$0 $0 $0 $0

$0 $0 $0 $0

Bubbles!	20th century German History	Entropy	Potent Potables	Equilibrium is K	A pHun Category
$200	$200	$600	$200	$200	$200
$400	$400	$800	$400	$400	$400
$600	$600	$200	$600	$600	$600
$800	$800	$1000	$800	$800	$800
$1000	$1000	$400	$1000	$1000	$1000

This is the grams of N_2O, nitrous oxide, in 500. mL of the gas at STP. R = 0.0821 L*atm/molK

0.982 g

$$1\ atm\ *0.5\ L = n\ *0.0821\ *273\ K$$

$$0.022\ mol\ *44\frac{g}{mol}$$
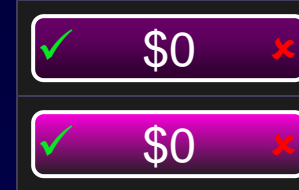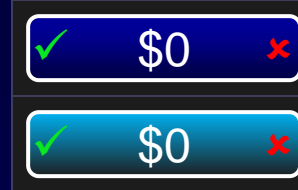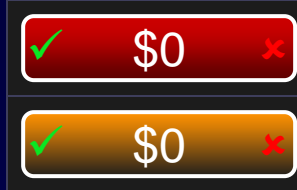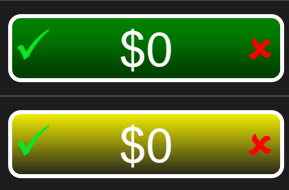
✓ $0 ✗   ✓ $0 ✗   ✓ $0 ✗   ✓ $0 ✗ $400

✓ $0 ✗   ✓ $0 ✗   ✓ $0 ✗   ✓ $0 ✗

This is the pressure of gas in an aerosol can at 475°C when its pressure is1.8 atm at 25°C. R = 0.0821 L*atm/molK

4.5 atm

$$\frac{V}{nR} = \frac{298\,K}{1.8\,atm} = \frac{748K}{P}$$

From this list: CO, CO_2, CO_3 or C_2O, this is the gas such that a 707 mg sample occupies a volume of 452 mL at 63°C and 745 mmHg. R = 0.0821 L*atm/molK and 1atm = 760 mmHg

CO$_2$

$$\frac{745}{760}\, atm \,*\, 0.452\, L = n \,*\, 0.0821 \,*\, (273 + 63)\, K$$

$$\frac{0.707 g}{0.016\, mol} = 44\, \frac{g}{mol}\, molar\ mass$$

This is the final volume of a bubble if it had 2.1 mL volume at the bottom of a lake at 4°C and 3.0 atm, and it rose to the water's surface, where the temperature is 25°C and the pressure is 0.95 atm. R = 0.0821 L*atm/molK

7.1 mL

$$\frac{3\,atm * 0.0021\,L}{277\,K} = nR = \frac{0.95\,atm * V}{298\,K}$$

This is the volume of dry air at 1.00 atm and 25°C required for burning 1.00 L liquid hexane (C_6H_{14}, density = 0.660 g/mL) completely, yielding carbon dioxide and water. Oxygen is 20.95% of dry air. R = 0.0821 L*atm/molK
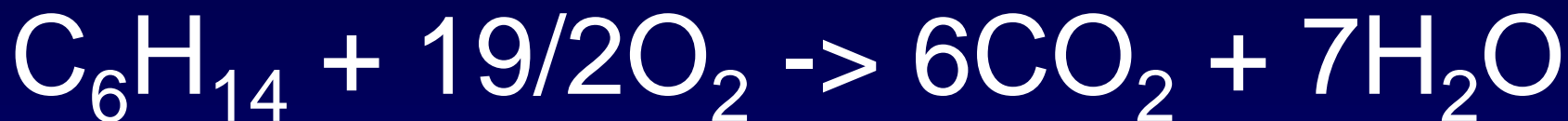
8490 L

