

MAINS+ADVANCED

TOPIC

CHEMICAL
EQUILIBRIUM

SOLUTIONS

CHEMICAL EQUILIBRIUM

Exercise-01

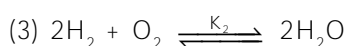
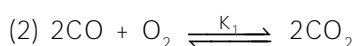
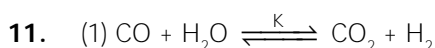
1. $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$
 $t = 0$ 1 mol
 $t = \infty$ 1-0.3 0.3 0.3
 Total moles at equilibrium (I kE; ij dty ekly) = 1.3

2. $K_c = \left[\frac{1}{1/8} \right]^2 = 64$

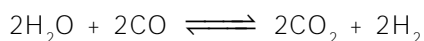
4. \therefore reaction is exothermic so an increasing temperature it shift to backward (vfhkfo; k m'ek{ki h gSvr%rki c<us ij ; g i'p fn'kk ea tk; xhA)

7. $K_p = \frac{P_{\text{CO}}^2}{P_{\text{CO}_2}} = \frac{8^2}{4} = 16$

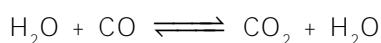
8. Greater value of K_c more is equilibrium favourable to products.
 (K_c dk vf/kd eku gks ij I kE; mRi kn dh vj gkskA)



By subtraction (2) - (3) we get :



Dividing by (2) ;



$$K = \left(\frac{K_1}{K_2} \right)^{1/2}$$

12. Changing concentration does not change K_c (I kE; ij dty ekly) K_c if joErr ugha gsk gS



$$t = 0 \quad 1\text{M}$$

$$t = \infty \quad 1-0.4 \quad 0.4 \quad 0.4$$

$$K_c = \frac{0.4 \times 0.4}{0.6} = 0.267$$

14. $\text{A}(\text{g}) + \text{B}(\text{g}) \rightleftharpoons 2\text{C}(\text{g})$

$$t = 0 \quad 3\text{M} \quad 1\text{M}$$

$$t = \infty \quad 3 - \frac{1}{3} \quad 1 - \frac{1}{3} \quad \frac{2}{3}$$

$$K_c = \frac{\left(\frac{2}{3}\right)^2}{\left(\frac{8}{3}\right)\left(\frac{2}{3}\right)} = \frac{1}{4}$$

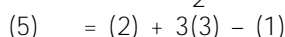
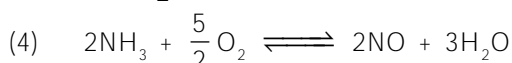
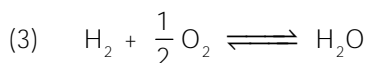
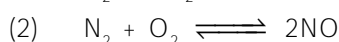
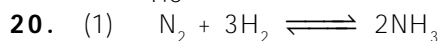
15. Pure solids of added do not change state of equilibrium.

(feyk; sx; sBk I kE; oLFk dks i fjoErr ugha d j rsg)

18. $\text{A} + \text{B} \rightleftharpoons \text{C} + \text{D}$
 $a \quad a$
 $a(1-\alpha) \quad a(1-\alpha) \quad a\alpha \quad a\alpha$

$$\frac{\alpha^2}{(1-\alpha)^2} = 9 \Rightarrow \alpha = 0.75$$

19. $K_c = \frac{1.5^2}{1.5^2} = 1$



$$\text{i.e. } K_4 = \frac{K_2 K_3^3}{K_1}$$

21. $\text{A} + \text{B} \rightleftharpoons \text{C} + \text{D}$

$$t = 0 \quad 3n \quad n \quad 0 \quad 0$$

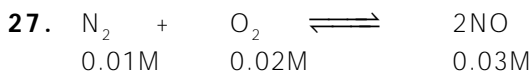
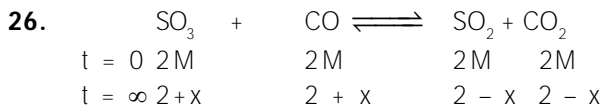
$$t = \infty \quad 3n-x \quad n-x \quad x \quad x$$

$$n-x = x \rightarrow x = \frac{n}{2} \quad \text{i.e. } [\text{D}]_{\text{eq.}} = \frac{n}{2}$$

