SCAN

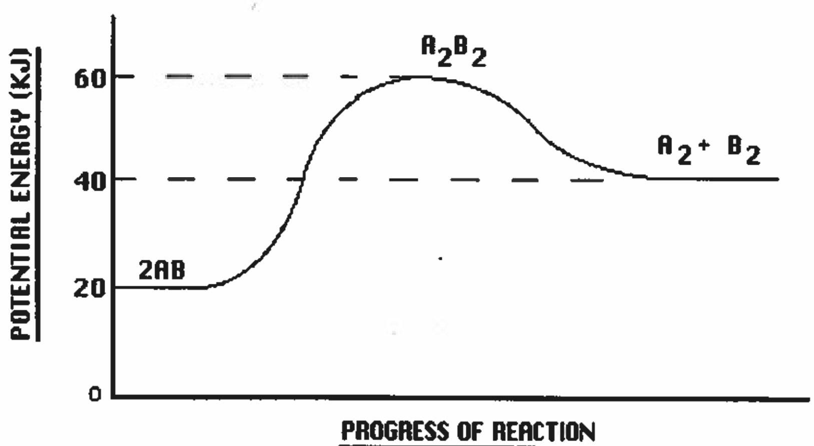
Key

Alter #21

Chemistry 12 -Review Sheet on Unit 2-Chemical Equilibrium

1. What two things are equal at ***equilibrium***? forward rate = reverse rate

2. Consider the following *potential energy* diagram:



a) Which reaction, forward or reverse, will be affected *more* by an increase in temperature? forward

b) Write a thermochemical equation for the forward reaction using the numerical value for the heat. $2AB + 20\,KJ \rightarrow A_2 + B_2$

c) When the temperature is first raised, which reaction will increase *most* in rate, forward or reverse? Explain why. forward as it has higher AE.

d) If the rate of the forward reaction is *faster* than the reverse reaction for awhile, what will happen to the $[A_2]$ and $[B_2]$? ↑

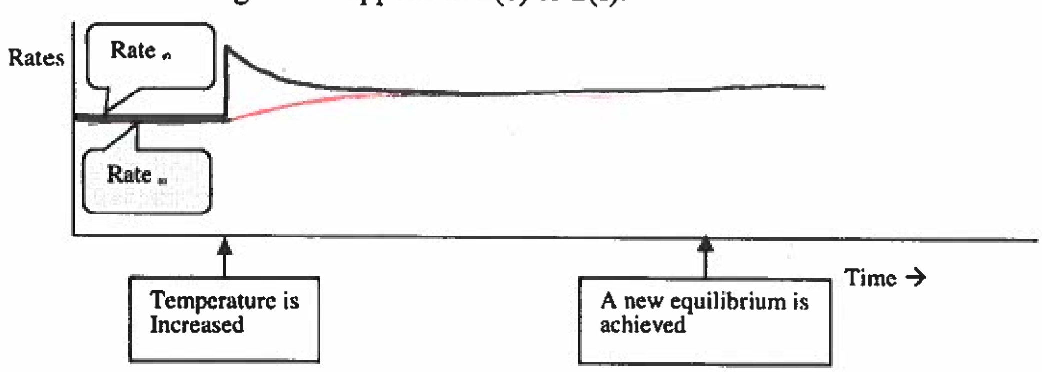
e) If the $[A_2]$ and $[B_2]$ increases, what will happen to the rate of the *reverse reaction*? ↑

f) When the reverse reaction rate *catches up* to the forward reaction rate, the system is again at equilibrium

g) Since, for awhile, *the rate of the forward reaction was faster than the rate of the reverse reaction*, there would be an *increase* in the concentrations of A_2 & B_2 and a *decrease* in the concentration of AB in the second equilibrium.

h) We can summarize by saying that the equilibrium has shifted to the right as a result of increasing the temperature.

i) Draw a graph showing the **rates** of the *forward* and *reverse* reactions vs. time summarizing what happens in 2(c) to 2(f).