$$C_6H_{14} + 19/2 O_2 \rightarrow 6CO_2 + 7H_2O$$

$$1.00 \; L \; * \; 0.660 \frac{g}{mL} * 1000 \frac{mL}{L} * \frac{1 mol \; hexane}{86.2 g} * \frac{19 mol O2}{2 mol hexane}$$

$$72.7 \; mol \; O2 * \frac{1 mol \; air}{0.2095 \; mol \; O2}$$

$$1.00 \; atm \; * V = 347 \; mol \; air * 0.0821 * 298 \; K$$

This is the equilibrium constant expression for the Haber-Bosch process

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

$$[NH_3]^2/([N_2][H_2]^3)$$
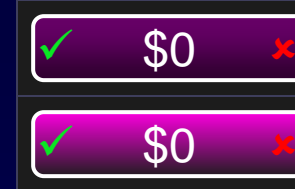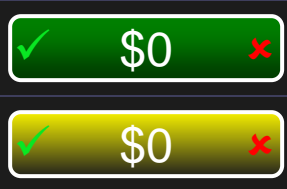
Pressurizing the container favors the formation of this side of the Haber-Bosch equilibrium
N_2 (g) + 3H_2 (g) ⇄ 2NH_3 (g)

The right-> it has fewer moles of gas

This is the equilibrium constant for the Haber Bosch:

$$2NH_3 \text{ (g)} \rightleftarrows N_2 \text{ (g)} + 3H_2 \text{ (g)}$$
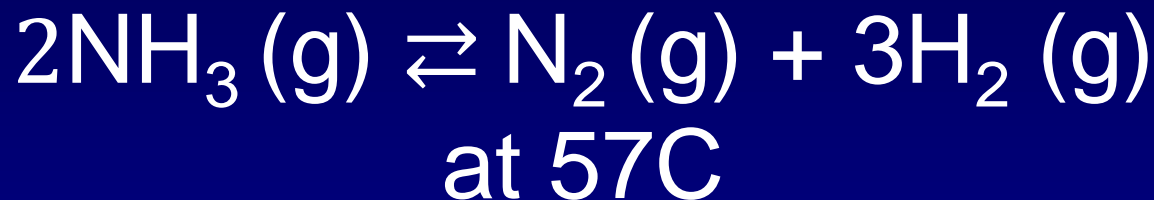
at 57C

Given that the equilibrium constant for

$$N_2 \text{ (g)} + 3H_2 \text{ (g)} \rightleftarrows 2NH_3 \text{ (g)}$$

is 49.3 at 57C.

$0 $0 $0 $0 $600

$0 $0 $0 $0

0.0203 (the reciprocal)

This is the equilibrium constant for the Haber Bosch:
$N_2 (g) + 3H_2 (g) \rightleftarrows 2NH_3 (g)$

Given that:

$N_2 (g) + Fe (s) \rightleftarrows FeN_2 (s)$ 　　　　　　　K = 15

$FeN_2 (s) + 3H_2 (g) \rightleftarrows 2NH_3 (g) + Fe(s)$ 　　K = 4

60

N_2 (g) + Fe (s) $\rightleftarrows$ FeN_2 (s)   K = 15 = 1/[N_2]
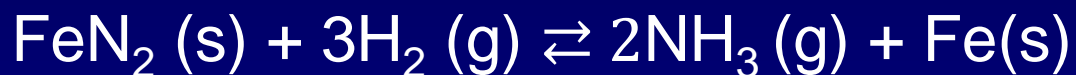
FeN_2 (s) + 3H_2 (g) $\rightleftarrows$ 2NH_3 (g) + Fe(s)   K = 4 = $[NH_3]^2/[H_2]^3$

For the desired constant, multiply together

$$[NH_3]^2/([N_2][H_2]^3)$$

This would be the NH_3 concentration when the Haber-Bosch process equilibrates after 1M H_2 and 1M N_2 combine at a temperature where K=$2.0*10^{-10}$