22. $K_c = \frac{K_1}{K_2} = \frac{b+x}{\alpha-x}$

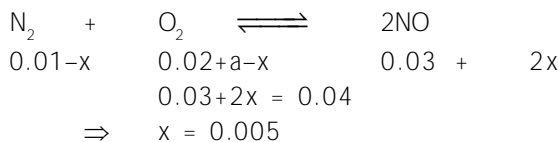
23. $K_p = K_c (\text{RT})^1 \quad K_c = \frac{0.03}{(0.0821 \times 700)^1}$

25. $K_c = \frac{0.33 \times 0.33}{0.67 \times 0.67} = \frac{1}{4}$



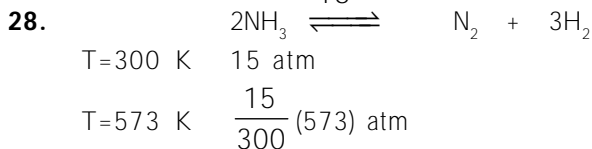
$$K_c = \frac{0.03^2}{0.01 \times 0.02} = 4.5$$

Let a moles of O₂ be added (ekuk O₂ ds a eky feyk; s x; s gš)

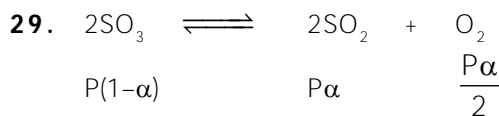


i.e.,
$$4.5 = \frac{(0.04)^2}{(0.015+a)(0.005)}$$

Moles of O₂ added = $a \times 100 = \frac{101}{18}$



$$\frac{15}{300} (573) [1 + \alpha] = 40.11 \Rightarrow \alpha = 0.4$$



$$P \left[1 + \frac{\alpha}{2} \right] = P_0$$

$$K_p = \frac{(P^2 \alpha^2) \left(P \frac{\alpha}{2} \right)}{P^2 (1-\alpha)^2} = \frac{P_0 \alpha^3}{(2+\alpha)(1-\alpha)^2}$$

32. By adding inert gas at constant pressure reaction shifts to increase number of gaseous molecules ∴ to left.

(fu; r nlc ij vfØ; xš feyklus ij vflkØ; k xš h; v.kq dh cMh gq h l ē; k dh vktj i frLFkfi r gksh gš)

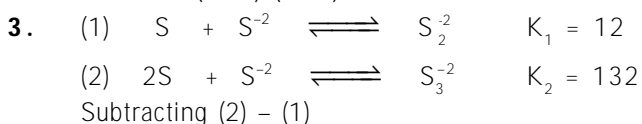
37. Slope of plot (xtQ dk <ky) = $\frac{-\Delta H^\circ}{2.303R} = 1$

$$\Rightarrow \Delta H^\circ = -2.303 \times 2 = 4.606 \text{ cal.}$$

Exercise-02

1. Greater value of K_c more is extent (K_c dk eku vf/kd rks ek=k vf/kd)
(I) K_c = 0.01, (II) K_c = 1, (III) K_c = 10⁴

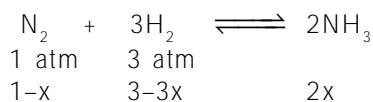
2.
$$K_c = 9 = \frac{(2/V)^2}{(2/V)^3(2/V)} ; V = 6\text{L}$$



$$\Rightarrow \text{S} + \text{S}_2^{-2} \rightleftharpoons \text{S}_3^{-2} \quad K_3 = \frac{132}{12} = 11$$

