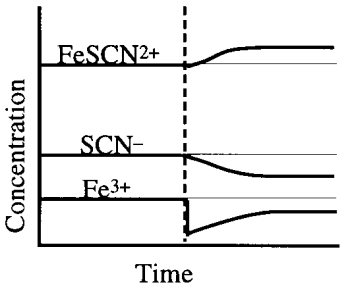
1. Given the system at equilibrium:

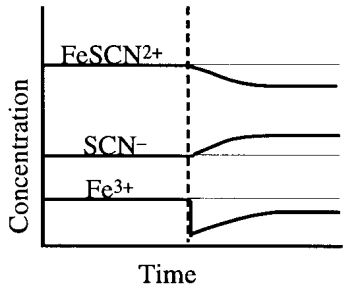
   $Fe^{3+}(aq) + SCN^{-}(aq) \leftrightarrow FeSCN^{2+}(aq)$

   What happens to the concentrations of the three ions when some Fe^{3+} ion is removed by precipitation from this aqueous solution, with the temperature remaining constant?

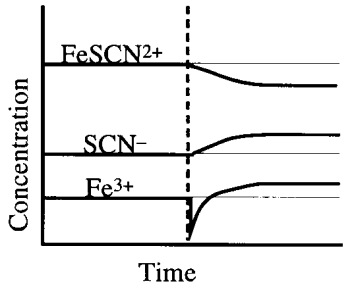
A)



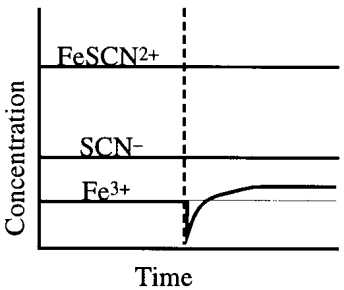
B)



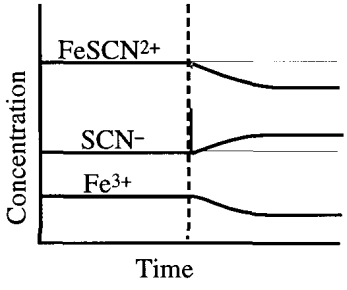
C)



D)



E)

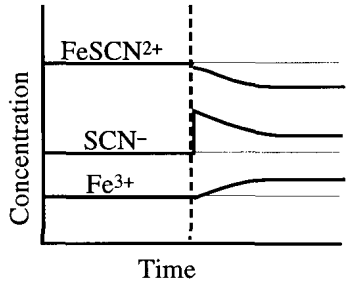


2. Given the system at equilibrium:

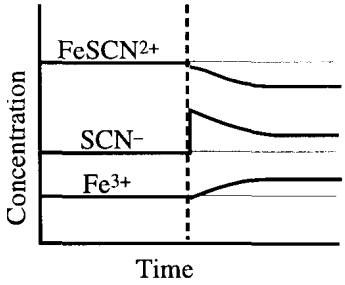
$Fe^{3+}(aq) + SCN^{-}(aq) \leftrightarrow FeSCN^{2+}(aq)$

What happens to the concentrations of the three ions when some KSCN(s) (a source of SCN^- ion) is added to this aqueous solution.

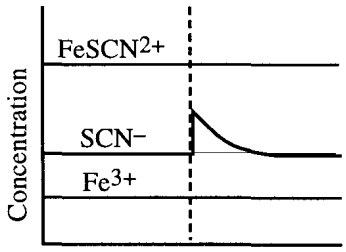
A)



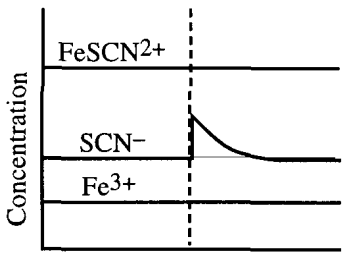
B)



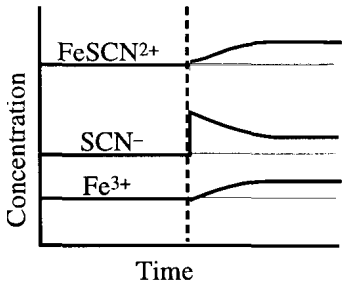
C)



D)



E)



Base your answers to questions **3** through **5** on the equation and the choices provided.

$$CN^-(aq) + H_2O(l) \leftrightarrow HCN(aq) + OH^-(aq)$$

(A) increases
(B) decreases
(C) remains the same
(D) increases, then decreases
(E) decreases, then increases