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

$1.4*10^{-5}$ M (=2 $*7.0*10^{-6}$)

$$N_2 + 3H_2 \rightleftarrows 2NH_3$$
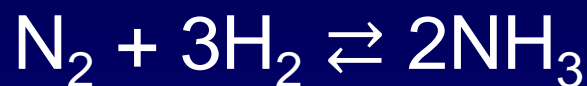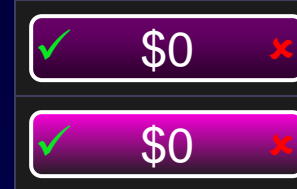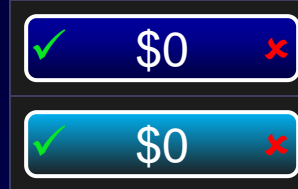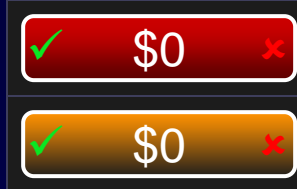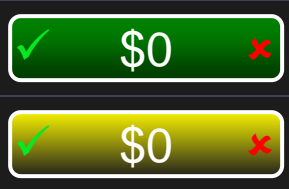
1	1	0
-x	-3x	+2x
1-x	1-3x	2x

$$2.0 * 10^{-10} = \frac{(2x)^2}{(1-x)(1-3x)^3} = \frac{4x^2}{1}$$

But K is small!

This species has the lowest standard entropy (S°) from this list:
$Br_2(l)$, $Cl_2(g)$, $F_2(g)$, $H_2(g)$, $I_2(s)$

$I_2(s)$
Solids have lowest entropy

These are the signs of H, S and G, for an exothermic reaction that is nonspontaneous at high temperatures
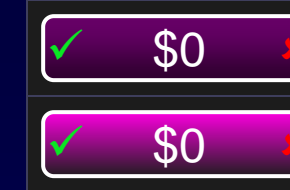
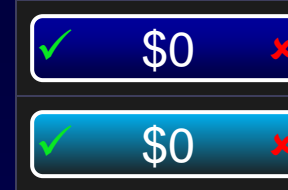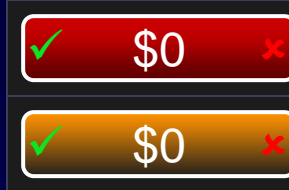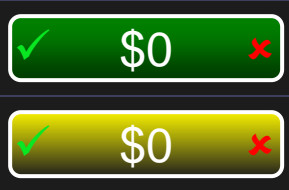| $0 | $0 | $0 | $0 | $400 |
| $0 | $0 | $0 | $0 | |

$$\Delta H < 0, \Delta S < 0, \Delta G > 0$$

This is the lowest temperature at which a reaction will be spontaneous if $\Delta S° = 75.8$ J/K·mol and $\Delta G° = 141$ kJ/mol at 25C

2160 K

$$141000\,\frac{J}{mol} = H - 298K * \frac{75.8J}{Kmol}$$

$$0 = 163.6kJ/mol - T * \frac{75.8J}{Kmol}$$

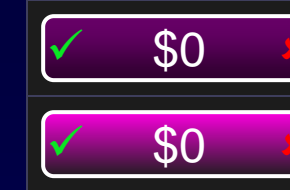# This is K for a reaction at 227°C with ΔH° = 81.2 kJ/mol and ΔS° = 128 J/K·mol

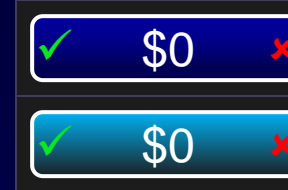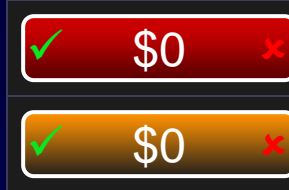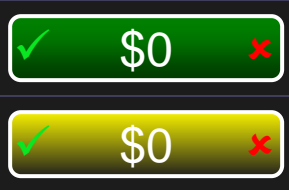# 0.0159

$$G = -8.314 * (227 + 273K) * lnK = 81,200 \, J/mol - (227 + 273K) * \frac{128J}{Kmol}$$

$$-\frac{4157J}{mol} * lnK = 17200 \, J/mol$$

$$K = e^{-4.137}$$

This is K_a for HCN(aq) at 25°.