4.
$$K_p = K_c (0.0821 \times T)^1$$

$$T = \frac{1}{0.0821} = 12 - 19 \text{ K}$$

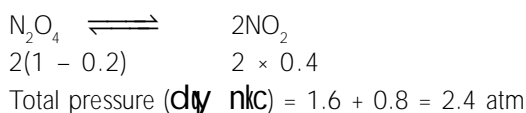


$$\Rightarrow 4 - 2x = 3 \Rightarrow x = \frac{1}{2}$$

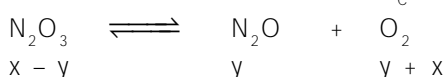
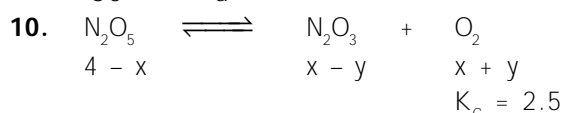
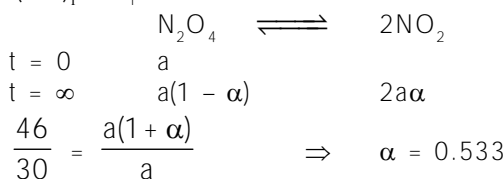
$$K_p = \frac{(1)^2}{(1/2)(3/2)^3}$$

6. For dissociation of NH₃ (NH₃ ds fo; ktu ds fy,)

$$K_p^1 = \frac{1}{K_p} = 0.5 \times 1.5^3$$



7.
$$\frac{(VD)_i}{(VD)_f} = \frac{n_f}{n_i}$$



$$x + y = 2.5$$

$$\frac{(x+y)(x-y)}{4-x} = 2.5$$

solving $y = 0.334 \text{ M}$

17. Hg (l) \rightleftharpoons Hg(g) $\Delta G^\circ = 31 \text{ kJ/mol}$

To start boiling $P_{\text{Hg}} = K_p$

When $\Delta G^\circ = -RT \ln K_p$

$$\Rightarrow 31 \times 10^3 = -8.31 \times 298 \ln K_p$$

- $K_p = 10^{-5.44}$
18. $\Delta_r G = -33 \times 10^3 + 8.314 \times 298 \times \ln \frac{(0.02)^2}{3^3 \times 1}$
 $\Delta_r G = -60.5 \text{ kJ/mol}$
19. (ii) $\text{H}_2 + \text{I}_2 \rightleftharpoons 2\text{HI}$
 $\frac{0.5}{7} - x \quad \frac{0.5}{7} - x \quad 2x$
- $$\frac{(2x)^2}{\left(\frac{0.5}{7} - x\right)^2} = 49$$
- Total pressure (dly nkc) $P_T = \frac{0.5}{7} \times 0.0821 \times 700$
- (iv) Partial pressure (vki kd nkc) of
 $\text{HI} = (2x) (0.0821) \times 700 = 6.385 \text{ atm}$

21. $\text{A} \rightleftharpoons \frac{n}{3}\text{B} + \frac{2n}{3}\text{C}$
 $t=0 \quad a$
 $t=\infty \quad a(1-\alpha) \quad a\alpha(n/3) \quad a\alpha(2n/3)$
 $\frac{D}{d} = \frac{a[1-\alpha+n\alpha]}{a} \quad \alpha = \frac{D-d}{d(n-1)}$
23. Adding inert gas at constant volume does not affect state of equilibrium
 (fu; r vk; ru ij vfØ; xS ds; lx ij l kE; kolFkk i hkkfor ugha gkrh gS)
26. $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$ as the reaction is exothermic so more NH_3 will be obtained at lower temperature.
 $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$ D; ki d vfØ; k m"ek(ki h gS vr% fuEu rki ij vf/kd NH_3 i klr glxhA

Exercise-03

COMPREHENSION # 1

1. $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}(s) \rightarrow \text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}(s) + \frac{3}{2}\text{H}_2\text{O}(g)$
 $\Delta H^\circ = \frac{3}{2}(-241.8) + (-1575) - (-2021)$
 For 1 kg $\text{CaSO}_4 \cdot 2\text{H}_2\text{O} = \frac{\Delta H^\circ}{172} \times 100 = 484 \text{ kJ}$