3. If HCN is removed, the [HCN]

A) A B) B C) C D) D E) E

4. If H_2O is removed, the $[CN^-]$

A) A B) B C) C D) D E) E

5. If the pressure is increased, the $[OH^-]$

A) A B) B C) C D) D E) E

Base your answers to questions **6** and **7** on the equation and the choices provided.

$$CaCO_3(s) + Heat \leftrightarrow CaO(s) + CO_2(g)$$

(A) increases
(B) decreases
(C) remains the same
(D) increases, then decreases
(E) decreases, then increases

6. If the pressure is decreased, the $[CO_2]$

A) A B) B C) C D) D E) E

7. If the pressure is increased, the K

A) A B) B C) C D) D E) E

Base your answers to questions **8** through **12** on the equation and the answers provided.

$20\ HNO_3(aq) + 3\ P_4(s) + 8\ H_2O(l) + Heat \leftrightarrow 12\ H_3PO_4(aq) + 20\ NO(g)$

(A) increases
(B) decreases
(C) remains the same
(D) increases, then decreases
(E) decreases, then increases

8. If some P_4 is added, the $[H_2O]$

A) A B) B C) C D) D E) E

9. If more HNO_3 is added, the $[H_3PO_4]$

A) A B) B C) C D) D E) E

10. If a little H_2O is added, the $[H_3PO_4]$

A) A B) B C) C D) D E) E

11. If the pressure is increased, the $[HNO_3]$

A) A B) B C) C D) D E) E

12. If temperature is decreased, the [NO]

A) A B) B C) C D) D E) E

Base your answers to questions **13** through **17** on the equation and the answers provided.

$4\ NO(g) + 3\ O_2(g) \leftrightarrow 2\ N_2O_5(g) + Heat$

(A) increases
(B) decreases
(C) remains the same
(D) increases, then decreases
(E) decreases, then increases

13. If some N_2O_5 is removed, the $[N_2O_5]$

A) A B) B C) C D) D E) E

14. If some NO is added, the $[O_2]$

A) A B) B C) C D) D E) E

15. If some O_2 is added, the $[O_2]$

A) A B) B C) C D) D E) E

16. If temperature is decreased, the Keq

A) A B) B C) C D) D E) E

17. If temperature is increased, the $[N_2O_5]$

A) A B) B C) C D) D E) E

---

18. A question asks that K_c be calculated for the reaction:

$$CS_2(g) + 4\ H_2(g) \leftrightarrow CH_4(g) + 2\ H_2S(g)$$

At equilibrium in a 5.00 L vessel, there are 5.5 moles of CH_4, 1.25 moles of H_2S, 1.5 moles of CS_2, and 1.5 moles of H_2.

$$K_c = \frac{[1.1] + [.25]^2}{[.3] + [.3]^4}$$

What is wrong with this equilibrium law expression?

A) Concentrations should be used in equilibrium constant expressions.
B) Concentrations must not be multiplied by the coefficients of the equation.
C) The equilibrium constant expression is equal to the [Products]÷[Reactants].
D) The equilibrium constant expression is the product of concentrations rather than the sum of the concentrations.
E) There is nothing wrong with this equilibrium law expression.

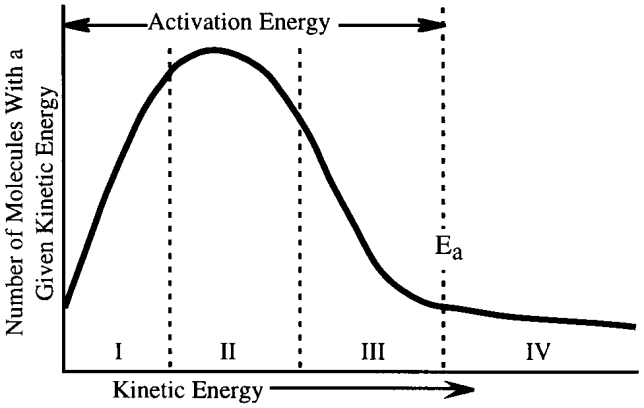
19. An equilibrium is established in the gas phase.

$$2\ NO_2(g) \leftrightarrow N_2O_4(g)$$

The equilibrium concentrations of both $[NO_2(g)]$ and $[N_2O_4(g)]$ are 0.1 M at constant temperature. What is the value of the equilibrium constant, K, at this temperature?

