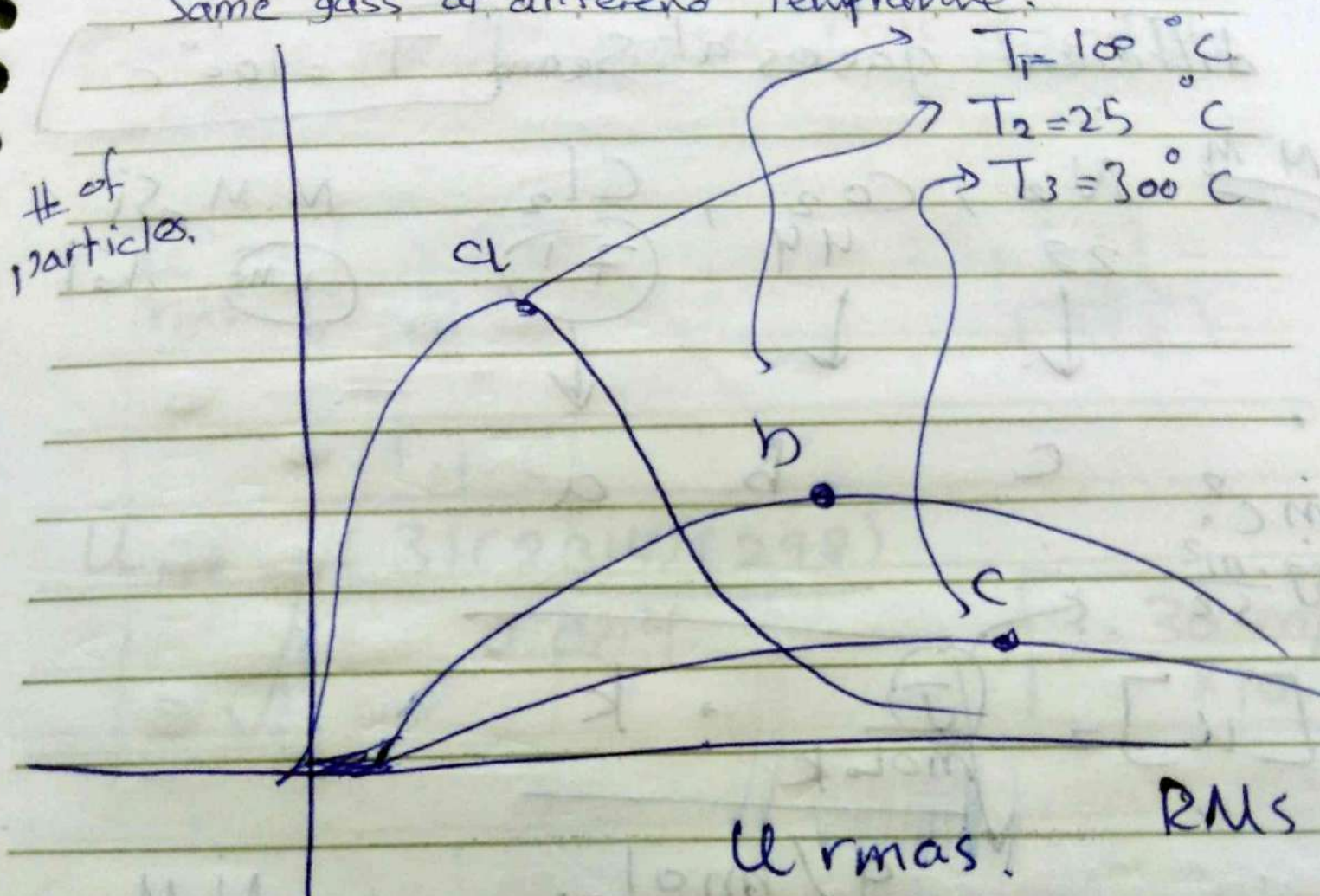


Subject _____

Day _____

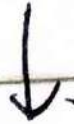
Date _____

Same gas at different Temperature.



different gases at same $T = 100^\circ \text{C}$ M.M Ne

28



c

 CO_2

44



b

 Cl_2

(71)



a

M.M, Si

(rms)

اقل

$$= m c^2$$

$$= \text{kg} \cdot \frac{\text{m}^2}{\text{s}^2}$$

$$[u] = \frac{\text{J}}{\text{mol} \cdot \text{K}} \cdot \text{K}$$

g/mol.

 kg/mol

M.M

بزرگتر

1000

1000 سے

$$[u] = \text{m/s}$$

Subject _____ Day _____ Date _____

Calculate He, N₂ gasses rms Speed at 25°C.

$$\overline{u}_{rms} = \sqrt{\frac{3RT}{M.M}}$$

$$25 + \frac{273}{25} = \boxed{298}$$

$$u_{He} = \sqrt{\frac{(3)(8.314)(298)}{0.004}}$$

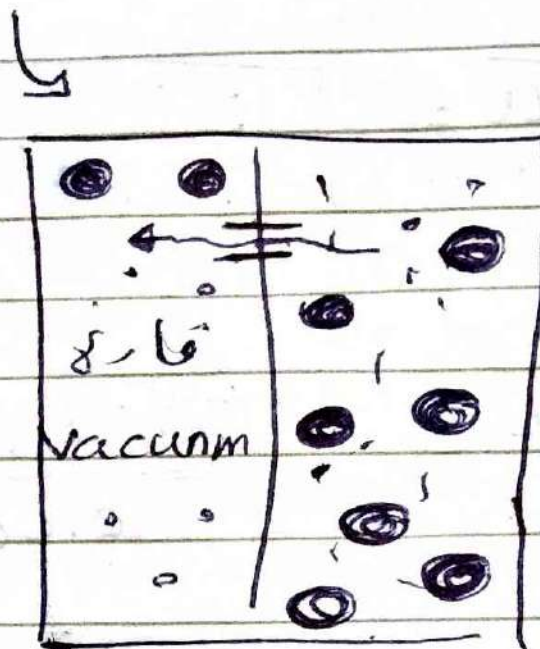
$$= \boxed{1.36 \text{ m/s} \times 10^3}$$

$$u_{rms} = \sqrt{\frac{(3)(8.314)(298)}{28 \times 10^{-3}}}$$

$$= \boxed{515 \text{ m/s}}$$

~~_____~~

Graham's Law of Diffusion and Effusion.



gas (A) and gas (B)

$$\frac{\text{rate of effusion (A)}}{\text{rate of effusion (B)}} = \frac{U_{rms} A}{U_{rms} B}$$

$$= \frac{\sqrt{\frac{3RT}{M \cdot M_A}}}{\sqrt{\frac{3RT}{M \cdot M_B}}}$$

$$\frac{\sqrt{3RT}}{M \cdot M_B}$$

$$\sqrt{\frac{M \cdot M_B}{M \cdot M_A}}$$

a gas effuses 2 times faster than Cl_2 gas at 25°C . Calculate M.M of the gas.

$$\frac{u_{\text{rms gas X}}}{u_{\text{rms Cl}_2}} = \sqrt{\frac{\text{M.M Cl}_2}{\text{M.M X}}}$$

$$2 = \sqrt{\frac{71}{\text{M.M}}}$$

$$4 = \frac{71}{\text{M.M}}$$

$$4 \text{ M.M} = \frac{71}{4} \quad \boxed{\text{M.M} = \frac{71}{4}}$$

Subject

$$M.M = 16$$

Day

Date

it takes CH_4 gas 3 minutes to diffum 10M
 How it will take SO_2 gas to Defuse to
 travel same distanz? $\{M.M = 64\}$

$$\frac{U_{\text{rms CH}_4}}{U_{\text{rms SO}_2}} = \sqrt{\frac{M.M_{\text{SO}_2}}{M.M_{\text{CH}_4}}}$$

$$\frac{0.2}{U_{\text{rms}}}$$

$$= 2$$

CH_4 is 2 times
 faster than SO_2

$$2 U_{\text{rms}} = \frac{0.2}{2} = 0.1$$

$$\frac{10}{t} = \frac{10}{0.1t}$$

$$t = 6 \text{ minute}$$

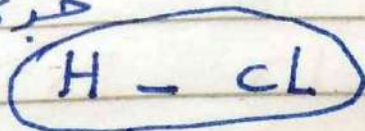
Subject _____

Day _____

Date _____

Chapter 12 Inter molecular force (IMF)

جزيء



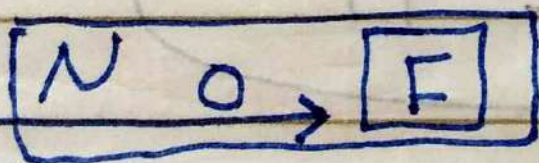
(IMF)



[electronegativity] E.N كهروسلبية

How strong an atom attracts electronic.
towards it self.

أعلى



periodic
table.

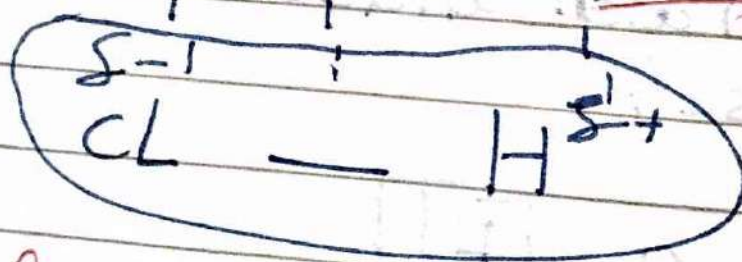
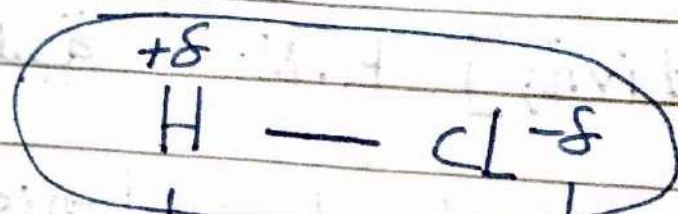
p s

↑ Cl

$H \text{ (Cl)}$ $\rightarrow$ Higher E.N
higher $\bar{e}$ density

δ^+ δ^-
 $H \text{ Cl}$

$\downarrow$ $\downarrow$ partly negative
partly positive.



جاذبه

$(\delta^+ \delta^-)$

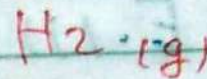
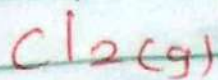
IMF forces) Types

جاذبه قطبيه

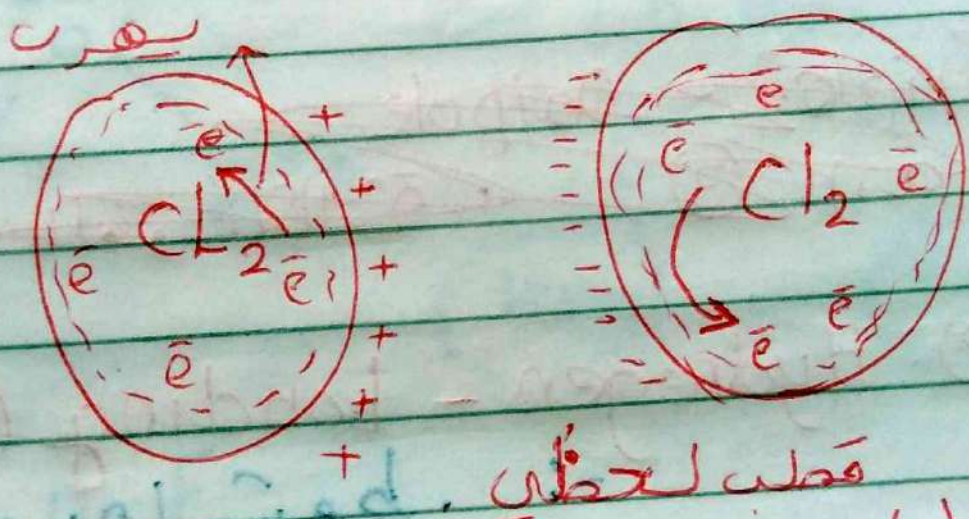
1- dipole - dipole

(D-D)

between polar molecules with different
(E.N)



② London dispersion forces (L.d.F)



Instantaneous (dipole moment)

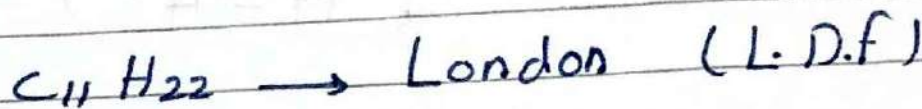
بين جزيئات غير القطبية مع بعضها
($\text{H} - \text{H}$) ($\text{Cl} - \text{Cl}$)

between Same E.N (لفظ كمرسلة)

~~at~~

* all Hydrocarbons contain C & H
are non polar $\Rightarrow$ have L.D.F

$$(E.N)_C = (E.N)_H$$



قوة لندن يوجد في جميع جزيئات داخلياً
مع HCl (لديها لندن وقوة dipole).

~~1) Dipole - Dipole~~
~~القوة القطبية~~

3) Hydrogen - bonding (H - bond)
لديها شروط :-

1) one molecule has to be polar (has Dipole - Dipole)
جزيء واحد على الأقل قطبي.

2) one molecule has a high E.N atom connected ~~type~~ directly to H atom. (N, O, F)



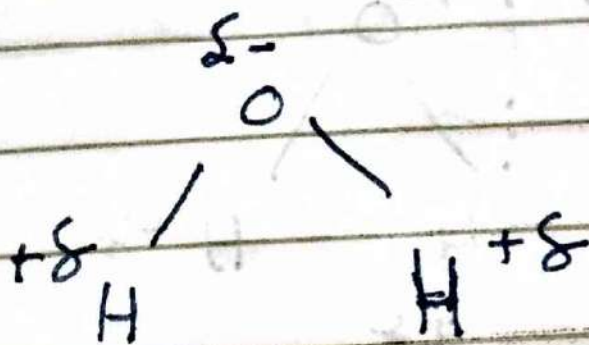
مرتبط مع H

3) The other molecule must have high (E.N) atom. (N, O, F)

مست مشروط يكون مرتبة مع (H) ! لا يكون مرتبة او غير مرتبة.

Example

(H₂O)



✓ (L.D.F)

✓ (D.D)

✓ الشرط

✓
✓
H₂O

— H₂O

1) L.D.F

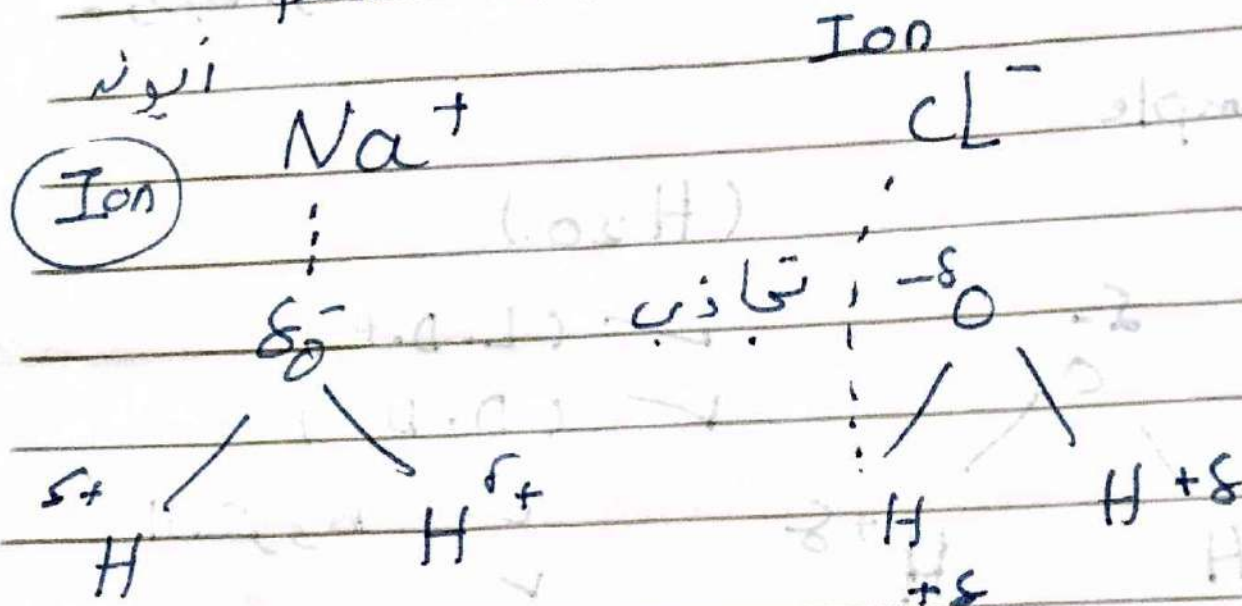
2) D.D

3) H. Bond

Force I.M.F

(4) Ion dipole I.M.F

between Ions (+ & -) and polar substance



I.M.F (Strength)

Ion dipole > H-bond > D-D > L.D.f

Determine all IMF in following and circle the Strongest one.



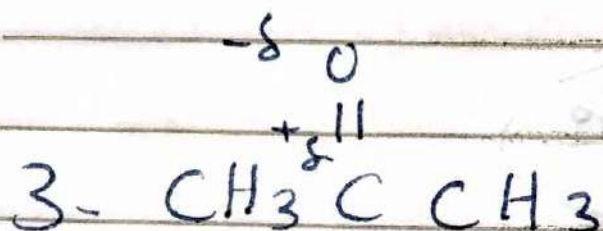
L.D.F



α - L.D.F

α - D-D

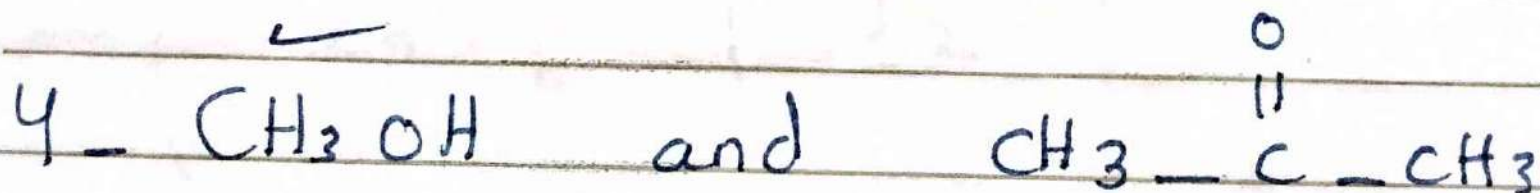
✓ - H Bond



- L.D.F

- D-D

- H Bond α



L.D.f

D-D

H Bond

(D-D)

تقوى قوتی

5. F^- / H_2O

L.D.F

Ion dipole. ✓

H-bond ✓

6. Cl^- or K^+ in H_2O

1) L.D.F

2) Ion dipole

L.D.F Strength.

M.M

I.M.F

L.D.F

$F_2(g)$

19

L.D.F

$Cl_2(g)$

35

L.D.F

$Br_2(l)$

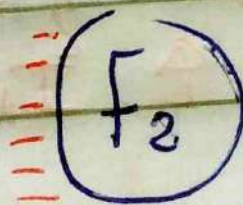
80

L.D.F

$I_2(s)$

130

L.D.F increase as $\uparrow$ mass / Size increase



physical properties that depend on I.M.F

تتطلب

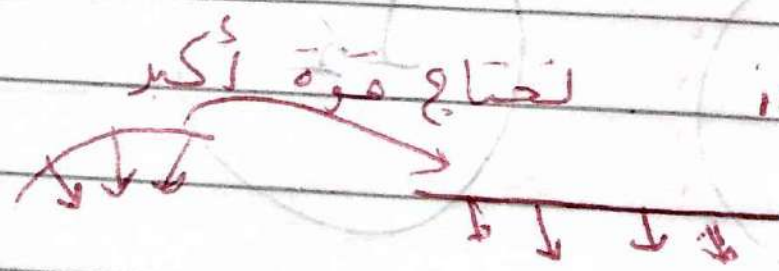
1) Vapor pressure (V.P) $\rightarrow$ as I.M.F. $\uparrow$ increasing
 $V.P \downarrow$ علاقة عكسية.

2) Boiling point (B.P) and melting point.
 كلما زادت قوة التجاذب نحتاج طاقة أكبر
 حرارية

as IMF $\uparrow \rightarrow$ B.p, M.p $\uparrow$
 (التوقف)

3) Viscosity (اللزوجة) $\uparrow$ resistance to flow
 كلما زادت لزوجة و اللزوجة IMF
 as $\uparrow$ IMF $\uparrow$ viscosity $\uparrow$

4) Surface Tension (التوتر السطحي) resistance to increase
 in surface area.



نحتاج قوة أكبر ليصبح مسطحاً

$\uparrow$ IMF $\Rightarrow \uparrow$ Surface Tension

التلصق والتلاصق

5. cohesive and adhesive Forces,

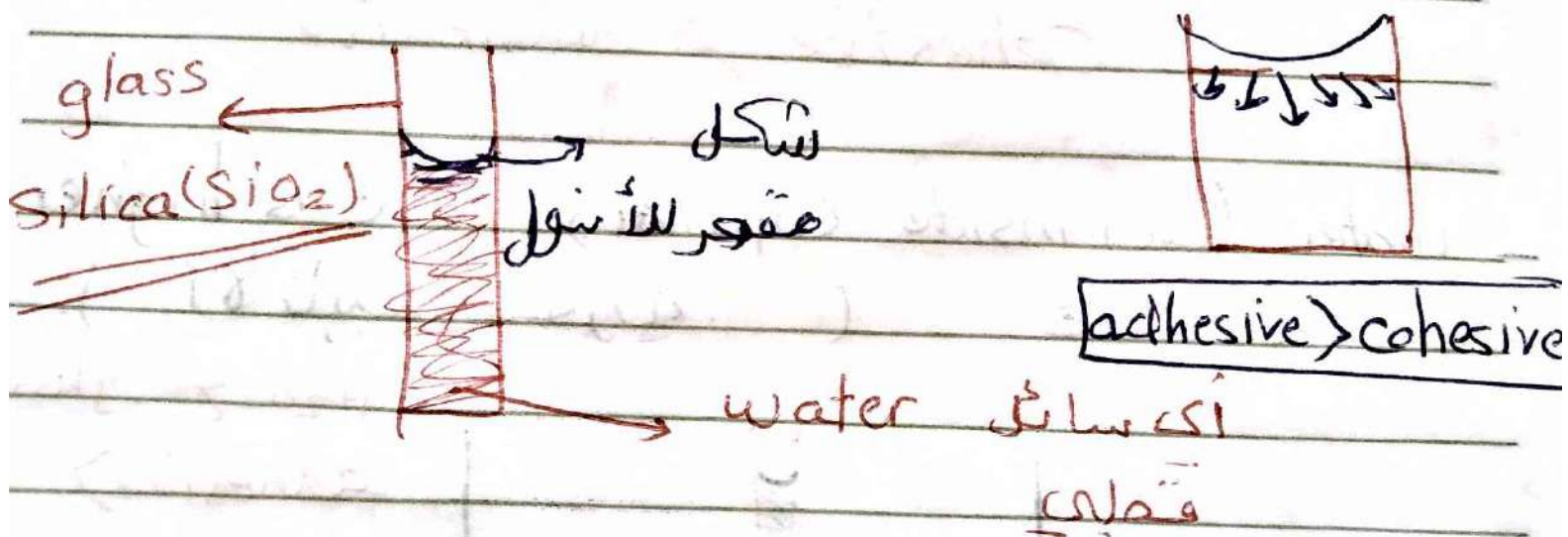
between same type of Substance

between different type of Substances.

(Cohesive and)
adhesive

التلصق والتلاصق

water form a concave meniscus in glass Tube



(cohesive)

water → water

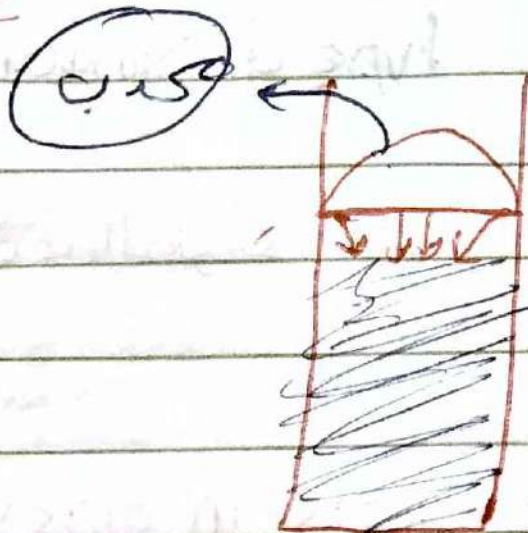
(adhesive)

water → glass

adhesive > Cohesive

زئبق سائل أو سدرب
 Mercury (Hg) Form Convex meniscus.

غير قاطبي
 غير قطبي

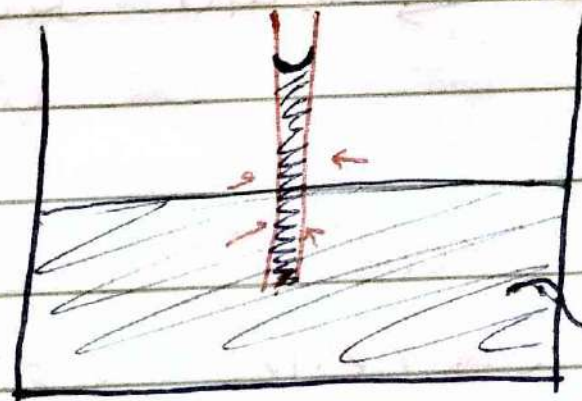


التجانس يكونه
 قاطبي مع قاطبي
 غير قاطبي مع غير قاطبي

Hg → Hg (cohesive)
 Hg → glass (adhesive)

$\text{Cohesive} > \text{adhesive}$

water Level inside Capillary tube is higher
 the out side (الارتفاع السخرية)

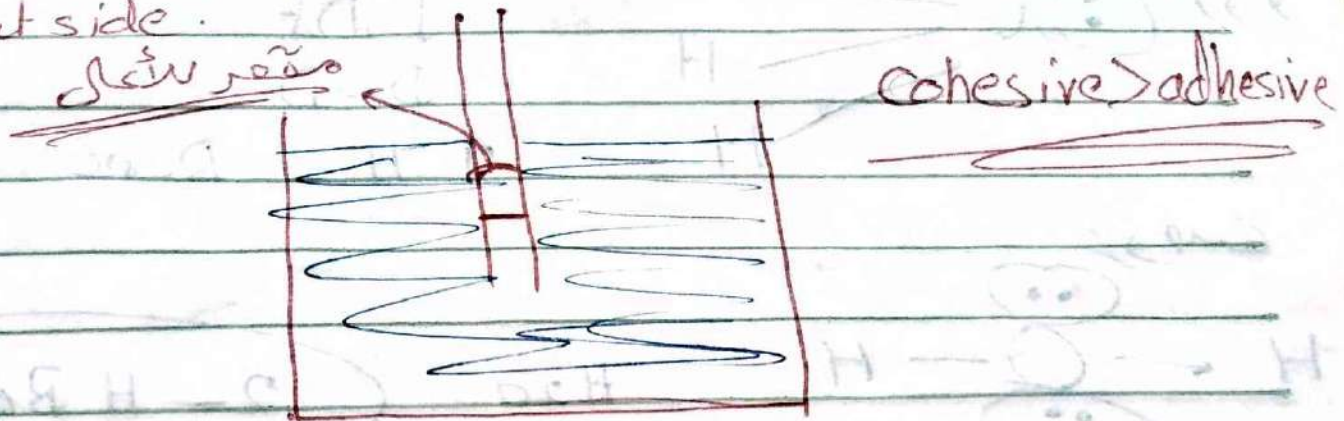


H₂O & glass
 adhesive)

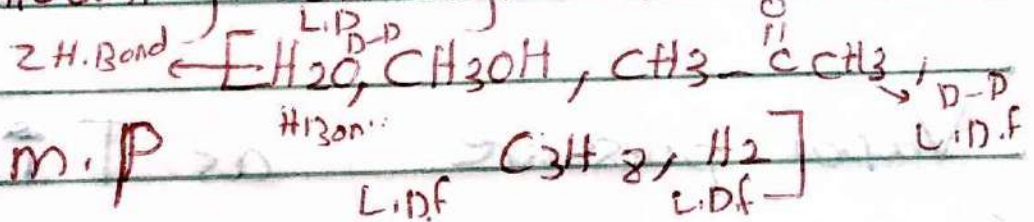
Cohesive
 H₂O - H₂O

water

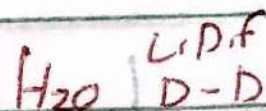
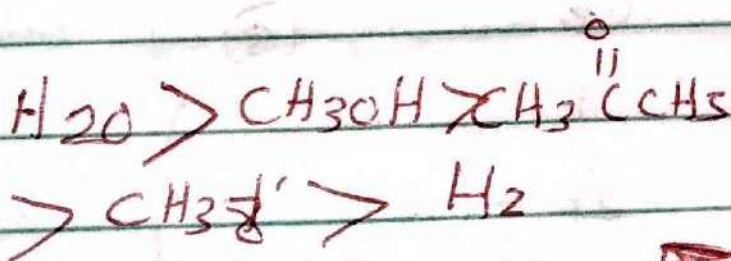
Hg level inside capiling tube is Lower than outside.



