EICoM
ELECTRICAL COMPUTER MECHATRONICS

تقدم لجنة

دفتر لمادة:

أساسيات كيمياء عامة

من شرح:

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(3.2) Avogadro's number and the Molar Mass of an element:

- The mole: number of atoms (ذرات)
  molecules (الجزيئات) in exactly the atomic mass
  molar mass of that substance
- This number of atoms = $6.023 * 10^{23}$
  this number is called (Avogadro's number)

- 1 mol (H_2O) molecules = $6.02 * 10^{23}$ H_2O molecules = 18 g H_2O
  (molar mass)
  ($2 * 1.007 + 15.994$) = (18 g)

*Ex: How many H_2O molecule are in 4.5 g H_2O???
- solution:
  1 mol → $6.02 * 10^{23}$ molecule → 18 g
  ??? → 4.5 g

$$\frac{4.5g * 6.02 * 10^{23} \text{ molecule}}{18g} = 1.5 * 10^{23} \text{ molecule}$$ #

*Ex: How many mole of H_2O are in 4.5 g H_2O???
- solution:
  1 mol → 18 g
  ??? → 4.5 g

$$\frac{4.5g * 1 \text{ mol}}{18g} = 0.25 \text{ mol}$$ #

→ (معاملات التحويل لـ H_2O) $\frac{1 \text{ mol}}{6.02 * 10^{23} \text{ molecule}}$
→ $\frac{6.02 * 10^{23} \text{ molecule}}{1 \text{ mol}}$
→ $\frac{1 \text{ mol}}{18 g}$
→ $\frac{18 g}{1 \text{ mol}}$

→ بنحل على أساسهم مثلاً الـ g بروح عالـ mol أو الـ mol بروح عالـ g وهكذا..

Five Apple

* Ex: How many H_2O molecule are in 4.5 g H_2O?

- solution: $4.5\,g\,H_2O = \frac{1\ mol\ H_2O}{18\,g\,H_2O} = \frac{6.02 \times 10^{23}\ molecule}{1\ mol\ H_2O}$

$$\frac{4.5 \times 6.02 \times 10^{23}}{18} = \boxed{1.5 \times 10^{23}\ molecule}\ \#$$

* Ex: How many mole of H_2O are in 4.5 g H_2O?

- solution: $4.5\,g\,H_2O = \frac{1\ mol\ H_2O}{18\,g\,H_2O}$

$$\frac{4.5}{18} = \boxed{0.25\ mole}\ \#$$

* Ex: How many mole of Fe_2O_3 are produced when 6 mole O_2 reacted??? when ($4Fe + 3O_2 \longrightarrow 2Fe_2O_3$)

- solution: العلاقة بين ال Fe_2O_3 وال O_2

$$4Fe + 3O_2 \longrightarrow 2Fe_2O_3$$

$3\ mol\ O_2 \longrightarrow 2\ mol\ Fe_2O_3$

$6\ mol\ O_2 \longrightarrow ???\ mol\ Fe_2O_3$

$$\frac{6 \times 2}{3} = \boxed{4\ mol\ Fe_2O_3}$$

($6\ mole\ O_2 \times \frac{2\ mole\ Fe_2O_3}{3\ mole\ O_2}$, $\frac{6 \times 2}{3} = 4$)

* Ex: How many gram of Fe_2O_3 are produced when 6 mole O_2 reacted??? when ($4Fe + 3O_2 \longrightarrow 2Fe_2O_3$)

- solution: $3\ mol\ O_2 \longrightarrow 2(2 \times 55.847 + 3 \times 15.994)\ g$

$6\ mol\ O_2 \longrightarrow ???$

$$\frac{319.352 \times 6}{3} \simeq \boxed{640\ g}\ \#$$

($6\ mole\ O_2 = \frac{2\ mol\ Fe_2O_3}{3\ mol\ O_2} = \frac{(2 \times 56 + 3 \times 16)\,g}{1\ mol\ Fe_2O_3}$)

(مهم)

* Ex: How many gram of Fe_2O_3 are produced when 192 g O_2??? when ($4Fe + 3O_2 \longrightarrow 2Fe_2O_3$)

- solution: (ممنوع التعامل مع الغرامات)

(يجب أن نحول الى المولات)

$1\ mol\ O_2 \longrightarrow (2 \times 15.994)$

$???\ mol\ O_2 \longrightarrow 192\ g$

$\boxed{6\ mol\ O_2}$

($192\,g\,O_2 = \frac{1\ mol\ O_2}{(2 \times 16)\,g\,O_2} = \frac{2\ mol\ Fe_2O_3}{3\ mol\ O_2} = \frac{(2 \times 56 + 3 \times 16)\,g}{1\ mol\ Fe_2O_3}$)

$3\,mol\ O_2 \longrightarrow 2(3*15.994+2*55.847)\,g$

$6\,mol\ O_2 \longrightarrow ???\ g$

$\frac{319.352*6}{3} = \boxed{640g}$ #

(P80)

* Ex80 How many gram of O_2 are need to react 50 gram of Na in the reaction ($4Na+O_2 \longrightarrow 2Na_2O$)

- Solution80

$1\,mol\ Na \longrightarrow 22.989767g$

$5g\ Na = \frac{1\,mol\ Na}{23g\ Na} = \frac{1\,mol\ O_2}{4\,mol\ Na} = \frac{2*16g}{1\,mol\ O_2}$?? $\longrightarrow 50g$

$\frac{50g*1mol}{22.989767g} = \boxed{2.174880676\,mol}$

$4\,mol\ Na \longrightarrow 32g\ O_2$

$2.17\,mol\ Na \longrightarrow ???$

$\frac{32*2.174880676}{4} = \boxed{17.3g}$ #

* Ex80 How many gram of O_2 reaction (the reaction between H_2 and O_2 produced 13.1g H_2O ??? $2H_2+O_2 \longrightarrow 2H_2O$

- Solution80 $1\,mol\ H_2O \longrightarrow (2*1+16)\,g$

$??? \longrightarrow 13.1g$

$\frac{13.1*1}{18} = \boxed{0.7\,mol}$

$2\,mol\ H_2O \longrightarrow (2*16)\,g$

$0.7\,mol \longrightarrow ???$

$\frac{2*16*0.7}{2} = \boxed{11.6g}$ #

$13.1g\ H_2O = \frac{1\,mol\ H_2O}{(2+16)g\ H_2O} = \frac{1\,mol\ O_2}{2\,mol\ H_2O} = \frac{(2*16)g}{1\,mol\ O_2}$

* (mole → gram → number of molecule or atom)

→ Ex: ① H_2O : $\frac{2\ mol\ H\ atom}{1\ mol\ H_2O}$ (أي أنه يوجد 2 مول من ذرات H في 1 مول من H_2O)

② H_2O : $\frac{1\ mol\ O\ atom}{1\ mol\ H_2O}$

③ H_2SO_4 : $\frac{2\ mol\ H\ atom(ov)}{1\ mol\ H_2SO_4}$ $\frac{4\ mol\ O\ atom}{1\ mol\ H_2SO_4}$

④ O_2 : $\frac{2\ mol\ O\ atom}{1\ mol\ O_2}$

(مهم)

Ex How many mol of oxygen atom in 64g O_2?

(كوّل إلى الوحدات) * $1\ mol\ O_2 \longrightarrow (2*16)g$

??? $\longrightarrow 64g$

$\frac{64}{32} = \boxed{2\ mol\ O_2}$

$64g\ O_2 = \frac{1\ mol\ O_2}{2*16g\ O_2} = \frac{2\ mol\ O}{1\ mol\ O_2}$ * $2\ mol\ atom\ O \longrightarrow 1\ mol\ O_2$

??? $\longrightarrow 2\ mol\ O_2$

$2*2 = \boxed{4\ mole}$ //

(مهم)

Ex How many oxygen atom (ذرات الأكسجين) in 64g O_2 molecule?

* $1\ mol\ O_2 \longrightarrow (2*16)g$

??? $\longrightarrow 64g$

$\frac{64}{32} = \boxed{2\ mol\ O_2}$

* $2\ mol\ atom\ O \longrightarrow 1\ mol\ O_2$

??? $\longrightarrow 2\ mol\ O_2$

$64g\ O_2 = \frac{1\ mol\ O_2}{2*16g\ O_2} = \frac{2\ mol\ O}{1\ mol\ O_2} = \frac{6.02*10^{23}\ atom}{1\ mol\ O}$ $\boxed{2*2 = 4\ mole}$

* 1 mole atom ——→ $6.02*10^{23}$ atom

4 mole atom ——→ ???

$4 * 6.02 * 10^{23} = \boxed{24.08*10^{23} \text{ O atom}}$ //

Ex How many mol of Nitrogen atom in 64g N_2???

- Solution:

1 mol N_2 ——→ $(2*14)$ g

??? ——→ 64g

$\frac{64}{28} = \boxed{2.28 \text{ mol } N_2}$

2 mole N atom ——→ 1 mole N_2

??? ——→ 2.28 mol N_2

$64g\ N_2 = \frac{1 \text{ mol } N_2}{2*14\ N_2} = \frac{2 \text{ mol N}}{1 \text{ mol } N_2}$ $2 * 2.28 = \boxed{4.57 \text{ mol N atom}}$ //

Ex How many of Nitrogen atom in 64g N_2 molecule???

- Solution:

1 mol N_2 ——→ $(2*14)$g

??? ——→ 64 g

$\frac{64}{28} = \boxed{2.28 \text{ mol } N_2}$

2 mole N atom ——→ 1 mole N_2

??? ——→ 2.28 mol N

$2.28 * 2 = \boxed{4.57 \text{ mol N atom}}$

1 mol atom ——→ $6.02*10^{23}$ atom

4.57 mole atom ——→ ???

$4.57 * 6.02 * 10^{23} = \boxed{2.752*10^{24} \text{ atom}}$ //

$64g\ N_2 = \frac{1 \text{ mol } N_2}{2*14\ g\ N_2} = \frac{2 \text{ mol N}}{1 \text{ mol } N_2} = \frac{6.02*10^{23} \text{ atom}}{1 \text{ mol N}}$

*** limiting Reactant ***

- (المادة المحددة للتفاعل)
- (وهي عبارة عن المادة التي تُستهلك بالكامل؟ وهي التي تحدد النواتج اي أن عليها تتوقف عليه النواتج... مثل المولات)

$$2H_2 + O_2 \longrightarrow 2H_2O$$

تساوي الغازات

5 ⇐ 10mol   7mol

- **limiting Reactant**: Reactant that consumed completely... and Reactant that limit the product...

- ففي هذا التفاعل إن الـ 10mol من الـ $2H_2$ تعطي 10mol من الـ $2H_2O$ بالإضافة أن $2H_2$ تستهلك كاملاً بينما O_2 لا تستهلك كاملاً فإن هناك 2mol فائض من الـ O_2... أي أن الـ (5mole) من الـ H_2 (هي المادة المحددة) تأخذ من الـ O_2 (7mol) الـ (5mol) لكن العكس (لا)...

* **excess Reactant** (المادة الفائضة): 7mol − 5mol = **2mol** #

*** Ex ***

$$Zn + S \longrightarrow ZnS$$
(12g) (6.5g)

→ (65.39 + 32.066 = 97.456g) ك.م

a) which is the limiting Reactant?
b) How many gram of excess Reactant?
c) How many gram of ZnS produced?
d) Percent yield? if you obtain 8.9g ZnS from the Reactant?

- Solution (a):

* 1 mole Zn → 65.39 g
??? → 12g

$$\frac{12}{65.39} = \boxed{0.183 \text{ mole Zn}}$$

$$12g\ Zn = \frac{1\,mol\ Zn}{65g\ Zn}$$

* 1 mol S → 32.066g
??? → 6.5g

$$\frac{6.5}{32.066} = \boxed{0.203 \text{ mol S}}$$

$$6.5g\ S = \frac{1\,mol\ S}{32g\ S}$$

∴ $Zn + S \longrightarrow ZnS$
0.183 mol   0.203 mol

∴ limiting Reactant هو Zn ← لأن الـ (0.183 mol) من الـ Zn
تأمن من الـ (0.202 mol) S
متبقيها ونكتب العكس لا يجوز...
أو لأن الـ (0.202) لا تأمن
من الـ (0.183) الـ (0.202)...

- Solution (b): excess Reactant = 0.202 − 0.183 = $\boxed{0.019 \text{ mol}}$ #

$0.019 \text{ mol S} \times \frac{32.8 \text{ S}}{1 \text{ mol S}}$

1 mol S ← 32.066 g
0.019 mol ← ???

0.019 * 32.066 = $\boxed{0.6 \text{ g}}$ #

- Solution (c): (يكون كتلة مولات الـ ZnS) B
نفس عدد مولات المادة المعطاة A
وتساوي (0.183)

$0.183 \text{ mol Zn} \times \frac{1 \text{ mol ZnS}}{1 \text{ mol Zn}} = \frac{(32+65) \text{ g}}{1 \text{ mol ZnS}}$

1 mol ZnS ← (65.39 + 32.066) g
0.183 mol ← ???

0.183 * 97.456 = $\boxed{17.8 \text{ g}}$ #

6.5 − 0.6 = 5.9 ⇐ (كمية الزنك الإضافية)
5.9 + 12 (الكتلة) = $\boxed{17.9 \text{ g}}$

- Solution (d): $\text{Percent yield} = \frac{\text{actual yield}}{\text{theoritical yield}} * 100\%$

$= \frac{8.9 \text{ g}}{17.8} * 100\%$

$= \boxed{50\%}$ #

← عند بتكتب السؤال بيعطي مقدار الـ (Percent yield) ومقدار الـ (actual yield) ويطلب مقدار الـ (theoritical yield)

$50\% = \frac{8.9}{???} * 100\%$

$\frac{50}{100} = \frac{8.9}{???}$ ⇐ Theoritical yield = 8.9 * 100 / 50

*** Ex (مهم) *** Calculate the gram of Al_2O_3 that produced from Reaction of 5g AL and 5g O_2 according to equation ($4AL + 3O_2 \longrightarrow 2AL_2O_3$)

(هذا المثال إذا كانت النسب كاملة)

a) 7.56g **b) 9.44g** c) 8.50g d) 6.38g

→ Solution:

$$4AL + 3O_2 \longrightarrow 2AL_2O_3$$

5g   5g

* 1 mole AL ⟶ 27g

??? ⟶ 5g

$$\frac{5}{27} = \boxed{0.185 \text{ mole AL}}$$

* 1 mole O_2 ⟶ (2*16) g

??? ⟶ 5g

$$\frac{5}{32} = \boxed{0.156 \text{ mole } O_2}$$

* $4AL + 3O_2 \longrightarrow 2AL_2O_3$

0.185 mol   0.156 mole

(نجيب كمية المادة المحددة للتفاعل) (نأخذ ال AL او O_2 ...) ⇒

4 mole AL ⟶ 3 mole O_2

??? ⟶ 0.156 mole O_2

$$\frac{0.156 * 4}{3} = \boxed{0.208 \text{ mole AL}}$$

← انا عندي 0.185 من ال AL (كمية أقل فهي المحددة للتفاعل)

(إذا أخذنا العكس) ⇒ 4 mole AL ⟶ 3 mole O_2

0.185 mole AL ⟶ ???

$$\frac{0.185 * 3}{4} = \boxed{0.138}$$

← أنا عندي 0.156 من ال O_2 (كمية أكبر فهي فائضة)

∴ limiting Reactant (AL) ⟶ (0.185 mole AL)

← بنبلش منها...

$$4AL + 3O_2 \longrightarrow 2AL_2O_3$$

* 4 mole AL → 2 mole AL_2O_3

0.185 mole AL → ???

$$\frac{0.185 * 2}{4} = \boxed{0.0925 \text{ mole } AL_2O_3}$$

* 1 mole AL_2O_3 → (2*27 + 3*16) g

0.0925 mole AL_2O_3 → ??? g

$$0.0925 * (2*27 + 3*16) = 9.435$$
$$= \boxed{9.44}\ g \ \#$$

* أو طريقة أخرى نأخذ ال AL ونحولها لمولات ومن ثم نحولها لغرامات ال AL_2O_3 وكذلك لل O_2 والكمية الأقل هي الأصح..

$$* \ 5g\ AL = \frac{1 \text{ mole } AL}{27\ g\ AL} = \frac{2 \text{ mole } AL_2O_3}{4 \text{ mole } AL} = \frac{(27*2+3*16)g\ AL_2O_3}{1 \text{ mole } AL_2O_3}$$

$$\frac{5 * 1 * 2 * (27*2 + 3*16)}{27 * 4} = 9.44\ g$$

$$* \ 5g\ O_2 = \frac{1 \text{ mole } O_2}{(2*16)g\ O_2} = \frac{2 \text{ mole } AL_2O_3}{3 \text{ mole } O_2} = \frac{(27*2+3*16)g\ AL_2O_3}{1 \text{ mole } AL_2O_3}$$

$$\frac{5 * 1 * 2 * (27*2 + 3*16)}{(2*16) * 3 * 1} = 10.625g$$

← الكمية الأقل 9.44g هي الأصح..