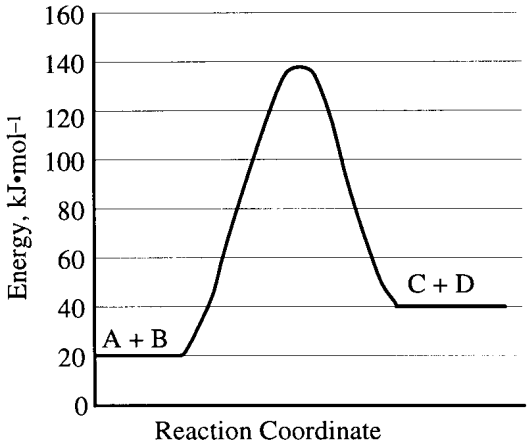
A) 0.01 B) 0.1 C) 1 D) 10 E) 100

20. The relative number of molecules with a given kinetic energy is plotted against kinetic energy. An uncatalyzed reaction with an activation energy, E_a, is being considered. In which region of the kinetic energy distribution graph will all collisions have the required energy for the reaction to occur?



A) Area I only
B) Area IV only
C) Areas II and III only
D) Areas I, II and III only
E) Areas I and IV only

Base your answers to questions **21** and **22** on the diagram below. The reaction A + B → C + D follows the energy path shown below.



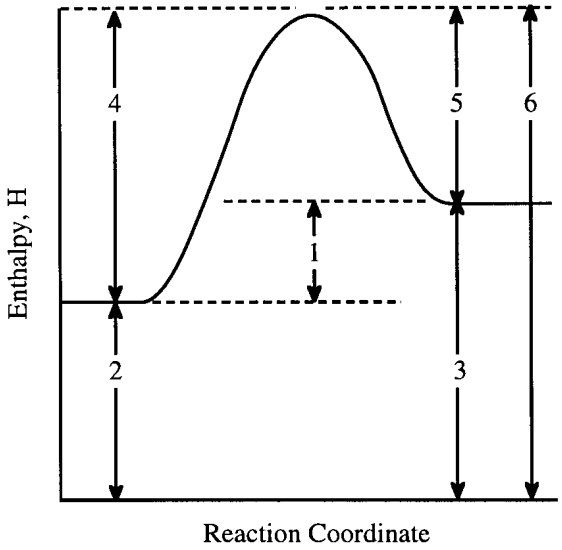
21. What is the activation energy for the *forward* reaction?

A) 20.0 kJ•mol^{-1} B) 40.0 kJ•mol^{-1}
C) 100. kJ•mol^{-1} D) 120. kJ•mol^{-1}
E) 140. kJ•mol^{-1}

22. What is the activation energy for the *reverse* reaction?

A) 20.0 kJ•mol^{-1} B) 40.0 kJ•mol^{-1}
C) 100. kJ•mol^{-1} D) 120. kJ•mol^{-1}
E) 140. kJ•mol^{-1}

Base your answers to questions **23** and **24** on the diagram shown below.



23. Which represents the activation energy for the forward reaction?

A) 1 B) 2 C) 3 D) 4 E) 6

24. The reaction diagrammed has a ΔH which is

A) negative and exothermic
B) positive and exothermic
C) positive and endothermic
D) negative and endothermic
E) Unable to be determined from the information given

---

25. Base your answer to the following question on the possible rate laws below for the reaction: A + B → C

(A) Rate = k[B]^2 (B) Rate = k[A][B]
(C) Rate = k[B]^2[A]
(D) Rate = k[B][A]^2 (E) Rate = k[B]^2 [A]^2

When [A] is tripled and [B] is constant then the initial rate of reaction remains constant.

A) A B) B C) C D) D E) E

Experimental $[H_2]$ (mol/L)		Initial [ICl] (mol/L)	Initial Rate of Reaction (mol/s•L)
1	.30	.20	3.0×10^{-3}
2	.30	.60	9.0×10^{-3}
3	.10	.60	1.0×10^{-3}

26. The above chart contains experimental data obtained from the following reaction:

$H_2 + 2\ ICl \rightarrow I_2 + 2\ HCl$

What is the experimental rate law for this reaction?

A) Rate = $k[H_2]/[ICl]$
B) Rate = $k[H_2][ICl]$
C) Rate = $k[H_2][ICl]^2$
D) Rate = $k[H_2]^2[ICl]^2$
E) Rate = $k[H_2]^2[ICl]$

Base your answers to questions **27** and **28** on on the table below, for the following reaction:

$2\ SO_2 + O_2 \rightarrow 2\ SO_3$

Experiment	$[SO_2]$	$[O_2]$	Rate
1	1.00 M	0.50 M	2.0×10^{-8} M/s
2	1.00 M	0.25 M	1.0×10^{-8} M/s
3	2.00 M	0.50 M	8.0×10^{-8} M/s

27. The value of the rate constant, k, for this reaction is

A) 4.0×10^{-8} B) 2.0×10^{-8} C) 1.0×10^{-8} D) 4.0×10^{-9} E) 2.0×10^{-9}

28. What is the experimental rate law for the reaction above?

A) Rate = $k[SO_2][O_2]^3$
B) Rate = $k[SO_2]^3[O_2]^2$
C) Rate = $k[SO_2][O_2]$
D) Rate = $k[SO_2]^2[O_2]$
E) Rate = $k[SO_2]^3$

29. Base your answer to the following question on the table below, which was obtained for the reaction $A + B \rightarrow C$.

