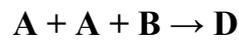
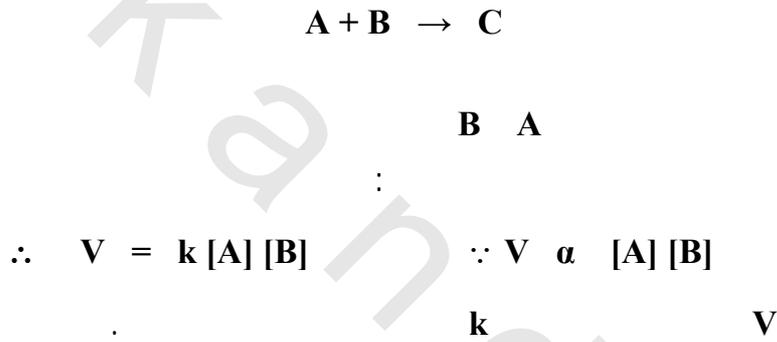


الباب الرابع عشر الاتزان الكيميائي

الباب الرابع عشر
الاتزان الكيميائي



$$V = k [A]^2 [B] \quad :$$

n A

:

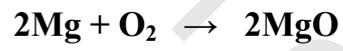
m B

$$V = k [A]^n [B]^m$$

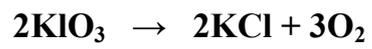
-k

التفاعلات العكسية والاتزان الكيميائي :

:

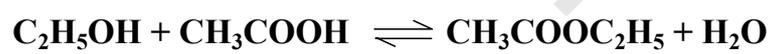
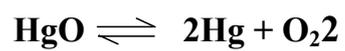


:



. Irreversible reactions

Reversible reactions

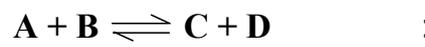


$\frac{2}{3}$ $\frac{2}{3}$

-

 $\frac{1}{3}$ $\frac{1}{3}$ $\frac{1}{3}$ $\frac{1}{3}$ $\frac{2}{3}$ $\frac{2}{3}$

تطبيق قانون فعل الكتلة على التفاعلات العكسية :



D, C

B, A

V₁

V₂

B, A

C, D

$$V_1 = k_1 [A] [B]$$

$$V_2 = k_2 [C] [D]$$

k₂ k₁

$$k_1 [A] [B] = k_2 [C] [D]$$

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

$$\frac{[C][D]}{[A][B]} = K \quad \frac{k_2}{k_1} = k$$

[D] [C] [B] [A]

K



$$\frac{[C]^p \cdot [D]^q}{[A]^m \cdot [B]^n} = K_C$$

" :

K

K

K

(10^6) K

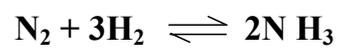
(10^{-6}) K

K

K_c

K_c

C



K_p

$$K_p = \frac{P^{2NH_3}}{P_{N_2} \cdot P^3_{H_2}} :$$

: K_p K_c bB aA $dD \quad cC$ $P^d_D \quad P^c_C \quad P^b_B \quad P^a_A$ 

:

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

$$= P \frac{n}{V} RT = CRT :$$

:

$$K_p = \frac{P^c_C \cdot P^d_D}{P^a_A \cdot P^b_B} \quad K_p = \frac{(C_c RT)^c (C_D RT)^d}{(C_A RT)^a (C_B RT)^b}$$

$$K_p = \frac{C^c_C \cdot C^d_D}{C^a_A \cdot C^b_B} \frac{(RT)^c \cdot (RT)^d}{(RT)^a (RT)^b} = K_c \cdot (RT)^{(c+d)-(a+b)}$$

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



$$K_c = K_p \quad n = 0$$

$$(\Delta n) \quad (c+d) > (a+b)$$

$$K_p > K_c$$

$$(\Delta n) \quad (a+b) > (c+d) \quad -$$

$$K_c > K_p$$

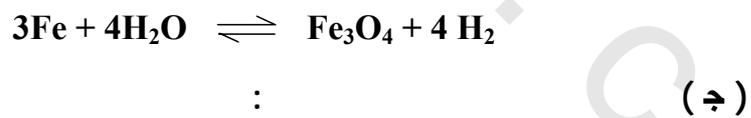
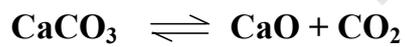
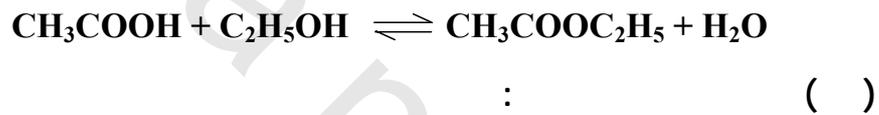
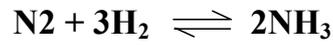
حالات الاتزان الكيميائي :

