Kinetics and Equilibrium Review

1. A 5.0-gram sample of zinc and a 50.-milliliter sample of hydrochloric acid are used in a chemical reaction. Which combination of these samples has the fastest reaction rate?
   1) a zinc strip and 1.0 M HCl(aq)
   2) a zinc strip and 3.0 M HCl(aq)
   3) zinc powder and 1.0 M HCl(aq)
   4) zinc powder and 3.0 M HCl(aq)

2. A piece of Mg(s) ribbon is held in a Bunsen burner flame and begins to burn according to the equation:

   $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$.

   The reaction begins because the reactants
   1) are activated by heat from the Bunsen burner flame
   2) are activated by heat from the burning magnesium
   3) underwent an increase in entropy
   4) underwent a decrease in entropy

Base your answers to questions **3** and **4** on the table below, which represents the production of 50 milliliters of CO_2 in the reaction of HCl with $NaHCO_3$. Five trials were performed under different conditions as shown. (The same mass of $NaHCO_3$ was used in each trial.)

Trial	Particle Size of $NaHCO_3$	Concentration of HCl	Temperature (°C) of HCl
A	small	1 M	20
B	large	1 M	20
C	large	1 M	40
D	small	2 M	40
E	large	2 M	40

3. Which trial would produce the fastest reaction?
   1) trial *A*
   2) trial *B*
   3) trial *C*
   4) trial *D*

4. Which two trials could be used to measure the effect of surface area?
   1) trials *A* and *B*
   2) trials *A* and *C*
   3) trials *A* and *D*
   4) trials *B* and *D*

---

5. Which statement best explains the role of a catalyst in a chemical reaction?
   1) A catalyst is added as an additional reactant and is consumed but not regenerated.
   2) A catalyst limits the amount of reactants used.
   3) A catalyst changes the kinds of products produced.
   4) A catalyst provides an alternate reaction pathway that requires less activation energy.

6. Why can an increase in temperature lead to more effective collisions between reactant particles and an increase in the rate of a chemical reaction?
   1) The activation energy of the reaction increases.
   2) The activation energy of the reaction decreases.
   3) The number of molecules with sufficient energy to react increases.
   4) The number of molecules with sufficient energy to react decreases.

7. If a catalyst is added to a system at equilibrium and the temperature and pressure remain constant, there will be no effect on the
   1) rate of the forward reaction
   2) rate of the reverse reaction
   3) activation energy of the reaction
   4) heat of reaction

8. Given the reaction:

   $Zn(s) + 2\ HCl(aq) \rightarrow Zn^{2+}(aq) + 2\ Cl^-(aq) + H_2(g)$

   If the concentration of HCl(aq) is increased, the frequency of reacting collisions will
   1) decrease, producing a decrease in the reaction rate
   2) decrease, producing an increase in the reaction rate
   3) increase, producing a decrease in the reaction rate
   4) increase, producing an increase in the reaction rate

9. As the number of effective collisions between reacting particles increases, the rate of reaction
   1) decreases
   2) increases
   3) remains the same

10. Given the reaction:

    $Fe(s) + 2\ HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$

    In this reaction, 5 grams of powdered iron will react faster than a 1-gram piece of solid iron because the powdered iron
    1) has less surface area
    2) has more surface area
    3) is less dense
    4) is more dense

11. How is a chemical reaction affected by the addition of a catalyst?
    1) The activation energy decreases.
    2) The heat of reaction increases.
    3) The number of collisions between particles decreases.
    4) The potential energy of the reactants increases.

12. At STP, which 4.0-gram zinc sample will react fastest with dilute hydrochloric acid?
    1) lump
    2) bar
    3) powdered
    4) sheet metal

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13. Given the reaction:

$$A_2(g) + B_2(g) \leftrightarrow 2\,AB(g) + \text{heat}$$

An increase in the concentration of $A_2(g)$ will

1) decrease the production of $AB(g)$
2) decrease the frequency of collisions between $A_2(g)$ and $B_2(g)$
3) increase the production of $B_2(g)$
4) increase the frequency of collisions between $A_2(g)$ and $B_2(g)$

14. Four aluminum samples are each reacted with separate 1 M copper sulfate solutions under the same conditions of temperature and pressure. Which aluminum sample would react most rapidly?