* **H.w.** calculate the gram of CO_2 that produced from Reaction of 1.93g C_2H_4 and 5.92g O_2 according to equation ($C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$)

→ Solution:

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$$

(1.93g) (5.92g) ???

$$* \; 1.93g = \frac{1 \text{ mole } C_2H_4}{(2*12+4*1)g \; C_2H_4} = \frac{2 \text{ mole } CO_2}{1 \text{ mole } C_2H_4} = \frac{(12+2*16)g \; CO_2}{1 \text{ mole } CO_2}$$

$$\frac{1.93*1*2*(12+2*16)}{(2*12+4*1)} = 6.06 \text{ g } CO_2$$

$$* \; 5.92g \; O_2 = \frac{1 \text{ mole } O_2}{2*16 \text{ g } O_2} = \frac{2 \text{ mole } CO_2}{3 \text{ mole } O_2} = \frac{(12+2*16) \text{ g } CO_2}{1 \text{ mole } CO_2}$$

$$\frac{5.92*1*2*(12+2*16)}{2*16*3*1} = 5.42 \text{ g } CO_2$$

(لها قيمة أقل في الجواب الصحيح)

والمادة المحددة للتفاعل هي الـ (O_2) .. limiting Reactant

percentage composition for element in compound

$$* \text{ percentage composition} = \frac{\text{Atom of element} * (A.w)}{(F.w) \text{ compound}} * 100\%$$

(Atom of element ← عدد ذرات; (A.w) ← (molar mass); (F.w) ← molar mass للمركب كاملاً)

→ Ex: $C_{12}H_{22}O_{11}$

① → $\%C = \frac{12*12}{(12*12+22*1+11*16)} * 100\% = \frac{144}{342} * 100\% = \boxed{42.1\%}$

② → $\%H = \frac{22*1}{(342)} * 100\% = \boxed{6.43\%}$

③ → $\%O = \frac{11*16}{342} * 100\% = (100-(42.1+6.43)) = \boxed{51.46\%}$

#

Empirical Formula from Analysis

Empirical Formula (صيغة أولية)	molecule formula (صيغة جزيئية)
CH_2O	$\frac{C_6H_{12}O_6}{6}$
CH	$\frac{C_6H_6}{6}$

*** عند قسمتها على ال(6) تتحول إلى الصيغة الأولية...

Ex8 what is the empirical formula of compound contain 85.7% by mass(C) and 14.3% by mass(H)???

-Solution: a) CH_3 b) CH_2 c) CH d) C_3H_8

Precentage لما تكون مئوية فيتم تحويلها للغرامات و من الغرامات يتم تحويلها للمولات ثم نقسم كل على أقل عدد و نوجد الناتج والصيغة للـ (empirical formula)...

(C) 85.7% $\rightarrow$ $85.7\,g\,C \times \frac{1\,mol\,C}{12\,g\,C} = \boxed{7.14\,mol\,C}$

(H) 14.3% $\rightarrow$ $14.3\,g\,H \times \frac{1\,mol\,H}{1\,g\,H} = \boxed{14.3\,mol\,H}$

(C) $\frac{7.14}{7.14} = ①\,C$

(H) $\frac{14.3}{7.14} = ②\,H$

$\Downarrow$

CH_2 #

Ex8: white powder is analyzed and found to contain 43.64% (P) and 56.36% (O) by mass ...
(molar mass of compound = 283.88 g/mol) ...
what is ① empirical formula?
② Molecule formula?

*Solution: ① (P) 43.64% ⟶ $43.64\,g\,P \times \frac{1\,mol\,P}{31\,g\,P} = \boxed{1.40\,mol}$

(O) 56.36% ⟶ $56.36\,g\,O \times \frac{1\,mol\,O}{16\,g\,O} = \boxed{3.52\,mol}$

(P) ⟶ $\frac{1.40}{1.40} = \boxed{1\,mol\,P}$ *2

(O) ⟶ $\frac{3.52}{1.40} = \boxed{2.51\,O}$ *2

لا يوجد هنالك كسر
من المولات فيجعلنا
نضرب كلاهما بعدد ابتداءً
من ال ① حتى يصل لعدد
صحيح مثل 5.99 فيقرب
لل ⑥ أو من البداية يطلع
عدد صحيح الجواب وهنا
نضرب كلاهما بالعدد (2)

⇓

$\boxed{P_2O_5}$ #

- يجب ضرب ال (P_2O_5) ② بعدد حتى نحصل على
ال Molecule formula
وهذا العدد يسمى (n)
ونحصل عليه عن طريق
قسمة Molecular wigh
wigh empirical formula
يعني قسمة الكتلة المولية للمركب
على كل الكتلة المولية لل
empirical formula فنحصل على
العدد (n) ...

$\Rightarrow \frac{283.88}{(2*31+5*16)} = ② = (n)$

(molar mass to P_2O_5)

$2 * P_2O_5 = \boxed{P_4O_{10}}$

(Molecule formula)

- مع العلم أنه لو أعطانا هذه
الصيغة وهي ال (Molecule formula)
وطلبنا ال (empirical formula)
نقسم على العدد الأصغر فيصبح
$PO_{2.5}$ ⟶ لا يكون
فنضرب بعدد
ابتداءً من
الواحد فيكون
هو العدد ②

⇓

$\boxed{P_2O_5}$

(إ) (الكتلة الموجودة في المركب كامل)

*** Ex 80 *** when 0.1156g unknow compound contain (C, H, N) react with oxygen 0.1638g CO_2 and 0.1676g H_2O, what is empirical formula???

$$* \; C, H, N \xrightarrow[\Delta]{O_2} \underset{(0.1638g)}{CO_2} + \underset{(0.1676g)}{H_2O}$$

$$* \; \frac{1 \text{ mol C}}{1 \text{ mol } CO_2} = \frac{12 \text{g C}}{44 \text{g } CO_2}$$

$$* \; \frac{2 \text{ mol H}}{1 \text{ mol } H_2O} = \frac{2 \text{g H}}{18 \text{g } H_2O}$$

لنوجد ال (precentage composition) لكل من ال H وال C ثم نطرح من 100 مجموعهم حتى نوجد النسبة لل N ...

$$* \; 0.1638 \text{g } CO_2 = \frac{12 \text{g C}}{44 \text{g } CO_2} \Rightarrow \frac{0.0446727272}{0.1156} \times 100\% = \boxed{38.64\%} \leftarrow (C)$$

$$* \; 0.1676 \text{g } H_2O = \frac{2 \text{g H}}{18 \text{g } H_2O} \Rightarrow \frac{0.0186222222}{0.1156} \times 100\% = \boxed{16.10\%} \leftarrow (H)$$

(لـ نقسم على كتلة المركب)

$$* \; 100\% - (38.64\% + 16.10\%) = \boxed{45.26\%} \leftarrow (N)$$

$$\Rightarrow (C) \; 38.64\% = 38.64 \text{g C} = \frac{1 \text{ mol C}}{12 \text{g C}} \Rightarrow \frac{3.22 \text{ mol}}{3.22} = \boxed{1 \text{ mol C}}$$

$$(H) \; 16.01\% = 16.01 \text{g H} = \frac{1 \text{ mol H}}{1 \text{g H}} \Rightarrow \frac{16.01 \text{ mol}}{3.22} = \boxed{5 \text{ mol H}}$$

$$(N) \; 45.26\% = 45.26 \text{g N} = \frac{1 \text{ mol N}}{14 \text{g N}} \Rightarrow \frac{3.23 \text{ mol}}{3.22} = \boxed{1 \text{ mol N}}$$

(لـ نقسم على اقل عدد)

$\therefore CH_5N$ #

Some gases in our lives

1. Air: $O_2, Ar, O_3, CO_2, H_2O, N_2$ ...
2. Noble gases: Ne, He, Kr, Xe ...
3. other gases: $F_2, Cl_2, NH_3, CH_4, CO, NO_2, SO_2$ ...

Nature of gases (طبيعة الغازات)

1. Compressible
2. have low density $D_{gas} = \frac{2g}{L}$, $D_{\text{solid or liquid}} = \frac{2g}{ml}$
3. Gass fill container

Unit of pressure (وحدات الضغط)

& $1\,atm = 760\,mmHg = 760\,torr = 1.01325 * 10^5\,Pa = 101.325\,KPa$ &

Ex (1) Convert 0.357 atm to torr???

- $1\,atm \longrightarrow 760\,mmHg$

  $0.357\,atm \longrightarrow ???$

  $0.357 * 760 = \boxed{271.32\,mmHg}$

- $760\,mmHg \longrightarrow 760\,torr$

  $271.32\,mmHg \longrightarrow ???$

  $\frac{271.32 * 760}{760} = \boxed{271.32\,torr}$ #

(2) Convert 142.2 Kpa to torr???

- $101.325\,Kpa \longrightarrow 1.01325 * 10^5\,Pa$

  $142.2\,Kpa \longrightarrow ???$

  $\frac{142.2 * 1.01325 * 10^5}{101.325} = \boxed{142200\,Pa}$

- $1.01325 * 10^5\,Pa \longrightarrow 760\,torr$

  $142200\,Pa \longrightarrow ???$

  $\frac{760 * 142200}{1.01325 * 10^5} = \boxed{1066.58\,torr}$ #

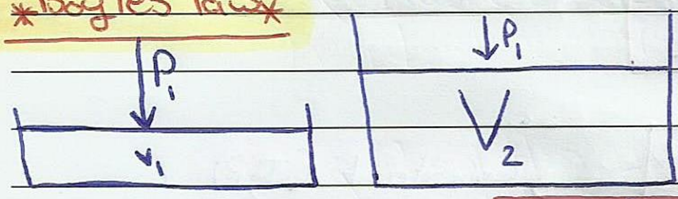
③ convert 475 mmHg in atm???

- 1 atm ⟶ 760 mmHg

??? ⟶ 475 mmHg

$$\frac{475\ \text{mmHg} \cdot 1\ \text{atm}}{760\ \text{mmHg}} = \boxed{0.625\ \text{atm}}$$ #

Boyles law



_ علاقة عكسية بين الـ P والـ V مع ثبات T ...

⟶ $P_1V_1 = P_2V_2$ ⟶ constant (T) ...

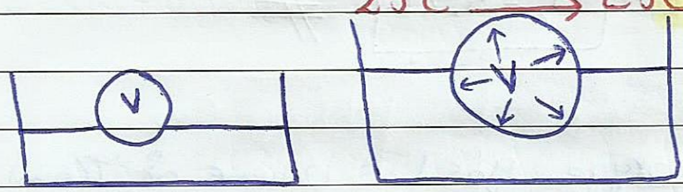
$PV = \text{constant}$

↑↓ ثابت

charles law

× دائماً درجة الحرارة يجب أن تكون في الـ (Kelvin) مثال :

25°c ⟶ 25°c + 273 = 298 K



_ علاقة طردية بين الـ V والـ T مع ثبات الـ P ...

T = 273 K —تضاعفت⟶ T = 546 K

V = 250 ml —تضاعفت⟶ V = 500 ml

⟶ نفس الوحدة لازم يكونوا

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

K

*Gay-lussac's law***

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \rightarrow \text{constant (V)}$$

1L = 1000 mL

القانون العام

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

$$\frac{n_1}{V_1} = \frac{n_2}{V_2} \rightarrow \text{constant (T,P)}$$

*Ex** (Boyles law) sample of nitrogen gas in 6.4L at pressure of 0.7 atm. what will be the new volume if the pressure changed to 1.4 atm.

a) 3.2L
b) 6.4L
c) 12.8L
d) 3200 mL

- Solution** $P_1V_1 = P_2V_2$

$$\frac{6.4 * 0.7}{1.4} = \frac{1.4 V_2}{1.4}$$

$$V_2 = 3.2L \quad \#$$

*Ex** (charles law) Sample of oxygen gas has volume of 720ml at temperature of 18°c, what temperature in (C°) in needed to change volume to 640 mL???

a) 443C°
b) 170C°
c) -82C°

- Solution** $V_1 = 720$ mL

$T_1 = 18 + 273 = 291$ K

$V_2 = 640$ mL

$T_2 = ???$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{720}{291} = \frac{640}{T_2}$$

$T_2 = 443.4$ K $- 273$

$T_2 = 170°c \quad \#$

Ex Gay-lussac's law* A gas has pressure at 2.0 atm at 18°c what will be the pressure new if the temperature risen to 62°c?

a) 1.9 atm
b) 2.0 atm
c) 2.3 atm
d) 1.8 atm

-Solution: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{2\ atm}{18+273} = \frac{P_2}{62+273}$

$\frac{2(62+273)}{(18+273)} = \frac{(18+273)P_2}{(18+273)}$

$P_2 = 2.3\ atm$ #

(mmHg) إلى atm

$2.3\ atm \times \frac{760\ mmHg}{1\ atm}$

$2.3 * 760 = 1748\ mmHg$

(القانون الموحد)

Ex Combined gas law* Sample of helium gas law has volume of 0.180 L, pressure of 0.800 atm and temperature of 29°c, what is the new temperature (c°) of the gas at volume of 90.0 mL and pressure of 3.2 atm???

-Solution: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$\frac{0.180 * 1000 * 0.800}{29+273} = \frac{90.0 * 3.2}{T_2}$

$T_2 = 604K - 273$

$T_2 = 331C^\circ$ #

*(STP): standard Temperature pressure

(ماذا تعرف عندما تذكر في السؤال)

($0^\circ C$, 273K) ← → (1 atm, 760 mmHg)

ahol (1 mole = 22.4 L)

Ex Sample of neon gas has volume of 15L at STP. what is new volume (L) of the gas as 2atm and $-25^\circ C$???