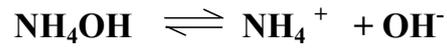
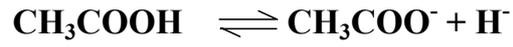
$$:$$

$$:$$

$$(\quad)$$

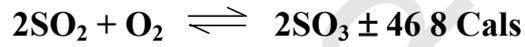
$$(\quad)$$





العوامل التي تؤثر على الاتزان الكيميائي (قاعدة لوتشاتيليه) :

1- تأثير درجة الحرارة :

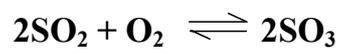


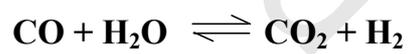
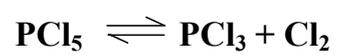
: ()



NO

2- تأثير الضغط :





تأثير التركيز :



) K

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

(

A

K

. K

B

A

B

D

C

. D C

D

C

. A

B

B

A

. D C

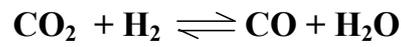
:

5

50%

K

:



X
X

X
X

V

:

$$[\text{CO}] = \frac{(1-X)}{V}$$

,

$$[\text{H}_2\text{O}] = \frac{(5-X)}{V}$$

$$[\text{CO}_2] = \frac{X}{V}$$

,

$$[\text{H}_2] = \frac{X}{V}$$

$$\frac{[\text{CO}_2][\text{H}_2]}{[\text{CO}][\text{H}_2\text{O}]} = K$$

,

$$\frac{\frac{X}{V} \times \frac{X}{V}}{\frac{(1-X)}{V} \times \frac{(5-X)}{V}} = 1$$

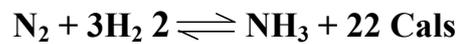
$$X^2 = 5 - 6X + X^2$$

$$\therefore X = \frac{5}{6} = 0.83 \text{ mole}$$

$$= \frac{0.83}{1} \times 100 = 83\%$$

تأثير العامل المساعد :

تطبيقات قاعدة لووشاتيليه :



Obeyikandi.com

:
:-1

°500 400

:
:-2

:
:-3

:
:-4

تطبيقات قاعدة لوشاتيليه على الاتزان الفيزيائي :

:

18

19.26

(°)

تطبيقات قاعدة لوتشاتيليه على الاتزان الكيميائي :

:

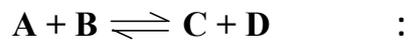
:



K_p

K_p

:



$$K_c = \frac{[C][D]}{[A][B]} \quad :$$

B A

B A

B A

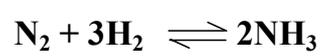
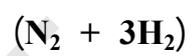
. K_c

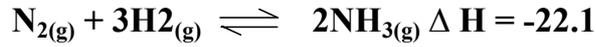
D C

B A

. B A

D C





: $T_2 \quad T_1$ K_2, K_1

$$\log K_2 = \log C - \frac{\Delta H}{2.303RT_2} \quad \dots (1)$$

$$\log K_1 = \log C - \frac{\Delta H}{2.303RT_1} \quad \dots (2)$$

: (1) (2)

$$\log K_2 - \log K_1 = -\frac{\Delta H}{2.303RT_2} + \frac{\Delta H}{2.303RT_1}$$

$$\log \left(\frac{K_2}{K_1} \right) = \frac{\Delta H}{2.303R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

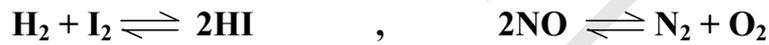
$$\log \left(\frac{K_2}{K_1} \right) = \frac{\Delta H}{2.303R} \left(\frac{T_2 - T_1}{T_2 \cdot T_1} \right)$$

تطبيقات قانون الاتزان ، وقاعدة لوشاتيليه :

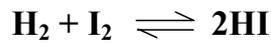
: :

: ()

:



$$K_p = K_c$$



a b o :

$$(a-x) (b-x) \quad 2x \quad :$$

$$(H_2) = \frac{a-x}{v} \quad (I_2) = \frac{b-x}{v} \quad (HI) = \frac{2x}{v} \quad (\quad / \quad)$$

(V)

$$K_c = \frac{(HI)(HI)}{(H_2)(I_2)} = \frac{\left(\frac{2x}{v}\right)^2}{\left(\frac{a-x}{v}\right)\left(\frac{b-x}{v}\right)} = \frac{\left(\frac{4x^2}{v^2}\right)}{\left(\frac{(a-x)(b-x)}{v^2}\right)} = \frac{4x^2}{(a-x)(b-x)}$$