Experiment	*Initial [A] (mol L^{-1})*	*Initial [B] (mol L^{-1})*	*Initial rate of formation of C (mol L^{-1} min^{-1})*
1	0.25	0.30	7.2×10^{-3}
2	0.50	0.30	14.4×10^{-3}
3	0.50	0.30	57.6×10^{-3}

Which concentrations would give an initial rate of 1.8×10^{-3} mol L^{-1} min^{-1}?

A) [A] = 0.25 mol L^{-1} [B] = 0.15 mol L^{-1} B) [A] = 0.125 mol L^{-1} [B] = 0.15 mol L^{-1}
C) [A] = 0.25 mol L^{-1} [B] = 0.30 mol L^{-1} D) [A] = 0.125 mol L^{-1} [B] = 0.30 mol L^{-1}
E) [A] = 0.125 mol L^{-1} [B] = 0.60 mol L^{-1}

30. I. When the pressure on a reaction at equilibrium is increased, the equilibrium will always shift to the products

BECAUSE

II. the available volume decreases.

A) I is *TRUE*, II is *FALSE*
B) I is *FALSE*, II is *TRUE*
C) I and II are *BOTH FALSE*
D) I and II are *BOTH TRUE* but II *IS NOT* a correct explanation of I
E) I and II are *BOTH TRUE* and II *IS* a correct explanation of I

31. I. Addition of the catalyst MnO_2 to the reaction for the decomposition of $KClO_3$ will result in a faster rate of reaction

BECAUSE

II. a catalyst lowers the activation energy.

A) I is *TRUE*, II is *FALSE*
B) I is *FALSE*, II is *TRUE*
C) I and II are *BOTH FALSE*
D) I and II are *BOTH TRUE* but II *IS NOT* a correct explanation of I
E) I and II are *BOTH TRUE* and II *IS* a correct explanation of I

32. I. A positive ΔG signifies an endothermic reaction

BECAUSE

II. the reaction is not spontaneous..

A) I is *TRUE*, II is *FALSE*
B) I is *FALSE*, II is *TRUE*
C) I and II are *BOTH FALSE*
D) I and II are *BOTH TRUE* but II *IS NOT* a correct explanation of I
E) I and II are *BOTH TRUE* and II *IS* a correct explanation of I

33. Given the reaction $H_2(g) + I_2(g) + \text{heat} \leftrightarrow 2\ HI(g)$, what effect will increasing the pressure have?

A) increase the $[H_2]$ B) increase the $[I_2]$
C) increase the [HI] D) decrease the [HI]
E) none of the above

34. Consider the reaction between $BaCO_3$ and an acid.

$$BaCO_3(s) + 2\ H^+(aq) \rightarrow Ba^{2+}(aq) + H_2O(l) + CO_2(g) + \text{Heat}$$

Which will increase the rate of evolution of carbon dioxide?

A) Adding water to the system
B) Decreasing the temperature
C) Using finely powdered $BaCO_3$
D) Increasing the barium ion concentration, $[Ba^{2+}]$
E) Using $H_2(g)$ instead of $H^+(aq)$

35. Increasing the temperature increases the reaction rate. This is best explained by a(n)

A) new reaction path.
B) higher activation energy.
C) increased concentration of reactants.
D) increased number of effective collisions.
E) increase in the potential energy of the reactants.

36. $2\ CrO_4^{2-}(aq) + H_2O(l) \leftrightarrow Cr_2O_7^{2-}(aq) + 2\ OH^-(aq)$

(yellow) (orange)

When HCl is added drop-by-drop to the yellow solution above, the solution turns orange. What is the reason for this color change?

A) $[OH^-]$ decreases, therefore equilibrium shifts right
B) $[OH^-]$ increases, therefore equilibrium shifts right
C) $[OH^-]$ decreases, therefore equilibrium shifts left
D) $[OH^-]$ increases, therefore equilibrium shifts left
E) $[OH^-]$ remains constant, therefore equilibrium shifts left