1) 1 gram bar of Al
2) 1 gram of Al ribbon
3) 1 gram of Al pellets
4) 1 gram of Al powder

15. Compared with the rate of an inorganic reaction, the rate of an organic reaction is usually

1) faster, because the organic particles are ions
2) faster, because the organic particles are molecules
3) slower, because the organic particles are ions
4) slower, because the organic particles are molecules

16. A catalyst lowers the activation energy of a reaction by

1) providing an alternate reaction pathway
2) decreasing the heat of reaction
3) increasing the mass of the reactants
4) changing the mole ratio of the reactants

17. Which conditions will increase the rate of a chemical reaction?

1) decreased temperature and decreased concentration of reactants
2) decreased temperature and increased concentration of reactants
3) increased temperature and decreased concentration of reactants
4) increased temperature and increased concentration of reactants

18. The activation energy of a chemical reaction can be *decreased* by the addition of

1) a catalyst
2) an indicator
3) electrical energy
4) thermal energy

19. Given the reaction:

$$CuSO_4(s) \leftrightarrow Cu^{2+}(aq) + SO^{2-}(aq)$$

The $CuSO_4(s)$ dissolves more rapidly when it is powdered because the increased surface area due to powdering permits

1) increased solvent contact
2) increased solute solubility
3) the equilibrium to shift to the left
4) the equilibrium to shift to the right

20. As the temperature increases, the rate of an exothermic reaction

1) decreases
2) increases
3) remains the same

21. A catalyst is added to a system at equilibrium. If the temperature remains constant, the activation energy of the forward reaction

1) decreases
2) increases
3) remains the same

22. An increase in the surface area of reactants in a heterogeneous reaction will result in

1) a decrease in the rate of the reaction
2) an increase in the rate of the reaction
3) a decrease in the heat of reaction
4) an increase in the heat of reaction

23. A catalyst works by

1) increasing the potential energy of the reactants
2) increasing the energy released during a reaction
3) decreasing the potential energy of the products
4) decreasing the activation energy required for a reaction

24. Two reactant particles collide with proper orientation. The collision will be effective if the particles have

1) high activation energy
2) high ionization energy
3) sufficient kinetic energy
4) sufficient potential energy

25. A 1.0-gram sample of powdered Zn reacts faster with HCl than a single 1.0-gram piece of Zn because the atoms in powdered Zn have

1) higher average kinetic energy
2) lower average kinetic energy
3) more contact with the H^+ ions in the acid
4) less contact with the H^+ ions in the acid

26. Charcoal reacts with oxygen according to the equation

$$C(s) + O_2(g) \rightarrow CO_2(g).$$

Which of the following changes would cause the greatest increase in the rate of reaction?

1) decreasing the concentration of $O_2(g)$
2) decreasing the pressure of $O_2(g)$
3) using charcoal in powdered form
4) using charcoal in lump form

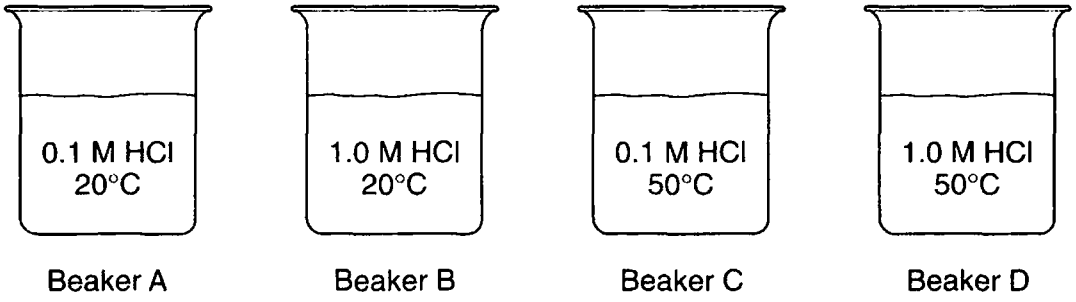
27. A 1.0-gram piece of zinc reacts with 5 milliliters of HCl(aq). Which of these conditions of concentration and temperature would produce the greatest rate of reaction?

1) 1.0 M HCl(aq) at 20.°C
2) 1.0 M HCl(aq) at 40.°C
3) 2.0 M HCl(aq) at 20.°C
4) 2.0 M HCl(aq) at 40.°C

28. Explain, in terms of collision theory, why the rate of a chemical reaction increases with an increase in temperature.

