Chapter 8, Chemical and Physical Change

1. Complete in not more than ten words: Thermodynamics deals with
   ……………..

   Ans. energy changes in chemical reactions.

2. Name, in order, the three thermodynamic quantities represented by \( H, S \)
   and \( G \) (as in \( \Delta H^\circ, \Delta S^\circ \) and \( \Delta G^\circ \)).

   Ans. enthalpy, entropy, free energy

3. Explain what is meant by "system" and "surroundings" in thermodynamics.

   Ans. The system is the reaction or process being studied; the surroundings
   are the remainder of the universe.

4. What is another name for the first law of thermodynamics?

   Ans. law of conservation of energy

5. Circle the appropriate word in each of the underlined pairs:

   In an endothermic reaction, the products are initially formed
   hotter/colder than the reactants, and in returning to the temperature
   of the surroundings, the system gains/loses heat from/to the
   surroundings.

   Ans. colder; gains

6. What is the name and symbol of the thermodynamic quantity (function)
   which is equal to the heat absorbed or liberated in a chemical reaction
   at constant pressure?

   Ans. enthalpy change, \( \Delta H^\circ \)

7. Circle the appropriate word in each of the underlined pairs:

   A reaction will never be spontaneous if it is exothermic/endothermic
   and there is an/a increase/decrease in disorder of the system.

   Ans. endothermic; decrease

8. What is the name and symbol of the single thermodynamic quantity
   (function) which determines whether or not a reaction is spontaneous?

   Ans. free energy change, \( \Delta G^\circ \)

9. What is the name of the technique for measuring the heat energy
   absorbed or released in a chemical reaction?

   Ans. calorimetry

10. How many small calories are equivalent to one nutritional Calorie?

    Ans. 1000 cal

11. Fill in the blanks: The specific heat of a substance is the number of
    calories (or joules); one gram; 1°C

    Ans. calories (or joules); one gram; 1°C

12. What process is the main source of energy in the human body?

    Ans. combustion of carbohydrates
13. A candy sample is completely combusted in a bomb calorimeter. The calorimeter contains 982 g of water, and the measured temperature increase is 2.62°C. What is the fuel value of the candy sample in nutritional Calories?

Ans. 2.57 Calories

14. A carbohydrate sample weighing 0.235 g was found to have a fuel value of 3.84 kJ. What is the fuel value of one gram of this carbohydrate, in nutritional Calories?

Ans. 3.91 Calories

15. Complete in not more than ten words: Kinetics deals with .................

Ans. the rates (and mechanisms) of chemical reactions.

16. What is the term used for the height of the energy barrier the reactants must overcome in order to form products in a reaction?

Ans. activation energy

17. Complete the following potential energy diagram for a reaction, in order to clearly identify the activation energy, the activated complex and the energy absorbed or released in the reaction.

Ans.

18. In one sentence, define a catalyst.

Ans. It is a substance which speeds up a chemical reaction without being consumed in the process.

19. What is the name given to a biological catalyst?

Ans. enzyme

20. A reaction is first order in reactant A, first order in B and second order in C. Write down the rate equation for this reaction.

Ans. rate = k[A][B][C]^2
21. For any given reaction, list three different ways in which one might speed up the reaction rate.

Ans. increase concentrations of reactants; increase temperature; add a catalyst

22. Write the equilibrium constant expression for the reaction:

\[2\text{NO}(g) + \text{O}_2(g) \rightleftharpoons 2\text{NO}_2(g)\]

Ans. 

\[K_{eq} = \frac{[\text{NO}_2]^2}{[\text{NO}]^2[\text{O}_2]}\]

23. Write the equilibrium constant for the following reaction (think carefully!):

\[\text{MgCO}_3(s) \rightleftharpoons \text{MgO}(s) + \text{CO}_2(g)\]

Ans. \(K_{eq} = [\text{CO}_2]\)

24. In the industrial synthesis of ammonia, the equilibrium constant expression may be written as

\[K_{eq} = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}\]

Calculate the value of this equilibrium constant, if the equilibrium concentrations in the reaction mixture at 600°C are:

\([\text{N}_2] = 0.830 \ M; [\text{H}_2] = 2.49 \ M; [\text{NH}_3] = 7.62 \ M\)

Ans. 4.53


Ans. If a stress is applied to a system at equilibrium, the equilibrium will shift in such a way as to minimize that stress.

26. When a cold-pack is activated, a chemical reaction occurs and the temperature of the pack contents drops sharply. Which of the following is a correct description of the reaction occurring in the pack?

A. The reaction is exothermic; \(\Delta H^\circ > 0\)
B. The reaction is exothermic; \(\Delta H^\circ < 0\)
C. The reaction is endothermic; \(\Delta H^\circ > 0\)
D. The reaction is endothermic; \(\Delta H^\circ < 0\)
E. None of the above statements is correct.

Ans. C

27. What is the measure of the randomness or disorder of a chemical system?

A. energy
B. calorimetry
C. entropy
D. enthalpy
E. free energy

Ans. C
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28. In general, which state of matter has the lowest entropy?