2. $\Delta S^\circ = \frac{3}{2}(188.6) + 130.5 - 194$
 $\Delta G = \Delta H^\circ - (298) \Delta S^\circ = -8.314 \times 298 \ln (P_{\text{H}_2\text{O}})^{3/2}$
 $\Rightarrow P_{\text{H}_2\text{O}} = 8.1 \times 10^{-3} \text{ bar}$

Exercise-4(A)

- 1.(b) $2\text{NH}_3 \rightleftharpoons \text{N}_2 + 3\text{H}_2$
 $3 \text{ atm} \quad 2 \text{ atm} \quad 1 \text{ atm}$
 $Q_p = 2/9 < K_p$
 \therefore shifts in forward direction (vxz fn'kk ea foLFkfi r)
6. $\text{CH}_4 + 2\text{H}_2\text{S} \rightleftharpoons \text{CS}_2 + 4\text{H}_2$
 $t=0 \quad 0.2\text{M} \quad 0.4\text{M} \quad 0.3\text{M} \quad 0.3\text{M}$
 $Q_c = \frac{(0.3)(0.3)^4}{(0.2)(0.4)^2} > K_c$
 \therefore shifts backward (i'p foLFkfi r)
7. $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$
 $0.036\text{M} \quad 0.15\text{M} \quad \text{CM}$
 $\frac{C^2}{(0.036)(0.15)^3} = 0.29$
8. $\text{N}_2 + \text{O}_2 \rightleftharpoons 2\text{NO}$
 $1.4 - x \quad 1.4 - x \quad 2x$
 $\Rightarrow \frac{(2x)^2}{(1.4 - x)^2} = 1.7 \times 10^{-3}$

9. $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$
 $0.16 - x \quad x \quad x$
 $\Rightarrow \frac{x^2}{0.16 - x} = 5.8 \times 10^{-2}$
10. $\text{ClF}_3 \rightleftharpoons \text{ClF} + \text{F}_2$
 $1.47 - x \quad x \quad x$
 $\Rightarrow \frac{x^2}{1.47 - x} = 0.14$
11. $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$
 $P_0(1-0.25) \quad 0.5 P_0 \quad P_0(1+0.25)=1.5$
 $K_p = \frac{[0.5P_0]^2}{P_0(0.75)} \quad P_0 = \frac{1.5}{1.25} \text{ atm}$
 $= \frac{0.25}{0.75} \times \frac{1.5}{1.25}$
12. $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$
 $P_0(1 - \alpha) \quad 2P_0\alpha \quad P_0(1 + \alpha) = 0.5$
 $\frac{4P_0\alpha^2}{1 - \alpha} = 0.667$

14. $PCl_5 \rightleftharpoons PCl_3 + Cl_2 \Rightarrow 1.1$ $P_0 = 4 \Rightarrow P_0 = \frac{4}{1.1}$ atm
 $P_0(1-0.1) \quad 0.1P_0 \quad 0.1P_0 \quad K_p = \frac{0.01P_0}{0.9} = \frac{P_0}{90} = \frac{4}{99}$ atm
 For 20% dissociation (20% fo; kt u ds fy,)
 $P_0^1 (1 - 0.2) \quad 0.2P_0^1 \quad 0.2P_0^1 \Rightarrow 1.2 P_0^1 = P_T$
 $\frac{0.04P_0^1}{0.8} = \frac{4}{99}$

15. $N_2 + 3H_2 \rightleftharpoons 2NH_3$
 $t = 0 \quad 16 \text{ atm} \quad 48 \text{ atm}$
 $t = \infty \quad 16 - x \quad 48 - 3x \quad 2x \Rightarrow \frac{2x}{64 - 2x} = \frac{1}{3}$
 $\Rightarrow x = 8$
 $K_p = \frac{16^2}{8(24)^3}$

16. $N_2O_4 \rightleftharpoons 2NO_2$ $P_0(1 + \alpha) = 5$
 $P_0(1-\alpha) \quad 2P_0\alpha \quad 1 + \alpha = \frac{92}{69}$
 $\Rightarrow KP = \frac{4P_0\alpha^2}{1-\alpha}$