Kinetics and Equilibrium Review

29. In each of the four beakers shown below, a 2.0-centimeter strip of magnesium ribbon reacts with 100 milliliters of HCl(aq) under the conditions shown.



In which beaker will the reaction occur at the fastest rate?

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

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30. Which event must *always* occur for a chemical reaction to take place?
    1) formation of a precipitate
    2) formation of a gas
    3) effective collisions between reacting particles
    4) addition of a catalyst to the reaction system

31. Which statement best describes how a catalyst increases the rate of a reaction?
    1) The catalyst provides an alternate reaction pathway with a higher activation energy.
    2) The catalyst provides an alternate reaction pathway with a lower activation energy.
    3) The catalyst provides the same reaction pathway with a higher activation energy.
    4) The catalyst provides the same reaction pathway with a lower activation energy.

32. Which statement must be true when solution equilibrium occurs?
    1) The solution is at STP.
    2) The solution is supersaturated.
    3) The concentration of the solution remains constant.
    4) The masses of the dissolved solute and the undissolved solute are equal.

33. Given the solution at equilibrium:

$$PbI_2(s) \leftrightarrow Pb^{2+}(aq) + 2I^-(aq)$$

The addition of which nitrate salt will cause a decrease in the concentration of $I^-(aq)$?

1) $Pb(NO_3)_2$ 3) $LiNO_3$
2) $Ca(NO_3)_2$ 4) KNO_3

34. When $AgNO_3(aq)$ is mixed with NaCl(aq), a reaction occurs which tends to go to completion and not reach equilibrium because

1) a gas is formed 3) a weak acid is formed
2) water is formed 4) a precipitate is formed

35. Given the equilibrium reaction:

$$N_2(g) + O_2(g) \leftrightarrow 2\ NO(g)$$

An increase in pressure produced by a decrease in volume at constant temperature would produce an increase in the concentration of

1) N_2, only 3) N_2 and O_2, only
2) NO, only 4) N_2, O_2, and NO

36. Given the reaction at equilibrium:

$$2\ SO_2(g) + O_2(g) \leftrightarrow 2\ SO_3(g) + \text{heat}$$

The concentration of $SO_3(g)$ may be increased by

1) decreasing the concentration of $SO_2(g)$
2) decreasing the concentration of $O_2(g)$
3) increasing the pressure
4) increasing the temperature

37. Given the reaction at equilibrium:

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

At constant temperature, which changes would produce a greater yield of $NH_3(g)$?

1) decreasing the pressure and decreasing the concentration of $N_2(g)$
2) decreasing the pressure and increasing the concentration of $N_2(g)$
3) increasing the pressure and decreasing the concentration of $N_2(g)$
4) increasing the pressure and increasing the concentration of $N_2(g)$

38. Which equilibrium constant indicates an equilibrium mixture that consists largely of products?

1) $K = 1 \times 10^0$ 3) $K = 3 \times 10^{-14}$
2) $K = 2 \times 10^{10}$ 4) $K = 4 \times 10^{-23}$

Kinetics and Equilibrium Review

39. Given the reaction at equilibrium:

$$AgI(s) \leftrightarrow Ag^{+}(aq) + I^{-}(aq)$$

What happens as KI(s) is added to the solution?

1) The concentration of $Ag^{+}(aq)$ decreases and the concentration of $I^{-}(aq)$ increases.
2) The concentration of $Ag^{+}(aq)$ decreases and the concentration of $I^{-}(aq)$ remains the same.
3) The concentration of $Ag^{+}(aq)$ increases and the concentration of $I^{-}(aq)$ increases.
4) The concentration of $Ag^{+}(aq)$ increases and the concentration of $I^{-}(aq)$ remains the same.

40. Given the system at equilibrium:

$$H_2(g) + F_2(g) \ * \ 2\ HF(g) + heat$$

Which change will *not* shift the point of equilibrium?

1) changing the pressure
2) changing the temperature
3) changing the concentration of $H_2(g)$
4) changing the concentration of HF(g)

41. Given the reaction at equilibrium:

$$BaCrO_4(s) \leftrightarrow Ba^{2+}(aq) + CrO_4^{2-}(aq)$$

Which substance, when added to the mixture will cause an increase in the amount of $BaCrO_4(s)$?