- Solution: $V_1 = 15\,L$

(STP) ⟹ Pressure$_1$ (1 atm) and temperature$_1$ (273K)

$V_2 = ???$

$P_2 = 2$ atm and $T_2 = -25^\circ c$

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

$$\frac{1 * 15}{273} = \frac{2 * V_2}{(-25+273)}$$

$$\boxed{V_2 = 6.8\,L}$$ #

***molar volume factor: 1 mole at STP = 22.4L (gas)

احفظ

(AT STP)

4.0g He	16.0g CH_4	44.0g CO_2
1 mole	1 mole	1 mole
V = 22.4L	V = 22.4L	V = 22.4L

(نسبة وتناسب)

Ex what is volume of CH_4 at STP of 4.00g?

a) 5.6L (boxed)
b) 2.6L
c) 44.8L
d) 11.2L

- Solution: $4g\,CH_4 \times \frac{1\,mole\,CH_4}{16\,g\,CH_4} \times \frac{22.4L}{1\,mole\,CH_4}$

$\boxed{V = 5.6\,L}$

(PBO)

*** Ideal gas law ***

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

$V \propto T$

$V \propto n$

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

$* \propto = R$ (constant)

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

$PV = nRT$ *

$R = 0.0821$ (atm)

$R = 62.4$ (mmHg)

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

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

*** Ex 8 *** If 2.86 mol of N_2O gas has a volume of 20.0 L at 23°C, what is the pressure (mmHg)???

$R = 62.4$ (mmHg) ... - Solution 8 $n = 2.86$ mol

$V = 20$ L

$T = 23 + 273 = 296$ K

$P = ???$

$P = \frac{nRT}{V} = \frac{2.86 * 62.4 * 296}{20} = 2640$ mmHg

#

(2020)

* Ex: 5.0 L container contain oxygen gas at 20°C and 735 mmHg. How many gram of oxygen gas in the container???
R = 62.4 (mmHg) ???

- solution: V = 5L
T = 20 + 273 = 293 K
P = 735 mmHg
R = 62.4 mmHg

$$*PV = \frac{\omega}{M.M} RT$$

$$5 * 735 = n * 62.4 * 293$$

$$\boxed{n = 0.2 \text{ mol}}$$

$$n = \frac{\omega}{M.M} \Rightarrow \omega = (2*16)*0.2$$

لـ O2 غازات

$$\boxed{\omega = 6.4 \text{ g } O_2} \quad \#$$

* Molar Mass of gas * → what is the molar mass of a gas if 0.250 g of the gas occupy 215 ml at 0.813 atm and 30.0°C ? R = 0.0821 atm ...

- Solution: $PV = \frac{\omega}{M.M} RT$

لازم التحويل إلى اللتر

$$10^{-3} * 0.813 * 215 = \frac{0.250}{M.M} * 0.0821 * (30+273)$$

$$10^{-3} * 174.795 = \frac{6.219 * 10^{-3}}{M.M}$$

$$\boxed{M.M = 35.5 \text{ g/mol}} \quad \#$$

$$D = \frac{M.M * P}{RT}$$

(poo)

* Ex: * Calculate the density of oxygen at STP ???

- Solution: * $T = 273K$ (O_2)
  * $P = 760$ mmHg
  * $U = 22.4L$
  * $R = 62.4$

$$D = \frac{32 * 760}{62.4 * 273} = \boxed{1.43 g/L} \ \#$$

* Gases in chemical equation *

(poo)

* Ex: * $Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2\uparrow$ (gas)

$453.6 * 10^3 g$ — ??? L in STP

- Solution: $453.6 * 10^3 g \times \frac{1 mol\ Fe}{56 g} \times \frac{1 mol\ H_2}{1 mol\ Fe}$

$$\boxed{n = 8100}$$

$$VP = nRT$$

$$V * 760 = n * 62.4 * 273$$

$$V * 760 = 8100 * 62.4 * 273$$

$$\boxed{U = 1.8 * 10^5\ L\ H_2} \ \#$$

(JT)

* 1 mole ⟶ 22.4 L

8100 mole ⟶ ???

$8100 * 22.4 = \boxed{1.8 * 10^5}$ #

Ex How many L of O_2 are need to react 28g NH_3 at 24°C and 0.95 atm??? ($4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$)

-solution

$$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$$
$$28g \quad ???$$

$$28g\ NH_3 = \frac{1\ mole\ NH_3}{(14+3*1)\ g\ NH_3} = \frac{5\ mol\ O_2}{4\ mol\ NH_3}$$

$$\frac{28*1*5}{(14+3)*4} = \boxed{2.058\ mol\ O_2}$$

$$PV = nRT$$

$$\frac{V*0.95}{0.95} = \frac{2.058*0.0821*(24+273)}{0.95} = \boxed{52.84\ L}\ \#$$

Daltons law

$$P_{total} = P_1 + P_2 + P_3 + \ldots\ldots$$

(partial pressure)

Ex: O_2, He

$$P_{total} = P_{O_2} + P_{He} \longrightarrow \left(P = \frac{nRT}{V}\right)$$
$$= n_{O_2}\frac{RT}{V} + n_{He}\frac{RT}{V}$$

$$= \frac{RT}{V}(n_{O_2} + n_{He})$$

(غازات)

Ex: 5 L scuba tank contain 1.05 mol O_2 and 0.418 mol He at 25°C. what is partial pressure of each gas, what is the total pressure???

- Solution:

O_2		He
$V = 5L$	(ثابتين) ⟷	$T = 25 + 273 = 298$
$n = 1.05$ mol		$n = 0.418$ mol

$$\Rightarrow P_{total} = (n_{O_2} + n_{He})\frac{RT}{V}$$
$$= (0.418 + 1.05) * \frac{0.0821 * 298}{5}$$
$$\boxed{= 7.19 \text{ atm}} \quad \#$$

$$\Rightarrow P_{O_2} = n_{O_2}\frac{RT}{V} = \frac{1.05 * 0.0821 * 298}{5} = \boxed{5.13 \text{ atm}}$$

$$\Rightarrow P_{He} = n_{He}\frac{RT}{V} = \frac{0.418 * 0.0821 * 298}{5} = \boxed{2.045 \text{ atm}}$$

(مهم)

Ex: 3.31 g $Pb(NO_3)_2$ (m.m = 331 g/mol) is heated in a cylinder with volume of 1.38 L. The salt decomposed to ($2Pb(NO_3)_{2(s)} \xrightarrow{\Delta} 2PbO_{(s)} + 4NO_{2(g)} + O_{2(g)}$) what is P in the cylinder??? if the temperature 300 K???

- Solution: الغازات فقط هي ال (NO_2, O_2) بنطلع عدد المولات لكل وحدة منها ونجمعهم ونضربهم في ($\frac{RT}{V}$)

$$* \; 3.31 \text{ g } Pb(NO_3)_2 = \frac{1 \text{ mole } Pb(NO_3)_2}{331 \text{ g } Pb(NO_3)_2} = \frac{4 \text{ mol}}{2 \text{ mol}}$$
$$\longrightarrow \boxed{0.02 \text{ mol } NO_2}$$

$$* \; 3.31 \text{ g } Pb(NO_3)_2 = \frac{1 \text{ mol } Pb(NO_3)_2}{331 \text{ g } Pb(NO_3)_2} = \frac{1 \text{ mol}}{2 \text{ mol}}$$
$$\longrightarrow \boxed{5 * 10^{-3} \; O_2 \text{ mol}}$$

$$\longrightarrow P_{total} = (n_{NO_2} + n_{O_2})\frac{RT}{V} = (5 * 10^{-3} + 0.02) * \frac{300 * 0.0821}{1.38}$$
$$\# \quad \boxed{= 0.446 \text{ atm}}$$

$$\frac{P_i}{P_t} = \frac{n_i}{n_t}$$

Exa NH_3 decomposed to N_2 and H_2 as ($2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$)
if 4atm NH_3 decomposed. calculate the total pressure?

a) 2 atm
b) 10 atm
c) 8 atm
d) 6 atm

_Solution

$2NH_3 \rightarrow N_2 + 3H_2$

(4atm) — P ??? P ??? — P_{total}

$$\frac{4}{P_t} = \frac{2\ mol}{4\ mol}$$ (3+1)

$$\frac{4*4}{2} = P_t$$

$$P_t = 8\ atm \quad \#$$

*** Molecular Effusion and diffusion ***

(root-mean square) and (effusion) and (speed of gas)

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

molar mass

$$R = 8.314\ \frac{Kg.\frac{m^2}{s^2}}{mol.K}$$ (ثابت جميع الغازات)

Exa Calculate root-mean square for helium (He) gas at 25°C???

_Solution $v = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3*8.314*298}{4*10^{-3}}}$

$$v = 1363.15\ m/s \quad \#$$

* صيغة سؤال ... (1) (H_2, O_2, N_2, Cl_2) ← رتبهم حسب الأسرع
(1) (3) (2) (4)

الأكبر الـ (ذو مس molar) أقل تطواسرع...

(2) حساب سرعة غاز بالنسبة لغاز آخر ... $\left(\frac{\mu_1}{\mu_2}\right)$

Ex: which gas will effuse faster, ammonia (NH_3) or carbondioxide (CO_2)
what are their relative rates of effuse???

- Solution: * Molar mass NH_3 = 17 g/mol → faster (الأقل كتلة مولية)
Molar mass CO_2 = 44 g/mol

لحساب النسبة بينهم من حيث السرعة... ← $* \frac{\mu_1}{\mu_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{M_{CO_2}}{M_{NH_3}}} = \sqrt{\frac{44}{17}} = 1.6$ //

Ex: An unknown gas (غاز مجهول) composed of diatomic molecule (على شكل X_2) (homonuclear) (متشابهات) effuse at rate is 0.355 times than O_2, what is the identity molecule gas???

- Solution: * molar mass $O_2 = 2*16 = 32$

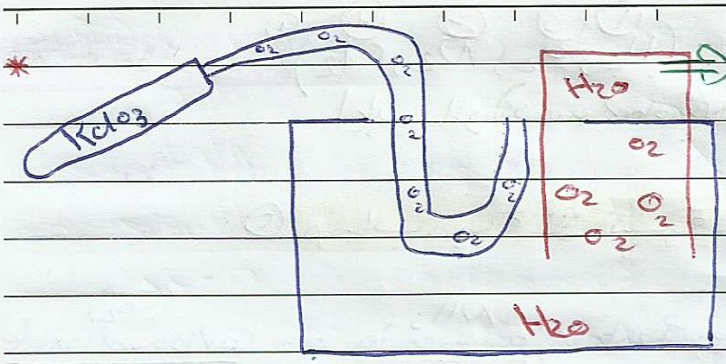
$$\frac{\mu_{X_2}}{\mu_{O_2}} = 0.355 = \sqrt{\frac{32}{M_{X_2}}}$$

$M_{X_2} = 254$ g/mol ⇒ $X = \frac{254}{2} = 127$ g/mol

← الـ (I) ← I_2

يعني الجدول الدوري ما بساوي 127

a) H_2
b) I_2 (boxed)
c) NO_2
d) N_2



$\Rightarrow P_{total} = P_{O_2} + P_{H_2O}$

(مثال)

* Ex: Sample of $KClO_3$ decomposed producing O_2, The volume of gas collected is 0.25L at 26°C and 765 torr total pressure. a) How many mol of O_2 are collected??? b) How many gram $KClO_3$ were decomposed???

- P_{H_2O} = 25 torr and $2KClO_{3(s)} \longrightarrow 2KCl_{(s)} + 3O_{2(g)}$

- Solution: $2KClO_3 \longrightarrow 2KCl + 3O_2$

$V = 0.25L$

$T = 26 + 273 = 299K$

$P_{O_2} = P_{total} - P_{H_2O} = 765 - 25 = 740$ mmHg

$R = 62.4$

(a) $*PV = nRT$

$$n = \frac{PV}{RT} = \frac{740 * 0.25}{62.4 * 299} = \boxed{9.91 * 10^{-3} \text{ mol}} \quad \#$$

(b) $$* 9.91 * 10^{-3} \text{ mol } O_2 \times \frac{2 \text{ mol } KClO_3}{3 \text{ mol } O_2} \times \frac{122.6 \text{ g } KClO_3}{1 \text{ mol } KClO_3}$$

$$= \boxed{0.811 \text{ g } KClO_3} \quad \#$$

* عشان تاخد الدرجات ...

Intermolecular forces liquides and Solids

*Intramolecular forces (1)

*تكون في نفس الجزيء

* [2] H–Cl

* [1] Na–Cl

*الرابطة أقوى...

* ⚠2 [2] called covalent bond (مشاركة)
  ↳ non metal + non metal (H–Cl)
* ⚠1 [1] called ionic bond..
  ↳ metal + non metal
  (Na^+ – Cl^-)

[3] *Intermolecular forces

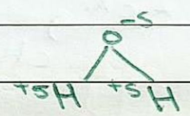
*جزيء مع جزيء آخر

* (H–Cl) ------ (H–Cl)
  δ^+ δ^- δ^+ δ^-

*الرابطة أضعف...

*تحدد إذا كانت المادة صلبة أو سائلة...

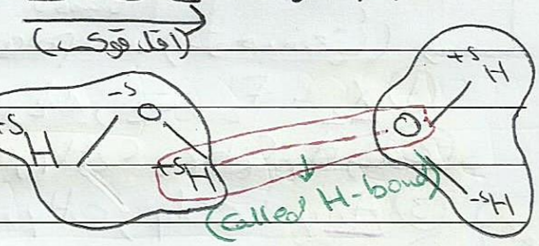
⚠3 ⇒ [1] ion – dipole
↓ Na^+, Cl^- ↓ H_2O



: حسب القوى [3]-[2]-[1] ...
(أقل قوى)

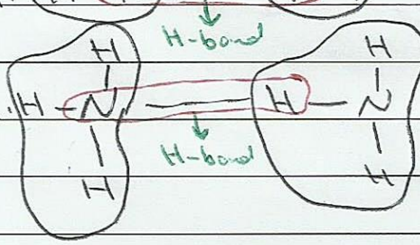
⚠(Y)
[2] H–bond → O–H, N–H, F–H
NOF ↵

⇒ Ex:



⇒ Ex: (H–F) ------ (H–F)
↓ H-bond

⇒ Ex:



5

3 Dipole-Dipole

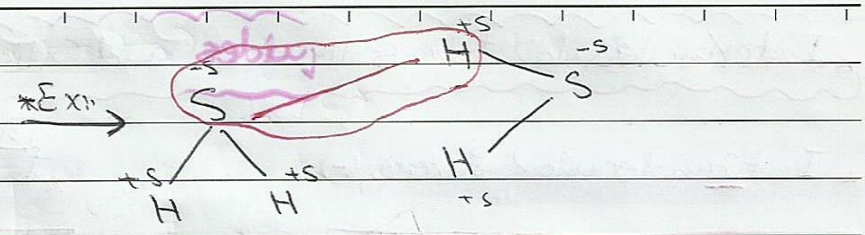
→ S-H

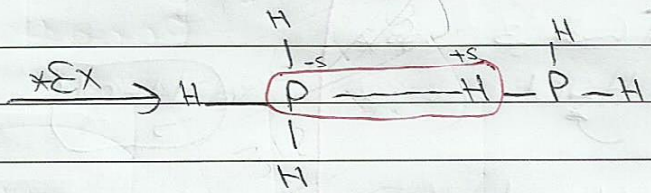
→ P-H

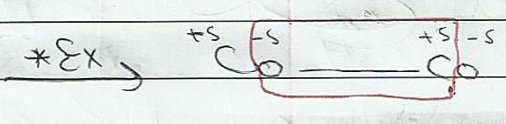
→ Cl-H

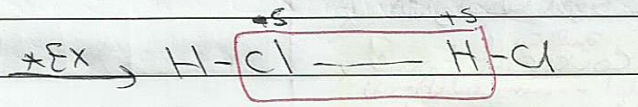
→ C-O

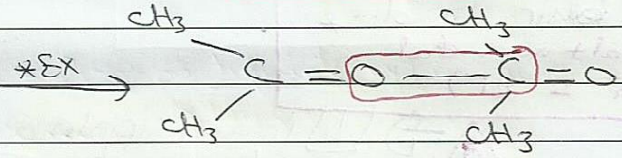
*Ex:

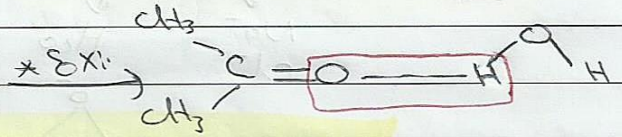












6

4 London dispersion forces (قوى لندن المشتتة):

↳ (غير قطبية) nonpolar compound

① X_2 : F_2, O_2, N_2, H_2 ——

② C_2H, C_6H_6, C_2H_4, C_2H_2 ——

③ AX_4 : CCl_4, CH_4, ——

④ AX_2 : CO_2, ——

Five Apple

** Ex: one of following have H-bond:
↳ Hydrogen-bond

a) H_2 → (London)

b) PH_3 → (Dipole - Dipole)

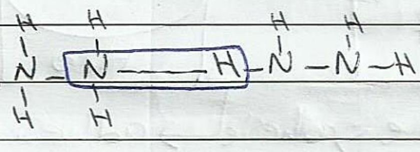
c) CH_4 → (London)

d) H_2O → (H-bond)

* Ex: in which of the following substance H-bond:

a) CH_4

b) H_2NNH_2 →



c) H_2S

d) CH_3F

(مهم)

* Ex: list the substance, (أيونية $BaCl_2$, H_2, CO, H-F, Ne) in order of increasing boiling point??? (من الأقل للأكبر)

a) Ne < H_2 < CO < $BaCl_2$ < H-F

(b) H_2 < Ne < CO < H-F < $BaCl_2$

إذا تساوى molar mass إذاً الأكبر B.P قطبية أكبر

c) H_2 < $BaCl_2$ < CO < H-F < Ne

d) H_2 < CO < H-F < $BaCl_2$ < Ne

*** Some properties of liquid ***

① viscosity (اللزوجة): resistance of liquid to flow...