17. $N_2O_4 \rightleftharpoons 2NO_2$
 $t=0 \quad a \text{ mol} \quad \frac{a(1+\alpha)}{a} = \frac{46}{30} \Rightarrow \alpha = \frac{8}{15}$
 $t=\infty \quad a(1-\alpha) \quad 2a\alpha$

19. $NH_2COONH_4(g) \rightleftharpoons 2NH_3(g) + CO_2(g)$
 Initial equilibrium $2P \quad P$
 $\Rightarrow K_p = 4P^3, P_T = 3P$
 Final equilibrium $3P \quad P^1$
 $\Rightarrow (3P)^2 P^1 = 4P^3 \Rightarrow P^1 = \frac{4P}{9}$

Ratio (vujkr) $\frac{P_T^1}{P_T} = \frac{31}{27} \quad P_T^1 = 3P + \frac{4P}{9} = \frac{31P}{9}$

20. Let n moles each of CO_2 & CaO be formed
 (ekuk CO_2 o CaO iR; d ds n eky cus gS)
 $0.04 \times 0.821 = n(0.0821) (1000)$

21. $(P_{H_2O})^6 = 6.4 \times 10^{85}$

22. $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$
 $t = 0 \quad 0.2 \text{ mol}$
 $t = \infty \quad 0.2(1-0.75) \quad 0.2 \times 0.75 \quad 0.2 \times 0.75$
 $K_p = P_{CO_2} \Rightarrow K_p(15) = (0.2 \times 0.75) (0.0821) (1000)$

30. At equilibrium $[A] = 0.3 \text{ M} [B] = 0.6 \text{ M}$
 Initially $[A] = 0.6 \text{ M}$

(i) $A \rightleftharpoons nB$
 $t = 0 \quad 0.6 \quad 0$
 $t = \infty \quad 0.3 \quad 0.6 = 0.3n \Rightarrow n = 2$

(ii) $K_c = \frac{0.6^2}{0.3}$

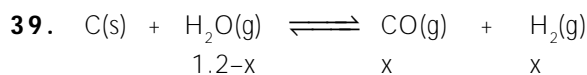
(iii) Initial rate = $\frac{\Delta[A]}{\Delta t} = \frac{0.6 - 0.5}{1} = 0.1 \text{ M hr}^{-1}$

32. At 300 K ; $K_1 = \frac{2 \times 10^{-2}}{4 \times 10^{-3}} = 5$

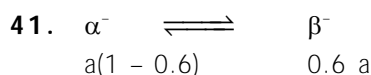
At 400 K ; $K_2 = \frac{4 \times 10^{-2}}{16 \times 10^{-4}} = 25$

$\log \frac{K_2}{K_1} = \frac{\Delta H}{2.303 \times 8.314} \left[\frac{1}{300} - \frac{1}{400} \right]$

36. $K_p = 0.313 \text{ atm} \quad K_c = \frac{0.313}{(0.0821 \times 298)^1}$



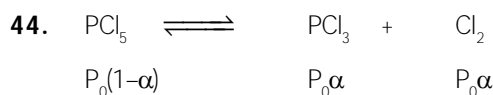
$\frac{x^2}{1.2-x} = 3 \times 10^{-2}$



$K_c = \frac{0.6}{0.4} = 1.5$

$\Delta G^\circ = -8.314 \times 298 \ln 1.5 \text{ J/mol}$

43. 0

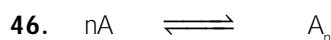


$1.78 = \frac{P_0\alpha^2}{1-\alpha}$

$P_0(1 + \alpha) = 1$

$M_{avg} = \frac{208.5}{1 + \alpha}$

$d_{mix} = \frac{\left[1 \times \frac{208.5}{1 + \alpha} \right]}{0.0821 \times 523}$