V

. K_p

p

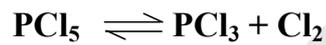
. $n = 0$

V

. $K_p = K_c :$

()

:



:

$K_p \quad K_c$

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

$\Delta n :$

1- 1-

R
T

: V

(⇌)



n 0 0 :

n(1-α) nα nα :

$$[\text{PCl}_5] = \frac{n(1-\alpha)}{V} \quad \text{PCl}_3 = \frac{\alpha-n}{V} \quad [\text{Cl}_2] = \frac{\alpha-n}{V}$$

:

$$\frac{n \alpha}{V} \quad \frac{n \alpha}{V}$$

$$K_c = \frac{(\text{PCl}_3)(\text{Cl}_2)}{(\text{PCl}_5)} = \frac{n(1-\alpha)}{V} = \frac{n\alpha^2}{(1-\alpha)V}$$

V

K_c

$$\left(\quad \right) \frac{\alpha^2}{1-\alpha} \quad \left(\quad \right)$$

. PCl₅

K_c

V

α

. PCl₅

دراسة تأثير الضغط على حالة الاتزان :

:

$$n_t = (n - n\alpha) + n\alpha + n\alpha = n(1 + \alpha)$$

$$\left(\frac{\text{عدد مولات المكونة}}{\text{عدد المولات الكلية}} \right) \times P =$$

$$\frac{1 - \alpha}{1 + \alpha} P =$$

$$\frac{\alpha}{1 + \alpha} P =$$

$$\frac{\alpha}{1 + \alpha} P =$$

:

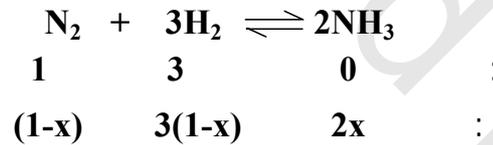
$$K_p = \frac{P_{\text{PCl}_3} P_{\text{PCl}_2}}{P_{\text{PCl}_5}} = \frac{\left(\frac{\alpha}{1 + \alpha}\right)P \left(\frac{\alpha}{1 + \alpha}\right)P}{\left(\frac{1 - \alpha}{1 + \alpha}\right)P} = \frac{\alpha^2}{1 - \alpha} P$$

$$K_p \quad (\alpha)$$

اتزان الأمونيا :

3

:



V =

$$[\text{N}_2] = \frac{1-x}{V} \quad [\text{H}_2] = \frac{3-3x}{V} \quad [\text{NH}_3] = \frac{2x}{V} :$$

: K_c

$$K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} = \frac{\left(\frac{2x}{V}\right)^2}{\left(\frac{1-x}{V}\right)\left(\frac{3-3x}{V}\right)^3} = \frac{4x^2V^2}{(1-x)(3-3x)^3} = \frac{4x^2V^2}{27(1-x)^4}$$

دراسة تأثير الضغط على التفاعل :

$$P =$$

$$(4-2x) = (1-x) + (3-3x) + 2x =$$

$$\frac{3-3x}{4-2x} \quad P = P_{\text{H}_2}$$

$$\frac{1-x}{4-2x} \quad P = P_{\text{N}_2}$$

$$\frac{2x}{4-2x} \quad P = P_{\text{NH}_3}$$

: K_p

$$K_p = \frac{P^2_{\text{NH}_3}}{P_{\text{N}_2} P^3_{\text{H}_2}} = \frac{\left[\left(\frac{2x}{4-2x}\right)P\right]^2}{\left(\frac{1-x}{4-2x}\right)P \left(\frac{3-3x}{4-2x}\right)^3 P^3} = \frac{4x^2(4-2x)^2}{27(1-x)^4 P^2}$$

)

x

(

$$K_p = \frac{64x^2}{27P^2}$$

$$x^2 = \frac{27}{64} K_p P^2$$

K_p

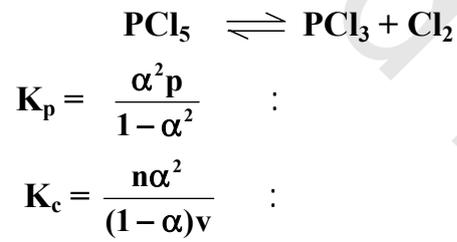
xap

500-400

تأثير إضافة غاز خامل على الاتزان :

$$\Delta n = 0$$

$$\Delta n \neq 0$$

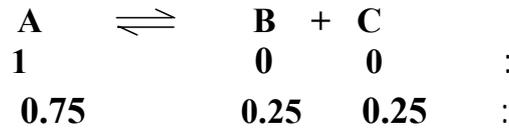


$$K_p$$

$$\%25 = (A)$$

$$0.5 =$$

:



$$1.25 = 0.75 + 0.25 + 0.25 =$$

$$P \frac{3}{5} = P \frac{0.75}{1.25} = P_A \quad (A)$$

$$P \frac{1}{5} = P \frac{0.25}{1.25} = P_B \quad (B)$$

$$P \frac{1}{5} = P \frac{0.25}{1.25} = P_C \quad (C)$$

:

$$K_p = \frac{P_B \cdot P_C}{P_A} = \frac{P \frac{1}{5} \times P \frac{1}{5}}{P \frac{3}{5}} = P \frac{1}{15}$$

$$K_p = \frac{1}{15}$$

$$1 = P$$

α

$$0.5 =$$

$$0.5 =$$

$$\cdot (1+\alpha) =$$

$$\cdot \left(\frac{1-\alpha}{1+\alpha} \right) \frac{1}{2} = P_A \quad (A)$$

$$\cdot \left(\frac{\alpha}{1+\alpha} \right) \frac{1}{2} = P_B \quad (B)$$

$$\cdot \left(\frac{\alpha}{1+\alpha} \right) \frac{1}{2} = P_C \quad (C)$$

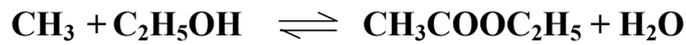
$$K_p = \frac{\left[\left(\frac{\alpha}{1+\alpha} \right) \left(\frac{1}{2} \right) \right]^2}{\frac{1-\alpha}{2(1+\alpha)}} = \frac{\frac{\alpha^2}{4(1+\alpha)^2}}{\frac{1-\alpha}{2(1+\alpha)}} = \frac{\alpha^2}{2(1+\alpha)(1-\alpha)} = \frac{1}{15}$$

$$\alpha = 0.343 :$$

$$0.343 \quad 0.25$$

الاتزان الكيميائي في المحاليل :

$$: \quad : \quad ()$$



$$\frac{a}{v} = 1 \quad \frac{b}{v} = 1$$

$$: (/)$$

$$0 \quad 0$$

$$: (/)$$

$$\frac{a-x}{v} = \frac{1}{3}$$

$$\frac{b-x}{v} = \frac{1}{3}$$

$$\frac{x}{v} = \frac{2}{3}$$

$$\frac{x}{v} = \frac{2}{3}$$

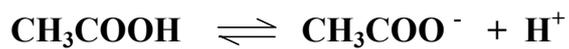
:

$$K_C = \frac{\left(\frac{x}{v}\right)^2}{\left(\frac{a-x}{v}\right)\left(\frac{b-x}{v}\right)} = \frac{x^2}{(a-x)(b-x)} = \frac{\left(\frac{2}{3}\right)^2}{\frac{1}{3} \times \frac{1}{3}} = 4$$

K_C

(n=0)

$$: \quad ()$$



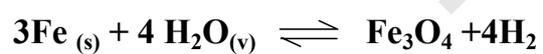
$$\frac{[\text{CH}_3\text{COO}^-][\text{H}^+]}{[\text{CH}_3\text{COOH}]} = K_C \quad :$$

(Ionization constant)

() ×

الاتزان غير المتجانس :

:- - - ()

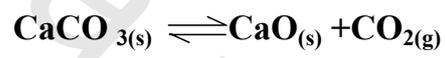


$$K_C = \frac{[\text{Fe}_3\text{O}_4]X[\text{H}_2]^4}{[\text{Fe}]^3[\text{H}_2\text{O}]^4}$$

$$K_C = \frac{[\text{H}_2]^4}{[\text{H}_2\text{O}]^4}$$

$$K_C = \frac{[\text{H}_2]}{[\text{H}_2\text{O}]}$$

()