1) K_2CO_3
2) $CaCO_3$
3) $BaCl_2$
4) $CaCl_2$

42. The temperature at which the solid and liquid phases of matter exist in equilibrium is called its

1) melting point
2) boiling point
3) heat of fusion
4) heat of vaporization

43. Which statement must be true for any chemical reaction at equilibrium?

1) The concentration of the products is greater than the concentration of the reactants.
2) The concentration of the products is less than the concentration of the reactants.
3) The concentration of the products and the concentration of the reactants are equal.
4) The concentration of the products and the concentration of the reactants are constant.

44. Given the reaction:

$$CO(g) + \text{¡}\ O_2(g) \leftrightarrow CO_2(g) + 67.7\ kcal$$

As the temperature increases, the rate of the forward reaction

1) decreases
2) increases
3) remains the same

45. Given the equilibrium reaction at STP:

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

Which statement correctly describes this system?

1) The forward and reverse reaction rates are equal.
2) The forward and reverse reaction rates are both increasing.
3) The concentrations of N_2O_4 and NO_2 are equal.
4) The concentrations of N_2O_4 and NO_2 are both increasing.

46. Given the reaction at equilibrium:

$$2\ CO(g) + O_2(g) \leftrightarrow 2\ CO_2(g)$$

Which statement regarding this reaction is always true?

1) The rates of the forward and reverse reactions are equal.
2) The reaction occurs in an open system.
3) The masses of the reactants and the products are equal.
4) The concentrations of the reactants and the products are equal.

47. Which statement correctly describes a chemical reaction at equilibrium?

1) The concentrations of the products and reactants are equal.
2) The concentrations of the products and reactants are constant.
3) The rate of the forward reaction is less than the rate of the reverse reaction.
4) The rate of the forward reaction is greater than the rate of the reverse reaction.

48. Which would be the equilibrium constant of a chemical reaction that goes most nearly to completion?

1) 2×10^{-15}
2) 2×10^{-1}
3) 2×10^{1}
4) 2×10^{15}

49. Given the equation representing a phase change at equilibrium:

$$C_2H_5OH(\text{-}) \leftrightarrow C_2H_5OH(g)$$

Which statement is true?

1) The forward process proceeds faster than the reverse process.
2) The reverse process proceeds faster than the forward process.
3) The forward and reverse processes proceed at the same rate.
4) The forward and reverse processes both stop.

50. Which equilibrium constant indicates the highest concentration of product?

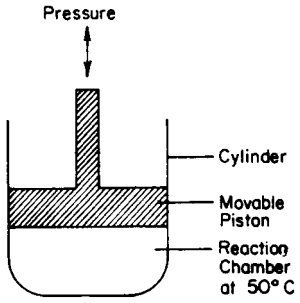
1) $K_{eq} = 1 \times 10^{-1}$
2) $K_{eq} = 2 \times 10^{-2}$
3) $K_{eq} = 3 \times 10^{-3}$
4) $K_{eq} = 4 \times 10^{-4}$

Kinetics and Equilibrium Review

51. The reaction

$$A(g) + B(g) \rightarrow C(g)$$

is occurring in the apparatus shown below.



The rate of reaction can be *decreased* by increasing the

1) pressure on the reactants
2) temperature of the reactants
3) concentration of reactant $A(g)$
4) volume of the reaction chamber

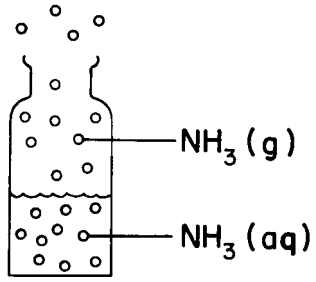
52. Given the reaction at equilibrium:

$$2\ SO_2(g) + O_2(g) \leftrightarrow 2\ SO_3(g) + \text{heat}$$

Which change will shift the equilibrium to the right?

1) decreasing $[SO_2]$
2) decreasing the pressure
3) increasing $[O_2]$
4) increasing the temperature

53. The diagram below shows a bottle containing $NH_3(g)$ dissolved in water.



How can the equilibrium,

$$NH_3(g) \leftrightarrow NH_3(aq),$$ be reached?

1) Add more water.
2) Add more $NH_3(g)$.
3) Cool the contents.
4) Stopper the bottle.

54. Based on Reference Table G, which amount of a compound dissolved in 100 grams of water at the stated temperature represents a system at equilibrium?