① viscosity decrease with increase temperature...

② viscosity depend on intermolecular forces...

② Surface tension (التوتر السطحي): energy required to increase surface area of a liquid...

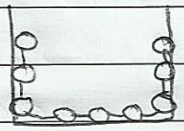
H_2O at 20°C 7.29×10^{-2} J/m²

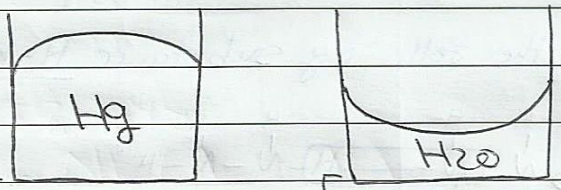
محتاج طاقة اكثر... ← Hg at 20°C 4.6×10^{-1} J/m²

(التماسك)

*cohesive forces هي 

(الالتصاق)

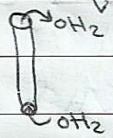
*adhesive forces هي 

(مهم) → 

cohesive forces > adhesive forces
adhesive forces > cohesive forces

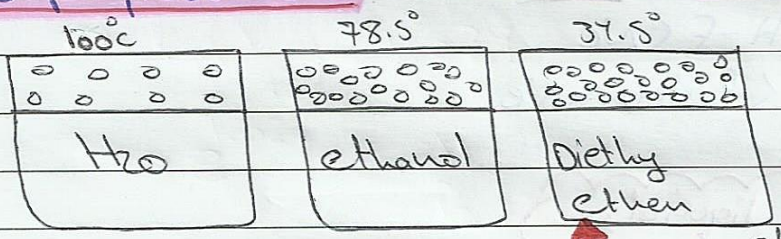
(الكابلرية الشعرية)

*capillary action هي The rise of liquids up in a very narrow tube...

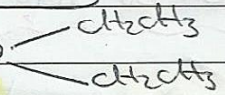


(مهم) (الضغط البخاري)

③ vapor pressure هي



CH_3CH_2OH



(إي سائل بخاره أكثر له ضغط بخاري أكبر)

* The weaker (أضعف) the intermolecular forces.
* The greater (أكبر) the vapor pressure.

* Vapor pressure ↑ with temperature.
(increase)

* Ex: which one of liquide have highest vapor pressure ?

a) $CH_3-CH_2OCH_2-CH_3$ — 34.5°C
b) C_2H_5OH — 78.5°C
c) H_2O — 100°C
d) $HO-CH_2CH_2OH$ — 198°C

→ * درجة الغليان اقل من vapor pressure اكبر ...

لو إذا كانت lowest الإجابة (d) ...

(enthalpy of vaporization) → $\frac{1\,atm}{100°C}$ → (من تحت الـ H_2O)

(حرارة التبخير) ← وهي كمية الحرارة التي يكتسبها الجسم أو السائل حتى يتحول من حالة سائلة لحالة غازية ...

$$\Rightarrow \ln\left(\frac{P_{vap_{T_1}}}{P_{vap_{T_2}}}\right) = \frac{\Delta H}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$R \rightarrow (8.3145)\ \frac{J}{K.mol}$

* Ex: The vapor pressure of H_2O at 25°C is 23.8 torr and the heat of vaporization is 43.9 KJ/mol. Calculate the vapore pressure of H_2O at 50°C ???

- solution:

$$\ln\left(\frac{23.8}{P_{vap_{T_2}}}\right) = \frac{43.9 \times 10^3\ \text{Joul}}{8.3145}\left(\frac{1}{50+273} - \frac{1}{25+273}\right)$$

$$\ln \frac{23.8}{P} = 5279.93(-2.59 \times 10^{-4})$$

$$\ln \frac{23.8}{P} = -1.37$$

$$e^{-1.37} = \frac{23.8}{P}$$

$$\boxed{P = 93.66\ \text{torr}}$$ #

Ex If ΔH_{vap} for water 40.7 KJ/mol, calculate the vapor pressure of pure water at 73°C???

- Solution: $\Delta H_{vap} = 40.7 * 10^3$ J/mol

$T_2 = 73°C$

$T_1 = 100°C$

$P_1 = 1$ atm

$P_2 = ???$

$R = 8.314S$

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

$$\ln\left(\frac{1\text{atm}}{P_2}\right) = \frac{40.7*10^3}{8.314S}\left(\frac{1}{73+273} - \frac{1}{100+273}\right)$$

$$\ln\left(\frac{1}{P_2}\right) = 4895.06\left(\frac{1}{346} - \frac{1}{373}\right)$$

$$\ln\left(\frac{1}{P_2}\right) = 14.147 - 13.123$$

$$\ln\left(\frac{1}{P_2}\right) = 1.024$$

$$e^{1.024} = \frac{1}{P_2}$$

$$2.784 = \frac{1}{P_2}$$

$$P_2 = \frac{1}{2.784} = \boxed{0.35 \text{ atm}} \#$$

* Ex * ccl4 has at 40°C → 313 torr
at 80°C → 512 torr
what is Boiling Point ccl4?

- Solution: $\ln\left(\frac{313}{512}\right) = \frac{\Delta H}{8.314}\left(\frac{1}{353} - \frac{1}{313}\right)$

$$-0.492 = \frac{\Delta H}{8.3145}\left(-3.62 * 10^{-4}\right)$$

$$-0.492 = -4.35 * 10^{-5}\ \Delta H$$

$\Delta H = 11310.34$ → 760 mmHg
→ $T_2 = ccl_4$

$$* \ln\left(\frac{760}{313}\right) = \frac{11310.34}{8.3145}\left(\frac{1}{313} - \frac{1}{T_{ccl_4}}\right)$$

$$0.887 = 1360.31\left(3.19 * 10^{-3} - \frac{1}{T_{ccl_4}}\right)$$

$$0.887 = 4.33 - \frac{1360.31}{T_{ccl_4}}$$

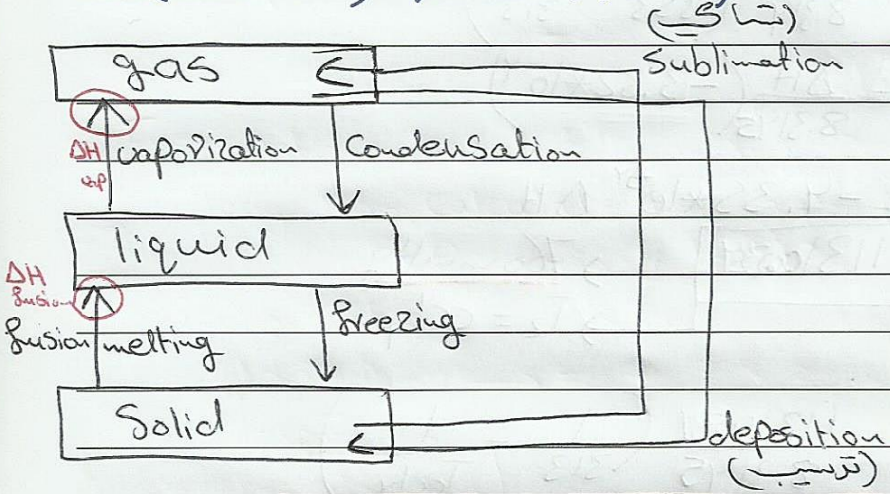
$$\frac{1360.31}{T_{ccl_4}} = 4.333 - 0.887$$

$T_{ccl_4} = 395.09\ K$ #

$T_{ccl_4} = 120\ ^\circ C$ #

Phase Change

→ 3 State of water :
(Solid → liquid → gas ...)



$$*\Delta H_{sublimation} = \left(\Delta H_{vap} + \Delta H_{fusion}\right)$$

$$*\Delta H_{deposition} = -\Delta H_{sublimation}$$

* * * * *

physical propertion of solution

- Solution
  - → solute (مذاب) (10g NaCl)
  - → Solvent (مذيب) (100 g H_2O)

* **Molarity**: = $\frac{n \text{ of mole solute}}{\text{volume solution (L)}}$ (M) ← بالوحدة

* → (3 M HCl → $\frac{3 \text{ mol HCl}}{1 L}$) * → (12 M HCl → $\frac{12 \text{ mol HCl}}{1 L}$) ← (ممكن يجيب لو أعطاك نفس الجزء الأول)

* **molality**: = $\frac{n \text{ of mole solute}}{\text{Kg solvent}}$ (m) لحرف صغير

* → (3 m NaCl → $\frac{3 \text{ mol NaCl}}{1 \text{ Kg } H_2O}$)

* **mole fraction**: (5 mol A ← solute صغير, 10 mol B ← solvent كبير) → mole fraction A = $\frac{n \text{ of mol A}}{\text{total mole}} = \left(\frac{5}{15}\right)$

mol fraction B = $\frac{n \text{ of mol B}}{\text{total mole}} = \left(\frac{10}{15}\right)$

* **mole**: = $\frac{wt}{M.M}$

Colligative properties

- الخواص المجمعة هي الخواص التي تعتمد على تركيز مولات المذاب Solute ...

1. vapor pressure (Raoult law) → (Acetone + H_2O)
2. Boiling point elvation → (sugar + H_2O)
3. freezing point depression. → (NaCl + H_2O)
4. osmosis.

[1] Vapor pressure (Raoult law)

mole fraction solvent = $\frac{\text{n of mole Solvent}}{\text{n of Solvent mol} + \text{n of mole Solute}}$

($\frac{wt}{M.M}$ ↑ , ↗ 46)

$P_A = X_A * P_A^\circ$ → vapor pressure Solvent

↓ vapor pressure solution

($\frac{wt}{M.M}$, $\frac{wt}{M.M}$)

M.M=46 ←

Ex Solution was made by mixing 2g ethanol (C_2H_5OH) with 100g H_2O calculate the vapor pressure of this solution at 70°C ($P^\circ_{H_2O} = 233.7$ torr)?

a) 0.5 atm

b) 0.33 atm

c) 0.067 atm

d) 0.285 atm

- Solution ** $P_A = X_A * P_A^\circ$

$$P_A = \frac{100/18}{\frac{100}{18} + \frac{2}{46}} * 233.7$$

← عكس في اسؤال يطلب هدول

$$P_A = \frac{5.55}{5.99} * 233.7$$

$$P_A = 216.53 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}}$$

$P_A = 0.285$ atm //

Ex8 Calculate the mass of $C_2H_8O_2$ that must be added to 0.5kg of H_2O to reduce vapor pressure of H_2O by 4.60 torr at 40°C ($P^\circ_{H_2O}$ at T=46°C = 55.3 torr) ???

$(55.3 - 4.60)$ = P_A

Solution: $P_A = X_A * P^\circ_A$

$$50.7 = \frac{0.5*10^3/18}{\frac{0.5*10^3}{18} + \frac{wt}{76}} * 55.3$$

$$50.7 = \frac{27.778}{27.778 + \frac{wt}{76}} * 55.3$$

$$0.9168 = \frac{27.778}{\frac{2111.128 + wt}{76}}$$

$$0.9168 = \frac{2111.128}{2111.128 + wt}$$

$$0.9168(2111.128 + wt) = 2111.128$$

$$2111.128 + wt = 2302.71$$

$$\boxed{wt = 191.58g} \#$$

Ex: The vapor pressure of H_2O at 20°C is 17.5 torr. If 20% sucrose added to water. Calculate the vapor pressure solution???

20% → sucrose

80% → H_2O

Solution:

$$P_{solution} = X_A * P^\circ$$

$$= \frac{80}{100} * 17.5$$

$$= 14 \text{ torr}$$ //

2 Boiling point elvation

$$\Delta T_b = K_b \, m \rightarrow = \frac{\text{wt / MM of mole solute}}{\text{Kg solvent}}$$

$(T - T^\circ)$

solution − solvent

Ex: Calculate the Boiling point (c°) of solution made by dissolving 30g of sucrose (M.M = 342) in 200g H_2O ($K_b = 0.51$). $T^\circ_{H_2O} = 100°C$?

Solution:

$$\Delta T_b = K_b \, m \quad \left(\text{moles of solute} / \text{Kg solvent}\right)$$

$$\Delta T_b = 0.51 * \frac{30/342}{0.2 \text{ Kg}}$$

$$\Delta T_b = 0.22$$

$$T - T^\circ = 0.22$$

$$T - 100 = 0.22$$

$$T = 100.22°C$$ //

3 Freezing point depression

$$\Delta T_f = -K_f \cdot m$$

* Ex: what mass of ethylene glycol ($C_2H_6O_2$ $M.M = 62.1$) (antifreeze) must added to (10L) H_2O (10Kg H_2O) to produce solution that freeze at (-23.3°C) ($K_f = 1.86$)???

- Solution: $\Delta T_f = -K_f \cdot m$

$$\Delta T_f = -K_f \cdot \frac{\text{n of mole solute}}{\text{Kg solvent}} \quad \rightarrow \frac{w}{M.M}$$

$T_{Solution} - T_{solvent} =$

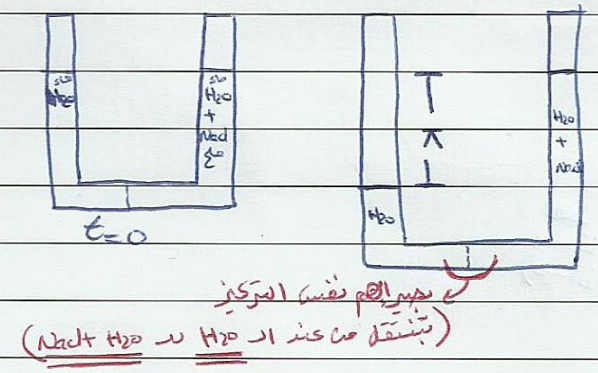
$-23.3 - 0 = -1.86 \cdot m$

$$12.5 \frac{mol}{Kg} = m$$

$$\rightarrow 12.5 = \frac{\frac{wt}{62.1}}{10}$$

$$wt = 7.76\ Kg \quad //$$

4 Osmosis



يصير الهم نفس التركيز
(بتنتقل من عند الـ H_2O لـ NaCl + H_2O)

$$-\pi V = nRT$$

$$\pi = \frac{nRT}{V} \quad \text{حجم} \leftarrow M$$

$$\pi = MRT \rightarrow \text{Kelvin}$$

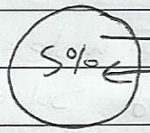
0.0821

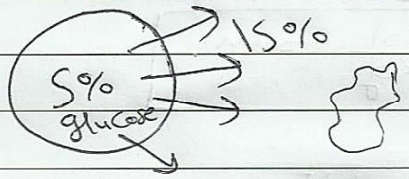
$$\text{at} \leftarrow \pi = \frac{\frac{wt}{M.M} RT}{V(L)}$$

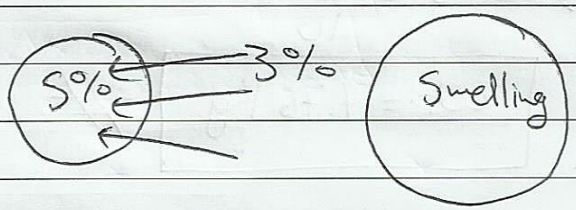
Ex what concentration of (sugger?) ... in water is need to produce solution with osmotic pressure = 7.7atm at 25°C???