A. solid
B. liquid
C. gas
D. plasma
E. supercritical fluid

Ans. A

29. Under normal conditions, which of the following would have the highest entropy?

A. oxygen gas
B. liquid water
C. ice
D. solid sodium chloride
E. solid iron

Ans. A

30. A granola bar contains 185 nutritional Calories. How many kilojoules is this?

A. \(7.74 \times 10^{-1}\) kJ
B. \(4.42 \times 10^{-2}\) kJ
C. 442 kJ
D. 774 kJ
E. \(1.85 \times 10^5\) kJ

Ans. D

31. When a sample of aqueous hydrochloric acid was neutralized with aqueous sodium hydroxide in a calorimeter, the temperature of 100.0 g of water surrounding the reaction increased from 25.0°C to 31.5°C. If the specific heat of water is 1.00 cal/(g°C), calculate the quantity of energy in calories involved in this neutralization reaction.

A. 1000 cal
B. 100.0 cal
C. 6.50 cal
D. 1250 cal
E. 650 cal

Ans. E

32. Ethylene glycol has a specific heat of 0.578 cal/(g°C). If 23.2 g of ethylene glycol absorbs 75.6 cal of heat energy, what will the temperature increase be?

A. 0.177°C
B. 1.88°C
C. 5.64°C
D. \(1.01 \times 10^3\)°C
E. \(3.03 \times 10^3\)°C

Ans. C
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33. In the potential energy diagram for a chemical reaction, what is the name used for the unstable species corresponding to the top of the energy barrier separating reactants from products?

A. catalyst  
B. activated complex  
C. intermediate  
D. free radical  
E. substrate

Ans. B

34. Which one of the following actions can alter the activation energy of a reaction?

A. changing the temperature  
B. changing the concentration of reactants  
C. changing the concentration of products  
D. changing the size of the reaction vessel  
E. adding a catalyst

Ans. E

35. One effect of a catalyst being added to a reaction mixture is

A. to increase the rate of collisions between reactants  
B. to slow down the rate of the reverse reaction  
C. to raise the temperature of the mixture  
D. to provide a new pathway for the reaction  
E. none of the above

Ans. D

36. In kinetics, the order of a reaction

A. is the inverse of the entropy of the system  
B. is measured experimentally  
C. can be deduced from the balanced equation for the reaction  
D. depends on the rate constant  
E. depends on the concentrations of reactants

Ans. B

37. When a chemical reaction reaches equilibrium

A. the forward reaction stops  
B. the reverse reaction stops  
C. one of the reactants has been completely consumed  
D. the equilibrium constant has reached its maximum value  
E. the rates of the forward and reverse reactions are equal

Ans. E
38. Consider the reversible reaction: \( A(g) \rightleftharpoons 2B(g) \)
At equilibrium, the concentration of \( A \) is 0.381 M and that of \( B \) is 0.154 M. What is the value of the equilibrium constant, \( K_{eq} \)?

A. 0.0622  
B. 0.404  
C. 1.06  
D. 2.47  
E. 16.1

Ans. A

39. Consider the reversible reaction: \( N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \)
What is the correct expression for the equilibrium constant, \( K_{eq} \), for this reaction?

A. \( \frac{[2NH_3]}{[N_2][3H_2]} \)  
B. \( \frac{2[NH_3]}{[N_2][3H_2]} \)  
C. \( \frac{[NH_3]^2}{[N_2][H_2]^3} \)  
D. \( \frac{[N_2][H_2]^3}{[NH_3]^2} \)  
E. \( \frac{[N_2][3H_2]}{2[NH_3]} \)

Ans. C

40. Which one of the following, if changed, would change the value of equilibrium constant, \( K_{eq} \), of a reaction?

A. concentration of reactants  
B. concentration of the products  
C. temperature  
D. catalyst  
E. size of reaction vessel

Ans. C

41. The reaction below is at equilibrium. Use LeChatelier's principle to predict the effect of adding more hydrogen gas to the equilibrium reaction mixture.
\( N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \)

A. The equilibrium position will remain unchanged.  
B. The equilibrium position will shift to the right.  
C. The equilibrium position will shift to the left.  
D. The equilibrium constant will increase.  
E. All of the nitrogen gas will be used up.

Ans. B

42. T  F  The driving force of a chemical reaction is to attain a state of higher potential energy.

Ans. F

43. T  F  Exothermic reactions are often, but not always, spontaneous.

Ans. T
44. T  F  Endothermic reactions are never spontaneous.
   Ans. F
45. T  F  A reaction that leads to an increase in the entropy of the system is always spontaneous.
   Ans. F
46. T  F  A reaction that leads to a decrease in the enthalpy of the system is always spontaneous.
   Ans. F
47. T  F  A reaction that leads to a decrease in the free energy of the system is always spontaneous.
   Ans. T
48. T  F  According to the second law of thermodynamics, a system and its surroundings spontaneously tend towards increasing order.
   Ans. F
49. T  F  In general, a liquid state will have a higher entropy than a solid state.
   Ans. T
50. T  F  A collision between reactant molecules which produces one or more product molecules is called an effective collision.
   Ans. T
51. T  F  Lowering the activation energy of a reaction will decrease its rate.
   Ans. F
52. T  F  The order of a reaction with respect to any reactant is shown in the rate equation.
   Ans. T
53. T  F  The equilibrium constant expression for a reaction can be written down if the balanced equation is known.
   Ans. T
54. T  F  Reactants and products which are solids or pure liquids do not appear in the equilibrium constant expression.
   Ans. T
55. T  F  Changing the temperature alters the value of the equilibrium constant for a reaction.
   Ans. T
56. T  F  LeChatelier's principle provides information about the rate of a reaction.
   Ans. F
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57.  T  F  Removal of a gaseous product from an equilibrium reaction mixture shifts the equilibrium toward formation of more products.
   Ans.  T

58.  T  F  A catalyst increases the equilibrium constant for a reaction.
   Ans.  F