1. A reaction is most likely to occur when reactant particles collide with

   A) proper energy, only
   B) proper orientation, only
   C) both proper energy and proper orientation
   D) neither proper energy nor proper orientation

2. The energy needed to start a chemical reaction is called

   A) potential energy B) kinetic energy
   C) activation energy D) ionization energy

3. After being ignited in a Bunsen burner flame, a piece of magnesium ribbon burns brightly, giving off heat and light. In this situation, the Bunsen burner flame provides

   A) ionization energy **B) activation energy**
   C) heat of reaction D) heat of vaporization

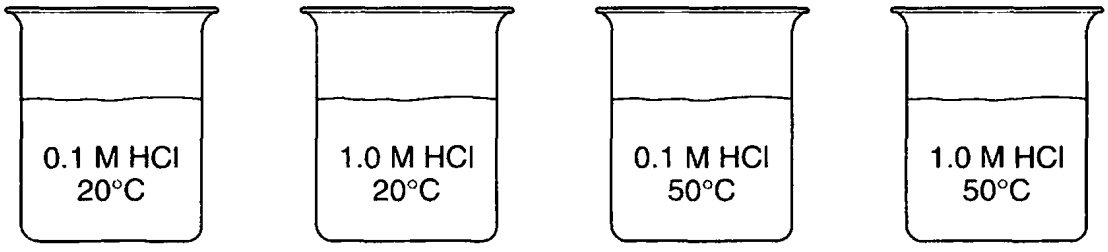
4. As the temperature increases, the rate of an exothermic reaction

   A) decreases **B) increases**
   C) remains the same

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

   A) decreased temperature and decreased concentration of reactants
   B) decreased temperature and increased concentration of reactants
   C) increased temperature and decreased concentration of reactants
   D) increased temperature and increased concentration of reactants

6. Base your answer to the following question on 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?

A) A B) B C) C **D) D**

7. As the concentration of reacting particles increases, the rate of reaction generally

   A) decreases **B) increases**
   C) remains the same

8. 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

   A) increased solvent contact
   B) increased solute solubility
   C) the equilibrium to shift to the left
   D) the equilibrium to shift to the right

9. Given the balanced equation representing a reaction:

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

   This reaction occurs more quickly when powdered iron is used instead of a single piece of iron of the same mass because the powdered iron

   A) acts as a better catalyst than the single piece of iron
   B) absorbs less energy than the single piece of iron
   C) has a greater surface area than the single piece of iron
   D) is more metallic than the single piece of iron

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

    A) providing an alternate reaction pathway
    B) decreasing the heat of reaction
    C) increasing the mass of the reactants
    D) changing the mole ratio of the reactants

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

    A) decreases B) increases
    C) remains the same

12. A catalyst works by

    A) increasing the potential energy of the reactants
    B) increasing the energy released during a reaction
    C) decreasing the potential energy of the products
    D) decreasing the activation energy required for a reaction

13. A student observed that when sodium hydroxide was dissolved in water, the temperature of the water increased. The student should conclude that the dissolving of sodium hydroxide

    A) is endothermic
    B) is exothermic
    C) produces an acid solution
    D) produces a salt solution

14. When an exothermic reaction occurs in a water solution, the temperature of the solution

    A) increases because energy is given off by the reaction
    B) increases because energy is absorbed by the reaction
    C) decreases because energy is given off by the reaction
    D) decreases because energy is absorbed by the reaction

15. In a rechargeable battery system, the discharging reaction is

    A) exothermic and the charging reaction is exothermic
    B) exothermic and the charging reaction is endothermic
    C) endothermic and the charging reaction is exothermic
    D) endothermic and the charging reaction is endothermic

16. A student observed that the temperature of water increased when a salt was dissolved in it. The student should conclude that dissolving the salt was

    A) involved in the formation of an acidic solution
    B) involved in the formation of a basic solution
    C) an exothermic reaction
    D) an endothermic reaction

17. Given the balanced equation representing a reaction:

    $Cu + S \rightarrow CuS + energy$

    Which statement explains why the energy term is written to the right of the arrow?