$1-x \quad \frac{x}{n}$

$\frac{PV}{RT} = 1-x + \frac{x}{n}$

$K_c = \frac{\frac{x}{nV}}{\left[\frac{1-x}{V} \right]^n} = \frac{xV^{n-1}}{n(1-x)^n}$

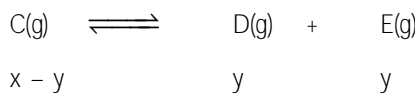
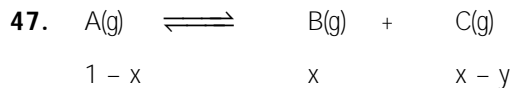
$K_c \approx \frac{xV^{n-1}}{n(1-nx)}$

$$\Rightarrow nK_c - nK_c x = xv^{n-1}$$

$$\Rightarrow x = \frac{nK_c}{V^{n-1}}$$

i.e. $\frac{PV}{RT} = 1 - \frac{nK_c}{V^{n-1}} + \frac{K_c}{V^{n-1}}$

$$\frac{PV}{RT} = \left[1 - \frac{(n-1)K_c}{V^{n-1}} \right]$$

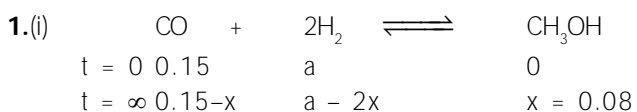


$$1 - x + x + x - y + 2y = 2$$

$$\Rightarrow x + y = 1$$

$$\frac{x-y}{x} = \frac{1}{5} \Rightarrow 5x - 5y = x; \frac{x}{y} = \frac{5}{4}$$

Exercise-4(B)



Total moles finally (vr ea dly esy)

$$= 0.15 + a - 2(0.08)$$

$$= a - 0.01$$

$$\Rightarrow 8.5 (2.5) = (a - 0.01) (0.0821) (750)$$

$$a = 0.355$$

Hence at equilibrium (vr% l ke; ij), [CO] = 0.07M,

$$[H_2] = 0.195 \text{ M} \qquad [CH_3OH] = 0.08$$

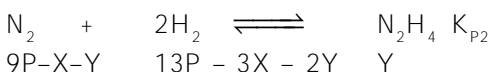
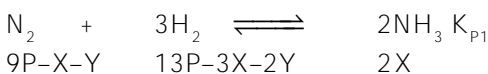
$$\therefore K_c = \frac{0.08 / 2.5}{\left(\frac{0.195}{2.5}\right)^2 \left(\frac{0.07}{2.5}\right)}$$

(ii) Total moles (dly esy) = 0.15 + 0.355 = 0.505

$$P(2.5) = (0.505) (0.0821) 750$$

$$P = 12.43 \text{ atm}$$

2. Let initial pressure of N₂ be 9P and of H₂ be 13P (ekuk N₂ dk ikjfflk d nlc 9P o H₂ dk 13P gA)



$$9P - X - Y + 13P - 3X - 2Y + 2X + Y = 7P_0 \quad \dots (1)$$

$$2X = P_0 \quad \dots (2)$$

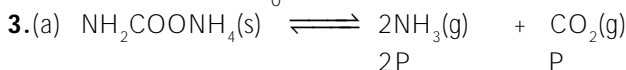
$$13P - 3X - 2Y = 2P_0 \quad \dots (3)$$

$$\text{Solving } x = P_0/2 \quad Y = 3P_0/2 \quad P = P_0/2$$

$$K_{P1} = \frac{(P_0)^2}{(4.5P_0 - 0.5P_0 - 1.5P_0)(6.5P_0 - 1.5P_0 - 3P_0)^3}$$

$$= \frac{P_0^2}{(2.5P_0)(8P_0^3)} = \frac{1}{20P_0^2}$$

and $K_{P2} = \frac{3}{20P_0^2}$



$$3P = 0.116$$

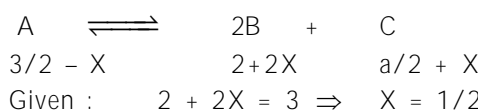
$$K_p = 4P^3 = 4 \left(\frac{0.116}{3}\right)^3$$