- Solution: $M = \frac{\pi}{RT}$

$$M = \frac{7.70}{0.0821 \times 298} = \boxed{0.31} \#$$

- Isotonic Solution: 

- hypotonic Solution: 

- hypetonic Solution: 

Colligative properties for electrolyte solutions

$C_6H_{12}O_6 \xrightarrow[(s)]{H_2O} C_6H_{12}O_6$

$NaCl_{(s)} \xrightarrow{H_2O} Na^+ + Cl^-$

(1) Vant Hoff → $\boxed{i = 2}$ (لهذا السبب (بسبب الأيونات))

- $MgCl_2$ → $i = 3$
- $MgSO_4$ → $i = 2$
- $FeCl_3$ → $i = 4$
- HCl → $i = 2$

- glucose → $i = 1$

تزاوج الأيونات

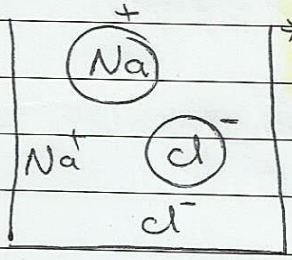
*ion pairing :

يحصل

*اختلاف القيمة المتوقعة لـ i عن القيمة الحسابية..

*i (observed) ← 1.9

*i = 2 ← expected



ليش؟؟؟

يحصل (فتح دائرة) ← ion pairing

① vapor pressure (Raoult law) :

$$P_A = X_A * P_A^\circ$$

$$= \frac{n_{solvent}}{n_{solvent} + (i)\, n \text{ of mole solute}} * P_A^\circ$$

(i) يمثل الذائب

* Ex: predict the vapor pressure of solution prepared by mixing 35 gram solid Na_2SO_4 ($M.M = 142 g/mol$) with 175 gram water at 25°c ($P^\circ_{H_2O} = 23.76$ torr) ؟؟؟

- Solution :

$$P_A = \frac{n_{solvent}}{n_{solvent} + (i)\, n \text{ of mole solute}} * P_A^\circ$$

$$P_A = \frac{\frac{175}{18}}{\frac{175}{18} + 3\left(\frac{35}{142}\right)} * 23.76$$

$$\boxed{P_A = 22 \text{ torr}} \quad //$$

(2) Boiling point elevation:

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

(3) Freezing point depression:

$$\Delta T_f = -i K_f \cdot m$$

(4) Osmosis:

$$\pi = iMRT$$

* Ex: The observed osmotic pressure for 0.1 M solution of $Fe(NH_4)_2(SO_4)_2$ at 25°c is 10.8 atm. Compare the expected and experimental value for (i)???

Solution: $i = \frac{\pi}{MRT}$

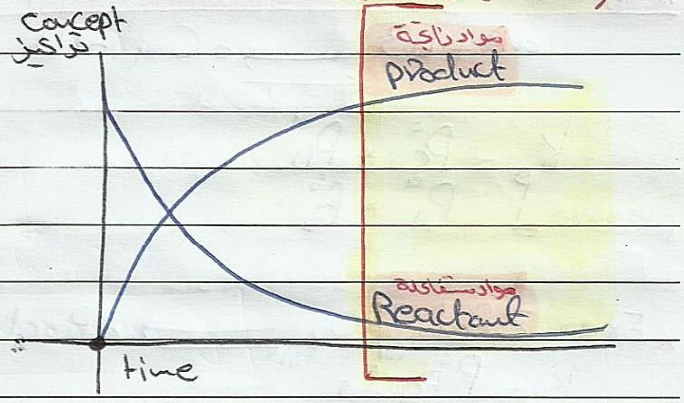
$$i = \frac{10.8}{0.1 * 0.0821 * 298} = \boxed{4.4} \quad \#$$

المتوقع انه يكون (i=5) بس لا ion pairing بيكون اقرب (4.4)..

Chapter (5)

الإتزان الكيميائي
Chemical equilibrium

(منطقة الإتزان)



*Concept of equilibrium

$$A + B \rightleftharpoons C + D$$

$(t=0)$	a_o	b_o	0	0
$(t=t)$	$a_o - x$	$b_o - x$	C	D

*equilibrium: It is the point at which no changes on concentration with time...

(and) Rate of Product = Rate of Reaction

(سرعة التفاعل الأمامي = سرعة التفاعل العكسي)

*The equilibrium constant (تركيز المواد الناتجة / تركيز المتفاعلة)

$$A + B \rightleftharpoons C + D \qquad aA + bB \rightleftharpoons cC + dD$$

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

*Exercise the equilibrium constant for the Reaction???

a) $2O_{3(g)} \rightleftharpoons 3O_{2(g)}$

$$K_c = \frac{[O_2]^3}{[O_3]^2}$$

b) $2NO_{(g)} + Cl_{2(g)} \rightleftharpoons 2NOCl$

$$K_c = \frac{[NOCl]^2}{[NO]^2 * [Cl_2]}$$

***equilibrium constant in Terms of pressure:**

$$aA + bB \rightleftharpoons cC + dD$$

$$K_p = \frac{P_C^c * P_D^d}{P_A^a * P_B^b}$$

pressure ↲

*Ex: $2PCl_{3(g)} + O_{2(g)} \rightleftharpoons 2POCl_{3(g)}$

$$K_{p_1} = \frac{P^2_{POCl_3}}{P^2_{PCl_3} * P_{O_2}}$$

(مهم) → predict the K_{p_2} for $2POCl_{3(g)} \rightleftharpoons 2PCl_{3(g)} + O_{2(g)}$

$$K_{p_2} = \frac{1}{K_{p_1}}$$

$$K_{p_2} = \frac{P^2_{PCl_3} * P_{O_2}}{P^2_{POCl_3}}$$

* (ممكن يعطينا اياها بالأرقام $K_{p_1} = 1*10^{30}$ ماذا نحسب $K_{p_2} = \frac{1}{1*10^{30}}$) ...

(انضربت بـ ② مرفوعة للأس)

$$4POCl_3 \rightleftharpoons 4PCl_3 + 2O_2$$

$$K_{p_3} = \frac{1}{(K_{p_1})^2}$$

$$4PCl_{3(g)} + 2O_2 \rightleftharpoons 4POCl_{3(g)}$$

$$K_{p_4} = (K_{p_1})^2$$

$$PCl_{3(g)} + 1/2\, O_{2(g)} \rightleftharpoons POCl_{3(g)}$$

$$K_{p_5} = \sqrt{K_{p_1}} = (K_{p_1})^{1/2}$$

* $POCl_{3(g)} \rightleftharpoons \frac{1}{2} O_2 + PCl_{3(g)}$ (المعكوس والضرب ©)

$$K_{p_6} = \frac{1}{(K_{p_1})^{1/2}} = (K_{p_1})^{-1/2} = \frac{1}{\sqrt{K_{p_1}}}$$

(جمع المعادلتين) * $2NO + O_2 \rightleftharpoons 2NO_2$

$$K_{c_1} = \frac{[NO_2]^2}{[NO]^2 * [O_2]}$$

(+)

* $N_2 + O_2 \rightleftharpoons 2NO$

$$K_{c_2} = \frac{[NO]^2}{[N_2] * [O_2]}$$

$$N_2 + 2O_2 \rightleftharpoons 2NO_2$$

$$K_{c_3} = \frac{[NO_2]^2}{[N_2] * [O_2]^2} \Rightarrow \therefore K_{c_3} = K_{c_1} * K_{c_2}$$ #

(في حالة جمع المعادلات يكون الـ Kc تكون ضرب وليس جمع)
(أي يصير كما الـ Kc بيصير كما الـ Kp)...

* Relationship between Kp and Kc *

(مهم)

* $K_p = K_c(RT)^{\Delta n}$ → (مولات الغازات)

R ↓ 0.0821; T ↳ Kelvin

* Δn :: (عدد مولات المواد الناتجة والتي في الحالة الغازية ⊖ عدد المولات من المواد المتفاعلة والتي في الحالة الغازية)

↳ (n of mol of gaseous product − n of mol of gas Reactant)

* $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

$\Delta n = 2 - 3 = -1$

لما في حالة تساوي عدد المولات فإن الـ $(K_c = K_p)$

* Ex: In the synthesis of ammonia from nitrogen and hydrogen, $K_c = 9.60$ at $300^\circ c$ and $R = 0.0821$

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

Calculate K_p???

Solution: $\Delta n = 2 - 4 = -2$

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

$K_p = 9.60 (0.0821 * (300 + 273))^{-2}$

$K_p = 7.37 * 10^{-3}$ //

(الإتزان الغير متجانس)

*** Heterogeneous equilibria ***

$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

↳ Homogeneous equilibrium ← * الإتزان متجانس يكون من كل المواد المتفاعلة والناتجة غازات..

* $2NaHCO_{3(s)} \rightleftharpoons Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$

$K_p = P_{CO_2} * P_{H_2O}$

$K_c = [CO_2] * [H_2O]$

s, l (صلب ومحلول)

g, aq (بخار ومحلول)

* $H_2O \rightleftharpoons H_2O_{(g)}$

$K_p = {}^{(1)}P_{H_2O}$

$K_c = [H_2O]$

* $CO_{2(g)} + H_{2(g)} \rightleftharpoons CO_{(g)} + H_2O_{(l)}$

$K_p = \frac{P_{CO}}{P_{CO_2} * P_{H_2}}$ $\quad K_c = \frac{[CO]}{[CO_2] * [H_2]}$

* $SnO_{2(s)} + 2CO_{(g)} \rightleftharpoons Sn_{(s)} + 2CO_{2(g)}$

$K_p = \frac{P^2_{CO_2}}{P^2_{CO}}$ $\quad K_c = \frac{[CO_2]^2}{[CO]^2}$

(مهم)

* Ex: what are the value of (K_p) and (K_c) of the Reaction $H_2O_{(l)} \rightleftharpoons H_2O_{(g)}$, Knowing that the partial pressure of H_2O at 25°c is 23.8 torr???

- solution ❀ $K_c \Rightarrow K_p = K_c (RT)^{\Delta n}$

$\frac{1\,atm}{760\,torr} * 23.8 = K_c (0.0821) * (25 + 273)$ ①

$$\boxed{K_c = 1.28 * 10^{-3}} \quad //$$

* Application of equilibrium Constant *

→ Calculate equilibrium concentration.

→ predicting direction of Reaction. (معرفة إتجاه التفاعل $\rightleftharpoons$)

* Ex * For the synthesis of ammonia $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ $K_p = 1.45 * 10^{-5}$ at 500°C the partical pressure of H_2 is 0.928atm and that of N_2 is 0.432atm. what is partical pressure of NH_3 (P_{NH_3})??? at equilibrium...

- Solution * $K_p = \frac{P^2_{NH_3}}{P^1_{N_2} * P^3_{H_2}}$

$$1.45 * 10^{-5} = \frac{X^2}{(0.432) * (0.928)^3}$$

$$X^2 = 5.01 * 10^{-6} \Rightarrow \boxed{X = 2.24 * 10^{-3}\ atm} \#$$

* Ex * 10L flask is filled with 0.2 mol of H_2 and 0.2mol I_2 at 448°C. The value of equilibrium constant K_c for the Reaction $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ is 49.5 what are the consentration of H_2, I_2, HI in the flask at equilibrium???

- Solution * ① $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ (49.5)

	$H_{2(g)}$	$I_{2(g)}$	$2HI_{(g)}$
	0.02M	0.02M	0
②	−X	−X	+2X
③ (Conc at equ)	0.02−X	0.02−X	2X

0.2mol H_2, 0.2mol I_2, 10L

$\Rightarrow K_c = 49.5$

$[H_2] = \frac{0.2}{10} = \boxed{0.02M}$

$[I_2] = \frac{0.2}{10} = \boxed{0.02M}$

④ $* K_c = \frac{[HI]^2}{[H_2] * [I_2]}$

$$49.5 = \frac{(2X)^2}{(0.02-X)(0.02-X)}$$

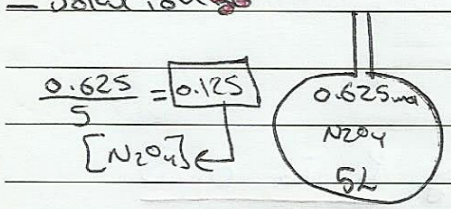
$$\sqrt{49.5} = \sqrt{\frac{(2X)^2}{(0.02-X)^2}}$$

$$\boxed{X = 0.0156M}$$

⑤ $\rightarrow 0.02 - 0.0156 = [H_2] = [I_2] = \boxed{4.5 * 10^{-3}}$

*Ex: 5L flask filled with 0.625mol of N_2O_4 if you know that concentration of N_2O_4 at equilibrium = 0.075 M, what is K_c for the Reaction ($2NO_2 \rightleftharpoons N_2O_4$)???

-Solution



initial conc –

change in conc –

conc at equi –

$2NO_2 \rightleftharpoons N_2O_4$

0 | 0.125 M

+2X | −X

2X | 0.125 − X = 0.075

X = 0.05 #

→ 2 * 0.05 = 0.1

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} = \frac{0.075}{(0.1)^2} = 7.5 \ \#$$

(000)

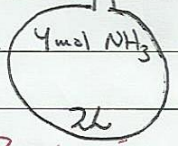
*Ex: 2L flask filled with 4mol NH_3 As in the Reaction : $2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$. At equilibrium it remain 2mol of NH_3 what is K_c???

-Solution

$2NH_3 \rightleftharpoons N_2 + 3H_2$

2mol | 0 | 0

$[NH_3] = \frac{4}{2} = 2$



−2X | +X | +3X

2 − 2X | X | 3X

X: $\frac{1}{2}$ ↵ 3X: $\frac{3}{2}$ ↵

① = $\frac{2mol}{2L}$ ← is the concentration of

2 − 2X = 1 → X = $\frac{1}{2}$

$$K_c = \frac{[N_2] * [H_2]^3}{[NH_3]^2} = \frac{(\frac{1}{2}) * (\frac{3}{2})^3}{(1)^2} = \frac{27}{16} \ \#$$

(معرفة اتجاه الاتزان)

*** Predicting direction for the Reaction ***

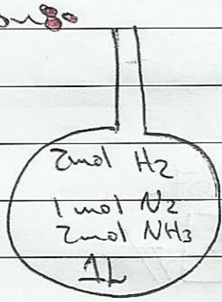
Ex: suppose we place mixture of

$2\,mol\ H_2$
$1\,mol\ N_2$ } → in (1L) at 472°C
$2\,mol\ NH_3$

will N_2 and H_2 react to from NH_3 Knowing K_c is 0.105

$N_2 + 3H_2 \rightleftharpoons 2NH_3$???