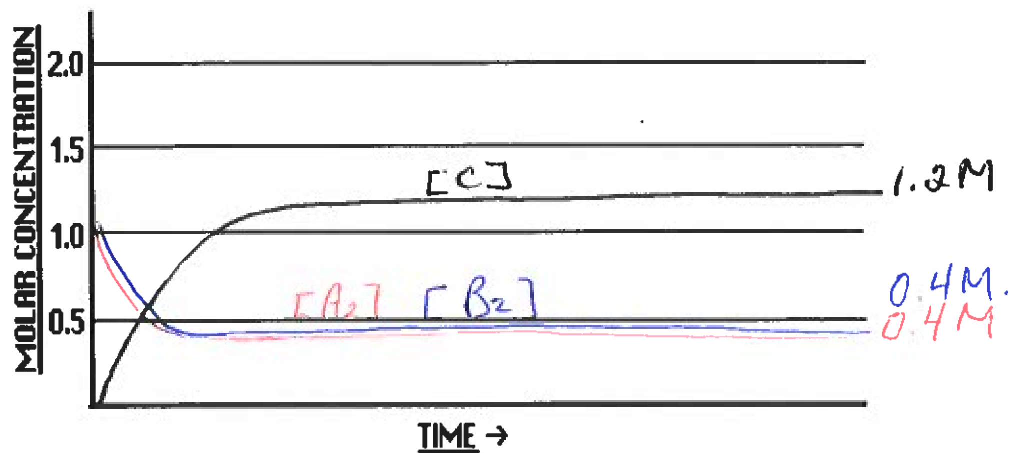
3. Consider the reaction: $A_{2(g)} + B_{2(g)} \rightleftarrows 2C_{(g)}$

a) If one mole of A_2 and one mole of B_2 are placed in a 1.0 L container, an equilibrium is established in which $[A_2]$ and $[B_2]$ = 0.40 M and [C] = 1.2 M. If 2.0 moles of C are placed into another 1.0 L container at the same temperature, what will the final concentrations of all the species be? (*HINT: This is* ***not*** *a calculation. It deals with how equilibrium can be approached from the left or from the right.*)

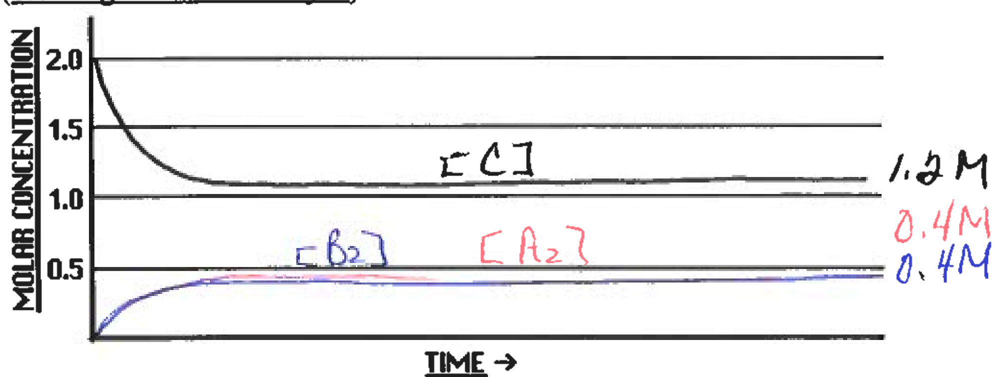
$[A_2]$ = 0.40 M $[B_2]$ = 0.40 M [C] = 1.2 M

The same eq. can be approached from reactants or products.

b) Sketch ***two*** graphs showing each of the activities performed in 3a. The graphs are concentration vs. time. (*Starting with 1 mole A_2 and 1 mole of B_2*)



(*Starting with 2 moles of C*)



4. Give ***four*** characteristics of the ***equilibrium*** state: – forward rate = reverse rate
– microscopic changes continue to occur
– macroscopic changes do not occur (T°C, Pressure, [ ])
– Eq. can be approached from L or R.