Arrange the following from highest to Lowest

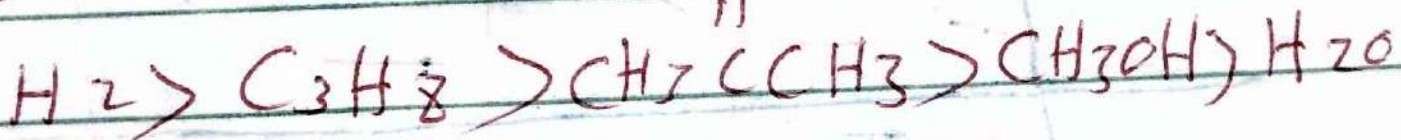


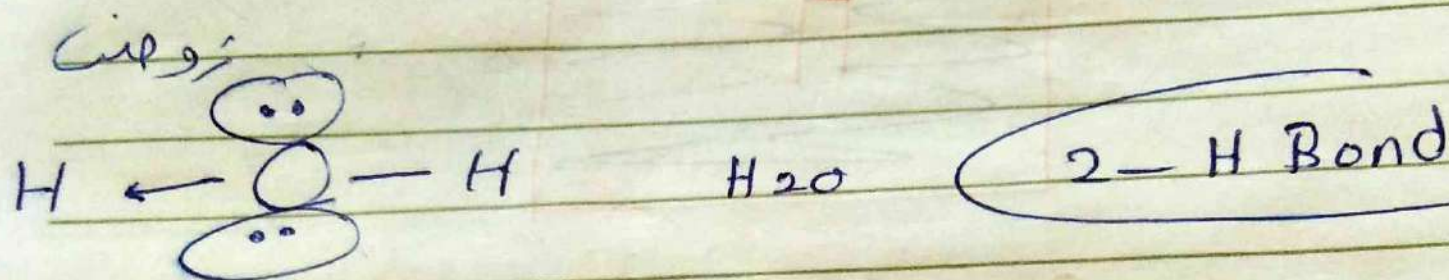
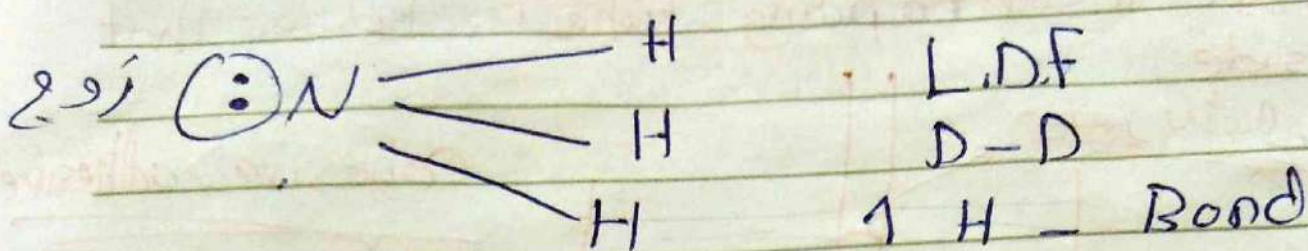
1) B.P or m.P



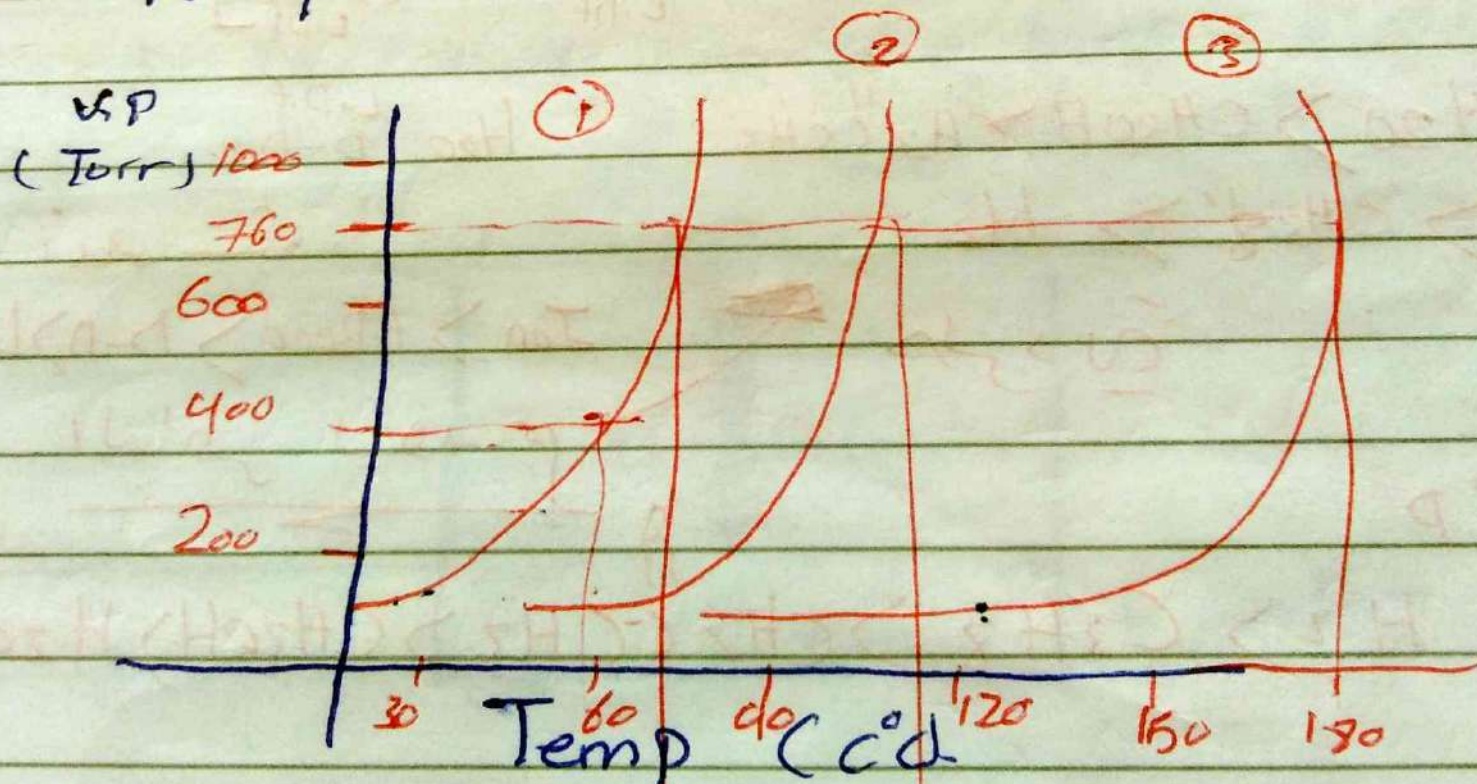
Ion > H-Bond > D-D > L.D.D
 الباقى رتبهم

V.P





Vapor pressure as $T \uparrow \Rightarrow \text{v.p} \uparrow$



كامل التظاير زاد العلية

Subject

Day

Date

Arrange from highest to Low end.

~~Boiling point~~

1) (V.P)

1 > 2 > 3

Normal Boiling Point:

→ At Normal condition $p = 1 \text{ atm}$ 760 Torr

2) (B.P)

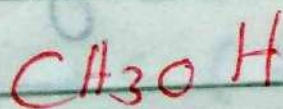
3 > 2 > 1

n-B.P (1) 60°C

(2) 110°C

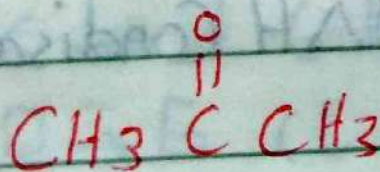
(3) 210°C

عن ظروف
الطبعة
 760°
atm



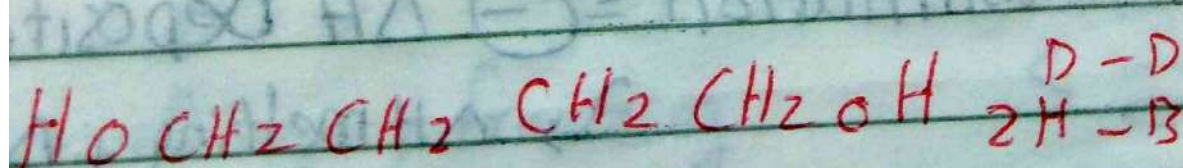
C, D, F
D-D
H-B, H

(2)



C, D, F
D-D

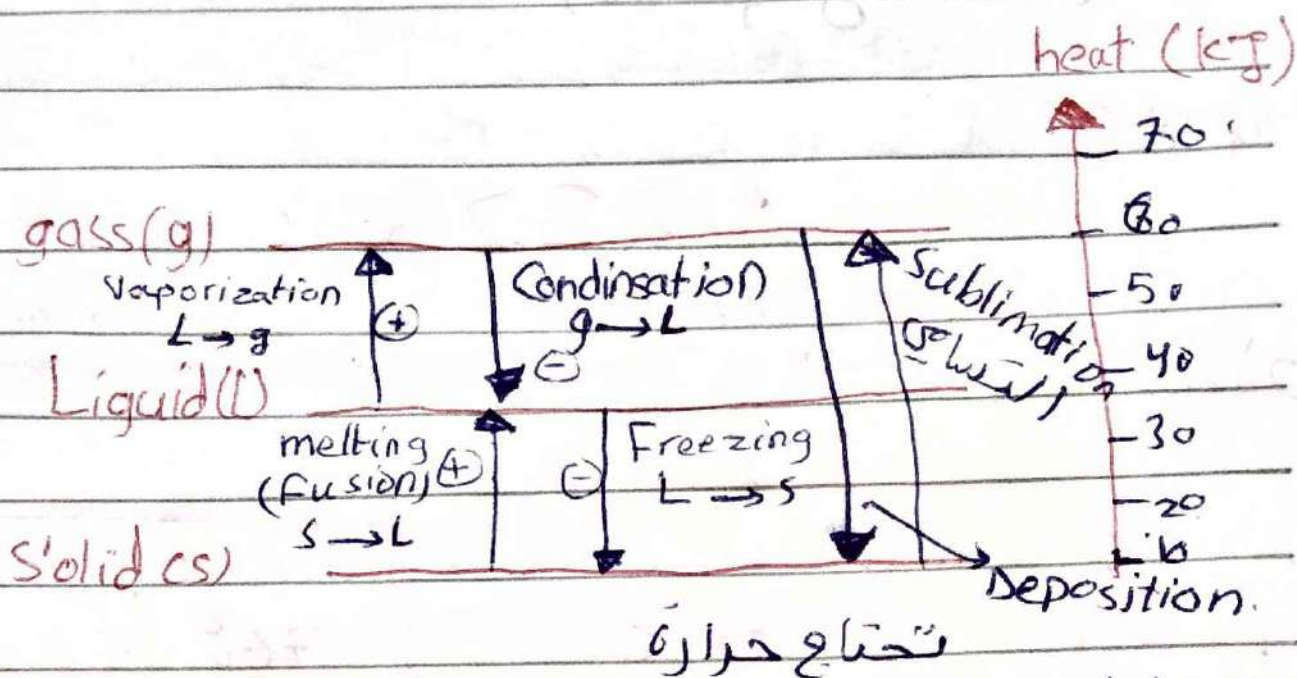
(1)



D-D
H-B

(3)

Heating and cooling curves



Heating (endothermic : absorb heat) $\Delta H (+)$
 Cooling (exothermic : release heat) $\Delta H (-)$

$$+ \Delta H \text{ melting} = - \Delta H \text{ freezing}$$

$$+ \Delta H \text{ vaporisation} = - \Delta H \text{ Condensation}$$

$$+ \Delta H \text{ Sublimation} = - \Delta H \text{ Deposition}$$

$$\rightarrow \Delta H \text{ melting} + \Delta H \text{ Vaporisation}$$

$$- \Delta H \text{ condensation}$$

$$- \Delta H \text{ freezing}$$

Subject _____ Day _____

State matter in 40°C $\rightarrow$ Liquid.
in 110°C $\rightarrow$ gas
in 0°C $\rightarrow$ S + L

2 - Determine Boiling point $\text{L} \rightarrow \text{g}$

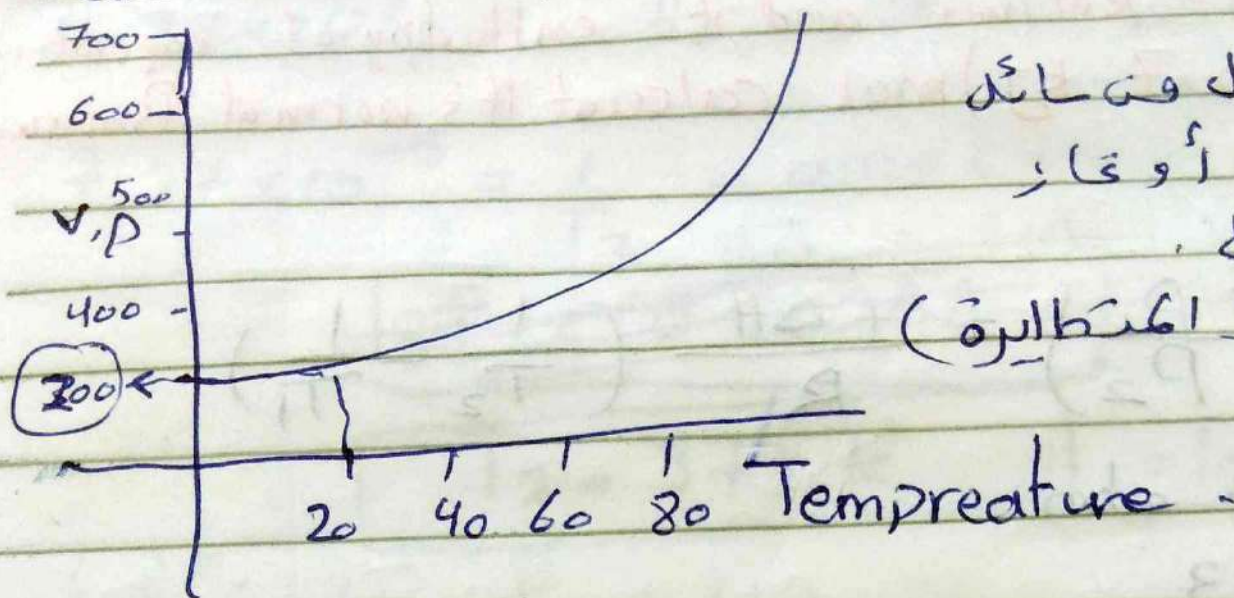
100°C

3 - Freezing point
melting point

0°C

~~hahaha~~

Clausius Clapeyron equation.



انتقال و سائده
ای غار اوقار
ای سائده
ای ابرار اخطایرة

$$\ln \frac{P_1}{P_2} = \frac{\Delta H_{vap}}{R} \left(\frac{1}{T_2} - \frac{1}{T_1} \right)$$

حاله تبخیر و غای
از P مول

vapor
pressure.

8.314 ~~kJ~~ mol.k

The vapor pressure of a liquid is 0.697 atm at 363 kelvin and its enthalpy of vaporization is 40.7 kJ/mol. Calculate its normal Boiling point.

$$\ln \left(\frac{P_1}{P_2} \right) = \frac{+\Delta H}{R} \left(\frac{1}{T_2} - \frac{1}{T_1} \right)$$

$$P_1 = 0.697 \text{ atm}$$

$$T_1 = 363$$

$$\Delta H$$

$$R =$$

$$P_2 = 1 \text{ atm}$$

$$T_2 = ??$$

$$\ln \left(\frac{0.697}{1} \right) = \frac{40.7 \times 10^3}{8.314} \left(\frac{1}{T_2} - \frac{1}{363} \right)$$
$$(-0.361)$$

$$T_2$$

$$\frac{-0.361}{4.89 \times 10^3} = \left(\frac{1}{T_2} - \frac{1}{373} \right) (0.00275)$$

$$7.37 \times 10^{-5} = \frac{1}{T_2} - 0.00275$$

~~$$T_2 = 0.00268$$~~

$$T_2 = 373 \text{ K} = 100^\circ \text{C}$$

② Calculate vapor pressure at 110°C

$$P_1 = 0.697$$

$$T_1 = 363$$

$$P_2 = ??$$

$$T_2 = 110^\circ \text{C} = 383$$

$$\ln \left(\frac{0.697}{P_2} \right) = 4.89 \times 10^3 \left(\frac{1}{383} - \frac{1}{363} \right)$$

$$\ln \left(\frac{0.697}{P_2} \right) = -0.7042$$

$$\frac{0.697}{P_2} = 0.4945$$

$$P_2 = 1.41 \text{ atm}$$

Subject _____ Day _____ Date _____

a Substance has vapor 0.697 atm
at ~~363~~ 363 K and its n-p is 373 K
Calculation. (ΔH).

$$\ln \left(\frac{P_1}{P_2} \right) = \frac{\Delta H}{8.314} \left(\frac{1}{T_2} - \frac{1}{T_1} \right)$$

$$\ln \left(\frac{P_1}{P_2} \right)$$

$$\Delta H = 40.7 \times 10^3 \text{ J/mol}$$

Subject _____ Day _____ Date _____

Ch 12) physical properties of solutions.
colligative properties.

Solution = Solvent + Solute
H₂O + Sugar

نسبة Solvent > Solute نسبة

- 1) Vapor pressure (v.p)
- 2) Boiling point elevation.
- 3) f.p depression
- 4) osmotic pressure.

1) V.p of solution

a) non-volatile, non electrolyte solute

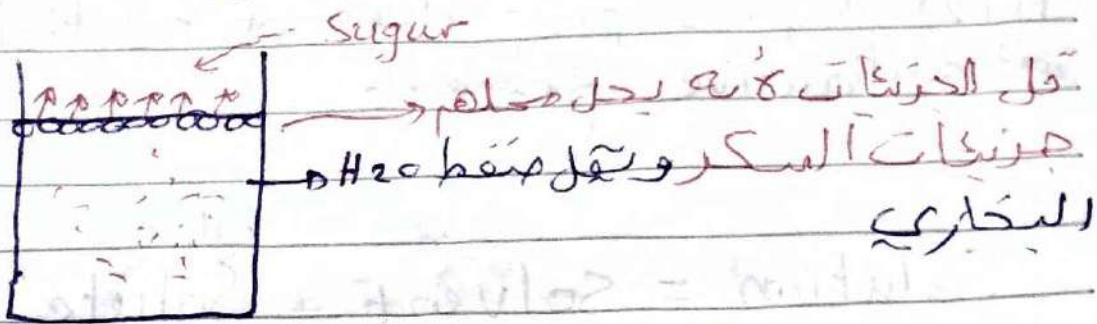
Ex

H₂O + Sugar
Solvent

V.p. المكونة H₂O
one volatile Component
متطايرة

(H₂O → Solvent)

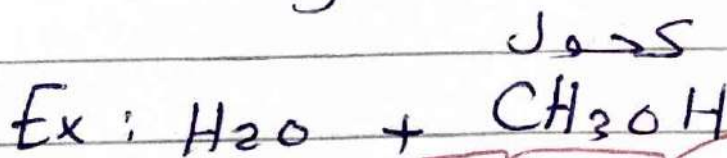
إذا كانت مادة متطايرة واحدة



$$P_{\text{solution}} < P_{\text{solvent}}^{\circ} \rightarrow \text{pure}$$

$$P_{\text{solution}} = P_{\text{solvent}}^{\circ} * \chi_{\text{solvent}}$$

الحالة الثانية
b) Volatile non-electrolyte Solution.



مادتين متطابرتين

$$P_{\text{solution}} = (P_{\text{solvent}}^{\circ} * \chi_{\text{solvent}}) +$$

$$(P_{\text{solute}}^{\circ} * \chi_{\text{solute}})$$

$$\sum \chi_{\text{solvent}} + \sum \chi_{\text{solute}} = 1$$

Example Substance A (v.p) 205 torr at 55°C
and Substance B v.p (130) torr at 55°C

$$M.M = 63 \text{ g/mol}$$

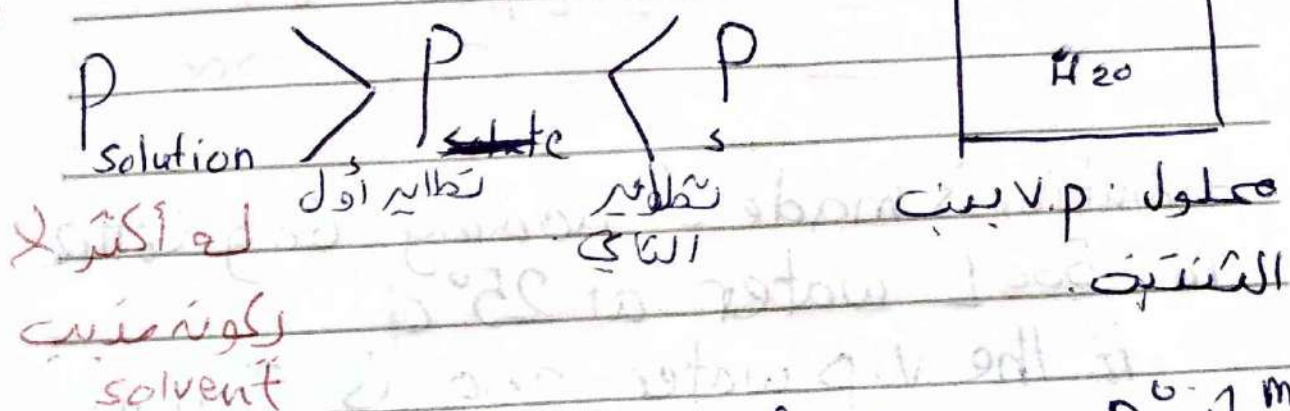
$$M.M_B = 78 \text{ g/mol}$$

v.p alcohol Δ P
H₂O

Solution made 10 g (A) - 25 g (B)

Calculate its vapor pressure.

زاد الضغط ← add to P



$$P_{\text{solution}} = P_A^{\circ} \times \text{mole fraction}_A + P_B^{\circ} \times \text{mole fraction}_B$$

$$n_A = \frac{10}{63} = 0.16 \text{ mole} \quad \Rightarrow \quad \frac{0.16}{0.32 + 0.167} = 0.33$$

$$n_B = \frac{25}{78} = 0.32 \text{ mole} \quad \Rightarrow \quad \frac{0.32}{0.16 + 0.167} = 0.67$$

$$P_{\text{solution}} = 205(0.33) + 130(0.67)$$

$$= 155 \text{ Torr}$$

② if the solution is V.P solution is 125 torr
calcut A, B mole frac 1)

$$125 = 205 X_A + 130 X_B \quad (1)$$

$$X_A + X_B = 1$$

(2)

$$X_B = 1 - X_A$$

$$205 X_A + 130(1 - X_A) = 125$$

A solution is made of adding 60 g C_6H_{12}
to 500 L water at $25^\circ C$

if the v.p water 250 is 27. torr
Calculate Solution v.p ??

$$P_{\text{solution}} = P_{\text{water}} \times \frac{1}{2}$$

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

$$1 = \frac{\text{mass}}{500 \text{ ml}}$$

$$\text{mass} = 500 \text{ g}$$

$$n_{\text{water}} = \frac{m}{M.M.}$$

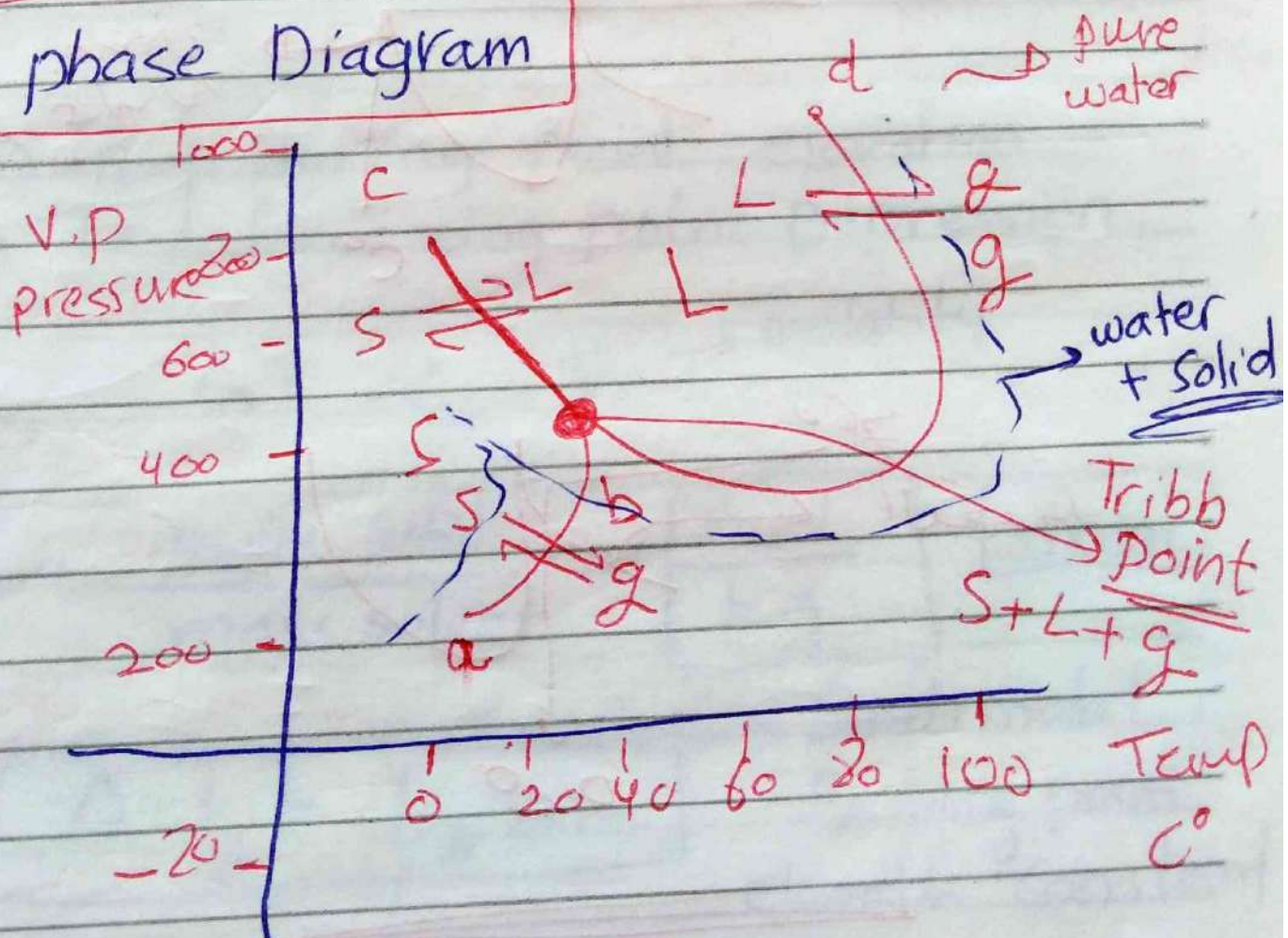
cont-...

2 - Boiling point elevation.

3 - freezing point Depression.