_Solution:



⇒ $2M\ H_2$, $1M\ N_2$, $2M\ NH_3$ (مولارية)

$*K_c$ (جديد) $= Q = \dfrac{[NH_3]^2 \downarrow}{[N_2] * [H_2]^3 \uparrow} = \dfrac{(2)^2}{(1)(2)^3} = \dfrac{4}{8} = 0.5 \downarrow$

$Q > K_c$

بدي اياها تساوي الـ K_c فبدي اتجاهها عكسي تقليل $[NH_3]$ وزيادة تركيز $[H_2]$ و $[N_2]$ وبالتالي:

$Q > K_c$ ⟶ shift to left

$Q < K_c$ ⟶ Shift to Right

وهاي هنا الاتجاه (←)

Chapter 6

Acid-Base Equilibria

Acids and Bases

*Arrhenius concept

↳ Acid substance give H^+ in H_2O

Base substance give OH^- in H_2O

↳ Ex: $HCl \xrightarrow{H_2O} H^+ + Cl^-$ (Acid)

$NaOH \xrightarrow{H_2O} OH^- + Na^+$ (Base)

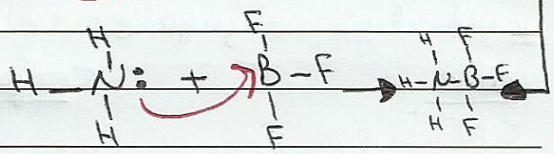
*Bronsted-lowry

↳ Acid substance donate H^+

Base substance accept H^+

↳ Ex: $HCl_{(g)} + H_2O \rightarrow H_3O^+ + Cl^-$

*Lewis



Base	Acid
Lewis donate $2e^-$	lewis accepet 2e

$\rightarrow HSO_3^-$

amphoteric

↳ acting as acid and Base

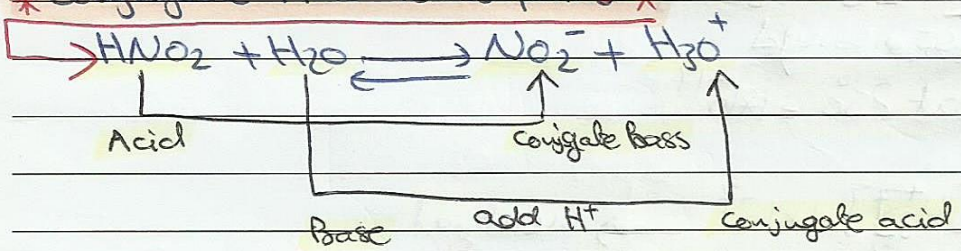
$H_2O + HCl \longrightarrow H_3O^+ + Cl^-$

base acid

$H_2O + NH_3 \longrightarrow NH_4^+ + OH^-$

acid base

Conjugate Acid-Bass pair



* what is conjugate base of each acid

Acid	Conjugate base
$HClO_4$	ClO_4^-
H_2S	HS^-
PH_4^+	PH_3
HCO_3^-	CO_3^{-2}

* what is conjugate acid of each bass

base	Conjugate acid
CN^-	HCN
SO_4^{-2}	HSO_4^-
H_2O	H_3O^+
HCO_3^-	H_2CO_3
NH_3	NH_4^+

(خودیونش آب)
* Autoionization of water *

* $H_2O_{(l)} + H_2O_{(l)} \rightleftharpoons OH^-_{(aq)} + H_3O^+_{(aq)}$
Acid base

$\rightarrow K_w = [OH^-][H_3O^+]$
(ثابت یونش آب)
at 25°C $= 1*10^{-14}$

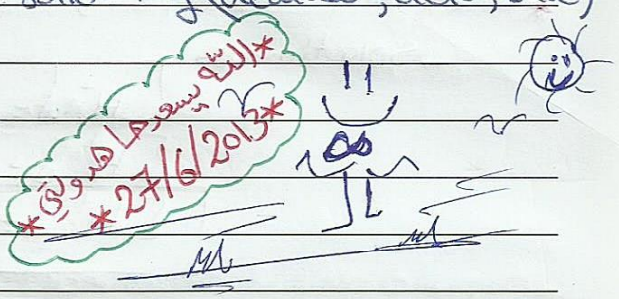
* $[OH^-] = [H^+] = 1*10^{-7}$ → neutral
* $[H^+] > [OH^-]$ → acid → $1*10^{-5} > 1*10^{-9}$
* $[OH^-] > [H^+]$ → base → $1*10^{-5} > 1*10^{-9}$

* Ex: Indicate whether each of the following (neutral, acid, base)

$[H^+] = 2*10^{-5}$ M ⟶ Acid

$[OH^-] = 3*10^{-9}$ M ⟶ Acid

$[OH^-] = 1*10^{-7}$ M ⟶ neutral



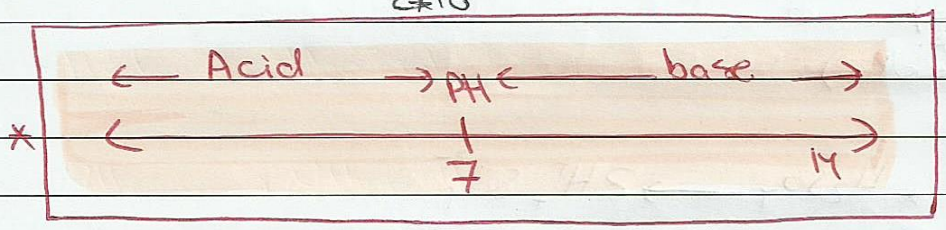
* Ex: Calculate concentration of H^+ in a) solution in which $[OH^-] = 0.01$ M
b) Solution in which $[OH^-] = 2*10^{-9}$ M

a) solution: $[H^+][OH^-] = K_w$

$[H^+] * 10^{-2} = 1*10^{-14}$

$\boxed{[H^+] = 1*10^{-12}}$ ⟶ base

b) $[H^+] = \frac{1*10^{-14}}{2*10^{-9}} = \boxed{0.5*10^{-5}}$ ⟶ acid



* $PH = -\log [H^+]$ ⟶ $PH = -\log 1*10^{-9}$

$\boxed{PH = 9}$

Power of hydrogen

* Ex * Sample of apple juice has pH of 3.76 calculate $[H^+]$???

Solution:

$$[H^+] = 10^{-PH}$$

$$[H^+] = 10^{-3.76}$$

$$\boxed{[H^+] = 1.7 * 10^{-4}\ M} \quad \#$$

* Strong Acid and Strong base *

* Strong Acid

↳ HCl, HBr, HI, HNO_3, $HClO_4$, $HClO_3$, H_2SO_4 ...

(ماده ای که در آب کامل تفکیک میشود)

* $HCl \xrightarrow{H_2O} H^+ + Cl^-$

100 mol — 0 — 0

0 — 100 mol — 100 mol

(تجزیه کامل یا تفکیک ۱۰۰٪ در آب)

(100% dissociation)

* $H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$

* Ex * what is pH of 0.2 M solution H_2SO_4 ??? ($[H^+]$ ←)

Solution: $H_2SO_4 \longrightarrow 2H^+ + SO_4^{-2}$

0.2 — 0 — 0

0 — 2(0.2) — 0.2

$[H^+] = 0.4$

$$PH = -\log[H^+]$$

$$= -\log(0.4)$$

$$\boxed{= 0.39} \quad \#$$

* Strong base *

→ NaOH, KOH, $Ca(OH)_2$, LiOH, RbOH, C_2OH, $Ba(OH)_2$, $Sr(OH)_2$

$$* NaOH \xrightarrow{H_2O} Na^+ + OH^-$$

100 mol	0	0
0	100 mol	100 mol

$$* Ca(OH)_2 \longrightarrow Ca^{2+} + 2OH^-$$

* Ex: what is pH of 0.011 M solution of $Ca(OH)_2$?

Solution: $Ca(OH)_2 \longrightarrow Ca^{2+} + 2OH^-$

0.011	0	0
0	0.011	2(0.011) = 0.022 M

$$K_w = [H^+][OH^-]$$
$$1 * 10^{-14} = [H^+]\,0.022$$
$$\boxed{4.6 * 10^{-13} = [H^+]}$$

$$pH = -\log[H^+]$$
$$pH = -\log(4.6 * 10^{-13})$$
$$\boxed{pH = 12.34} \quad //$$

(أو بطريقة ثانية) *** $\boxed{pH + pOH = 14}$ ⟹ $pOH = -\log[OH^-]$

$pOH = -\log(0.022)$

$\boxed{pOH = 1.66}$

→ $14 - 1.66 = pH$

$\boxed{12.34 = pH}$

*Strong base (Ionic metal oxide)

Na_2O, CaO

$$Na_2O + H_2O \longrightarrow 2NaOH$$
$$0.1\,M \qquad\qquad 0.1\,M$$

Ex 0.01 mol Na_2O react with H_2O to form 1L solution calculate pH???

- Solution

$$Na_2O + H_2O \longrightarrow 2OH^- \rightarrow 2NaOH(aq)$$
$$\frac{0.01\,mol}{1L} \qquad\qquad 0$$

$$0 \qquad\qquad \boxed{2(0.01M) = 0.02\,M}$$

$$*POH = -\log[OH^-]$$
$$= -\log(0.02)$$
$$= 1.7$$
$$PH = 14 - 1.7 = \boxed{12.30}$$

*Strong base (Ionic Hydride)

$Na^{+1}H^{-1} = H^-$

N^{3-}

$NaOH \xrightarrow{H_2O} OH^-$

$N^{3-} \xrightarrow{H_2O} 3OH^-$

weak acids:

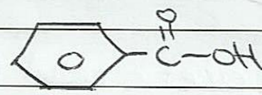
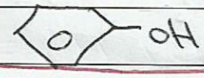
→ Ex: $CH_3-\underset{\underset{O}{\|}}{C}-OH \rightleftharpoons H^+ + CH_3-\overset{\overset{O}{\|}}{C}-O^-$

(كلّ حمض ضعيف لهُ قاعدة مرافقة قويـة)

$$\uparrow K_a = \frac{\uparrow [H^+][CH_3-\overset{O}{\overset{\|}{C}}-O^-]}{[CH_3-\overset{O}{\overset{\|}{C}}-OH]}$$

a → acids

كلما كانت Ka كبيرة يكون [H⁺] اكبر...

	Ka	
HF	6.8×10^{-4}	→ اقوى حمض من حيث ال H^+
HNO_2	4.5×10^{-4}	
	6.3×10^{-5}	
$CH_3-\overset{\overset{O}{\|}}{C}-OH$	1.8×10^{-5}	
	1.3×10^{-10}	اضعف حمض من حيث ال H^+

*Ex: 0.1M $H-\overset{\overset{O}{\|}}{C}-OH$ has pH = 2.38, a) calculate Ka

(مهم) b) percent ionization for this solution. (نسبة التأين للحمض الضعيف)

Solution: ⓐ $H-\overset{\overset{O}{\|}}{C}-OH \rightleftharpoons H^+ + H-\overset{\overset{O}{\|}}{C}-O$

	$HCOOH$	H^+	$HCOO^-$
	0.1	0	0
	−x	+x	+x
	0.1−x	x	x
	$0.1-(4.2\times10^{-3})$	4.2×10^{-3}	4.2×10^{-4}

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

$2.38 = -\log(x)$

$x = 4.2 \times 10^{-3} \rightarrow [H^+]$

$$K_a = \frac{(4.2 \times 10^{-3})^2}{0.1-(4.2 \times 10^{-3})} = 1.8 \times 10^{-4} \quad //$$

(b) percent ionization $= \frac{[H^+]}{[H-\overset{O}{\overset{\|}{C}}-OH]} \times 100\%$

$= \frac{4.2\times10^{-3}}{0.1} \times 100\%$

$= \boxed{4.2\%}$ #

$H-\overset{O}{\overset{\|}{C}}-OH \rightarrow H^+ + H-\overset{O}{\overset{\|}{C}}-O^-$

100 mol | 0 | 0

96 mol | 4

*** using Ka to calculate PH ***

* Ex: Calculate PH of 0.3 M of acetic acid ($CH_3-\overset{O}{\overset{\|}{C}}-OH$) ($K_a = 1.8\times10^{-5}$)

- Solution:

$CH_3-\overset{O}{\overset{\|}{C}}-OH \rightleftharpoons CH_3-\overset{O}{\overset{\|}{C}}-O^- + H^+$

0.3 | 0 | 0

$-X$ | $+X$ | $+X$

$0.3-X$ | X | X

$K_a = \frac{X^2}{0.3-X} = 1.8\times10^{-5}$

$X^2 = 5.4\times10^{-6}$

$X = 2.3\times10^{-3}$

$[H^+]$ تساوي

$PH = -\log[H^+] = -\log(2.3\times10^{-3})$

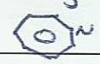
$= 2.64$ #

percent ionization $= \boxed{0.77\%}$

*** weak base :: ***

→ $NH_{3(aq)} \underset{OH^- \quad H^+}{\overset{H_2O}{\rightleftharpoons}} OH^-_{(aq)} + NH_4^+{}_{(aq)}$

$$* \uparrow K_b = \frac{\uparrow [OH^-][NH_4^+]}{[NH_3]}$$

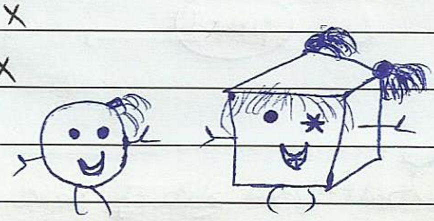
↳ Base	Kb	
NH_3	$1.8*10^{-5}$	
	$1.7*10^{-9}$	→ (الأقل)
H — N — OH (N–H)	$1.1*10^{-8}$	(من حيث القاعدية)
H — N — CH_3 (N–H)	$4.4*10^{-4}$	(الأكبر) (من حيث القاعدية)
ClO^-	$3.3*10^{-7}$	

***Ex :: *** calculate Concentration of OH^- in 0.15M NH_3, $K_b = 1.8*10^{-5}$???

- Solution ::

$$NH_3 \overset{(H)(OH)}{\rightleftharpoons} OH^- + NH_4^+$$

NH_3	OH^-	NH_4^+
0.15	0	0
−x	+x	+x
0.15−x	x	x



$$* \ Kb = \frac{x^2}{0.15 - x} = 1.8*10^{-5}$$

(ح نشيلها)

$x^2 = 2.7*10^{-6}$

$x = 1.6*10^{-3}$ M

لو ممكن يطلب الـ (PH) بنطلع تركيز الـ $[H^+]$ ثم الـ (PH)..

*** Relationship between Ka and Kb ***

$$Ka \cdot Kb = 1 \times 10^{-14}$$

Acid	Ka	base	Kb
HF	6.8×10^{-4}	F^-	? (1.47×10^{-11})
$CH_3-\overset{\overset{O}{\|}}{C}-OH$	? (1.78×10^{-5})	$CH_3-\overset{\overset{O}{\|}}{C}-O$	5.6×10^{-10}
NH_4^+	5.6×10^{-10}	NH_3	? (1.78×10^{-5})
HCO_3^-	? (5.55×10^{-11})	CO_3	1.8×10^{-4}

$\rightarrow Ka \cdot Kb = 1 \times 10^{-14}$

$6.8 \times 10^{-4} \, Kb = 1 \times 10^{-14}$

$\boxed{K_b = 1.5 \times 10^{-11}}$ //

*** Acid-base properties of Salt solution ***

(1) Salt from strong base and strong acid...

Ex: NaCl → NaOH, Hcl — pH = 7

$Ca(NO_3)_2$ → $Ca(OH)_2$, HNO_3

(2) Salt from strong base and weak acid...

NaClO → NaOH, HClO

$Ba(CH_3-\overset{\overset{O}{\|}}{C}-O^-)$ → $Ba(OH)_2$, $CH_3-\overset{\overset{O}{\|}}{C}-OH$

(3) Salt from weak base and strong acid

NH_4Cl → NH_4OH, Hcl

NH_3 in H_2O — pH < 7

$Al(NO_3)_3$ → $Al(OH)_3$, HNO_3 — pH < 7

④ Salt from weak acid weak base...