ΔH° for H⁺, CN⁻ and HCN are 0, 151.0 and 105.4 kJ/mol, respectively. ΔS° are 0, 117.99 and 128.9 J/molK, respectively.

2.73×10^{-9}

$HCN \rightleftarrows H^+ + CN^-$

$$H = (151 + 0) - 105.4 = 45.6 \, kJ/mol$$

$$S = (117.99 + 0) - 128.9 = -10.91 \, J/molK$$

$$-8.314 * (298K) * lnK = 45{,}600J/mol - (298K) * \frac{-10.91J}{Kmol}$$

$$Ln(K) = -19.7$$

A sample of gaseous ethanol, at 100 torr, would have this pressure if the container volume is doubled at constant temperature

50 torr

- P and V are inversely related.

Gaseous ethanol, at 298K and 745 torr with V=37.42 L, would occupy this volume at 894 torr and 313K

32.7 L

- $P_1V_1/n_1T_1 = P_2V_2/n_2T_2$
- Moles are constant and cancel

- $745*37.42/298 = 894x/313$
- Note the use of torr and not atm on both sides is OK.

This is the Gibbs Energy for the reaction which makes methanol:
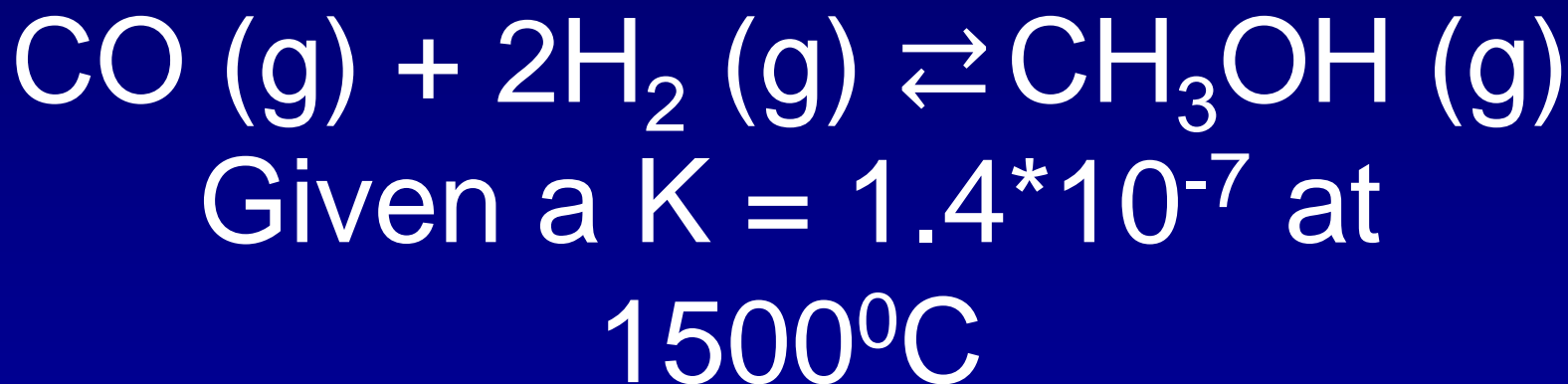
$CO\ (g) + 2H_2\ (g) \rightleftarrows CH_3OH\ (g)$

Given a K = $1.4*10^{-7}$ at 1500^0C

+233 kJ/mol

- G = -RTln(K)

- = -8.314 J/molK * 1773 K * ln(1.4*10^{-7})

This is the boiling point of pentanol given the reaction has $\Delta H = 55.5$ kJ/mol and $\Delta S = 148$ J/mol*K