إذا زدت مادة إك مادة تزداد درجة غليانها
وتقل درجة التجمد إك مولاً غير متطابقة

phase Diagram

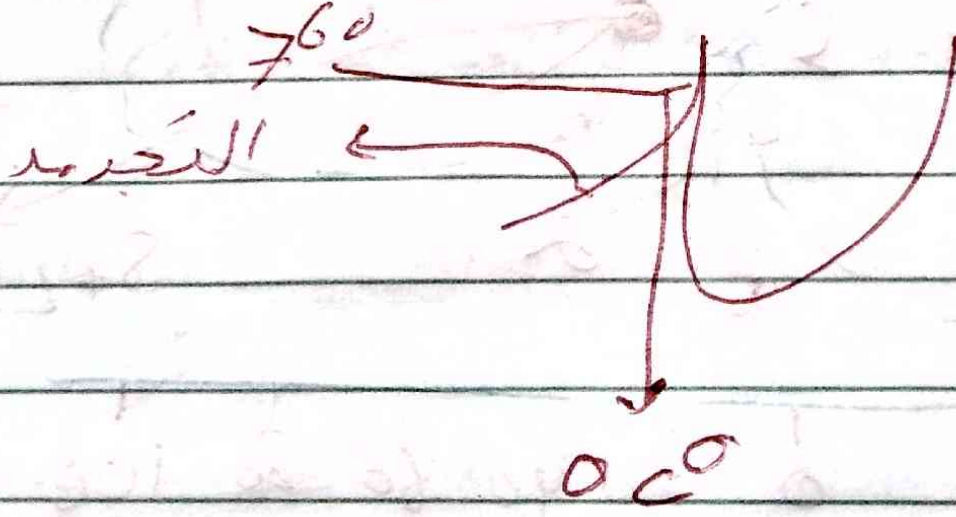
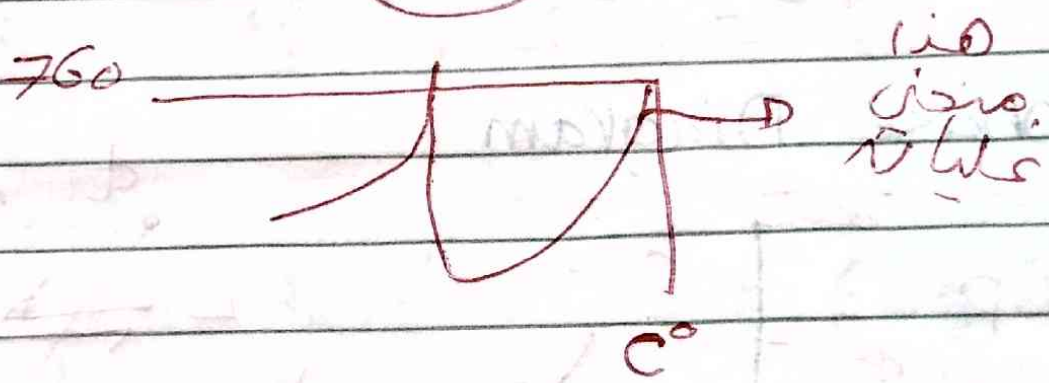




1 atm = 760 torr

Determine Normal Boiling point

$\neq 100$



Subject _____

(Boiling point elevation)

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عند إضافة مادة تزداد درجة الغليان على

المذيب النقي.

تقل درجة التجمد

$$\left\{ \begin{array}{l} \Delta T_B = \text{حرارة غليان} - \text{حرارة تجمد} \\ \Delta T_f = \text{حرارة التجمد} - \text{حرارة التجمد} \end{array} \right.$$

$$\left(\begin{array}{l} \Delta T_B \quad 115 - 100^\circ = 15 \\ \Delta T_f \quad +10 - 0 = 10 \end{array} \right)$$

ΔT_B } Boiling point elevation
 ΔT_f } Freezing point Depression.

$$\Delta T \propto m \rightarrow \text{molality}$$

$$m = \frac{\text{moles solute}}{\text{mass solvent}} = \frac{\text{mol}}{\text{kg}} \quad \boxed{\text{molal}}$$

depend solvent

$$\Delta T_B = K_B m$$

Boiling point elevation Constant

$$\Delta T_f = T_f m$$

Const. for freezing point

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$$\Delta T = k \cdot m \rightarrow \text{molality}$$

↓
depends on solvent

Boiling
point
elevation

$$\Delta T_b = k_b \cdot m \cdot i$$

vanst Hoff
factor

$$\Delta T_f = k_f \cdot m \cdot i$$

constant

freezing point Depression

$k \cdot m$
or

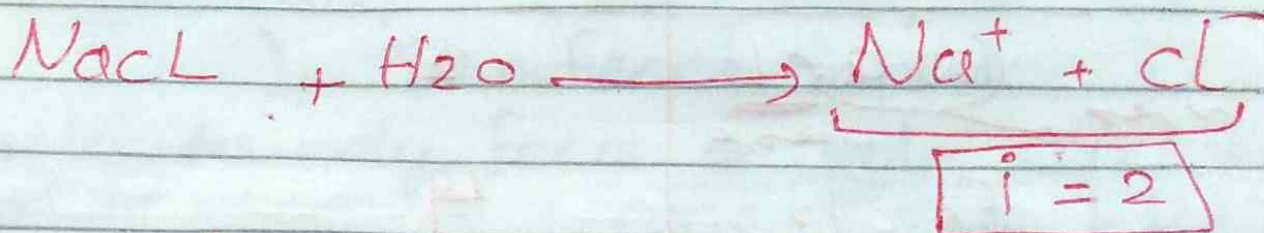
$$T_b \text{ solution} = T_b \text{ solvent} + \Delta T_b$$

$$T_f \text{ solution} = T_f \text{ solvent} - \Delta T_f$$

antifreeze

depression

$$\left[\begin{array}{l} i \text{ for non electrolyte} = 1 \\ i \text{ for electrolyte} = \# \text{ of ions} \end{array} \right]$$

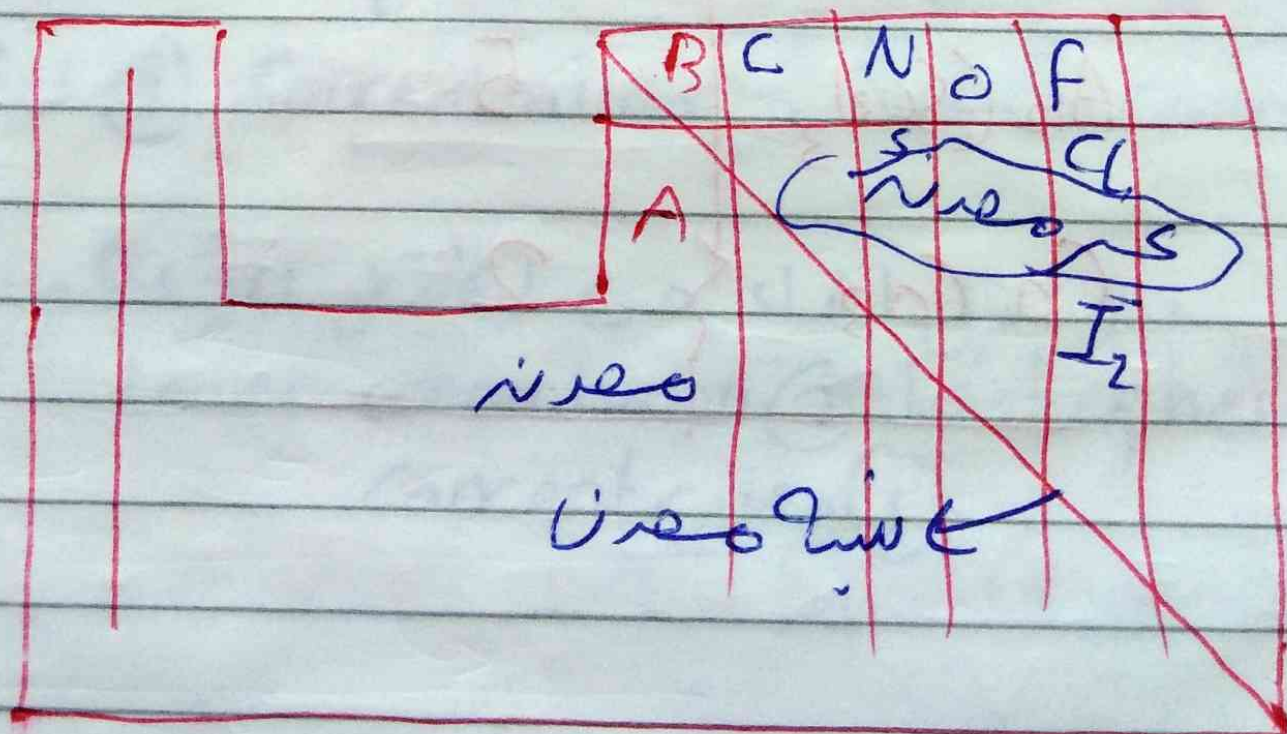


electrolytes = ionic Compounds.

(+ve) Cation + (-ve) anion

(or)

metal + non metal
(+) (-)



Compound

1

NaCl

2

FeCl₃

4

CaBr₂

3

فرک
عصبون ← C₆H₅NH₃
عترایونی

1

Na₂ SO₄

3

K₃ (PO₄)

4

Al₂ (SO₄)₃

5

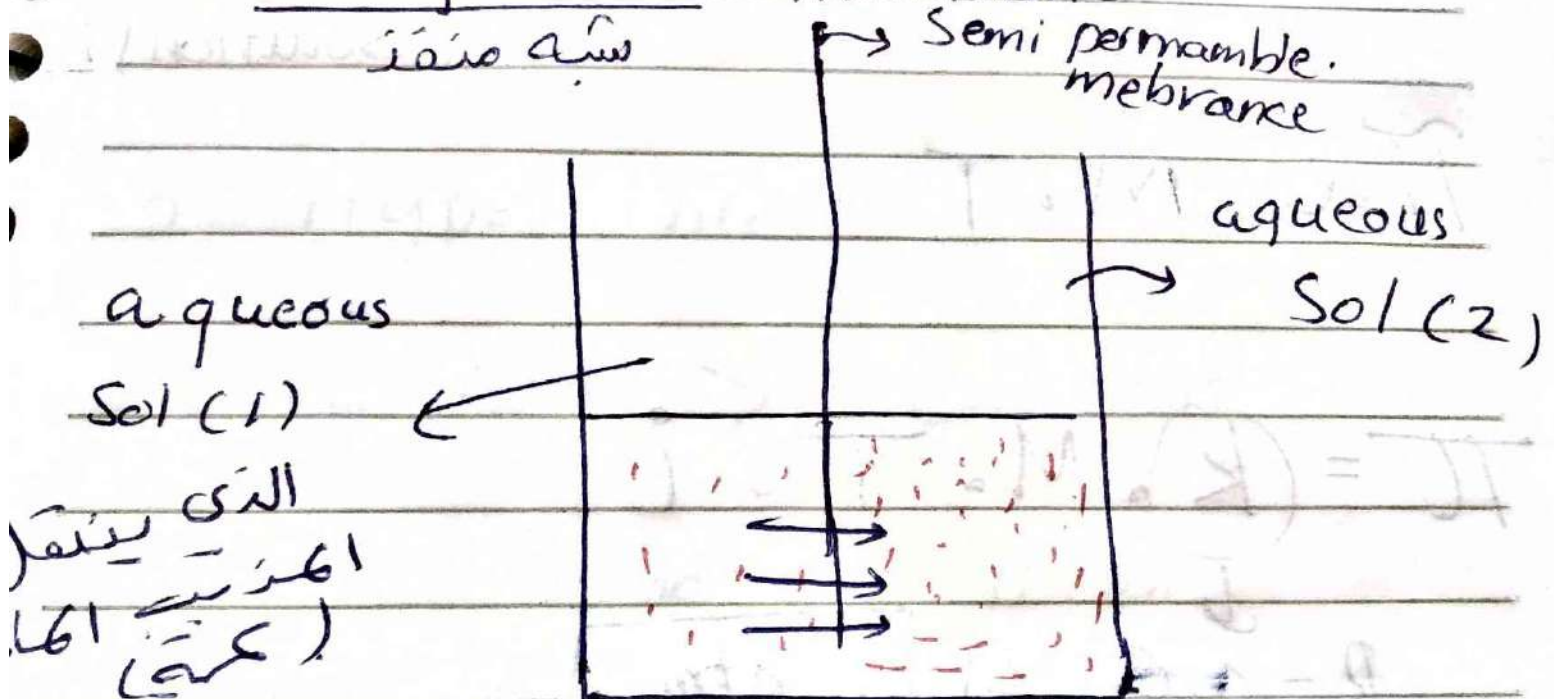
CaCO₃

2

4) Osmotic pressure (π) (osmosis)

↳ Transfer of Solvent

molecules only from low soln concentration
to high conc. Soln through
a Semi permeable membrane.



Sol (2) Concentration $>$ Sol (1) Concentration

ينتقل المذيبات من الأقل تركيزاً
from Lower concentration (2) to higher
concentration (1)

$\pi \propto \text{Concentration}$

$$\pi \propto M \longrightarrow = \frac{\text{moles of Solute}}{\text{Volume of Sol} \text{ (Solution)}}$$

$$\pi \propto M \cdot T$$

$$\pi = (k) \cdot M \cdot T \cdot i$$

$R = 0.0821$

$$\frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

$$\pi = M R T i$$

$$\pi = \frac{n}{V} R T i$$

$$\pi V = n R T \cdot i$$

Types of Soln

1 - Isotonic : Soln Concentration =
Salt Cell concentration
↳ Soln

$$\pi_{\text{Salt}} = \pi_{\text{cell}}$$

2 - Hypertonic

$$\text{Salt Con} > \text{Cell Conc}$$

$$\pi_{\text{salt}} > \pi_{\text{cell}}$$

سيتقل الماء من الخلية الى
(will Shrink and dry out)

3 - Hypotonic

$$\text{Salt con} < \text{Cell con}$$

سيتقل من الخلية الى داخل الخلية

Cell will swell and burst.

Calculate the B.p of Solution made by adding 60g FeCl_2 to 200mL H_2O

$$K_b - \text{H}_2\text{O} = 0.51 \frac{^\circ\text{C}}{m}$$

$$K_f \text{H}_2\text{O} = 1.86 \frac{^\circ\text{C}}{m}$$

(3)

$$\Delta T_b = K_b \times \frac{\text{moles of solute}}{\text{mass solvent}} \times i$$

$\xrightarrow{200} \text{mass solvent} \xrightarrow{\times 200\text{L}} 1 = \frac{m}{\text{density}}$
 $\frac{\text{moles FeCl}_2}{\text{kg H}_2\text{O}} \quad \text{density } 200\text{g}$

$$n = \frac{m}{M.M}$$

$$\frac{60}{55.6} \quad n = \boxed{\quad}$$

$$= 0.51 \times 0.48 \times 3$$

$$0.51 \times \frac{200}{2.4} \times 3$$

$$= \boxed{3.7^\circ\text{C}}$$

$$T_b \text{ Soln} = T_{\text{solvent}} + \Delta T$$

$$100 + 3.7$$

$$= \boxed{103.7}$$

arrange the following in order of decreasing B.P or decreasing f.p.

H₂O Solvent

1) 1m aqueous Soln of

$C_6H_{12}O_6$, KCl , $CaBr_2$, Na_3PO_4 , H_2O

$\Delta T = k \cdot m \cdot i$

الان بطلی کا اقل درجہ
پرکھنے کا اقل درجہ

B.P $Na_3PO_4 > CaBr_2 > KCl > C_6H_{12}O_6 > H_2O$

F.P $H_2O > C_6H_{12}O_6 > KCl > CaBr_2 > Na_3PO_4$

2) aqueous soln

$3 \times (3)$

0.5×4

(2)

3 molal $C_6H_{12}O_6$ (2) 0.5m $FeCl_3$

(3) 0.6 m $CuCl_2$
 (0.18)

$\Delta T = k \cdot m \cdot i$

B.P $1 > 2 > 3$

f.p $3 > 2 > 1$

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which has highest change in ~~temp~~

(f.p)

1. (m) soln of substance A

in

$$k_f = 1.26$$

H₂O

Acetone

$$k_f = 10$$

$$\Delta T = \frac{k \cdot m \cdot i}{\sqrt{\alpha}} \propto \alpha$$

Acetone > H₂O

التغير في الحرارة = k_f بالتغير في الحرارة

Subject ما تسمى ΔT أو k_f Date _____

25 g of unknown organic compound is added to 25 g Cyclohexene. The f.p. of Cyclohexene was lowered by 16°K . Determine the unknown (M.M.)

k_f cyclohexene
20.2

$$k = C + 273$$

$$1.6 = C + 273$$

$\frac{1.6}{m} \times i$
 $\frac{1.6}{m}$

$$\Delta T_f = k_f \cdot m \cdot i$$

$$\frac{1.6}{20.2} = 20.2 \times m \times 1$$

$$m = 0.079$$

$$0.079 = \frac{n \text{ Solute Unknown}}{m \text{ Solvent } \frac{25}{1000}}$$

$$n \text{ solute unknown} = 0.001975 \text{ mole.}$$

$$M.M = \frac{0.25}{0.001975} = 126 \text{ g/mol.}$$

Eye drops must be isotonic with human eye.

A commercial eye drops soln. 0.327 M
 what is the osmotic pressure of human:
 at 25 °C + 273

isotonic

$$\pi = M R T i$$

$\pi_{\text{eye drop}} = \pi_{\text{human}}$
 $M_{\text{eye}} = M_{\text{drop}}$

$$= 0.327 \times 0.0821 \times 298 \times 1$$

$\pi_{\text{drop}} = 8. \text{ atm}$

$\pi_{\text{eye}} = 8. \text{ atm}$

The osmotic pressure of certain protein.

1.59 torr at $25^{\circ}\text{C} \rightarrow \frac{273}{298}$

← A solution contain 3.5 mg protein in 5 mL water.

← Calculate protein's mass.

5×10^{-3}

3.5×10^{-3}

$$M.M = \frac{m}{n}$$

$$\pi V = n R T i$$

$$\frac{\pi V}{R T i} = n_{\text{protein}}$$

$$= \frac{1.59}{760} * 5 \times 10^{-3}$$

=

$$4.14 \times 10^{-7}$$

$$\cancel{5 \times 10^{-3}} * \underline{298} * \underline{1} * 0.0821$$

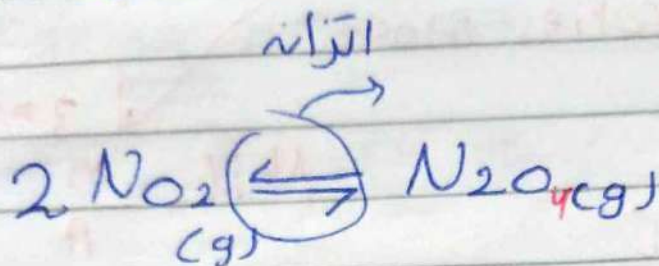
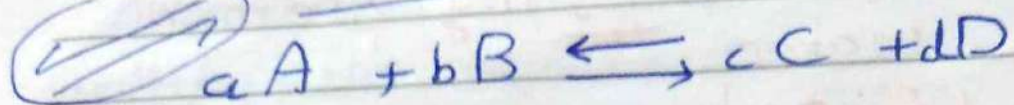
$$M.M = \frac{3.5 \times 10^{-3}}{4.14 \times 10^{-7}}$$

$$4.14 \times 10^{-7}$$

$$M.M = 8.45 \times 10^3 \text{ g/mol}$$

B Chemical equilibrium (eqm or eq)

equilibrium



$$[\text{NO}_2] > 0 \quad 2M$$

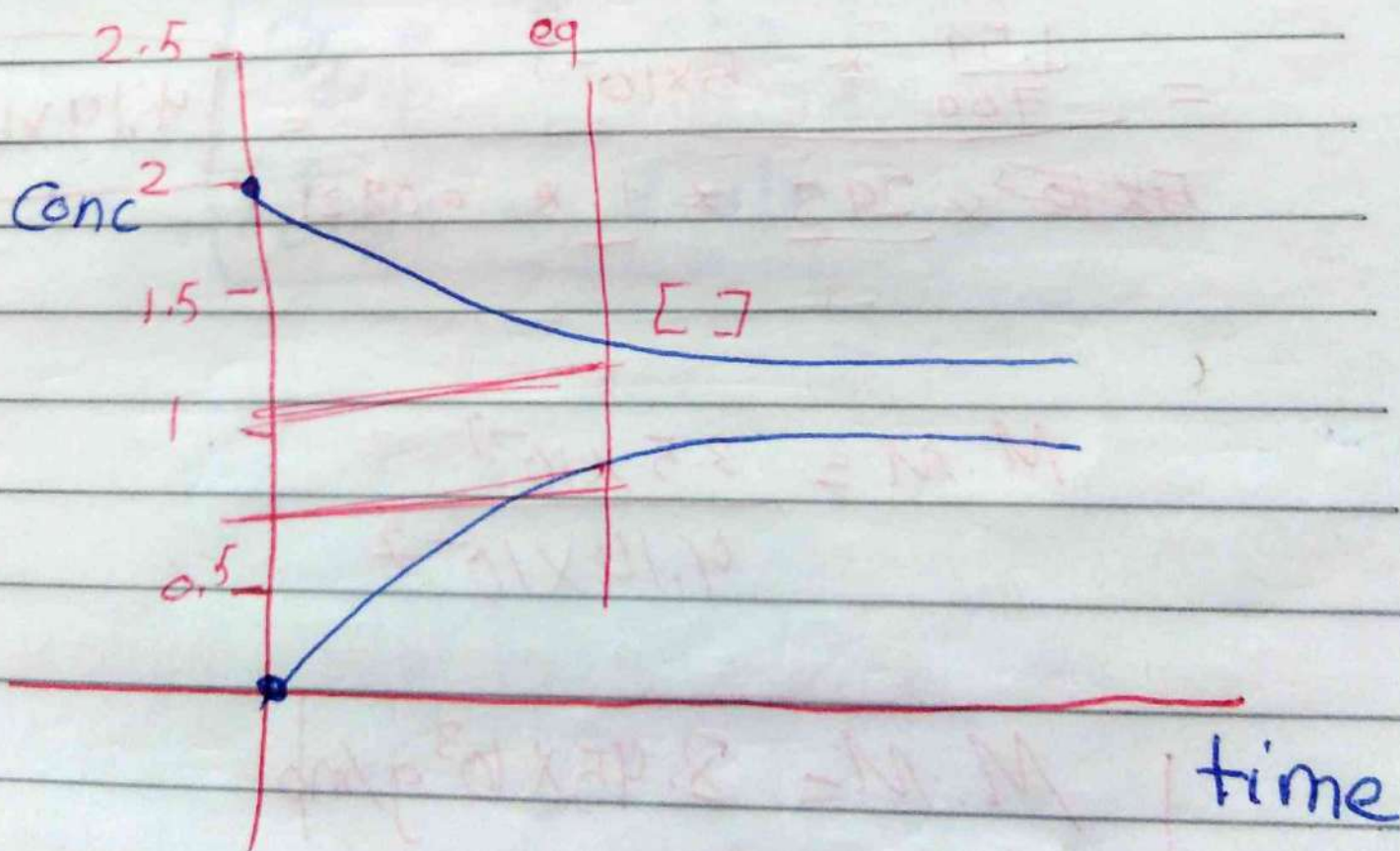
$$[\text{N}_2\text{O}_4]_i = 0$$

Concentration

[]

Molarity

$\left[\frac{M}{L} \right]$



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in equ $\frac{[\text{Products}]_{eq}}{[\text{Reactant}]_{eq}}$ is constant

eqm constant (k_{eq})

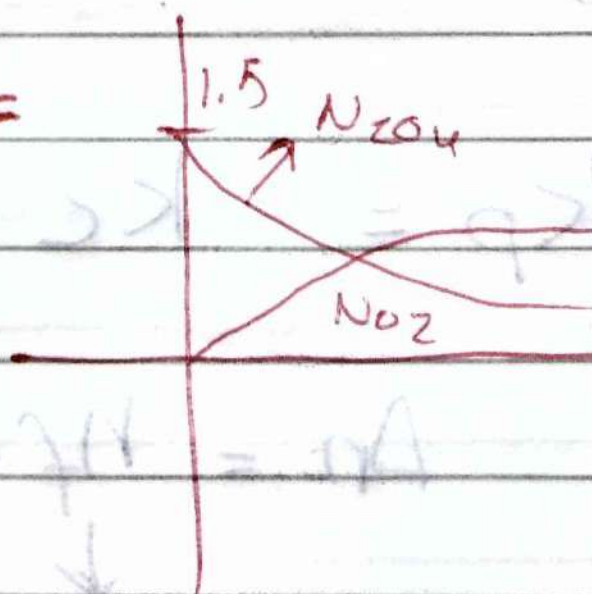
- k_{eq} depend only on Temperature -

$$K_c = \frac{[C]_{eq}^c [D]_{eq}^d}{[A]_{eq}^a [B]_{eq}^b}$$

$k_c = \frac{[N_2O_4]}{[NO_2]^2} = \frac{0.5}{(1)^2} = 0.5$

التركيز

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} =$$



1.5

للقانون

 K_p

↓

=

 P_n P_n $[P]^c$ $[P]^d$ $[P_A]^a$ $[P_B]^b$

Interm

of pressure

only for
gases

$$P = \frac{nRT}{V}$$

التركيز

$$M = [] = MRT = P$$

$$K_p = \frac{([C]RT)^c ([D]RT)^d}{([A]RT)^a ([B]RT)^b}$$

$$= \frac{[C]^c [D]^d}{[A]^a [B]^b} \frac{(RT)^c (RT)^d}{(RT)^a (RT)^b}$$

 $RT^{c+d-a-b}$

المتغيرات النواحي

$$K_p = K_c (RT)^{\Delta n}$$

$$\Delta n = n_f + n_j$$

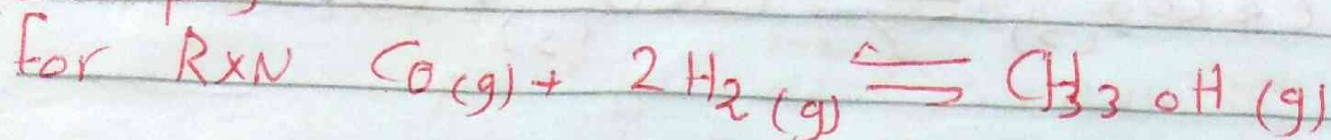
↓

↓

المتغيرات النواحي

Subject _____ Day _____ Date _____

[Example]



K_c is 10.5 at 220°C Calculate K_p .

$$K_p = K_c (RT)^{\Delta n}$$

↓ kelvin

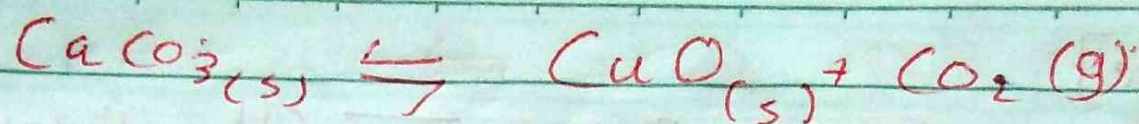
$$\Delta n = 1 - (1 + 2)$$

$$= -2$$

$$= 10.5 * (0.0821 * 493)^{-2}$$

$$K_p = 6.41 \times 10^{-3}$$

Subject _____ Day _____ Date _____



$$K_p = [\text{CO}_2]^1 \quad \Delta n = 1 + 0 - (0) = \textcircled{1}$$

$$K_c = \frac{[\text{CO}_2]_{eq} [\text{CaO}]_{eq}}{[\text{CaCO}_3]_{eq}}$$



pure Solid (s) and pure liquid are not included in K (term) only include (g) and Solution (aq)

(g, aq) // (K) في الحالات جمع

$$K = [\text{CO}_2(g)]$$



$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{\text{g}}{\text{mL}} \quad 1 \text{ L} = 1000 \text{ mL}$$

Relations between (k_c / k_p)



$$k_1 = \frac{[C]^c}{[A]^a [B]^b}$$



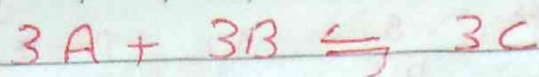
$$k_2 = \frac{[A][B]}{[C]}$$

$$k_2 = \frac{1}{k_1}$$

$$10 = \frac{1}{k_1}$$

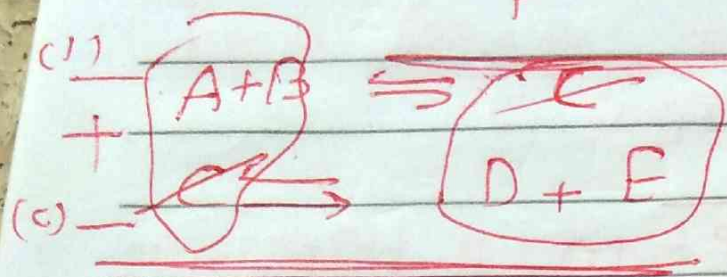
$$k_1 = \frac{1}{10}$$

$$k_2 = 10$$

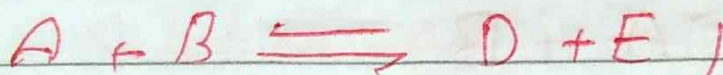


$$k_3 = \frac{[C]^3}{[A]^3[B]^3}$$

$$k_4 = (k_3)^3$$



$$k_4 = \frac{[D][E]}{[C]}$$



$$k_5 = \frac{[D][E]}{[A][B]}$$

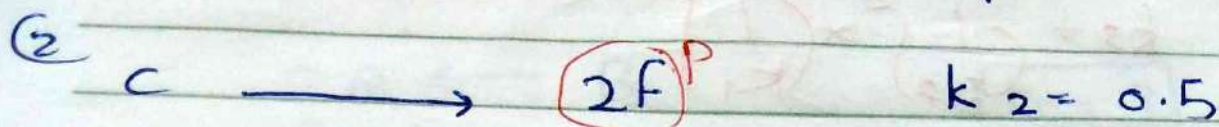
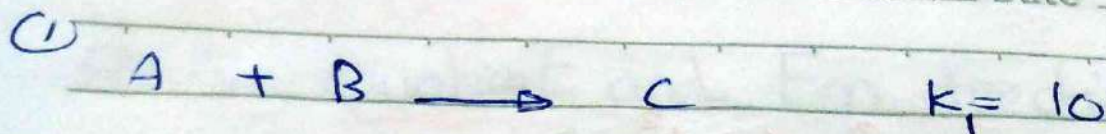
$$3 = (2 + 1)$$