1) 20 g $KClO_3$ at 80°C
2) 40 g KNO_3 at 25°C
3) 40 g KCl at 60°C
4) 60 g $NaNO_3$ at 40°C

55. Given the reaction at equilibrium:

$$2\ SO_2(g) + O_2(g) \leftrightarrow 2\ SO_3(g) + 44\ \text{kcal}$$

Which change will increase the concentration of $SO_3(g)$?

1) increasing the temperature
2) increasing the concentration of $O_2(g)$
3) decreasing the pressure
4) decreasing the concentration of $SO_2(g)$

56. Given the reaction:

$$Zn(s) + HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

As the concentration of the HCl(aq) decreases at constant temperature, the rate of the reaction

1) decreases
2) increases
3) remains the same

57. Given the reaction at equilibrium:

$$PbCl_2(s) \leftrightarrow Pb^{2+}(aq) + 2Cl^-(aq)$$

When KCl(s) is added to the system, the equilibrium shifts to the

1) right, and the concentration of Pb^{2+} (aq) ions decreases
2) right, and the concentration of Pb^{2+}(aq) ions increases
3) left, and the concentration of Pb^{2+}(aq) ions decreases
4) left, and the concentration of Pb^{2+}(aq) ions increases

58. Given the phase equilibrium in a closed container:

$$H_2O(g) \leftrightarrow H_2O(\ell)$$

Compared to the rate of gas formation, the rate of liquid formation is

1) slower
2) faster
3) the same

59. Given the reaction at equilibrium:

$$N_2(g) + 3\ H_2(g) \leftrightarrow 2\ NH_3(g) + 22\ \text{kcal}$$

Which stress would cause the equilibrium to shift to the left?

1) increasing the temperature
2) increasing the pressure
3) adding $N_2(g)$ to the system
4) adding $H_2(g)$ to the system

60. Given the equation representing a reaction at equilibrium:

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

Explain, in terms of collision theory, why the rate of the forward reaction *decreases* when the concentration of $N_2(g)$ is decreased.

Kinetics and Equilibrium Review

61. Given the system at equilibrium:

$$AgCl(s) \leftrightarrow Ag^{+}(aq) + Cl^{-}(aq)$$

When NaCl(s) is added to the system, the equilibrium will shift to the

1) right and the concentration of AgCl(s) will decrease
2) right and the concentration of AgCl(s) will increase
3) left and the concentration of $Ag^{+}(aq)$ will decrease
4) left and the concentration of $Ag^{+}(aq)$ will increase

62. Given the reaction at equilibrium:

$$A_2(g) + B_2(g) \leftrightarrow 2\,AB(g) + \text{heat}$$

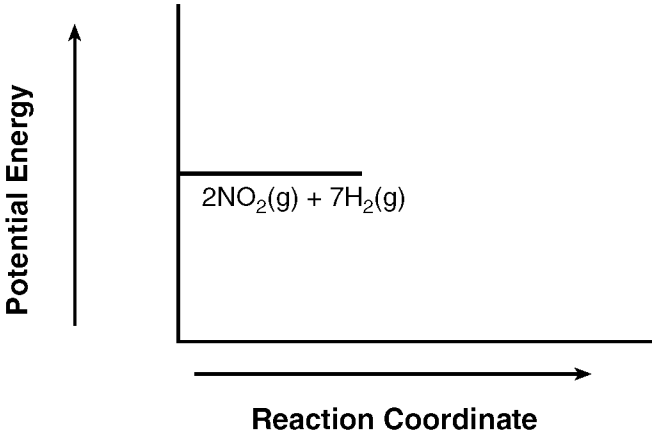
Which stress on the system at equilibrium will increase the concentration of $AB(g)$?

1) decreasing the concentration of $A_2(g)$
2) increasing the concentration of $B_2(g)$
3) decreasing the pressure
4) increasing the temperature

63. Base your answer to the following question on the information below.

Given the reaction at equilibrium:

$$2NO_2(g) + 7H_2(g) \leftrightarrow 2NH_3(g) + 4H_2O(g) + 1127\ kJ$$



Complete the potential energy diagram above for the forward reaction. Be sure your drawing shows the activation energy and the potential energy of the products.