4. Let equilibrium concentration of C be a M. (ekuk C dh l ke; l klærk a M gS)

$$K_c = \frac{(4^2)(a)}{3} = \frac{16a}{3} \dots (1)$$

on doubling volume all concentration are halved and equilibrium shifts forward

(vk; ru nqpk djust ij l lkh l klærk vk/kh gks tkrh gS rFlk l ke; ihNs foLFkkfir gks tkrk gS)



$$K_c = \frac{(3)^2 \left(\frac{a}{2} + \frac{1}{2}\right)}{\left(\frac{3}{2} - \frac{1}{2}\right) 16a} = \frac{9(a+1)}{2a} \dots (2)$$

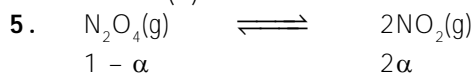
From (1) & (2),

$$\Rightarrow 32a = 27a + 27$$

$$\Rightarrow 5a = 27$$

$$a = 5.4$$

$$K_c = \frac{9(3.2)}{(1)} = 28.8$$



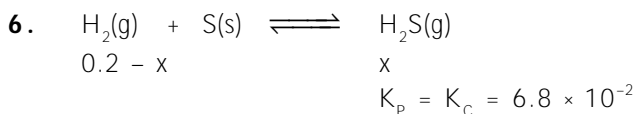
Average molar mass, $M_{\text{average}} (M_{\text{avr}} \text{ r ekyj}$

$$\text{æ0; eku) = } \frac{1.8 \times 0.0821 \times 346}{1} = 51.1$$

$$\frac{92}{51.1} = 1 + \alpha \Rightarrow \alpha = 0.8$$

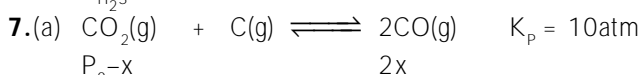
$$P_{N_2O_4} = \left(\frac{1-\alpha}{1+\alpha}\right) (l) \qquad P_{N_2} = \left(\frac{2\alpha}{1+\alpha}\right) (l)$$

$$K_p = \frac{4\alpha^2/(1+\alpha)^2}{1-\alpha/1+\alpha} = \frac{4\alpha^2}{1-\alpha^2}; K_c = K_p(RT)^{-1}$$



$$\frac{x}{0.2-x} = 6.8 \times 10^{-2} \Rightarrow x = 0.012$$

$$P_{H_2S} = (x) RT = 0.012 (0.0821) (363)$$



$$\frac{4x^2}{P_0 - x} = 10 \text{ \& } P_0 + x = 4$$

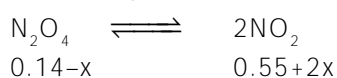
(b) Let total pressure be P atm (ekuk dly nlc P atm gš)

$$P_{CO_2} = 0.06 P \qquad P_{CO} = 0.94 P$$

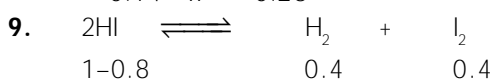
$$K_p = 10 = \frac{(0.94P)^2}{0.06P} \Rightarrow P = 0.08 \text{ atm}$$

8. $K_p = 1.1^2/0.28 \text{ atm}$

On doubling volume (vk; ru nqk djust ij)



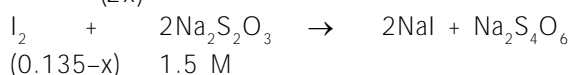
$$\frac{(0.55+2x)^2}{0.14-x} = \frac{1.1^2}{0.28}$$



$$K_c = \frac{0.4 \times 0.4}{0.2^2} = 4$$

Let x mol of H_2 & I_2 react (ekuk H_2 o I_2 ds x esy fØ; k djrs gš)