إذا جمعنا تفاعلات ضرب (k) التوازنية

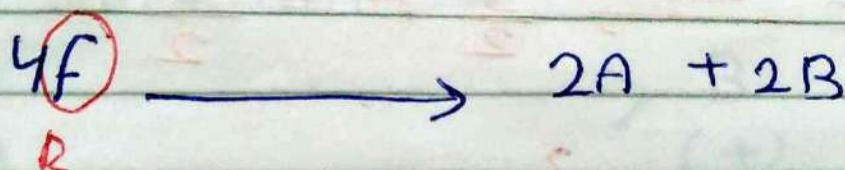
$$k_3 = k_1 * k_2 = \frac{[C]}{[A][B]} * \frac{[D][C]}{[C]}$$

$$k_3 = \frac{[D][C]}{[A][B]}$$

Subject _____ Day _____ Date _____

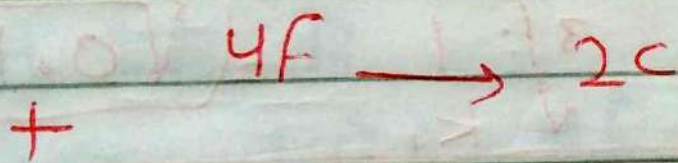


Calculate (K) for

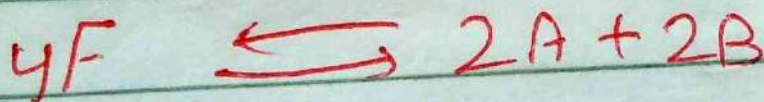


flip (2) and
multiply (2)

$$K_2' = \left(\frac{1}{0.5}\right)^2 = 4$$



$$K_1' = \left(\frac{1}{10}\right)^2 = \underline{\underline{0.01}}$$



$$\frac{1}{100} \times 4 = \frac{4}{100} = \left(\frac{1}{25}\right)$$

Subject _____

$$k_3 = \left(\frac{1}{k_2}\right)^2 \times \left(\frac{1}{k_1}\right)^2$$

$$k_3 = \frac{1}{\$25} = \boxed{0.04}$$

$$\textcircled{2} \quad \frac{3}{2} C \xrightarrow{\quad} \frac{3}{2} A + \frac{3}{2} B$$

$$k_4 = \left(\frac{1}{k_1}\right)^{\frac{3}{2}}$$

$$\sqrt[3]{\frac{1}{k_1}} = \boxed{\sqrt[3]{0.1}}$$

a. use help

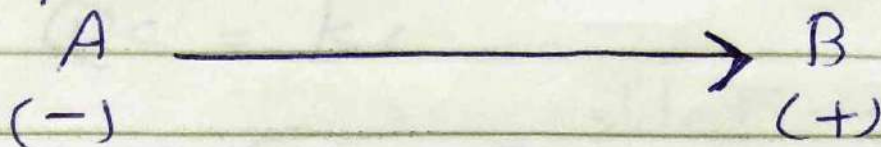
Rxn Quotient and Eqn direction

$$K_c = 3$$

$$[A]_i = 5M$$

$$[B]_i = 0$$

Eqm direction



$$K > 1$$

$$[Prod] > [React]$$

$$K < 1$$

$$[Prod] < [React]$$

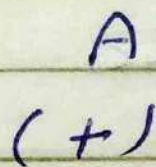
$$K = 1$$

$$[Prod] = [React]$$



$$[A]_i = 0$$

$$[B]_i = 0.5$$



$$[A]_i = 3M \quad [B]_i = 2M$$

use Reaction Q =

$$Q_c = \frac{[Prod]_i}{[React]_i} = \frac{(2)^1}{(3)^2}$$

$$Q_c = \frac{[\text{Prod}]^a}{[\text{Rea}]^b}$$

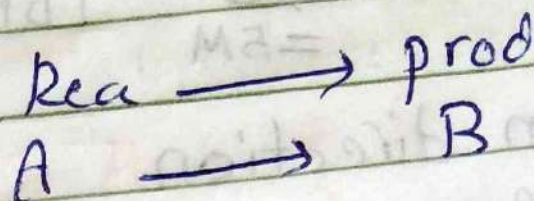
Subject

Day

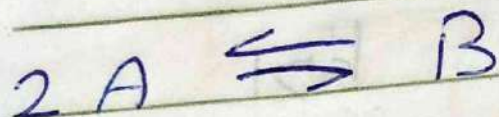
Date

$$Q_c < K_c$$

$$\frac{2}{9} < 3$$



$$K_c = 3$$



$$Q_c = \frac{[B]}{[A]^2} = \frac{0.5}{0.1^2} = 5$$

$$Q_c = \frac{[\text{Prod}]}{[\text{React}]}$$

$$Q_c > K_c$$

Reactant $\longleftarrow$ product



$$K_c = 3$$

$$[A]_i = 1 \text{ M}$$

$$[B]_i = 3$$

$$Q_c = \frac{[3]}{[1]^2} = \boxed{3}$$

$$Q_c = K_c$$

No Shift in Equilibrium in it
The concentration is Constant.

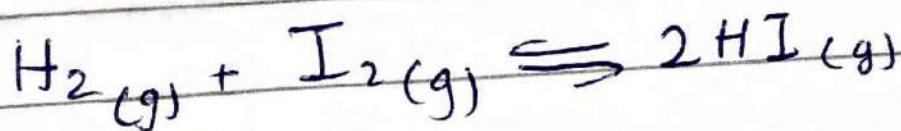
Calculation of Equilibrium Concentrations and Eqm constant.

$$K_c = \frac{[\text{Products}]_{\text{eqm}}}{[\text{Reaction}]_{\text{eqm}}}$$

using ICE Table

1 mol of H_2 and 1 mole of I_2 was placed in 2L Container and let to react according to $\text{H}_2 + \text{I}_2 \rightleftharpoons 2\text{HI}$ if $K_c = 54.3$ at 430°C

Calculate concentration of Eqm.



$$M = \frac{n}{V(L)}$$

$$0.5$$

$$\frac{1}{2} = 0.5$$

Initiant Amounts

Concentration

$$0.5\text{ M} + 0.5\text{ M} \rightleftharpoons 0$$

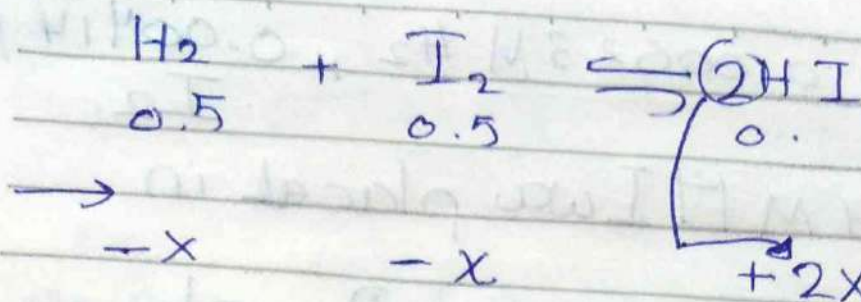
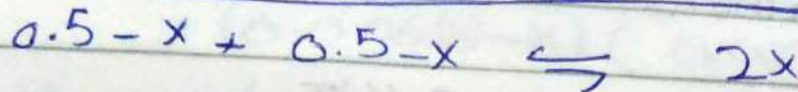
Change
direction



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Equ
con.

$$K = \frac{[\text{HI}]_{\text{eqm}}^2}{[\text{H}_2]_{\text{eqm}} [\text{I}_2]_{\text{eqm}}}$$

(1) + (2)

$$0.5 - x = 0.107$$

$$\sqrt{54.3} = \frac{(2x)^2}{(0.5 - x)^2}$$

$$2x = 0.393$$

$$\approx 0.8 \text{ M}$$

~~4.8~~

$$\sqrt{54.3} = \frac{2x}{0.5 - x}$$

$$2x = \sqrt{54.3} * 0.5 - \sqrt{54.3} - x$$

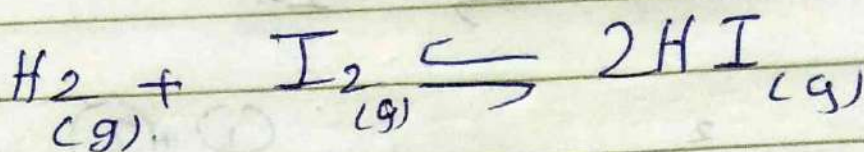
7.27 ...

$$x = 0.393 \text{ M}$$

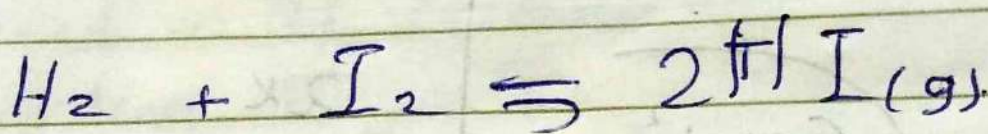
A mixture of 0.00623 M H_2 , 0.00414 M I_2 .

and 0.0224 M HI was placed in

2. L Containers let to React.



if K_c for Rxn is 54.3



I	0.00623	0.00414	0.0224
---	---------	---------	--------

~~Qc = 19.5~~

$$Q_c = \frac{(\text{HI})^2}{[\text{H}_2][\text{I}_2]} = 19.5$$

$$Q_c < K_c$$

$$0.00623 - x \quad 0.00414 - x \rightleftharpoons 0.0224 + 2x$$

$$K_c = 54.3 = \frac{(0.0224 + 2x)^2}{(0.00623 - x)(0.00414 - x)}$$

Solve quadratic

$$ax^2 + bx + c$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$a = 50.3$$

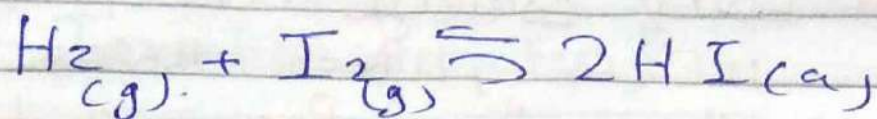
$$b = -0.654$$

$$c = 7.89 \times 10^{-4}$$

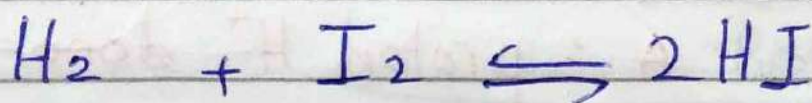
$$50.3x^2 - 0.654x + 7.89 \times 10^{-4} = 0$$

(3)

A mixture of 0.001 M H_2 , 0.003 M I_2 and 0.025 M HI was placed in 2 L container and let the reactant



if the eqm conc of HI found to be 0.02
Calculate K_c at $200^\circ C$.



initial Concn.	0.001	0.003	0.025
	+X	+X	-2X
Change		0	
← at eq HI is	0.001 - X	0.003 - X	0.020
	0.250	0.003	
	0.0250	0.025	
		0.028	
			$X = 0.025 M$

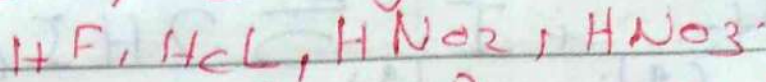
$$K_c = \frac{[HI]^2}{[H][I]} = \frac{(0.025)^2}{(0.028)(0.026)}$$

$$K_c = 20.8$$

الحموض والقواعد (Acids and Basics) (A) (B)

تفاعل

* Brønsted Lowry Lowery Acid: proton H^+ donor



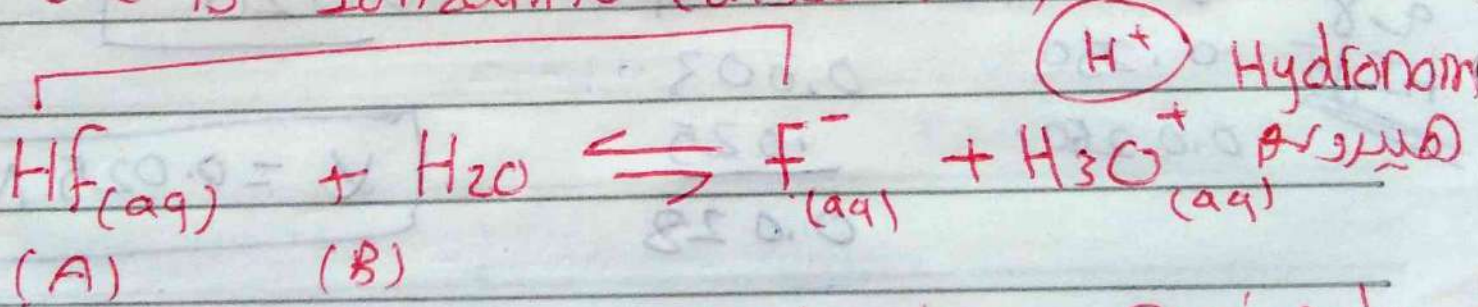
* " " " Basic: proton H^+

acceptor
 NH_3

Arrhenius A: proton H^+ donor

" B: hydroxide or H^- donor.
 $NaOH$

A and B Ionization (dissociation) in water



H^+

Hydronium

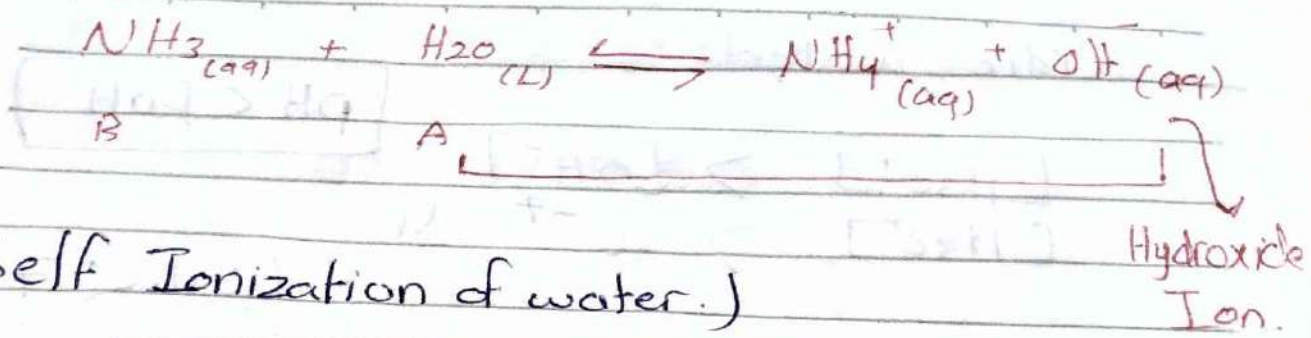
أحادي الهيدروجين

conjugate conjugate

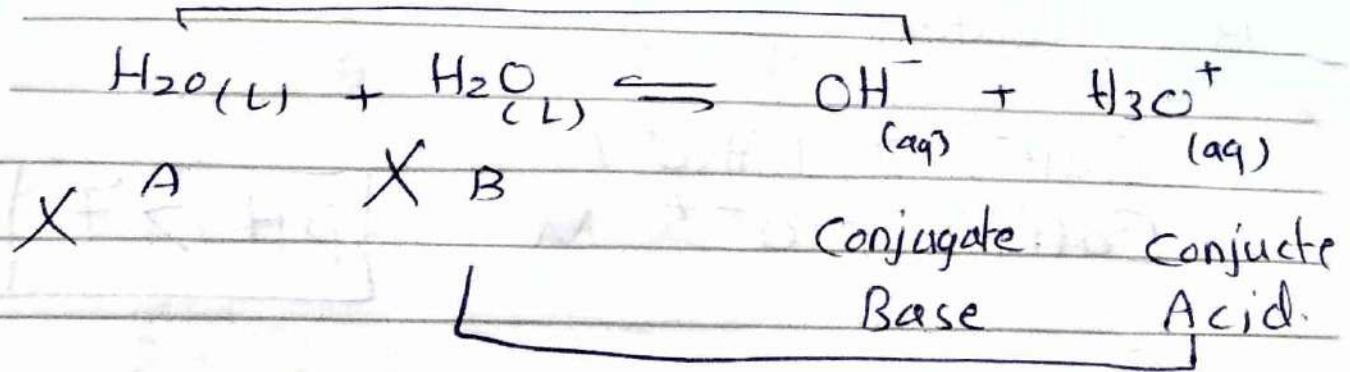
base Acid

قاعدة مرافقة = حمض

حمض مرافق = قاعدة



(Self Ionization of water.)



$$K_c = [\text{OH}^-][\text{H}_3\text{O}^+]$$

$$K_w = [\text{OH}^-][\text{H}_3\text{O}^+] = \boxed{1 \times 10^{-14} \text{ at } 25^\circ}$$

neutral water $[\text{H}_3\text{O}^+] = [\text{OH}^-]$

$$[\text{H}_3\text{O}^+] = \frac{10^{-14}}{[\text{OH}^-]}$$

$$[\text{OH}^-] = \frac{10^{-14}}{[\text{H}_3\text{O}^+]}$$

$$x^2 = \sqrt{10^{-14}}$$

$$x = \sqrt{10^{-14}} = 10^{-7}$$

(بالمتعادل)

acidic water

$$\text{pH} < \text{pOH}$$

$$[\text{H}_3\text{O}^+] > [\text{OH}^-]$$

$$[\text{H}_3\text{O}^+] > 10^{-7} \text{ M}$$

$$\text{pH} < 7$$

Basic water

$$[\text{OH}^-] > [\text{H}_3\text{O}^+]$$

$$[\text{OH}^-] > 10^{-7} \text{ M}$$

$$\text{pH} > 7$$

p function

$$\text{p}(x) = -\text{Log}(x)$$

$$\begin{aligned} \text{p}(10) &= -\text{Log } 10 \\ &= \textcircled{-10} \end{aligned}$$

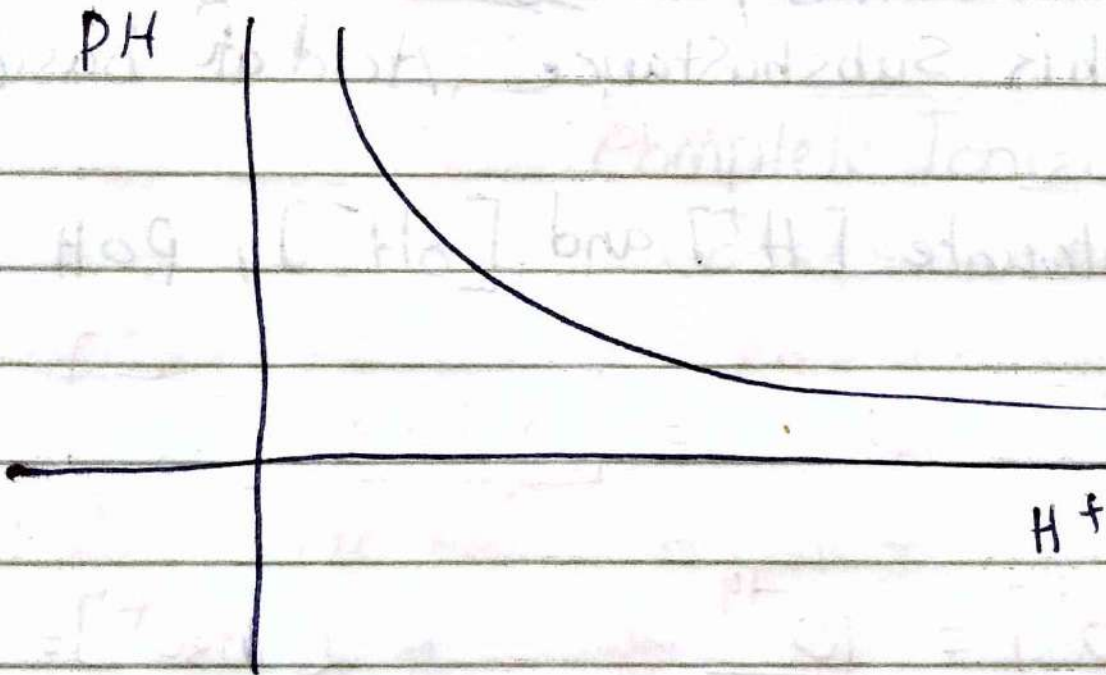
$$\begin{aligned} \text{p}(0.1) &= -\text{Log}(0.1) \\ &= -(-1) \\ &= \textcircled{+1} \end{aligned}$$

$$pK_w = pOH + pH = -\log 10^{-14} = \textcircled{14}$$

$$pOH + pH = 14$$

$$\begin{aligned} pOH &= 14 - pH \\ pH &= 14 - pOH \end{aligned}$$

$[H^+] \leftarrow pH$ معكافه سى پى



Neutral water $pH = pOH = \textcircled{7}$

$$pH = -\log [H_3O^+]$$

$$[H_3O^+] = 10^{-pH}$$

$$pOH = -\log [OH^-]$$

$$[OH^-] = 10^{-pOH} = 10^{-(14-pH)}$$

A Substance has pH ~~2.3 x 10⁻⁴~~ 3.4 in water
is this substance Acid or basic?

Calculate $[H^+]$ and $[OH^-]$, pOH

$$[H^+] = 10^{-3.4} = 3.98 \times 10^{-4}$$

$$[OH^-] = \frac{10^{-14}}{3.98 \times 10^{-4}}$$

$$[H_3O^+] =$$

$$2.51 \times 10^{-11}$$

$$pOH = 14 - pH$$

$$14 - 3.4$$

$$10.6$$

$$[OH^-] = 10^{-pOH}$$

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To determine pH , $[\text{OH}^-]$ only $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ are important $\rightarrow [\text{H}^+]$

في القوي

$$\text{SA} = [\text{H}_3\text{O}^+] = [\text{Acid}]$$



$$[\text{HBr}] = [\text{H}_3\text{O}^+]$$

S.B $[\text{OH}^-] = [\text{القاعدة}]$ أو $2[\text{القاعدة}]$

Calculate the pH of 0.0075 M $\text{Sr}(\text{OH})_2$

$$[\text{OH}^-] = 2[\text{Sr}(\text{OH})_2]$$

$$[\text{OH}^-] = 2 \times 0.0075$$

$$= 0.015$$

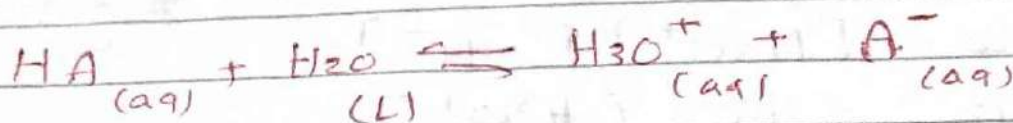
$$[\text{H}^+] = \frac{10^{-14}}{0.015}$$

$$[\text{H}^+] =$$

$$\text{pOH} = -\log [\text{OH}^-]$$

$$\text{pH} = 14 - \text{pOH}$$

إذا كانت ثابت التوازن K_a يكون ضعيفاً ويكون K_b قوياً (في الأماض والقواعد القوية لا يوجد K_b / K_a)
 weak acid and Basiso. (Incomplete Ionization)



1m

0.05 0.05

5% Ionized.

95% HA (لم يمتدسكو)

as HA and

0.05 as $[H^+]$

SA

HCl

HBr

HI

H₂SO₄

HNO₃

HClO₄

HClO₃

$[OH^-]$

$[القاعدة] =$

تركيزها نفس

$[H^+]$ ↑
 $[القاعدة]$

$[OH^-]$

SB

LiOH

NaOH

KOH

RbOH

CsOH

Ca(OH)₂

Ba(OH)₂

Sr(OH)₂

Mg(OH)₂

$[OH^-]$

$2[القاعدة]$

$[H^+]$
 $[H_3O^+]$

يساوي
 تركيزها

إذا كان K_a
 ضعيفاً

Subject

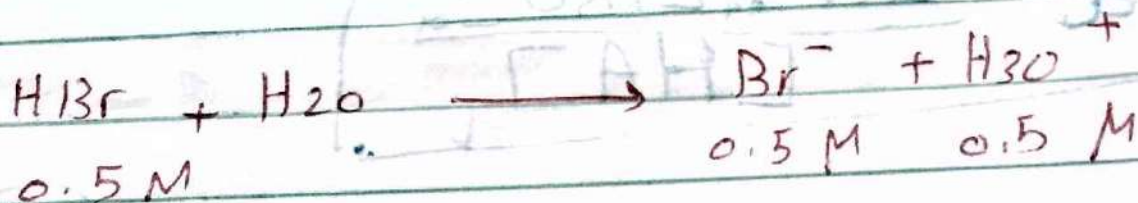
Day

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To determine pH only $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ are important

في القوى

$$\text{SA} = [\text{H}_3\text{O}^+] = [\text{Acid}]$$



$$[\text{HBr}] = [\text{H}_3\text{O}^+]$$

S.B $[\text{OH}^-] = 2[\text{base}]$

Calculate the pH of 0.0075 M $\text{Sr}(\text{OH})_2$

$$[\text{OH}^-] = 2[\text{Sr}(\text{OH})_2]$$

$$[\text{OH}^-] = 2 \times 0.0075$$

$$= 0.015$$

$$[\text{H}^+] = \frac{10^{-14}}{0.015}$$

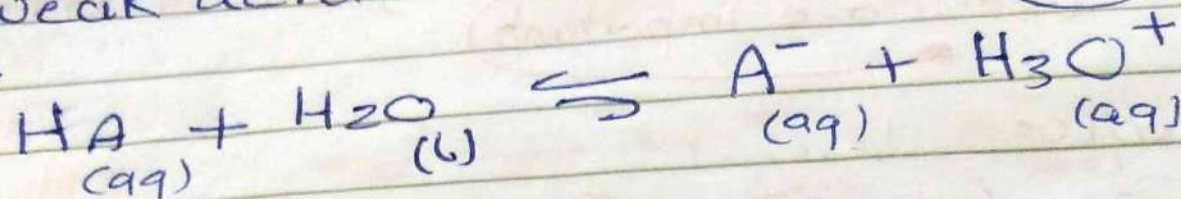
$$[\text{H}^+] =$$

$$\text{pOH} = -\log [\text{OH}^-]$$

$$\text{pH} = 14 - \text{pOH}$$

- weak acids and Basics.

W.A

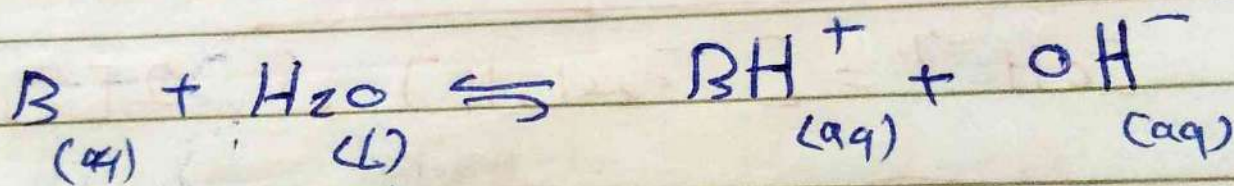


(acid)

$$K_a = \frac{[\text{A}^{-}]_{eq} [\text{H}_3\text{O}^{+}]_{eq}}{[\text{HA}]_{eq}}$$

(Base)

weak Base



$$K_b = \frac{[\text{HB}^{+}]_{eq} [\text{OH}^{-}]_{eq}}{[\text{B}]_{eq}}$$

base

To determine pH of weak acids and Bases need to determine $[H_3O^+]$ or $[OH^-]$ in equilibrium using K_a , K_b and Ice Table.

Example Calculate pH of 0.036 M HNO_2
 Soln K_a $HNO_2 = 4.5 \times 10^{-4}$

-determine Acid or Base and Strong or weak.