102^0C (375K)

- $T = \Delta H / \Delta S = 55{,}500/148$

This mass of methanol (32g/mol) was initially present in a 3.00L vessel which, at equilibrium, contains 0.426 M H_2

$$CH_3OH \text{ (g)} \rightleftarrows CO \text{ (g)} + 2H_2 \text{ (g)}$$

$$K = 6.90 \times 10^{-2}$$

74.3 g

$CH_3OH\ (g) \rightleftarrows CO\ (g) + 2H_2\ (g)$

x	0	0
-y	+y	+2y
X-y	y (0.213)	2y = 0.426

$$6.9 * 10^{-2} = \frac{(0.426)^2 (0.213)}{(x - 0.213)}; x = 0.773\ M$$

0.773 mol/L * 3L * 32 g/mol

This is the correct equilibrium constant expression for the following reaction

Fe_2O_3 (s) + $3H_2$ (g) $\rightleftarrows$ 2Fe (s) + $3H_2O$ (g)

$$Kc = [H_2O]^3 / [H_2]^3$$

This is what increasing the volume of the container would do to this equilibrium:
$3Fe(s) + 4H_2O(g) \rightleftarrows Fe_3O_4(s) + 4H_2(g)$,
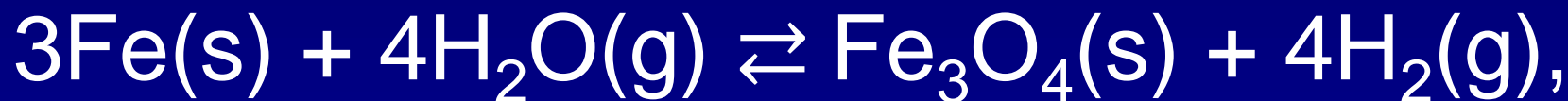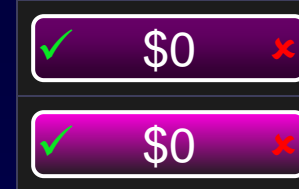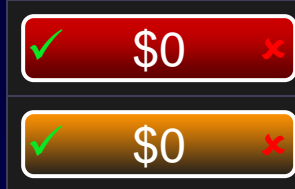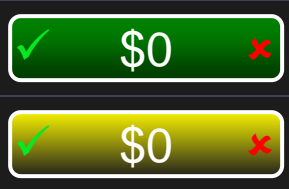
Cause no change
Equal moles of gas on both sides of equilibrium

This is K for the equilibrium $S_2Cl_4 \rightleftarrows 2SCl_2$

When 4.21 moles of S_2Cl_4 are introduced into a 2.0 L vessel, 1.25 moles of S_2Cl_4 are found unreacted at equilibrium.

$0 $0 $0 $0

$0 $0 $0 $0

$600

14

$$S_2Cl_4 \rightleftarrows 2SCl_2$$

	S₂Cl₄	2SCl₂
I	2.105	0
C	-X	+2X
E	0.625	2X

X= 1.48
2X= 2.96

K = 2.96^2 /0.625

This is which direction is spontaneous when
$[SO_2] = 0.010$ M; $[SO_3] = 10.0$ M; $[O_2] = 0.010$ M.

At 700 K, the equilibrium of
$2SO_2(g) + O_2(g) \rightleftarrows 2SO_3(g)$
has the equilibrium constant
$Kc = 4.3 \times 10^6,$
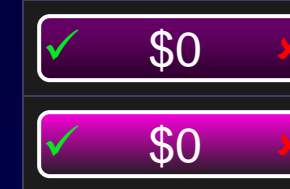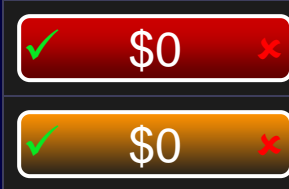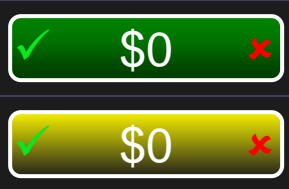
Qc > Kc, the reaction proceeds from right to left to reach equilibrium