5. Define ***enthalpy***:
– heat content of the system

6. Define ***entropy***:
– disorder or randomness

7. For the reaction: $ZnCl_{2(aq)}$ + $H_{2(g)}$ ⇄ $Zn_{(s)}$ + $2HCl_{(aq)}$ $\Delta H = +152$ kJ (endo)
Considering enthalpy and entropy, if the reactants are combined will the reaction *go to completion, not occur at all* or *reach a state of equilibrium*? Why?
minimum enthalpy = reactants } will not occur!
maximum entropy = reactants }

8. For the reaction: $2NaHCO_{3(s)}$ + heat ⇄ $Na_2SO_{3(s)}$ + $CO_{2(g)}$ + $H_2O_{(g)}$
Considering enthalpy and entropy, if the reactants are combined will the reaction *go to completion, not occur at all* or *reach a state of equilibrium*? Why?
minimum enthalpy = reactants } will reach
maximum entropy = products } equilibrium

9. Summarize Le Chatelier's Principle:
When a "stress" is imposed on an equilibrium processes will occur to counteract the change and a new equilibrium will be established.

10. For the reaction: $Na_{(s)}$ + $H_2O_{(l)}$ ⇄ $Na^+_{(aq)}$ + $OH^-_{(aq)}$ + ½ $H_{2(g)}$ + 184 kJ
Which way will the equilibrium shift when the following changes are made:
a) $NaCl_{(aq)}$ is added .... left
b) The pressure is increased .... left
c) The $[OH^-]$ is decreased .... right
d) The temperature is decreased .... right
e) The volume of the container is decreased .... left
f) The solid sodium is chopped into smaller pieces.. no shift
g) A catalyst is added .... no shift

12. For the following reaction: $4NH_{3(g)}$ + $5O_{2(g)}$ + heat ⇄ $4NO_{(g)}$ + $6H_2O_{(g)}$
Which way will the equilibrium shift (if any) when the following changes are made:
a) [NO] is decreased .... right
b) $[O_2]$ is increased .... right
c) $[NH_3]$ is increased .... right
d) The temperature is decreased .... left
e) The volume of the container is increased ...↓P right
f) The total pressure is increased .... left
g) Helium gas is added to increase the total pressure left ~~no shift~~ ~~right~~
h) The temperature is increased .... right
i) A catalyst is added .... no shift

13. Consider the following system: $2SO_{2(g)}$ + $O_{2(g)}$ ⇄ $2SO_{3(g)}$ $\Delta H = -99$ kJ/mol
What are *four* things which could be done in order to increase the yield of SO_3?

- increase the pressure
- decrease the temperature
- ↑ $[SO_2]$
- ↑ $[O_2]$

14. Write the *Keq expression* for the following reaction: (*Be careful of phases!*)

$2NaHCO_{3(s)}$ + heat ⇄ $Na_2SO_{3(s)}$ + $CO_{2(g)}$ + $H_2O_{(g)}$

$Keq = [CO_2][H_2O]$

15. In an experiment at 423°C, the following concentrations were measured for the ***equilibrium*** system: $2HI_{(g)}$ ⇄ $H_{2(g)}$ + $I_{2(g)}$

$[HI] = 17.7 \times 10^{-3}$ M, $[H_2] = 1.83 \times 10^{-3}$ M and $[I_2] = 3.13 \times 10^{-3}$ M.

a) Calculate the *value* for the equilibrium constant (Keq) at 423°C .

$$Keq = \frac{[H_2][I_2]}{[HI]^2} = \frac{(1.83\times10^{-3})(3.13\times10^{-3})}{(17.7\times10^{-3})^2} = 0.0183$$

b) If, at 423°C , the $[H_2]$ and $[I_2] = 4.8 \times 10^{-3}$ M, calculate the [HI].