I	0.036	0	0
C	-x	+x	+x
E	(0.036-x)	x	x

$$\Rightarrow HNO_2 + H_2O \rightleftharpoons NO_2^- + H_3O^+$$

0.036	0	0
-x	+x	+x
(0.036-x)	x	x

$$K_a = \frac{x^2}{0.036-x}$$

$$4.5 \times 10^{-4} =$$

- x can be neglected if $x < 5\%$ of the initial amount of concentration.

$\Rightarrow$ neglect x

$$4.5 \times 10^{-4} = \frac{x^2}{0.036} \quad \cancel{x \text{ neglected}}$$

$$x = \sqrt{4.5 \times 10^{-4} \times 0.036}$$

$$x = 4 \times 10^{-3}$$

is x negligible??

$$= \frac{4 \times 10^{-3}}{36 \times 10^{-3}}$$

find $x\%$

$$x = 11.1\%$$

x is not negligible

⇒ Need to solve quadratic equation.

$$x^2 + 4.5 \times 10^{-4}x - 1.62 \times 10^{-5} = 0$$

$$x = 3.8 \times 10^{-3}$$

$$[H_3O^+]_{eq} = x = 3.8 \times 10^{-3}$$

$$pH = -\log(3.8 \times 10^{-3})$$

$$= 2.42$$

if x is negligible

$$[H_3O] = x = \sqrt{4.5 \times 10^{-4} \times 0.36}$$

$$x = \sqrt{k_a \times \text{التركيز الابتدائي}}$$

$$x = \sqrt{k_c \times \text{التركيز الابتدائي}}$$

$$\frac{\text{التركيز عند التوازن}}{\text{التركيز الابتدائي}} = \text{النسبة}$$

$$\text{for Acids} = \frac{\sqrt{K_a \times A_i}}{[A]_i} \times 100\% < 5\%$$

$$\text{for Basics} = \frac{\sqrt{K_b \times [A_i]}}{[A]_i} \times 100\% < 5\%$$

Calculate PH of 0.4^MNH_3 soln

$$K_b = 1.8 \times 10^{-5}$$

أساس ←

$\text{NH}_3 \Rightarrow \text{weak Base}$

if x is negligible = $\sqrt{K_b \times \text{التركيز الابتدائي}}$

$$\sqrt{0.4 \times 1.8 \times 10^{-5}}$$

أعبر عن
التركيز
بـ x

$$= 2.7 \times 10^{-3}$$

$[A_i]$

$$= 0.07 < 5\% \text{ good}$$

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$$pOH = -\log [OH^-]$$

$$pOH = -\log(2.7 \times 10^{-3})$$

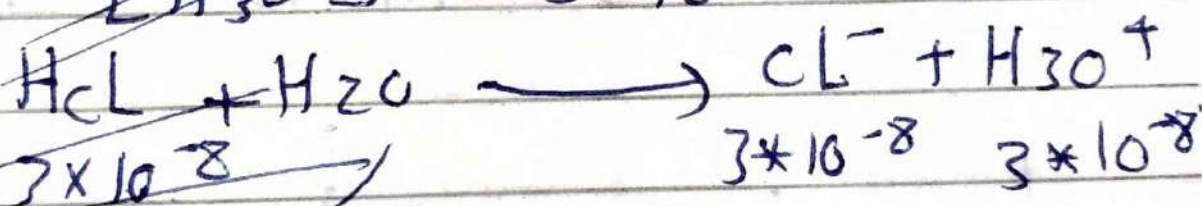
2.57

$$pH = 14 - pOH$$

$$\rightarrow 11.43$$

What is the pH of $3 \times 10^{-8} M$ HCl?

$$[H_3O^+] = 3 \times 10^{-8}$$



$$[H^+]_{\text{Total}} = 3 \times 10^{-8} + 10^{-7}$$

$$-\log(1.3 \times 10^{-7})$$

$$pH = \boxed{6.9}$$

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The pH of 0.1 M soln of HCOOH is 2.39 Calculate K_a .



$$[\text{H}_3\text{O}^+]_{eq} = 10^{-2.39} = [4.1 \times 10^{-3}]$$

$$\boxed{4.1 \times 10^{-3}}$$

$$x = 4.1 \times 10^{-3}$$
$$\begin{array}{c} 0.1 \\ -x \end{array}$$

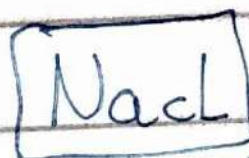
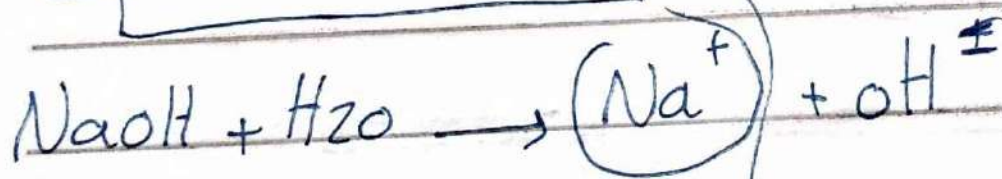
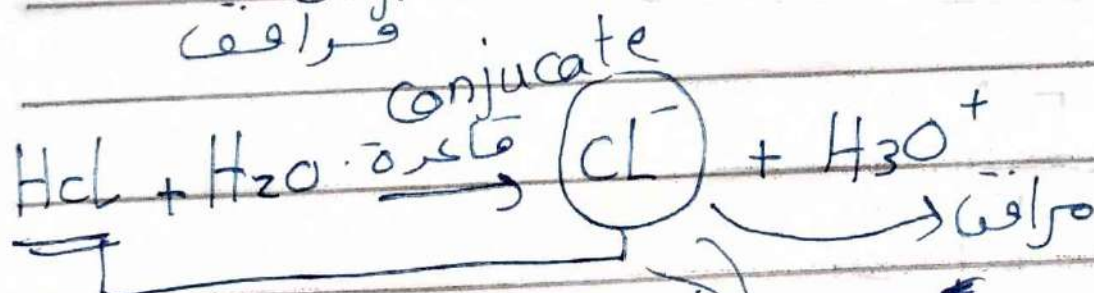
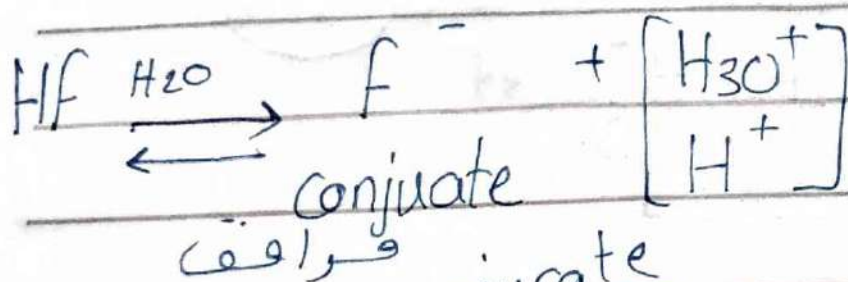
$$\rightleftharpoons \begin{array}{cc} +x & +x \\ 4.1 \times 10^{-3} & 4.1 \times 10^{-3} \end{array}$$

$$K_a = \frac{(4.1 \times 10^{-3})^2}{(0.1 - 0.0041)} = 1.8 \times 10^{-4}$$

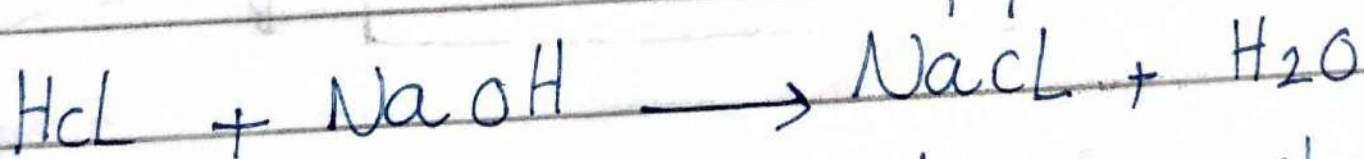
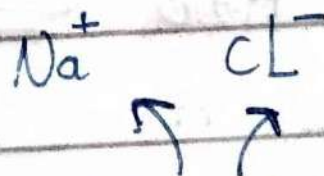
⇒ Acid and base properties of salts.

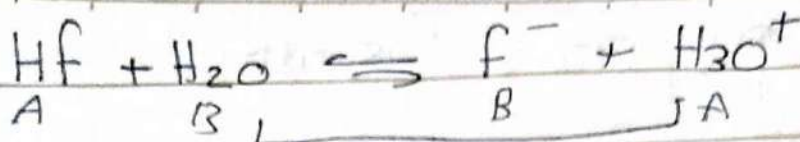
Salts: Ionic Compound.

[+ve ion and -ve ion]
[metal + non metal]

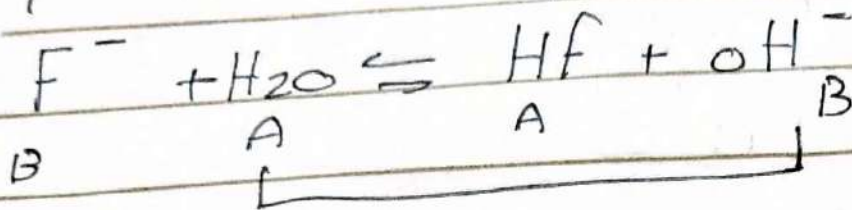
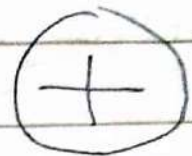


Conjugate Acid + Conjugate Base → Salt.



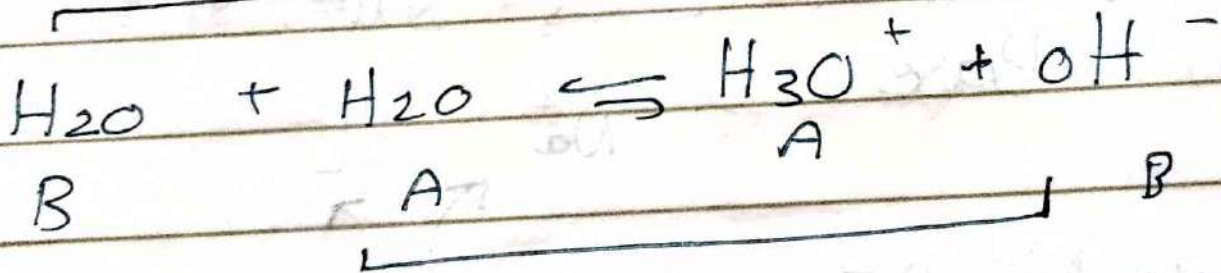


$$K_a = \frac{[\text{F}^-][\text{H}_3\text{O}^+]}{[\text{HF}]}$$



$$K_b = \frac{[\text{HF}][\text{OH}^-]}{[\text{F}^-]}$$

1) + 2)



$$K_w = K_a \times K_b$$

For Any acid and It's conjugate Base
and Any Base and It's Conjugated Acid

$$K_a \cdot K_b = K_w = 10^{-14}$$

$$K_a = \frac{10^{-14}}{K_b}$$

للأسيد مع قاعدته مرافقة
والعكس

$$K_w = K_a \cdot K_b$$

$$K_b = \frac{10^{-14}}{K_a}$$

$$[p(K_a) + p(K_b) = p(K_w) = 14]$$

أقوى حمض له أضعف قاعدة مرافقة وبالعكس
Acid or Base Strength increase the Strength
of conjugate base & acid decrease

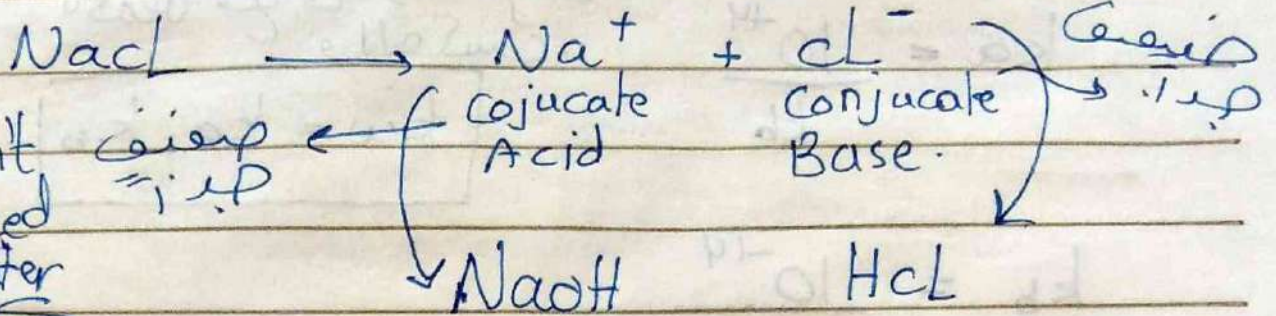
$$[K_a \cdot K_b = 10^{-14}]$$

~~Pre~~

predict acidning basciting (pH) of the follow

نفسه
نفسه

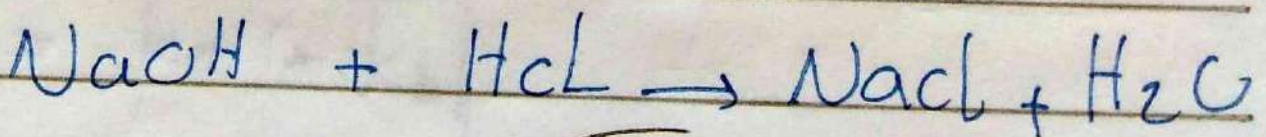
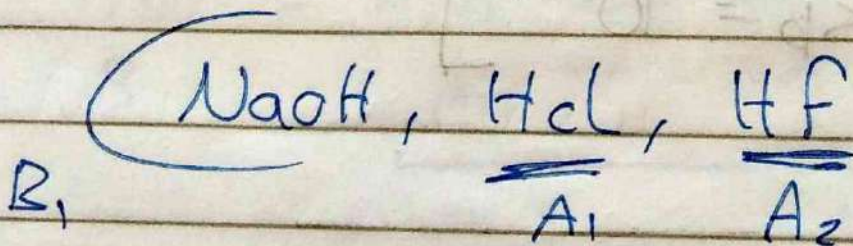
1) NaCl (Salt)



doesn't
Ionized
in water

doesn't affect
water (pH)

- The strongest Acid Reacts with
Strongest Base. أقوى سبب ينال معاً



$\text{pH} = 7$

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والأيونات تكون ورافقة

[موجب ← حمض]

[سالب ← قاعدة]

مرافقة ←

 Na^+ H_2O H_2O

A

A

B

مضيق
مبدأمضيق
مبدأ Cl^-
B H_2O H_2O

B

A

 $\text{pH} = 7$

HA

 $K_a = 10^{-16}$

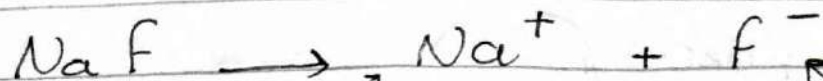
*

 H_2O^+ H_2O 10^{-14} 10^{-14} $\text{pH} = 7$ الذي يتفاعل مع الماء الذي يكونه
قوى منه لكي يتفاعل.

② NaF

conjugate base

~~conjugate acid~~



Conjugate
Acid

Base

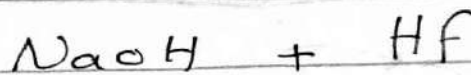
very strong

SLGI

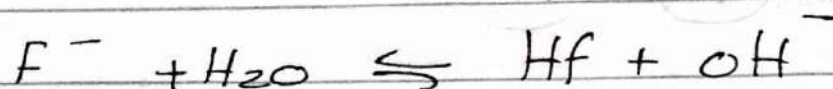
No Reaction

with water

Very
strong



react
with
water



$\text{pH} > 7$

Base

③ NH_4Cl



very
stronger
than
water
weak
R

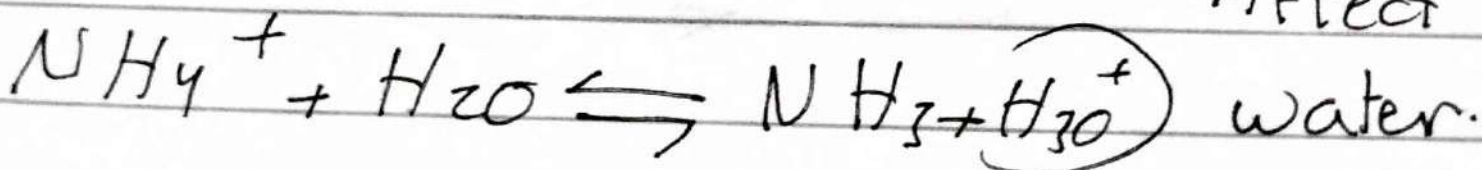
NH_3

+

HCl

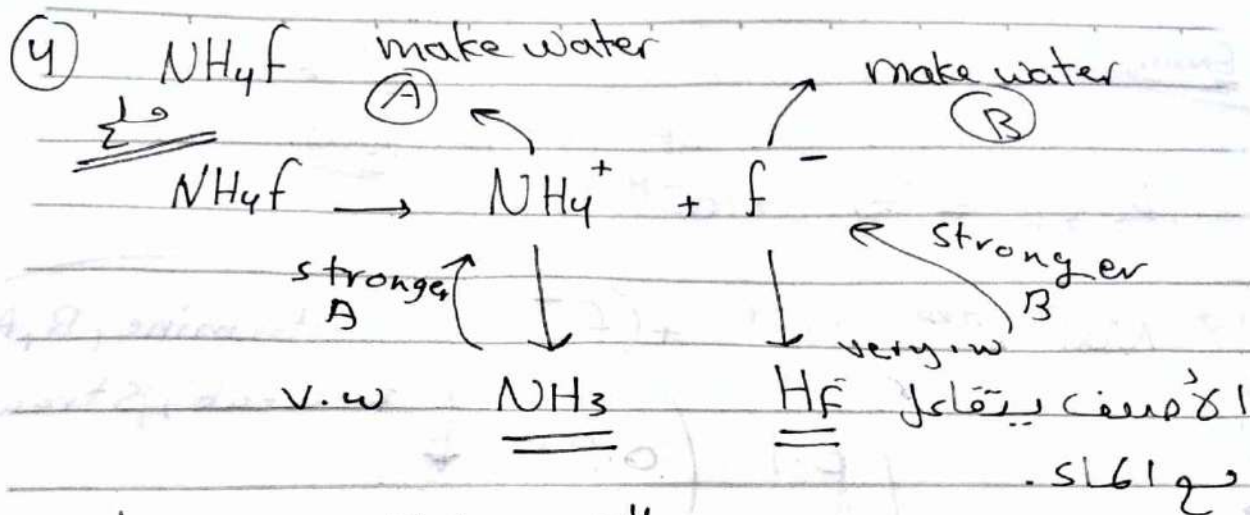
very
weak.

does not
Affect



water.

$\text{pH} < 7$



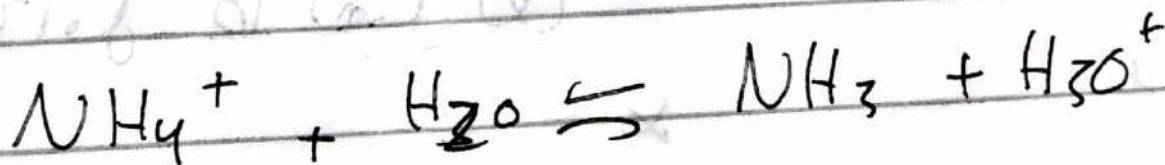
$$K_a \text{ HF} = 7.1 \times 10^{-4}$$

$$K_a \text{ NH}_3 = 1.8 \times 10^{-5}$$

$$K_b \text{ F}^- = \frac{K_w}{K_a \text{ HF}} = \frac{10^{-14}}{7.1 \times 10^{-4}} = 1.4 \times 10^{-10}$$

$$K_a \text{ NH}_4^+ = \frac{K_w}{K_b \text{ NH}_3} = \frac{10^{-14}}{1.8 \times 10^{-5}} = 5.5 \times 10^{-10}$$

$$K_a \text{ NH}_4^+ > K_b \text{ F}^-$$

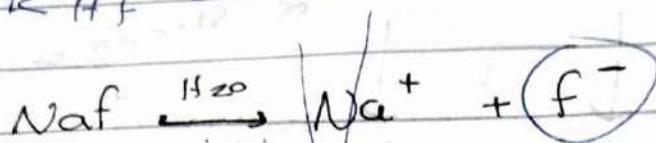


$$\text{pH} < 7$$

Examples

calculate pH of 0.1 M Naf give

$$K_{Hf} = 7.1 \times 10^{-4}$$



تفكك
الحمض
قوي

0.1

0.1

0.1

1) determine, B, A, S
2) weak, Strong

2) write dissociation

NaOH

HF

(equation)

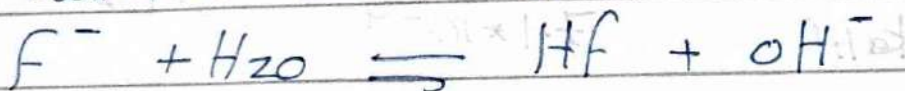
Strong

weak

concentration

write Ionization eqn in
water of the Strong Ion.

3) determine ion
strength



5) determine pH $\rightarrow [\text{OH}^-] [\text{H}_2\text{O}^+]$

Ice Table $\rightarrow K_a$

$$K_b \text{ F}^- = \frac{K_w}{K_{Hf}} = 1.4 \times 10^{-11}$$

0.1M

-x

0

x

x

0

x

أي تي اقل 10^{-5} نزل

.1 - x

x

x

x²

$$K_b = \frac{x^2}{(0.1 - x)}$$

$$x = \sqrt{K_b \times [\text{F}^-]}$$

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$$x = \sqrt{1.4 \times 10^{-12}} \quad x = \boxed{1.183 \times 10^{-6}}$$

$$pOH = -\log (1.183 \times 10^{-6})$$

$$\boxed{pH > 7}$$

$$= \boxed{5.928}$$

↓
الأسهل أقوى يكونه

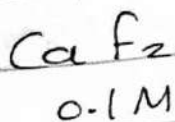
$$pH = 14 - 5.928$$

للمرافقات .

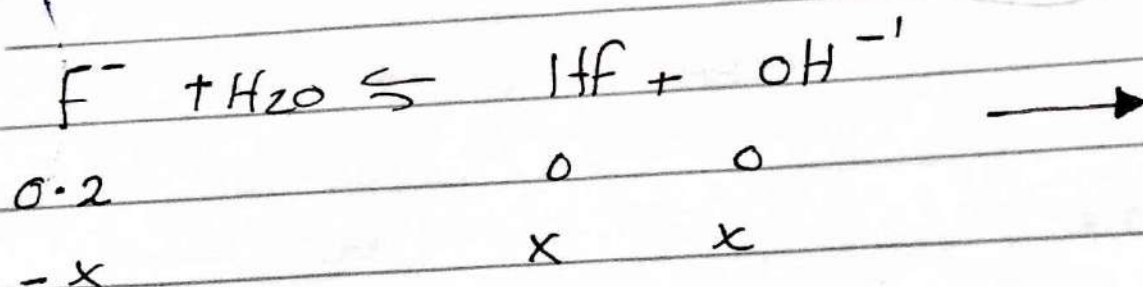
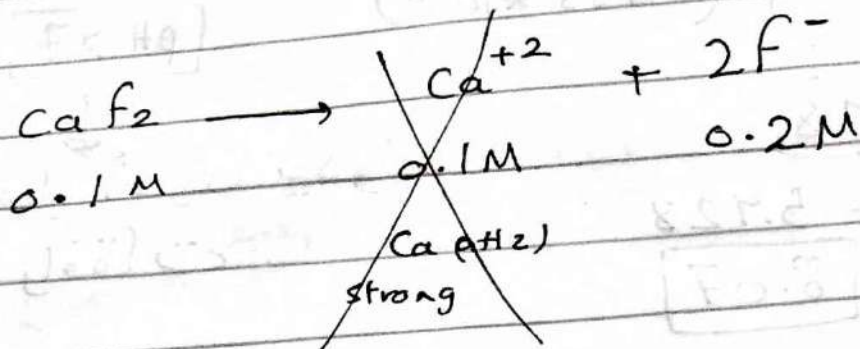
$$= \boxed{8.07}$$

CaF₂

(H.w)



H.W



$$K_{b \text{ F}^-} = \frac{K_w}{K_{a \text{ HF}}} = \frac{10^{-14}}{1.4 \times 10^{-4}}$$

$$= 1.4 \times 10^{-11}$$

$$\sqrt{1.4 \times 10^{-11} \times 0.2}$$

$$0.2$$

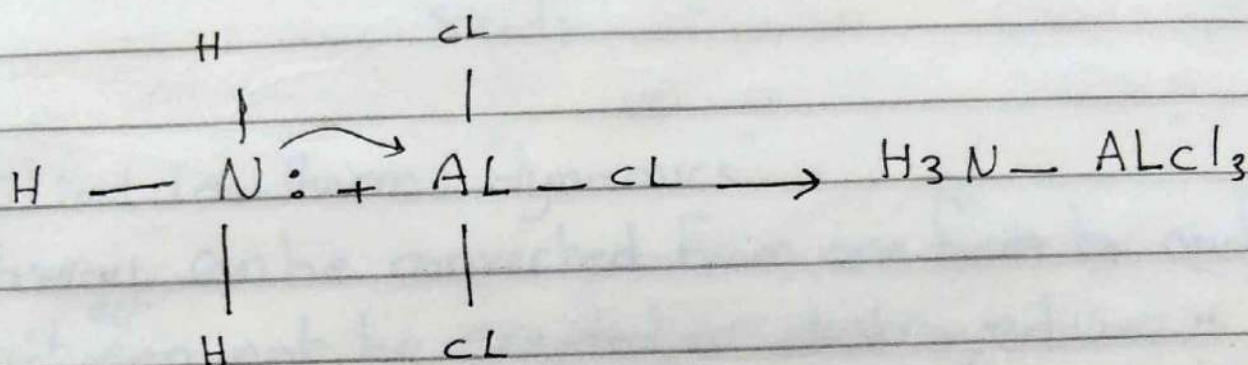
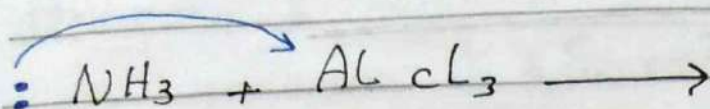
$$x = \sqrt{1.4 \times 10^{-11} \cdot 0.2}$$

Lewis Acid and Bases

(-e) يقبل

Lewis acid $\rightarrow$ Lone electron acceptor

Lewis base $\rightarrow$ " " donor
يمنح



Lewis
Base

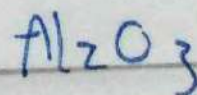
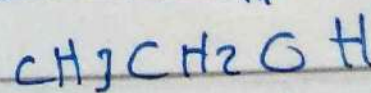
Lewis
Acid

donor

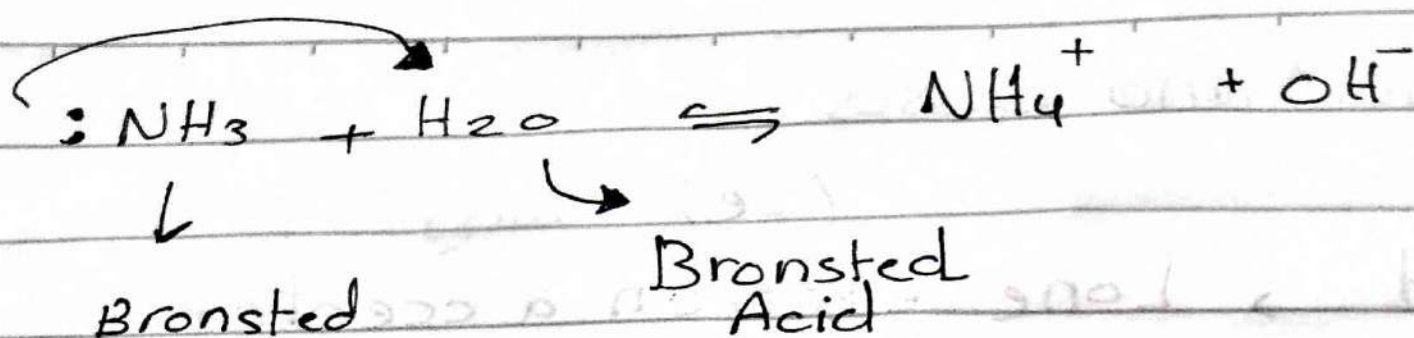


Lewis
Base

Lewis
Acid



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Ch 16 Thermo chemistry

(Study heat flow in chemical RXN)

Universe = System + Surrounding

↓ انتقال طاقة

Rxn under
Study.

1) first Law Thermo dynamics.