    A) The compound CuS is composed of two metals.
    B) The compound CuS is composed of two nonmetals.
    C) Energy is absorbed as the bonds in CuS form.
    D) Energy is released as the bonds in CuS form.

18. According to Reference Table I, what happens when two moles of gaseous ethane are formed from its elements?

    A) 42 kJ are absorbed
    B) 42 kJ are released
    C) 84 kJ are absorbed
    D) 84 kJ are released

19. Which reaction is accompanied by the release of the greatest amount of energy?

    A) combustion of 10. g of propane
    B) electrolysis of 10. g of water
    C) nuclear fission of 10. g of uranium
    D) oxidation of 10. g of iron

20. The following set of procedures was used by a student to determine the heat of solution of NaOH.
    (*A*) Read the original temperature of the water.
    (*B*) Read the final temperature of the solution.
    (*C*) Pour a measured amount of water into a beaker.
    (*D*) Stir the mixture.
    (*E*) Add the sodium hydroxide.
    What is the correct order of procedures for making this determination?

    A) $A \rightarrow C \rightarrow E \rightarrow B \rightarrow D$
    B) $E \rightarrow D \rightarrow C \rightarrow A \rightarrow B$
    C) $C \rightarrow A \rightarrow E \rightarrow D \rightarrow B$
    D) $C \rightarrow E \rightarrow D \rightarrow A \rightarrow B$

21. Changes in activation energy during a chemical reaction are represented by a

    A) cooling curve
    B) heating curve
    C) ionization energy diagram
    D) potential energy diagram

22. In a potential energy diagram, the difference between the potential energy of the products and the potential energy of the reaction is equal to the

    A) heat of reaction
    B) entropy of the reaction
    C) activation energy of the forward reaction
    D) activation energy of the reverse reaction

23. A system is said to be in a state of dynamic equilibrium when the

    A) concentration of products is greater than the concentration of reactants
    B) concentration of products is the same as the concentration of reactants
    C) rate at which products are formed is greater than the rate at which reactants are formed
    D) rate at which products are formed is the same as the rate at which reactants are formed

24. Which type or types of change, if any, can reach equilibrium?

    A) a chemical change, only
    B) a physical change, only
    C) both a chemical and a physical change
    D) neither a chemical nor a physical change

25. A solution that is at equilibrium must be

    A) concentrated B) dilute
    C) saturated D) unsaturated

26. As the pressure on the surface of a liquid *decreases,* the temperature at which the liquid will boil

    A) decreases B) increases
    C) remains the same

27. 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

    A) slower B) faster
    C) the same

28. Given the reaction at equilibrium:

    $H_2(g) + Cl_2(g) \leftrightarrow 2\ HCl(g)$

    As the pressure increases at constant temperature, the mass of $H_2(g)$

    A) decreases B) increases
    C) remains the same

29. Given the reaction at equilibrium:

$$2\ SO_2(g) + O_2(g) \leftrightarrow 2\ SO_3(g)$$

As the pressure is increased at constant temperature, the number of moles of $SO_3(g)$ produced will

A) decrease **B) increase**
C) remain the same

30. In the equilibrium reaction:

$$A(g) + 2\ B(g) + \text{heat} \leftrightarrow AB_2(g)$$

the rate of the forward reaction will increase if there is

A) an increase in pressure
B) an increase in the volume of the reaction vessel
C) a decrease in temperature
D) a decrease in the concentration of A (g)

31. Given the reaction at equilibrium:

$$2\ A(g) + 3\ B(g) \leftrightarrow A_2B_3(g) + \text{heat}$$

Which change will not affect the equilibrium concentrations of $A(g)$, $B(g)$, and $A_2B_3(g)$?