64. Base your answer to the following question on the information below.

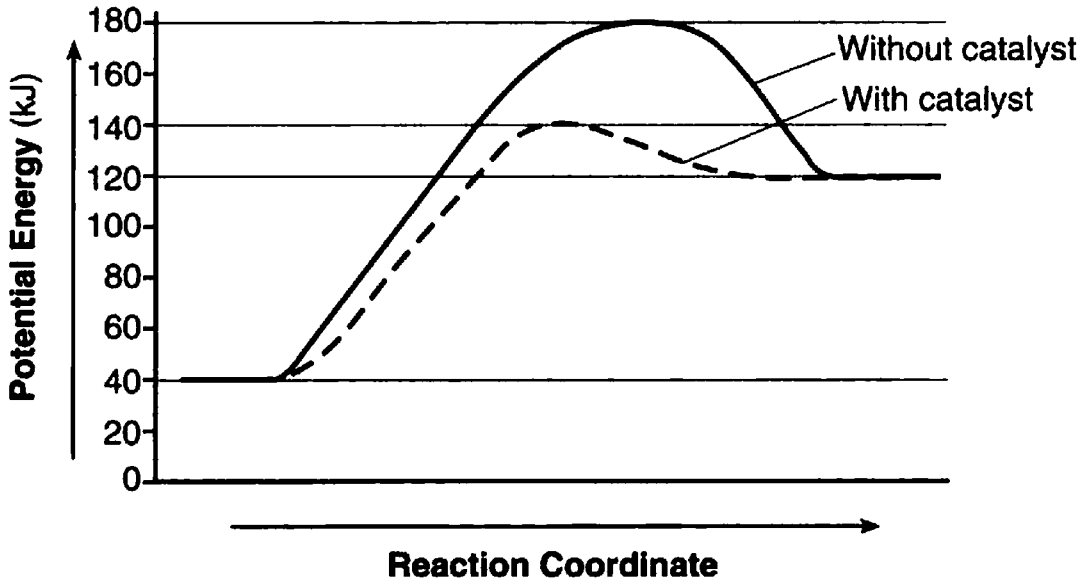
Given the equilibrium equation at 298 K:

$$KNO_3(s) + 34.89\ kJ \ * \ K^{+}(aq) + NO_3^{-}(aq)$$

Describe, in terms of *LeChatelier's principle*, why an increase in temperature increases the solubility of KNO_3.

Kinetics and Equilibrium Review

65. Base your answer to the following question on the potential energy diagram below.



What is the activation energy for the forward reaction with the catalyst?

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66. Base your answer to the following question on the information below, which describes the smelting of iron ore, and on your knowledge of chemistry.

In the smelting of iron ore, Fe_2O_3 is reduced in a blast furnace at high temperature by a reaction with carbon monoxide. Crushed limestone, $CaCO_3$, is also added to the mixture to remove impurities in the ore. The carbon monoxide is formed by the oxidation of carbon(coke), as shown in the reaction below:

$$2\ C + O_2 \ - \ 2\ CO + \text{energy}$$

Liquid iron flows from the bottom of the blast furnace and is processed into different alloys of iron.

What is the oxidation number of carbon in $CaCO_3$?

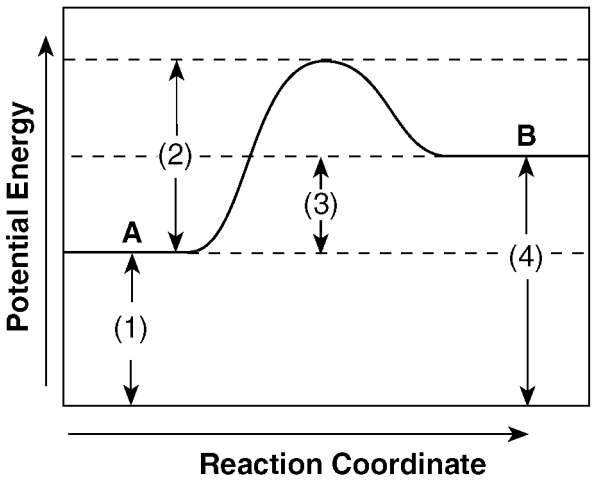
67. Base your answer to the following question on the information below.

A beaker contains 100.0 milliliters of a dilute aqueous solution of ethanoic acid at equilibrium. The equation below represents this system.

$$HC_2H_3O_2\ (aq) \leftrightarrow H^+\ (aq) + C_2H_3O_2^-\ (aq)$$

Compare the rate of the forward reaction to the rate of the reverse reaction for this system.