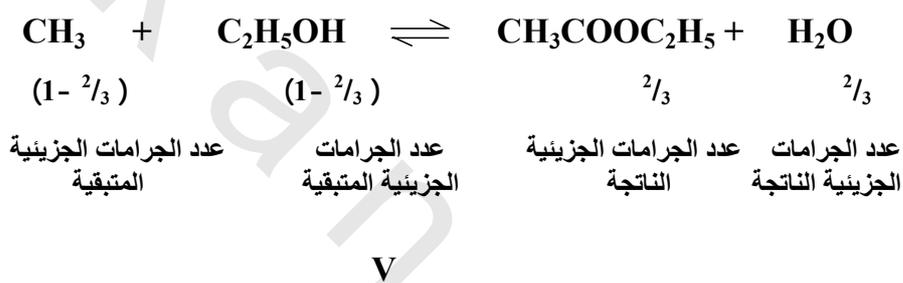
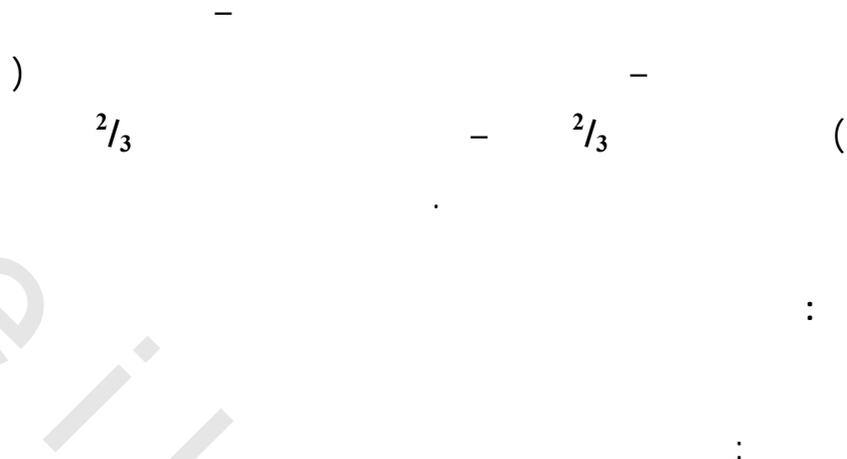


$$K_P = \frac{P_{\text{CaO}} P_{\text{CO}_2}}{P_{\text{CaCO}_3}}$$

* * *

" أمثلة محلولة "

: (1)



:

$$\begin{aligned} [\text{CH}_3\text{COOH}] &= (1 - \frac{2}{3})/V = (\frac{1}{3})/V & \text{M} \\ [\text{C}_2\text{H}_5\text{OH}] &= (1 - \frac{2}{3})/V = (\frac{1}{3})/V & \text{M} \\ [\text{CH}_3\text{COOC}_2\text{H}_5] &= (1 - \frac{2}{3})/V = (\frac{2}{3})/V & \text{M} \\ [\text{H}_2\text{O}] &= (\frac{2}{3})/V & \text{M} \end{aligned}$$

$$K = \frac{[\text{CH}_3\text{COOC}_2\text{H}_5][\text{H}_2\text{O}]}{[\text{CH}_3\text{COOH}][\text{C}_2\text{H}_5\text{OH}]} = \frac{(\frac{2}{3})/V \times (\frac{2}{3})/V}{(\frac{1}{3})/V \times (\frac{1}{3})/V} = 4$$

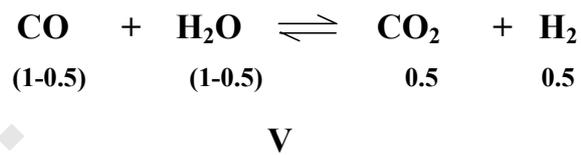
: (2)

() ° 850

0.5

0.5

:



:

$$[\text{CO}] = (1-0.5)/V = 0.5/V \quad \text{M}$$

$$[\text{H}_2\text{O}] = (1-0.5)/V = 0.5/V \quad \text{M}$$

$$[\text{CO}_2] = 0.5/V \quad \text{M}$$

$$[\text{H}_2] = 0.5/V \quad \text{M}$$

$$K = \frac{[\text{CO}_2][\text{H}_2]}{[\text{CO}][\text{H}_2\text{O}]} = \frac{0.5/V \times 0.5/V}{0.5/V \times 0.5/V} = 1$$

: (3)

- 0.05

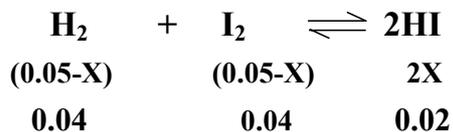
- 0.05

%20

()

:

:



x

%20

x

. 2x

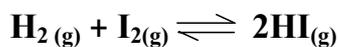
:

: (4)



721K

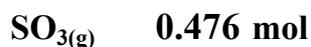
$$1.30 \times 10^{-3} \quad 1.84 \times 10^{-3}$$



:

$$K_C = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} = \frac{(1.3 \times 10^{-2})^2}{(1.84 \times 10^{-3})^2} \quad K_C = \frac{1.69 \times 10^{-4}}{3.38 \times 10^{-6}} = 50$$

: (5)



:

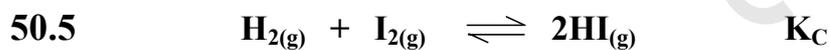
K_C 1105 K

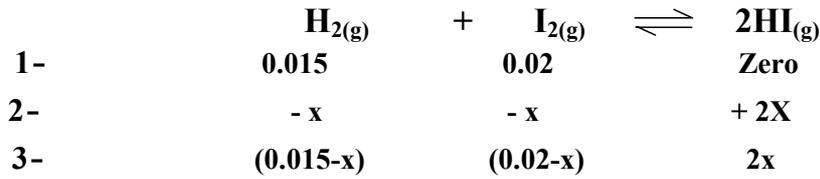
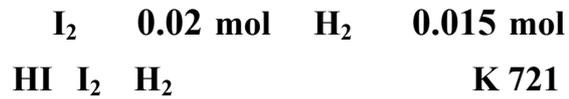


1-	0.476	Zero	Zero	
2-	-2 x	+ 2x	+ X	
3-	0.238	0.238	+ 0.119	

$$\frac{[\text{SO}_2]^2[\text{O}_2]}{[\text{SO}_3]^2} = \frac{(0.238)^2 \times 0.119}{(0.238)^2} = 0.119$$

: (6)





$$K_C = \frac{[\text{HI}]_2}{[\text{H}_2][\text{I}_2]} = 50.5 = \frac{(2x)^2}{(0.015-x)(0.02-x)}$$

$$50.5 = \frac{4x^2}{x^2 - 0.035x + 0.0003} \quad 46.5x^2 - 1.77x + 0.015 = 0$$

$$ax^2 + bx + c = 0$$

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

$$x = \frac{-(1.77) \pm \sqrt{(1.77)^2 - 4 \times 46.5 \times 0.015}}{2 \times 46.5}$$

$$x = 0.025 \quad \text{و} \quad 0.013$$



$$0.013$$

$$\text{مول/لتر} \quad [\text{H}_2] = 0.015 - x = 0.015 - 0.013 = 0.002 \quad \text{عند الاتزان}$$

$$[\text{H}_2] = 0.020 - x = 0.020 - 0.013 = 0.007 \quad \text{مول/لتر}$$

$$[\text{HI}] = 2x = 2 \times 0.013 = 0.026 \quad \text{مول/لتر}$$

: (7)



$$K_P \quad 1100 \text{ K} \quad / \quad 0.0271 \quad K_C$$

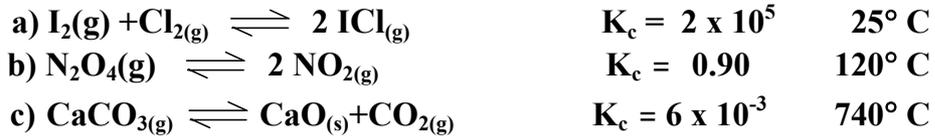
$$\Delta N = (n_p)_g - (n_r)_g = 3 - 2 = +1$$

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

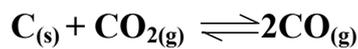
$$K_p = 0.0271 (0.082 \times 1100)^1 = 2.44$$

$$\Delta n \quad K_p > K_c$$

$$K_p$$



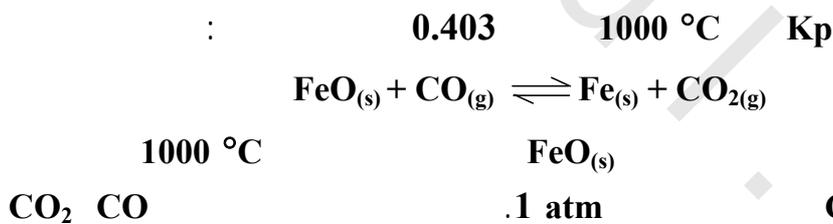
: (8)

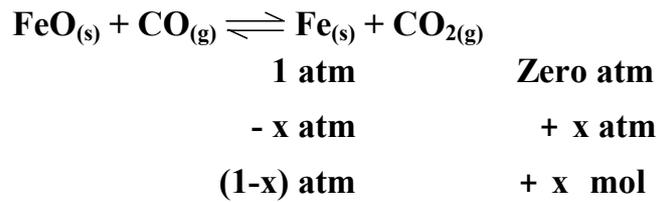


$$K_p = \frac{(P_{CO})^2}{P_{CO_2}} \quad 167.5 = \frac{(P_{CO})^2}{0.1} \quad (P_{CO})^2 = 16.75$$

$$P_{CO} = 4.10 \text{ atm}$$

: (9)





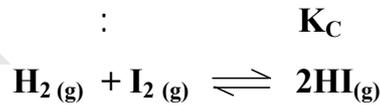
$$K_p = \frac{P_{\text{CO}_2}}{P_{\text{CO}}} \qquad 0.403 = \frac{x}{1-x}$$

$$X = 0.403 - 0.403x \quad 1.403x = 0.403 \quad x = \frac{0.403}{1.403} = 0.287 \text{ atm}$$

$$P_{\text{CO}_2} = x = 0.287 \text{ atm} \qquad \text{CO}_2$$

$$P_{\text{CO}} = 1-x = 1-0.287 = 0.713 \text{ atm} \qquad \text{CO}$$

: (10)