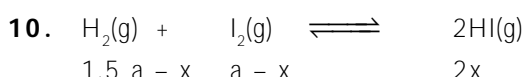
$$4 = \frac{(0.135-x)^2}{(2x)^2}$$



If V L of hypo are used (; fn gkbi ks ds V L iz Ør gq)

$$(0.135 - x) \times 2 = 1.5 V$$

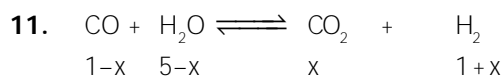
Let initially a mole I_2 & (1.5 a) mol H_2 be present (ekuk i ljk es esy I_2 o (1.5 a) esy H_2 mi flkr glrs gš)



$$\frac{a-x}{2x} = \frac{1}{18} \Rightarrow 9a - 9x = x$$

$$x = 9a/10$$

$$K_c = \frac{[2(9a/10)]^2}{\left(1.5a - \frac{9a}{10}\right)(a - 9a/10)} = \frac{81 \times 4}{6 \times 1} = 54$$



$$\frac{x(1+x)}{(1-x)(5-x)} = 7.3 \text{ Solving } x = 0.938$$

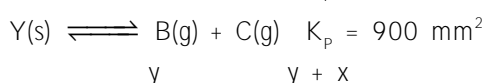
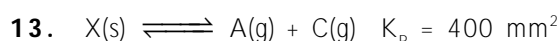
12. $\frac{r_{mix}}{r_{Kr}} = \sqrt{\frac{M_{Kr}}{M_{avg.}}} = 1.16$

$$\text{Solving, M average} = \frac{83.8}{1.16^2}$$

$$\frac{71}{M_{avg.}} = 1 + \alpha.$$

$$K_p = \frac{4\alpha^2}{1-\alpha^2}$$

$$\Rightarrow K_c = \frac{K_p}{(0.0821)(1473)} = 6.3 \times 10^{-4}$$



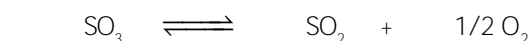
$$x(x+y) = 400$$

$$y(x+y) = 900$$

(b) Mole ratio of A & B (A o B dk esy vujkr) = $\frac{x}{y} = \frac{4}{9}$

(c) Total pressure (dly nlc) = 2(x+y)

14. M average = $\frac{12.8 \times 0.0821 \times 1000}{1.642} = 64$



$$t = 0 \quad 1$$

$$t = \infty \quad 1-\alpha \qquad \qquad \qquad \alpha \qquad \qquad \qquad \alpha/2$$

$$\frac{80}{64} = 1 + \alpha/2 \Rightarrow \alpha = 0.5$$

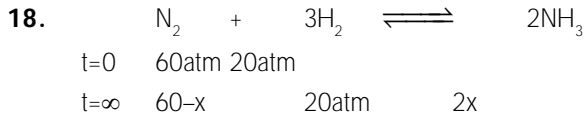
15. At 288 K, $M_{avg.} = \frac{3.62 \times 0.0821 \times 288}{1}$

$$\frac{92}{M_{avg.}} = 1 + \alpha \Rightarrow K_{p1} = \frac{4\alpha^2}{1-\alpha^2}$$

$$\text{Similarly at 348K, } M'_{avg.} = \frac{1.84 \times 0.0821 \times 348}{1}$$

$$\frac{92}{M'_{avg}} = 1 + \alpha' \Rightarrow K_{P_2} = \frac{4\alpha'^2}{1-\alpha'^2}$$

$$\log \frac{K_{P_2}}{K_{P_1}} = \frac{\Delta H^\circ}{2.303R} \left[\frac{1}{288} - \frac{1}{348} \right]$$



$$\frac{2x}{80-2x} = \frac{1}{10} \Rightarrow 20x = 80 - 2x \Rightarrow x = \frac{80}{22}$$

$$\Rightarrow K_p = \frac{\left[2\left(\frac{80}{22}\right) \right]^2}{\left[60 - \frac{80}{22} \right] \left[20 - \frac{240}{22} \right]^3}$$

19. $-16.5 \times 10^3 = -8.314 \times 298 \times 2.303 \log K_1$
 $K_2 = K_1^2$

$$K_3 = \frac{1}{K_1}$$

let initial pressure of NO be p and of NO₂ be 2p