A) adding more $A(g)$
B) adding a catalyst
C) increasing the temperature
D) increasing the pressure

32. Given the reaction at equilibrium:

$$A(g) + B(g) \leftrightarrow C(g) + D(g)$$

The addition of a catalyst will

A) shift the equilibrium to the right
B) shift the equilibrium to the left
C) increase the rate of forward and reverse reactions equally
D) have no effect on the forward or reverse reactions

33. 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

A) decreases B) increases
C) remains the same

34. Given the reaction at equilibrium:

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

As the concentration of $N_2(g)$ increases, the concentration of $O_2(g)$ will

A) decrease B) increase
C) remain the same

35. Given the reaction at equilibrium:

$$A(g) + B(g) \rightleftharpoons AB(g) + \text{heat}$$

The concentration of $A(g)$ can be increased by

A) lowering the temperature
B) adding a catalyst
C) increasing the concentration of $AB(g)$
D) increasing the concentration of $B(g)$

36. Given the reaction at equilibrium:

$$SO_2(g) + NO_2(g) = SO_3(g) + NO(g)$$

The amount of $SO_3(g)$ will increase if the concentration of

A) NO(g) increases **B) $SO_2(g)$ increases**
C) $NO_2(g)$ decreases D) $SO_2(g)$ decreases

37. Given the Haber reaction at equilibrium:

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

Which stress on the system will decrease the production of $NH_3(g)$?

A) increasing the concentration of $N_2(g)$
B) increasing the pressure on the system
C) decreasing the concentration of $H_2(g)$
D) decreasing the temperature on the system

38. Given the equilibrium reaction in a closed system:

$$H_2(g) + I_2(g) + \text{heat} \leftrightarrow 2\ HI(g)$$

What will be the result of an increase in temperature?

A) The equilibrium will shift to the left and $[H_2]$ will increase.
B) The equilibrium will shift to the left and $[H_2]$ will decrease.
C) The equilibrium will shift to the right and [HI] will increase.
D) The equilibrium will shift to the right and [HI] will decrease.

39. An increase in the temperature of a system at equilibrium favors the

A) endothermic reaction and decreases its rate
B) endothermic reaction and increases its rate
C) exothermic reaction and decreases its rate
D) exothermic reaction and increases its rate

40. Given the equilibrium system:

$$2\,A(g) + B(g) + 10\text{ kcal} \leftrightarrow C(g)$$

Which conditions would yield the most product?

A) low temperature and high pressure
B) low temperature and low pressure
C) high temperature and high pressure
D) high temperature and low pressure

41. Which equation shows an increase in entropy?

A) $CO_2(g) \rightarrow CO_2(s)$
B) $CO_2(\ell) \rightarrow CO_2(g)$
C) $CH_3OH(\ell) \rightarrow CH_3OH(s)$
D) $CH_3OH(g) \rightarrow CH_3OH(\ell)$

42. The entropy of a sample of H_2O increases as the sample changes from a

A) gas to a liquid
B) gas to a solid
C) liquid to a gas
D) liquid to a solid

Base your answers to questions **43** and **44** on the information below.

Several steps are involved in the industrial production of sulfuric acid. One step involves the oxidation of sulfur dioxide gas to form sulfur trioxide gas. A catalyst is used to increase the rate of production of sulfur trioxide gas. In a rigid cylinder with a movable piston, this reaction reaches equilibrium, as represented by the equation below.

$$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g) + 392\text{ kJ}$$

43. State, in terms of the concentration of $SO_3(g)$, what occurs when more $O_2(g)$ is added to the reaction at equilibrium.

44. Explain, in terms of collision theory, why increasing the pressure of the gases in the cylinder increases the rate of the forward reaction.

Base your answers to questions **45** and **46** on the information below.
The balanced equation below represents the decomposition of potassium chlorate.

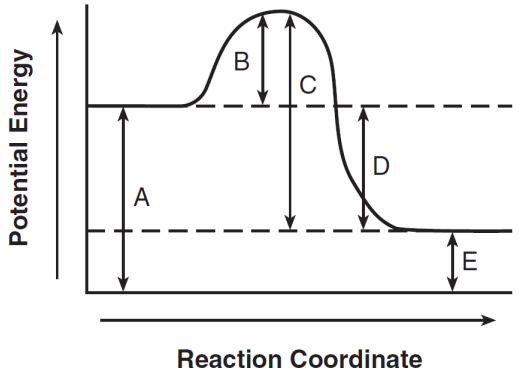
$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

45. State why the entropy of the reactant is less than the entropy of the products.

46. Determine the oxidation number of chlorine in the reactant in the equation.

Base your answers to questions **47** and **48** on the information below.