$$Q = [SO_3]^2 / [SO_2]^2[O_2] = 10^2/0.01^3 = 10^8$$

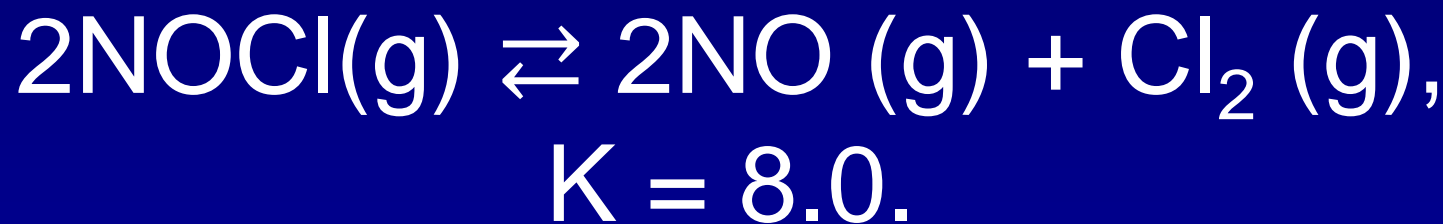This is the concentration of NOCl needed in a 4.00 L reaction vessel to make 1.00 M of NOCl exist at equilibrium.
$2NOCl(g) \rightleftarrows 2NO(g) + Cl_2(g)$, K = 8.0.

3.52 M

$$2NOCl(g) \rightleftarrows 2NO\ (g) + Cl_2\ (g),$$

I	Y	0	0
C	-2X	+2X	+X
E	Y-2X = 1	2X	X

$$(2X)^2 X/1^2 = 8 \qquad X=1.26$$

$$Y - 2(1.26) = 1$$

This is the concentration of H⁺ in a 2.5 M HCl solution

$0 $0 $0 $0

$0 $0 $0 $0

$200

2.5 M

This is the conjugate base of HCO_3^-.

| $0 | $0 | $0 | $0 | $400 |
| $0 | $0 | $0 | $0 | |

$$CO_3{}^{2-}$$

This is the OH⁻ ion concentration in a 5.2×10^{-4} M HNO_3 solution

1.9×10^{-11} M

$$1*10^{-14} / (5.2*10^{-4})$$

This is the pH of a 0.080 M solution of the weak base pyridine (C_5H_5N; K_b = 1.7 x 10^{-9})

9.07

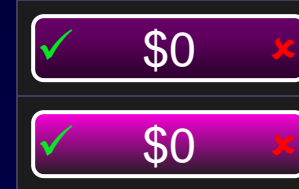pyridine $\rightleftarrows$ OH$^-$ + Hpyridine
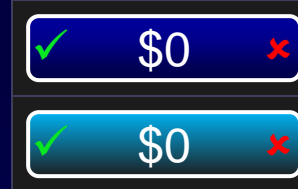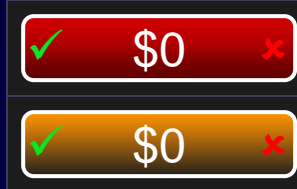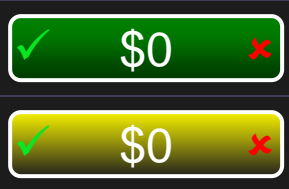
0.08   0   0

-x   +x   +x

0.08-x   x   x

$$1.7 * 10^{-9} = \frac{x^2}{0.08 - x}$$

-log(x) = pOH

14-pOH = pH

Board

This is the pH of the mixture of 5.5 L sample of a 0.25 M HNO_3 solution with 1.2 L of a 0.34 M HCl solution.

0.57

Total volume = 5.5 + 1.2 = 6.7 L

Total moles = 5.5 L * 0.25 + 1.2*0.34 = 1.783

-log(1.783/6.7)