Energy can be converted From one form to another
but can not be created or destroyed

لا تفنى

Δu

$$\Delta E_{\text{universe}} = 0$$

الذي يكسب (+)

فقد (+)

$$0 = \Delta E_{\text{System}} + \Delta E_{\text{Surrounding}}$$

طارد (-)

الذي يكتسب (-)

$$\Delta E_{\text{system}} = - \Delta E_{\text{surrding}}$$

(-)

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[تاريخ القاء]

$$\boxed{\text{Energy} = q + w}$$

$\downarrow$ heat $\downarrow$ work

$$\boxed{w = -P \Delta V}$$

[تقليل]

(1)

Done by the system

$$\boxed{w(-)}$$

expansion

(توسع)

> 0

exothermic

(releases heat)

$$q = (-)$$

< 0

endothermic

absorb heat

$$q = (+)$$

 $\Delta V (+)$ $P (+)$

$$w = -P \Delta V = (-)$$

Done on the System.

$$w (+)$$

Compression

تقليل

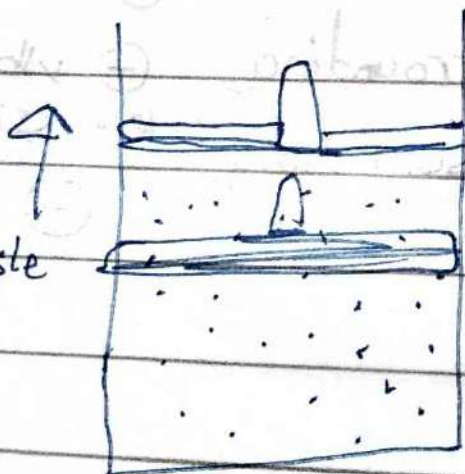
 $\Delta V (-)$ $P (+)$

$$w = -P \Delta V$$

$$\boxed{w (+)}$$

$$\Delta \text{heat} = h_f - h_i$$

$$H_{\text{product}} - H_{\text{reactants}}$$



$$\boxed{w = -P \Delta V} \quad \text{at constant pressure, Temperature.}$$

$$PV = nRT$$

$$-P \Delta V = -\Delta n RT \quad \text{at constant pressure, Temperature.}$$

work

$$\boxed{w = -\Delta n R T} \quad \text{8.314}$$

$$J = \text{atm} \cdot L = \frac{\text{mol} \cdot J}{\text{mol} \cdot K} \cdot K$$

$$R = 8.314 \frac{J}{\text{mol} \cdot K} = 0.0821 \cancel{\text{atm} \cdot L} \frac{\text{mol} \cdot K}{\text{mol} \cdot K}$$

$$1 \text{ atm} \cdot L = \frac{8.314 J}{0.0821} = \boxed{101.3 J}$$

$$\boxed{w = -P \Delta V (101.3)}$$

Example Calculate the work if gas is expand
from 2.0 L to 6.0 L

1) against 1.2 atm

2) against vacuum.

$p = 0$ slab

$$\Delta V = V_f - V_i$$

$$6 - 2$$

$$= +4$$

$$W = - p \Delta V (101.3)$$

$$= -1.2 \times 4 \times (101.3)$$

$$= -490 \text{ J}$$

zero

$$W = - (p) \Delta V$$

$$W = \text{Zero J}$$

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done on the Syst

Example The work calculated when gas is compressed is 462 during process 128 J heat $\oplus$ transferred to the Surrounding. $(-)$

exotherm - calculate the energy.

$$E = Q + W$$

$$W = +462 \text{ J}$$

$$Q = -128 \text{ J}$$

$$E = -128 \text{ J} + 462 \text{ J}$$

$$E = \boxed{+334 \text{ J}}$$

$$\Delta E = q + w$$

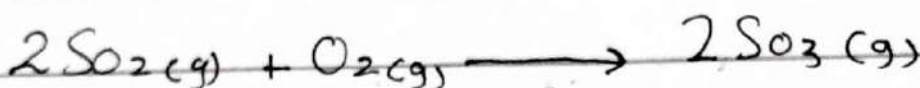
Enthalpy (ΔH) ~~heat (q) kJ~~ ^ج ~~is called~~
 (heat) q

J/mol

J / kJ

kJ/mol

enthalpy ^{متغيرة}
 $(\Delta H) = \frac{q \text{ (heat)}}{n \text{ (mole)}}$
 $q = \Delta H * n$



$$\Delta H_{\text{Rxn}} = -198.2$$

kJ/mol

$$\Delta H_{\text{Rxn}} = H_{\text{product}} - H_{\text{react.}}$$

According to
coefficients of
balanced equations.

$$\frac{-198.2}{2 \text{ mol SO}_2} = \frac{-198.2}{1 \text{ O}_2 \text{ moles}} = \frac{-198.2}{2 \text{ mol SO}_3}$$

(2) mol SO₂

(1) O₂ moles

(2) mol SO₃

Calculate heat Released when 87.9 g of SO₂ React.

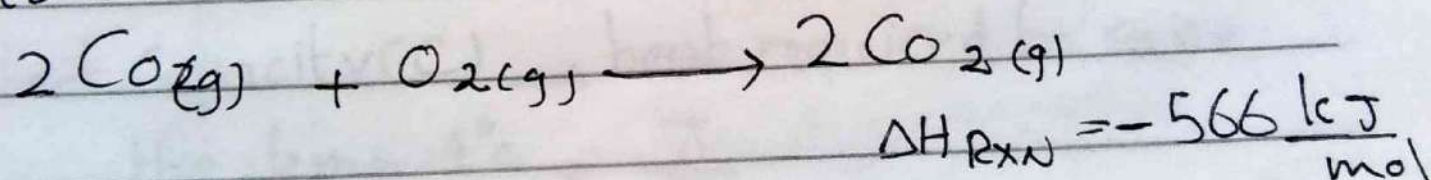
$$q = \Delta H \times n$$

$$n_{\text{SO}_2} = \frac{m}{\text{M.M}} = \frac{87.9}{64} = 1.37 \text{ SO}_2$$

$$q = \frac{-198 \text{ kJ}}{2 \text{ mol SO}_2} \times 1.37 \text{ mole SO}_2$$

$$q = -136 \text{ kJ}$$

Calculate Change in Energy when 1.5 m Co are
Converted to Co₂ at 1 atm and 25°C according
to



$$\Delta E = q \times w$$

$$q = \Delta H \times n$$

$$= \frac{-566}{2} \times 1.5 = -424.5 \text{ kJ}$$

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$$w = - \underset{\substack{\downarrow \\ \text{atm}}}{p} \underset{\substack{\downarrow \\ L}}{\Delta V} (101.3)$$

$$w = - \underset{\substack{\downarrow \\ \text{only for gasses}}}{\Delta n} R T$$

$$\Delta n = \text{moles of products} - \text{moles of reactants}$$

$$2 - (2+1) = (-1)$$

$$w = - 1 * 8.314 * 298$$

$$w = 2477 \text{ J} = 2.477 \text{ kJ}$$

$$\Delta E = q + w$$

$$= -424.5 + 2.477$$

$$= \boxed{-422 \text{ kJ}}$$

Calorimetry

Instrument $\rightarrow$ Calorimeter $\rightarrow$ used to measure calories (heat)

Calorimeter Types :-

- (1) Constant $\nearrow$ pressure Calorimeter (Coffe cup Calorimeter)
- 2) " Volume " " (bomb calorimeter)

$$q = \Delta T \cdot m \cdot [S]$$

(heat) $\downarrow$ $\downarrow$ $\downarrow$ $\downarrow$
 change in Temp ($^{\circ}\text{C}$) mass Specific heat capacity $\frac{\text{J}}{\text{g} \cdot ^{\circ}\text{C}}$
 for $\frac{1(\text{g})}{\text{to increase to } 1^{\circ}\text{C}}$

heat Capacity (C) $\rightarrow$ heat required to raise the temp 1°C $= \frac{\text{J}}{^{\circ}\text{C}}$

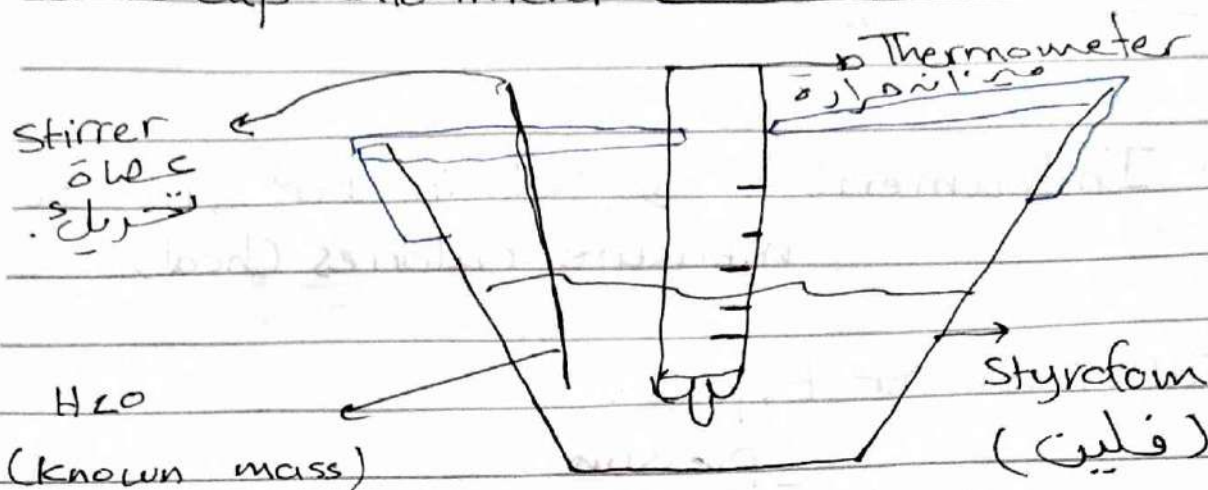
$$q = \Delta T \cdot C$$

$$C = S \cdot m$$

$[C]$ $\frac{\text{J}}{^{\circ}\text{C} \cdot \text{g}}$

$$[C] = \left[\frac{\text{J}}{^{\circ}\text{C}} \right]$$

* Coffee cup Calorimeter (constant pressure)



$$\Delta T \quad T_i \longrightarrow T_f$$

m

- constant pressure Calorimeter

$$\left. \begin{aligned} q_{\text{lost}} &= -q_{\text{gained}} \\ q_{\text{system}} &= -q_{\text{surrounding}} \end{aligned} \right\}$$

$$q_{\text{system}} = - \left(\cancel{q_{\text{cup}}}^{\text{neg.}} + \cancel{q_{\text{H}_2\text{O}}}^{\text{neglected}} \right)$$

$$q_{\text{system}} = -q_{\text{H}_2\text{O}}$$

$$= (\Delta T \cdot m \cdot S)_{\text{H}_2\text{O}}$$

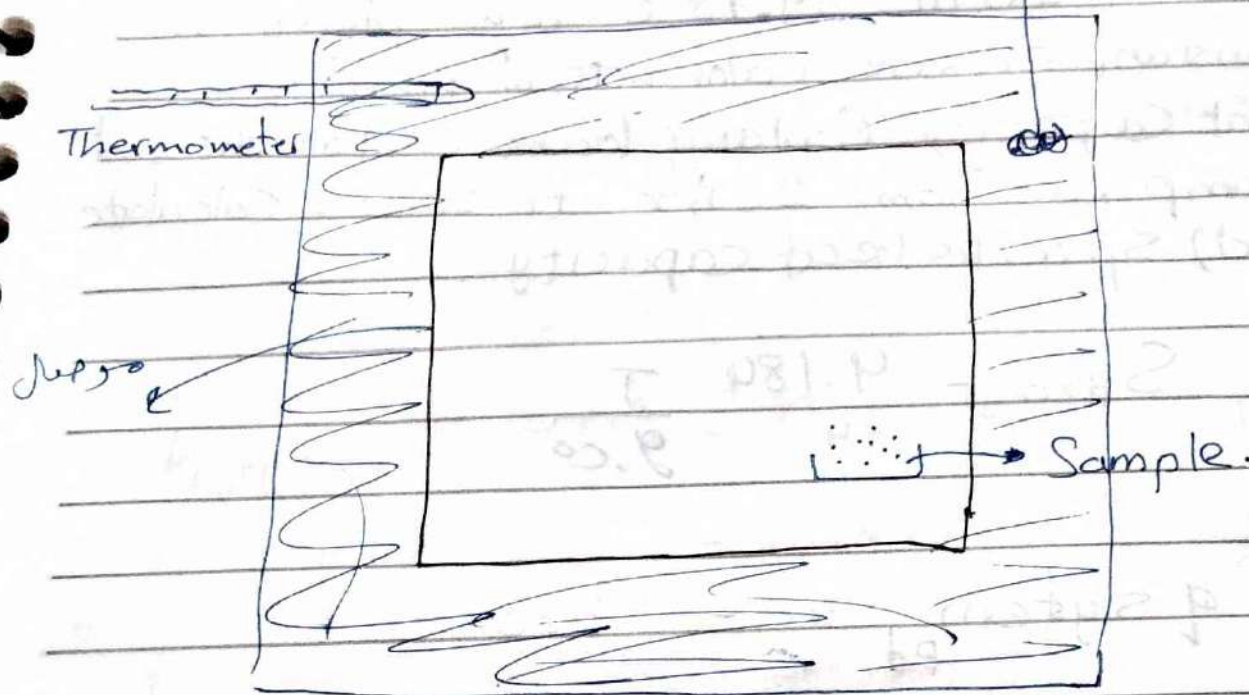
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Stirrer

(2) Constant volume.



$$q_{\text{system}} = -q_{\text{surrounding}}$$

$$q_{\text{system}} = - (q_{\text{H}_2\text{O}} + q_{\text{bomb calorimeter}})$$

$$= - ((\Delta T \cdot m \cdot S)_{\text{H}_2\text{O}} + (\Delta T \cdot m \cdot S)_{\text{calorimeter}})$$

$$T_{i \text{ H}_2\text{O}} = T_{i \text{ calorimeter}}$$

$$T_{f \text{ H}_2\text{O}} = T_{f \text{ calorimeter}}$$

$$\Delta T_{\text{H}_2\text{O}} = \Delta T_{\text{calorimeter}}$$

$$q_{\text{system}} = - \Delta T (m \cdot S_{\text{H}_2\text{O}} + m \cdot S_{\text{calorimeter}})$$

$$q_{\text{system}} = - \Delta T (C_{\text{H}_2\text{O}} + C_{\text{calorimeter}})$$

Example A lead of Pb pellet at 26.47 g mass at 89.98 °C was placed in constant pressure calorimeter of negligible heat capacity containing 100 mL water. The water temp rises from 22.5 °C to 23.17 °C. Calculate c_p specific heat capacity.

$$S_{H_2O} = 4.184 \frac{J}{g \cdot ^\circ C}$$

$$q_{system, Pd} = -q_{H_2O}$$

$$\Delta T \cdot m \cdot S_{Pd} = -(\Delta T \cdot m \cdot S_{H_2O})$$

$$\Delta T = T_f - T_i$$

$$= (23.17 - 89.98)(26.47) S = - (23.17 - 22.5)(100g)(4.184)$$

$$S_{Pd} = 0.158 \text{ J/g} \cdot ^\circ C$$

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[C] $\frac{\text{kJ}}{\text{C}^\circ}$ [S] $\frac{\text{kJ}}{\text{g} \cdot \text{C}^\circ}$

a 1.435 of naphthalene C_{10}H_8 was burned in constant v Calorimeter of heat capacity of the bomb plus water equal 10.7 kJ/C. if the water temperature from 20.28°C to 25.95°C. Calculate Molar heat of Combustion.

$$q_{\text{naphthalene}} = -\Delta T (C_{\text{H}_2\text{O}} + C_{\text{bomb}})$$

$$= -(25.95 - 20.28) \times (10.7) \frac{\text{kJ}}{\text{C}^\circ}$$

$$q_{\text{C}_{10}\text{H}_8} = -60.67 \text{ kJ}$$

$$\Delta H = \frac{q}{n}$$

$$\Delta H = \frac{-60.67}{n}$$

$$\frac{m}{M.M} = \frac{1.435}{(8 \times 12) + (10 \times 16)}$$

$$\Delta H = -54.16 \text{ kJ/mol}$$

$$20 \text{ ml} = 200 \text{ g}$$

- * 100 ml of 0.5 M HCl was mixed with 100 ml of 0.6 M NaOH sol in constant p Calorimeter with negligible heat capacity. If the initial temp of HCl 22.5 and final ~~26~~ 25.86 °C and NaOH

Calculate the molar heat of Neutralization. Rxn

$$S_{\text{soln}} = S_{\text{H}_2\text{O}} = 4.134 \frac{\text{J}}{\text{g} \cdot \text{C}}$$

$$d_{\text{soln}} = d_{\text{H}_2\text{O}} = 1 \text{ g/ml}$$

$$q_{\text{system}} = - q_{\text{H}_2\text{O}}$$

$$q_{\text{HCl} + \text{NaOH}} = - q_{\text{H}_2\text{O}}$$

$$- \Delta T \cdot m \cdot S$$

↗ Total mass

$$= - (25.86 - 22.5) (200) (4.134)$$

$$q_{\text{system}} = - 2.81 \times 10^3 \text{ J}$$

$$= - 2.81 \text{ kJ}$$

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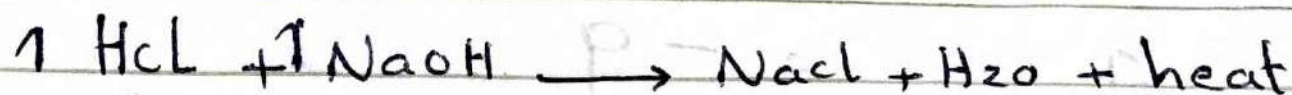
$$\Delta H = \frac{q}{n}$$

 $\downarrow$ L.R

$$M = \frac{n}{V(L)}$$

~~$$M = \frac{n}{V(L)}$$~~

$$n = M \cdot V(L)$$



$$n_{\text{HCl}} = M \cdot V = 0.5 \times 0.1 = 0.05$$

$$n_{\text{NaOH}} = M \cdot V = 0.6 \times 0.1 = 0.06$$

$$\Delta H = \frac{q}{n} = \frac{-2.81}{0.05} = -56.2$$

$$\Delta H_{\text{CF}} = \Delta T$$

H.W

100ml of water at 90°C was mixed with 55ml water at 42°C in a const p Calorimeter of negligible heat capacity.
Find final Temp of water.

$$q_{\text{system}} = -q_{\text{H}_2\text{O}}$$

Ans

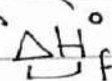
$$q_{\text{Hot water}} = -q_{\text{cold water}}$$

$$\Delta T \cdot m \cdot s = \Delta T \cdot m \cdot s$$

$$(T_f - 90) \cdot 100 = (T_f - 42) \cdot 55$$

$$\boxed{T_f = 72.96^{\circ}\text{C}}$$

Standard enthalpy of formation

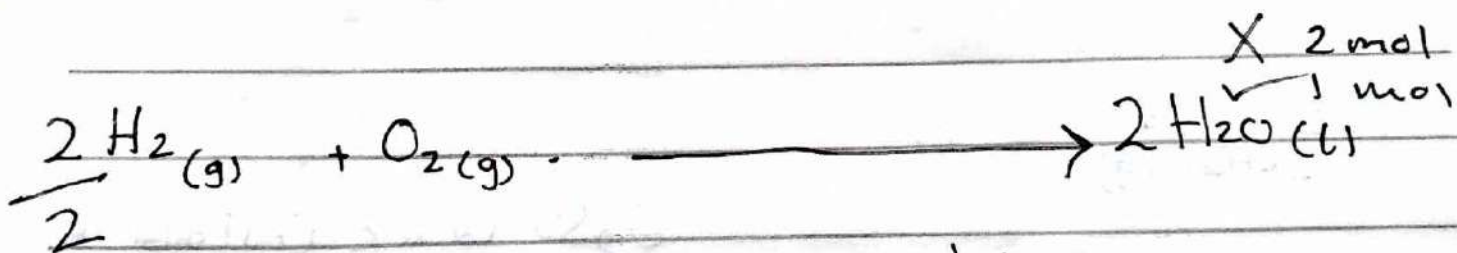
1 mole
in standard
conditions

The heat change results from the formation of a
from its elements at standard conditions

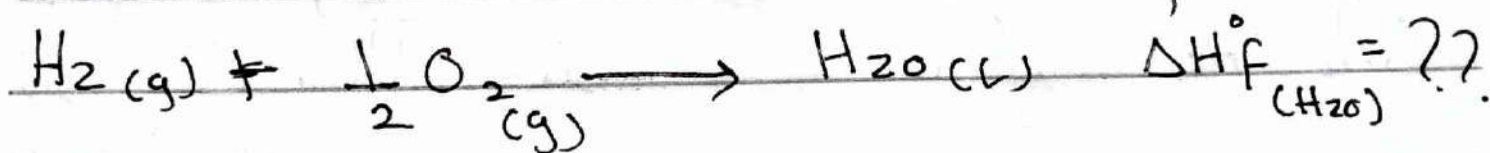
↳ 1 atm

 25°C = (T) , 25°C !

write the formation equation.

1) $\text{H}_2\text{O}(\text{l})$ 2) $\text{CH}_3\text{OH}(\text{l})$ 

جداول



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 ΔH_f° تصريفا

تكوين

(Standard enthalpy in Reactions)

$$\Delta H_{\text{rxn}}^\circ = \Delta H_{\text{products}}^\circ - \Delta H_{\text{Reactant}}^\circ$$

$$= \sum (n \cdot \Delta H_{f, \text{products}}^\circ) - \sum (n \cdot \Delta H_{\text{react}}^\circ)$$

$$\Rightarrow \Delta H_f^\circ \text{ elements} = 0$$



$$\Delta H_f = x$$



$$\Delta H_{f, \text{H}_2\text{O}}^\circ = 0$$

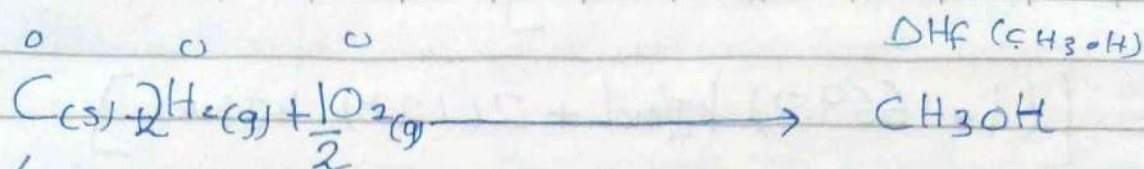
* العناصر عندما تكون

حالة = صفر طاقيا

الترتيب سائل عند

الطرق الاعيانية





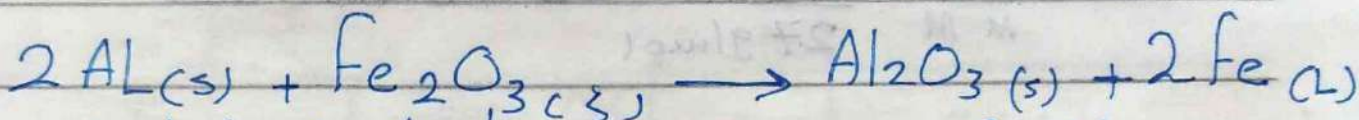
$$\Delta H_f^\circ (\text{CH}_3\text{OH}) =$$

C graphite = 0

C diamond $\neq$ 0

Calculate standard enthalpy of Rxn

Labels



2) Calculate heat released per gram of Al.

$$\Delta H^\circ_{\text{Rxn}} = ??$$

$$\Delta H^\circ_{\text{Rxn}} = \sum n \cdot \Delta H_f^\circ \text{ prod} - \sum n \cdot \Delta H_f^\circ \text{ React}$$

$$\left[1 \cdot \Delta H_f^\circ (\text{Al}_2\text{O}_3)_{(\text{s})} + 2 \cdot \Delta H_f^\circ \text{ Fe}_{(\text{l})} \right]$$

$$- \left[2 \cdot \Delta H_f^\circ \text{ Al}_{(\text{s})} + 1 \cdot \Delta H_f^\circ (\text{Fe}_2\text{O}_3)_{(\text{s})} \right]$$

المسألة تتطلب معرفة قيم ΔH_f° للمركبات المتضمنة في التفاعل

من الجدول

Subject $\left[\begin{array}{l} \Delta H = \frac{q}{n} \\ \Delta H_f^\circ \rightarrow \text{Tables} \end{array} \right]$ Day _____ Date _____

$$\left[(1 \times 1669.8) \text{ kJ/mol} + 2(12.4) \text{ kJ/mol} \right] \\ - \left[2(0) + 1(-826 \text{ kJ/mol}) \right]$$

$$= \boxed{-319 \text{ kJ/mol}}$$

2) 1g

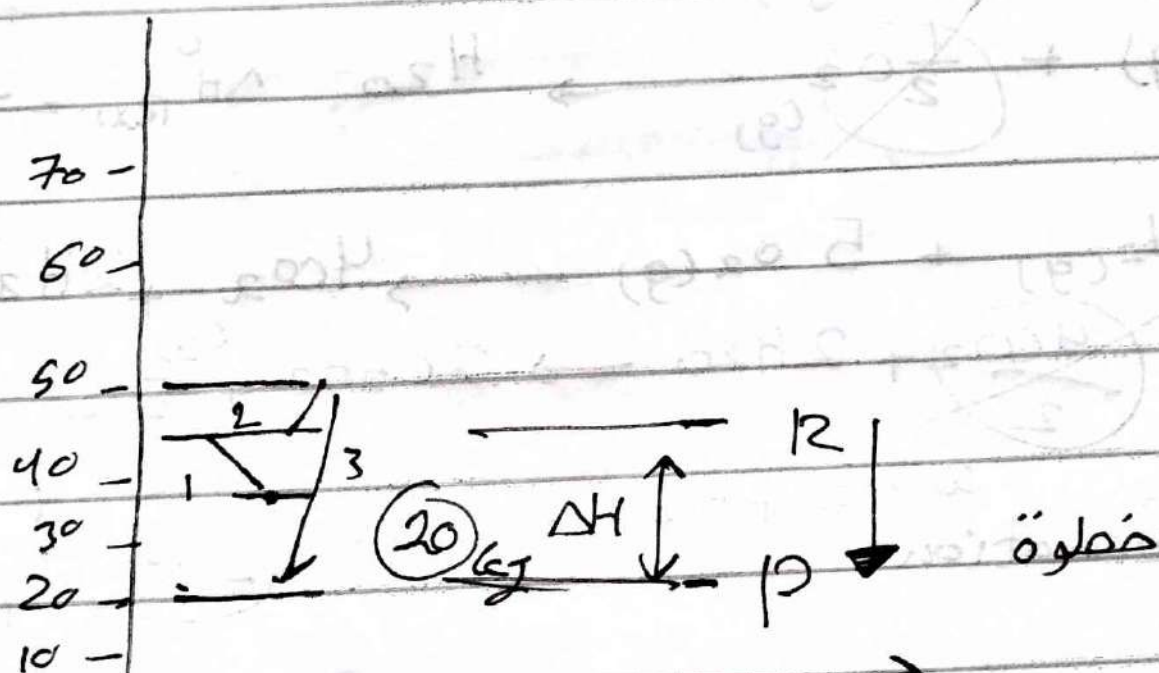
$$n_{\text{Al}} = \frac{m}{M.M} = \frac{1 \text{ g}}{27 \text{ g/mol}} = 0.037 \text{ mol}$$

$$q = \Delta H \cdot n$$

$$= \frac{-319}{2} \times 0.037 = \boxed{-15.17 \text{ kJ}}$$

((Hesse's law))

when Reactants are converted to products the change in enthalpy is the same whether the Rxn takes places in one Step or in series of Steps.