The chemical reaction between methane and oxygen is represented by the potential energy diagram and balanced equation below.



$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(\ell) + 890.4\ kJ$$

47. Explain, in terms of collision theory, why a lower concentration of oxygen gas *decreases* the rate of this reaction.

48. Which potential energy interval in the diagram represents the activation energy of the forward reaction?

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

At room temperature, a reaction occurs when $KIO_3(aq)$ is mixed with $NaHSO_3(aq)$ that contains a small amount of starch. The colorless reaction mixture turns dark blue after a period of time that depends on the concentration of the reactants.
In a laboratory, 12 drops of a 0.02 M $NaHSO_3(aq)$ solution containing starch were placed in each of six test tubes. A different number of drops of 0.02 M $KIO_3(aq)$ and enough water to maintain a constant volume were added to each test tube and the time for the dark-blue color to appear was measured. The data were recorded in the table below.

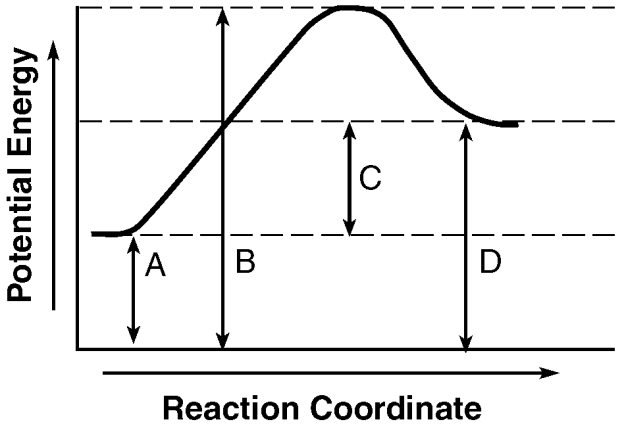
Data Table

Test Tube	A	B	C	D	E	F
Number of Drops of 0.02 M $KIO_3(aq)$	2	4	6	8	10	12
Time for Dark-Blue Color to Appear (s)	210.	88	49	39	33	27

Identify *one* factor, other than the concentration of the reactants, that would affect the rate of this reaction.

50. 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.



Identify a reactant listed in Reference Table *I* that could be mixed with water for use in a chemical cold pack.

Answer Key
Regents review Kinetics & equilibrium 2011-2012

1. **C**
2. **C**
3. **B**
4. **B**
5. **D**
6. **D**
7. **B**
8. **A**
9. **C**
10. **A**
11. **A**
12. **D**
13. **B**
14. **A**
15. **B**
16. **C**
17. **D**
18. **C**
19. **C**
20. **C**
21. **D**
22. **A**
23. **D**
24. **C**
25. **C**
26. **A**
27. **C**
28. **C**
29. **B**
30. **A**
31. **B**
32. **C**
33. **A**
34. **A**
35. **C**
36. **B**
37. **C**
38. **C**
39. **B**
40. **C**
41. **B**
42. **C**
43. The concentration of $SO_3(g)$ increases.
44. When the pressure in the cylinder is increased, the $SO_2(g)$ molecules and $O_2(g)$ molecules collide more frequently, producing more $SO_3(g)$.
45. – The gaseous product is more disordered than the solid reactant. – The solid reactant is more ordered than the products.
46. – $^{+}5$
47. Acceptable responses include, but are not limited to: • A lower concentration of oxygen gas decreases the number of effective collisions between O_2 molecules and CH_4 molecules.
48. *B*
49. the temperature of the reactants or a catalyst
50. Allow credit for **KNO_3** or **NaCl** or **NH_4Cl** or **NH_4NO_3**, or **potassium nitrate** or **sodium chloride** or **ammonium chloride** or **ammonium nitrate**.