50.5

$$[\text{H}_2] = 0.015 \text{ M} \quad [\text{I}_2] = 0.0012 \text{ M} \quad [\text{HI}] = 0.025 \text{ M}$$

$$\frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} = \frac{0.025^2}{0.015 \times 0.0012} = 34.7 \qquad Q$$

(Q < K_c) K_c 34.7 Q

: (11)

$$36.9 \text{ L/mol} \qquad 827^\circ \text{ C} \qquad K_c$$

$$2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{SO}_{3(g)}$$

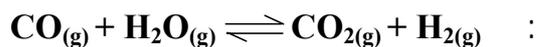
$\frac{0.05}{5}$	$\frac{0.3}{5}$	$\frac{0.125}{5}$	/
0.01	0.06	0.025	

$$Q = \frac{[\text{SO}_3]^2}{[\text{SO}_2][\text{O}_2]} = \frac{(0.025)^2}{(0.01)^2(0.06)} = 104.2 : Q$$

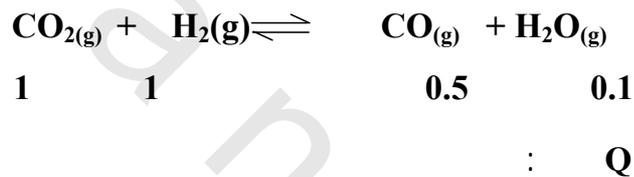
. $K_C = 36.9$ $Q = 104.2$:

. $Q > K_C$:

: (12)



1	$\cdot \text{H}_2$	0.1	CO_2	0.1	690 K	0.5	H_2O	1	CO	K_C
---	--------------------	-------	---------------	-------	-----------------	-------	----------------------	-----	-------------	-------



$$Q = \frac{[\text{CO}_2][\text{H}_2]}{[\text{CO}][\text{H}_2\text{O}]} = \frac{0.5 \times 0.1}{1 \times 1} = 0.5$$

$$Q = 0.05 \quad K_C = 0.1$$

$$Q < K_C$$

الأسئلة

-1

-2

-3

-4

-5

-6

-7

-8

-9

$n \neq 0$

()

$n = 0$

()

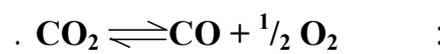
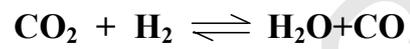
()

$K_C \quad K_P$

-10



-11

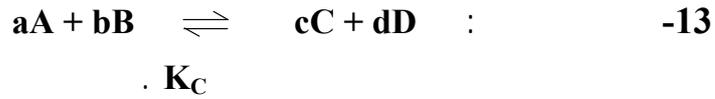


:

$K_C \quad K_P$

-12

- a) $\text{H}_2(\text{g}) + \text{C}_2\text{H}_4(\text{g}) \rightleftharpoons \text{C}_2\text{H}_6(\text{g})$
 b) $2\text{H}_2(\text{g}) + \text{C}_2\text{H}_2(\text{g}) \rightleftharpoons \text{C}_2\text{H}_6(\text{g})$
 c) $\text{NO}_2(\text{g}) + \text{SO}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g}) + \text{NO}(\text{g})$
 d) $3\text{O}_2(\text{g}) \rightleftharpoons 2\text{O}_3(\text{g})$



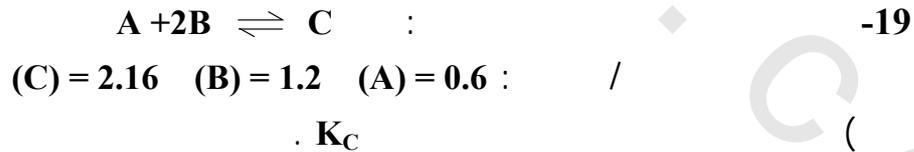
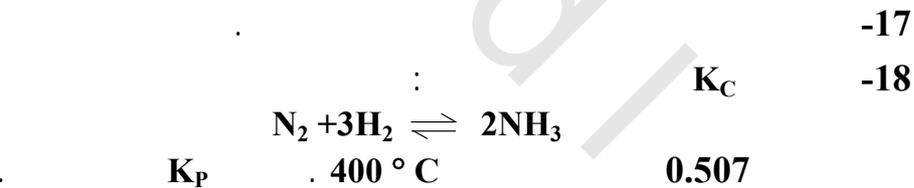
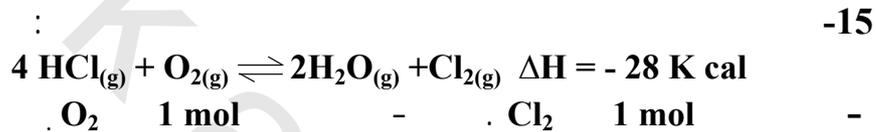
$$K_C = K_P \cdot (PV = nRT)$$