K_b

$NH_4(CH_3-\overset{O}{\overset{\|}{C}}-O)$

NH_4CN

$FeCO_3$

* $K_a > K_b$ Acid pH < 7
* $K_b > K_a$ base pH > 7

(pOH)

* Ex: calculate pH of 0.3 M solution of NH_4Cl (K_b of $NH_3 = 1.8*10^{-5}$)

a) 0.7

b) 11.67

c) 4.89

d) 8.49

e) 3.33

NH_4Cl → NH_3 + HCl

solution: $NH_4Cl \rightarrow NH_4OH + H^+$

	0.3	0	0
	−x	+x	+x
	0.3−x	x	x

* $K_b = 1.8*10^{-5}$

$K_a = \frac{1*10^{-14}}{1.8*10^{-5}} = 5.6*10^{-10}$

$5.6*10^{-10} = \frac{[x]^2}{0.3-x}$

$[H^+] - x = 1.3*10^{-5}$

* $pH = -\log(1.3*10^{-5}) = 4.88$

Chapter (7)

(الكيمياء الحرارية)

Thermochemistry

→ The Relationship between chemical Reaction and energy.

→ unite of energy is Joule = J

1 cal = 4.184 J

*Ex: 23 cal in J ???

- Solution: 1 cal → 4.184 J
23 cal → ???
⟹ 23 * 4.184 = **96.232 J**

*** System and surrounding ***

System (النظام) — Surrounding (المحيط)

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)} + Heat$

← ماهو داخل الوعاء (System)

→ الوعاء نفسه وما يحيط به (Surrounding)

*** Internal energy is ***

→ $\Delta E = E_{final} - E_{initial}$

$\Delta E = q + w$ (q: heat, w: work)

→ $\Delta E = (-)$ ⟶ Exothermic طارد

$\Delta E = (+)$ ⟶ Endothermic ماص

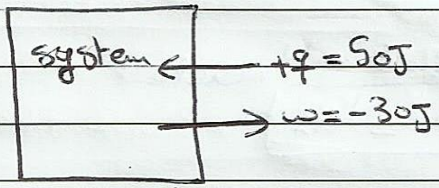
→

System ← (+q) heat, ← (+w) work	$\Delta E = q + w = (+)$
System → (−q) heat, → (−w) work	$\Delta E = -q + -w = (-)$

* Ex: system absorb 50J as heat and does 30J as work?

ΔE → a) -20J
b) +20J
c) 80J
d) -80J

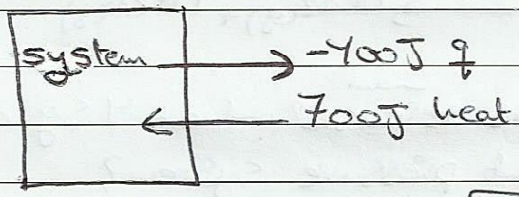
- Solution:



$\Delta E = 50 - 30 = \boxed{20J}$ #

* Ex: In particular processes, the surrounding perform 700J of work upon the system, while the system evolves 400J of heat to the surrounding, ΔE (internal energy change)???

- Solution:



$\Delta E = 700 - 400 = \boxed{300J}$ #

*** ΔE → (q, w) نظام مغلق
ΔH → q (نظام مفتوح)

*** ΔH (enthalpy): the amount of the heat absorbed or released by a system at constant pressure 760 mm Hg.

* $\Delta H = H_{final} - H_{initial}$
ΔH = (-) exothermic Reaction
ΔH = (+) endothermic Reaction

Enthalpy of Reaction

→ $2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(L)}$

$\Delta H = H_{product} - H_{Reactant}$

$\Delta H = -483.6\ Kg$

(لأنه تفاعل احتراق)

(- تزداد الحرارة مع ازدياد كمية المادة...)

Some propertion for enthalpy

① enthalpy is extensive propertien.

$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$ $(\Delta H = -802\ KJ)$

2X $2CH_{4(g)} + 4O_{2(g)} \longrightarrow 2CO_{2(g)} + 4H_2O_{(g)}$ $(\Delta H = -1604\ KJ)$

Ex: How much heat is released (انبعث) when 4.5g of CH_4 is burned in constant pressure system?

$(CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)})$ $(\Delta H = -802\ KJ)$

solution: $4.5g\ CH_4 = \frac{1 mol\ CH_4}{16g\ CH_4} = \frac{-802\ KJ}{1 mol\ CH_4}$

$-226\ KJ$ #

② (- إذا عكسنا التفاعل نعكس اشارة ΔH)

→ $CO_{2(g)} + 2H_2O_{(g)} \longrightarrow CH_{4(g)} + 2O_{2(g)}$ $(\Delta H = 802\ KJ)$

③ (إذا جمعنا معادلتين أو أكثر نجمع ΔH)

$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$ $(\Delta H = -802\ KJ)$

(+)

$2H_2O_{(g)} \longrightarrow 2H_2O_{(L)}$ $(\Delta H = -88\ KJ)$

$CH_{4(g)} + 2O_2 \longrightarrow CO_{2(g)} + 2H_2O_{(L)}$ $(\Delta H = -890\ KJ)$

نجمع ΔH

* Instrument used to calculate ΔH
  → calorimeter

* heat capacity and specific heat
  السعة الحرارية والحرارة النوعية

* heat capacity: the amount of heat required to an object to rais its temperature 1°c or 1K...
  * كمية الحرارة التي يكتسبها الجسم لترفع درجة حرارته درجة سيليزية واحدة أو درجة كلفن واحدة..

* specific heat: the amount of heat required to an (1g) object to rais its temperature 1°c or 1K...

* molar heat capacity: the amount of heat required to an (1 mole) object to rais its temperature 1°c or 1K...

⇒ specific heat = $\frac{q}{m \times \Delta t} = \frac{J}{g \times C^{\circ}_{sp}(K)}$
كمية الحرارة ÷ الكتلة × التغير في درجة الحرارة

* Ex: Calculate the specific heat of water if 209 J is required to increase the temperature of 50g of water by 1K?

- Solution: specific heat = $\frac{q}{m \times \Delta t} = \frac{209\ J}{50g \times 1} = \boxed{4.18\ \frac{J}{g.K}}$ #

Ex: (a) How much heat is needed to warm 250 g of H_2O from 22°C to its boiling point (98°C)???

(b) what is molar heat capacity of H_2O? (ﷺ)

- solution: (a) q = specific heat capacity * m * Δt

$= 4.18 * 250 * 76K = \boxed{7.9 \times 10^4 J}$ #

تحفظ للماء

(b) $\frac{4.18 J}{g.K} \times \frac{18 g}{1 mol} = \boxed{75.2 J/mol.K}$ #

(H.w) The specific heat of iron is $0.452 \frac{J}{g.C°}$ if 240 J of heat is added to 7.05 g piece of iron at 25°C, what would be the final temperature.

a) 100°C (circled)
b) 75°C
c) -100°C
d) -75°C

- solution: specific heat $= \frac{q}{m \times (T_f - T_i)}$

$0.452 = \frac{240}{7.05 (T_f - 25)}$

$\boxed{T_f = 100°C}$

مبادئ علمك ..

*** Calorimetry ***

(الحرارة الممتصة للماء) $q_{H_2O} = q_{rxn}$ (الحرارة الخارجة للتفاعل)

$$\Delta H_{H_2O} = \Delta H_{rxn}$$

$$\text{specific heat } H_2O \times m \times \Delta T = \Delta H_{rxn}$$

$$4.18 \frac{J}{g \cdot C^\circ} \times 100g \times (40-25)C^\circ = \Delta H_{rxn}$$

$$\boxed{6270\,J = \Delta H_{rxn}}$$

قانون هس (مهم)

*** Hess's law ***

*Ex: Using the information below

① $MnO_{2(s)} \longrightarrow MnO_{(s)} + \frac{1}{2}O_{2(g)}$ $\Delta H_1 = 136\ KJ$

② $MnO_{2(s)} + Mn_{(s)} \longrightarrow 2MnO_{(s)}$ $\Delta H_2 = -249\ KJ$

نبقي لانه موقع الـ Mn نفسه بدون تغيير

calculate ΔH_3 for: $Mn_{(s)} + O_{2(g)} \longrightarrow MnO_{2(s)}$ $(\Delta H_3 = ???)$

- Solution:

لـ O_2 موجود متفرق في التفاعلات وفي المعادلة الأولى في النواتج فالمعادلة نقلبها ونضربها بـ (2) ...

① $2MnO_{(s)} + O_{2(g)} \longrightarrow 2MnO_{2(s)}$ $(\Delta H_1 = -272\ KJ)$

+

② $MnO_{2(s)} + Mn_{(s)} \longrightarrow 2MnO_{(s)}$ $(\Delta H_2 = -249\ KJ)$

ينتج المعادلة المطلوبة ... ← $Mn_{(s)} + O_{2(g)} \longrightarrow MnO_{2(s)}$ $(\Delta H_3 = -272 - 249\ KJ)$

$(\Delta H_3 = -521\ KJ)$ #

* **Ex:** Using the information given below:

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$ ($\Delta H_1 = -26\ KJ$)

$3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$ ($\Delta H_2 = -59\ KJ$)

(لازم نتخلص منه) $Fe_3O_4 + CO \longrightarrow 3FeO + CO_2$ ($\Delta H_3 = 38\ KJ$)

calculate ΔH_4 for the Rxn???

$FeO + CO \longrightarrow Fe + CO_2$

- Solution: * بنتخلص من الأشياء الإضافية مثل ال (Fe_2O_3)...

ونعكس $(2X)\ Fe_3O_4 + CO \longrightarrow 3FeO + CO_2$ ($\Delta H_3 = 38\ KJ$)

$(3X)\ Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$ ($\Delta H_1 = -26\ KJ$) (+)

نعكس $3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$ ($\Delta H_2 = -59\ KJ$)

$\frac{6}{6} FeO + \frac{6}{6} CO \longrightarrow \frac{6}{6} Fe + \frac{6}{6} CO_2$ $\boxed{\left(\frac{\Delta H}{6}\right) = -15.8\ KJ}$

(حل آخر) $3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$ ($\Delta H = -59\ KJ$)

(+) $2Fe_3O_4 + 2CO \longrightarrow 6FeO + 2CO_2$ ($\Delta H = 76\ KJ$)

$3Fe_2O_3 + 3CO \longrightarrow 6FeO + 3CO_2$ ($\Delta H = 17$)

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$ ($\Delta H = -26$)

(+) $3Fe_2O_3 + 3CO \longrightarrow 6FeO + 3CO_2$ ($\Delta H = 17$)

$9CO_2 + 6Fe \longrightarrow 9CO + 3Fe_2O_3$ ($\Delta H = 78$)

$6CO_2 + 6Fe \longrightarrow 6CO + 6FeO$ ($\Delta H = 95$)

$CO_2 + Fe \longrightarrow CO + FeO$ ($\Delta H = 15.8$)

$CO + FeO \longrightarrow Fe + CO_2$ ($\Delta H = -15.8$)

//

$\rightarrow \Delta H_{rxn} = \Delta H_{product} - \Delta H_{reaction}$

Standard enthalpy of Rxn

$$\Delta H^\circ = \sum n \Delta H_f^\circ (product) - \sum m \Delta H_f^\circ (Reaction)$$

(ملاحظات مهمة) → ① enthalpy of any element (الاساسية) in the standard state is (zero)...

$\boxed{\Delta H_f^\circ = 0} \rightarrow Al_{(s)}, Mn_{(s)}, N_{2(g)}, Fe_{(s)}, O_{2(g)}, H_{2(g)}$ ......

② ΔH° = rxn at constant pressure and 25°C 1 atm.

ΔH = rxn at 1 atm

$$* \Delta H_f \Rightarrow H_2 + \frac{1}{2} O_2 \longrightarrow H_2O_{(l)}$$

$$\Delta H_f = H^\circ_{H_2O} - (H^\circ_{H_2} + \frac{1}{2} H^\circ_{O_2})$$

(zero)

$$\boxed{\Delta H_f = H^\circ_{H_2O_{(l)}}}$$

Ex: ΔH° for combustion of $C_6H_{12}O_6$ (glucose) is -2816 KJ. what is ΔH_f° for glucose?

$$C_6H_{12}O_{6(s)} + 6O_{2(g)} \longrightarrow 6CO_{2(g)} + 6H_2O_{(l)} \quad (\Delta H = -2816 KJ)$$

???

- Solution: $\Delta H_f^\circ = \Delta H^\circ_{f\,product} - \Delta H^\circ_{f\,reactant}$

	ΔH
CO_2	-393.5
H_2O	-285.8
O_2	0
$C_6H_{12}O_6$	???

$-2816 KJ = (6 * -285.8 + 6 * -393.5) - (X)$

$-2816 KJ = -4075.8 KJ - X$

$$\boxed{X = -1259.8 KJ}$$

Ex8: what is ΔH° for combustion of C_4H_{10}

$$C_4H_{10(g)} + 6\tfrac{1}{2}O_2 \rightarrow 5H_2O_{(L)} + 4CO_{2(g)}$$

-124.73 ∴ -285.83 -393.5

-Solution: $((4*-393.5)+(5*-285.83))-(-124.73) = \Delta H^\circ$

$\boxed{\Delta H^\circ = -2878.72}$ #

* entropy, Free energy and equilibrium *

- Thermodynamics : study of energy and its transformations.
- Spontaneous change (التغير التلقائي) : change takes places without outside assistance.

(هو التغير الذي يحدث دون مساعدة خارجية)

$Mg_{(s)} + HCl_{(aq)} \longrightarrow MgCl_2 + H_2 \uparrow$ $(\Delta H = (-))$...

- entropy (العشوائية) : It is measure of randomness...
(مقياس للعشوائية) ↳ (ΔS)

* $H_2O_{(s)} \xrightarrow{heat} H_2O_{(g)}$

$\Delta S = S_{final} - S_{initial}$
(اكبر) (اقل)
للغازات

$\boxed{\Delta S = (+)}$ #

* Ex : * predict wether ΔS is (+ve) or (-ve).

1. $Ag^+_{(aq)} + Cl^-_{(aq)} \longrightarrow AgCl_{(s)}$ $\Delta S = $ (كبير - قليل) $= \boxed{-ve}$
2. $4Fe_{(s)} + 3O_{2(g)} \longrightarrow 2Fe_2O_{3(s)}$ $\Delta S = \boxed{-ve}$
3. (حسب عدد المولات) $N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$ $\Delta S = \boxed{-ve}$
4. (حسب عدد المولات) $N_{2(g)} + O_{2(g)} \longrightarrow 2NO_{(g)}$ $\Delta S \simeq \boxed{zero}$

* Ex : * Calculate of entropy change $\boxed{\Delta S^\circ}$ ⟶ (قانون)

$$\Delta S^\circ = \Sigma n S^\circ(product) - \Sigma m S^\circ(Reactant)$$

calculate ΔS° for the synthesis ammonia from $N_{2(g)}$ and $H_{2(g)}$

$N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$

S°	191.5 $\frac{J}{mol.K}$	130.6		192.5 $\frac{J}{mol.K}$

- solution : $\Delta S^\circ = [2mol \times 192.5] - [3 \times 130.6 + 1mol \times 191.5]$

$\boxed{\Delta S^\circ = -198.3 \frac{J}{K}}$ #

- free energy & useful work (ΔG)

$$* \ \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

(ΔG° → J, ΔH° → J, T → K, ΔS° → $\frac{J}{K}$)

ΔH	ΔS	changes	$\Delta G = \Delta H - T\Delta S$
(−)	(+)	spont. rxn	$\Delta G = (-)$
(+)	(−)	non spont. rxn	$\Delta G = (+)$
(+)	(+)	if (T) is very high	$\Delta G = (-)$
(−)	(−)	if (T) is very low	$\Delta G = (-)$

note ΔH element form = zero
ΔG element form = zero
ΔS element form X zero
[illegible] ...