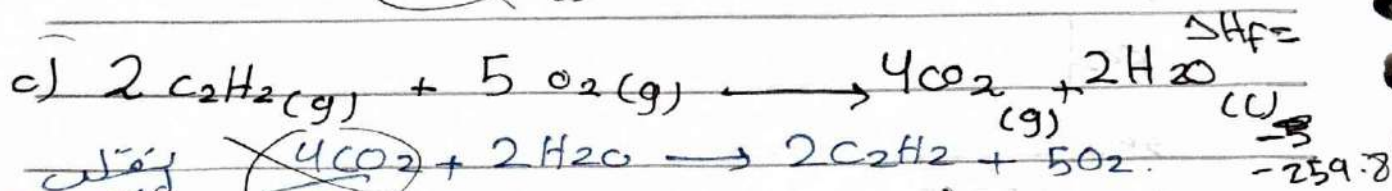
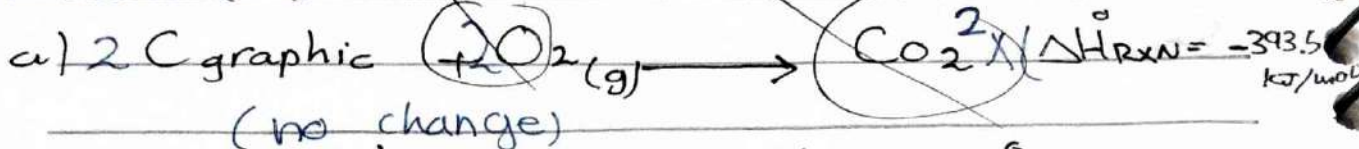
$$\Delta H = \text{النهائي} - \text{البداية}$$

$$A = (1) + (2) + (3)$$

Calculate the standard heat of formation of $C_2H_2(g)$ given

~~C_2H_2~~

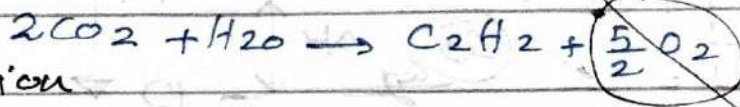
multiply (*2)



flip and divide



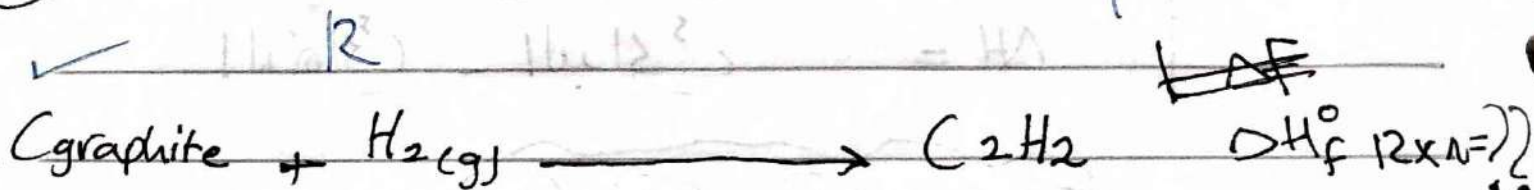
write formation



o.j.e
(1-1)
259.8

P

④



$$\Delta H_{\text{f}} C_2H_2 = 2 \Delta H_{\text{f}}^{\text{a}} + \Delta H_{\text{f}}^{\text{b}} - \frac{\Delta H_{\text{f}}^{\text{c}}}{2}$$

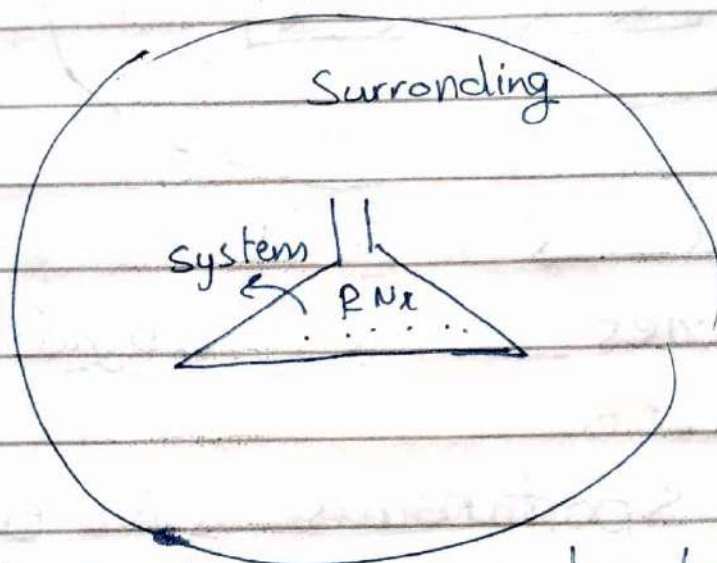
$$\Delta H_{\text{f}} = +226.6$$

Ch 17 and Ch 18 } Thermodynamics

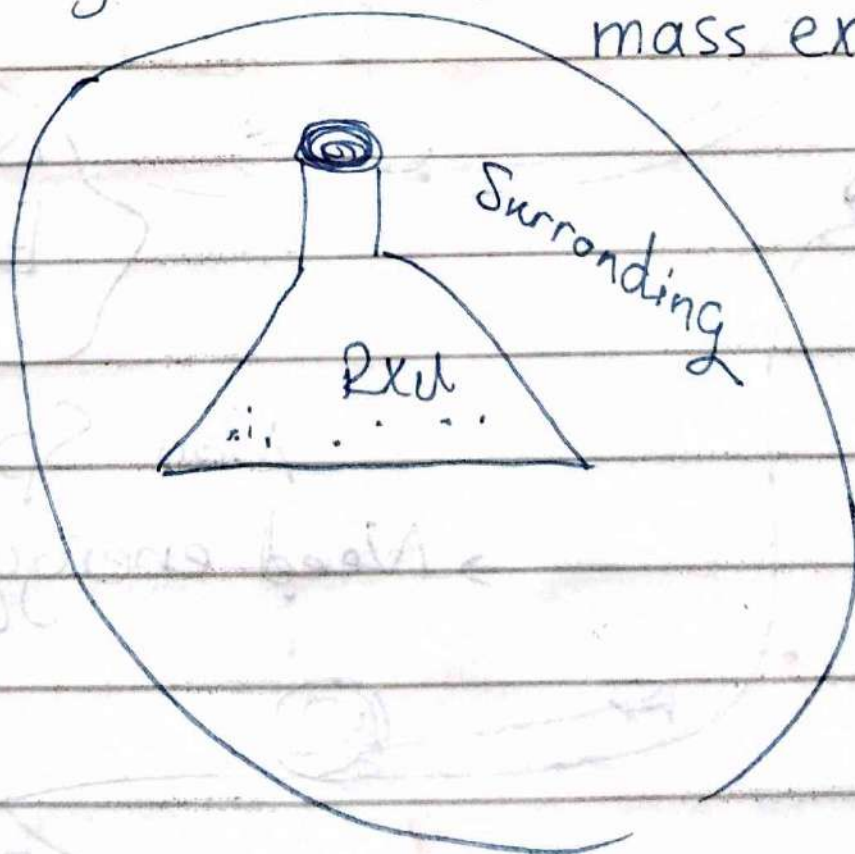
Spontaneous / Non-Spontaneous process
↳ Gibbs Free Energy.

Type of Systems ..

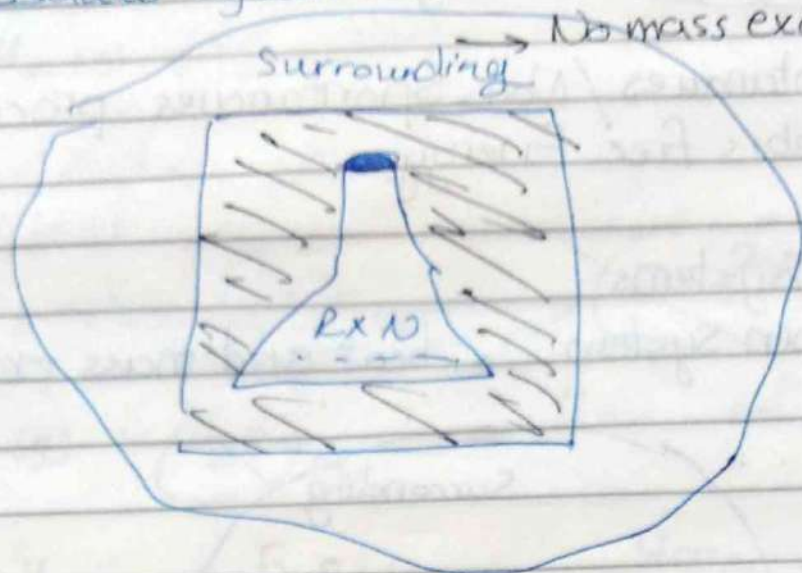
1 - open System → heat and mass exchange.



2 - closed System. → heat exchange No mass exchange.

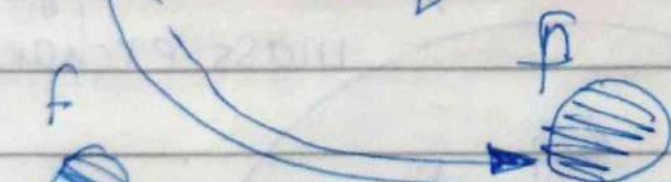


3- Isolated System → No heat exchange
No mass exchange.



Spontaneous → تلقائي
Non Spontaneous → غير تلقائي

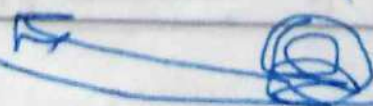
spontaneous → No energy required to happen



$$\Delta E = (-)$$

$$E_f < E_i$$

Non Spontaneous
→ Need energy to happen



$$\Delta E = (+)$$

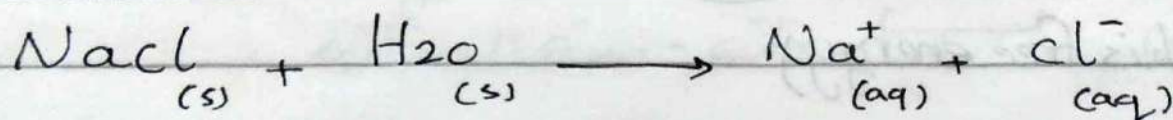
$$E_f > E_i$$

Subject _____ Day _____ Date _____

الطاقة الأقل تكون استقرار أعلى.

$$\Delta E = q + \cancel{w}$$

Any system refers to exothermic system.
and increase in Entropy $\boxed{\Delta S (+)}$ ($\Delta H (-)$)
(وحرارة أقل)



$\Delta H (+)$

~~ΔE~~ العملية تلقائية ولكن

$\Delta E (-)$

تدخل عملية

الاضوائية، Randomness Entropy (S) :
احتمالية الانتقال أقل من احتمالية المزج
ويميل التفاعل إلى العشوائية.

① حالة المادة Solid > Liquid > Gas
تزداد العشوائية.

الحرارة $T \uparrow = S \uparrow$ as

عدد الأشياء

(Gibbs free energy)

$$\Delta G = \Delta H - T \Delta S$$

Spont $\Delta G (-)$ → باتجاه التواتج

non Spont $\Delta G (+)$ → باتجاه المتفاعلات

$\Delta G = 0$ At equilibrium

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تصنيف
تزايد
Date
g > l > s
→

determin sign ΔS ?

1) Freezing Ethanol

 $\Delta S (-)$

2) dissolving Sugar

 $\Delta S (+)$ 3) ~~heat~~ Cooling N_2 from $28^\circ C$ to $20^\circ C$ قلت درجة الحرارة $\Delta S (-)$

أقل

عشوائية أعلى

4) $CaCO_3(s)$ $\longrightarrow$ $CaO(s) + CO_2(g)$ $\Delta S = S_{\text{production}} - S_{\text{Reaction}}$ $\Delta S (+)$

تزداد

تقل عشوائية

 $3H_2(g)$ $+ N_2(g)$ $\longrightarrow$ $2NH_3(g)$

4 gass

2 gass.

 $\Delta S (-)$

5)

 H_2 $+ Cl_2$ $\longrightarrow$ $2HCl(g)$

(g)

(g)

(g)

2

2

 $\Delta S \sim 0$

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3rd law Thermodynamic --

The entropy of perfect Crystalline Substance at the absolute Zero Temp ($T=0(K)$ $T=-273^{\circ}C$) is Zero
(عشوائية عند الصفر المطلق = صفر) وتزداد فوق الصفر المطلق.

- Standard entropy of reaction (ΔS°)

1 atm
5°C

$$\Delta S^{\circ}_{Rxn} = S^{\circ}_{products} - S^{\circ}_{React}$$

in
Tables

$$= \left(\sum n \cdot \underline{S^{\circ}_{product}} \right) - \left(\sum n \cdot \underline{S^{\circ}_{reactants}} \right)$$

(Tables)

S° لجميع $\rightarrow$ موجبة

Subject _____ Day _____ Date _____

ΔS°

Calculate Standard entropy for



$\Delta S^\circ (-)$

$$\Delta S^\circ = \sum n \cdot S^\circ_{\text{product}} - \sum n \cdot S^\circ_{\text{React}}$$

$$= (2 \times S^\circ_{\text{NH}_3}) - (3 \times S^\circ_{\text{H}_2} + 1 \times S^\circ_{\text{N}_2})$$

$$2(193) \frac{\text{J}}{\text{mol} \cdot \text{K}} - [3 \times 131 + 1 \times 192] \frac{\text{J}}{\text{mol} \cdot \text{K}}$$

$$= \boxed{-199 \frac{\text{J}}{\text{mol} \cdot \text{K}}}$$

$$\Delta G = \Delta H - T \Delta S$$

Subject ΔH ΔS ΔG

$$\Delta H - T \Delta S$$

Day Date

ΔH	ΔS	ΔG Spont or non Spont
(-) Fav	(+) Fav	Spontaneous All temperture. $\Delta G -$
(+) not Fav	(-) Not Favourite	Non Spontaneous $\Delta G (+)$ Always (+)
(-) favourite	(-) Not favourite	$\Delta G (+)$

$\Delta G(-)$ عند درجة حرارة منخفضة

ولذلك $T < T_{eq}$ لقد درجته > درجة

(+) Not favourite

(+) favourite

$$\Delta G = \Delta H - T \Delta S$$

$\Delta G = -$

نزدقة الحرارة
 $\Delta G(-)$ at
high temp.

$$T > T_{eq}$$

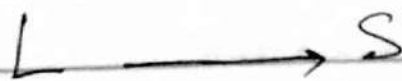
At equilibrium $\Delta G = 0$

$$\Delta G = \Delta H - T \Delta S$$

$$\Delta H = T \Delta S$$

$$\frac{\Delta H}{\Delta S} = T$$

العدد القابل هي درجة حرارة عند الاتزان.



تجميد الماء

$$\Delta H (-)$$

$$\Delta S (-)$$

Spont at low Temp.

H_2O at $25^\circ C \longrightarrow$ Non Spontaneous.

H_2O at $(-1^\circ C) \longrightarrow$ Spontaneous.

$$T < T_{eq}$$

$$\hookrightarrow 0^\circ C$$

$$H_2O \quad 0^\circ C \longrightarrow \Delta G = 0$$



$$\Delta H (+)$$

$$\Delta S (+)$$

Spontaneous at $T > T_{eq} = 100^\circ C$

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~~H₂O at~~ Spontaneous at $T > T_{eq}$.

$$T > 273$$

H₂O at 105° Spontaneous,

H₂O at 85° Not Spontaneous.

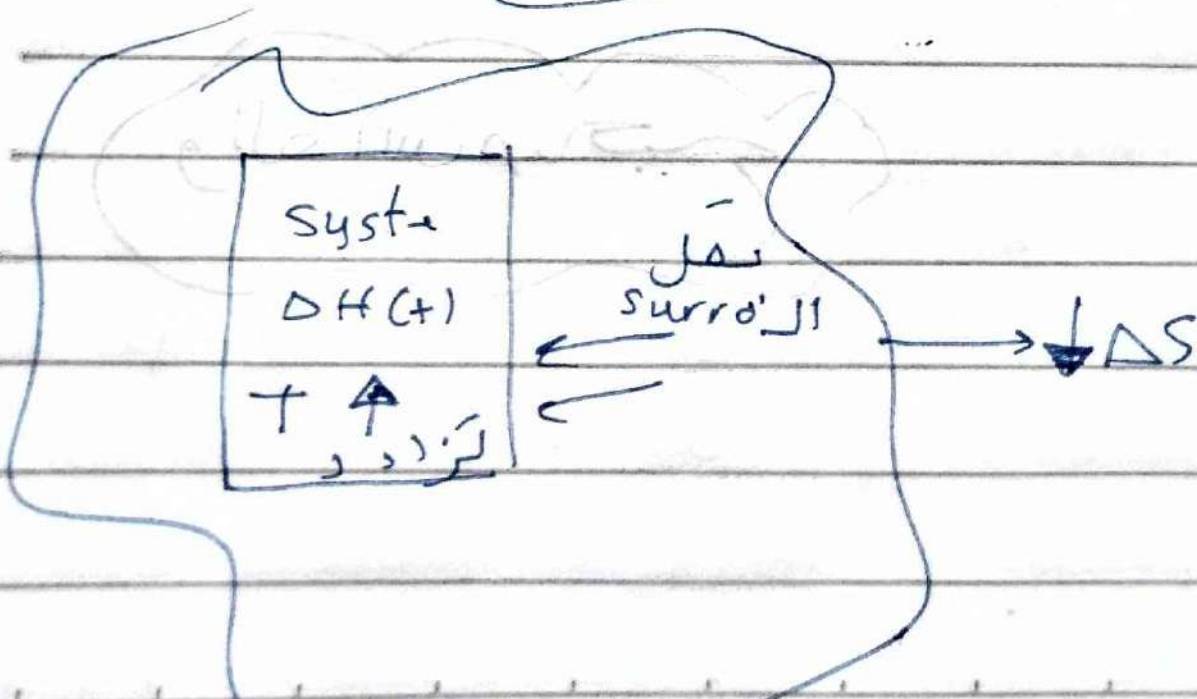
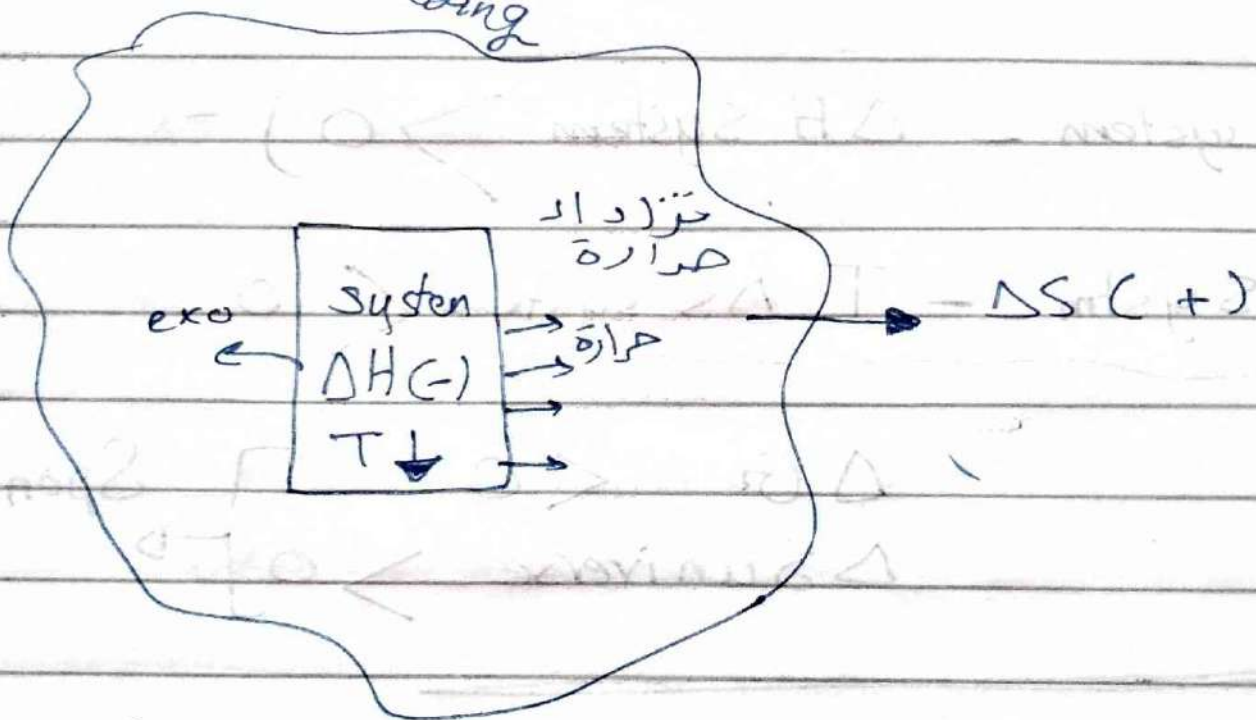
2nd law of Thermodynamics :-

The entropy of the universe increases in a spontaneous process and remains unchanged in eqm process.

(spont process) $\Delta S_{\text{universe}} > 0$

$$\Delta S_{\text{universe}} = S_{\text{system}} + S_{\text{surrounding}}$$

$$\Delta G < 0$$



$$\Delta S_{\text{(surround)}} = - \frac{\Delta H_{\text{System}}}{T_{\text{system}}}$$

$$\Delta S_{\text{system}} + \Delta S_{\text{surround}} = \Delta S_{\text{universe}}$$

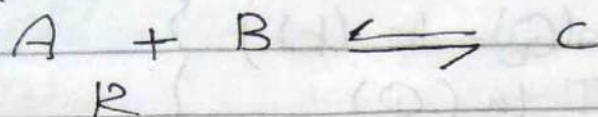
$$T \left(\Delta S_{\text{system}} - \frac{\Delta H_{\text{system}}}{T} \right) > 0$$

$$(T \Delta S_{\text{system}} - \Delta H_{\text{system}} > 0) -$$

$$\Delta H_{\text{system}} - T \Delta S_{\text{system}} < 0$$

$$\left. \begin{array}{l} \Delta G < 0 \\ \Delta S_{\text{universe}} > 0 \end{array} \right\} \rightarrow \text{Spontaneous}$$

والله اعلم بالصواب



Rxn

$\Delta G(-)$ Spont Direction $\longrightarrow Q < K$

$\Delta G(+)$ non Spont Direction RXN $\longleftarrow Q > K$

$\Delta G = 0$ at equilibrium No Shift $\rightleftharpoons Q = K$

ΔG and equilibrium

standard (Tables)

$$\Delta G = \Delta G^\circ + RT(\ln Q)$$

at equilibrium

$$\Delta G = 0$$

8.314

$$0 = \Delta G^\circ + RT \ln(Q)$$

$$\Delta G^\circ = -RT \ln(K)$$

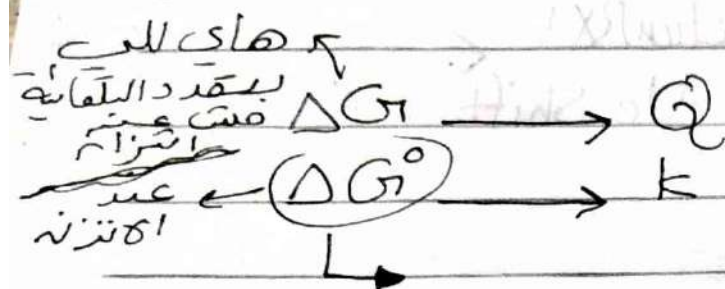
$$Q = K$$

1 atm
25°C

$$\ln K = \frac{-\Delta G^\circ}{RT}$$

$$e^{\frac{\Delta G^\circ}{RT}} = K$$

$$\begin{cases} \Delta G = RT (\ln(Q) - \ln(K)) \\ \Delta G = \Delta G^\circ + RT \ln(Q) \end{cases}$$



$k > 1 \rightarrow [\text{products}] > [\text{Reactants}]$
 $\Delta G^\circ (-)$

$k < 1 \rightarrow [\text{product}] < [\text{React}]$
 $\Delta G^\circ (+)$

$k = 1 \rightarrow [\text{products}] = [\text{React}]$
 $\Delta G^\circ (0)$

Example The equilibrium Const of Rxn

$$K_p = 0.113 \text{ at } 25^\circ\text{C}$$

At



If initial pressure $P_{\text{NO}_2} = 0.122 \text{ atm}$.

$$P_{\text{N}_2\text{O}_4} = 0.453 \text{ atm}$$

Calculate ΔG and Reaction Direction.

$$\Delta G = \Delta G^\circ + RT \ln(Q)$$

$$\Delta G = RT (\ln Q - \ln K)$$

$$\Delta G^\circ = -RT \ln(K)$$

$$\Delta G^\circ = -(8.314)(298) \ln(0.113)$$

$$\Delta G^\circ = +5.3 \text{ kJ/mol}$$

$$\Delta G = 5285 + (8.314)(298) \ln(0.003) = 8462 \text{ J}$$

$$Q_p = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]} = \frac{(0.122)^2}{(0.453)} = 0.003$$

Solution
 $\Delta G(-)$

melting

The molar heat of fusion Benzene is $+10.9 \text{ kJ/mol}$.

- Calculate entropy change for fusion if mp of benzene is 5.5°C .
- Calculate entropy change for 1.5 mol.

$$\Delta G = \Delta H - T \Delta S$$

$$\frac{\Delta H}{\Delta S} = T_{\text{eq}}$$

$$\Delta S$$

$$\Delta S_{\text{fusion}} = \frac{\Delta H}{T} = \frac{10.9 \text{ kJ/mol}}{278.5 \text{ K}} = 0.039 \text{ kJ/mol}$$

$$= 39 \text{ J/mol.K}$$

$$\Delta S \bigg|_{1.5 \text{ mol}} = 39 \frac{\text{J}}{\text{mol.K}} \times 1.5 \text{ mol}$$

$$\Delta S = 58.5 \text{ J/K}$$

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Calculate Standard Free energy of



$$\Delta G^\circ = \sum n_p \Delta G_f^\circ \text{prod} - \sum n_r \Delta G_f^\circ \text{React}$$

$$\Delta G^\circ = (2 \Delta G_f^\circ \text{H}_2\text{O} + \Delta G_f^\circ \text{CO}_2) - (\Delta G_f^\circ \text{CH}_4 + 2 \Delta G_f^\circ \text{O}_2)$$

$$\Delta G^\circ =$$

$$\Delta G_f^\circ \text{ element} = 0$$

$$\Delta G_f^\circ \text{ elements} = 0$$

$$\Delta G_f^\circ \text{ elements} = 0$$

$$1(-39.4) + 2(-237.2) -$$

$$= -813.8 \text{ kJ/mol}$$

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Calculate k at 25°C .
273

$$\Delta G^{\circ} = -RT \ln(k)$$

$$-813 = -8.314(298) \ln(k)$$

$$k = 2.44 \times 10^{143}$$

$$e^{330.16}$$

$$k > 1$$

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النقلات الكهربائية

Ch 18

electro chemistry

اختزال

أكسدة

Reduction oxidation - RXN.