$$K_C = K_P \cdot \frac{P_{\text{total}}}{P_{\text{total}}}$$

$$K_C = K_P \cdot \frac{P_{\text{total}}}{P_{\text{total}}}$$

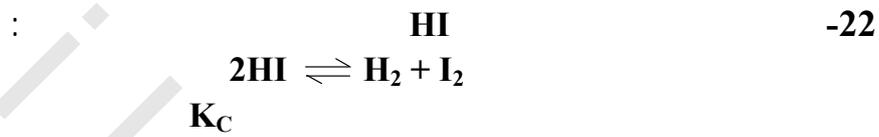
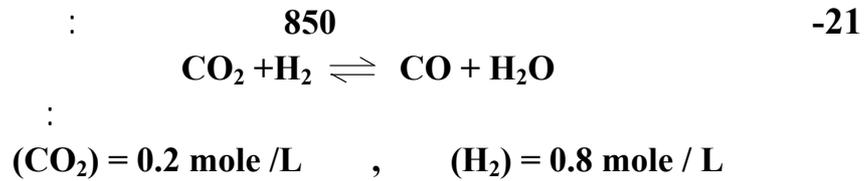
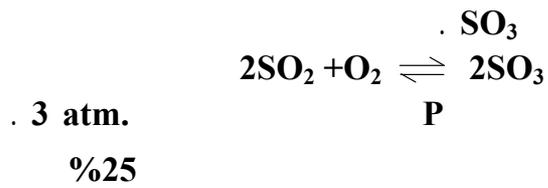
$$K_C = K_P \cdot \frac{P_{\text{total}}}{P_{\text{total}}}$$

- a- $\text{CuS}(\text{s}) + \text{H}_2(\text{g}) \rightleftharpoons \text{Cu}(\text{s}) + \text{H}_2\text{O}(\text{g})$
 b- $4\text{CuO}(\text{s}) \rightleftharpoons 2\text{Cu}_2\text{O}(\text{s}) + \text{O}_2(\text{g})$
 c- $\text{C}(\text{s}) + \text{S}_2(\text{g}) \rightleftharpoons \text{CS}_2(\text{g})$
 d- $\text{NH}_2\text{COONH}_4(\text{s}) \rightleftharpoons 2\text{NH}_3(\text{g}) + \text{CO}_2(\text{g})$
 e- $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s}) \rightleftharpoons \text{CuSO}_4(\text{s}) + 5\text{H}_2\text{O}(\text{g})$

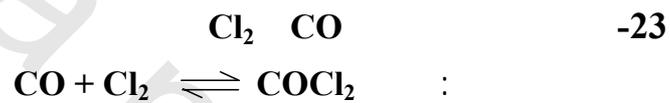


B A (

O₂ 4 mole SO₂ 8 mole -20

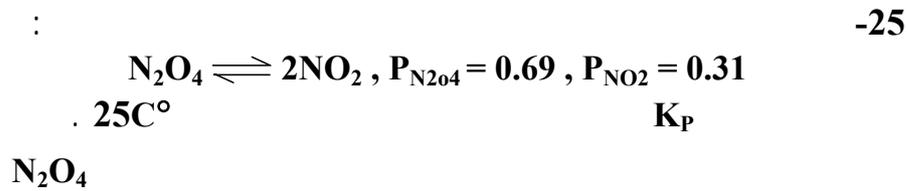


$$\frac{1}{64} =$$



-24

100°C



. 25°C 10 atm

400°C -26

PNI₃ = PN₂=6.74 atm , PH₂=20.23atm , :

. 3.03 atm

40 mm , 50 mm

1800 mm Hg

$$K_P = \frac{P^4\text{H}_2}{P^4\text{H}_2\text{O}} = \frac{(940)^4}{(50)^4} \qquad \frac{P^4\text{H}_2}{P^4\text{H}_2\text{O}} = \frac{(1800)^4}{P^4\text{H}_2\text{O}}$$

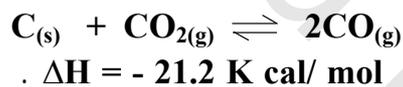
P_{H₂O} = 95.5 mm.

-27



-28

CO CO₂ -29



. CO

- . CO₂

- ->

CO (C)