* Ex: standard free energy change ΔG°

$$\Delta G^\circ = \Sigma n G^\circ product - \Sigma m G^\circ reactant$$

calculate ΔG° (standard free energy change) for

① $N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$

إذا انعكس تنعكس الإشارة
وبالعكس spont ...

ΔG°	0	0	−16.66 KJ/mol

$\Delta G^\circ = (2mol * -16.66 \frac{KJ}{mol}) - 0$

spont [illegible] $\boxed{\Delta G^\circ = -33.32 \ KJ}$

② $2NH_{3(g)} \longrightarrow 3H_{2(g)} + N_{2(g)}$

$\boxed{\Delta G^\circ = 33.32 \ KJ}$

(non spont) [illegible]

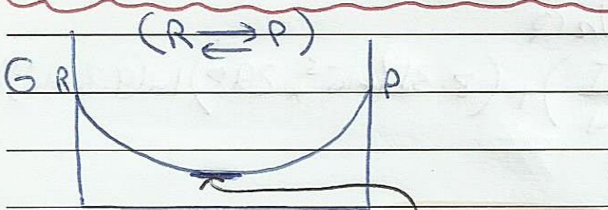
Ex8 $H_2O_{(s)} \longrightarrow H_2O_{(g)}$ $T = 100 + 273 = 373$

(لأنها لا تكون سالبة)

	ΔG	ΔH	ΔS
a)	+	+	−
b)	+	+	+
(c)	−	+	+
d)	+	−	−
e)	−	−	+

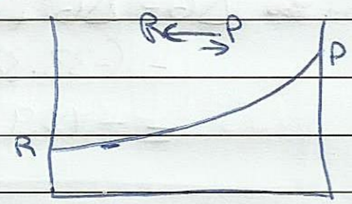
* عندما يتحول من ال (S) الى (g) فان ΔH موجبة لأن ال q موجبة وعندما يتحول من ال (L) الى (g) تكون ΔH سالبة لأن q سالبة.

Free energy and equilibrium



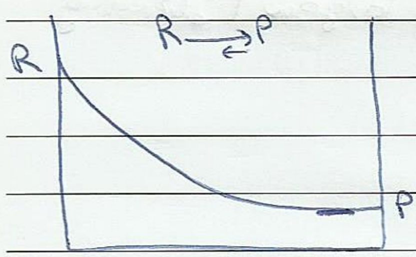
$\Delta G = G_P - G_R$

$G = zero$



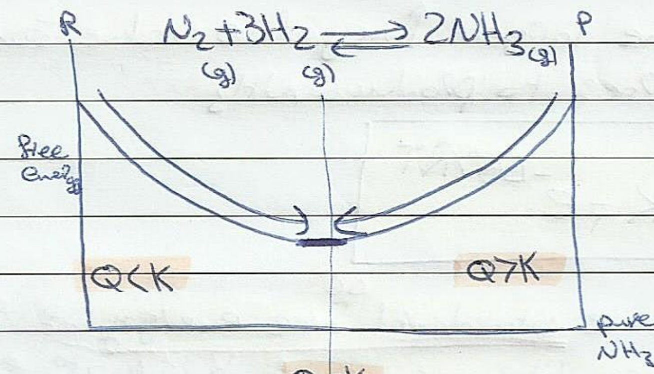
$\Delta G = G_P - G_R$

$\Delta G = +ve$



$\Delta G = G_P - G_R$ (كبيرة صغيرة)

$\Delta G = -ve$



$Q = K$

$\Delta G = 0$

(عند الاتزان)

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

$R = 8.314 \frac{J}{mol.K}$

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

(لأنه ΔG صفر وال Q=K)

$\Delta G = \Delta G^\circ$ عند الاتزان

$K = 1 \Rightarrow M = 1\,M$

$P = 1\,atm$

Ex Calculate ΔG at 298K for a Rxn that consist of 0.1 atm N_2, 3.0 atm H_2, 0.5 atm NH_3

$$N_{2(g)} + 3H_{2(g)} \rightleftarrows 2NH_{3(g)}$$

(volume)

- Solution: $\Delta G = \Delta G^\circ + RT \ln Q$

$$= (-33.32\ KJ) + (8.314 * 10^{-3} * 298) \ln(9.3 * 10^{-3})$$

$$= -44.9\ \frac{KJ}{mol}$$

$$Q = \frac{P^2_{NH_3}}{P_{N_2} * P^3_{H_2}} = \frac{(0.5)^2}{(1)(3)^3} = \boxed{9.3 \times 10^{-3}}$$

⇒ The larger ↑ negative value for ΔG larger ↑ driving forces to produces NH_3

⇒ $\boxed{K = e^{-\Delta G^\circ / RT}}$

Ex use standard (ΔG°) free energy of formations to calculate equilibrium constant K_p at 25°c for the Rxn

$$N_{2(g)} + 3H_{2(g)} \rightleftarrows 2NH_{3(g)}$$

$$K_p = e^{(33.32) * 10^3 / (8.314 * (25 + 273))}$$

$$\boxed{K_p = e^{13.4} = 7 * 10^5} \#$$

(page)

Ex: For the Rxn $2NO_2 \rightleftharpoons N_2O_4$

$\Delta H^\circ = 56.9$ KJ

$\Delta S^\circ = -175$ J/K

Calculate K_p at 100°c ???

-Solution:

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

$= 56.9 - (100+273) * -175 * 10^{-3}$

$= 122.2$ KJ

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

$K = e^{-122.2 * 10^3 / 8.314 * 373}$

$K = 7.8 * 10^{-18}$ #

Ex: one mole of $A_{(g)}$ and one mole of $B_{(g)}$ are placed in 1L flask and heat 400K. The Rxn $A_{(g)} + B_{(g)} \rightleftharpoons C_{(g)}$ is found to occure (حدث تفاعل وليس تسبب). At equilibrium, 0.78 mol of $C_{(g)}$ are present, what is ΔG° (Standard free energy change) for this Rxn.

a) -9.2 KJ/mol

b) -6.7 KJ/mol

c) -0.38 KJ/mol

d) +0.84 KJ/mol

-Solution:

	$A_{(g)}$	+ $B_{(g)}$	$\rightleftharpoons C_{(g)}$
	1M	1M	0
	-x	-x	+x
	(1-x)	(1-x)	x = 0.78 M
	0.22	0.22	0.78

$K = \frac{[C]}{[A][B]} = \frac{0.78}{(0.22)^2} = 16.12$

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

$= -8.314 * 400 * \ln(16.12)$

$= -9.2 * 10^3$ J

$= -9.2 \frac{KJ}{mol}$

* Ex: In the following Rxn at 298K and 1atm

$2SO_{2(g)} + O_{2(g)} \longrightarrow 2SO_{3(g)}$ $\quad \Delta H^\circ = -198\ KJ$

If $\Delta G^\circ = -140\ KJ$

$\Delta S = ??$

a) $-195\ \frac{J}{K}$ b) $-0.195\ J/K$ c) $0.149\ \frac{J}{K}$ d) $58\ KJ$

- solution: $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

$-140\ KJ = -198\ KJ - 298K * \Delta S^\circ$

$\Delta S^\circ = -0.195\ \frac{KJ}{K}$

$\boxed{\Delta S^\circ = -195\ \frac{J}{K}}$ #

* Electrochemistry *

* chapter (9) *

* **Galvanic cell**: Generation of an electric current from spontaneous chemical Rxn...

* **electrolysis**: Generation of an chemical Rxn from electric current...

[1] Galvanic Cell.

\- Redox : اختزال Reduction : gain of e^- Ex $\rightarrow Cu^{2+} + 2e^- \rightarrow Cu_{(s)}$

(م زيادة عدد الأكسدة)

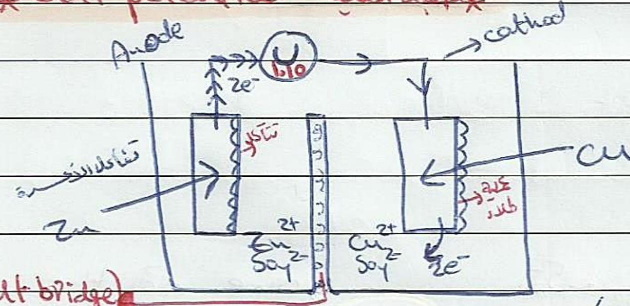
أكسدة Oxidation : loss of e^- Ex $\rightarrow Zn_{(s)} \rightarrow Zn^{2+} + 2e^-$

(م نقصان عدد الأكسدة)

$$Zn_{(s)} + Cu^{2+} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$$

(Redox Rxn)

** Cell potential جهد الخلية *



(salt bridge)

$Zn_{(s)} \rightarrow Zn^{2+} + 2e^-$ $(E^\circ = 0.76V)$

$Cu^{2+} + 2e^- \rightarrow Cu_{(s)}$ $(E^\circ = 0.34V)$

(+) → 1.10V ← قراءة الفولتميتر

(oxidizing agent) عامل مؤكسد

(Reducing agent)

(جهد الخلية)

* **cell potential**: The "Pull" of electron by oxidizing agent through a wire from reducing agent.

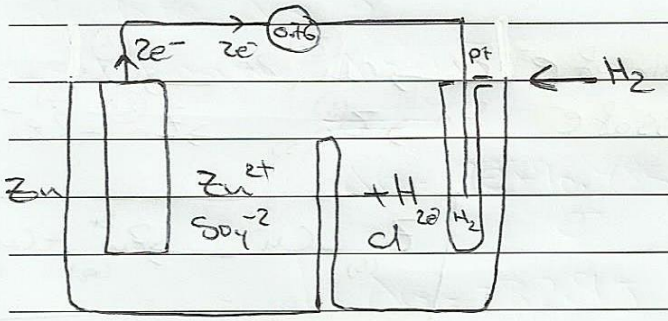
$$E_{cell} \left(unit = \underset{volt}{V} = \frac{J}{columb} \right)$$

Standard Reduction potential

$$*2H^+_{(aq)} + Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + H_{2(g)}$$

$Zn \longrightarrow Zn^{2+} + 2e^-$ $(E^\circ = (x = -0.76))$

$2H^+_{(s)} + 2e^- \longrightarrow H_{2(g)}$ $(E = zero)$



$Zn + 2H^+ \longrightarrow Zn^{2+} + H_2$ $(E^\circ = 0.76)$

$\longrightarrow E^\circ$ @ Conc = 1M = 1 atm
temperature = 25°c

$*Zn^{2+} + 2e^- \longrightarrow Zn_{(s)}$ $(E^\circ = -0.76)$ ← الأصغر تكسية

$Cu^{2+} + 2e^- \longrightarrow Cu_{(s)}$ $(E^\circ = 0.34)$ ← الأكبر تكسية

Cu^{2+} (strong oxidizing agent) ← حسب قيمة (E°) الأكبر ...

- one of the following is strong oxidizing agent ???

*Ex@ calculate E°_{cell} for $Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$???

$Cu^{2+} + 2e^- \longrightarrow Cu$ $(E^\circ = 0.34)$

$Zn^{2+} + 2e^- \longrightarrow Zn$ $(E^\circ = -0.76)$

- Solution @ $Zn \longrightarrow Zn^{2+} + 2e^-$ $(E^\circ = 0.76)$ *إذا عكسنا التفاعل تعكس إشارة (E°) وإذا ضربنا أو قسمنا ما بتضرب ولا بتقسم الـ E°

$\oplus$ $Cu^{2+} + 2e^- \longrightarrow Cu$ $(E^\circ = 0.34)$

$Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu$ $(E^\circ = 1.10V)$

Ex: consider galvanis cell on redox Rxn.

$Fe^{3+}_{(aq)} + Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + Fe^{2+}_{(aq)}$

$Fe^{3+} + e^- \longrightarrow Fe^{2+}$ ($E^\circ = 0.77\,v$) (يبقى)

$Cu^{2+} + 2e^- \longrightarrow Cu$ ($E^\circ = 0.34\,v$) (نعكسها)

- Solution:

$2Fe^{3+} + 2e^- \longrightarrow 2Fe^{2+}$ ($E^\circ = 0.77$)

$Cu \longrightarrow Cu^{2+} + 2e^-$ ($E^\circ = -0.34$)

$2Fe^{3+} + Cu \longrightarrow Cu^{2+} + 2Fe^{2+}$ ($E^\circ = 0.43\,v$)

(+6) ([illegible]) (+6)

Ex: consider galvanis cell on redox Rxn.

$Al^{3+}_{(aq)} + Mg_{(s)} \longrightarrow Al_{(s)} + Mg^{2+}$

$Al^{3+} + 3e^- \longrightarrow Al_{(s)}$ ($E^\circ = -1.66\,v$) (يبقى)

$Mg^{2+} + 2e^- \longrightarrow Mg_{(s)}$ ($E^\circ = -2.37\,v$) (نعكسها)

Give the balanced cell rxn and calculate E°_{cell} for the Rxn?

- Solution:

$2/\ Al^{3+} + 3e^- \longrightarrow Al$ ($E^\circ = -1.66$)

$3/\ Mg \longrightarrow Mg^{2+} + 2e^-$ ($E^\circ = 2.37$)

$2Al^{3+}_{(aq)} + 6e^- \longrightarrow 2Al_{(s)}$ ($E^\circ = -1.66$)

$3Mg_{(s)} \longrightarrow 3Mg^{2+} + 6e^-$ ($E^\circ = 2.37$)

$2Al^{3+}_{(aq)} + 3Mg_{(s)} \longrightarrow 2Al_{(s)} + 3Mg^{2+}$ ($E^\circ = 0.71\,v$)

(+6) (+6)

Ex: $Zn / Zn^{2+} // H^+, H_2 / Pt$

$Zn \longrightarrow Zn^{2+} + 2e^-$

$2H^+ + 2e^- \longrightarrow H_2$

$Zn + 2H^+ \longrightarrow H_2 + Zn^{2+}$

* Nernst equation *

$$\Delta G^\circ = -nFE^\circ$$

n → mole of e^-; F → $\frac{96.485\,C}{mol\ of\ e^-}$; E → $\frac{J}{C}$

Ex: $2Fe^{3+} + Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + 2Fe^{2+}_{(aq)}$ ($E^\circ = 0.43\ \frac{J}{C}$)

$Fe^{3+} + e^- \longrightarrow Fe^{2+}$ ($E^\circ = 0.77$)

$Cu^{2+} + 2e^- \longrightarrow Cu$ ($E^\circ = 0.34$)

calculate ΔG°???

- solution: $\Delta G^\circ = (n)FE^\circ$

اللي بتنتقل

$$\Delta G^\circ = 2e \times \frac{96.485}{e^-} \times 0.43$$

$$\boxed{\Delta G^\circ = -829\,J}$$ #

$$\boxed{E = E^\circ - \frac{0.0591}{n} \log Q}$$ (مهم)

Ex: calculate E at concentration 3M Cu and 2M Zn???

$Zn_{(s)} + Cu^{2+}_{(aq)}\,(3M) \longrightarrow Cu_{(s)} + Zn^{2+}_{(aq)}\,(2M)$ ($E^\circ = 1.1$)

- Solution: $E = E^\circ - \frac{0.0591}{n} \log Q$

$$E = 1.1 - \frac{0.0591}{2} \log \frac{2}{3}$$

$\boxed{E = 1.015}$

Ex: $2Al_{(s)} + 3Mn^{2+}(0.5M) \longrightarrow 2Al^{3+}(1.5M) + 3Mn_{(s)}$ ($E^\circ = 0.48$)

calculate E ???

- Solution: $E = 0.48 - \frac{0.0591}{6} \log \frac{(1.5)^2}{(0.5)^3} = \boxed{0.470}$ #

* * * * * *

Eng. Hanan Farah