$$Keq = 0.0183 = \frac{(4.8\times10^{-3})^2}{[HI]^2}$$

$$\sqrt{0.0183} = \frac{4.8\times10^{-3}}{[HI]} \rightarrow [HI] = \frac{4.8\times10^{-3}}{\sqrt{0.0183}}$$

[HI] = 0.36 M

16. Given the equilibrium equation: $X_{2(g)}$ + $3Y_{2(g)}$ ⇄ $2XY_3$

If 2.0 moles of X_2 and 2.0 moles of Y_2 are added to a 1.0 L container, an equilibrium is established in which the $[Y_2] = 0.80$ M. Find $[X_2]$ and $[XY_3]$ at equilibrium and the Keq. (make an ICE table)

	X_2	+ $3Y_2$	⇄ $2XY_3$
I	2.0	2.0	0
C	−0.40	−1.2	+0.80
E	1.6M	0.80M	0.80M

$$Keq = \frac{0.80^2}{(1.6)(0.80)}$$

Keq = 0.78

17. The equation: $A_{(g)}$ + $B_{(g)}$ + heat ⇄ $C_{(g)}$ + $D_{(g)}$ has a Keq = ***49*** at 25°C. What, if anything, would happen to the *value* of the equilibrium constant if the *temperature is increased*? Explain.

If T°C ↑, eq would shif to right, ↑ [C] & [D]

this would lead to a higher Keq value.

18. The Keq for the reaction: $2SO_{2(g)}$ + $O_{2(g)}$ ⇄ $2SO_{3(g)}$ is ***85.0*** at 25°C.

What is the Keq for the reaction : $2SO_{3(g)}$ ⇄ $2SO_{2(g)}$ + $O_{2(g)}$

As it is the opposite rxn, the Keq is the inverse $\frac{1}{85} = 0.0118$.

19. How does the addition of a *catalyst* affect the Keq for a system?

It speeds rxn but does not change keq.

21. Consider the following equilibrium: $2SO_{2(g)}$ + $O_{2(g)}$ ⇄ $2SO_{3(g)}$ Keq = *6.5* at a certain temperature. What will ~~occur equilibrium concentrations be~~ occur when 1.0 mol of SO_2, 1.0 mol of O_2, and 1.0 mol of SO_3 are placed in a 1.0 L container and allowed to reach equilibrium?

	$2SO_2$	+ O_2	⇄ $2SO_3$
I	1.0	1.0	1.0
C	$-2x$	$-x$	$+2x$
E	$1.0-2x$	$1.0-x$	$1+2x$

(not necessary to find x as it will lead to quadratic)

Trial keq = 1 < 6.5
→ will shift right
[O_2] will ↑
[SO_3] will ↑
[SO_2] will ↓.

24. Choose the equilibrium which most *favours the reactants*.

a) $NO + 1/2O_2$ ⇄ NO_2 Keq = 4.4×10^{7}
b) $CO + 1/2O_2$ ⇄ CO_2 Keq = 4.0×10^{-3}
c) $C + H_2O$ ⇄ $CO + H_2$ Keq = 3.1×10^{3}
d) $NO + H_2O$ ⇄ NO_2 H_2 Keq = 1.0×10^{-22} ← smallest keq most favours reactants

26. Given the equilibrium equation: $XY_{(g)}$ + *heat* ⇄ $X_{(g)}$ + $Y_{(g)}$

If initially, at equilibrium, the [XY] = 3.0 M, the [X] = 5.0 M and the [Y] = 6.0 M, draw a graph showing qualitatively what happens to the concentrations of each species as the following changes are made to the system:

Time I - The *temperature is decreased*.
Time II - Some $X_{(g)}$ is removed from the system
Time III - Some $XY_{(g)}$ is added to the system
time IV - The *total pressure is increased*.