Redox Rxns.

charge increase

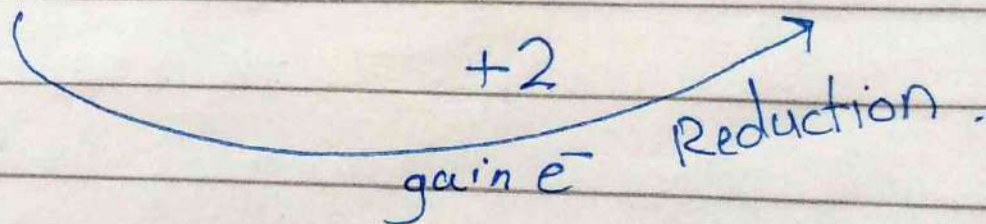
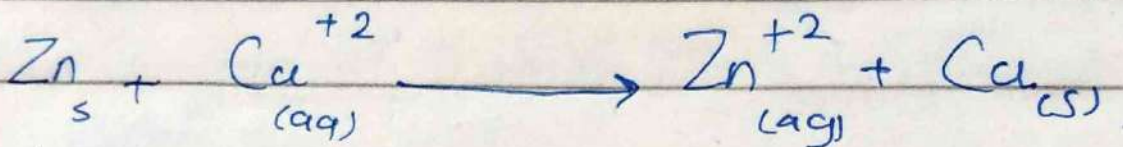
الشحير
**** oil

Oxidation : los e^- (زيادة) oxiadai is losing

Reduction : gain e^- (تقل الشحنة)

charge decrease

Losing e^- oxidain



Zn(s) oxidited (Reducing ageant) Redactant
Cu⁺² Reduceed) (~~Reducin~~
(oxiditng ageant)

مؤكسد oxidant

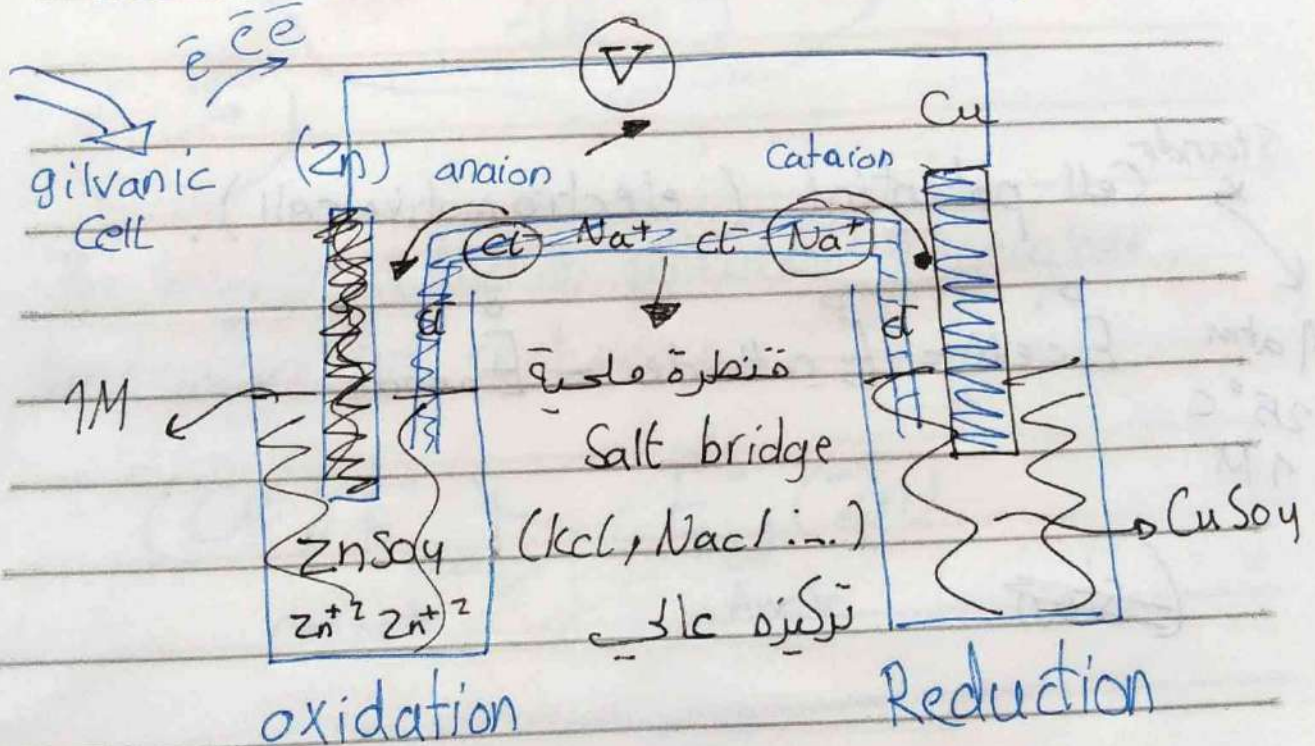
الاكسدة في ال ع في التوازن
اختزال في ال ع في التوازن

CuSO_4
 CuCl_2
 $\text{Cu}(\text{NO}_3)_2$

مادة
كهرلية

Oxidation half $\text{Zn} \rightarrow \text{Zn}^{+2} + 2e$

Reduction half $\text{Cu}^{+2} + 2e \rightarrow \text{Cu}$



$\text{Zn}_{(s)} \rightarrow \text{Zn}^{+2}_{(aq)} + 2e$

$\text{Cu}^{+2} + 2e \rightarrow \text{Cu}$

شحنة (+)
Anode (Anion electron)

شحنة (-)
Cathode (Cation electron)

الأكسدة (الأكسدة)

الاختزال (الاختزال)

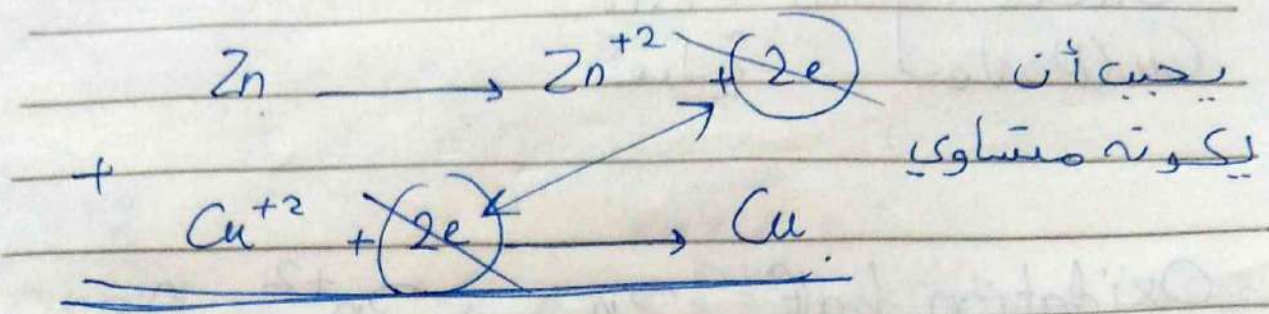
تقل Mass

تزداد Mass

يزداد $[\text{Zn}^{+2}]$

يقل $[\text{Cu}^{+2}]$

Number of electron each half (equal)



Standard Cell potential (electromotive cell).

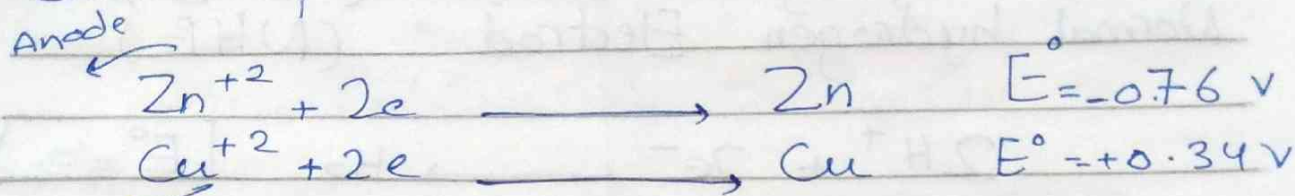
1 atm
25°C
1 M

$$E_{\text{cell}}^{\circ} = E_{\text{cathode}}^{\circ} - E_{\text{anode}}^{\circ}$$

~~Standard~~

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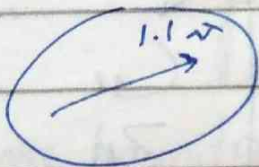
Standard potential. Reduction tables ...



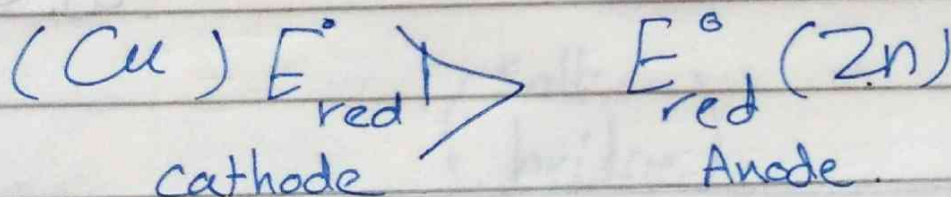
Cathode $\swarrow$

$$E^\circ_{\text{cathode}} - E^\circ_{\text{Anode}}$$

$$E_{\text{cell}} = 0.34 - (-0.76)$$
$$= 1.10 \text{ V}$$



The higher reduction potential the higher tendency to reduce.



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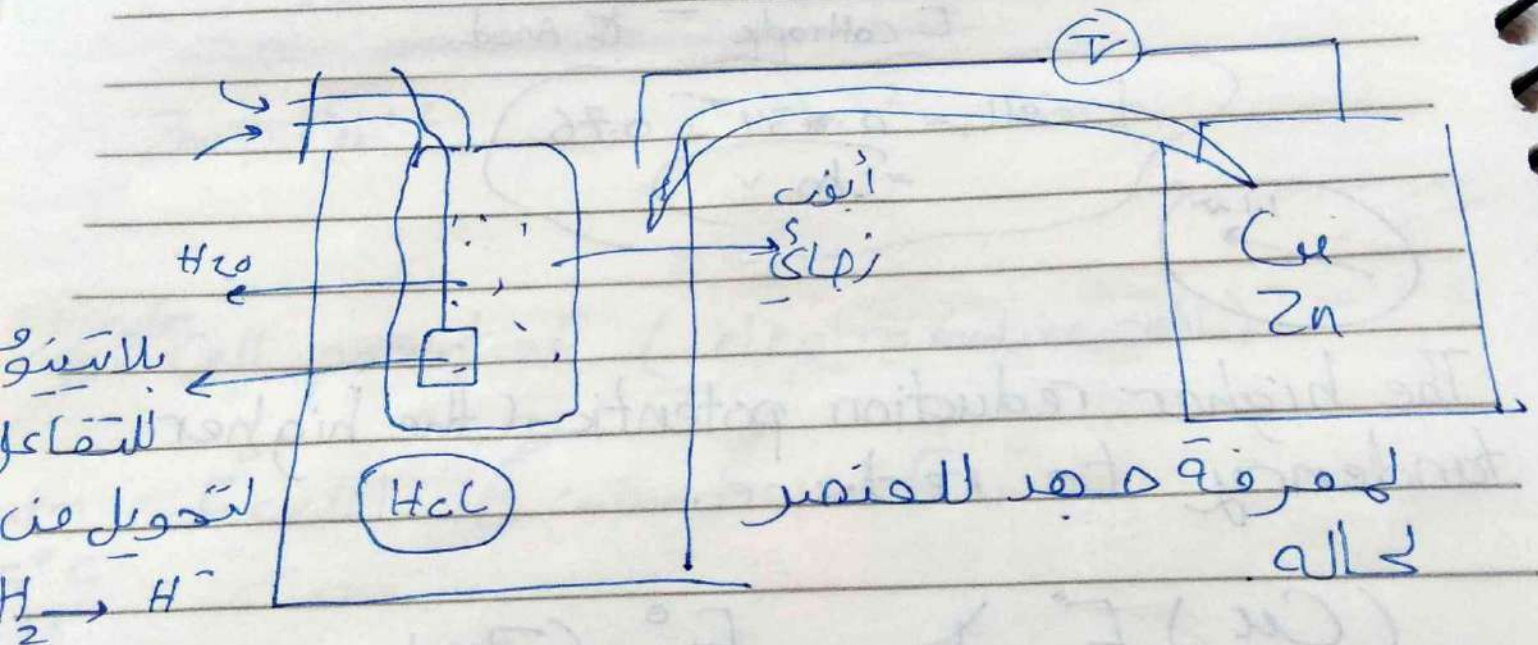
مقياس الجهد الكهروكيميائي

Standard hydrogen Electrode (SHE)

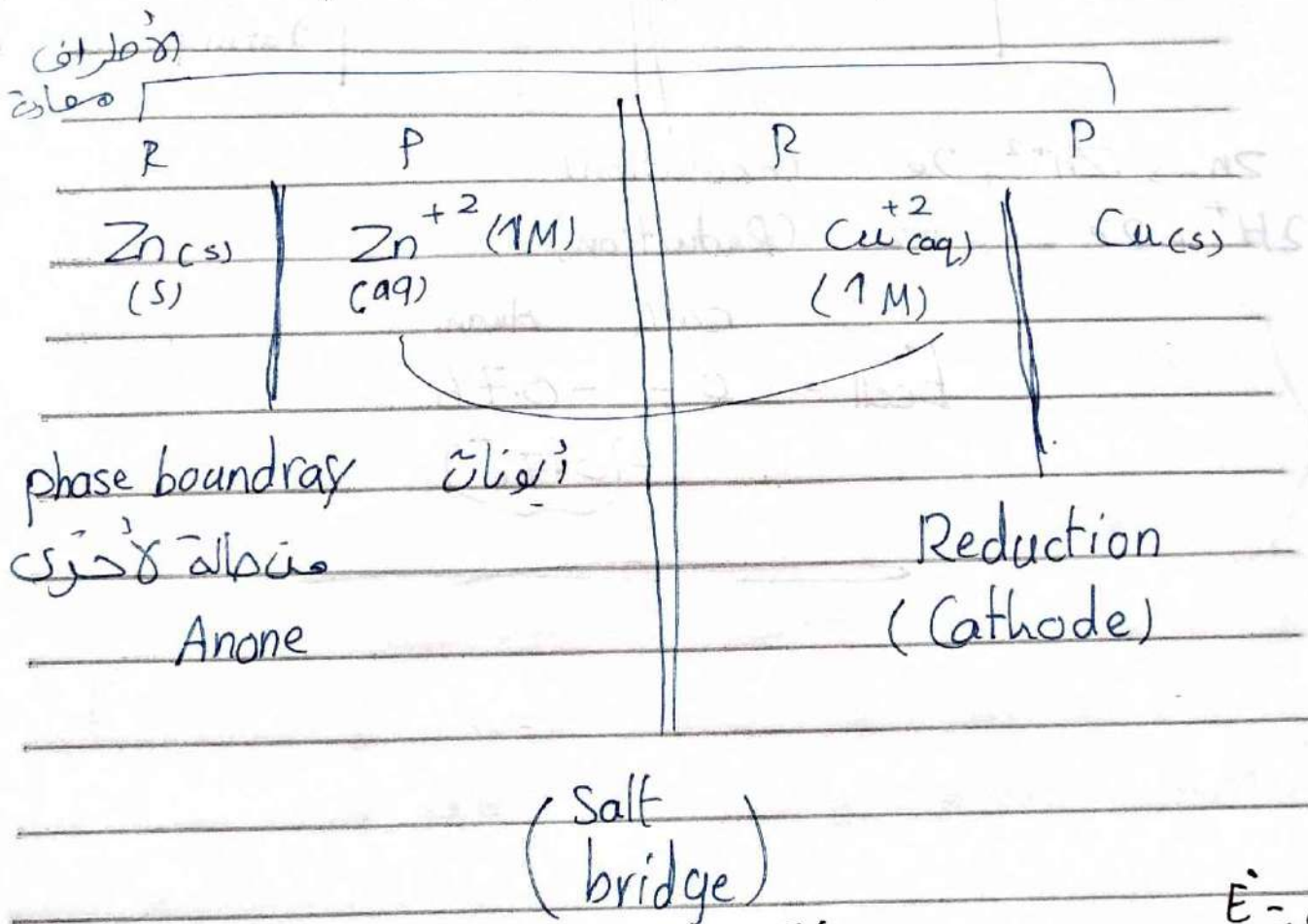
Normal hydrogen Electrode (NHE).



$$E^{\circ} = 0$$

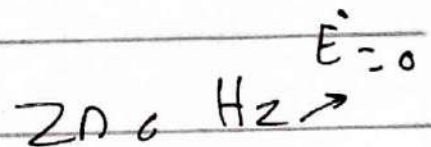


السؤال الخامس
Line notation of Galvanic cell



(Salt bridge)

$$E^\circ = -0.76$$

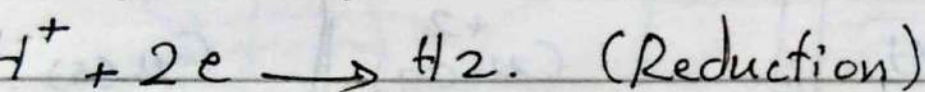
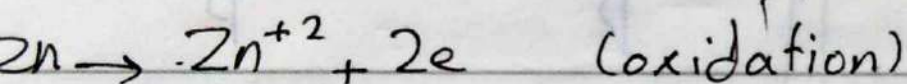
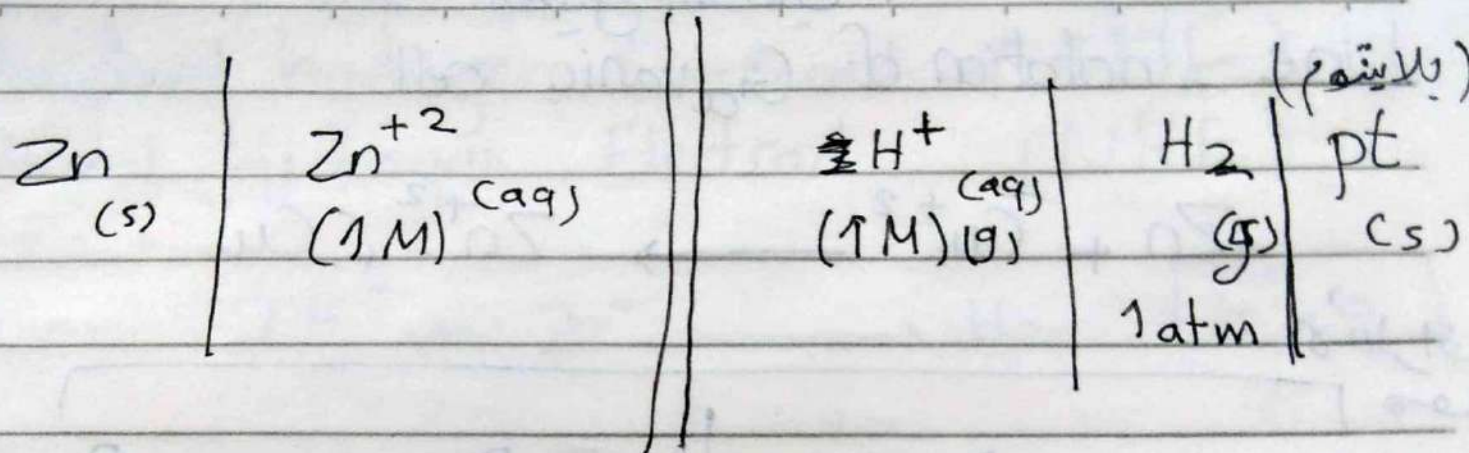


Represent the cell between Zn and Hydrogen in line notation representation

$\text{H}_2 \rightarrow$ Cathode

$\text{Zn} \rightarrow$ Anode

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Cath Anon.

$$E_{\text{cell}} = 0 - -0.76$$
$$= \boxed{0.76}$$

E cell Spontaneous or non Spontaneous

$$\begin{cases} E (+) \Rightarrow \text{Spont} \\ E (-) \Rightarrow \text{nonSpont} \\ E = 0 \Rightarrow \text{Equilibrium.} \end{cases}$$

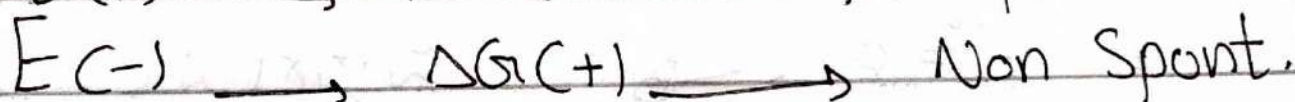
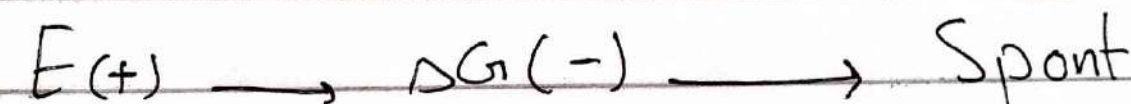


number
electrons $\nwarrow$

$\nearrow$ Faradays Const 96500 k/mol

$$\Delta G = -n F E$$

$\searrow$ Cell potential.



$$\Delta G^\circ = -n F E^\circ$$

8.314

25 $\nearrow$ = 298 K

$$\Delta G^\circ = -n F E^\circ = -RT \ln K$$

$\nwarrow$ 96500

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Spontaneous E°
non Spontaneous أو

25°C عند

$$E^\circ = \frac{0.0257}{n} \ln k$$

حرارة أخرى

$$E^\circ = \frac{RT \ln(k)}{n F}$$

$$k > 1 \quad E^\circ (+) \quad [product] > [Reactants]$$

$$k < 1 \quad E^\circ (-)$$

$$k = 1 \quad E^\circ = 0$$

$$[product] = [Reactants]$$

$$\Delta G^\circ = -RT \ln(k)$$

$$G^\circ \longleftrightarrow k$$

$$\Delta G^\circ = -n F E^\circ$$

$$E^\circ$$

$$E^\circ = \frac{0.0257}{n} \ln(k)$$

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$$\Delta G = -nFE = \Delta G^\circ + RT \ln Q$$

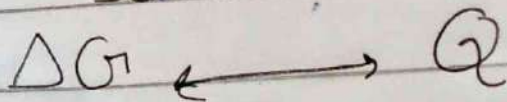
$$E = E^\circ - \frac{RT}{nf} \ln Q$$

زي حرارة

25° C

$$E = E^\circ - \frac{0.0257}{n} \ln Q$$

$$\Delta G = \Delta G^\circ + RT \ln Q$$



~~$$\Delta G = -nFE$$~~

$$\Delta G = -nFE$$

E

$$E = E^\circ - \frac{RT}{nf} \ln Q$$

$$E = \frac{0.0257}{n} (\ln k - \ln Q)$$

$$Q < k$$



E(+)

Spon للنواتج

$$Q > k$$



E(-)

non Spon للمتفاعلات

$$Q = k \text{ At Equ } E = 0$$

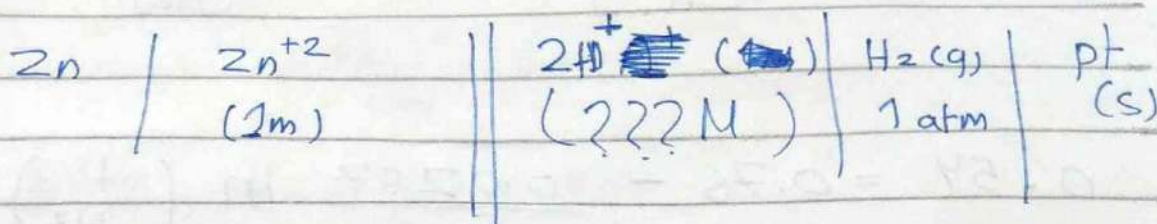
Nernst equations

$$E = E^{\circ} - \frac{0.0257}{n}$$

~~$$E = E^{\circ} - \frac{RT}{nF}$$~~

- تحديد الاتجاه
- تحديد تفاعلية
- المقابل
- تحديد حثية عند الظروف
- غير القياسية

Consider the cell below



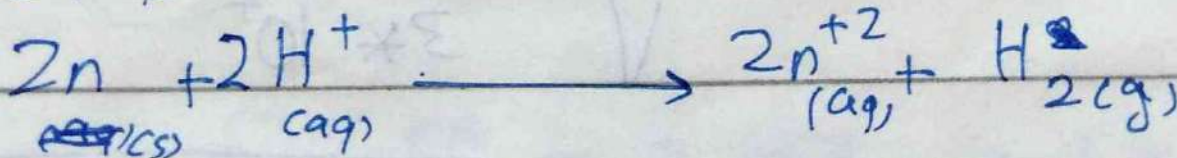
if cell potential is 0.45 V at 25°C calculate H^+ concentration?

$$E = 0.54 \text{ V}$$

$$E^\circ = E^\circ_{\text{cathode}} - E^\circ_{\text{Anode}}$$

$$= 0 - (-0.76) = 0.76 \text{ V}$$

$$E = E^\circ - \frac{0.0257}{n} \ln Q$$



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$$\textcircled{Q} = \frac{[2n^{++}][F^-][H_2]}{[H_2O]}$$

$$1 \times 10^{-14}$$

$$0.54 - 0.46 = \frac{0.0257}{2} \ln \left(\frac{1}{[H_2]} \right)$$

$$[-.54 - 0.46] = \frac{0.0257}{2} \ln \left(\frac{1}{[H_2]} \right)$$

$$\ln \left(\frac{1}{[H_2]} \right) = \frac{0.22 + 2}{0.0257}$$

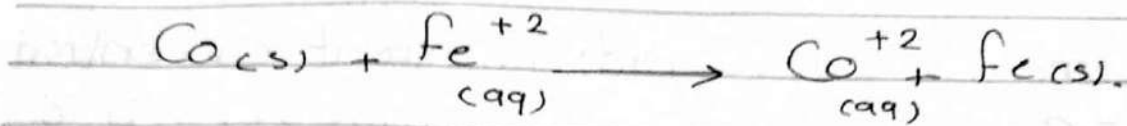
$$\ln \left(\frac{1}{[H_2]} \right) = 17.1$$

$$\frac{1}{[H_2]} = e^{17.1}$$

$$[H_2] = \sqrt{\frac{1}{3 \times 10^7}}$$

$$= 2 \times 10^{-4} \text{ M}$$

② Predict the Reaction is spontaneous



given $[\text{Co}^{+2}] = 0.15 \text{ M}$

$[\text{Fe}^{+2}] = 0.69 \text{ M}$

$E^\circ_{\text{Co}^{+2}} = -0.28 \text{ V}$

$E^\circ = -0.44 + 0.28$

$E^\circ_{\text{Fe}^{+2}} = -0.44 \text{ V}$

$$E = E^\circ - \frac{0.0257}{n} \ln Q \quad Q = \frac{[\text{Co}^{+2}]}{[\text{Fe}^{+2}]}$$

$$0.22 = \frac{0.15}{0.69}$$

$$E^\circ = E_{\text{Fe}} - E_{\text{Co}}$$

$$= -0.44 + 0.28$$

$$= -0.16 \text{ V}$$

$$E = E^\circ - \frac{0.0257}{n} \ln (0.22)$$

$$= -0.16 + 0.09$$

$$E = -0.14 \text{ V}$$

Non Spontaneous

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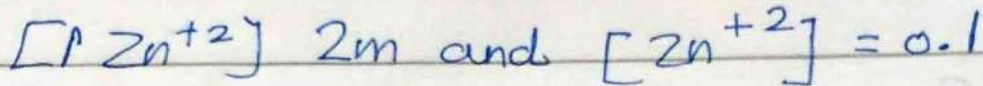
ملايا التراكيز

- Concentration Cells

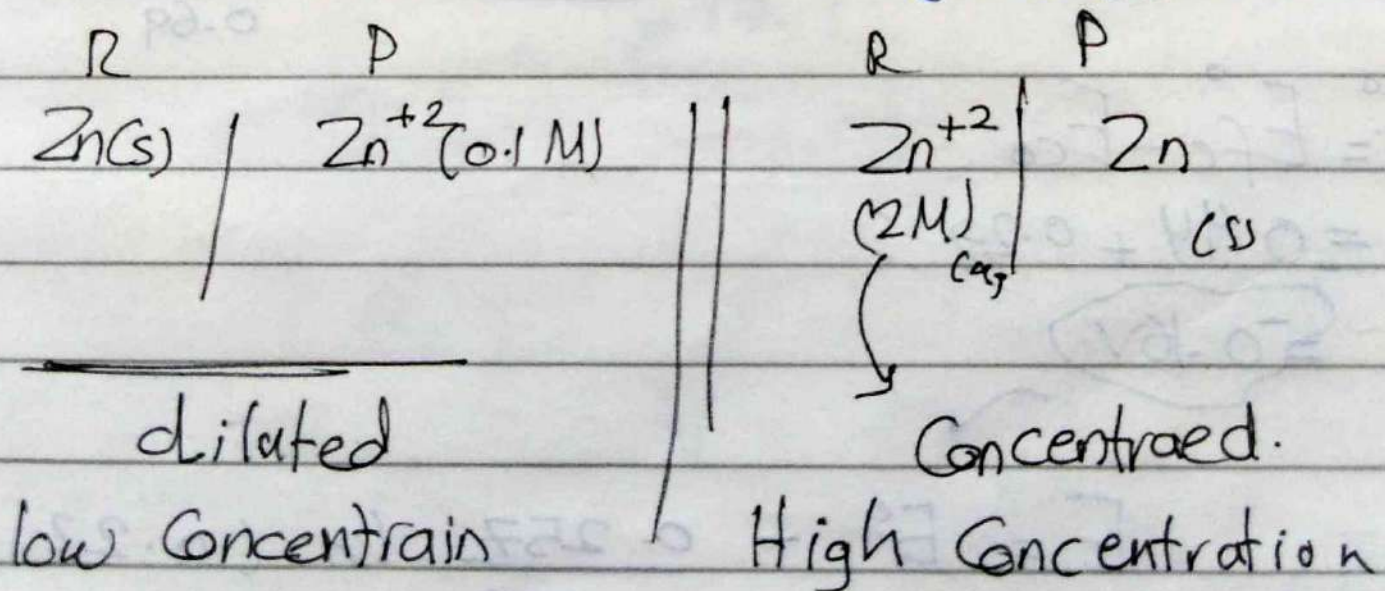
Same Substance with different concentration
 لا تتم عند الظروف العادية في الوقياس تكون
 $E = E^0$

$$E^0_{Zn} = -0.76$$

galvanic cells and Concentration cell.



دائماً الذي له تركيز أعلى يختزل والأقل تركيز يكون
 الكسب (بأكسد).



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$$Q = \frac{[Zn^{+2}](0.1)}{[Zn^{+2}](0.2)} = \frac{0.05}{0.1} = \frac{\text{diluted}}{\text{concentrated.}}$$

$$E = E^0$$

$$- \frac{0.0257}{n(2e)} \ln Q$$

$$E = 0 - \frac{0.0257}{2} \ln (0.05)$$

$$E = \text{---} \text{ موجب } (+0.38)$$

$E(+)$ → (Spontaneous)