68. Base your answer to the following question on the potential energy diagram and the equation below.

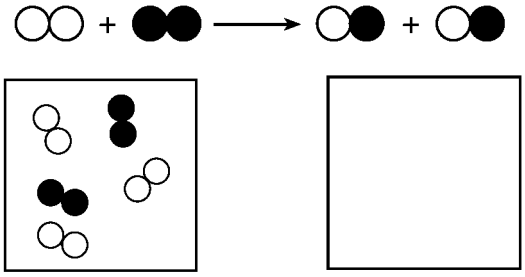


$$2\ C(s) + H_2(g) + 227.4\ kJ \rightarrow C_2H_2(g)$$

If 682.2 kilojoules are absorbed, how many moles of $C_2H_2(g)$ are produced?

Kinetics and Equilibrium Review

69. Given below the reaction between two different elements in the gaseous state. Box *A* below represents a mixture of the two reactants before the reaction occurs. The product of this reaction is a gas. In Box *B* provided below, draw the system after the reaction has gone to completion, based on the Law of Conservation of Matter.



Box A
System Before Reaction

Box B
System After Reation Has Gone to Completion

70. Base your answer to the following question on the information and balanced equation below.

Given the equation for a reaction at equilibrium:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + \text{energy}$$

Explain, in terms of collisions between molecules, why increasing the concentration of $O_2(g)$ produces a *decrease* in the concentration of $SO_2(g)$.

71. Base your answer to the following question on the information below.

A student wishes to investigate how the reaction rate changes with a change in concentration of HCl(aq).

Given the reaction:

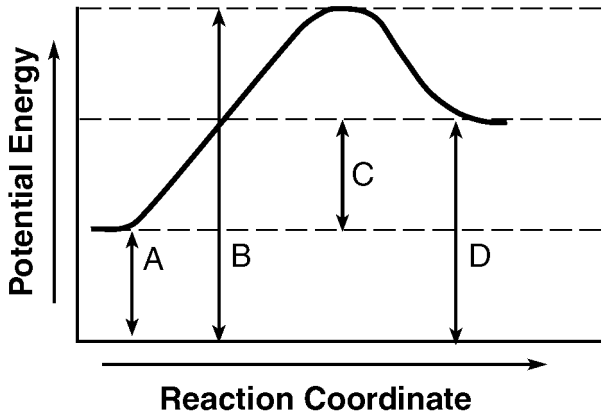
$$Zn(s) + HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$$

Identify one other variable that might affect the rate and should be held constant during this investigation.

Kinetics and Equilibrium Review

72. Base your answer to the following question on the information and potential energy diagram below.

Chemical cold packs are often used to reduce swelling after an athletic injury. The diagram represents the potential energy changes when a cold pack is activated.



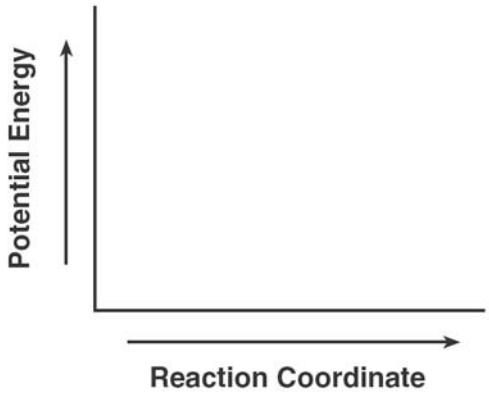
Which lettered interval on the diagram represents the heat of reaction?

73. Base your answer to the following question on

Propane is a fuel that is sold in rigid, pressurized cylinders. Most of the propane in a cylinder is liquid, with gas in the space above the liquid level. When propane is released from the cylinder, the propane leaves the cylinder as a gas. Propane gas is

$$C_3H8(g) + 5O_2(g) \; - \; 2CO_2(g) + 4H_2O(.) + 2219.2kJ$$

A small amount of methanethiol, which has a distinct odor, is added to the propane to help consumers detect a propane leak. In methanethiol, the odor is caused by the thiol functional group (–SH). Methanethiol, CH3SH, has a structure that is very similar to the structure of methanol.



On the diagram *above*, draw a potential energy diagram for this reaction.

Kinetics and Equilibrium Review

74. Base your answer to the following question on the information below.

Ethanol, C_2H_5OH, is a volatile and flammable liquid with a distinct odor at room temperature. Ethanol is soluble in water. The boiling point of ethanol is 78.2ºC at 1 atmosphere. Ethanol can be used as a fuel to produce heat energy, as shown by the balanced equation below.

$$C_2H_5OH(\ell) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell) + 1367\ kJ$$

At 1 atmosphere, compare the boiling point of pure ethanol to the boiling point of a solution in which a nonvolatile substance is dissolved in ethanol.

75. Given the equation:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

a Name the general type of reaction shown above._____

b Explain, in terms of particle behavior, why entropy is increasing during this reaction.

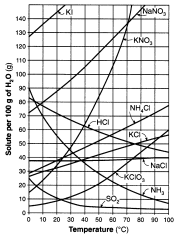
Reference Tables

Table E
Selected Polyatomic Ions

H_3O^+	hydronium	CrO_4^{2-}	chromate
Hg_2^{2+}	dimercury (I)	$Cr_2O_7^{2-}$	dichromate
NH_4^+	ammonium	MnO_4^-	permanganate
$C_2H_3O_2^-$ / CH_3COO^-	acetate	NO_2^-	nitrite
CN^-	cyanide	NO_3^-	nitrate
CO_3^{2-}	carbonate	O_2^{2-}	peroxide
HCO_3^-	hydrogen carbonate	OH^-	hydroxide
$C_2O_4^{2-}$	oxalate	PO_4^{3-}	phosphate
ClO^-	hypochlorite	SCN^-	thiocyanate
ClO_2^-	chlorite	SO_3^{2-}	sulfite
ClO_3^-	chlorate	SO_4^{2-}	sulfate
ClO_4^-	perchlorate	HSO_4^-	hydrogen sulfate
		$S_2O_3^{2-}$	thiosulfate

Reference Tables

Table G Solubility Curves



Kinetics and Equilibrium Review
Answer Key
[New Exam]

1. 4
2. 1
3. 4
4. 1
5. 4
6. 3
7. 4
8. 4
9. 2
10. 2
11. 1
12. 3
13. 4
14. 4
15. 4
16. 1
17. 4
18. 1
19. 1
20. 2
21. 1
22. 2
23. 4
24. 3
25. 3
26. 3
27. 4
28. As temperature increases, the rate of a chemical reaction increases because the reactant particles move faster and collide more often.
29. 4
30. 3
31. 2
32. 3
33. 1
34. 4
35. 4
36. 3
37. 4
38. 2
39. 1
40. 1
41. 3
42. 1
43. 4
44. 2
45. 1
46. 1
47. 2
48. 4
49. 3
50. 1
51. 4
52. 3
53. 4
54. 2
55. 2
56. 1
57. 3
58. 3
59. 1
60. *Examples:* – The rate of the forward reaction decreases because there are fewer N_2 molecules to collide with H_2 molecules. – The

rate slows down because collisions are less frequent. – fewer effective collisions

61. 3

62. 2

63. Essay

64. Increasing the temperature favors the forward, endothermic reaction *or* Adding heat shifts the reaction to the right

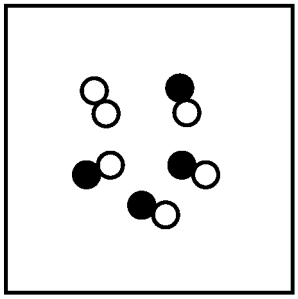
65. +100 kj or 100 kj.

66. 4 *or* +4

67. The rate of the forward reaction equals the rate of the reverse reaction.

68. three

69. **Example:**



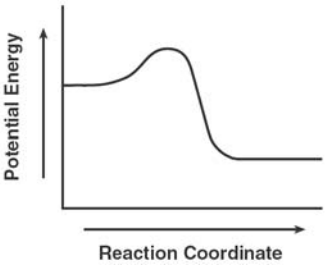
Box B
System After Reaction Has Gone to Completion

70. Examples: – A higher concentration of $O_2(g)$ causes more collisions and reactions with $SO_2(g)$ molecules, decreasing $SO_2(g)$ concentration. – More collisions between reactants shift the reaction to the right.

71. Examples: – temperature; – surface area of Zn; – amount of Zn; – Zn; – concentration of Zn; – [Zn]

72. Allow credit for **C**.

73.



74. *Examples:* – Ethanol's boiling point is lower than the boiling point of the solution – The solution's boiling point is higher than 78.2ºC

75. *a)* decomposition or analysis. b) Acceptable responses include, but are not limited to, these examples: – The particles in the gas product are less organized than the particles in the solid reactant. – increasing randomness
– A gas is more chaotic than a solid.